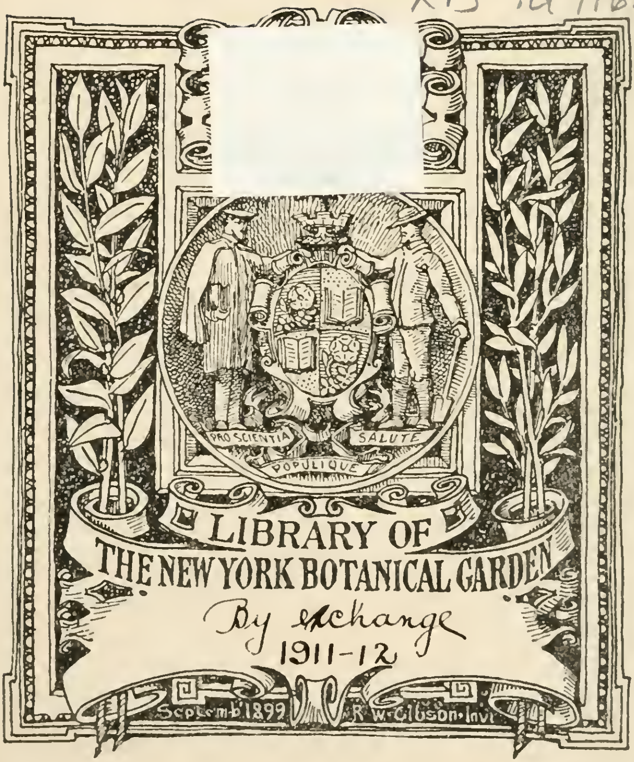
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BUREAU OF PLANT INDUSTRY—BULLETIN NO. 218.

B. T. GALLOWAY, *Chief of Bureau.*

CROSSBREEDING CORN.

BY

C. P. HARTLEY, ERNEST B. BROWN, C. H. KYLE,
AND L. L. ZOOK,

Office of Corn Investigations.

ISSUED FEBRUARY 17, 1912.

WASHINGTON:
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BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., August 14, 1911.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 218 of the series of this Bureau a paper by C. P. Hartley, Ernest B. Brown, C. H. Kyle, and L. L. Zook, entitled "Crossbreeding Corn." This article presents one feature of the work of the Office of Corn Investigations on the project of finding and developing higher yielding strains of corn for different geographical sections of the United States. The success that is being attained along this line is due to the utilization of the effects of acclimatization, adaptation, crossbreeding, and selection.

The results of field tests in four States are given in detail. In this report the results are assembled in a manner to show the relative productiveness of first-generation crosses and their parent varieties. While these results include a part of the data that are being assembled to show the effects on corn of acclimatization and adaptation, only such mention is here made of these influences as will prevent their effects being attributed to crossbreeding.

These investigations assist in determining what varieties and what combinations of varieties can be most profitably grown in different localities. They also assist in revealing the qualities of seed corn that influence its productivity. Knowledge of this nature is especially needed at this time to assist in establishing successful methods of corn improvement embracing the good effects of selecting fine-appearing ears and of crossbreeding, without leading practical corn growers into the belief that prize-winning ears are necessarily profitable seed ears or that a well-selected and well-adapted variety is usually less productive than its first-generation cross.

The results presented here are the first results of a series of tests being conducted with many varieties under various environments. More work more accurately conducted is necessary before general conclusions of a positive nature are warranted, but the urgent need of facts concerning our most widely grown and most valuable crop makes it advisable to publish in detail these results, which are at once of both local and general value.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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CROSSBREEDING CORN.

INTRODUCTION.

In the United States corn has become the leading and most universally grown crop, perhaps more because of its natural adaptability and productiveness than because of any improvement of the plant intentionally accomplished by man. Human efforts have doubtless had a great influence upon the evolution of maize, and it has been modified so as better to meet human needs. These changes, however, have come about probably more because of the interdependent relations that have existed between man and corn than through knowledge intentionally applied. The evolutionary steps that have developed the maize plant as it exists to-day are so little understood that they are of little value in indicating methods to be adopted or avoided in further improving this crop. Such improvement may rest upon a close study of the effects upon the plant of different methods of breeding and a correct application of the principles evolved.

The success of the work of the Office of Corn Investigations in originating and improving high-yielding strains of corn for different sections of the United States has been due to the utilization of the effects of acclimatization, crossbreeding, and selection. Of these three factors crossbreeding is the principal one here under consideration; but as these as well as other factors—such as seasonal and soil conditions—usually operate together in influencing plant growth, the effects of all factors that can not be eliminated must receive consideration whenever comparisons are made.

Because crossbreeding of corn is so readily accomplished, and the results are so varied and interesting, and because crossbreeding is so generally recognized as a very important process in plant improvement, the corn investigations of the Department of Agriculture during 1900 and for several years following consisted very largely in crossbreeding all types obtainable. Of the first-generation crosses tested some were unusually productive, some good, some indifferent, and some unusually poor producers. The indifferent and poor-producing crosses were discarded and selection work started with the unusually productive ones. As the work progressed some decreased in productiveness while others retained their high-yielding qualities, and a few have come into general culture as the best grain-producing strains of certain localities.

As most of these crosses when tested in various localities were found to be seldom superior to local strains, the improvement of local strains by selection or by crossbreeding and selection combined became a more prominent feature of the corn work. This feature has proved highly satisfactory and profitable to practical farmers, and much experimental evidence has been obtained to demonstrate that strains can be greatly increased in productiveness by centgener selection.

Investigations and observations have indicated a number of lines for the improvement of general practices in seed-corn production. In this connection attention is called to the following points regarding corn: (1) That self-fertilization reduces productiveness; (2) that constant isolation, especially when unaccompanied by judicious selection, may result in the multiplication of undesirable individuals and the augmentation of their undesirable characters; (3) that the emphasis which has unfortunately been placed upon the possibility of improving productiveness by planting fine-appearing, prize-winning ears has reacted against the improvement of yields through the selection of seed from high-yielding individuals; (4) that the adaptation of the floral parts of maize to facilitate crossbreeding has played an important part in its evolution, perhaps assisting in giving it greater vigor, productiveness, adaptability, and freedom from disease than other cereals.

One or more of these features has reduced yields in so many instances where increased yields were expected that some, and especially those who have not witnessed improvement by selection, have become skeptical regarding possibility of increasing yields by selection and desirous of trying radically different methods.

Crossbred seed frequently gives better yields than either parent, especially if one or both parents are poor producers as a result of self-fertilization, inbreeding, or lack of adaptation or acclimatization. Since crossbred seed corn frequently yields less than one and sometimes less than either of the parent varieties, it would be very unwise to advise the general planting of crossbred seed without first demonstrating what varieties should be crossed in different localities to produce seed of higher yielding power than that of the best existing strains. The profits that may result from following reliable methods and the losses that may result from following erroneous methods along these lines are tremendous because of the great extent to which corn is grown.

As acclimatization, crossbreeding, and selection have proved efficient in increasing the productiveness of corn, the question of practical importance is a determination of the best combination of these influencing factors. All these factors necessarily have a strong bearing upon the results presented in this paper. These results are presented here, however, with especial reference to the comparative productiveness of first-generation crosses and their parent varieties. In a future bulletin the results in these tests attributable to the effects of acclimatization and adaptation will be combined with results of other work and treated with especial reference to these factors and their influence upon yield.

TESTS IN MARYLAND.

WORK OF 1909.

CHOICE OF VARIETIES.

In order to make the tests of as much practical value as possible, varieties grown by successful corn growers in Maryland and adjoining States were chosen. Composite samples shelled from a hundred or more ears were used in order to equalize results of individual ear variations.

Detailed information regarding the history and description of these varieties is given in Table I, together with the germinating power of each lot of seed, both in the spring of 1909 and of 1910.

TABLE I.—*Varieties of corn and first-generation crosses used in Maryland tests.*

Variety.	Parentage.	Adapted to climatic and soil conditions of—	Days to mature.	Color and class.	Height of stalk (feet).		Germination (per cent).[1]		
					Pure variety.	First-generation cross.	Pure variety.		Crossed seed, 1910.
							1909.	1910.	
Selection:									
No. 119	Boone County White; a pure selection since 1880	Washington, D. C., for 10 years.	120	White dent	9.25	10.00	100.0	98 100	99
No. 159	do	Auburn, Nebr., for 2 years	120	do	9.00	9.00	98.0	96 94	99
No. 137	do	Central Texas, for 5 years	120	do	9.50	9.75		83 97	98
No. 138	do	Murfreesboro, Tenn., for 10 years.	120	do	9.25	9.75	95.0	97 98	100
Whitecap	White and yellow strains mixed years ago	Marshallton, Del	120	Mixed dent	9.25	9.00	96.5	97	99
Ohio Leaming	A pure selection since 1826	Wilmington, Ohio, since 1826.	110	Yellow dent	8.25	8.25	99.5	99	99
Illinois Leaming	Selection from Ohio Leaming	Champaign, Ill., for 25 years.	115	do	9.00	9.50	87.5	94	100
Reid Yellow Dent	A cross; pure bred since 1847	East Lynn, Ill., since 1847	115	do	8.75	9.00	98.5	96	100
Sturges Hybrid Flint	An unstable cross of several years' selection	Fairfield, Conn	100	Yellow flint	7.00	8.50	98.0	100	100
Silvermine	Pure selection since 1890	Sibley, Ill., for 20 years	110	White dent	8.75	9.25	86.5	85	100
Golden Eagle	Pure selection since 1871	Toulon, Ill., since 1871	110	Yellow dent	8.00	8.75	93.5	98	99
Fraley Yellow Dent	A local strain of no particular breeding	Derwood, Md., for 15 years	120	do	9.50	9.75	100.0	100	99
Selection 77	A cross; pure bred since 1880	Piketon, Ohio, since 1880	120	White dent	9.50	9.25	96.0	92 87	100
Red Blaze	Somewhat variable type of Bloody Butcher	Sullivan, Ind	120	Red dent	8.50	9.50	99.0	98	97
Cross:									
No. 100	Cross of Dotson with Boone County White; pure bred since 1902.	Washington, D. C., since 1902.	120	White dent	9.00	9.25	98.5	99 100	100
No. 120	Cross of Hickory King with Boone County White; pure bred since 1902.	do	120	do	9.50	9.75	99.0	99 99	100
Hickory King	A distinct and fairly pure-bred strain	Hickory, Va., since 1880	125	do	10.00	10.00	95.0	90	96
Selection 78	A pure selection of Clarage	Sabina, Ohio, for 12 years	120	Yellow dent	9.50	9.75	99.0	99 100	99

[1] Of the two percentages of germination shown by means of braces in the 1910 column the lower one refers to seed of 1909; all other percentages of germination refer to original (1908) seed.

CROSSING THE VARIETIES.

Selection 119, which has been undergoing improvement for 10 years by the ear-to-row method of breeding and adaptation to conditions of the Potomac River soils near Washington, was chosen as the male parent, and the crossed seed was obtained by planting one of the other varieties in every third row in a field of this variety located 3 miles south of Washington, D. C., on a small tributary of the Potomac. As soon as the tassels appeared they were removed from all the varieties, so that no pollen matured in the field except on the rows of Selection 119, which fertilized the silks of all the other varieties, forming the supply of crossed seed, the productiveness of which was compared in 1910 with pure seed of the parents. About 30 of the best ears from these detasseled rows were chosen as seed for these tests. These ears were shelled, making a composite sample of each cross, which was used in planting all of the tests.

A supply of the original seed of all the varieties used in making these crosses was retained in the seed-corn room of the Department of Agriculture according to the best known methods of seed preservation.

GROWING PURE-BRED SEED FOR COMPARISON.

In order that the tests of productiveness might not be restricted to the old seed of the parent varieties, isolated plats of eight of the varieties, including the male parent—Selection 119—were grown in 1909 from the original seed. These 1909 plats were grown in the same localities and under the same conditions as the original seed.

WORK OF 1910.

LOCATION OF TESTS.

Duplicate tests of productiveness were made at Derwood and at Pike Crossing, Md. Derwood is located about 16 miles northwest of Washington, where the soil is of a red-clay, flint-stone nature, and the two tests were located on similar soil. Pike Crossing is situated about 5 miles north of Washington, where the soil is of a mica, red-clay nature. At Pike Crossing the two tests adjoined, but the first test was located on land that had been in sod for some 10 years or more, while the duplicate test was located on impoverished soil that had grown truck crops for fully as many years. At these points the season of 1910 was unusually dry and unfavorable for corn.

ORDER OF PLANTING THE TEST ROWS.

In order to have the means of comparing the productiveness of the crossed seed grown in 1909 with seed of the parents grown the same season and with the original seed of the parents used in making the crosses, the plantings were made in the order shown in Table II.

It will be seen that by this order the original or 1908 seed of the two parent varieties is planted on either side of the crossed seed, and that adjoining these two rows is a row from the seed of each parent grown in 1909. In all four of the tests the varieties were planted in the same relative order.

EQUALITY OF CONDITIONS FOR GROWTH AND PRODUCTIVENESS.

Care was taken to so locate the rows that those to be compared would have equal facilities for growth and productiveness. At each location and for each test rows of uniform width were marked off both ways. Five kernels were planted in each hill and the stand thinned to two stalks tò the hill. Practically a perfect stand of plants was obtained for each row of each test. Each variety and first-generation cross was thus represented by the same number of plants, occupying the same number of square feet of adjacent, apparently similar, soil.

PRESENTATION OF RESULTS IN MARYLAND.

FIELD RECORDS IN DETAIL.

Table II presents full details of both the original and the duplicate test at Derwood and of like tests at Pike Crossing. The order of occurrence of the varieties in the table is the same as in the test plats.

TABLE II.—*Tests of parent varieties and first-generation crosses of corn.*

AT DERWOOD, MD.[1]

Field row No.	Variety and cross.	First test.						Duplicate test.					
		Number of stalks.	Yield.					Number of stalks.	Yield.				
			Ears.	Increase over male parent.	Number of ears.		Stover.		Ears.	Increase over male parent.	Number of ears.		Stover.
					Good.	Poor.					Good.	Poor.	
			Lbs.	*P. ct.*			*Lbs.*		*Lbs.*	*P. ct.*			*Lbs.*
10	Selection 119, 1909....	100	53	......	35	45	52	100	70	......	65	28	65
11	Selection 159, 1909.....	100	53	......	40	51	47	98	66	......	60	30	60
12	Selection 159, original.	100	64	......	45	59	51	100	71	......	60	36	61
13	Selection 159×Selection 119.............	100	56	− 3	20	71	61	102	71	1	60	41	60
14	Selection 119, original.	100	60	......	40	56	61	99	66	......	65	31	63
15	Selection 119, 1909.....	100	63	......	50	45	59	100	71	......	63	34	61
16	Selection 137, 1909.....	100	58	......	35	56	67	98	60	......	55	37	66
17	Selection 137, original.	97	56	......	40	43	62	100	63	......	60	37	61
18	Selection 137×Selection 119.............	101	67	8	40	60	67	100	75	6	65	33	72
19	Selection 119, original.	100	56	......	45	43	62	98	64	......	50	45	64
20	Selection 119, 1909....	99	61	......	35	57	59	100	70	......	65	29	60
21	Selection 138, 1909....	100	47	......	26	59	71	100	51	......	45	42	74
22	Selection 138, original.	100	47	......	20	70	66	99	60	......	50	45	68
23	Selection 138×Selection 119.............	100	58	− 9	50	54	74	100	68	0	60	38	69
24	Selection 119, original.	100	60	......	30	62	61	99	55	......	45	41	59
25	Selection 119, 1909....	100	67	......	57	39	57	100	66	......	55	43	55

[1] Length of row 164 feet.

TABLE II.—*Test of parent varieties and first-generation crosses of corn*—Continued.

AT DERWOOD, MD.—Continued.

Field row No.	Variety and cross.	First test. Number of stalks.	First test. Yield. Ears.	First test. Yield. Increase over male parent.	First test. Yield. Number of ears. Good.	First test. Yield. Number of ears. Poor.	First test. Yield. Stover.	Duplicate test. Number of stalks.	Duplicate test. Yield. Ears.	Duplicate test. Yield. Increase over male parent.	Duplicate test. Yield. Number of ears. Good.	Duplicate test. Yield. Number of ears. Poor.	Duplicate test. Yield. Stover.
			Lbs.	*P. ct.*			*Lbs.*		*Lbs.*	*P. ct.*			*Lbs.*
26	Selection 119×Selection 119	100	60	−10	60	64	51	101	66	− 3	50	45	62
27	Selection 119, original	99	58	......	20	74	54	100	70	......	60	34	63
28	Whitecap, original	100	49	......	35	63	49	100	53	......	40	54	58
29	Whitecap × Selection 119	100	58	−13	30	70	55	100	72	6	60	39	72
30	Selection 119, original	100	54	......	54	60	53	99	63	......	55	39	55
31	Selection 119, 1909	100	66	......	50	47	49	100	70	......	60	36	56
32	Ohio Leaming, original	100	46	......	26	63	27	100	50	......	50	33	31
33	Ohio Leaming × Selection 119	100	56	− 8	35	70	35	100	74	17	70	30	41
34	Selection 119, original	100	56	......	32	65	53	97	69	......	50	47	50
35	Selection 119, 1909	98	56	......	25	64	53	100	56	......	65	39	43
36	Illinois Leaming, original	100	46	......	41	52	35	101	46	......	50	38	34
37	Illinois Leaming×Selection 119	99	58	− 1	59	55	47	100	55	− 7	45	52	42
38	Selection 119, original	98	48	......	35	63	52	100	54	......	45	54	50
39	Selection 119, 1909	99	61	......	46	48	58	100	62	......	60	39	48
40	Reid Yellow Dent, original	99	50	......	47	46	39	101	49	......	56	29	29
41	Reid Yellow Dent× Selection 119	99	61	− 6	45	56	50	99	60	3	60	43	49
42	Selection 119, original	99	50	......	45	49	61	99	56	......	50	52	57
43	Selection 119, 1909	101	69	......	50	51	62	101	55	......	55	39	44
44	Sturges Hybrid Flint, original	100	34	......	22	76	33	106	30	......	40	52	26
45	Sturges Hybrid Flint ×Selection 119	100	58	−11	62	45	49	100	44	−11	40	56	35
46	Selection 119, original	99	60	......	40	62	69	99	[1] 34	......	20	60	37
47	Selection 119, 1909	100	62	......	40	57	60	99	44	......	30	64	45
48	Silvermine, original	100	50	......	25	62	37	101	41	......	33	43	34
49	Silvermine×Selection 119	100	57	−11	20	77	47	100	54	− 4	47	40	44
50	Selection 119, 1909	98	66	......	43	52	64	98	69	......	50	47	56
51	Golden Eagle, original	100	43	......	25	75	30	100	45	......	48	41	36
52	Golden Eagle×Selection 119	98	60	− 7	35	64	45	100	57	−10	45	55	44
53	Selection 119, 1909	100	63	......	45	53	62	101	58	......	52	43	49
54	Fraley Yellow Dent, original	100	59	......	45	54	64	99	59	......	55	45	54
55	Fraley Yellow Dent× Selection 119	98	59	0	43	63	56	100	60	0	50	40	68
56	Selection 119, 1909	100	55	......	35	61	55	99	62	......	54	42	49
57	Selection 77, 1909	100	53	......	30	66	48	100	59	......	55	45	58
58	Selection 77, original	100	48	......	30	65	47	101	64	......	55	42	53
59	Selection 77 × Selection 119	100	55	− 5	25	70	48	97	58	− 7	40	55	53
60	Selection 119, 1909	100	61	......	40	45	57	100	63	......	50	48	56
61	Red Blaze, original	97	46	......	55	37	34	100	51	......	70	28	38
62	Red Blaze×Selection 119	100	59	− 9	43	52	45	98	65	5	65	36	50
63	Selection 119, 1909	100	69	......	75	25	57	100	61	......	50	48	51
64	Cross 100, 1909	99	53	......	45	48	58	99	47	......	50	43	55
65	Cross 100, original	100	44	......	40	55	48	100	41	......	40	45	48
66	Cross 100×Selection 119	100	51	−14	30	65	51	98	60	0	60	45	52
67	Selection 119, 1909	101	49	......	35	61	48	100	59	......	45	53	50
68	Cross 120, 1909	100	55	......	50	46	49	100	63	......	74	25	57
69	Cross 120, original	99	57	......	37	60	49	99	61	......	45	50	56
70	Cross 120×Selection 119	100	62	18	29	65	52	99	74	27	57	45	69
71	Selection 119, 1909	100	56	......	40	60	52	98	58	......	45	47	53
72	Hickory King, original	100	51	......	55	51	78	100	60	......	60	29	48

[1] Unreliable, as this row occupied the dead furrow.

TABLE II.—*Tests of parent varieties and first-generation crosses of corn*—Continued.

AT DERWOOD, MD.—Continued.

Field row No.	Variety and cross.	First test.						Duplicate test.					
		Number of stalks.	Yield.					Number of stalks.	Yield.				
			Ears.	Increase over male parent.	Number of ears.		Stover.		Ears.	Increase over male parent.	Number of ears.		Stover.
					Good.	Poor.					Good.	Poor.	
			Lbs.	*P. ct.*			*Lbs.*		*Lbs.*	*P. ct.*			*Lbs.*
73	Hickory King×Selection 119	101	63	7	52	50	79	100	74	21	77	24	83
74	Selection 119, 1909	100	62	......	30	74	59	99	64	......	48	47	59
75	Selection 78, 1909	100	55	......	35	62	50	99	58	......	54	41	51
76	Selection 78, original	99	58	......	35	77	48	99	70	......	60	37	55
77	Selection 78 × Selection 119	99	58	−5	20	80	56	99	70	4	60	41	67
78	Selection 119, 1909	100	60	......	38	64	60	99	70	......	50	47	65

AT PIKE CROSSING, MD.[1]

Field row No.	Variety and cross.	First test: Number of stalks.	Ears.	Increase over male parent.	Good.	Poor.	Stover.	Duplicate test: Number of stalks.	Ears.	Increase over male parent.	Good.	Poor.	Stover.
3	Selection 159, original	By mistake this row was cut.						73	16	......	5	46	35
4	Selection 159×Selection 119	82	40	−20	32	42	39	79	11	0	0	46	34
5	Selection 119, original	80	48	......	47	32	39	82	10	......	0	39	35
6	Selection 119, 1909	79	50	......	51	24	40	82	11	......	0	50	37
7	Selection 137, original	81	42	......	32	36	40	79	5½	......	0	27	31
8	Selection 137×Selection 119	82	50	2	47	32	46	76	6	−44	0	30	26
9	Selection 119, original	78	44	......	40	34	45	86	7¾	......	0	39	31
10	Selection 119, 1909	82	48	......	48	30	42	82	10½	......	1	51	32
11	Selection 138, original	76	36	......	29	38	48	80	4½	......	0	24	32
12	Selection 138×Selection 119	85	55	16	54	27	61	82	5½	−49	0	25	43
13	Selection 119, original	79	42	......	36	35	48	80	7¾	......	0	33	33
14	Selection 119, 1909	86	47	......	45	36	46	77	11	......	0	48	34
15	Selection 119×Selection 119	80	44	−12	43	31	42	76	7	−45	0	33	35
16	Selection 119, original	80	43	......	39	37	43	79	8¾	......	1	38	36
17	Whitecap, original	80	39	......	40	26	42	77	4	......	0	21	29
18	Whitecap × Selection 119	84	48	−4	43	33	49	81	5	−61	0	26	39
19	Selection 119, original	85	47	......	44	34	45	79	6½	......	0	36	35
20	Selection 119, 1909	83	53	......	47	32	50	82	14½	......	1	51	37
21	Ohio Leaming, original	81	36	......	31	48	25	81	8	......	1	43	21
22	Ohio Leaming×Selection 119	83	45	−16	48	29	34	80	9	−36	0	46	27
23	Selection 119, original	80	54	......	48	28	48	81	12½	......	2	49	38
24	Selection 119, 1909	81	54	......	50	29	50	80	13¾	......	0	54	37
25	Illinois Leaming, original	78	43	......	51	28	33	82	7	......	0	41	30
26	Illinois Leaming×Selection 119	83	47	−12	52	22	50	82	8	−44	0	43	39
27	Selection 119, original	79	52	......	52	24	47	81	9¾	......	0	41	41
28	Selection 119, 1909	81	53	......	52	24	57	79	15	......	0	59	35
29	Reid Yellow Dent, original	80	36	......	38	36	32	78	6½	......	0	38	26
30	Reid Yellow Dent × Selection 119	82	49	−7	54	24	45	81	12¾	−27	0	59	36
31	Selection 119, original	82	51	......	44	32	49	81	12¾	......	0	48	41
32	Selection 119, 1909	82	52	......	47	28	54	81	20	......	0	65	39
33	Sturges Hybrid Flint, original	85	32	......	44	33	27	81	7	......	0	36	26
34	Sturges Hybrid Flint × Selection 119	82	49	−1	56	20	41	82	19	−15	10	50	37
35	Selection 119, original	82	49	......	55	21	45	80	21	......	2	54	46
36	Selection 119, 1909	83	47	......	36	39	49	77	24½	......	4	57	41
37	Silvermine, original	77	32	......	20	52	46	73	14½	......	0	55	24
38	Silvermine×Selection 119	86	40	−20	33	37	39	82	14½	−12	0	58	37
39	Selection 119, original	79	56	......	44	32	48	79	7	......	0	32	46
40	Selection 119, 1909	82	53	......	48	31	52	81	8½	......	0	40	42

[1] Length of row 135 feet.

TABLE II.—*Tests of parent varieties and first-generation crosses of corn*—Continued.

AT PIKE CROSSING, MD.—Continued.

Field row No.	Variety and cross.	First test.						Duplicate test.					
		Number of stalks.	Yield.					Number of stalks.	Yield.				
			Ears.	Increase over male parent.	Number of ears.		Stover.		Ears.	Increase over male parent.	Number of ears.		Stover.
					Good.	Poor.					Good.	Poor.	
			Lbs.	*P. ct.*			*Lbs.*		*Lbs.*	*P. ct.*			*Lbs.*
41	Golden Eagle, original	74	26	......	20	46	25	81	2½	......	0	20	21
42	Golden Eagle × Selection 119	78	45	−8	26	46	36	84	6¾	−21	0	39	32
43	Selection 119, original	74	45	......	40	28	45	80	7½	......	0	34	43
44	Selection 119, 1909	78	45	......	44	28	46	80	8½	......	0	39	46
45	Fraley Yellow Dent, original	79	50	......	48	27	53	82	5	......	0	29	46
46	Fraley Yellow Dent × Selection 119	77	44	−10	40	25	53	84	9½	12	1	44	54
47	Selection 119, original	79	50	......	47	28	55	[1] 81	8½	......	0	44	49
48	Selection 119, 1909	77	53	......	48	23	58	81	12	......	0	58	51
49	Selection 77, original	77	48	......	40	32	50	82	6¾	......	0	40	42
50	Selection 77 × Selection 119	71	46	−13	41	21	48	82	8	−20	0	44	48
51	Selection 119, original	78	52	......	40	34	56	[1] 81	8	......	0	42	52
52	Selection 119, 1909	79	53	......	44	29	59	82	8½	......	0	42	49
53	Red Blaze, original	79	44	......	52	20	44	81	6	......	0	37	29
54	Red Blaze × Selection 119	73	48	−9	52	18	45	81	7½	−20	0	42	44
55	Selection 119, original	78	55	......	48	24	54	[1] 82	10¼	......	1	50	48
56	Selection 119, 1909	73	52	......	52	16	58	82	12½	......	1	51	48
57	Cross 100, original	80	40	......	40	24	49	82	4½	......	2	16	44
58	Cross 100 × Selection 119	71	48	−14	48	17	50	81	10	−31	4	35	55
59	Selection 119, original	72	52	......	52	17	50	[1] 82	16½	......	4	45	50
60	Selection 119, 1909	82	60	......	52	24	51	82	18	......	5	45	57
61	Cross 120, original	65	43	......	38	24	48	81	17¾	......	10	36	44
62	Cross 120 × Selection 119	77	58	12	60	12	57	82	20½	22	10	42	56
63	Selection 119, original	82	53	......	45	38	47	[1] 82	15½	......	6	46	53
64	Selection 119, 1909	80	44	......	36	37	51	80	17	......	6	39	53
65	Hickory King, original	68	35	......	44	20	56	80	18	......	12	45	47
66	Hickory King × Selection 119	75	49	10	58	14	51	83	17¾	6	6	40	54
67	Selection 119, original	75	42	......	28	37	51	[1] 80	16½	......	3	49	50
68	Selection 119, 1909	80	45	......	36	40	48	80	13¾	......	5	33	48
69	Selection 78, original	77	33	......	24	39	33	83	9½	......	0	34	36
70	Selection 78 × Selection 119	82	42	2	32	38	36	81	14¼	11	4	41	42
71	Selection 119, original	80	37	......	20	46	46	[1] 81	12	......	1	41	45
72	Selection 119, 1909	81	37	......	23	43	46	79	15	......	6	39	41

[1] 1909 seed substituted for original seed.

Table II shows the usual inexplicable variations of test-plat work. Especially do such variations occur in the duplicate planting at Pike Crossing where the soil was so deplete of humus that from a financial standpoint the crop was a failure. Under these very adverse conditions it is rather surprising that the results accord with those of the other three tests as well as they do.

COMPARATIVE PRODUCTIVENESS OF SEEDS OF 1908 AND 1909.

Table II shows 42 instances in which the 1908 seed and 1909 seed of the male parent were planted in adjacent rows. In 33 of these 42 instances the 1909 seed produced the better, in five the 1908 seed produced the better, and in four the yield was the same. The 1908 seed produced 1,797 pounds of ears and the 1909 seed produced 1,938 pounds, a decreased yield of 7 per cent, due, perhaps, to the poor development or loss of vigor of the 1908 seed. The 1909 seed was grown from the 1908 seed under conditions that prevented any crossing with other varieties. Its greater productiveness therefore can not be attributed to mixture with other varieties.

While the 1908 seed of Selection 119 produced 7 per cent less than its progeny seed grown in 1909, it is not certain that the age of the 1908 seed was the cause of the decreased productiveness as the seed germinated perfectly the spring following its maturity, and also showed a germination of 98 per cent in the spring of 1910. The 1909 seed showed a germination of 100 per cent in the spring of 1910.

A comparison of the productiveness of the 1908 and 1909 seed of the female parents shows sufficient instances in which the 1908 seed produced better than the 1909 seed to make the average production of the 1908 seed equal to that of the 1909 seed.

CROSSES COMPARED IN PRODUCTIVENESS WITH THE MALE PARENT.

In computing the per cent of increased yield over the male parent in Table II the seed of the male parent grown the same year the crossing was accomplished is considered. As none of the female parents consistently produced better than the male parent, the male parent of all the crosses, Selection 119, is taken as the basis with which to compare the crosses. In all cases the average yield of two rows, the nearest one on either side of the cross, is compared with the cross.

Considering that contradictory results from any of the four tests is sufficient cause for ignoring all four of the tests, we have remaining five crosses which produced uniformly less than their male parent, and two comparisons in which the cross uniformly produced better than either parent.

The five first-generation crosses (× Selection 119) that uniformly produced less than the better of the two parents are Illinois Leaming, Sturges Hybrid Flint, Silvermine, Golden Eagle, and Selection 77.

The two first-generation crosses (× Selection 119) that uniformly produced better than either parent are Cross 120 and Hickory King.

COMBINED RESULTS OF THE FOUR MARYLAND TESTS.

In Table III the four separate Maryland tests are combined. In the Derwood test some of the female-parent varieties were represented by both 1908 and 1909 seed. In such instances the average of the two has been used. In these combined results this comparison of the crosses with the better yielding of the two parents is a straight comparison of the crosses with their male parent, for it is more productive than any of the female parents except Fraley Yellow Dent, which it equals.

TABLE III.—*Productiveness of first-generation crosses of corn compared with that of the better parent, 1909 seed of the male parent being considered.*

Row No.	Variety and cross.	Number of stalks.[1]	Grain yield.		Stover yield.		Moisture in shelled grain when ears were weighed.	Water-free basis.	
			Ears.	Increase over better parent.	Weight.	Increase over heavier stover-producing parent.		Ears.	Increase over better parent.
			Pounds.	*P. ct.*	*Pounds.*	*P. ct.*	*P. ct.*	*Pounds.*	*P. ct.*
1	Selection 159 × Selection 119.	363	178	−9	194	−2	31.4	122.1	−12
3	Selection 119, 1909	361	195	....	197	....	28.8	138.8	....
4	Selection 137	358	167	....	200	....	28.5	119.4	....
5	Selection 137 × Selection 119.	359	198	3	211	6	30.0	138.6	1
7	Selection 119, 1909	363	190	....	193	....	28.8	135.3	....
8	Selection 138	356	144	....	220	....	30.2	100.5	....
9	Selection 138 × Selection 119.	367	187	−2	247	12	31.9	127.4	−6
11	Selection 119, 1909	363	191	....	192	....	28.8	136.0	....
12	Selection 119 × Selection 119.	357	177	−10	190	−1	28.8	126.1	−10
14	Whitecap, original	357	145	....	178	....	27.2	105.6	....
15	Whitecap × Selection 119	365	183	−7	215	12	27.7	132.3	−6
17	Selection 119, 1909	365	204	....	192	....	28.8	145.3	....
18	Ohio Leaming, original	362	140	....	104	....	22.1	109.1	....
19	Ohio Leaming × Selection 119	363	184	−4	137	−27	22.2	143.1	5
21	Selection 119, 1909	359	180	....	183	....	28.8	128.2	....
22	Illinois Leaming, original	361	142	....	132	....	27.6	102.8	....
23	Illinois Leaming × Selection 119	364	168	−9	178	−7	26.7	123.1	−7
25	Selection 119, 1909	359	191	....	198	....	28.8	136.0	....
26	Reid Yellow Dent, original	358	142	....	126	....	24.8	106.7	....
27	Reid Yellow Dent × Selection 119	361	183	−5	180	−9	26.3	134.8	−2
29	Selection 119, 1909	365	196	....	199	....	28.8	139.6	....
30	Sturges Hybrid Flint, original	372	103	....	112	....	19.9	82.5	....
31	Sturges Hybrid Flint × Selection 119	364	170	−9	162	−18	25.5	126.7	−5
32	Selection 119, 1909	359	178	....	195	....	28.8	126.8	....
33	Silvermine, original	351	138	....	141	....	23.8	105.2	....
34	Silvermine × Selection 119	368	166	−11	167	−18	27.6	120.2	−10
35	Selection 119, 1909	359	197	....	214	....	28.8	140.3	....
36	Golden Eagle, original	355	117	....	112	....	25.6	87.0	....
37	Golden Eagle × Selection 119.	360	169	−9	157	−25	25.5	125.9	−5
38	Selection 119, 1909	359	175	....	203	....	28.8	124.6	....
39	Fraley Yellow Dent, original.	360	173	....	217	....	27.2	125.9	....
40	Fraley Yellow Dent × Selection 119	359	173	−3	231	6	29.2	122.4	−3
41	Selection 119, 1909	357	180	....	212	....	28.8	128.2	....
42	Selection 77	360	168	....	195	....	30.7	116.4	....
43	Selection 77 × Selection 119	350	167	−9	197	−9	30.0	116.9	−10
44	Selection 119, 1909	361	186	....	223	....	28.8	132.5	....
45	Red Blaze, original	357	147	....	145	....	26.0	108.8	....
46	Red Blaze × Selection 119	352	180	−5	184	−16	27.4	130.7	−3
47	Selection 119, 1909	355	193	....	214	....	28.8	137.4	....
48	Cross 100	361	138	....	198	....	27.4	100.2	....
49	Cross 100 × Selection 119	350	169	−11	208	−0.2	29.3	119.5	−11
50	Selection 119, 1909	365	185	....	203	....	28.8	131.7	....
51	Cross 120	345	179	....	198	....	32.2	121.4	....
52	Cross 120 × Selection 119	358	215	20	234	14	29.2	152.2	19
53	Selection 119, 1909	359	174	....	209	....	28.8	123.9	....
54	Hickory King, original	348	164	....	265	....	33.7	108.7	....
55	Hickory King × Selection 119	359	204	13	267	1	32.0	138.7	8
56	Selection 119, 1909	359	186	....	215	....	28.8	132.5	....
57	Selection 78	359	163	....	171	....	28.1	117.2	....
58	Selection 78 × Selection 119	361	184	0.3	201	−6	29.8	129.3	−1
59	Selection 119, 1909	360	181	....	214	....	28.8	128.9	....

[1] Length of row 598 feet.

Eleven of the fourteen crosses of distinct varieties produced less grain than the better yielding of the two parents. When the pounds of ears harvested is reduced to a water-free basis, according to the percentage of water in the shelled grain at harvest time, the general results remain the same, namely, 11 comparisons in which the first-generation cross produced less and 3 in which it produced more than the better yielding of the two parents.

In Table IV those crosses which produced better than either parent are classed as advantageous. The others are classed as disadvantageous.

TABLE IV.—*First-generation crosses of corn (male parent, Selection 119), showing pounds of grain produced (water-free basis) and classified as advantageous and disadvantageous.*

Female parent and classification.	Yield. Of parent. Female.	Yield. Of parent. Male.	Yield. Of cross.	Yield. Increase over better parent.
Disadvantageous—Crosses less productive than the better parent:	*Pounds.*	*Pounds.*	*Pounds.*	*Per cent.*
Whitecap	106	141	132	− 6
Illinois Leaming	103	132	123	− 7
Reid Yellow Dent	107	138	135	− 2
Sturges Hybrid Flint	83	133	127	− 5
Silvermine	105	134	120	−10
Golden Eagle	87	132	126	− 5
Fraley Yellow Dent	126	126	122	− 3
Selection 77	116	130	117	−10
Red Blaze	109	135	131	− 3
Cross 100	100	135	120	−11
Selection 78	117	131	129	− 1
Average	105	133	126	− 6
Advantageous—Crosses more productive than the better parent:				
Ohio Leaming	109	137	143	5
Cross 120	121	128	152	19
Hickory King	109	128	139	8
Average	113	131	145	10

ADVANTAGEOUS CROSSES.

Without consideration of water content the Ohio Leaming cross would be a disadvantageous cross, but the dryness of the ears, due doubtless in some degree to the earliness of the female parent, causes it to fall into the class of advantageous crosses with an increased yield of 5 per cent over Selection 119. A cross made in 1900 in which this strain of Leaming was used as male parent also produced dry and unusually solid ears.

Cross 120 was originated in 1902 by planting occasional rows of Hickory King in a field of Selection 119. All Hickory King stalks were detasseled. Since 1902 Cross 120 and Selection 119 have been improved in yield and adapted to climatic and soil conditions near Washington, D. C., by yearly growing ear-to-row breeding plats and saving seed from the best stalks of the highest yielding rows.

It is of especial interest that these two improved, acclimated, and related strains when crossed in 1909 should give a first-generation cross of much greater yielding power than either parent. This first-generation cross produced better than any of the other first-generation crosses and better than any of the other varieties tested. It is the only cross that produced far better than either parent in all four tests. By these tests the value of the seed of this particular first-generation cross for the conditions prevailing at these points in Maryland in 1910 has been demonstrated. These two strains are now being crossed extensively in producing seed for general planting. This cross-pollinated seed is designated "First-Generation Cross No. 182."

The third and last advantageous cross of the 14 crosses, as classified in Table IV, is the same cross that gave origin to Cross 120, which, after six years of selection and adaptation, produces somewhat less than the first-generation cross of the same parents made in 1909, after each parent has undergone six years of selection and adaptation. This fact indicates that it is more profitable to acclimate and improve the parents of an advantageous cross separately and cross them yearly to obtain seed than to cross them once and then rely upon the acclimatization and improvement of the cross. Furthermore, since Cross 120, after six years of improvement, when crossed with Selection 119 gives a first-generation cross of superior productiveness, it would seem that the recrossing of a cross sometimes gives better seed than the crossing of the original pure-bred varieties. The advantage may be due to adaptation, as one of the original parents, Hickory King, has not been adapted to conditions near Washington, D. C.

DISADVANTAGEOUS CROSSES.

The Whitecap variety is adapted to conditions in Delaware, where it is quite extensively grown. It yields a very large ear, with a large cob, and yellow kernels with white caps. Neither in weight of ears as harvested nor on a water-free basis did the first generation cross of Whitecap and Selection 119 produce as well as the male parent.

The Illinois Leaming, though a pure selection from the Ohio Leaming, is now very unlike it in appearance. The Illinois Leaming is of a rougher type, with broader kernels. According to pounds of ears at harvest the crosses of the two strains of Leaming with Selection 119 fell below the male parent in production. The Illinois Leaming cross did not produce as well as the Ohio Leaming cross, and the grain contained more water at harvest time. Making the comparison of yields on a water-free basis the Ohio Leaming cross is advantageous and the Illinois Leaming cross is disadvantageous.

Sturges Hybrid Flint, the only flint variety used in these experiments, is a large-eared yellow corn adapted to Connecticut conditions. It has stalks considerably shorter than those of the male parent and is 20 days earlier. The cross was intermediate between the two parents in size and time of maturity. The first-generation cross produced much better than the female parent, but not quite as well as the male parent.

Silvermine, a white dent, and Golden Eagle, a yellow dent, are the earliest varieties used in these experiments except Sturges Hybrid Flint. Their first-generation crosses with Selection 119 produced much better than the female parents, but not quite as well as the male parent. In comparison with the results from this same seed as tested in California (discussed later) it should be noted here that, while in Maryland Silvermine is but an average producer and Golden Eagle is second to the poorest of all the varieties, under California conditions both these varieties rank very high in production.

Fraley Yellow Dent is the variety that for 15 years has been grown on the Derwood farm on which two of these four tests were made. It is a productive variety adapted to the conditions at Derwood and unrelated to Selection 119. Among the 14 first-generation crosses tested this is the only instance in which both parents are more productive than the first-generation cross. The 1908 seed of the female parent produced slightly better than the cross. Except that Fraley Yellow Dent differs in color from the male parent and has not been improved by ear-to-row selection, the conditions of this disadvantageous cross are similar to those of the most advantageous cross of the series, both parents being well adapted to climatic and soil conditions and highly productive.

Selection 77 resembles Cross 120 and like it has undergone many years of selection. Cross 120 is adapted to Maryland conditions, and Selection 77 to Scioto River Valley conditions in Ohio. With Selection 119 as male parent Cross 120 makes a highly advantageous cross and Selection 77 a disadvantageous cross.

Cross 100 was made at the same time (1902) and in the same manner as Cross 120, Boone County White being the male parent in each case. Hickory King, a broad-kerneled small-cobbed corn, was female parent of Cross 120, and Dotson, a long-kerneled, small-eared, small-cobbed corn, was female parent of Cross 100. The two crosses have had similar ear-to-row selection since 1902. Cross 100 has yearly been grown on poorer soil than has Cross 120. Although of such similar history and treatment, when these crosses are crossed with the related variety, Boone County White, one makes a highly advantageous first-generation cross and the other a disadvantageous first-generation cross.

Of all the varieties used as female parents, the most productive and the seven least productive formed disadvantageous first-generation crosses with Selection 119.

COMPARISON OF FIRST-GENERATION CROSSES WITH THE 1908 SEED OF BOTH PARENTS.

Although placing the odds in favor of the crosses, a comparison is here made between the productiveness of first-generation crosses and that of the parents as grown from the original (1908) seed.

There are 31 instances in which the first-generation cross occupied a row between rows of either parent in which the 2-year-old seed was planted. In these 31 comparisons the cross exceeds the better of the two parents in 14, equals it in 1, and produces less in 16. Of these 16 cases the male parent exceeds the cross in 15 and the female parent (the Fraley Yellow Dent variety) once.

It should be noted here that if these Maryland tests had been restricted to the original seed of the parents, as has been done in a few reported tests of this nature, the first-generation crosses would have stood much higher in production in comparison with the parent varieties.

RELATIVE GRAIN PRODUCTION OF PARENT VARIETIES AND FIRST-GENERATION CROSSES.

Expressed in terms of bushels per acre, allowing 70 pounds of ears containing 15 per cent of moisture to the bushel, the parents and crosses rank as follows for the four tests combined:

Male parent, 1909 seed	49
First-generation crosses, 1909 seed	47
Male parent, 1908 seed	45
Female parents, mostly 1908 seed	39

This relative production is shown in figure 1. As the yield for each field row shown in the diagram is the combined yield of a row from each of the four tests, the curves show the relative production of the different lots of seed with fluctuating variations and variations due to soil conditions somewhat reduced.

The four Maryland tests show the production of the crosses in general to be much above the average for the parents and somewhat below the male parent. Of the 14 crosses between distinct strains the cross of Cross 120 with Selection 119 is the only one that is remarkably superior to Selection 119 for the soil and climatic conditions under which the tests were conducted. The increased productiveness of this cross seems sufficient to warrant the crossing of these two strains in producing seed for general use in Maryland and Virginia, where conditions similar to those of the tests exist.

As 1909 seed of the male parent occupied every third or fourth row in all four of the tests, a check or standard is afforded for comparing the productiveness of all the varieties and crosses. In Table V the varieties and first-generation crosses are classified and arranged in separate columns in the order of their productiveness, the most productive being mentioned first and ranked as 1. In computing the comparative productiveness of the varieties and crosses for this table the yield of a variety is decreased or increased proportionately

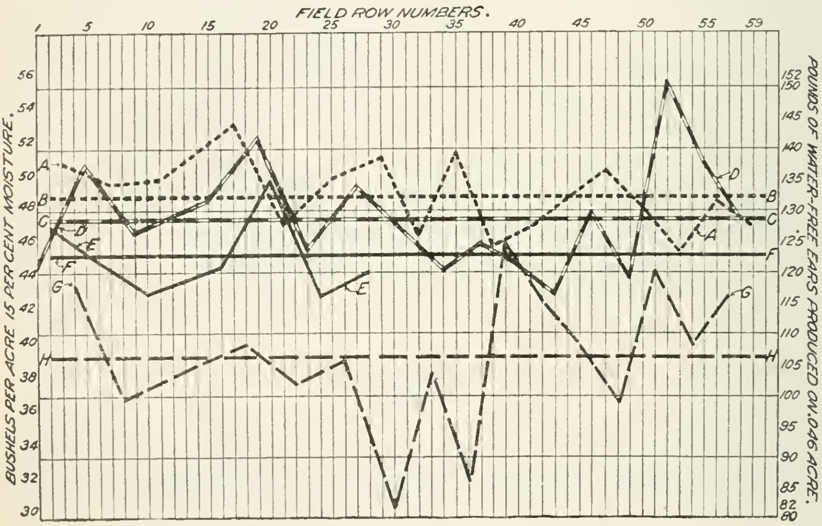


FIG. 1.—Diagram showing the relative production of parent varieties of corn and their first-generation crosses in Maryland, 1910: *A*, Male parent, variation of 1909 seed; *B*, male parent, mean of 1909 seed; *C*, mean of crosses; *D*, variation of crosses; *E*, male parent, variation of 1908 seed; *F*, male parent, mean of 1908 seed; *G*, variation of female parents; *H*, mean of female parents.

as the average yield of the two nearest rows of Selection 119 exceeds or falls short of the general average of Selection 119 for all rows in all the tests.

From the seven best female parents the crosses of six are found among the seven best crosses, Selection 77 being the only high-producing variety whose cross is a poor producer. Along with this indication that the productiveness of the parents influences the productiveness of the cross there are sufficient exceptions to indicate that the productiveness of a first-generation cross is sometimes determined to a great degree by other factors.

TABLE V.—*Parent varieties and crosses classified and ranked according to the computed production of ear corn (basis of 15 per cent moisture).*

Rank.	First-generation cross (× Selection 119).	Parent variety.	Yield per acre.
			Bushels.
1	Cross 120		58
2	Hickory King		53
3	Ohio Leaming		51
4		Selection 119 (average for 60 rows)	49
5		Fraley Yellow Dent	48
6	Selection 78		48
7	Reid Yellow Dent		47
8	Fraley Yellow Dent		47
9	Red Blaze		47
10	Sturges Hybrid Flint		46
11	Golden Eagle		46
12		Cross 120	46
13	Whitecap		46
14	Illinois Leaming		45
15	Silvermine		44
16	Selection 77		44
17		Selection 78	44
18		Selection 77	43
19	Cross 100		43
20		Hickory King	41
21		Red Blaze	39
22		Ohio Leaming	39
23		Silvermine	38
24		Illinois Leaming	38
25		Reid Yellow Dent	38
26		Whitecap	36
27		Cross 100	36
28		Golden Eagle	32
29		Sturges Hybrid Flint	30

STOVER WEIGHTS OF PARENTS AND CROSSES COMPARED.

As no determinations were made of the water content of the stover, a comparison of weights of stover at harvest time does not represent food value and is of little importance except in indicating the earliness of maturity of the crosses and parent varieties. The stalks of the later maturing varieties contained considerable sap when weighed the latter part of October, while those of the earlier maturing varieties contained very little sap. In 4 cases out of the 14 the stover weight of the crosses is lighter than the average of the two parents. In 3 of these 4 cases the female parent matures fully 10 days earlier than Selection 119.

In general, the crosses seemed intermediate between the parents regarding height and time of maturing. It seems that the earlier maturing parents transmitted to their crosses their early-maturing character in sufficient degree to cause the stover to weigh less than the average for the two parents. Sturges Hybrid, the only flint variety in the test, is an exception in this respect. In no instance was the stover weight of a cross as light as that of the lighter producing parent.

The cross of Cross 120, which gave so remarkable an increase in grain production, also gave 14 per cent increased stover weight over the heavier producing parent and 16 per cent increase over the average of its two parents. The Whitecap cross also gave 16 per cent increase over the average of its two parents and 12 per cent over the heavier producing parent, but in grain production it fell 6 per cent below the better of its two parents.

Of the 14 first-generation crosses of distinct varieties 10 produced fewer pounds of stover than the heavier yielding of the two parents.

CORN CROSSES AT CHICO, CAL., 1910.

CONDITIONS OF THE TEST.

The crosses made in 1909 in Maryland were also grown at Chico, Cal., in 1910, in comparison with their parent varieties. The plantings were so arranged that each row of the cross came between rows of its parent varieties.

The soil upon which these plantings were made was medium loam which had grown alfalfa for four years previous to 1910.

The land was broken to a depth of about 10 inches in December, 1909, with a second breaking in April, 1910, to a depth of 6 inches, and marked out in shallow furrows 3½ feet apart. Both plowings were made in lands running north and south and the corn rows were marked out east and west, so that no rows would fall on dead or back furrows.

On April 14 three kernels were dropped by hand in each hill in the furrows and lightly covered with the foot. Hills were 3½ feet apart in the row and 80 to each row. Four cultivations were given during the season.

On account of the surface soil being somewhat dry at planting time and some seed being taken by gophers, an uneven stand resulted.

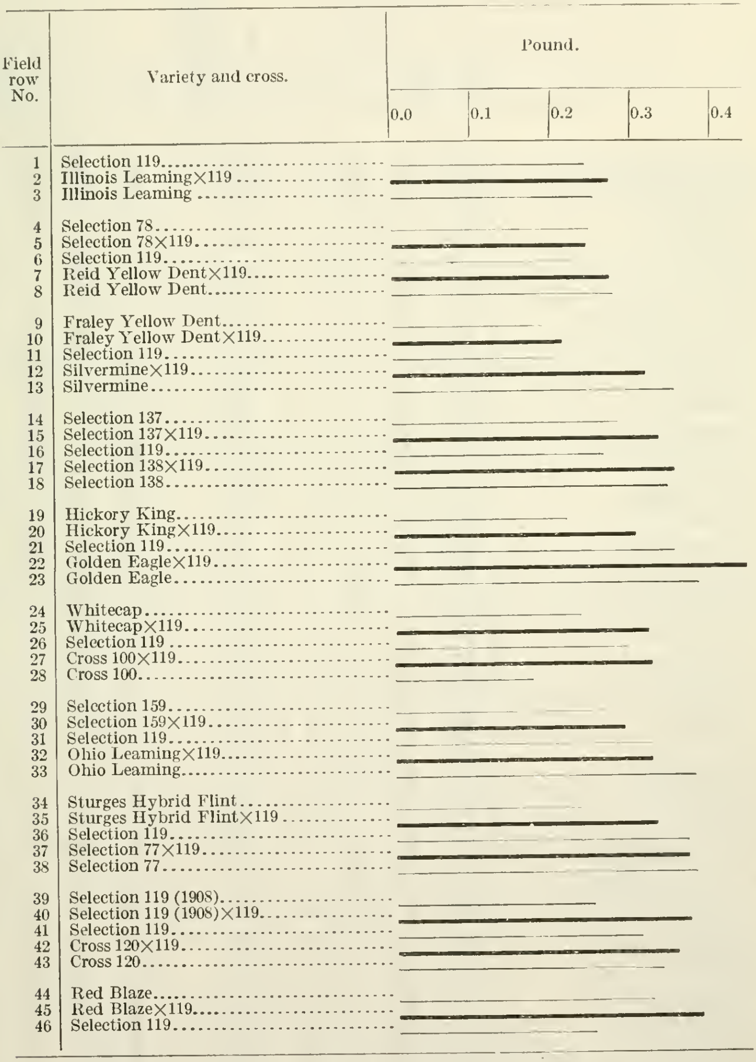
The rainfall after planting amounted to less than one-half inch and no irrigation was given. Sufficient water was contained in the soil early in the season to give all varieties a good growth of stalk, the average height being about 8½ feet. This moisture supply was not great enough, however, to produce a good crop of ears. Many of the ears were small and about 25 per cent of the stalks were barren.

The number of stalks per row, number of hills, average number of stalks per hill, pounds of ears per row, average number of pounds per stalk, percentage increase in yield per stalk of cross over the better parent, number of good and poor ears, and weight of stover are given in Table VI.

The order of plantings is preserved in the table, but for greater ease in comparing the cross with its parent varieties each row of Selection 119 is given twice.

The yield per stalk of the different varieties is represented graphically in diagram 1.

DIAGRAM 1.—*Variation in yield per stalk of crosses and parent varieties of corn at Chico, Cal., 1910.*[1]



[1] The yield of first-generation crosses is indicated by the heavier lines.

Table VI.—*Tests of production of parent varieties and first-generation crosses of corn at Chico, Cal., 1910.*

Field row No.	Variety and cross.	Stalks.	Hills.	Stalks per hill.	Yield. Weight of ears. In row.	Yield. Weight of ears. Per stalk.	Yield. Weight of ears. Increase per stalk over better parent.	Yield. Number of ears. Good.	Yield. Number of ears. Poor.	Yield. Weight of stover. Per row.	Yield. Weight of stover. Per stalk.
					Lbs.	Lbs.	P. ct.			Lbs.	Lbs.
1	Selection 119	169	72	2.4	41	0.242	......	52	75	130	0.770
2	Illinois Leaming×119	140	65	2.1	37	.264	4	48	68	106	.757
3	Illinois Leaming	111	50	2.2	28	.254	......	40	48	69	.622
4	Selection 78	131	52	2.5	31	.247	......	48	42	83	.633
5	Selection 78×119	142	61	2.3	35	.248	0	52	57	106	.747
6	Selection 119	155	71	2.2	35	.226	......	40	68	137	.884
6	Selection 119	155	71	2.2	35	.226	......	40	68	137	.884
7	Reid Yellow Dent×119	122	56	2.2	34	.278	−1	52	44	85	.697
8	Reid Yellow Dent	146	68	2.1	41	.281	......	57	51	97	.665
9	Fraley Yellow Dent	142	67	2.1	27	.190	......	38	58	118	.832
10	Fraley Yellow Dent×119	149	70	2.3	32	.215	0	40	60	133	.894
11	Selection 119	159	68	2.4	34	.214	......	36	75	121	.761
11	Selection 119	159	68	2.4	34	.214	......	36	75	121	.761
12	Silvermine×119	160	68	2.3	51	.318	−17	65	68	123	.769
13	Silvermine	107	60	1.8	41	.383	......	55	54	70	.654
14	Selection 137	108	60	1.8	31	.287	......	42	58	99	.916
15	Selection 137×119	148	64	2.3	47	.331	15	60	60	134	.906
16	Selection 119	147	63	2.3	39	.265	......	57	68	117	.796
16	Selection 119	147	63	2.3	39	.265	......	57	68	117	.796
17	Selection 138×119	141	67	2.1	50	.355	4	62	72	156	1.105
18	Selection 138	146	69	2.1	50	.342	......	68	70	135	.925
19	Hickory King	122	59	2.1	27	.221	......	56	62	106	.870
20	Hickory King×119	129	60	2.1	39	.303	−15	72	52	122	.946
21	Selection 119	163	70	2.3	58	.356	......	74	80	132	.810
21	Selection 119	163	70	2.3	58	.356	......	74	80	132	.810
22	Golden Eagle×119	144	66	2.2	64	.445	16	92	47	120	.834
23	Golden Eagle	122	58	2.1	47	.385	......	72	42	75	.615
24	Whitecap	109	50	2.2	26	.238	......	35	52	110	1.010
25	Whitecap×119	116	59	2.0	37	.319	8	44	56	129	1.113
26	Selection 119	126	53	2.4	37	.294	......	37	69	110	.872
26	Selection 119	126	53	2.4	37	.294	......	37	69	110	.872
27	Cross 100×119	123	61	2.0	40	.325	11	55	60	113	.918
28	Cross 100	121	58	2.1	21	.173	......	52	63	101	.834
29	Selection 159	99	53	1.9	26	.263	......	34	54	85	.859
30	Selection 159×119	107	54	2.0	31	.290	−11	40	57	104	.972
31	Selection 119	115	52	2.2	37½	.326	......	46	57	111	.965
31	Selection 119	115	52	2.2	37½	.326	......	46	57	111	.965
32	Ohio Leaming×119	114	53	2.1	37	.324	−15	50	62	92	.806
33	Ohio Leaming	102	54	1.9	39	.382	......	64	40	60	.587
34	Sturges Hybrid Flint	79	49	1.6	19	.241	......	40	40	67	.849
35	Sturges Hybrid Flint×119	106	50	2.1	35	.330	−11	52	60	106	1.000
36	Selection 119	80	41	2.0	29½	.369	......	42	40	77	.961
36	Selection 119	80	41	2.0	29½	.369	......	42	40	77	.961
37	Selection 77×119	95	44	2.2	30½	.369	0	36	52	90	.946
38	Selection 77	71	35	2.0	27	.380	......	44	32	70	.986
39	Selection 119 (1908)	95	45	2.1	23½	.248	......	26	63	93	.930
40	Selection 119×119	83	50	1.7	31	.373	20	32	63	94	1.130
41	Selection 119	95	46	2.1	29½	.310	......	36	52	93	.930
41	Selection 119	95	46	2.1	29½	.310	......	36	52	93	.930
42	Cross 120×119	111	59	1.9	41	.373	12	45	68	125	1.125
43	Cross 120	75	39	1.9	25	.334	......	43	37	67	.893
44	Red Blaze	67	37	1.8	22	.328	......	38	38	54	.806
45	Red Blaze×119	111	57	1.9	43½	.395	20	64	54	97	.875
46	Selection 119	89	44	2.0	22	.247	......	26	58	80	.900

COMPARISON OF CROSSES WITH PARENT VARIETIES.

It has been claimed, though not universally accepted, that first-generation corn crosses are superior in producing power to the varieties crossed. The data herein submitted seem to bear out such a conclusion when the majority of cases and the average of all are considered.

Of the 18 crosses included in this test, only 2 do not exceed in yield the average of the two varieties crossed. The average yield per stalk of the 10 plantings of Selection 119 is 0.280 pound; for the 18 varieties used as female parents, 0.284 pound; and for the crosses, 0.320 pound; an increase of 0.038 pound per stalk in favor of the average of the crosses.

There is no special advantage in growing first-generation crosses unless such crosses can be depended upon to yield consistently and constantly more than either of the varieties used in making the cross. This gain must be sufficiently large to insure compensation for the rather careful work necessary in making the cross and in keeping pure two varieties of corn for this purpose.

Of the 18 crosses in this test, 9 exceed either parent in the yield per stalk, and 9 are equaled or exceeded by one or the other of the parents. The difference in the yields of the better parent and of the cross ranges in amount from 4 to 20 per cent in the 9 comparisons in which the crosses exceed, and from zero to 17 per cent in the 9 in which the better parent exceeds the cross.

Not only are there the same number of comparisons in which the cross exceeds and fails to exceed the better parent, but the average yield per stalk of the crosses and that of the better parents is the same, being 0.320 pound in each case.

These data do not show that first-generation crosses can, in the greater number of cases, be depended upon to produce more than the better of the two varieties crossed.

Two additional crosses were grown in the test at Chico. The male parent used was Selection 160, a large yellow flint. This corn has been grown in California for 12 years or more and at Chico for 5 years. It seems to be well acclimated and has proved to be the best yielder of a number of varieties grown at Chico in the last 3 years.

The two varieties used as female parents were Ohio Leaming and Silvermine. Next to Selection 160 these have been the highest yielding of the varieties tested at Chico.

The crosses were made by hand-pollinating ears of these two varieties with pollen from Selection 160 in the varietal test rows at Chico in 1909. Several ears in each variety were also pollinated with pollen from different stalks of the same variety. In this way seed of the cross and that of the female parent used in the experiment in 1910 was grown under identical conditions in 1909. The Selection 160 seed was also taken from the 1909 crop and from detasseled stalks in a near-by, though sufficiently isolated, field.

These two crosses are compared with their parent varieties in Table VII.

TABLE VII.—*Relative productiveness of first-generation crosses and parent varieties of corn crosses made and tested at Chico, Cal.*

Row No.	Variety and cross.	Stalks.	Hills.	Stalks per hill.	Yield.				
					Weight of ears.			Number of ears.	
					In row.	Per stalk.	Decrease per stalk under better parent.	Good.	Poor.
					Pounds.	*Pounds.*	*P. ct.*		
47	Silvermine	149	65	2.3	54	0.362	....	72	52
48	Silvermine × Selection 160	139	61	2.1	53	.382	10	88	46
49	Selection 160	140	64	2.2	59.5	.425	....	112	44
49	Selection 160	140	64	2.2	59.5	.425	....	112	44
50	Ohio Leaming × Selection 160	152	63	2.4	60.5	.398	9	111	61
51	Ohio Leaming	144	67	2.1	42	.282	....	58	50

RELATION OF ADAPTATION AND YIELD OF PARENT VARIETIES TO THE BEHAVIOR OF THE CROSSES.

Since there is a wide range of variability in the behavior of crosses between different varieties, it is of importance to discover, if possible, whether these differences have any relation to the yielding power of the parent varieties.

In this test, as is usual in a series of varieties collected from different localities and subjected to adverse conditions, a wide difference exists in the response of the different varieties to these conditions. Since all of the varieties are well selected and improved for the localities from which they came, the yield of each may be taken as an indication of its adaptation to the conditions of the test.

The highest yielding crosses (× Selection 119), arranged according to productiveness, are: Golden Eagle, Red Blaze, Cross 120, Selection 77, and Selection 138. A comparison of the yields of the original varieties shows that the female parents of these crosses rank in productiveness as follows: Golden Eagle, first; Red Blaze, seventh; Cross 120, sixth; Selection 77, fourth; Selection 138, fifth. The fact that the female parents of these high-yielding crosses rank high in yield among the original varieties is an indication that the adaptation and productivity of the parent variety determine the adaptation and productivity of the cross to some extent; or, in general, the highest yielding crosses may be expected to result from crossing the highest yielding varieties. This view is supported by the results of a test of the same varieties and crosses in Maryland and also by the results obtained from the two crosses with Selection 160.

While this influence apparently exists, it is not sufficiently constant to be relied upon, as is shown by comparing the crosses Silvermine × Selection 119 and Ohio Leaming × Selection 119. The female parents of these crosses rank second and third in yield among the original varieties; the crosses are surpassed in productiveness by the crosses Sturges Hybrid Flint × Selection 119 and Cross 100 × Selection 119, the female parents of which rank low in yield.

The four best producers of the original varieties are Golden Eagle, Silvermine, Ohio Leaming, and Selection 77. The crosses of these four varieties with Selection 119 are distributed in the following manner as regards the degree of benefit from crossing: One case in which the cross shows a decided increase over the better parent, one in which the cross is intermediate between the two parents, and two in which the cross about equals the poorer parent.

The five poorest producing varieties are Cross 100, Fraley Yellow Dent, Hickory King, Whitecap, and Sturges Hybrid Flint. The crosses of these five varieties with Selection 119 are distributed as follows as regards benefit from crossing: Three better than the better parent, and two intermediate between the two parents.

The crosses with Selection 119 that show the greatest gain in yield over the better of their two parents are those of Red Blaze, Golden Eagle, Selection 137, and Cross 120. If yields of the original varieties and of the crosses are both considered, the female parents of these high-yielding crosses may be classed as one good and three intermediate in respect to yield.

From the examples set forth in the preceding paragraphs it would seem that no constant relation exists between the productivity of varieties and the increase or decrease in yield of their crosses as compared with the parent varieties. The lack of constancy in this relation may be seen in the following crosses: Ohio Leaming × Selection 119 produces less than either parent, although both are high-yielding varieties that have been pure bred for many years; the cross of Red Blaze (a high-yielding and well-selected variety) × Selection 119 gives an increase in yield of 20 per cent over the better parent; the cross of Cross 100, the lowest yielding variety in the test, with Selection 119 gives an increase in yield of 11 per cent over the better parent and practically equals in yield that of Ohio Leaming × Selection 119 (ranking eighth in yield among the crosses); while Fraley Yellow Dent, the next lowest yielding variety, crossed with Selection 119 is the lowest yielding cross in the test and is exceeded by all the varieties except Cross 100 and Fraley Yellow Dent.

These results show that some varieties combine or "nick" well, when crossed, forming crosses that are superior in yielding power to either parent, while other varieties do not combine well and the crosses are either less productive than the better parent or inferior to both parents. The factors that determine what the productiveness of the cross will be are not known, and apparently no external characters are discernible by which we can judge of their presence or absence. It is important, therefore, that crosses of varieties should be tried experimentally to ascertain their productiveness before growing them commercially or before making a general agricultural application of this method of corn breeding.

It is worthy of note that the crosses which produced best under the somewhat adverse conditions at Chico are not from the same combinations as those which produced best under conditions of normal rainfall in Maryland.

Table VII shows a comparison between an acclimated, well-adapted variety, the crosses of this with two varieties of later introduction, and these two varieties themselves.

In each of these comparisons the cross is intermediate in yield per stalk between the two varieties crossed. In other words, nothing was gained in yield by crossing an adapted, well-acclimated variety with a variety of later introduction, even though this variety is also a good yielder.

TESTS IN TEXAS.

WORK OF 1909.

Seed of a number of pure-bred varieties of corn was obtained early in 1909 for use in crossbreeding experiments in Texas A list of these varieties and a brief description is given in Table VIII. The varieties were planted at Waco, Tex., early in March, 1909, one row of each of the other varieties alternating with two rows of Chisholm (the variety chosen to be the male parent). Tassels were removed from the stalks of all varieties except the Chisholm before any pollen had been shed. The crosses made in this manner, each having the same male parent but a different female parent, were planted in 1910 at Sherman, at Waco, and at Corsicana.

TABLE VIII.—*Varieties of corn and first-generation crosses used in Texas tests.*

Variety.	Parentage.	Region of growth.	Days to mature.	Color and class.	Height of stalk (feet).[1]	
					Pure variety.	First-generation cross.
Huffman	Pure selection since 1851	Central Tennessee for 60 years	140	White dent	8 –8½	7 –7½
Selection 136	Laguna, from Mexico	Central Texas for 7 years	125–130	....do	7½–8	6 –8
Selection 137	Boone County White	Central Texas for 5 years	110–115	....do	6½	6½
Singleton	A selection from a strawberry type of corn	Northern Texas for 30 years	120	Striped dent	7½–8	7 –7½
McCullough	A cross of two yellow varieties made in 1901	Northern Texas a number of years	120	Yellow dent	7	7
Gorham Yellow	Believed to have originated from a Kansas variety.	Central Texas for 5 years or longer	120	....do	6	6 –6½
Dan Patch	Native strain in South Texas, probably mixed with Mexican varieties.	South-central Texas 25 years or longer	110	White dent	6½	6 –7
Blow	A local native variety in Anderson County	Eastern Texas for 24 years	120	....do	6½–7	6½–7
Lily of the Valley	Chisholm	Northern Texas a number of years	120	....do	6½–7	6½–7
Schieberle	A cross between a white dent variety and Gourd Seed.	Southern Texas for 20 years	125–130	....do	7½–8	6½–7
Munson	Taken from Georgia to Texas previous to 1905.	Central and northern Texas 6 years or longer	125–130	....do	6 –7	7
Gourd Seed	Native unselected variety	South-central Texas about 30 years	120	....do	7 –7½	6½–7
Ferguson Yellow	Northern Texas variety of yellow corn	Northern Texas	120	Yellow dent	7	7
Mosby Prolific	South American and Mississippi varieties crossed in 1876 in Mississippi.	Southern and northern Texas 5 years	120	White dent	6 –7	6 –7
Surcropper	Native strain in southern Texas grown under various names; probably at some time mixed with Mexican varieties.	South-central Texas 25 years or longer; northern Texas 4 years.	110	....do	6 –7	6½
Chisholm	A red-cob white dent—well known in northern Texas.	Northern Texas about 30 years	120	....do	6	....

[1] As grown at Waco.

WORK OF 1910.

TEST AT SHERMAN, TEX.

The test at Sherman was located upon fertile black upland of uniform appearance. All the land used had been cropped the same the previous year, had been broken deep, and was in good condition when the corn was planted.

The planting was made in hills 3½ feet apart each way; the crop was cultivated frequently, and the ground kept free of grass and weeds. The season at Sherman was extremely dry and the yields were very light.

The order in which the varieties and crosses were planted and their field-row numbers are shown in Table IX. Because of lack of uniformity in number of stalks per row of the different varieties, the comparisons have been made on the basis of production per stalk rather than on row yields. This method is followed in all cases.

The comparison is made between the yield of the cross and the higher yielding of the two parents. For practical purposes the cross can not be regarded as an improvement upon existing conditions or as worthy of propagation unless it is superior to the better parent. Where the comparison is between the cross and male parent the average of the two rows of the male parent nearest the cross has been used. This was also done in the test at Waco and Corsicana. The seed of the female parents used in the experiment is in every case taken from the 1908 crop, that is, from the same lot of seed that was used for the beginning of the experiment in 1909. The seed of the crosses is from the 1909 crop. The seed of Chisholm (the male parent) is in part from the 1908 crop, but mostly from the 1909 crop, entirely so at Sherman and Corsicana, and also in the greater part of the Waco test.

When the crop was harvested, determinations showed the percentage of moisture to be approximately the same for the different varieties. Taking into consideration the unavoidable percentage of error, it was believed that nothing would be gained by calculating the yields to a water-free basis. In computing the production per stalk only the main stalks were considered, as the suckers were not productive at any of the three places.

TABLE IX.—*Comparative productiveness of parent varieties of corn and first-generation crosses at Sherman, Tex., in 1910.*

[Area of each row one-seventieth of an acre.]

Row No.	Variety and cross.	Main stalks per row.	Suckers per row.	Yield of ears (husked). Per row.	Per stalk.	Increase over better parent.	Number of ears. Good.	Poor.
				Pounds.	*Pounds.*	*Per ct.*		
2	Chisholm	76	3	9½	0.125	....	3	37
3	Huffman × Chisholm	101	17	9	.089	−28	2	40
4	Huffman	105	39	3	.029	....	0	16
5	Chisholm	81	4	10	.123	....	4	39
6	Schieberle × Chisholm	107	7	9½	.089	−32	0	41
7	Schieberle	101	5	11½	.114	....	0	49
8	Chisholm	84	6	11¾	.140	....	5	44
9	Munson × Chisholm	100	19	12	.120	−21	3	49
10	Munson	97	21	9	.093	....	0	43
11	Chisholm	79	1	13	.165	....	6	45
12	Gourd Seed × Chisholm	96	13	17	.177	16	5	68
13	Gourd Seed	98	4	14	.143	....	0	57
14	Chisholm	89	0	12½	.140	....	6	39
15	Lily of the Valley × Chisholm	100	7	18¼	.182	5	6	57
16	Lily of the Valley	95	6	16½	.174	....	8	56
17	Chisholm	78	2	12½	.160	....	4	43
18	Blow × Chisholm	101	27	14½	.144	−17	2	61
19	Blow	101	11	9	.089	....	0	49
20	Chisholm	84	3	15½	.184	....	2	57
21	Selection 136 × Chisholm	100	9	19½	.195	23	6	66
22	Selection 136	101	13	16	.158	....	3	72
23	Chisholm	81	8	10½	.130	....	0	48
24	Surcropper × Chisholm	106	3	23¼	.219	− 8	5	79
25	Surcropper	100	6	23¾	.238	....	8	80
26	Chisholm	94	8	12	.128	....	1	47
27	Dan Patch × Chisholm	93	8	23	.247	13	3	83
28	Dan Patch	94	5	20½	.218	....	5	74
29	Chisholm	89	7	12	.135	....	4	45
30	Selection 137 × Chisholm	102	22	17½	.172	− 6	4	71
31	Selection 137	92	6	16¾	.182	....	4	62
32	Chisholm	81	8	14	.173	....	2	51
35	Mosby Prolific × Chisholm	103	15	12	.117	−33	2	58
36	Mosby Prolific	92	35	8	.087	....	0	61
37	Chisholm	101	10	18	.178	....	6	62
38	Gorham Yellow × Chisholm	103	17	14½	.141	− 8	5	53
39	Gorham Yellow	96	13	11½	.120	....	1	56
40	Chisholm	101	14	13	.129	....	4	53
41	Ferguson Yellow × Chisholm	101	10	12½	.124	−15	1	69
42	Ferguson Yellow	98	13	13½	.138	....	3	65
43	Chisholm	95	6	15½	.163	....	3	68
44	McCullough × Chisholm	98	3	15	.153	− 2	4	56
45	McCullough	100	10	13	.130	....	2	63
46	Chisholm	100	10	15	.150	....	0	70
47	Singleton × Chisholm	96	12	11¾	.122	−22	0	59
48	Singleton	98	6	11	.112	....	0	52

In 11 out of 15 comparisons the cross ranges from 2 to 33 per cent lower in yield than the better parent; in the remaining four comparisons the cross outyields the better parent by 5 to 23 per cent.

TEST AT WACO, TEX.

At Waco the test was located on deep Brazos Valley sand and the corn was drilled in rows 3½ feet apart. A late frost killed some of the plants and so interfered to some extent with the uniformity of the stand. For this reason the comparisons of yields, as in the test at Sherman, have been made on the basis of production per stalk. The stands of three of the crosses were so uneven and irregular that the comparisons could not be regarded as of value, and accordingly have not been considered in the results. The order of planting the varieties and crosses and their field-row numbers are shown in Table X.

TABLE X.—*Comparative productiveness of parent varieties of corn and first-generation crosses at Waco, Tex., in 1910.*

[Area of each row one-seventieth of an acre.]

Row No.	Variety and cross.	Main stalks per row.	Suckers per row.	Yield of ears (husked). Per row.	Per stalk.	Increase over better parent.	Number of ears. Good.	Poor.
				Pounds.	*Pounds.*	*Per ct.*		
4	Chisholm	46	0	19	0.413	....	19	21
5	Schieberle×Chisholm	54	0	30½	.565	7	31	24
6	Schieberle	38	0	20	.526	....	20	14
7	Chisholm	37	0	14	.378	....	11	26
8	Singleton×Chisholm	53	0	26½	.500	3	34	16
9	Singleton	37	0	18	.486	....	14	22
10	Chisholm	53	0	20	.377	....	20	27
11	McCullough×Chisholm	49	0	24	.490	29	30	20
12	McCullough	48	0	15	.312	....	13	30
13	Chisholm	54	0	20½	.380	....	19	30
14	Ferguson Yellow×Chisholm	60	0	32	.533	21	38	23
15	Ferguson Yellow	50	0	22	.440	....	15	34
16	Chisholm	65	0	29	.446	....	23	38
17	Gorham Yellow×Chisholm	51	0	26	.510	23	21	32
18	Gorham Yellow	34	0	12	.353	....	10	19
26	Selection 137	40	0	12	.300	....	4	30
27	Selection 137×Chisholm	55	0	20	.364	−18	21	32
28	Chisholm	55	0	24	.436	....	30	20
29	Selection 136	65	0	34	.523	....	38	30
30	Selection 136×Chisholm	75	0	43	.573	10	45	30
31	Chisholm	38	0	17	.447	....	12	27
32	Surecropper	51	0	21	.412	....	20	33
33	Surecropper×Chisholm	46	0	20	.435	3	23	23
34	Chisholm	35	0	14	.400	....	14	18
38	Blow	51	0	19	.373	....	15	34
39	Blow×Chisholm	63	0	28½	.452	4	25	41
40	Chisholm	48	0	22	.458	....	22	26
41	Gourd Seed	66	2	38½	.583	....	40	25
42	Gourd Seed×Chisholm	68	0	42½	.625	7	56	15
43	Chisholm	35	0	14	.400	....	10	23
44	Munson	45	0	25	.556	....	26	21
45	Munson×Chisholm	52	0	30	.577	4	30	25
46	Chisholm	49	0	23	.469	....	22	24
47	Mosby Prolific	44	3	16	.364	....	24	24
48	Mosby Prolific×Chisholm	53	5	23	.434	− 9	42	13
49	Chisholm	41	0	20	.488	....	16	32

In 10 of the 12 comparisons the cross outyields the better parent, the increase ranging from 3 to 29 per cent; in the remaining 2 comparisons the cross yields 18 and 9 per cent less than the better parent.

TEST AT CORSICANA, TEX.

At Corsicana the test was located on sandy loam of medium fertility. The corn was planted in hills 3½ feet apart each way, cultivated well, and kept free of grass and weeds. The planting was made in a different manner from that at Sherman and at Waco, a smaller number of rows of Chisholm were planted and these were arranged so that two of the crosses were planted adjacent to the same row of Chisholm. One of the crosses (Schieberle×Chisholm) was cut by mistake when green and fed to stock. The order of planting the varieties and crosses, and their field-row numbers, together with the results of the test, are shown in Table XI.

TABLE XI.—*Comparative productiveness of parent varieties of corn and first-generation crosses at Corsicana, Tex., in 1910.*

[Area of each row one eighty-sixth of an acre.]

Row No.	Variety and cross.	Main stalks per row.	Suckers per row.	Yield of ears (husked).			Number of ears.	
				Per row.	Per stalk.	Increase over better parent.	Good.	Poor.
				Pounds.	*Pounds.*	*Per ct.*		
7	Singleton	74	6	23½	0.317	....	24	32
8	Singleton×Chisholm	76	2	24½	.322	2	27	37
9	Chisholm	70	4	20½	.293	....	28	28
10	McCullough×Chisholm	78	0	27	.346	11	32	30
11	McCullough	75	2	23½	.313	....	30	33
12	Ferguson Yellow	83	0	34½	.416	....	40	35
13	Ferguson Yellow×Chisholm	83	0	32	.386	− 7	40	30
14	Chisholm	84	4	26½	.315	....	30	33
15	Gorham Yellow×Chisholm	77	0	30½	.396	21	40	31
16	Gorham Yellow	69	0	22	.319	....	20	40
17	Selection 136	83	0	35	.422	....	48	28
18	Selection 136×Chisholm	80	5	35	.437	4	40	36
19	Chisholm	65	0	22	.338	....	23	30
20	Surcropper×Chisholm	87	3	35½	.408	− 2	40	40
21	Surcropper	79	0	33	.418	....	36	43
22	Dan Patch	78	2	34	.436	....	44	28
23	Dan Patch×Chisholm	84	12	39	.464	6	38	47
24	Chisholm	85	3	30	.353	....	35	38
25	Blow×Chisholm	95	5	34½	.363	− 2	36	48
26	Blow	77	3	25	.325	....	26	40
27	Lily of the Valley	75	2	30½	.407	....	26	34
28	Lily of the Valley×Chisholm	74	0	39½	.534	31	51	26
29	Chisholm	67	5	26	.388	....	28	30
30	Gourd Seed×Chisholm	78	7	34½	.442	7	40	36
31	Gourd Seed	76	0	31½	.414	....	28	41
32	Munson	77	3	25½	.331	....	28	40
33	Munson×Chisholm	84	4	30½	.363	− 2	32	43
34	Chisholm	76	0	27	.355	....	35	30
35	Mosby Prolific×Chisholm	85	8	34	.400	6	52	27
36	Mosby Prolific	81	11	27½	.340	....	52	30
37	Selection 137	68	0	25	.368	....	30	28
38	Selection 137×Chisholm	77	0	28½	.370	− 2	32	36
39	Chisholm	75	3	30	.400	....	28	34
46	Chisholm	77	4	23	.299	....	24	44
47	Huffman×Chisholm	79	8	21½	.272	−14	24	44
48	Huffman	77	0	18	.234	....	16	36

The cross outyields the better parent in 8 comparisons out of the 14, the increase ranging from 2 to 31 per cent; in the remaining 6 comparisons the better parent outyields the cross by 1 to 9 per cent.

THE THREE TEXAS TESTS CONSIDERED COLLECTIVELY.

In considering the three tests collectively the relatively higher production of the Chisholm variety (male parent) at Sherman than at Waco and Corsicana is apparent. At Sherman it outyields the cross in 9 and the female parent in 10 out of 15 comparisons. At Waco it outyields the cross in but 2 and the female in 5 out of 12 comparisons. At Corsicana it outyields the cross in 4 and the female parent in 5 out of 14 comparisons. The results at Waco and Corsicana are practically a reversal of the results with Chisholm at Sherman.

The 5 varieties that outyield Chisholm at Sherman are Surcropper, Dan Patch, Selection 137, Lily of the Valley, and Ferguson Yellow Dent. The first three varieties are earlier maturing than Chisholm; their increase in yield over Chisholm is considerably greater than the increase of Lily of the Valley and Ferguson Yellow Dent over Chisholm. This would indicate that the superiority of the first three varieties has been due chiefly to their earliness, which made them particularly suited to the drought conditions that prevailed at Sherman in 1910. From previous experience there is reason to believe that during a normal season Chisholm would be considerably more productive than any of these three varieties. The fourth variety (Lily of the Valley) is another strain of the same variety as Chisholm, its increase over Chisholm is not especially significant, although perhaps indicating a slight superiority, as Lily of the Valley outyielded Chisholm also at Corsicana. The increase of Ferguson Yellow over Chisholm is slight, and can not be regarded as indicating very much, if any, superiority. Taking into consideration the average behavior of Chisholm in all the rows in which it was planted, it perhaps should be considered as superior to any of the varieties for practical growing at Sherman.

The relatively greater productiveness of Chisholm in the Sherman test than at Waco and at Corsicana is due probably to the fact that Chisholm is a northern Texas variety, and the particular strain used in these experiments has been grown for many years on fertile black lands near Sherman. This doubtless has caused the variety to be better adapted to its environment at Sherman than it was at Waco or at Corsicana. Its yields also indicate that it was better adapted to the Sherman environment than were the other varieties in the test. The higher yields of the three early maturing varieties does not seem to have been due to better adaptation, but rather that the abnormal conditions of the season were less disastrous to them than to the later maturing varieties. The increase of Ferguson Yellow Dent, itself a northern Texas variety, is so slight that no generalization is warranted that it is better adapted to the Sherman environment than is Chisholm.

Of the varieties used as female parents none has been bred for any length of time for the conditions encountered at any of the three places. At Sherman the conditions were very adverse and the yields very poor. At Waco, in the Brazos Valley, conditions were more favorable. The soil retained the moisture better than the soil at

Sherman and more moisture was available for the growing crop; higher yields were made, but Chisholm seems to be less suited to the conditions than most of the other varieties. The female parents made an increase of 223 per cent in average production per stalk over their average production per stalk at Sherman; the same increase for Chisholm is 186 per cent. The results at Corsicana were similar and as pronounced, although actual yields were lower than at Waco.

As has been stated, Chisholm at Sherman, to which conditions it has been thoroughly adapted, outyielded the cross in 9 out of 15 comparisons. At Waco, planted in the deep, sandy soil of the Brazos Valley, conditions to which the variety is apparently not adapted, it is outyielded by the cross in 10 out of 12 comparisons. At Corsicana, under conditions to which it was apparently also not adapted, it is outyielded by the cross in 10 out of 14 comparisons.

In the Waco and Corsicana tests the crosses in the majority of comparisons outyielded the parent varieties. None of the varieties used in the tests had been bred for any length of time for the environmental conditions encountered at either place. At Sherman the Chisholm variety, which has been grown for many years in that locality, outyielded the crosses in most of the comparisons. This would indicate that in general a variety well adapted to its environment is not improved nor its productiveness increased by crossing with other varieties possibly less adapted to the environment. What results would be obtained by crossing varieties that have been bred in the same locality and under the same conditions for a long period will have to be determined by further experimental work. Although in this connection attention should be called to the fact that crosses with such varieties as McCullough, Ferguson Yellow, and Singleton (all established northern Texas varieties that have been bred under very similar conditions to Chisholm) are less productive than Chisholm.

THE PRODUCTIVITY OF THE PARENT VARIETIES AND ITS INFLUENCE UPON THE PRODUCTIVITY OF THE CROSSES.

In Table XII an attempt has been made to trace as far as the fifth or sixth rank in yield the factors showing to what extent the highest yielding crosses are progeny of the highest yielding varieties; also to what extent the highest yielding crosses may be identical with the crosses showing highest percentage of gain over better parent.

Table XIII is a similar enumeration of the poorest yielding varieties, poorest yielding crosses, and crosses showing the greatest percentage of decrease as compared with the better parent.

In the Sherman test the six highest yielding crosses are identical with the crosses of the six highest yielding female parents, but they do not rank in exactly the same order as the parent varieties. The crosses showing the greatest percentage of increase over the better parent are identical with four of the highest yielding crosses. In the list of poorest yielding crosses four are identical with four of the crosses of the poorest yielding female parents with Chisholm. The crosses showing the greatest percentage of decrease as compared with the better parent are the same as the poorest yielding crosses and, with one exception, are progeny of the poorest yielding female parents.

In the Waco test four of the highest yielding crosses are identical with four of the crosses of the highest yielding female parents. Of the crosses listed as showing the greatest percentage of increase over the better parent four are identical with four of the highest yielding crosses, three are progeny of three of the highest yielding female parents, and two are progeny of two of the poorest yielding female parents. Four of the poorest yielding crosses are progeny of four of the poorest yielding female parents. The two crosses that are less productive than the better parent are both progeny of low-yielding female parents.

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TABLE XII.—*Relation of the highest yielding crosses and crosses showing highest percentage of increase to the highest yielding parents, in Texas, 1910.*

Locality.	Female parent (best yielding, in order of productiveness).		Cross.		High-yielding cross.		Cross showing high percentage of increase over better parent.	
	Variety.	Yield per stalk.	Variety (× Chisholm) and rank.	Yield per stalk.	Variety (× Chisholm) and rank.	Yield per stalk.	Variety (× Chisholm).	Gain.
		Pounds.		*Pounds.*		*Pounds.*		*Per cent.*
Sherman	Surcropper	0.238	Surcropper, 2	0.219	Dan Patch, 1	0.247	Selection 136	23
	Dan Patch [1]	.218	Dan Patch, 1	.247	Surcropper, 2	.219	Gourd Seed	16
	Selection 137	.182	Selection 137, 6	.172	Selection 136, 3	.195	Dan Patch	13
	Lily of the Valley [1]	.174	Lily of the Valley, 4	.182	Lily of the Valley, 4	.182	Lily of the Valley	5
	Selection 136	.158	Selection 136, 3	.195	Gourd Seed, 5	.177		
	Gourd Seed	.143	Gourd Seed, 5	.177	Selection 137, 6	.172		
Waco	Gourd Seed	.583	Gourd Seed, 1	.625	Gourd Seed, 1	.625	McCullough	29
	Munson	.556	Munson, 2	.577	Munson, 2	.577	Gorham Yellow	23
	Schieberle [2]	.526	Schieberle, 4	.565	Selection 136, 3	.573	Ferguson Yellow	21
	Selection 136	.523	Selection 136, 3	.573	Schieberle, 4	.565	Selection 136	10
	Singleton	.486	Singleton, 7	.500	Ferguson Yellow, 5	.533	Gourd Seed	7
							Schieberle	7
Corsicana	Dan Patch	.436	Dan Patch, 2	.464	Lily of the Valley, 1	.534	Lily of the Valley	31
	Selection 136	.422	Selection 136, 4	.437	Dan Patch, 2	.464	Gorham Yellow	24
	Surcropper	.418	Surcropper, 5	.408	Gourd Seed, 3	.442	McCullough	11
	Ferguson Yellow	.416	Ferguson Yellow, 8	.386	Selection 136, 4	.437	Gourd Seed	7
	Gourd Seed	.414	Gourd Seed, 3	.442	Surcropper, 5	.408	Mosby Prolific	6
							Dan Patch	6

[1] Not in the test at Waco.

[2] Not in the test at Corsicana.

TABLE XIII.—*Relation of the lowest yielding crosses and crosses showing greatest percentage of decrease to the lowest yielding parents in Texas, 1910.*

Locality.	Female parent (poorest yielding in inverse order of productiveness).		Cross.		Poor-yielding cross.		Cross showing high percentage of decrease from better parent.	
	Variety.	Yield per stalk.	Variety (× Chisholm) and rank.	Yield per stalk.	Variety (× Chisholm) and rank.	Yield per stalk.	Variety (× Chisholm).	Decrease.
		Pounds.		*Pounds.*		*Pounds.*		*Per cent.*
Sherman	Huffman[1]	0.029	Huffman, 14	0.089	Huffman, 14	0.089	Mosby Prolific	33
	Mosby Prolific	.087	Mosby Prolific, 13	.117	Schieberle, 14	.089	Schieberle	32
	Blow	.089	Blow, 8	.144	Mosby Prolific, 13	.117	Huffman	28
	Munson	.093	Munson, 12	.120	Munson, 12	.120	Singleton	22
	Singleton	.112	Singleton, 11	.122	Singleton, 11	.122	Munson	21
Waco	Selection 137	.300	Selection 137, 12	.364	Selection 137, 12	.364	Selection 137	18
	McCullough	.312	McCullough, 8	.490	Mosby Prolific, 11	.434	Mosby Prolific	9
	Gorham Yellow	.353	Gorham Yellow, 6	.510	Surcropper, 10	.435		
	Mosby Prolific	.364	Mosby Prolific, 11	.434	Blow, 9	.452		
	Blow	.373	Blow, 9	.452	McCullough, 8	.490		
Corsicana	Huffman	.234	Huffman, 13	.272	Huffman, 13	.272	Huffman	9
	McCullough	.313	McCullough, 11	.346	Singleton, 12	.322	Ferguson Yellow	7
	Singleton	.317	Singleton, 12	.322	McCullough, 11	.346	Selection 137	2
	Gorham Yellow	.319	Gorham Yellow, 7	.396	Blow, 10	.363	Munson	2
	Blow	.325	Blow, 10	.363	Munson, 10	.363	Surcropper	2

[1] Not in test at Waco.

In the Corsicana test four of the highest yielding crosses are progeny of four of the highest yielding female parents. Among the crosses showing the greatest percentage increase over the better parent three are identical with three of the highest yielding crosses, two are progeny of the high-yielding female parents, and two are progeny of the poor-yielding female parents. Of the poorest yielding crosses, four are progeny of four of the poorest yielding female parents. Out of the crosses showing the greatest percentage of decrease from the better parent, one is the progeny of the poorest yielding female parent, and two are the progeny of two of the highest yielding female parents. Two are identical with two of the poorest yielding crosses.

It is evident in these tests that in general the most productive crosses have come from the most productive female parents; that the crosses showing the greatest percentage of increase over the better parents are in most instances identical with the highest yielding crosses. Likewise, in most cases, the poorest yielding crosses are from the poorest yielding female parents, as are also most of the crosses that show the greatest percentage of decrease in yield. There is no instance in which one of the highest yielding crosses springs from one of the poorest yielding female parents.

There are, however, both in the test at Waco and at Corsicana, two crosses (Gorham Yellow × Chisholm and McCullough × Chisholm) which stand high in the list of crosses showing greatest percentage increase over the better parent; they rank among the crosses in actual production per stalk sixth and eighth, respectively, at Waco, while at Corsicana the rank is seventh and eleventh. The female parents of these crosses are among the poorest yielding varieties at both places. These two comparisons are the most striking among the crosses in regard to increase over the parent varieties, but their actual yield is less than the best producing original varieties in the test, and there would be no incentive to grow them commercially.

These results would indicate the most promising method of securing increased yields to be by crossing the highest yielding varieties, but such a method would necessitate the previous testing of the varieties to ascertain the highest yielding, and the crosses could not then with certainty be depended upon to give increased yields, as is seen in the case of the cross Surcropper × Chisholm, which is less productive than Surcropper at both Sherman and Corsicana and but little more productive at Waco. Selection 137 × Chisholm is less productive than Selection 137 (the better parent) at Sherman, and less than Chisholm (the better parent) at Waco and at Corsicana. The crosses Gourd Seed × Chisholm and Selection 136 × Chisholm were among the highest yielding in the three tests, the Dan Patch × Chisholm was not in the test at Waco, but at Sherman and at Corsicana it ranks among the highest yielders. These crosses also ranked well as regards percentage of increased yield over better parent.

Apparently, then, there are some varieties that combine well and their crosses will give decidedly increased yields; while the crosses of other varieties either show no improvement in yield, or an actual decrease. As no method is known of selecting the varieties the crosses of which can be depended upon to give increased yields, the importance of testing experimentally all crosses before growing them commercially may be readily appreciated by the farmer or corn grower who has in mind the betterment of his general crop by such methods of breeding.

TESTS AT STATESBORO, GA.

VARIETIES USED IN THE EXPERIMENTS.

ALDRICH PERFECTION.

Aldrich Perfection was obtained from a field near Barnwell, S. C. This variety is not very uniform in type, but has a large, deep, characteristic kernel. The kernel is very irregular in shape and gives the ear a very rough appearance. The variety is grown near Barnwell on very sandy land. As grown at Statesboro, it seemed poorly adapted the first year and the market quality was poor. During the second year it seemed better adapted and the market quality was fair.

COCKE PROLIFIC.

Cocke Prolific for this work was obtained from the North Carolina experiment station. The type showed much variation, but the variety has a characteristic appearance. As grown at Statesboro, the ears were fairly sound, but were seriously damaged by weevils. The adaptability was about the same both years.

MARLBORO PROLIFIC.

Marlboro Prolific was selected from a farm near Cheraw, S. C., where it has been grown for many years. The type of ear is not very uniform, but it has a characteristic appearance. The native soil of this variety is sandy, with sandy clay subsoil. As grown at Statesboro, Marlboro Prolific seemed to produce fairly well both years. The grain was seriously damaged by weevils, otherwise it was in good condition.

MOSBY PROLIFIC.

As grown at Montgomery, Ala., Mosby Prolific shows close selection and distinct type. The land upon which the corn was grown is low and flat. The soil is dark and is classed as limestone. As grown at Statesboro, the ears were fairly sound and seemed fairly well adapted during both seasons. It was seriously injured by weevils before harvesting.

NATIVE OF STATESBORO.

The variation in color indicates that the Native of Statesboro variety of corn is badly mixed, but the comparatively straight rows of well-formed, deep kernels and the shape of the ear show that it has had selection along certain lines. It has been grown on a farm near the one on which this test was made for 18 or 20 years, without the introduction of other seed, so far as is known. As grown in the test, the ears were fairly sound during both seasons. Weevils were found within practically all of the shucks, but only a small amount of damage had been done by the time the corn was harvested the first year and none the second year.

RODGERS WHITE DENT.

Rodgers White Dent was selected from a field near Darlington, S. C. The type of the ears and uniformity of the corn is probably more perfect than any other in the test. It has been the selection of one man for years. The land on which the corn has been grown is sandy, with sandy clay subsoil. As grown at Statesboro, the market quality was very good and during both seasons it seemed fairly well adapted.

SANDERS PROLIFIC.

As grown and developed at Danielsville, Ga., Sanders Prolific shows considerable selection and has a characteristic type. The seed used in these experiments was field selected. The field is upland and consists of a very poor red clay. Suitable seed could be found only where sediment had accumulated above the terraces. As grown at Statesboro, Ga., the ears tended to be chaffy and were badly damaged by weevils before harvesting. It was poorly adapted to Statesboro conditions in 1909, but one of the best, except for weevils, in 1910.

STATION YELLOW.

The Station Yellow variety of corn was obtained from the Alabama experiment station, and was especially recommended for resisting weevils. No selection was claimed for this corn, but it is known that it is a native of long standing at Auburn, Ala. It is flinty and has a fairly uniform golden color. It has been grown largely upon poor upland clay. As grown at Statesboro, its market quality was fully the equal of any grown in the experiment. Weevils were found in practically all of the shucks, but little damage had been done at time of harvesting.

TINDAL.

The Tindal corn is a mixture of Marlboro Prolific with a native corn near Manning, S. C., where the variety is being grown. This seed was selected from the grower's field three or four years after the mixture had first been made. The type is mostly that of Marlboro Prolific, though there is considerable variation. In the Orange Judd Farmer's national corn test in 1906 this corn took first prize, with 182 bushels per acre. The soil on which this corn was grown is sandy, with sandy clay subsoil near surface. As grown at Statesboro, it performed much the same as Marlboro Prolific.

WHELCHEL.

The Whelchel variety of corn was bred and developed at Gainesville, Ga., and is the result of crossing at least three varieties, one of which was Boone County White. The original ears used in this test were unusually large. The bushel from which the 10 ears were taken contained only 64 ears. Much variation is still seen in the type. The corn was developed on rich red-clay land. This variety proved poorly adapted to Statesboro conditions. Many ears developed poorly and many of those that did develop rotted in the husk. The market quality was unusually bad, and it was extremely difficult to obtain sufficiently strong germinating seed for the second year's work. The apparently high yield in 1910 was due at least to some extent to the moisture contained in the ears at harvest time. The quality of the corn was very poor.

WILLIAMSON.

The Williamson corn has been grown and selected near Darlington, S. C., for a good many years, and the type of ear, the kernels, and their rows are unusually uniform. The color, however, is not fixed and varies from nearly white to nearly yellow. In general the kernels are white or cream capped, shading into a yellow toward the cob. The cobs are mostly red, but there are some white ones. The variety has been developed on sandy soil with a sandy, clay subsoil, which at present is quite fertile. As grown at Statesboro the ears showed a slight tendency to spoil in the field, but its adaptation seemed to be nearly as good as the native seed, and it had not been greatly damaged by weevils when harvested.

WORK OF 1909.

Eleven varieties of corn represented by 10 ears of each were used. The seed of the ears was not mixed, but planted in adjacent rows. The corn was dropped in hills, and two stalks, from 6 to 8 inches apart, were left in a hill.

Each hill represented two ears. In all 10 rows representing a variety the first plant in each hill was from the same ear. These plants served both as a standard of comparison and as a sire to the variety in that set of 10. The second plant in all hills of any one row represented one ear of a female parent and was detasseled.

Duplicate plantings were made from each of the ears. In one instance the standard or sire ears were of the Marlboro Prolific variety, and in the other instance the standard or sire ears were of the Rodgers White Dent variety.

The standard or sire ears used were also grouped and detasseled the same as the ears of the other varieties, so that a study of both the male and the female was afforded. Furthermore, by thus comparing the standards of all the varieties in the test the several varieties themselves could be compared.

The arrangement of the varieties with their pollen-bearing standards is given in Table XIV. The two fields in which the crossing was accomplished were well isolated.

TABLE XIV.—*Arrangement of the varieties of corn with their pollen-bearing standards.*

Variety receiving pollen.		Ear No. of sire.	
Ears Nos.—	Name.	Marlboro Prolific.	Rodgers White Dent.
1 to 10	Aldrich Perfection	8	22
1 to 10	Cocke Prolific	9	24
1 to 10	Marlboro Prolific	3	7
1 to 10	Mosby Prolific	2	2
1 to 10	Native of Statesboro	3	3
1 to 10	Rodgers White Dent	7	20
1 to 10	Sanders Prolific	1	1
1 to 10	Station Yellow	5	15
1 to 10	Tindal	10	14
1 to 10	Whelchel	4	4
1 to 10	Williamson	6	17

CHARACTER OF THE SOIL.

The crossing was accomplished in 1909 at Statesboro, Ga., on coastal plain sand. The soil where the Marlboro Prolific sire was used had a fairly compact, sandy, clay subsoil 10 to 12 inches below the surface, and the land was fairly fertile. The soil where the Rodgers White Dent sire was used had less clay in the subsoil, and the land was naturally less fertile.

CULTURE.

The land was plowed deep. No commercial fertilizer was applied direct to the corn where Marlboro Prolific was used as sire, the land having previously been fertilized for rape. A complete fertilizer at the rate of about 800 pounds per acre was applied to the land where the Rodgers sire was used. The land was listed with a turning plow, and the corn was planted in the bottom of the furrows. Eight square feet were allowed each plant, the rows being 4 feet apart each way. The cultivation was with sweeps and harrows, and the last cultivation left the land level.

HARVEST.

The corn was harvested when thoroughly dry in the field. The weights were taken separately of all ears grown on the standard or sire stalks and of all the ears grown on the detasseled stalks of a row, and the two weights were recorded separately. Only normal hills with normal surroundings were considered, and the number of these hills considered was recorded under the heading "Number of perfect hills."

WORK OF 1910.

Only a portion of the seed from the original ears of this experiment was planted in 1909. The remnant seed of each ear was preserved in a separate glass bottle at Washington, D. C., until the spring of 1910, when it was tested for germination and planted in comparison with crossed progeny that had been growing at Statesboro in 1909, as previously described.

VITALITY OF SEED TESTED BEFORE PLANTING.

Vitality tests were made by the Seed Laboratory of the United States Department of Agriculture of all the ears planted in the experiment. Each ear was represented in the germination test by 10 kernels from various parts of the ear. The results were recorded as so many kernels germinating strong and so many germinating weak. The pure or 2-year-old seed averaged about 90 per cent strong the spring of 1910, and was unusually uniform in this particular, but the vitality of the crossed seed was usually low, and in some cases it was impossible to obtain satisfactory seed, even though the best was chosen. The crossed progeny was represented by a single ear selected largely because its vitality was the best available.

Table XV shows the variability in the germinating power both within the variety and between the varieties.

TABLE XV.—*Germination record of 11 varieties of corn cross-fertilized with Marlboro Prolific pollen.*

Name of variety and character of germination.	Nos. of ears tested.										Average of 10 ears.
	1	2	3	4	5	6	7	8	9	10	
Aldrich Perfection:											
Strong	0	3	4	5	0	8	5	5	5	7	4.2
Weak	8	3	4	5	9	2	3	1	2	3	4.0
Cocke Prolific:											
Strong	9	10	10	5	8	5	9	8	10	5	7.9
Weak	1	0	0	4	2	4	1	2	0	5	1.9
Marlboro Prolific:											
Strong	10	8	4	6	7	6	10	10	10	8	7.9
Weak	0	2	5	3	3	3	0	0	0	2	1.8
Mosby Prolific:											
Strong	10	9	8	8	8	8	7	8	10	5	8.5
Weak	0	1	2	2	1	0	2	2	0	5	1.1
Native of Statesboro:											
Strong	10	10	10	7	10	10	5	7	7	8	8.4
Weak	0	0	0	3	0	0	5	3	3	2	1.6
Rodgers White Dent:											
Strong	9	9	10	10	10	10	9	10	10	8	9.5
Weak	1	1	0	0	0	0	1	0	0	2	.5
Sanders Prolific:											
Strong	5	7	10	8	9	3	5	0	2	4	5.3
Weak	2	1	0	1	1	4	5	10	7	5	3.6
Station Yellow:											
Strong	10	1	6	8	7	10	8	10	6	4	7.0
Weak	0	9	4	1	3	0	2	0	3	5	2.7
Tindal:											
Strong	8	10	9	10	10	9	10	8	8	10	9.2
Weak	2	0	1	0	0	1	0	0	2	0	.6
Whelchel:											
Strong	2	0	0	5	3	7	0	3	3	0	2.3
Weak	7	5	9	5	6	3	7	4	7	10	6.3
Williamson:											
Strong	10	10	10	5	10	5	6	9	4	9	7.8
Weak	0	0	0	2	0	5	3	0	6	0	1.6

An unusual quantity of this seed was planted in each hill and later thinned to the stand desired. When the corn came up and started to grow, the vigor of the crossed and of the uncrossed plants was not noticeably different. The productiveness of the female parents in comparison with the first-generation crosses was tested at Statesboro, and upon the same farm where the crosses were produced the previous year, but in a different field. The field had been brought into cultivation more recently than those used in 1909, and although not rich it was quite uniformly fertile.

The seed was planted in hills, and two stalks were left to the hill. The stalks stood from 6 to 8 inches apart in the hill. The first member of each hill in a row was from the remnant seed, and the second member of the hill was progeny of the first, which had been cross-pollinated the previous year.

PLAN OF TESTING PRODUCTIVENESS IN 1910.

Diagram 2 shows the arrangement of this 1910 planting. The varieties were planted in alphabetical order, and their ears in numerical order. As shown in the plan, each hill, for example, of row 1 in section 1 contained two stalks; the first stalk was from original ear 1 of Aldrich Perfection, and the second stalk from an ear descending directly from ear 1 of Aldrich Perfection, and which was cross-pollinated in 1909 with pollen from Rodgers White Dent.

DIAGRAM 2.—*Plan of testing plats for comparing the productiveness in 1910 of original pure-bred ears of corn and their crossbred progeny ears.*

[Key to the varieties and their crossbred progeny (10 ears of each and 10 rows of each except of *T*): *A*, Aldrich Perfection and its cross with Rodgers White Dent; *B*, Aldrich Perfection and its cross with Marlboro Prolific; *C*, Cocke Prolific and its cross with Rodgers White Dent; *D*, Cocke Prolific and its cross with Marlboro Prolific; *E*, Marlboro Prolific and its cross with Rodgers White Dent; *F*, Marlboro Prolific and its cross with Marlboro Prolific; *G*, Mosby Prolific and its cross with Rodgers White Dent; *H*, Mosby Prolific and its cross with Marlboro Prolific; *I*, Native of Statesboro and its cross with Rodgers White Dent; *J*, Native of Statesboro and its cross with Marlboro Prolific; *K*, Rodgers White Dent and its cross with Rodgers White Dent; *L*, Rodgers White Dent and its cross with Marlboro Prolific; *M*, Sanders Prolific and its cross with Rodgers White Dent; *N*, Sanders Prolific and its cross with Marlboro Prolific; *O*, Station Yellow and its cross with Rodgers White Dent; *P*, Station Yellow and its cross with Marlboro Prolific; *Q*, Tindal and its cross with Rodgers White Dent; *R*, Tindal and its cross with Marlboro Prolific; *S*, Whelchel and its cross with Rodgers White Dent; *T*, Whelchel and its cross with Marlboro Prolific (17 rows); *U*, Williamson and its cross with Rodgers White Dent; *V*, Williamson and its cross with Marlboro Prolific.]

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Section 1.	Section 2.	Section 3.	Section 4.	Section 5.	Section 6.	Section 7.
A: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*D*: 3, 4, 5, 6, 7, 8, 9, 10	*G*: 5, 6, 7, 9, 9, 10	*J*: 7, 8, 9, 10	*M*: 9, 10	*Q*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*T*: 3, 3, 4, 4, 5, 5, 6, 6, 7, 8, 8, 9, 9, 10, 10 [1]
B: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*E*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*H*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*K*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*N*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*R*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*U*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
C: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*F*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*I*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*L*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*O*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*S*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*V*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
D: 1, 2	*G*: 1, 2, 3, 4	*J*: 1, 2, 3, 4, 5, 6	*M*: 1, 2, 3, 4, 5, 6, 7, 8	*P*: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10	*T*: 1, 2	

North. West. Tenant's cabin

[1] The land at the south end of section 7 was unusually rich, and the stand was made thinner because of chickens of near-by tenant.

CONDITIONS FOR GROWTH.

The land had been thoroughly plowed several weeks previous to planting. Just before planting, furrows were opened with a large shovel, which not only permitted planting below the level in moist earth, but also helped to throw to one side hidden obstructions that might interfere with a uniform thrust of the hand planters used.

A marked wire was used to regulate both the spacing of the hills in the row and the spacing of the stalks in the hills.

The writer and his assistant planted all of the seed. Each man carried seed for a certain member of the hill only, and together they planted each hill. On removing the planter from the ground the foot was placed upon the spot and the weight of the body was thrown upon it in stepping forward to the next hill. Care was taken to remove trash or any other obstruction that might interfere with proper planting.

Nine square feet per plant were allowed, so that very little competition for sunlight was possible among the plants. The rainfall was abundant except for a week or 10 days previous to tasseling. A liberal supply of commercial fertilizer was used.

Abnormal growth (barrenness, smut, etc.) was very rare among the plants, but there were missing members of some hills and a few missing hills. However, in securing the data that follow, consideration was taken only of hills that grew under normal conditions and whose members seemed to have had equal opportunity and were normal.

MANNER OF HARVESTING.

The harvesting was done by four men. One carried a notebook and kept all of the records. Another carried a knife and selected and cut the hills of a row that were suitable. The other two men took the stalks as they were cut, one carrying the first member only and the other carrying the second member only.

The fodder was thus collected and carried to the end of the rows and there weighed, and the collective weights of the two members of each hill were recorded separately.

The ears were then separated from the stover, and the weight of each together with the number of ears was recorded.

MOISTURE IN GRAIN HARVESTED.

Through the courtesy of the Office of Grain Standardization moisture determinations were obtained of grain shelled from many ears of each variety and each cross. The extreme variation among the varieties and crosses was less than 2 per cent of moisture. The shelled grain of Aldrich Perfection and Whelchel contained 16 per cent of moisture, and the other varieties and crosses contained about 1 per cent less. The appearance of the large cobs of the Whelchel and Aldrich Perfection varieties and the rotting of the ears indicated that the entire ears of these varieties contained a greater excess of moisture than did the shelled grain. In these two cases a correction for moisture content would give a more valuable comparison, but since the moisture content of the entire ears was not determined the comparisons of productiveness are in all cases based on the weight of ears as harvested.

PRESENTATION OF RESULTS IN GEORGIA.

DATA COLLECTED AT HARVEST.

Table XVI gives in detail the data collected at harvest time in 1910.

TABLE XVI.—*Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.*

ALDRICH PERFECTION ♀ × MARLBORO PROLIFIC ♂.[1]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	14	Ears	9.75	9.50	0.70	0.68	−0.02	− 3	15	14
		Stalks	13.75	14.25	.98	1.02	.04	4		
2	8	Ears	4.25	5.00	.53	.63	.10	18	8	7
		Stalks	6.25	8.25	.78	1.03	.25	32		
3	12	Ears	5.75	7.25	.48	.60	.12	26	12	12
		Stalks	8.75	11.50	.73	.96	.23	31		
4	19	Ears	11.00	11.50	.58	.61	.03	5	20	19
		Stalks	15.25	17.25	.80	.91	.11	13		
5	12	Ears	6.75	7.75	.56	.65	.09	15	13	12
		Stalks	10.00	11.50	.83	.96	.13	15		
6	14	Ears	4.25	8.50	.30	.61	.31	100	14	14
		Stalks	17.00	12.75	1.21	.91	− .30	− 25		
7	13	Ears	8.50	6.75	.65	.52	− .13	− 21	13	13
		Stalks	16.25	10.25	1.25	.79	− .46	− 37		
8	8	Ears	5.00	5.00	.63	.63	.00	0	8	8
		Stalks	8.00	7.50	1.00	.94	− .06	− 6		
9	16	Ears	4.50	7.25	.28	.45	.17	61	16	16
		Stalks	15.75	12.25	.98	.77	− .21	− 22		
10	16	Ears	8.75	8.00	.55	.50	− .05	− 9	16	16
		Stalks	13.00	11.25	.81	.70	− .11	− 13		

[1] Favoring the cross: Ears, 6 out of 10; stalks, 5 out of 10. Average weight of ears per stalk produced by the female parent, 0.52 pound; by the cross, 0.58 pound. Average weight of stover per stalk produced by female parent, 0.94 pound; by the cross, 0.88 pound. Increased yield of cross over the female parent: Grain, 12 per cent; stover, −6 per cent.

TABLE XVI.—*Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.*—Continued.

ALDRICH PERFECTION ♀ × RODGERS WHITE DENT ♂.[1]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	14	Ears	8.00	6.25	0.57	0.45	−0.12	− 22	14	14
		Stalks	9.50	12.50	.68	.89	.21	32		
2	21	Ears	11.25	13.00	.54	.62	.08	16	21	21
		Stalks	17.25	20.25	.82	.96	.14	17		
3	8	Ears	3.25	5.00	.41	.63	.22	54	8	9
		Stalks	7.25	8.00	.91	1.00	.09	10		
4	24	Ears	13.25	13.25	.55	.55	.00	0	24	25
		Stalks	19.50	21.00	.81	.88	.07	8		
5	14	Ears	7.25	8.00	.52	.57	.05	10	14	15
		Stalks	11.00	12.50	.79	.89	.10	14		
6	18	Ears	8.50	11.50	.47	.64	.17	35	18	20
		Stalks	14.00	16.75	.78	.93	.15	20		
7	15	Ears	9.25	9.75	.62	.65	.03	5	15	19
		Stalks	14.50	16.00	.97	1.07	.10	10		
8	17	Ears	9.25	11.00	.54	.65	.11	19	17	17
		Stalks	14.75	17.75	.87	1.04	.17	20		
9	8	Ears	3.75	5.25	.47	.66	.19	40	8	10
		Stalks	6.25	8.00	.78	1.00	.22	28		
10	12	Ears	7.50	6.75	.63	.56	− .07	−10	12	12
		Stalks	10.75	10.50	.90	.88	− .02	− 2		

COCKE PROLIFIC ♀ × MARLBORO PROLIFIC ♂.[2]

Seed ear No.	Number of perfect hills.	Kind of product.	Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	22	Ears	10.25	10.50	0.47	0.48	0.01	2	26	24
		Stalks	17.25	16.00	.78	.73	− .05	− 7		
2	18	Ears	10.50	10.50	.58	.58	.00	0	20	23
		Stalks	16.00	15.75	.89	.88	− .01	− 2		
3	21	Ears	9.00	10.00	.43	.48	.05	11	21	23
		Stalks	13.00	14.25	.62	.68	.06	10		
4	20	Ears	10.00	8.75	.50	.44	− .06	−13	21	20
		Stalks	16.50	13.50	.83	.68	− .15	−18		
5	18	Ears	10.50	10.25	.58	.57	− .01	− 2	25	25
		Stalks	16.00	14.75	.89	.82	− .07	− 8		
6	23	Ears	10.75	13.50	.47	.59	.12	26	29	28
		Stalks	17.25	20.50	.75	.89	.14	19		
7	24	Ears	11.75	12.50	.49	.52	.03	6	27	25
		Stalks	20.25	19.25	.84	.80	− .04	− 5		
8	19	Ears	11.00	12.00	.58	.63	.05	9	24	28
		Stalks	17.00	17.25	.89	.91	.02	1		
9	21	Ears	9.00	12.50	.43	.60	.17	39	21	30
		Stalks	14.50	19.75	.69	.94	.25	36		
10	18	Ears	11.00	11.75	.61	.65	.04	7	28	23
		Stalks	18.25	17.50	1.01	.97	− .04	− 4		

[1] Favoring the cross: Ears, 7 out of 10; stalks, 9 out of 10. Average weight of ears per stalk produced by the female parent, 0.54 pound; by the cross, 0.59 pound. Average weight of stover per stalk produced by female parent, 0.83 pound; by the cross, 0.95 pound. Increased yield of cross over the female parent: Grain, 10 per cent; stover, 15 per cent.

[2] Favoring the cross: Ears, 7 out of 10; stalks, 4 out of 10. Average weight of ears per stalk produced by the female parent, 0.51 pound; by the cross, 0.55 pound. Average weight of stover per stalk produced by female parent, 0.81 pound; by the cross, 0.83 pound. Increased yield of cross over the female parent: Grain, 8 per cent; stover, 2 per cent.

TABLE XVI.—*Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.*—Continued.

COCKE PROLIFIC ♀ × RODGERS WHITE DENT ♂.[1]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Weight of product (pounds). Total. Cross.	Weight of product (pounds). Per stalk. Original.	Weight of product (pounds). Per stalk. Cross.	Weight of product (pounds). Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	13	Ears	6.75	5.75	0.52	0.44	−0.08	−15	13	13
		Stalks	12.00	9.25	.92	.71	− .21	−23	....	....
2	18	Ears	9.25	10.00	.51	.56	.05	8	18	20
		Stalks	14.00	14.50	.78	.81	.03	4	....	....
3	21	Ears	9.00	10.00	.43	.48	.05	11	22	22
		Stalks	12.75	15.25	.61	.73	.12	20	....	....
4	18	Ears	8.25	7.00	.46	.39	− .07	−15	20	18
		Stalks	14.25	10.00	.79	.56	− .23	−30	....	....
5	12	Ears	5.75	4.25	.48	.35	− .13	−26	13	12
		Stalks	8.75	6.25	.73	.52	− .21	−29	....	....
6	14	Ears	6.25	6.75	.45	.48	.03	8	16	14
		Stalks	9.75	9.25	.70	.66	− .04	− 5	....	....
7	21	Ears	10.25	10.50	.49	.50	.01	2	22	21
		Stalks	16.25	15.25	.77	.73	− .04	− 6	....	....
8	23	Ears	11.75	13.75	.51	.60	.09	17	28	31
		Stalks	17.00	19.50	.74	.85	.11	15	....	....
9	21	Ears	9.00	9.50	.43	.45	.02	6	25	22
		Stalks	14.50	16.00	.69	.76	.07	10	....	....
10	15	Ears	6.50	7.25	.43	.48	.05	12	16	17
		Stalks	9.25	10.50	.62	.70	.08	14	....	....

MARLBORO PROLIFIC ♀ × MARLBORO PROLIFIC ♂.[2]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Weight of product (pounds). Total. Cross.	Weight of product (pounds). Per stalk. Original.	Weight of product (pounds). Per stalk. Cross.	Weight of product (pounds). Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	21	Ears	10.75	11.00	0.51	0.52	0.01	2	27	27
		Stalks	19.00	17.25	.90	.82	− .08	− 9	....	....
2	18	Ears	9.25	11.50	.51	.64	.13	24	19	25
		Stalks	14.50	18.75	.81	1.04	.23	29	....	....
3	21	Ears	11.00	12.00	.52	.57	.05	9	25	28
		Stalks	18.50	21.25	.88	1.01	.13	15	....	....
4	20	Ears	10.75	8.00	.54	.40	− .14	−26	22	30
		Stalks	16.25	13.25	.81	.66	− .15	−18	....	....
5	15	Ears	7.75	6.50	.52	.43	− .09	−16	20	16
		Stalks	13.25	11.25	.88	.75	− .13	−15	....	....
6	19	Ears	9.00	10.00	.47	.53	.06	11	23	22
		Stalks	13.50	15.25	.71	.80	.09	13	....	....
7	22	Ears	9.75	12.25	.44	.56	.12	26	26	33
		Stalks	15.25	19.25	.69	.88	.19	26	....	....
8	25	Ears	11.50	14.25	.46	.57	.11	24	29	38
		Stalks	19.50	21.75	.78	.87	.09	12	....	....
9	23	Ears	12.25	10.75	.53	.47	− .06	−12	30	26
		Stalks	19.00	17.00	.83	.74	− .09	−11	....	....
10	23	Ears	10.00	9.25	.43	.40	− .03	− 8	27	24
		Stalks	16.00	13.75	.70	.60	− .10	−14	....	....

[1] Favoring the cross: Ears, 7 out of 10; stalks, 5 out of 10. Average weight of ears per stalk produced by the female parent, 0.47 pound; by the cross, 0.48 pound. Average weight of stover per stalk produced by female parent, 0.73 pound; by the cross, 0.71 pound. Increased yield of cross over the female parent: Grain, 2 per cent; stover, 2 per cent.

[2] Favoring the cross: Ears, 6 out of 10; stalks, 5 out of 10. Average weight of ears per stalk produced by the female parent, 0.49 pound; by the cross, 0.51 pound. Average weight of stover per stalk produced by female parent, 0.80 pound; by the cross, 0.82 pound. Increased yield of cross over the female parent: Grain, 3 per cent; stover, 2 per cent.

TABLE XVI.—*Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.*—Continued.

MARLBORO PROLIFIC ♀ × RODGERS WHITE DENT ♂.[1]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	25	Ears	14.50	13.25	0.58	0.53	−0.05	−9	33	28
		Stalks	26.50	25.25	1.06	1.01	−.05	−5		
2	26	Ears	12.50	14.00	.48	.54	.06	12	28	27
		Stalks	21.00	25.00	.81	.96	.15	19		
3	22	Ears	11.50	12.00	.52	.55	.03	4	29	27
		Stalks	19.75	23.25	.90	1.06	.16	18		
4	25	Ears	14.50	15.00	.58	.60	.02	3	37	27
		Stalks	26.25	26.75	1.05	1.07	.02	2		
5	22	Ears	12.00	13.00	.55	.59	.04	8	27	28
		Stalks	21.00	23.00	.95	1.05	.10	10		
6	21	Ears	11.00	12.00	.52	.57	.05	9	28	23
		Stalks	18.50	21.00	.88	1.00	.12	14		
7	24	Ears	10.75	13.50	.45	.56	.11	26	29	28
		Stalks	19.00	23.50	.79	.98	.19	24		
8	21	Ears	12.00	11.75	.57	.56	−.01	−2	29	22
		Stalks	22.00	19.50	1.05	.93	−.12	−11		
9	18	Ears	10.50	10.50	.58	.58	.00	0	22	20
		Stalks	17.00	17.25	.94	.96	.02	1		
10	15	Ears	7.50	10.00	.50	.67	.17	33	15	22
		Stalks	12.75	15.75	.85	1.05	.20	24		

MOSBY PROLIFIC ♀ × MARLBORO PROLIFIC ♂.[2]

Seed ear No.	Number of perfect hills.	Kind of product.	Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	25	Ears	12.00	13.75	0.48	0.55	0.07	15	35	34
		Stalks	21.00	22.75	.84	.91	.07	8		
2	20	Ears	12.50	13.00	.63	.65	.02	4	34	30
		Stalks	20.00	20.00	1.00	1.00	.00	0		
3	19	Ears	8.00	10.00	.42	.53	.11	25	24	25
		Stalks	14.50	16.50	.76	.87	.11	14		
4	19	Ears	8.75	9.50	.46	.50	.04	9	20	20
		Stalks	14.25	15.50	.75	.82	.07	9		
5	20	Ears	9.00	11.75	.45	.59	.14	31	22	26
		Stalks	15.50	18.25	.78	.91	.13	18		
6	16	Ears	7.75	9.25	.48	.58	.10	19	19	18
		Stalks	13.75	14.75	.86	.92	.06	7		
7	17	Ears	8.25	9.00	.49	.53	.04	9	19	18
		Stalks	14.00	14.00	.82	.82	.00	0		
8	13	Ears	8.00	8.75	.62	.67	.05	9	18	19
		Stalks	13.75	15.25	1.06	1.17	.11	11		
9	17	Ears	8.75	9.00	.51	.53	.02	3	18	23
		Stalks	15.00	14.00	.88	.82	−.06	−7		
10	23	Ears	9.00	10.00	.39	.43	.04	11	23	25
		Stalks	18.00	18.00	.78	.78	.00	0		

[1] Favoring the cross: Ears, 7 out of 10; stalks, 8 out of 10. Average weight of ears per stalk produced by the female parent, 0.53 pound; by the cross, 0.57 pound. Average weight of stover per stalk produced by female parent, 0.93 pound; by the cross, 1.01 pounds. Increased yield of cross over the female parent: Grain, 7 per cent; stover, 8 per cent.

[2] Favoring the cross: Ears, 10 out of 10; stalks, 6 out of 10. Average weight of ears per stalk produced by the female parent, 0.49 pound; by the cross, 0.55 pound. Average weight of stover per stalk produced by female parent, 0.85 pound; by the cross, 0.89 pound. Increased yield of cross over the female parent: Grain, 13 per cent; stover, 6 per cent.

TABLE XVI.—*Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.*—Continued.

MOSBY PROLIFIC ♀ × RODGERS WHITE DENT ♂.[1]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	18	Ears	6.75	10.00	0.38	0.56	0.18	48	25	23
		Stalks	13.00	15.75	.72	.88	.16	21	......	......
2	17	Ears	6.75	8.25	.40	.49	.09	22	18	20
		Stalks	11.25	12.25	.66	.72	.06	9	......	......
3	22	Ears	8.75	12.50	.40	.57	.17	43	27	31
		Stalks	14.75	20.25	.67	.92	.25	37	......	......
4	18	Ears	9.00	11.50	.50	.64	.14	28	21	22
		Stalks	14.50	18.50	.81	1.03	.22	28	......	......
5	22	Ears	8.50	11.00	.39	.50	.11	29	22	27
		Stalks	14.25	17.50	.65	.80	.15	23	......	......
6	20	Ears	8.50	11.50	.43	.58	.15	35	23	27
		Stalks	14.75	18.00	.74	.90	.16	22	......	......
7	22	Ears	10.25	12.75	.47	.58	.11	24	25	27
		Stalks	17.25	20.50	.78	.93	.15	19	......	......
8	23	Ears	10.25	13.00	.45	.57	.12	27	31	26
		Stalks	19.50	21.75	.85	.95	.10	12	......	......
9	18	Ears	10.00	10.75	.56	.60	.04	8	22	22
		Stalks	16.75	18.50	.93	1.03	.10	10	......	......
10	25	Ears	10.75	13.75	.43	.55	.12	28	28	29
		Stalks	20.25	23.25	.81	.93	.12	15	......	......

NATIVE OF STATESBORO ♀ × MARLBORO PROLIFIC ♂.[2]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	21	Ears	13.25	12.75	0.63	0.61	−0.02	−4	22	23
		Stalks	21.25	20.00	1.01	.95	−.06	−6	......	......
2	20	Ears	10.75	11.50	.54	.58	.04	7	21	22
		Stalks	17.50	18.00	.88	.90	.02	3	......	......
3	7	Ears	3.25	3.25	.46	.46	.00	0	7	8
		Stalks	5.50	5.00	.79	.71	−.08	−9	......	......
4	23	Ears	11.25	12.25	.49	.53	.04	9	24	25
		Stalks	18.75	21.50	.82	.93	.11	15	......	......
5	21	Ears	9.00	10.50	.43	.50	.07	17	22	21
		Stalks	15.25	17.75	.73	.85	.12	16	......	......
6	13	Ears	7.00	6.75	.54	.52	−.02	−4	14	14
		Stalks	11.00	11.50	.85	.88	.03	5	......	......
7	15	Ears	7.25	7.00	.48	.47	−.01	−3	15	16
		Stalks	11.25	11.00	.75	.73	−.02	−2	......	......
8	10	Ears	6.00	6.25	.60	.63	.03	4	11	15
		Stalks	10.00	10.50	1.00	1.05	.05	5	......	......
9	18	Ears	7.75	10.00	.43	.56	.13	29	18	19
		Stalks	13.25	15.25	.74	.85	.11	15	......	......
10	13	Ears	6.75	7.00	.52	.54	.02	4	13	14
		Stalks	9.75	10.50	.75	.81	.06	8	......	......

[1] Favoring the cross: Ears, 10 out of 10; stalks, 10 out of 10. Average weight of ears per stalk produced by the female parent, 0.44 pound; by the cross, 0.56 pound. Average weight of stover per stalk produced by female parent, 0.76 pound; by the cross, 0.91 pound. Increased yield of cross over the female parent: Grain, 28 per cent; stover, 19 per cent.

[2] Favoring the cross: Ears, 6 out of 10; stalks, 7 out of 10. Average weight of ears per stalk produced by the female parent, 0.51 pound; by the cross, 0.54 pound. Average weight of stover per stalk produced by female parent, 0.83 pound; by the cross, 0.88 pound. Increased yield of cross over the female parent: Grain, 6 per cent; stover, 6 per cent.

TABLE XVI.—*Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.*—Continued.

NATIVE OF STATESBORO ♀ × RODGERS WHITE DENT ♂.[1]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	15	Ears	9.50	7.50	0.63	0.50	−0.13	−21	17	15
		Stalks	15.50	12.75	1.03	.85	− .18	−18		
2	18	Ears	10.75	11.00	.60	.61	.01	2	19	22
		Stalks	18.75	18.50	1.04	1.03	− .01	− 1		
3	11	Ears	7.25	7.25	.66	.66	.00	0	12	14
		Stalks	12.25	12.25	1.11	1.11	.00	0		
4	12	Ears	7.00	6.00	.58	.50	− .08	−14	12	12
		Stalks	12.25	9.50	1.02	.79	− .23	−22		
5	17	Ears	9.50	10.50	.56	.62	.06	11	17	17
		Stalks	16.50	17.50	.97	1.03	.06	6		
6	11	Ears	5.50	6.00	.50	.55	.05	9	12	11
		Stalks	11.50	10.50	1.05	.95	− .10	− 9		
7	18	Ears	8.00	8.25	.44	.46	.02	3	18	20
		Stalks	15.00	14.25	.83	.79	− .04	− 5		
8	19	Ears	8.25	10.50	.43	.55	.12	27	19	19
		Stalks	14.50	18.75	.76	.99	.23	29		
9	22	Ears	7.75	12.00	.35	.55	.20	55	23	22
		Stalks	14.00	20.50	.64	.93	.29	46		
10	21	Ears	9.75	9.75	.46	.46	.00	0	21	21
		Stalks	14.25	16.75	.68	.80	.12	18		

RODGERS WHITE DENT ♀ × MARLBORO PROLIFIC ♂.[2]

Seed ear No.	Number of perfect hills.	Kind of product.	Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	18	Ears	10.00	10.75	0.56	0.60	0.04	8	18	24
		Stalks	15.50	16.75	.86	.93	.07	8		
2	22	Ears	11.50	11.00	.52	.50	− .02	− 4	26	22
		Stalks	16.75	17.00	.76	.77	.01	1		
3	19	Ears	9.75	12.00	.51	.63	.12	23	22	23
		Stalks	15.75	19.00	.83	1.00	.17	21		
4	21	Ears	12.00	11.75	.57	.56	− .01	− 2	28	27
		Stalks	17.50	18.75	.83	.89	.06	7		
5	25	Ears	11.75	13.00	.47	.52	.05	11	25	30
		Stalks	18.25	20.50	.73	.82	.09	12		
6	17	Ears	7.50	10.25	.44	.60	.16	37	17	19
		Stalks	12.25	15.25	.72	.90	.18	24		
7	22	Ears	10.00	10.50	.45	.48	.03	5	22	22
		Stalks	15.75	16.75	.72	.76	.04	6		
8	17	Ears	9.25	9.25	.54	.54	.00	0	17	19
		Stalks	14.50	14.75	.85	.87	.02	2		
9	12	Ears	5.25	6.75	.44	.56	.12	28	13	14
		Stalks	8.00	11.00	.67	.92	.25	38		
10	17	Ears	8.50	9.50	.50	.56	.06	12	19	20
		Stalks	13.50	15.00	.79	.88	.09	11		

[1] Favoring the cross: Ears, 6 out of 10; stalks, 4 out of 10. Average weight of ears per stalk produced by the female parent, 0.51 pound; by the cross, 0.54 pound. Average weight of stover per stalk produced by female parent, 0.88 pound; by the cross, 0.92 pound. Increased yield of cross over the female parent: Grain, 7 per cent; stover, 5 per cent.

[2] Favoring the cross: Ears, 7 out of 10; stalks, 10 out of 10. Average weight of ears per stalk produced by the female parent, 0.50 pound; by the cross, 0.55 pound. Average weight of stover per stalk produced by female parent, 0.78 pound; by the cross, 0.87 pound. Increased yield of cross over the female parent: Grain, 10 per cent; stover, 12 per cent.

Table XVI.—*Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.*—Continued.

Rodgers White Dent ♀ × Rodgers White Dent ♂.[1]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	11	Ears	7.00	5.25	0.64	0.48	−0.16	−25	13	11
		Stalks	11.25	8.25	1.02	.75	− .27	−27		
2	23	Ears	13.25	11.25	.58	.49	− .09	−15	28	25
		Stalks	21.25	17.00	.92	.74	− .18	−20		
3	14	Ears	7.25	6.75	.52	.48	− .04	− 7	14	14
		Stalks	11.00	10.75	.79	.77	− .02	− 2		
4	22	Ears	13.25	13.50	.60	.61	.01	2	31	28
		Stalks	21.00	22.00	.95	1.00	.05	5		
5	22	Ears	12.50	9.75	.57	.44	− .13	−22	28	25
		Stalks	19.75	16.00	.90	.73	− .17	−19		
6	22	Ears	10.75	9.75	.49	.44	− .05	− 9	22	22
		Stalks	17.50	14.50	.80	.66	− .14	−17		
7	16	Ears	8.25	8.25	.52	.52	.00	0	16	18
		Stalks	13.50	12.75	.84	.80	− .04	− 6		
8	20	Ears	13.50	10.50	.68	.53	− .15	−22	20	21
		Stalks	21.25	15.25	1.06	.76	− .30	−28		
9	16	Ears	7.50	8.25	.47	.52	.05	10	18	16
		Stalks	11.50	13.25	.72	.83	.11	15		
10	20	Ears	10.00	11.50	.50	.58	.08	15	22	21
		Stalks	15.50	18.25	.78	.91	.13	18		

Sanders Prolific ♀ × Marlboro Prolific ♂.[2]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	11	Ears	6.75	6.00	0.61	0.55	−0.06	−11	12	14
		Stalks	12.75	10.25	1.16	.93	− .23	−20		
2	21	Ears	10.25	13.25	.49	.63	.14	29	21	27
		Stalks	15.75	23.75	.75	1.13	.38	51		
3	12	Ears	8.00	9.00	.67	.75	.08	13	17	17
		Stalks	12.00	13.50	1.00	1.13	.13	13		
4	16	Ears	8.25	8.25	.52	.52	.00	0	17	17
		Stalks	13.75	13.50	.86	.84	− .02	− 2		
5	19	Ears	11.25	11.50	.59	.61	.02	2	25	25
		Stalks	19.50	17.75	1.03	.93	− .10	− 9		
6	13	Ears	7.00	7.25	.54	.56	.02	4	14	18
		Stalks	13.00	12.25	1.00	.94	− .06	− 6		
7	17	Ears	9.75	11.50	.57	.68	.11	18	21	23
		Stalks	15.00	17.50	.88	1.03	.15	17		
8	22	Ears	12.00	10.50	.55	.48	− .07	−13	25	22
		Stalks	20.00	20.00	.91	.91	.00	0		
9	7	Ears	4.00	4.25	.57	.61	.04	6	7	9
		Stalks	7.25	6.50	1.04	.93	− .11	−10		
10	18	Ears	11.00	10.00	.61	.56	− .05	− 9	20	21
		Stalks	17.00	15.50	.94	.86	− .08	− 9		

[1] Favoring the cross: Ears, 3 out of 10; stalks, 3 out of 10. Average weight of ears per stalk produced by the female parent, 0.56 pound; by the cross, 0.51 pound. Average weight of stover per stalk produced by female parent, 0.88 pound; by the cross, 0.80 pound. Increased yield of cross over the female parent: Grain, −8 per cent; stover, −9 per cent.

[2] Favoring the cross: Ears, 6 out of 10; stalks, 3 out of 10. Average weight of ears per stalk produced by the female parent, 0.57 pound; by the cross, 0.59 pound. Average weight of stover per stalk produced by female parent, 0.94 pound; by the cross, 0.96 pound. Increased yield of cross over the female parent: Grain, 4 per cent; stover, 3 per cent.

TABLE XVI.—*Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.*—Continued.

SANDERS PROLIFIC ♀ × RODGERS WHITE DENT ♂.[1]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	10	Ears	4.75	5.00	0.48	0.50	0.02	5	10	11
		Stalks	6.75	7.25	.68	.73	.05	7		
2	20	Ears	9.50	11.50	.48	.58	.10	21	21	23
		Stalks	14.50	18.00	.73	.90	.17	24		
3	15	Ears	7.50	10.25	.50	.68	.18	37	16	19
		Stalks	12.25	16.00	.82	1.07	.25	31		
4	18	Ears	9.75	10.50	.54	.58	.04	8	19	21
		Stalks	14.75	18.00	.82	1.00	.18	22		
5	4	Ears	2.50	2.25	.63	.56	−.07	−10	5	4
		Stalks	5.00	3.50	1.25	.88	−.37	−30		
6	20	Ears	10.00	12.50	.50	.63	.13	25	21	23
		Stalks	15.00	20.00	.75	1.00	.25	33		
7	15	Ears	8.25	8.25	.55	.55	.00	0	20	16
		Stalks	11.25	12.25	.75	.82	.07	9		
8	18	Ears	10.25	10.25	.57	.57	.00	0	21	21
		Stalks	15.00	14.75	.83	.82	−.01	−2		
9	21	Ears	9.50	10.75	.45	.51	.06	13	22	25
		Stalks	14.25	17.50	.68	.83	.15	23		
10	23	Ears	10.50	12.25	.46	.53	.07	17	24	23
		Stalks	16.00	19.25	.70	.84	.14	20		

STATION YELLOW ♀ × MARLBORO PROLIFIC ♂.[2]

Seed ear No.	Number of perfect hills.	Kind of product.	Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	19	Ears	9.25	13.75	0.49	0.72	0.23	49	20	31
		Stalks	15.50	20.50	.82	1.08	.26	32		
2	21	Ears	10.25	10.25	.49	.49	.00	0	23	23
		Stalks	17.00	16.00	.81	.76	−.05	−6		
3	15	Ears	8.50	7.75	.57	.52	−.05	−9	19	18
		Stalks	14.50	11.75	.97	.78	−.19	−19		
4	17	Ears	8.25	8.00	.49	.47	−.02	−3	18	23
		Stalks	13.00	12.50	.76	.74	−.02	−4		
5	19	Ears	8.75	10.50	.46	.55	.09	20	19	23
		Stalks	13.00	17.25	.68	.91	.23	33		
6	19	Ears	9.00	10.00	.47	.53	.06	11	20	21
		Stalks	14.50	15.00	.76	.79	.03	3		
7	12	Ears	5.50	6.00	.46	.50	.04	9	12	15
		Stalks	8.75	11.00	.73	.92	.19	26		
8	18	Ears	10.00	9.75	.56	.54	−.02	−3	18	18
		Stalks	15.25	15.00	.85	.83	−.02	−2		
9	15	Ears	7.50	10.75	.50	.72	.22	43	15	24
		Stalks	11.50	15.75	.77	1.05	.28	37		
10	19	Ears	10.00	10.50	.53	.55	.02	5	25	23
		Stalks	14.75	16.50	.78	.87	.09	12		

[1] Favoring the cross: Ears, 7 out of 10; stalks, 8 out of 10. Average weight of ears per stalk produced by the female parent, 0.50 pound; by the cross, 0.57 pound. Average weight of stover per stalk produced by female parent, 0.76 pound; by the cross, 0.89 pound. Increased yield of cross over the female parent: Grain, 13 per cent; stover, 17 per cent.

[2] Favoring the cross: Ears, 6 out of 10; stalks, 6 out of 10. Average weight of ears per stalk produced by the female parent, 0.50 pound; by the cross, 0.56 pound. Average weight of stover per stalk produced by female parent, 0.79 pound; by the cross, 0.87 pound. Increased yield of cross over the female parent: Grain, 12 per cent; stover, 10 per cent.

TABLE XVI.—*Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.*—Continued.

STATION YELLOW ♀ × RODGERS WHITE DENT ♂.[1]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	16	Ears	8.25	8.75	0.52	0.55	0.03	6	17	17
		Stalks	13.00	14.00	.81	.88	.07	8		
2	22	Ears	11.75	15.75	.53	.72	.19	34	24	24
		Stalks	20.00	26.50	.91	1.20	.29	33		
3	18	Ears	11.00	10.50	.61	.58	−.03	− 5	20	19
		Stalks	19.25	19.50	1.07	1.08	.01	1		
4	19	Ears	10.00	11.00	.53	.58	.05	10	23	19
		Stalks	16.50	18.25	.87	.96	.09	11		
5	22	Ears	9.50	13.25	.43	.60	.17	39	22	26
		Stalks	14.00	19.75	.64	.90	.26	41		
6	19	Ears	11.25	12.25	.59	.64	.05	9	26	21
		Stalks	19.00	19.50	1.00	1.03	.03	3		
7	16	Ears	8.75	8.75	.55	.55	.00	0	16	16
		Stalks	15.00	16.00	.94	1.00	.06	7		
8	21	Ears	11.75	13.50	.56	.64	.08	15	21	21
		Stalks	19.25	21.00	.92	1.00	.08	9		
9	20	Ears	8.50	10.75	.43	.54	.11	26	20	21
		Stalks	13.00	17.50	.65	.88	.23	35		
10	18	Ears	8.50	7.75	.47	.43	−.04	− 9	20	19
		Stalks	13.75	12.25	.76	.68	−.08	−11		

TINDAL ♀ × MARLBORO PROLIFIC ♂.[2]

Seed ear No.	Number of perfect hills.	Kind of product.	Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	22	Ears	11.75	12.00	0.53	0.55	0.02	2	30	34
		Stalks	17.50	18.75	.80	.85	.05	7		
2	19	Ears	9.50	9.50	.50	.50	.00	0	27	25
		Stalks	14.50	14.75	.76	.78	.02	2		
3	23	Ears	12.00	12.00	.52	.52	.00	0	33	32
		Stalks	18.00	18.75	.78	.82	.04	4		
4	21	Ears	11.00	12.25	.52	.58	.06	11	30	33
		Stalks	17.75	19.25	.85	.92	.07	8		
5	18	Ears	9.50	8.25	.53	.46	−.07	−13	26	23
		Stalks	16.25	13.50	.90	.75	−.15	−17		
6	15	Ears	7.50	7.50	.50	.50	.00	0	19	16
		Stalks	12.50	12.00	.83	.80	−.03	− 4		
7	24	Ears	15.00	11.25	.63	.47	−.16	−25	37	26
		Stalks	23.75	18.00	.99	.75	−.24	−24		
8	17	Ears	9.00	9.75	.53	.57	.04	8	21	21
		Stalks	14.00	15.00	.82	.88	.06	7		
9	18	Ears	9.00	8.75	.50	.49	−.01	− 3	19	19
		Stalks	13.50	13.50	.75	.75	.00	0		
10	24	Ears	12.00	12.25	.50	.51	.01	2	33	26
		Stalks	18.00	18.75	.75	.78	.03	4		

[1] Favoring the cross: Ears, 7 out of 10; stalks, 9 out of 10. Average weight of ears per stalk produced by the female parent, 0.52 pound; by the cross, 0.59 pound. Average weight of stover per stalk produced by female parent, 0.85 pound; by the cross, 0.96 pound. Increased yield of cross over the female parent: Grain, 13 per cent; stover, 13 per cent.

[2] Favoring the cross: Ears, 4 out of 10; stalks, 6 out of 10. Average weight of ears per stalk produced by the female parent, 0.53 pound; by the cross, 0.51 pound. Average weight of stover per stalk produced by female parent, 0.82 pound; by the cross, 0.81 pound. Increased yield of cross over the female parent: Grain, −3 per cent; stover, −2 per cent.

TABLE XVI.—*Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.*—Continued.

TINDAL ♀ × RODGERS WHITE DENT ♂.[1]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	12	Ears	6.00	5.75	0.50	0.48	−0.02	− 4	18	14
		Stalks	9.25	9.25	.77	.77	.00	0		
2	20	Ears	9.50	10.75	.48	.54	.06	13	26	22
		Stalks	15.75	17.25	.79	.86	.07	10		
3	24	Ears	10.25	12.25	.43	.51	.08	20	29	28
		Stalks	15.00	19.50	.63	.81	.18	30		
4	20	Ears	9.75	10.50	.49	.53	.04	8	26	22
		Stalks	15.25	16.00	.76	.80	.04	5		
5	16	Ears	7.50	8.00	.47	.50	.03	7	17	18
		Stalks	11.75	12.25	.73	.77	.04	4		
6	23	Ears	11.50	14.00	.50	.61	.11	22	27	32
		Stalks	18.75	21.00	.82	.91	.09	12		
7	16	Ears	9.25	8.00	.58	.50	− .08	−14	22	16
		Stalks	14.00	13.00	.88	.81	− .07	− 7		
8	13	Ears	7.00	7.50	.54	.58	.04	7	14	13
		Stalks	10.50	11.25	.81	.87	.06	7		
9	13	Ears	6.50	7.75	.50	.60	.10	19	15	14
		Stalks	10.25	10.50	.79	.81	.02	2		
10	18	Ears	10.00	9.25	.56	.51	− .05	− 8	25	22
		Stalks	14.25	14.75	.79	.82	.03	4		

WHELCHEL ♀ × MARLBORO PROLIFIC ♂.[2]

Seed ear No.	Number of perfect hills.	Kind of product.	Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	9	Ears	4.25	5.25	0.47	0.58	0.11	24	9	9
		Stalks	8.00	9.50	.89	1.06	.17	19		
2	8	Ears	5.00	4.00	.63	.50	−.13	−20	9	10
		Stalks	8.75	8.25	1.09	1.03	−.06	− 6		
3	7	Ears	4.75	4.25	.68	.61	−.07	−10	8	7
		Stalks	8.25	7.50	1.18	1.07	−.11	− 9		
4	24	Ears	15.75	15.75	.66	.66	.00	0	26	29
		Stalks	26.75	27.75	1.11	1.16	.05	4		
5	17	Ears	9.75	10.75	.57	.63	.06	10	17	17
		Stalks	16.00	19.00	.94	1.12	.18	19		
6	20	Ears	12.50	14.75	.63	.74	.11	18	21	26
		Stalks	25.00	25.50	1.25	1.28	.03	2		
7	12	Ears	9.00	7.75	.75	.65	−.10	−14	12	12
		Stalks	16.00	13.00	1.33	1.08	−.25	−19		
8	6	Ears	4.50	5.00	.75	.83	.08	11	7	9
		Stalks	8.00	7.75	1.33	1.29	−.04	− 3		
9	18	Ears	11.75	14.00	.65	.78	.13	19	19	23
		Stalks	20.75	23.75	1.15	1.32	.17	14		
10	22	Ears	15.50	16.50	.70	.75	.05	6	22	29
		Stalks	27.50	27.50	1.25	1.25	.00	0		

[1] Favoring the cross: Ears, 7 out of 10; stalks, 8 out of 10. Average weight of ears per stalk produced by the female parent, 0.50 pound; by the cross, 0.54 pound. Average weight of stover per stalk produced by female parent, 0.77 pound; by the cross, 0.83 pound. Increased yield of cross over the female parent: Grain, 7 per cent; stover, 7 per cent.

[2] Favoring the cross: Ears, 6 out of 10; stalks, 5 out of 10. Average weight of ears per stalk produced by the female parent, 0.65 pound; by the cross, 0.69 pound. Average weight of stover per stalk produced by female parent, 1.15 pounds; by the cross, 1.19 pounds. Increased yield of cross over the female parent: Grain, 6 per cent; stover, 3 per cent.

TABLE XVI.—*Yield record of 11 varieties of corn and their crossed progeny tested at Statesboro, Ga.*—Continued.

WILLIAMSON ♀ × MARLBORO PROLIFIC ♂.[1]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	11	Ears	4.50	5.00	0.41	0.45	0.04	11	11	11
		Stalks	7.00	8.50	.64	.77	.13	21		
2	14	Ears	6.50	9.00	.46	.64	.18	38	16	18
		Stalks	11.75	13.75	.84	.98	.14	17		
3	13	Ears	7.25	7.00	.56	.54	−.02	−3	13	15
		Stalks	11.75	11.50	.90	.88	−.02	−2		
4	13	Ears	6.25	6.50	.48	.50	.02	4	14	15
		Stalks	10.25	9.75	.79	.75	−.04	−5		
5	17	Ears	6.50	10.00	.38	.59	.21	54	17	19
		Stalks	10.50	17.25	.62	1.01	.39	64		
6	17	Ears	8.50	8.50	.50	.50	.00	0	18	17
		Stalks	13.00	13.00	.76	.76	.00	0		

WILLIAMSON ♀ × RODGERS WHITE DENT ♂.[2]

Seed ear No.	Number of perfect hills.	Kind of product.	Weight of product (pounds). Total. Original.	Total. Cross.	Per stalk. Original.	Per stalk. Cross.	Per stalk. Difference.	Per cent of difference.	Number of ears produced. Original.	Number of ears produced. Cross.
1	18	Ears	8.50	9.50	0.47	0.53	0.06	12	19	21
		Stalks	15.50	17.50	.86	.97	.11	13		
2	22	Ears	10.75	14.75	.49	.67	.18	37	22	28
		Stalks	18.50	25.75	.84	1.17	.33	39		
3	18	Ears	10.50	11.00	.58	.61	.03	5	19	20
		Stalks	16.75	17.50	.93	.97	.04	4		
4	23	Ears	11.50	14.50	.50	.63	.13	26	26	22
		Stalks	20.25	26.00	.88	1.13	.25	28		
5	14	Ears	6.75	7.50	.48	.54	.06	11	14	15
		Stalks	11.25	12.50	.80	.89	.09	11		
6	16	Ears	7.00	9.00	.44	.56	.12	29	16	16
		Stalks	11.75	15.50	.73	.97	.24	32		
7	6	Ears	3.75	3.25	.63	.54	−.09	−13	7	6
		Stalks	6.75	5.50	1.13	.92	−.21	−19		
8	8	Ears	4.25	5.00	.53	.63	.10	18	9	8
		Stalks	6.75	8.25	.84	1.03	.19	22		
9	15	Ears	7.75	8.00	.52	.53	.01	3	16	15
		Stalks	13.00	13.00	.87	.87	.00	0		
10	15	Ears	7.50	6.75	.50	.45	−.05	10	15	15
		Stalks	12.00	12.00	.80	.80	.00	0		

[1] Favoring the cross: Ears, 4 out of 6; stalks, 3 out of 6. Average weight of ears per stalk produced by the female parent, 0.46 pound; by the cross, 0.54 pound. Average weight of stover per stalk produced by female parent, 0.76 pound; by the cross, 0.87 pound. Increased yield of cross over the female parent: Grain, 16 per cent; stover, 14 per cent.

[2] Favoring the cross: Ears, 8 out of 10; stalks, 7 out of 10. Average weight of ears per stalk produced by the female parent, 0.50 pound; by the cross, 0.58 pound. Average weight of stover per stalk produced by female parent, 0.85 pound; by the cross, 0.99 pound. Increased yield of cross over the female parent: Grain, 14 per cent; stover, 16 per cent.

In Table XVII a comparison of the effect of crossing is made between the varieties as a whole, when crossed by Marlboro Prolific and when crossed by Rodgers White Dent. The percentage of increase or decrease in yield of the cross is given, and also the number of rows out of 10 in which the production of the crossed ears was greater than that of the original 2-year-old seed of the female parent grown in the same hills with the cross.

TABLE XVII.—*Summary of the 10 ears of each variety tested with their crossed progeny.*

Female variety.	Marlboro Prolific sire.				Rodgers White Dent sire.			
	Increase of cross over 1908 seed of female parent.		Rows favoring the cross.		Increase of cross over 1908 seed of female parent.		Rows favoring the cross.	
	Ears.	Stalks.	Ears.	Stalks.	Ears.	Stalks.	Ears.	Stalks.
	Per cent.	*Per cent.*			*Per cent.*	*Per cent.*		
Aldrich Perfection	12	−6	6	5	10	15	7	9
Cocke Prolific	8	2	7	4	2	−2	7	5
Marlboro Prolific	3	2	6	5	7	8	7	8
Mosby Prolific	13	6	10	6	28	19	10	10
Native of Statesboro	6	6	6	7	7	5	6	4
Rodgers White Dent	10	12	7	10	−8	−9	3	3
Sanders Prolific	4	3	6	3	13	17	7	8
Station Yellow	12	10	6	6	13	13	7	9
Tindal	−3	−2	4	6	7	7	7	8
Williamson	16	14	[1] 4	[1] 3	14	16	8	7
General results	7	4	6.9	6.1	9	9	6.9	7

[1] Only six rows considered.

Table XVII shows that when crossed with Marlboro Prolific all but one variety (Tindal) gave a gain in ears, and all but two varieties gave a gain in stover. When crossed with Rodgers White Dent all varieties except the sire variety itself gave a gain in ears, and only two gave a loss in stover.

SOME CROSSES SUPERIOR TO EITHER PARENT.

Since the yields of the crosses are compared only with the female parent, it might be concluded that this general higher yield of the crosses is probably due to the still greater productiveness of the male parent. This conclusion, however, is not supported in the cases where Marlboro Prolific and Rodgers White Dent serve as females in the experiment. In both instances the resulting cross produced better than its female parent and since Rodgers White Dent is more productive than Marlboro Prolific, as shown in Table XVII, the cross in which Rodgers White Dent served as female must be considered more productive than either parent.

In Table XVIII is shown the average ranking of the varieties according to their productiveness in 1910 in the test plats at Statesboro, Ga., where each variety was grown in the same hills with its crossed progeny.

TABLE XVIII.—*Arrangement of varieties of corn in the order of their productiveness, as indicated by the average yield per stalk when grown in hills with their crosses.*

Name of variety.	Ears per stalk.	Average rank.	Name of variety.	Ears per stalk.	Average rank.
	Pounds.			*Pounds.*	
Sanders Prolific	0.535	1	Native of Statesboro	0.51	4*b*
Aldrich Perfection	.53	2*a*	Station Yellow	.51	4*c*
Rodgers White Dent	.53	2*b*	Cocke Prolific	.49	5
Tindal	.515	3	Williamson	.48	6
Marlboro Prolific	.51	4*a*	Mosby Prolific	.465	7

It will be seen that seven varieties equal or excel Marlboro Prolific. When these seven varieties are crossed with Marlboro Prolific as sire six out of the seven first-generation crosses exceed the Marlboro Prolific in grain production, and five in stover production.

It will also be seen that two varieties equal or excel Rodgers White Dent. When these two varieties are crossed with Rodgers White Dent as sire both of the first-generation crosses exceed the Rodgers White Dent in grain and stover production. It will thus be seen that out of the 20 crosses made 8 have given grain yields greater than the better parent, and 7 have given stover yields greater than the better parent.

RELATION OF THE PRODUCTIVITY OF THE CROSSES TO THE PRODUCTIVITY OF THE PURE STRAINS.

It is a striking point in connection with the foregoing table that all those female varieties giving more productive crosses than either parent are grouped at one end—the upper end—of the ranking list for production and with but one break in the rank. None fall below fourth in production in a total ranking of seven. With one exception the varieties that can not be said to have given advantageous crosses with either sire are grouped at the other or lower end of the ranking list.

Omitting Marlboro Prolific and Rodgers White Dent, nine other varieties are crossed by each of these sires. In six out of the nine comparisons the crosses with Rodgers White Dent are more productive than those with Marlboro Prolific.

In view of these points and the fact that Rodgers White Dent is more productive than Marlboro Prolific it is found that the productiveness of both parents seems to stand out clearly as a factor in influencing high yield in first-generation crosses.

The Tindal variety, however, is a striking exception to this seeming tendency. The rank of this variety is third in productiveness, but when crossed by Marlboro Prolific its yield was actually less than its poorest producing parent; and when crossed by Rodgers White Dent the cross was less productive than that sire.

Because of this exception, this apparent tendency can not be relied upon as a guide in the selection of suitable varieties for practical crossing.

ADAPTATION AS A FACTOR IN THE PRODUCTION OF HIGHER YIELDS THROUGH CROSSING.

As the difference between the lowest and the highest producers is less than 5 bushels per acre, it would seem that it might be questionable to dicuss this subject with the data at hand. In justice to the subject, however, it should be stated that the appearance of the corn produced indicated more variability in adaptation than do the weights.

It is interesting to note in this connection that the variety Mosby Prolific is farthest from home, that it has been carried to a more radically different soil than any of the other varieties, and that it is ranked lowest in yield and failed to give a practical cross. Cocke Prolific is the next farthest from home, ranks third from the bottom of the list, and was impractical for crossing with either Marlboro Prolific or Rodgers White Dent. The Williamson corn ranks next to Mosby Prolific; as it had been given considerable selection at home for years, it is reasonable to suppose that its low yield is due to poor adaptation.

It is thus seen that three out of the four varieties that were impractical as crosses with either of the two sires were also poorly adapted to the conditions at Statesboro. The Tindal variety again stands out as an exception.

INFLUENCE OF SEASONAL DIFFERENCES.

In 1909, while the crosses for this test were being grown, a careful comparison of the varieties was made. The season was different from that of 1910, and the effect is clearly shown by the ranking obtained at that time.

The ranking for 1909 was:

First	Tindal.	Sixth	Williamson.
Second	Station Yellow.	Seventh	Mosby Prolific.
Third	Native of Statesboro.	Eighth	Aldrich Perfection.
Fourth	Rodgers White Dent.	Ninth	Cocke Prolific.
Fifth	Marlboro Prolific.	Tenth	Sanders Prolific.

Apparently the difference between the two seasons has resulted in changing Sanders Prolific from last to first in rank and Aldrich Perfection from eighth to second. The first year less difference in production was shown between the two sire varieties than was shown the second year. In 1909 Mosby Prolific (poorest in 1910) ranked better than Aldrich Perfection (second in 1910). Tindal ranked high both years.

The differences shown by the two tests are radical, but hardly more than is frequently found in variety tests of more than one year.

If, as has been previously indicated, there is usually a relation between high yield and adaptation and the advantageous crossing of corn, then it would seem that seasonal differences may play an important part.

INFERENCES DRAWN FROM THE FOREGOING DATA.

From these tests it would seem that the productivity of first-generation crosses is usually correlated to the productivity of the parent varieties, and the yield of the parent varieties is largely dependent upon their adaptation to the location and the season during which the test is made.

As seasonal differences have a marked effect upon the comparative production of varieties the success of a cross one season may be found fleeting if continued.

The fact that the variety Tindal in its adverse performance toward crossing has rather emphatically ignored all the influences of rank and adaptation that seem to govern other varieties may indicate that advantageous exceptions may also be found; but whatever further investigation may demonstrate, present knowledge indicates that the economic increasing of corn yields by means of crossing is attended with many complexities.

GENERAL CONSIDERATION OF ALL THE TESTS.

INDICATIONS OF INTERMEDIACY.

As the varieties crossbred at the various points are varieties that have met with general favor as grain producers, the characters of the male and female parents of each cross are not radically different, and consequently any intermediacy of a cross is not as apparent as it might be if the parents were much unlike. However, in many instances intermediacy between the two parents was observed regarding various characters; such as productiveness, height of stalk, length of growing season, and percentage of moisture.

Averages of many crosses usually indicate intermediacy, because exceptions in one direction from the median points are offset by exceptions in the other direction, but under the conditions of these and other tests of this nature so few instances have been shown in which the first-generation crosses produced less than the average of the two parents as to indicate that the average productiveness of first-generation corn crosses is usually above the average of the parents. It may be that this indication will not be found entirely due to advantages regarding adaptation, age of seed, self-fertilization, etc., that most of the reported tests [1] have given to the first-generation

[1] Beal, W. J. Reports, Michigan Board of Agriculture, 1876, 1877, 1881, and 1882.

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crosses, and that further work with all conditions more nearly equalized will demonstrate a general tendency for first-generation crosses to produce better than the average of the parents. Such a general tendency might be due to prepotency of the higher yielding parent. It is more profitable to grow the higher yielding parent except in cases in which the first-generation cross produces better than either parent. Since some first-generation crosses are more productive and some are less productive than their better parent, the greatest benefit can be obtained by planting such as may be found more productive than the highest yielding variety of a community.

PERCENTAGE OF MOISTURE IN SHELLED GRAIN OF CROSSES AND PARENT VARIETIES.

Because of care in allowing the ears of all varieties to dry thoroughly before yields were weighed it has not been necessary to calculate corrections for moisture content except in the Maryland tests. The moisture content of shelled grain from a large number of ears of each variety at each point was determined by the Office of Grain Standardization of the Bureau of Plant Industry. Regarding this character, averages as given in Table XIX show the first-generation crosses to be intermediate between the parents.

TABLE XIX.—*Average percentage of moisture in shelled grain of crosses and parent varieties on dates when yields were weighed.*

Tests.	Female parents.	Male parents.	Average of both parents.	First-generation crosses.
Maryland	27.29	28.77	28.03	28.32
California	10.22	11.74	10.98	10.90
Texas	12.39	11.45	11.92	12.13
Georgia	15.40	15.01	15.21	15.00
General average	16.33	16.74	16.54	16.59

UNRELIABILITY OF AVERAGES FOR SPECIFIC INSTANCES.

With investigations of this nature the investigators as well as the readers are desirous that the work should discover some law of nature. However, the development and evolution of plants furnish so many exceptions and variations to even general laws that it is impossible to foretell the effects of crossbreeding particular varieties by the effects secured previously from crossbreeding other varieties. Types, varieties, strains, ears, and even kernels of corn contain in their lineage such complexity of structure and characters that it is not surprising that this work, necessarily of a preliminary nature, should unfold more problems than it solves.

The results are interesting because they contain evidence in support of various theories, but the chief value of the work is its indication of what can be accomplished in the field of research and more especially in establishing methods of producing high-yielding seed corn.

The influences that show with the greatest uniformity in these tests are those of acclimatization and adaptation. The results given here of these influences will be combined in a future publication with results obtained in other localities showing the effects on maize of acclimatization and adaptation. In studying the effects attributable to crossbreeding it is necessary to recognize the effects due both to acclimatization and to adaptation. The distinction between the effects of acclimatization and of adaptation is brought out in the tests of identically the same lots of seed in Maryland and in California. In Maryland, because of their acclimatization and adaptation some varieties produced much better than others of the same growing period which were brought from distant States. None of these varieties were acclimated to California conditions, though some of the earliest maturing, which were least productive in Maryland, were most productive in California. Their early maturity proved an adaptation which enabled them to escape the later and drier part of the summer. In Texas, varieties that have been subjected for years to practically the same climatic conditions indicate different degrees of adaptation to clay soils and to sandy soils.

Tests of this nature thus far reported indicate that first-generation crosses usually produce better than the average of the two parents. It is not certain that this is entirely due to the advantages that these tests have given to the crosses regarding age and vitality of seed, or to the year of adaptation and selection incident to growing the crossbred seed under the same environment in which the test of productiveness was afterwards made, but to which the parent varieties were not adapted. If further tests should show that with all conditions equalized there still exists a tendency for first-generation crosses to produce better than the average of the two parents, it might be taken as an indication that the higher yielding parent is usually prepotent.

A production better than the average of the two parents, unless it be better than the production of either parent, would furnish no practical method of originating strains superior to those already existing, except in cases in which the crossing might originate strains that combine or nick better than previously existing strains. When all influencing factors, such as age and maturity of seed, acclimatization, and adaptation are equal, and the first-generation cross is more productive than either parent, it is a clear instance in which a practical advantage is derived by crossbreeding.

Variations found to apply to varieties are also found to apply to different ears within a variety when they are crossbred and tested separately—in other words, some ears are crossed with another variety advantageously and some disadvantageously, though in general there is a tendency for the different ears of a variety to respond similarly to the crossing. Another line of work being conducted by the Office of Corn Investigations indicates that what has just been said about the crossing of one variety with another also applies to the crossbreeding of individual plants within a variety. Just as certain pairs of varieties combine or nick advantageously, while other pairs nick disadvantageously, so some pairs of individual plants nick advantageously, while other pairs nick disadvantageously. This shows the results obtained by crossing two varieties without reference to individual plants to be but an average of the results that would be obtained by crossing many individual plants of those varieties. The average results may be an improvement over either parent and still fall short of what could be obtained by restricting the crossing to the individuals that nick most advantageously.

In connection with this consideration of crossbreeding, it is interesting to note that such varieties as Selection 119, Selection 160, and Chisholm, which are among the most profitable varieties for their respective localities, have not been crossbred or mixed with other varieties for many years. The same can be said of leading strains of corn of other localities, and their merits are doubtless largely due to effects of selection, acclimatization, and adaptation.

The results of these tests show that with corn some first-generation crosses are more productive than either parent, that some are intermediate between the two parents in productiveness, and that some are less productive than either parent. They also show that the determination of the particular first-generation crosses that can be most profitably grown is attended with so many complexities that careful tests must be made in a locality before the farmers of that locality can be intelligently advised whether it is to their interest to continue planting a pure-bred strain, or to plant a first-generation cross of certain strains.

In crossbreeding corn for practical results it seems the duty of State experiment stations and of corn breeders to determine what two varieties nick to best advantage in producing seed for different environments. Whether the yearly production of a particular first-generation cross will be found advisable, or whether its use in making other crosses will be found more profitable, must be established by further work, and perhaps for each individual case. Progress in producing higher yielding strains of corn depends upon the proper combination and application of the effects of acclimatization, adaptation, crossbreeding, and selection.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 219.

B. T. GALLOWAY, *Chief of Bureau.*

AMERICAN MEDICINAL LEAVES AND HERBS.

BY

ALICE HENKEL,

Assistant, Drug-Plant Investigations.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., April 15, 1911.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 219 of the series of this Bureau the accompanying manuscript, entitled "American Medicinal Leaves and Herbs." This paper was prepared by Miss Alice Henkel, Assistant in Drug-Plant Investigations, and has been submitted by the Physiologist in charge with a view to its publication.

Thirty-six plants furnishing leaves and herbs for medicinal use are fully described, and in some instances brief descriptions of related species are included therewith. Of the above number, 15 are official in the United States Pharmacopœia.

This bulletin forms the third installment on the subject of American medicinal plants and has been prepared to meet the steady demand for information of this character. It is intended as a guide and reference book for those who may be interested in the study or collection of the medicinal plants of this country. The first bulletin of this series treats of American root drugs, and the second of American medicinal barks.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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AMERICAN MEDICINAL LEAVES AND HERBS.

INTRODUCTION.

Less difficulty will be encountered in the collection of leaves and herbs than in the case of other portions of plants, for not only is recognition easier, since, especially in the matter of herbs, these parts are usually gathered at a time when the plants are in flower, but the labor is less arduous, for there are no roots to dig or barks to peel.

Of the three dozen medicinal plants mentioned in this bulletin, 15 are recognized as official in the Eighth Decennial Revision of the United States Pharmacopœia. This is more than half of all the leaves and herbs included in the Pharmacopœia.

Among the plants included in this bulletin are peppermint and spearmint, which are found not only in the wild state but the cultivation of which for the distillation of the oil constitutes an important American industry. Especially is this true of peppermint, thousands of acres being devoted to the cultivation of this plant, principally in the States of Michigan and New York. A number of other plants mentioned in this paper furnish useful oils, such as oil of wintergreen, pennyroyal, fleabane, tansy, wormwood, and fireweed.

As in the case of other bulletins of this series, an effort has been made to include in it only such plants as seem most in demand, lack of space forbidding a consideration of others which are or have been used to a more limited extent. With two or three exceptions the illustrations have been reproduced from photographs taken from nature by Mr. C. L. Lochman.

COLLECTION OF LEAVES AND HERBS.

Leaves are usually collected when they have attained full development and may be obtained by cutting off the entire plant and stripping the leaves from the stem, using a scythe to mow the plants where they occur in sufficient abundance to warrant this, or the leaves may be picked from the plants as they grow in the field. Whenever the plants are cut down in quantity they must be carefully looked over afterwards for the purpose of sorting out such other plants as may have been accidentally cut with them. Stems should be discarded as much as possible, and where a leaf is composed of several leaflets these are usually detached from the stems.

In gathering herbs only the flowering tops and leaves and the more tender stems should be taken, the coarse and large stems being rejected. All withered, diseased, or discolored portions should be removed from both leaves and herbs.

In order that they may retain their bright-green color and characteristic odor after drying, leaves and herbs must be carefully dried in the shade, allowing the air to circulate freely but keeping out all moisture; dampness will darken them, and they must therefore be placed under cover at night or in rainy weather. A bright color is desirable, as such a product will sell more readily.

To dry them the leaves and herbs should be spread out thinly on clean racks or shelves and turned frequently until thoroughly dry. They readily absorb moisture and when perfectly cured should be stored in a dry place.

Leaves and herbs generally become very brittle when they are dry and must be very carefully packed to cause as little crushing as possible. They should be firmly packed in sound burlap or gunny sacks or in dry, clean boxes or barrels. Before shipping the goods, however, good-sized representative samples of the leaves and herbs to be disposed of should be sent to drug dealers for their inspection, together with a letter stating how large a quantity the collector has to sell.

With the changes in prices that are constantly taking place in the drug market it is, of course, impossible to give definite prices in this paper, and only approximate quotations are therefore included in order that the collector may form some idea concerning the possible range of prices. Only through correspondence with drug dealers can the actual price then prevailing be ascertained.

PLANTS FURNISHING MEDICINAL LEAVES AND HERBS.

Each section contains synonyms, the pharmacopœial name (if any), the common names, habitat, range, descriptions, and information concerning the collection, prices, and uses of the plants.

The medicinal uses are referred to in a general way only, since it is not within the province of a publication of this kind to give detailed information in regard to such matters. Advice concerning the proper remedies to use should be sought only from physicians. The statements made in this paper as to medicinal uses are based on information contained in various dispensatories and other works relating to materia medica.

SWEET FERN.

Comptonia peregrina (L.) Coulter.

Synonyms.—*Comptonia asplenifolia* Gaertn.; *Myrica asplenifolia* L.; *Liquidambar asplenifolia* L.; *Liquidambar peregrina* L.

Other common names.—Fern gale, fern bush, meadow fern, shrubby fern, Canada sweet gale, spleenwort bush, sweet bush, sweet ferry.

Habitat and range.—Sweet fern is usually found on hillsides, in dry soil, in Canada and the northeastern United States. It is indigenous.

Description.—The fragrant odor and the resemblance of the leaves of this plant to those of a fern have given rise to the common name "sweet fern." It is a shrub with reddish-brown bark, growing from about 1 to 3 feet in height, with slender, erect or spreading branches, the leaves hairy when young. The thin narrow leaves are borne on short stalks and are linear oblong or linear lance shaped, about 3 to 6 inches long and from one-fourth to half an inch wide, deeply divided into many lobes, the margins of which are generally entire or sparingly toothed. The catkins expand with the leaves. (Fig. 1.)

FIG. 1.—Sweet fern (*Comptonia peregrina*), leaves, male and female catkins.

The staminate or male flowers are produced in cylindrical catkins in clusters at the ends of the branches and are about an inch in length, the kidney-shaped scales overlapping. The pistillate or female flowers are borne in egg-shaped or roundish-oval catkins, the eight awl-shaped bractlets persisting and surrounding the one-seeded, shining, light-brown nut, giving it a burlike appearance. The whole plant has a spicy, aromatic odor, which is more pronounced when the leaves are bruised. Sweet fern belongs to the bayberry family (Myricaceæ).

Collection, prices, and uses.—The entire plant is used, but especially the leaves and tops. It has a fragrant, spicy odor and an aromatic, slightly bitter, and astringent taste.

The present price of sweet fern is about 3 to 5 cents a pound.

It is used for its tonic and astringent properties, principally in a domestic way, as a remedy in diarrheal complaints.

LIVERLEAF.

(1) *Hepatica hepatica* (L.) Karst.; (2) *Hepatica acuta* (Pursh) Britton.

Synonyms. (1) *Hepatica triloba* Chaix.; *Anemone hepatica* L. (2) *Hepatica triloba* var. *acuta* Pursh; *Hepatica acutiloba* DC.

Other common names.—(1) Round-leaved hepatica, common liverleaf, kidney liverleaf, liverwort (incorrect), noble liverwort, heart liverwort, three-leaved liverwort, liverweed, herb-trinity, golden trefoil, ivy flower, mouse-ears, squirrel cup; (2) heart liverleaf, acute-lobed liverleaf, sharp-lobed liverleaf, sharp-lobed hepatica.

Habitat and range.—The common liverleaf is found in woods from Nova Scotia to northern Florida and west to Iowa and Missouri, while the heart liverleaf occurs from Quebec to Ontario, south to Georgia (but rare near the coast), and west to Iowa and Minnesota.

FIG. 2.—Liverleaf (*Hepatica hepatica*), flowering plant.

Description.—The hepaticas are among the earliest of our spring flowers, blossoming about March, and frequently before that time. They grow only about 4 to 6 inches in height, with leaves produced from the roots on long soft-hairy stalks and spreading on the ground. The thick and leathery evergreen leaves are kidney shaped or roundish and deeply divided into three oval, blunt lobes; the young leaves are pale green and soft hairy, but the older ones become leathery and smooth, expanding when mature to almost 3 inches across; they are dark green above, sometimes with a purplish tinge, and also of a purplish color on the under surface. The flowers, which are about one-half inch in diameter, are borne singly on slender, hairy stalks arising from the root, and vary in color from bluish to purple or white. Immediately beneath the flower are three small, stemless, oval, and blunt leaflets or bracts, which are thickly covered with soft, silky hairs. (Fig. 2.)

The heart liverleaf is very similar to the common liverleaf. It grows perhaps a trifle taller and the lobes of the leaf and the small leaflets or bracts immediately under the flower are more sharply pointed.

The hepaticas are members of the crowfoot family (Ranunculaceæ) and are perennials. The name "liverwort," often given to these plants, is incorrect, since it belongs to an entirely different genus.

Collection, prices, and uses.—The leaves, which were official in the United States Pharmacopœia from 1830 to 1880, are the parts employed; they should be collected in April. They lose about three-fourths of their weight in drying. The price at present paid for them is about 4 to 5 cents a pound.

Liverleaf is employed for its tonic properties and is said to be useful in affections of the liver.

CELANDINE.

Chelidonium majus L.

Other common names.—Chelidonium, garden celandine, greater celandine, tetterwort, killwart, wart flower, wartweed, wartwort, felonwort, cockfoot, devil's-milk, Jacob's ladder, swallowwort, wretweed.

Habitat and range.—Celandine, naturalized from Europe, is found in rich damp soil along fences and roadsides near towns from Maine to Ontario and southward. It is common from southern Maine to Pennsylvania.

Description.—This plant, which has rather weak, brittle stems arising from a reddish-brown, branching root, is a biennial belonging to the poppy family (Papaveraceæ) and, like other members of this family, contains an acrid juice, which in this species is colored yellow. It is an erect, branched, sparingly hairy herb, from about 1 to 2 feet in height, with thin leaves 4 to 8 inches in length. The leaves, which are lyre shaped in outline, are deeply and variously cleft, the lobes thus formed being oval, blunt, and wavy or round toothed, or rather deeply cut. They have a grayish-green appearance, especially on the lower surface. The small, 4-petaled, sulphur-yellow flowers of the celandine are produced from about April to September, followed by smooth, long, pod-shaped capsules crowned with the persistent style and stigma and containing numerous seeds. (Fig. 3.)

FIG. 3.—Celandine (*Chelidonium majus*), leaves, flowers, and seed pods.

Collection, prices, and uses.—The entire plant, which was official in the United States Pharmacopœia for 1890, is used. It should be collected when the herb is in flower. At present it brings about 6 or 8 cents a pound.

The fresh plant has an unpleasant, acrid odor when bruised, but in the dried state it is odorless. It has a persistent acrid and somewhat salty taste.

Celandine is an old remedy. It has cathartic and diuretic properties, promotes perspiration, and has been used as an expectorant. The juice has been employed externally for warts, corns, and some forms of skin diseases.

WITCH-HAZEL.

Hamamelis virginiana L.

Pharmacopœial name.—Hamamelidis folia.

Other common names.—Snapping hazel, winterbloom, wych-hazel, striped alder, spotted alder, tobacco wood.

Habitat and range.—The home of this native shrub is in low damp woods from New Brunswick to Minnesota and south to Florida and Texas.

Description.—This shrub, while it may grow to 25 feet in height, is more frequently found reaching a height of only 8 to 15 feet, its crooked stem and long forking branches covered with smoothish brown bark, sometimes with an addition of lichens. A peculiar feature about witch-hazel is its flowering in very late fall or even early winter, when its branches are destitute of leaves, the seed forming but not ripening until the following season.

FIG. 4.—Witch-hazel (*Hamamelis virginiana*), leaves, flowers, and capsules.

The leaves are rather large, 3 to 5 inches long, thick, and borne on short stalks; they are broadly oval or heart-shaped oval, sometimes pointed and sometimes blunt at the apex, with uneven sides at the base, and wavy margins. The older leaves are smooth, but when young they are covered with downy hairs. The upper surface of the leaves is a light-green or brownish-green color, while the lower surface is pale green and somewhat shining, with prominent veins. The threadlike bright-yellow flowers, which appear very late in autumn, are rather odd looking and consist of a 4-parted corolla with four long, narrow, strap-shaped petals, which are twisted in various ways when in full flower. The seed capsule does not mature until the following season, when the beaked and densely hairy seed case bursts open elastically, scattering with great force and to a considerable distance the large, shining-black, hard seeds. (Fig. 4.) This interesting shrub is a member of the witch-hazel family (Hamamelidaceæ).

Collection, prices, and uses.—Witch-hazel leaves are official in the United States Pharmacopœia. They should be collected in autumn and carefully dried. Formerly the leaves alone were recognized in the United States Pharmacopœia, but now the bark and twigs are also official. The leaves have a faint odor and an astringent, somewhat bitter, and aromatic taste. They bring about 2 to 3 cents a pound.

The soothing properties of witch-hazel were known among the Indians, and it is still employed for the relief of inflammatory conditions.

AMERICAN SENNA.

Cassia marilandica L.

Synonym.—*Senna marilandica* Link.

Other common names.—Wild senna, locust plant.

Habitat and range.—American senna generally frequents wet or swampy soils from New England to North Carolina and westward to Louisiana and Nebraska.

Description.—This is a native species, a member of the senna family (Cæsalpiniaceæ), which is closely related to the pea family. It is a perennial herb, its round grooved stems reaching about 4 to 6 feet in height. The leaves, which are borne on long, somewhat bristly hairy stalks, are 6 to 8 inches long and consist of from 12 to 20 leaflets placed opposite to each other on the stem. Each leaflet is oblong or lance-shaped oblong, blunt at the top but terminating with a short, stiff point, rounded at the base and from 1 to 1½ inches long, the stalks supporting them being rather short; the upper surface is of a pale-green color, while underneath it is still lighter in color and covered with a bloom. On the upper surface of the leaf stem, near its base, is a prominent club-shaped gland, borne on a stalk.

Fig. 5.—American senna (*Cassia marilandica*), leaves, flowers, and seed pods.

The numerous yellow flowers are borne on slender, hairy stems, produced in clusters in the axils of the leaves at the top of the plant and appearing from about August to September. The pods are about 3 inches in length, linear, somewhat curved and drooping, slightly hairy at first, flat, and narrowed on the sides between the seeds. They contain numerous small, flat, dark-brown seeds. (Fig. 5.)

Collection, prices, and uses.—The leaves, or rather the leaflets, are the parts employed and should be gathered at flowering time, which usually occurs during July and August. They were official in the United States Pharmacopœia from 1820 to 1880. American senna leaves have a very slight odor and a rather disagreeable taste, somewhat like that of the foreign senna. It is used for purposes similar to the well-known senna of commerce imported from abroad, having, like that, cathartic properties.

The price at present paid for American senna is about 6 to 8 cents a pound.

EVENING PRIMROSE.

Oenothera biennis L.

Synonyms.—*Onagra biennis* (L.) Scop.; *Oenothera muricata* L.

Other common names.—Common evening primrose, wild evening primrose, field evening primrose, tree primrose, fever plant, night willow-herb, king's cure-all,[1] large rampion, scurvish, scabish.

Habitat and range.—This is a widely distributed herb, its range extending from Labrador south to Florida and west to the Rocky Mountains. It usually frequents fields and waste places, occurring in dry soil.

FIG. 6.—Evening primrose (*Oenothera biennis*), leaves, flowers, and capsules.

Description.—The evening primrose is a coarse annual or biennial weed, which has the peculiarity that its flowers do not open until evening, remaining open all night and closing the next morning, but not expanding again. It is generally stout and erect in growth, from 1 foot to about 5 feet in height, simple or branched, usually hairy and leafy. The leaves are 1 to 6 inches in length, lance shaped and sharp pointed at the top, with wavy toothed margins narrowing toward the base. With the exception of some of the leaves near the base, most of them are stemless. The spikes of fragrant sulphur-yellow flowers are produced from about June to October and, as already stated and as indicated by the name "evening" primrose, they are open late in the evening and during the night. They are borne at the end of the stem and are interspersed with leafy bracts. Each flower has four spreading petals and measures about 1 to 2 inches across. The seed capsules are oblong and hairy, about an inch in length, and narrowed at the top. (Fig. 6.) This plant belongs to the evening primrose family (Onagraceæ).

Collection, prices, and uses.—The entire plant is used. It is collected about flowering time, bringing about 5 cents a pound. The herb has a somewhat astringent and mucilaginous taste, but no odor. It has been used for coughs and asthmatic troubles, and an ointment made therefrom has been employed as an application in skin affections.

[1] A misleading name.

YERBA SANTA.

Eriodictyon californicum (H. and A.) Greene.

Pharmacopœial name.—Eriodictyon.

Synonym.—*Eriodictyon glutinosum* Benth.

Other common names.—Mountain balm, consumptive's weed,[1] bear's-weed, gum plant, tarweed.

Description.—This evergreen shrub, a member of the waterleaf family (Hydrophyllaceæ), reaches a height of from 3 to 4 feet, bearing glutinous leaves. The stem is smooth, but exudes a gummy substance. The dark-green leaves are from 3 to 4 inches in length, placed alternately on the stem, oblong or oval lance shaped, leathery, narrowing gradually into a short stalk, and with margins generally toothed, except perhaps at the base: the upper surface is smooth, with depressed veins, the prominent veins on the under surface forming a strong network and the spaces between the veins covered with short felty hairs, giving it a white appearance. The leaves are coated with a resinous substance, making them appear as if varnished. The rather showy whitish or pale-blue flowers are borne in clusters at the top of the plant, the tubular, funnel-shaped corolla measuring about half an inch in length and having five spreading lobes. (Fig. 7.) The seed capsule is oval, grayish brown, and contains small, reddish-brown, shriveled seeds.

Fig. 7.—Yerba santa (*Eriodictyon californicum*), leaves and flowers.

Collection, prices, and uses.—The leaves are the parts collected for medicinal use and are official in the United States Pharmacopœia. The price paid for them is about 5 cents a pound. Yerba santa has expectorant properties and is employed for throat and bronchial affections. It is also used as a bitter tonic. The odor is aromatic and the taste balsamic and sweetish.

[1] A popular but misleading name.

PIPSISSEWA.

Chimaphila umbellata (L.) Nutt.

Pharmacopœial name.—Chimaphila.

Synonyms.—*Pyrola umbellata* L.; *Chimaphila corymbosa* Pursh.

Other common names.—Prince's pine, pyrola, rheumatism weed, bitter wintergreen, ground holly, king's cure, love-in-winter, noble pine, pine tulip.

Habitat and range.—Pipsissewa is a native of this country, growing in dry, shady woods, especially in pine forests, and its range extends from Nova Scotia to British Columbia, south to Georgia, Mexico, and California. It also occurs in Europe and Asia.

FIG. 8.—Pipsissewa (*B*) and spotted wintergreen (*A*) (*Chimaphila umbellata* and *C. maculata*), flowering and fruiting plants.

Description.—This small perennial herb, a foot or less in height, has a long, running, partly underground stem. It belongs to the heath family (Ericaceæ) and has shining evergreen leaves of a somewhat leathery texture placed in a circle around the stem, usually near the top or scattered along it. They are dark green, broader at the top, with a sharp or blunt apex, narrowing toward the base and with margins sharply toothed; they are from about 1 to 2 inches long and about three-eighths to a little more than half an inch wide at the broadest part. From about June to August the pipsissewa may be found in flower, its pretty waxy-white or pinkish fragrant flowers, consisting of five rounded, concave petals, each one with a dark-pink spot at the base, nodding in clusters from the top of the erect stem. The brown capsules contain numerous very small seeds. (Fig. 8.)

Collection, prices, and uses.—Although the United States Pharmacopœia directs that the leaves be used, the entire plant is frequently employed, as all parts of it are active. Pipsissewa leaves have no odor, but a bitter, astringent taste. They bring about 4 cents a pound. Pipsissewa has slightly tonic, astringent, and diuretic properties and is sometimes employed in rheumatic and kidney affections. Externally it has been applied to ulcers.

Another species.—The leaves of the spotted wintergreen (*Chimaphila maculata* Pursh) were official in the Pharmacopœia of the United States from 1830 to 1840. These may be distinguished from the leaves of *C. umbellata* (pipsissewa) by their olive-green color marked with white along the midrib and veins. They are lance shaped in outline and are broadest at the base instead of at the top as in *C. umbellata*.

MOUNTAIN LAUREL.

Kalmia latifolia L.

Other common names.—Broad-leaved laurel, broad-leaved kalmia, American laurel, sheep laurel, rose laurel, spurge laurel, small laurel, wood laurel, kalmia, calico bush, spoonwood, spoonhunt, ivy bush, big-leaved ivy, wicky, calmoun.

Habitat and range.—The mountain laurel is found in sandy or rocky soil in woods from New Brunswick south to Ohio, Florida, and Louisiana.

Description.—This is an evergreen shrub from about 4 to 20 feet in height, with leathery leaves, and when in flower it is one of the most beautiful and showy of our native plants. It has very stiff branches and leathery oval or elliptical leaves borne on stems, mostly alternate, pointed at both ends, with margins entire, smooth and bright green on both sides, and having terminal, clammy-hairy clusters of flowers, which appear from about May to June. The buds are rather oddly shaped and fluted, at first of a deep rose color, expanding into saucer-shaped, more delicately tinted, whitish-pink flowers. Each saucer-shaped flower is provided with 10 pockets holding the anthers of the stamens, but from which these free themselves elastically when the flower is fully expanded. (Fig. 9.) The seed capsule is somewhat globular, the calyx and threadlike style remaining attached until the capsules open. Mountain laurel, which belongs to the heath family (Ericaceæ), is poisonous to sheep and calves.

FIG. 9.—Mountain laurel (*Kalmia latifolia*), leaves and flowers.

Collection, prices, and uses.—The leaves, which bring about 3 to 4 cents a pound, are collected in the fall. They are used for their astringent properties.

GRAVEL PLANT.

Epigaea repens L.

Other common names.—Trailing arbutus, Mayflower, shad-flower, ground laurel, mountain pink, winter pink.

Habitat and range.—This shrubby little plant spreads out on the ground in sandy soil, being found especially under evergreen trees from Florida to Michigan and northward.

FIG. 10.—Gravel plant (*Epigaea repens*), leaves and flowers.

Description.—The gravel plant is one of our early spring flowers, and under its more popular name "trailing arbutus" it is greatly prized on account of its delicate shell-pink, waxy blossoms with their faint yet spicy fragrance. Gravel plant is the name that is generally applied to it in the drug trade. It spreads on the ground with stems 6 inches or more in length and has rust-colored hairy twigs bearing evergreen leaves. The leaves are green above and below, thick and leathery, oval or roundish, sometimes with the top pointed, blunt, or having a short stiff point and a rounded or heart-shaped base. The margins are unbroken and the upper surface is smooth, while the lower surface is somewhat hairy. The leaves measure from 1 to 3 inches in length and are about half as wide, the hairy stalks supporting them ranging from one-fourth of an inch to 2 inches in length. Early in the year, from about March to May, the flower clusters appear. These are borne in the axils of the leaves and at the ends of the branches and consist of several waxy, pinkish-white, fragrant flowers with saucer-shaped, 5-lobed corolla, the throat of the corolla tube being very densely hairy within. (Fig. 10.) The seed capsule is somewhat roundish, flattened, five celled, and contains numerous seeds. The gravel plant belongs to the heath family (Ericaceæ) and is a perennial.

Collection, prices, and uses.—The leaves are collected at flowering time and are worth about 3 or 4 cents a pound. They have a bitter, astringent taste and are said to possess astringent and diuretic properties.

WINTERGREEN.

Gaultheria procumbens L.

Other common names.—Gaultheria, spring wintergreen, creeping wintergreen, aromatic wintergreen, spicy wintergreen, checkerberry, teaberry, partridge berry, grouseberry, spiceberry, chickenberry, deerberry, groundberry, hillberry, ivyberry, boxberry, redberry tea, Canadian tea, mountain tea, ivory plum, chinks, drunkards, red pollom, rapper dandies, wax cluster.

FIG. 11.—Wintergreen (*Gaultheria procumbens*), flowering and fruiting plants.

Habitat and range.—This small native perennial frequents sandy soils in cool damp woods, occurring especially under evergreen trees in Canada and the northeastern United States.

Description.—Wintergreen is an aromatic, evergreen plant with an underground or creeping stem producing erect branches not more than 6 inches in height, the lower part of which is smooth and naked, while near the ends are borne the crowded clusters of evergreen leaves. These are alternate, shining dark green above, lighter colored underneath, spicy, thick and leathery, oval and narrowing toward the base, 1 to 1½ inches in length, and of varying width. From about June to September the solitary, somewhat urn-shaped and five-toothed white and waxy flowers appear, borne on recurved stems in the axils of the leaves. (Fig. 11.) These are followed by globular, somewhat flattened berries, which ripen in autumn and remain on the plant, sometimes until spring. They are bright red, five celled, mealy, and spicy. All parts of the plant, which belongs to the heath family (Ericaceæ), are aromatic.

Collection, prices, and uses.—The leaves of wintergreen, or gaultheria, were at one time official in the United States Pharmacopœia, but now only the oil of wintergreen, distilled from the leaves, is so regarded. The leaves should be collected in autumn. Sometimes the entire plant is pulled up and, after drying, the leaves readily shake off. The price paid to collectors ranges from about 3 to 4 cents a pound.

Wintergreen has stimulant, antiseptic, and diuretic properties. Its chief use, however, seems to be as a flavoring agent.

BEARBERRY.

Arctostaphylos uva-ursi (L.) Spreng.

Pharmacopœial name.—Uva ursi.

Other common names.—Red bearberry, bear's-grape, bear's bilberry, bear's whortleberry, foxberry, upland cranberry, mountain cranberry, crowberry, mealberry, rockberry, mountain box, kinnikinnic, killikinic, universe vine, brawlins, burren myrtle, creashak, sagachomi, rapper dandies (fruit).

Fig. 12.—Bearberry (*Arctostaphylos uva-ursi*), leaves and fruits.

Habitat and range.—Bearberry is a native of this country, growing in dry sandy or rocky soil from the Middle Atlantic States north to Labrador and westward to California and Alaska.

Description.—The bearberry is a low, much-branched shrub trailing over the ground and having leathery, evergreen leaves. It is a member of the heath family (Ericaceæ) and produces its pretty waxy flowers about May.

The numerous crowded leaves are thick and leathery, evergreen, about one-half to 1 inch in length, blunt and widest at the top and narrowing at the base, with a network of fine veins, smooth, and with margins entire. The flowers are few, borne in short drooping clusters at the ends of the branches, and are ovoid or somewhat bell shaped in form, four or five lobed, white with a pinkish tinge. They are followed by smooth, red, globular fruits, with an insipid, rather dry pulp, containing five nutlets. (Fig. 12.)

Collection, prices, and uses.—Bearberry or uva ursi leaves, official in the United States Pharmacopœia, are collected in autumn. Collectors receive from about 2 to 4 cents a pound for them. Bearberry leaves have a bitter, astringent taste and a faint odor. They act on the kidneys and bladder and have astringent and tonic properties.

Another species.—The leaves of manzanita (*Arctostaphylos glauca* Lindl.), a shrub-like tree, 9 to 25 feet high, have properties similar to uva ursi and are also used in medicine for similar purposes. They are of a leathery texture, pale green, ovate oblong in shape, with unbroken margins, and about 2 inches in length. Manzanita grows in California, in dry rocky districts on the western slopes of the Sierras.

BUCK BEAN.

Menyanthes trifoliata L.

Other common names.—Bog bean, bog myrtle, bog hop, bog nut, brook bean, bean trefoil, marsh trefoil, water trefoil, bitter trefoil, water shamrock, marsh clover, moonflower, bitterworm.

Habitat and range.—The buck bean is a marsh herb occurring in North America as far south as Pennsylvania, Minnesota, and California. It is also native in Europe.

Description.—This perennial herb arises from a long, black, creeping, scaly rootstock, the leaves being produced from the end of the same on erect sheathing stems measuring about 2 to 10 inches in height. The leaves consist of three oblong-oval or broadly oval leaflets $1\frac{1}{2}$ to 3 inches long, somewhat fleshy and smooth, blunt at the top, with margins entire and narrowed toward the base; the upper surface is pale green and the lower surface somewhat glossy, with the thick midrib light in color. The flower cluster is produced from May to July on a long, thick, naked stalk arising from the rootstock It bears from 10 to 20 flowers, each with a funnel-shaped tube terminating in five segments which are pinkish purple or whitish on the outside and whitish and thickly bearded with white hairs within. (Fig. 13.) The capsules which follow are ovate, blunt at the top, smooth and light brown, and contain numerous smooth and shining seeds. Buck bean is a perennial belonging to the buck-bean family (Menyanthaceæ).

FIG. 13.—Buck bean (*Menyanthes trifoliata*), flowering plant.

Collection, prices, and uses.—The leaves are generally collected in spring. They lose more than three-fourths of their weight in drying. The price paid per pound is about 6 to 8 cents.

Buck-bean leaves have a very bitter taste, but no odor. Large doses are said to have cathartic and sometimes emetic action, but the principal use of buck-bean leaves is as a bitter tonic. They have been employed in dyspepsia, fevers, rheumatic and skin affections, and also as a remedy against worms.

The rootstock is also sometimes employed medicinally and was recognized in the United States Pharmacopœia from 1830 to 1840.

SKULLCAP.

Scutellaria lateriflora L.

Pharmacopœial name.—Scutellaria.

Other common names.—American skullcap, blue skullcap, mad-dog skullcap, side-flowering skullcap, madweed, hoodwort, blue pimpernel, hooded willow-herb.

Habitat and range.—This species is native in damp places along banks of streams from Canada southward to Florida, New Mexico, and Washington.

Fig. 14.—Skullcap (*Scutellaria lateriflora*), flowering branch, showing also seed capsules.

Description.—The lip-shaped flowers and squarish stems of the skullcap indicate that it is a member of the mint family (Menthaceæ). It is a perennial of slender, erect habit, its square, leafy, branching stem ranging from 8 inches to 2 feet in height, smooth, or sometimes hairy at the top. The leaves are placed opposite to each other on the stem on slender stalks and are about 1 to 3 inches in length and about one-third as wide, thin in texture, oblong or lance shaped, with margins coarsely toothed. They gradually become smaller toward the top, and sometimes those at the very top have the margins unbroken. The flowers are borne in narrow, spikelike, one-sided clusters, generally in the axils of the leaves, but frequently also at the top, and are interspersed with leafy bracts. They appear from about July to September and are blue, shading off to whitish. The tubular, 2-lipped flowers are about a quarter of an inch in length, and the calyx, or outer green covering of the flower, is also two lipped, the upper lip shaped like a helmet and closing in fruit. (Fig. 14.)

Collection, prices, and uses.—The dried plant is at present official in the United States Pharmacopœia. The entire plant is collected when in flower and should be carefully dried in the shade. The price ranges from about 3 to 4 cents a pound.

Very frequently collectors will gather some other species in place of the official plant, most of those thus wrongly finding their way into the market being generally of stouter growth, with broader leaves and much larger flowers.

This plant was once considered valuable for the prevention of hydrophobia, whence the names "mad-dog skullcap" and "madweed," but it is now known to be useless for that purpose. It is used principally as a tonic and to a limited extent for allaying nervous irritation of various kinds.

HOREHOUND.

Marrubium vulgare L.

Pharmacopœial name.—Marrubium.

Other common names.—Houndsbene, marvel, marrube.

Habitat and range.—Horehound grows in dry sandy or stony soil in waste places, along roadsides and near dwellings, in fields, and pastures. It is found from Maine to South Carolina, Texas, and westward to California and Oregon. It is very abundant in pastures in Oregon and California, and especially in southern California, where it is a very troublesome weed, covering vast areas and in such dense masses as to crowd out all other vegetation. It has been naturalized from Europe.

FIG. 15.—Horehound (*Marrubium vulgare*), leaves, flowers, and seed clusters.

Description.—The entire plant is thickly covered with hairs, which give it a whitish, woolly appearance. It is a bushy, branching herb, having a pleasant aromatic odor, and is about 1 to 3 feet high, with many woolly stems rounded below and four angled above, with opposite, oval or roundish, wrinkled, strongly veined, and very hoary leaves. The leaves are about 1 to 2 inches in length, placed opposite each other on the stem, oval or nearly round, somewhat blunt at the apex, and narrowed or somewhat heart shaped at the base, the margins round toothed; the upper surface is wrinkled and somewhat hairy, while the lower surface is very hoary and prominently veined. The lip-shaped flowers, which appear from June to September, show that it is a member of the mint family (Menthaceæ). These are borne in dense woolly clusters in the axils of the leaves and are whitish, two lipped, the upper lip two lobed, the lower three lobed. The hooked calyx teeth of the mature flower heads cling to the wool of sheep, resulting in the scattering of the seeds. (Fig. 15.)

Collection, prices, and uses.—The leaves and tops are the parts used in medicine and are official in the United States Pharmacopœia. These are gathered just before the plant is in flower, the coarse stalks being rejected. They should be carefully dried in the shade. The odor is pleasant, rather aromatic, but diminishes in drying. The taste is bitter and persistent. Horehound at present brings about $1\frac{1}{2}$ to 2 cents a pound.

It is well known as a domestic remedy for colds and is also used in dyspepsia and for expelling worms.

CATNIP.

Nepeta cataria L.

Other common names.—Cataria, catmint, catwort, catrup, field mint.

Habitat and range.—Catnip, a common weed naturalized from Europe, occurs in rather dry soil in waste places and cultivated land from Canada to Minnesota and south to Virginia and Arkansas.

FIG. 16.—Catnip (*Nepeta cataria*), leaves and flowers.

Description.—The fine white hairs on the stems of this plant give it a somewhat whitish appearance. Catnip reaches about 2 to 3 feet in height, with erect, square, and branched stems. It is a perennial belonging to the mint family (Menthaceæ).

The opposite leaves are heart shaped or oblong, with a pointed apex, the upper surface green, the lower grayish green with fine white hairs, the margins finely scalloped and 1 to 2½ inches in length.

About June to September the many-flowered, rather thick spikes are produced at the ends of the stem and branches. The whitish flowers, dotted with purple, are two lipped, the upper lip notched or two cleft, the lower one with three lobes, the middle lobe broadest and sometimes two cleft. (Fig. 16).

Collection, prices, and uses.—The leaves and flowering tops, which have a strong odor and a bitter taste, are collected when the plant is in flower and are carefully dried. The coarser stems and branches should be rejected. Catnip was official in the United States Pharmacopœia from 1840 to 1880. The price ranges from 3 to 5 cents a pound.

Catnip is used as a mild stimulant and tonic and as an emmenagogue. It also has a quieting effect on the nervous system.

MOTHERWORT.

Leonurus cardiaca L.

Synonym.—*Cardiaca vulgaris* Moench.

Other common names.—Throwwort, cowthwort, lion's-tail, lion's-ear.

Habitat and range.—Motherwort, naturalized from Europe and a native also of Asia, is found about dwellings and in waste places, its range in this country extending from Nova Scotia to North Carolina, Minnesota, and Nebraska.

Description.—The rather stout, erect, 4-angled stem of this perennial herb attains a height of from 2 to 5 feet, is sparingly hairy, and has upright branches. The rough, dark-green leaves are borne on long stems, the lower ones rounded, about 2 to 4 inches wide and three to five lobed, the lobes pointed, toothed, or variously cut, the upper narrower ones three cleft with lance-shaped lobes. Motherwort flowers in summer, the pale-purple or pinkish lip-shaped blossoms produced in the axils of the leaves being arranged in dense circles around the stem; the upper lip is densely covered with white, woolly hairs on the outside and the lower lip is three lobed and mottled. (Fig. 17.) Motherwort belongs to the mint family (Menthaceæ).

FIG. 17.—Motherwort (*Leonurus cardiaca*), leaves, flowers, and seed clusters.

Collection, prices, and uses.—The leaves and flowering tops are collected during the flowering season. They have an aromatic odor and a very bitter taste. At present they bring about 3 to 5 cents a pound.

Motherwort has stimulant, slightly tonic properties and is used also to promote perspiration.

PENNYROYAL.

Hedeoma pulegioides (L.) Pers.

Pharmacopœial name.—Hedeoma.

Other common names.—American pennyroyal, mock pennyroyal, squaw mint, tick-weed, stinking balm, mosquito plant.

FIG. 18.—Pennyroyal (*Hedeoma pulegioides*), leaves and flowers.

Habitat and range.—Pennyroyal is found in dry soil from Nova Scotia and Quebec to Dakota and southward.

Description.—This very strongly aromatic annual of the mint family (Menthaceæ) is of rather insignificant appearance, being a low-growing plant, about 6 inches to a foot or so in height, with a slender, erect, much-branched and somewhat hairy stem.

The opposite leaves are small, scarcely exceeding three-fourths of an inch in length and becoming smaller toward the top of the plant. They are borne on short stems and are oblong ovate in shape, thin, blunt at the apex, narrowed at the base, and with margins sparingly toothed. The branchlets are four angled and somewhat hairy, and the loose flower clusters, appearing from July to September in the axils of the leaves, consist of a few pale-bluish flowers with 2-lipped corolla, the erect upper one entire or slightly notched or two lobed, while the lower spreading lip is three cleft. (Fig. 18.)

Collection, prices, and uses.—The leaves and flowering tops are official in the United States Pharmacopœia, as is also the oil of pennyroyal distilled from them. They should be collected while in flower. The price paid to collectors ranges from about 1¼ to 2½ cents a pound.

Pennyroyal has a strong mintlike odor and pungent taste and is used as an aromatic stimulant, carminative, and emmenagogue. The odor is very repulsive to insects, and pennyroyal is therefore much used for keeping away mosquitoes and other troublesome insects.

BUGLEWEED.

Lycopus virginicus L.

Other common names.—Buglewort, sweet bugleweed, American water horehound, carpenter's herb, green archangel, gypsyweed, Paul's betony, wood betony, wolf foot, purple archangel, water bugle, gypsywort, gypsy herb, Virginia horehound.

Habitat and range.—Bugleweed is a native herb frequenting wet, shady places from Canada to Florida, Missouri, and Nebraska.

Description.—This perennial herb of the mint family (Menthaceæ) has long, threadlike runners and a bluntly 4-angled, smooth, slender, erect or ascending stem from 6 inches to 2 feet in height. The leaves are dark green or of a purplish tinge, about 2 inches in length, long pointed at the apex and narrowed toward the base, the upper portion of the margin being toothed. The small, tubular, bell-shaped, 4-lobed flowers are purplish and are produced from about July to September They are borne in dense clusters in the axils of the leaves and are followed by 3-sided nutlets. (Fig. 19.)

FIG. 19.—Bugleweed (*Lycopus virginicus*), leaves and flowers.

Collection, prices, and uses.—The entire herb, which was official from 1830 to 1880, should be gathered during the flowering period. It brings about 3 to 4 cents a pound. The plant has a rather pleasant, mintlike odor, but the taste is bitter and disagreeable. It has sedative, tonic, and astringent properties.

PEPPERMINT.

Mentha piperita L.

Pharmacopœial name.—Mentha piperita.

Other common names.—American mint, brandy mint, lamb mint, lammint, State mint (in New York).

Habitat and range.—Peppermint is naturalized from Europe and is found in damp places from Nova Scotia to Minnesota and south to Florida and Tennessee. It is largely cultivated, principally in Michigan and New York, where the distillation of the plants for the oil is carried on commercially on a very extensive scale, and also in parts of Indiana, Iowa, and Wisconsin.

FIG. 20.—Peppermint (*Mentha piperita*), leaves and flowers.

Description.—Peppermint propagates by means of its long, running roots, from which are produced smooth, square stems, from 1 to 3 feet in height, erect and branching. The dark-green leaves are borne on stalks and are lance shaped, 1 to 2 inches in length and about half as wide, pointed at the apex and rounded or narrowed at the base, with margins sharply toothed; they are smooth on both sides, or sometimes the veins on the lower surface are hairy.

This aromatic perennial of the mint family (Menthaceæ) is in flower from July to September, the small purplish blossoms having a tubular, 5-toothed calyx and a 4-lobed corolla. They are placed in circles around the stem, forming thick, blunt, terminal spikes. (Fig. 20.)

Collection, prices, and uses.—The dried leaves and flowering tops are the parts directed to be used by the United States Pharmacopœia. These must be collected as soon as the flowers begin to open and should be carefully dried in the shade. Dried peppermint leaves and tops bring about 3½ to 4½ cents a pound.

The pungent odor of peppermint is familiar, as is likewise the agreeable taste, burning at first and followed by a feeling of coolness in the mouth. It is a well-known remedy for stomach and intestinal troubles.

The oil, which is obtained by distillation with water from the fresh or partially dried leaves and flowering tops, is also official in the United States Pharmacopœia. While a less acreage was devoted to peppermint during 1910, conditions were favorable to its growth, and the crop is estimated to have amounted to about 200,000 pounds. The wholesale quotations for peppermint oil in the spring of 1911 ranged from $2.85 to $2.95 a pound.

SPEARMINT.

Mentha spicata L.

Pharmacopœial name.—Mentha viridis.

Synonym.—*Mentha viridis* L.

Other common names.—Mint, brown mint, garden mint, lamb mint, mackerel mint, Our Lady's mint, sage of Bethlehem.

Habitat and range.—Like peppermint, the spearmint has also been naturalized from Europe and may be found in moist fields and waste places from Nova Scotia to Utah and south to Florida. It is also cultivated to some extent for the distillation of the oil and is a familiar plant in gardens for domestic use.

Fig. 21.—Spearmint (*Mentha spicata*), leaves, flowers, and running rootstock.

Description.—Spearmint very much resembles peppermint. It does not grow perhaps quite so tall, the lance-shaped leaves are generally stemless or at least with very short stems, and the flowering spikes are narrow and pointed instead of thick and blunt. (Fig. 21.) The flowering period is the same as for peppermint—from July to September.

Collection, prices, and uses.—The dried leaves and flowering tops are official in the United States Pharmacopœia and should be collected before the flowers are fully developed. The price at present is about 3½ cents a pound.

Spearmint is used for similar purposes as peppermint, although its action is milder. The odor and taste closely resemble those of peppermint, but a difference may be detected, the flavor of spearmint being by some regarded as more agreeable. Oil of spearmint is also official in the United States Pharmacopœia. It is obtained from the fresh or partially dried leaves and flowering tops.

JIMSON WEED.

Datura stramonium L.

Pharmacopœial name.—Stramonium.

Other common names.—Jamestown weed (from which the name "jimson weed" is derived), Jamestown lily, thorn apple, devil's apple, mad-apple, apple of Peru, stinkweed, stinkwort, devil's-trumpet, fireweed, dewtry.

Fig. 22.—Jimson weed (*Datura stramonium*), leaves, flowers, and capsules.

Habitat and range.—This is a very common weed in fields and waste places almost everywhere in the United States except in the North and West. It is widely scattered in nearly all warm countries.

Description.—Jimson weed is an ill-scented, poisonous annual belonging to the nightshade family (Solanaceæ). Its stout, yellowish-green stems are about 2 to 5 feet high, much forked, and leafy with large, thin, wavy-toothed leaves. The leaves are from 3 to 8 inches long, thin, smooth, pointed at the top and usually narrowed at the base, somewhat lobed or irregularly toothed and waved, veiny, the upper surface dark green, while the lower surface is a lighter green. The flowers are large (about 3 inches in length), white, funnel shaped, rather showy, and with a pronounced odor. Jimson weed is in flower from about May to September, and the seed pods which follow are dry, oval, prickly capsules, about as large as a horse-chestnut, which upon ripening burst open into four valves containing numerous black, wrinkled, kidney-shaped seeds, which are poisonous (Fig. 22.)

Collection, prices, and uses.—The leaves of the jimson weed, yielding, when assayed by the United States Pharmacopœia process, not less than 0.35 per cent of its alkaloids, are official under the name "Stramonium." They are collected at the time jimson weed is in flower, the entire plant being cut or pulled up and the leaves stripped and carefully dried in the shade. They have an unpleasant, narcotic odor and a bitter, nauseous taste. Drying diminishes the disagreeable odor. The collector may receive from 2 to 5 cents a pound for the leaves.

The leaves, which are poisonous, cause dilation of the pupil of the eye and also have narcotic, antispasmodic, anodyne, and diuretic properties. In asthma they are frequently employed in the form of cigarettes, which are smoked, or the fumes are inhaled.

The seeds are also used in medicine.

BALMONY.

Chelone glabra L.

Other common names.—Turtlehead, turtle bloom, fishmouth, codhead, salt-rheum weed, snake-head, bitter herb, shell flower.

Habitat and range.—This native perennial grows in swamps and along streams from Newfoundland to Manitoba and south to Florida and Kansas.

Description.—Balmony is a slender, erect herb, with a 4-angled stem 1 to 3 feet in height, occasionally branched. The short-stemmed leaves, which are from 3 to 6 inches in length, are narrowly lance shaped to broadly lance shaped, the lower ones sometimes broadly oval, narrowing toward the base and with margins furnished with sharp, close-lying teeth. In late summer or early fall the showy clusters of whitish or pinkish flowers are produced. Each flower is about an inch in length, with a tubular, inflated corolla, with the mouth slightly open and resembling the head of a turtle or snake; its broad arched upper lip is keeled in the center and notched at the apex, while the lower lip is three lobed, the smallest lobe in the center, and the throat bearded with woolly hairs. (Fig. 23.) The seed capsule is oval, about half an inch in length, and contains numerous small seeds.

FIG. 23.—Balmony (*Chelone glabra*), leaves and flowers.

Collection, prices, and uses.—The herb (especially the leaves), which brings from 3 to 4 cents a pound, should be collected during the flowering period.

Balmony has a very bitter taste, but no odor, and is used as a tonic, for its cathartic properties, and for expelling worms.

COMMON SPEEDWELL.

Veronica officinalis L.

Other common names.—Paul's betony, ground-hele, fluellin, upland speedwell.

Habitat and range.—This little herb frequents dry fields and woods from Nova Scotia to Michigan and south to North Carolina and Tennessee. It also occurs in Europe and Asia.

Description.—The common speedwell creeps over the ground by means of rather woody stems rooting at the joints and sends up branches from 3 to 10 inches in height. It is hairy all over. The leaves are opposite to each other on the stem, on short stalks, grayish green and soft hairy, oblong or oval in shape, and about one-half to an inch in length; they are blunt at the apex, with margins saw toothed and narrowing into the stalks. From about May to July the elongated, narrow, spikelike flower clusters are produced from the leaf axils, crowded with small, pale-blue flowers. (Fig. 24.) The capsule is obovate, triangular, and compressed, and contains numerous flat seeds. The speedwell is a perennial belonging to the figwort family (Scrophulariaceæ).

Fig 24.—Common speedwell (*Veronica officinalis*), leaves and flowers.

Collection, prices, and uses.—The leaves and flowering tops, which bring about 3 to 5 cents a pound, should be collected about May or June. When fresh they have a faint, agreeable odor, which is lacking when dry. The taste is bitter and aromatic and somewhat astringent.

Speedwell has been used for asthmatic troubles and coughs and also for its alterative, tonic, and diuretic properties.

FOXGLOVE.

Digitalis purpurea L.

Pharmacopœial name.—Digitalis.

Other common names.—Purple foxglove, thimbles, fairy cap, fairy thimbles, fairy fingers, fairy bells, dog's-finger, finger flower, lady's-glove, lady's-finger, lady's-thimble, popdock, flap dock, flop dock, lion's-mouth, rabbit's-flower, cottagers, throatwort, Scotch mercury.

Habitat and range.—Originally introduced into this country from Europe as an ornamental garden plant, foxglove may now be found wild in a few localities in parts of Oregon, Washington, and West Virginia, having escaped from cultivation and assumed the character of a weed. It occurs along roads and fence rows, in small cleared places, and on the borders of timber land.

Description.—Foxglove, a biennial or perennial belonging to the figwort family (Scrophulariaceæ), during the first year of its growth produces only a dense rosette of leaves, but in the second season the downy and leafy flowering stalk, reaching a height of 3 to 4 feet, appears. The basal leaves are rather large, with long stalks, while the upper ones gradually become smaller and are borne on shorter leafstalks. The ovate or oval leaves, 4 to 12 inches long and about half as wide, the upper surface of which is dull green and wrinkled, are narrowed at the base into long winged stalks; the lower surface of the leaves shows a thick network of prominent veins and is grayish, with soft, short hairs. The apex is blunt or pointed and the margins are round toothed. When foxglove is in flower, about June, it is a most handsome plant, the long terminal clusters (about 14 inches in length) of numerous tubular, bell-shaped flowers making a very showy appearance. The individual flowers are about 2 inches long and vary in color from whitish through lavender and purple; the inside of the lower lobe is white, with crimson spots and furnished with long, soft, white hairs. (Fig. 25.) The capsule is ovoid, two celled, and many seeded.

FIG. 25.—Foxglove (*Digitalis purpurea*), leaves and flowers.

Collection, prices, and uses.—The leaves, which are official in the United States Pharmacopœia, are collected from plants of the second year's growth just about the time that they are coming into flower. They should be very carefully dried in the shade soon after collection and as rapidly as possible, preserving them in dark, airtight receptacles. The leaves soon lose their medicinal properties if not properly dried or if exposed to light and moisture. Foxglove brings about 6 to 8 cents a pound. At present most of the foxglove or digitalis used comes to this country from Europe, where the plant grows wild and is also cultivated.

Foxglove has a faint, rather peculiar odor and a very bitter, nauseous taste. Preparations made from it are of great value in affections of the heart, but they are poisonous and should be used only on the advice of a physician.

SQUAW VINE.

Mitchella repens L.

Other common names.—Checkerberry, partridgeberry, deerberry, hive vine, squawberry, twinberry, chickenberry, cowberry, boxberry, foxberry, partridge vine, winter clover, wild running box, oneberry, pigeonberry, snakeberry, two-eyed berry, squaw-plum.

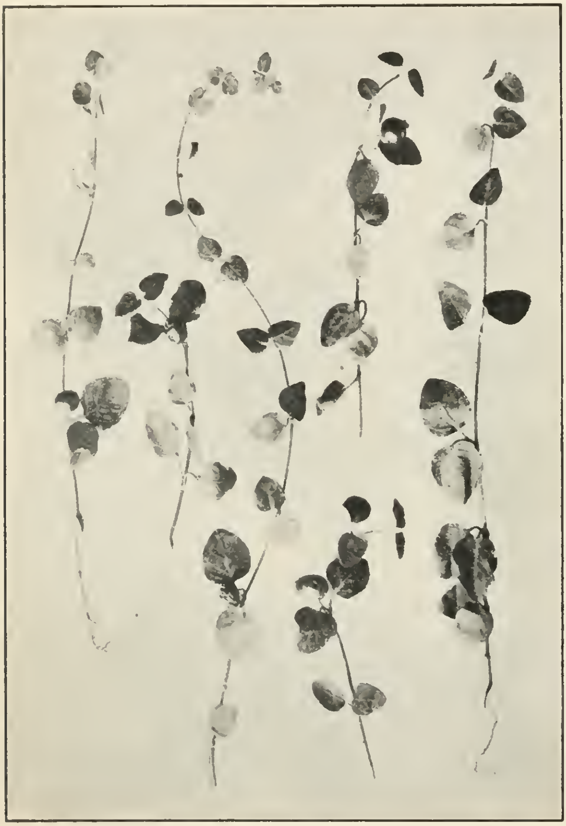

FIG. 26.—Squaw vine (*Mitchella repens*), leaves and fruits.

Habitat and range.—The squaw vine is common in woods from Nova Scotia to Minnesota and south to Florida and Arkansas, where it is generally found creeping about the bases of trees.

Description.—This slender, creeping or trailing evergreen herb, a member of the madder family (Rubiaceæ), has stems 6 to 12 inches long, rooting at the joints, and roundish-oval, rather thick, shining, dark-green opposite leaves about half an inch in length, which are blunt at the apex and rounded or somewhat heart shaped at the base, with margins entire. Sometimes the leaves show whitish veins. The plant flowers from about April to June, producing fragrant whitish, sometimes pale-purplish, funnel-shaped and 4-lobed flowers, two borne together on a stalk and having the ovaries (seed-bearing portion) united, resulting in a double, berrylike fruit. These fruits are red and contain eight small, bony nutlets. (Fig. 26.) They remain on the vine through the winter and are edible, though practically tasteless.

Collection, prices, and uses.—The leaves and stems (herb) are collected at almost any time of the year and range in price from about 3½ to 4 cents a pound.

The leaves have no odor and are somewhat astringent and bitter. Squaw vine has tonic, astringent, and diuretic properties.

LOBELIA.

Lobelia inflata L.

Pharmacopœial name.—Lobelia.

Other common names.—Indian tobacco, wild tobacco, asthma weed, gagroot, vomitwort, puke weed, emetic herb, bladder pod, low belia, eyebright.

Habitat and range.—Lobelia may be found in sunny situations in open woodlands, old fields and pastures, and along roadsides nearly everywhere in the United States, but especially east of the Mississippi River.

Fig. 27.—Lobelia (*Lobelia inflata*), leaves, flowers, and inflated capsules.

Description.—This poisonous plant, an annual belonging to the bellflower family (Campanulaceæ), contains an acrid, milky juice. Its simple stem has but few short branches and is smooth above, while the lower part is rough hairy. The leaves are placed alternately along the stem, those on the upper portion small and stemless and the lower leaves larger and borne on stalks. They are pale green and thin in texture, from 1 to about 2 inches in length, oblong or oval, blunt at the apex, the margins irregularly saw toothed, and both upper and lower surfaces furnished with short hairs.

Lobelia may be found in flower from summer until frost, but its pale-blue flowers, while very numerous, are very small and inconspicuous. They are borne on very short stems in the axils of the upper leaves. The lower lip of each flower has three lobes and the upper one two segments, from the center of which the tube is cleft to the base. The inflated capsules are nearly round, marked with parallel grooves, and contain very numerous extremely minute dark-brown seeds. (Fig. 27.)

Collection, prices, and uses.—The Pharmacopœia directs that the leaves and tops be collected after some of the capsules have become inflated. Not too much of the stemmy portion should be included. The leaves and tops should be dried in the shade and when dry kept in covered receptacles. The price paid for the dried leaves and tops is about 3 cents a pound.

Lobelia has expectorant properties, acts upon the nervous system and bowels, causes vomiting, and is poisonous.

The seed of lobelia is also employed in medicine.

BONESET.

Eupatorium perfoliatum L.

Pharmacopœial name.—Eupatorium.

Synonym.—*Eupatorium connatum* Michx.

Other common names.—Thoroughwort, thorough-stem, thoroughwax, wood boneset, teasel, agueweed, feverwort, sweating plant, crosswort, vegetable antimony, Indian sage, wild sage, tearal, wild isaac.

FIG. 28.—Boneset (*Eupatorium perfoliatum*), leaves and flowers.

Habitat and range.—Boneset is a common weed in low, wet ground, along streams, and on the edges of swamps and in thickets from Canada to Florida and west to Texas and Nebraska.

Description.—This plant is easily recognized by the peculiar arrangement of the leaves, which are opposite to each other, but joined together at the base, which makes it appear as though they were one, with the stem passing through the center. It is a perennial plant belonging to the aster family (Asteraceæ), and is erect, growing rather tall, from 1 to 5 feet in height. The stout stems are rough hairy, and the leaves, united at the base, are rough, very prominently veined, wrinkled, dark green above, lighter green and downy beneath, lance shaped, tapering to a point, and with bluntly toothed margins. The crowded, flat-topped clusters of flowers are produced from about July to September and consist of numerous white tubular flowers united in dense heads. (Fig. 28.)

Collection, prices, and uses.—The leaves and flowering tops, official in the United States Pharmacopœia, are collected when the plants are in flower, stripped from the stalk, and carefully dried. They lose considerable of their weight in drying. The price per pound for boneset is about 2 cents.

Boneset leaves and tops have a bitter, astringent taste and a slightly aromatic odor. They form an old and popular remedy in the treatment of fever and ague, as implied by some of the common names given to the plant. Boneset is also employed in colds, dyspepsia, jaundice, and as a tonic. In large doses it acts as an emetic and cathartic.

GUM PLANT.

(1) *Grindelia robusta* Nutt.; (2) *Grindelia squarrosa* (Pursh) Dunal.

Pharmacopœial name.—Grindelia.

Other common names.—(2) Broad-leaved gum plant, scaly grindelia.

Habitat and range.—The gum plant (*Grindelia robusta*) occurs in the States west of the Rocky Mountains, while the broad-leaved gum plant (*G. squarrosa*) is more widely distributed, being of common occurrence on the plains and prairies from the Saskatchewan to Minnesota, south to Texas and Mexico, and westward to California.

Description.—The name "gum plant" is applied especially to *Grindelia robusta* on account of the fact that the entire plant is covered with a resinous substance, giving it a gummy, varnished appearance. It is an erect perennial herb belonging to the aster family (Asteraceæ) and has a round smooth stem, about 1½ feet in height. The leaves are pale green, leathery in texture and rather rigid, coated with resin and showing numerous translucent dots, and are about an inch in length. In outline they are oblong spatulate—that is, having a broad, rounded top gradually narrowing toward the base—clasping the stem and with margins somewhat saw toothed The plant branches freely near the top, each branch somewhat reddish and terminating in a large yellow flower. The yellow flowers are about three-fourths of an inch in diameter, broader than long, and are borne singly at the ends of the branches. Immediately beneath the flower is a set of numerous, thick, overlapping scales (the involucre), the tips of which are rolled forward, the whole heavily coated with resin.

Fig. 29.—Scaly grindelia (*Grindelia squarrosa*), leaves and flowers.

The broad-leaved gum plant (*Grindelia squarrosa*) is very similar to *G. robusta*, except that it is smaller and less gummy in appearance. It is more sparingly branched near the top and the branches seem more reddish. The leaves are also clasping, but they are longer, about 2 inches in length, and broader, thinner in texture and not rigid, and more prominently toothed. The smaller flower heads are generally longer than broad and have narrower involucral scales, the recurved tips of which are longer and more slender. (Fig. 29.)

Collection, prices, and uses.—The leaves and flowering tops of both species of Grindelia are official in the United States Pharmacopœia, and should be collected about the time that the flowers have come into full bloom. The price ranges from about 5 to 10 cents a pound. While both species are official, the leaves and tops of *Grindelia squarrosa*, being more prevalent, are generally used.

The odor of grindelia is balsamic and the taste resinous, sharply aromatic, and slightly bitter. The drug is sometimes used in asthmatic and similar affections, as a stomachic, tonic, and externally in cases of poisoning by poison ivy.

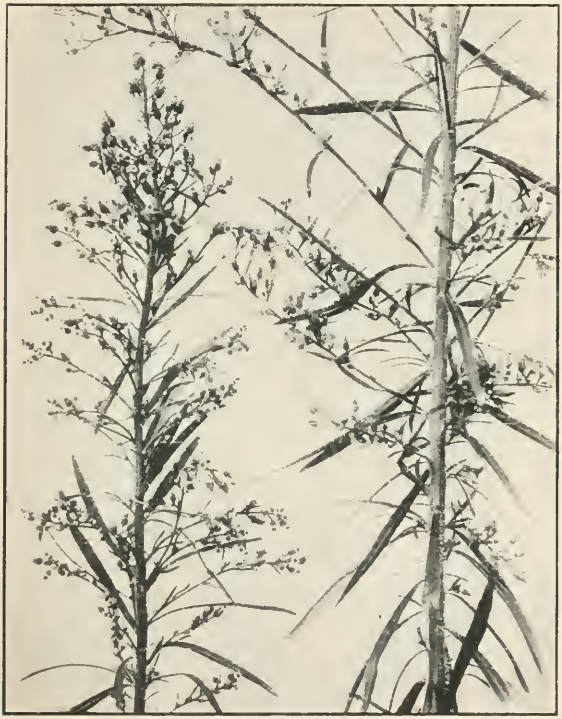

FIG. 30.—Canada fleabane (*Leptilon canadense*), flowering tops.

CANADA FLEABANE.

Leptilon canadense (L.) Britton.

Synonym.—*Erigeron canadensis* L.

Other common names.—Erigeron, horseweed, mare's-tail, Canada erigeron, butterweed, bitterweed, cow's-tail, colt's-tail, fireweed, bloodstanch, hogweed, prideweed, scabious.

Habitat and range.—Canada fleabane is common in fields and waste places and along roadsides almost throughout North America. It is also widely distributed as a weed in the Old World and in South America.

Description.—The size of this weed, which is an annual, depends upon the kind of soil in which it grows, the height varying from a few inches only to sometimes 10 feet in favorable soil. The erect stem is bristly hairy or sometimes smooth, and in the larger plants usually branched near the top. The leaves are usually somewhat hairy, the lower ones 1 to 4 inches long, broader at the top and narrowing toward the base, with margins toothed, lobed, or unbroken, while those scattered along the stem are rather narrow with margins generally entire. This weed, which belongs to the aster family (Asteraceæ), produces from June to November numerous heads of small, inconspicuous white flowers, followed by an abundance of seed. (Fig. 30.)

Collection, prices, and uses.—The entire herb is used; it should be collected during the flowering period and carefully dried. The price paid is about 5 to 6 cents a pound.

By distillation of the fresh flowering herb a volatile oil is obtained, known as oil of fleabane or oil of erigeron, which is sometimes employed in attempting to control hemorrhages and diarrheal affections. The leaves and tops were formerly official in the United States Pharmacopœia, from 1820 to 1880, but the oil alone is now recognized as official. The herb, which has a faint agreeable odor and an astringent and bitter taste, is also used for hemorrhages from various sources and the bleeding of wounds. It is also employed in diarrhea and dropsy.

FIG. 31.—Yarrow (*Achillea millefolium*), leaves and flowers.

YARROW.

Achillea millefolium L.

Other common names.—Millefolium, milfoil, thousand-leaf, thousand-leaf clover, gordolobo, green arrow, soldier's woundwort, nosebleed, dog daisy, bloodwort, sanguinary, carpenter's grass, old-man's-pepper, cammock.

Habitat and range.—Yarrow is very common along roadsides and in old fields, pastures, and meadows from the New England States to Missouri and in scattered localities in other parts of the country.

Description.—This weed, a perennial of the aster family (Asteraceæ), is about 10 to 20 inches in height and has many dark-green feathery leaves, narrowly oblong or lance shaped in outline and very finely divided into numerous crowded parts or segments. Some of the leaves, especially the basal ones, which are borne on stems, are as much as 10 inches in length and about half an inch or an inch in width. The leaves toward the top of the plant become smaller and stemless. From about June to September the flat-topped flowering heads are produced in abundance and consist of numerous small, white (sometimes rose-colored), densely crowded flowers. (Fig. 31.) Yarrow has a strong odor, and when it is eaten by cows the odor and bitter taste are transmitted to dairy products.

Collection, prices, and uses.—The entire plant is collected at the time that it is in flower and is carefully dried. The coarser stems are rejected. Considerable shrinkage takes place in drying, the plant losing about four-fifths of its weight. The prices paid for yarrow are from about 3 to 5 cents a pound. Yarrow was official in the United States Pharmacopœia from 1860 to 1880. It has a strong, aromatic odor, very much like chamomile, and a sharp, bitter taste. It has been used as a stimulant tonic, for its action upon the bladder, and for checking excessive discharges.

Fig. 32. Tansy (*Tanacetum vulgare*), leaves and flowers.

TANSY.

Tanacetum vulgare L.

Other common names.—Tanacetum, bitter buttons, ginger plant, parsley fern, scented fern, English cost, hindheal.

Habitat and range.—This is another garden plant introduced into this country from Europe and now escaped from cultivation, occurring as a weed along waysides and fences from New England to Minnesota and southward to North Carolina and Missouri.

Description.—Tansy is strong-scented perennial herb with finely divided, fernlike leaves and yellow buttonlike flowers, and belongs to the aster family (Asteraceæ). It has a stout, somewhat reddish, erect stem, usually smooth, 1½ to 3 feet high, and branching near the top.

The entire leaf is about 6 inches long, its general outline oval, but it is divided nearly to the midrib into about seven pairs of segments, or lobes, which like the terminal one are again divided for about two-thirds of the distance to the midvein into smaller lobes having saw-toothed margins, giving to the leaf a somewhat feathery or fernlike appearance. The yellow flowers, borne in terminal clusters, are roundish and flat topped, surrounded by a set of dry, overlapping scales (the involucre). (Fig. 32.) Tansy is in flower from about July to September.

Collection, prices, and uses.—The leaves and flowering tops of tansy are collected at the time of flowering and are carefully dried. They lose about four-fifths of their weight in drying. Their price ranges from about 3 to 5 cents a pound.

Tansy has a strong, aromatic odor and a bitter taste. It is poisonous and has been known to produce fatal results. It has stimulant, tonic, and emmenagogue properties and is also used as a remedy against worms.

WORMWOOD.

Artemisia absinthium L.

Synonym.—*Artemisia vulgaris* Lam.

Other common names.—Absinthium, absinth, madderwort, mingwort, old-woman, warmot, mugwort.

Habitat and range.—Wormwood, naturalized from Europe and mostly escaped from gardens in this country, is found in waste places and along roadsides from Newfoundland to New York and westward. It is occasionally cultivated.

FIG. 33.—Wormwood (*Artemisia absinthium*), leaves and flowers.

Description.—This shrubby, aromatic, much-branched perennial of the aster family (Asteraceæ) is from 2 to 4 feet in height, hoary, the young shoots silvery white with fine silky hairs. The grayish-green leaves are from 2 to 5 inches long, the lower long-stalked ones two to three times divided into leaflets with lance-shaped lobes, the upper leaves gradually becoming more simple and stemless and borne on short stems and the uppermost linear with unbroken margins. The flower clusters, appearing from July to October, consist of numerous small, insignificant, drooping, flat-globular, yellow heads. (Fig. 33.)

Collection, prices, and uses.—When the plant is in flower the leaves and flowering tops are collected. These were official in the United States Pharmacopœia for 1890. The price paid for wormwood is about 4 cents a pound. Wormwood has an aromatic odor and an exceedingly bitter taste, and is used as a tonic, stomachic, stimulant, against fevers, and for expelling worms.

An oil is obtained from wormwood by distillation which is the main ingredient in the dangerous liqueur known as absinth, long a popular drink in France, in which country, however, the use of the oil is now prohibited except by pharmacists in making up prescriptions.

COLTSFOOT.

Tussilago farfara L.

Other common names.—Coughwort, assfoot, horsefoot, foalfoot, bull's-foot, horsehoof, colt-herb, clayweed, cleats, dove-dock, dummyweed, ginger, gingerroot, hoofs, sowfoot, British tobacco, gowan.

Habitat and range.—Coltsfoot has been naturalized in this country from Europe, and is found along brooks and in wet places and moist clayey soil along roadsides from Nova Scotia and New Brunswick to Massachusetts, New York, and Minnesota.

FIG. 34.—Coltsfoot (*Tussilago farfara*), plant showing root, leaves, and flowers.

Description.—In spring the white-woolly, scaly flowering stalks with their yellow blossoms are the first to appear, the leaves not being produced until the seed has formed or at least toward the latter part of the flowering stage. The flowering stalks are several, arising from the root, and are from 3 to 18 inches in height, each one bearing at the top a single, large yellow head, reminding one of a dandelion, having in the center what are called disk flowers, which are tubular, and surrounded by what are known as ray flowers, which are strap shaped. When the seed is ripe the head looks somewhat like a dandelion "blow." The flowering heads are erect, after flowering nodding, and again erect in fruit. The bright-yellow flowers only open in sunshiny weather. They have a honeylike odor.

The leaves, as already stated, appear when the flowers are almost through blossoming, or even afterwards. They are large, 3 to 7 inches wide, almost round or heart shaped in outline, or, according to some of the names applied to it, shaped like a horse's hoof; the margins are slightly lobed and sharply toothed. The upper surface is smooth and green, while the lower is white with densely matted woolly hairs. All the leaves arise from the root and are borne on long, erect stalks. (Fig. 34.)

Collection, prices, and uses.—All parts of coltsfoot are active, but the leaves are mostly employed; they should be collected in June or July, or about the time when they are nearly full size. When dry, they break very readily. Collectors are paid about 3½ cents a pound.

Coltsfoot leaves form a popular remedy in coughs and other affections of the chest and throat, having a soothing effect on irritated mucous membranes.

The flowers are also used; likewise the root.

FIREWEED.

Erechthites hieracifolia (L.) Raf.

Synonym.—Senecio hieracifolius L.

Another common name.—Pilewort.

Habitat and range.—Fireweed is found in woods, fields, and waste places from Canada to Florida, Louisiana, and Nebraska, springing up in especial abundance where land has been burned over, whence the name "fireweed."

FIG. 35.—Fireweed (*Erechthites hieracifolia*), leaves and flowering tops.

Description.—This weed is a native of this country and is an ill-smelling annual belonging to the aster family (Asteraceæ). The stem is from 1 to 8 feet in height, grooved, branched, and juicy. The light-green leaves are rather large, from 2 to 8 inches long, thin in texture, lance shaped or oval lance shaped, the margins toothed or sometimes deeply cut. The upper ones usually have a clasping base or are at least stemless, while the margins of those lower down narrow into the stems.

Fireweed is in flower from about July to September, the flat-topped clusters of greenish-white or whitish heads being produced from the ends of the stem and branches. The green outer covering of each flower head is cylindrical, with the base considerably swollen. (Fig. 35.) The seed is furnished with numerous soft white bristles.

Collection, prices, and uses.—The entire plant is used and is gathered in summer. The leaves turn black in drying. The price paid to collectors ranges from about 2 to 3 cents a pound.

An oil is obtained by distillation from the fresh plant. Fireweed has a disagreeable taste and odor. It has astringent, tonic, and alterative properties.

BLESSED THISTLE.

Cnicus benedictus L.

Synonyms.—Centaurea benedicta L.; *Carduus benedictus* Cam.; *Carbenia benedicta* Adans.

Other common names.—Holy thistle, St. Benedict's thistle, Our Lady's thistle, bitter thistle, spotted thistle, cursed thistle, blessed cardus, spotted cardus.

FIG. 36.—Blessed thistle (*Cnicus benedictus*), leaves and flowers.

Habitat and range.—The blessed thistle is a weed which has been introduced into this country from southern Europe and is found in waste places and stony, uncultivated localities from Nova Scotia to Maryland and the Southern States; also on the Pacific coast. It is cultivated in many parts of Europe.

Description.—In height this annual plant of the aster family (Asteraceæ) scarcely exceeds 2 feet, with coarse erect stems, branched and rather woolly. The leaves are large, 3 to 6 inches long or more, oblong lance shaped, thin, more or less hairy, with margins wavy lobed and spiny. The lower leaves and those at the bottom are narrowed toward the base into winged stems, while those near the top are stemless and clasping. The yellow flower heads, which appear from about May to August, are situated at the ends of the branches, almost hidden by the upper leaves, and are about an inch and a half in length. Immediately surrounding the yellow flower heads are scales of a leathery texture, tipped with long, hard, branching, yellowish-red spines. (Fig. 36.)

Collection, prices, and uses.—The leafy flowering tops and the other leaves are gathered preferably just before or during the blossoming period and then are thoroughly and quickly dried. In the fresh state the leaves and tops have a rather disagreeable odor, which they lose on drying. They are bright green when fresh and grayish green and woolly when dry. Collectors receive about 6 to 8 cents a pound.

The taste of the blessed thistle is very bitter and salty and somewhat acrid. It is used principally as a bitter tonic.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 220.

B. T. GALLOWAY, *Chief of Bureau.*

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., April 15, 1911.

Sir: I have the honor to transmit herewith a paper entitled "Relation of Drought to Weevil Resistance in Cotton," by Mr. O. F. Cook, of this Bureau, and to recommend its publication as Bulletin No. 220 of the Bureau series.

It has been ascertained that dry weather gives a distinct advantage in the production of cotton in the presence of the boll weevil. This relation is being taken into account in improving varieties and cultural methods in the direction of weevil resistance. The present report shows that several biological factors must be considered in the study of the practical problem of securing a rapid, uninterrupted development of the crop.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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RELATION OF DROUGHT TO WEEVIL RESISTANCE IN COTTON.

INTRODUCTION.

An important relation between weevil resistance and drought resistance has been recognized for several years past. Special ability to resist drought is to be reckoned as one of the factors of weevil resistance, because more drought-resistant varieties can be grown in the drier regions of the Southwest, where the weevils are often unable to propagate and do relatively little damage. A rapid extension of cotton culture is taking place in this part of the United States.

The farming public in Texas is coming to look upon dry weather in the early part of the season as the most important factor in the production of a good crop of cotton. At first it was supposed that the fate of the weevils during the winter would determine the possibilities of production in the following season. Measures for reducing the number of weevils in the fall and spring received much attention, but it is now understood that dry weather makes it possible to secure a crop, even in a season when the weevils survive the winter in large numbers. In southern and western Texas the reduction of weevil injuries by drought is a very definite factor of weevil resistance, tending to place these regions more nearly on a basis of equality with other parts of the State for purposes of cotton production. In favorable seasons the same factor of dry weather becomes effective over much larger areas, as notably illustrated in the last two years, 1909 and 1910.

In order to take full advantage of other measures for combating the weevils, the relation of drought to the behavior of the growing plants must be considered, no less than the direct effect of the drought upon the weevils. Questions of the value of early and late varieties and of early and late planting require to be reconsidered and given further study now that the effects of dry weather are more fully appreciated. It is only by a careful study and full recognition of all the factors that the true possibilities of cotton culture in the presence of the weevils can be realized.

Without a supply of moisture in the soil the same drought that hinders the reproduction of the weevils will also stop the growth of the plants, thus reducing the advantage that might be gained from the dry weather. But if the land has been well prepared by deep plowing and thorough cultivation so that it absorbs and retains moisture, the plants continue to grow and set their crop through the dry weather. The weevils do not prosper during drought because the young larvæ are killed when the infested buds fall off and lie exposed on the hot, dry ground. The importance of thorough tillage is especially great in the very compact impervious soils of the "black-land prairies" that produce a large part of the Texas cotton crop. Unless such soils are stirred by cultivation very little water penetrates beyond the surface layers, and these are very soon dried out.

Under conditions of humidity other factors determine the success or failure of the crop. Wet and cloudy weather is likely to interfere with the growth of the plants without checking the propagation of the weevils. The more humid the climate the greater the necessity for a rapid, uninterrupted development of the plants if a crop is to be set before the weevils can prevent.

With conditions continuously favorable the weevils can seldom cause any complete loss of the crop, but if a period of unfavorable weather interrupts the growth of the cotton after the first crop of buds has been infested, enough weevils may be bred to infest all the subsequent buds, so that no crop can be set. The luxuriant growth of the plants may continue, each producing hundreds of flower buds, but all pruned off by the weevils. A whole field of the overluxuriant weevil-pruned cotton may not average more than two or three bolls to the plant.

The idea of avoiding weevil injuries by early planting needs to be supplemented by a recognition of the importance of securing an uninterrupted development of the plants. The chief object to be attained is the early setting of the crop in as short a period as possible after the plants have begun to produce flower buds in which the weevils can breed. This object should be taken into account in the breeding and adaptation of varieties and in devising improved methods of culture for weevil-infested regions.

COMPLETE CESSATION OF WEEVIL INJURIES DURING DROUGHT.

The condition of the cotton on the San Antonio Experiment Farm in the middle of July, 1909, afforded an unusually striking illustration of the importance of dry weather as a factor of cotton production in Texas. In spite of the fact that weevils appeared very numerous in the same fields early in the season and infested nearly all of the first buds, no damage was being done in the middle of July, nor were there evidences of any recent injuries by weevils. A careful search over several different plats of cotton failed to find a single bud, or "square," with a normal weevil puncture. Weevil larvæ could still be found in very small numbers in old squares on the ground under the plants, but almost invariably dead or dying. Not a single adult weevil was found. The only weevils that appeared likely to survive were a few small larvæ in some of the earlier bolls, and these would not do further injury in that season, for the larvæ develop very slowly in the bolls and are not likely to emerge until the bolls open at maturity.

Careful examinations of the same plats had been made by Mr. S. H. Hastings, superintendent of the San Antonio farm, in May and June, when an unusually heavy infestation of weevils was found. Under date of June 14, Mr. Hastings reported that nearly all the buds had been destroyed by the weevils as fast as they were formed and that a total failure of the crop was threatened. Had the weather continued favorable for the weevils there was certainly no prospect that the later buds could have fared any better than their predecessors, but the advent of dry weather completely changed the situation and set a definite limit to the activities of the weevils. Similar cases had been observed in previous years when there seemed to be a lessening of weevil injuries as the season advanced instead of the increase that had been feared, but no such complete interruption of injuries by weevils during the growing season of the cotton had been observed.

The effects of heat and dryness upon the weevil larvæ were doubtless intensified indirectly by the influence of the drought upon the plants. Injured buds are dropped much more promptly in dry weather, and in severe drought even the uninjured buds may fall off, thus lessening still further the weevil's opportunities of propagation. The result of the earlier falling of the infested buds is to expose the larvæ to adverse conditions at earlier stages in their development and for longer periods of time.

The effect of the prolonged drought in completely preventing the continuation of the weevil injuries was not confined in the season of 1909 to the vicinity of San Antonio. The same condition of unusually heavy infestation appeared early in the season in the experiments conducted at Waco, Tex., by Dr. D. A. Saunders, and the same complete cessation of weevil injuries was observed with the advance of drought. Careful examination of several fields of cotton in the vicinity of Waco on August 18 and 19 by Dr. Saunders and the writer showed that no injury was being done by the weevils, though the insects remained active in more luxuriant fields on rich bottom lands of the same district.

Though the conditions of drought that gave the complete protection against the weevils were generally so severe as to interfere seriously with the growth of the plants and would undoubtedly have prevented the development of any considerable crop unless rain had come, the facts are of interest in their practical bearings upon the problem of weevil resistance. The complete cessation of weevil injuries, even after the weevils had survived the winter in unusual numbers and had begun to feed and breed in the buds of the young plants, makes it evident that the highest importance must be placed on the dry weather. The values of special weevil-resisting varieties and of special methods of culture must also be considered as means of gaining greater advantages from dry weather.

EARLY PLANTING IN DRY REGIONS.

The object that has been sought by early planting and by the use of early varieties is to give the cotton an opportunity to set as many bolls as possible early in the season, before the weevils have become numerous enough to infest all the buds and bolls and thus set a limit to the crop. A farmer who plants too late may have his cotton stocked with weevils from fields planted earlier by his neighbors and may suffer more seriously than they.

The best plan would be for a community to plant all of its cotton as nearly as possible at the same date. The date should be selected with a view to securing the most rapid development of the crop, and for this it is necessary that the plants make prompt and continuous growth. The amount of weevil injury is determined by the relation between the development of the cotton and the reproduction of the weevils. Any loss of time on the part of the cotton by delay or interruption of growth can only increase the relative proportion of weevil injury and diminish the crop. Anything that gives the cotton an advantage over the weevils should be taken into account in the problem of weevil resistance, whether the advantage is gained by methods of culture or by specialized characters of the plants themselves. The largest results are to be obtained by combining the cultural and the biological factors.

If each farmer attempts to plant earlier than his neighbors, the product of the community is likely to be reduced, for two reasons: Cotton that is planted too early may be injured so that maturity is retarded instead of being hastened and the weevils bred in early cotton may inflict increased injuries upon the later fields. Cotton that has been severely checked by cold or by extremes of wet or dry weather in the early stages of growth often suffers a permanent injury, either by being stunted in growth or by becoming abnormal in other respects. A smaller crop is obtained and that of inferior quality. And even if no other change of characters takes place, experiments at San Antonio, Tex., in 1906 showed that the checking of the growth of an early planting may render it actually later in the development of its crop than a later planting of the same variety in the same place. Later planting not only secured more cotton, but a larger part of the crop was ripened before a given date, in spite of the fact that the plantings were made side by side, so that the later rows were readily accessible to the boll weevils bred in the early rows.[1]

That the same result would be obtained in all cases is not to be expected, for these experiments were made under dry-weather conditions. But in the season of 1906 the summer drought was not severe enough to stop the reproduction of the weevils, all the plantings being quite seriously infested. The later plantings might have shown still greater superiority if they had been isolated from the early plantings, but in that case there could have been no assurance that other conditions of soil and moisture were the same.

If very early planting could insure a correspondingly early harvest, it might be argued that cotton should always be planted at the earliest possible date, without reference to scarcity or abundance of weevils. But in view of the experiments mentioned above, showing that later plantings may overtake very early plantings and ripen an earlier crop, it is plain that early planting, like any other cultural expedient, must be used with discretion and not carried to an unpractical extreme.

Of course, it is only in regions subject to drought that the weevils can be expected to become less destructive as the season advances, but in the dry regions of southern and western Texas this consideration seems to be of practical importance. Fields planted in May sometimes mature a full crop before being invaded at all by the weevils, even in localities where fields planted in March have suffered quite severely. Though such complete immunity of late plantings from weevil injuries may be of rare occurrence, the fact that good crops are sometimes secured in this way often leads the farmer to take the chance of a late sowing of cotton after a winter crop has been harvested or after some other spring crop has failed. The possibilities of late planting are obviously of much more importance in regions where winter crops can be grown than in more northern localities where the growing season is only long enough for the cotton and winter crops are not used, at least on land that is to be planted to cotton.

A heavy infestation of boll weevils in the early part of the season interferes with the growth of the plants long before the fruiting

[1] See "Local Adjustment of Cotton Varieties," Bulletin 159, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1909, p. 49.

stage is reached. The weevils begin by gnawing the terminal vegetative buds in the spring, before there are any flower buds to feed upon. This hinders growth of the young plants and forces the growth of vegetative branches at the base of the plants instead of allowing fruiting branches to be produced early in the season. Weevil-infested fields of cotton can often be recognized, even at a distance, by changes in habits of growth, before the differences in yield become apparent. Such expedients as the picking of the adult weevils by hand and the poisoning of the leaf buds of the young plants are much more advantageous early in the season, not only in reducing the number of weevils, but in allowing the cotton to make more rapid and normal growth. Yet it is very difficult to determine how much advantage is secured from such efforts, owing to the great variation in seasons and in the abundance of weevils in different fields, or even in parts of the same field.

Drought is more effective in holding weevils in check if the dry weather begins before the cotton plants are large enough to provide the necessary food and shelter for the weevils. If the plants continue to make good growth during weather that is too dry for the weevils to propagate, the crop can be set and brought to maturity without serious damage, even in localities where earlier plantings have suffered severely from the weevils. This explains the very great advantage that is generally to be gained in dry regions by plowing the land in the fall and maintaining the tilth through the winter as a preparation for the planting of cotton, in order to have as much moisture as possible available in the soil and thus enable a more continuous growth to be made during any periods of dry weather that may occur in the early part of the growing season.

With proper attention to the preparation of the land, cotton can be grown even without irrigation in many districts of the Southwest that have been looked upon hitherto as hopeless deserts. The drought-resistant qualities of the cotton plant are only beginning to be appreciated, perhaps because the chief centers of production have been located in humid regions. In localities where small supplies of irrigation water can be developed they can probably be used to much better advantage with cotton than with any other crop. The general danger in irrigated regions is the excessive use of water. The chief obstacle to the extension of cotton culture in the Southwestern States is the scarcity and high cost of labor, but the progress that is being made in the invention of cotton-picking machinery indicates that this limitation may be removed in the near future.

IMPROVEMENT OF QUALITY BY CULTURAL METHODS.

Cultural methods that allow a continuous development of the plants may also help to counteract weevil injuries. Interruptions of growth not only invite greater damage from weevils but injure the quality of the fiber. If the presence of the boll weevil can induce the farmer to adopt better methods of culture, better staples can be produced, so that a lessening of the crop may be compensated by an increase in value. To improve the fiber so as to be able to sell small crops for as much or more than the former large crops would be a very practical method of reducing the losses inflicted by the weevils. Reduced production of long-staple Upland cotton in Louisiana and Mississippi is increasing the demand for superior varieties of intermediate lengths, from an inch to an inch and a quarter. These can be grown in many parts of the cotton belt where only short and inferior varieties are now planted.

With the boll weevil as a further obstacle the tendency is for the careless farmer to give up the culture of cotton, but farmers who adopt the other precautions to make cotton profitable under weevil conditions are likely to take the additional step of adopting better varieties and maintaining the uniformity of their stocks by the necessary selection.

Longer and stronger staples could be produced over a large part of Texas if better varieties were grown and better methods of culture were applied, so that the fiber could be properly ripened instead of growth being suddenly checked by drought and the bolls opened prematurely. Even under conditions of extreme drought it is possible to produce fiber of good quality if the plants are not checked. Though plants that develop under dry conditions may remain very small for lack of moisture, they may still produce excellent lint. This was well shown in experiments at San Antonio, Tex., in 1910. A season of continuous drought produced better fiber than the previous year when the drought was interrupted by a rain at the middle of July. The rain allowed a larger growth of the plants, with larger demands for moisture, but no other rains came to maintain the supply. Though the rain undoubtedly increased the crop, much of the fiber suffered in quality because the plants were checked during the fruiting period and the bolls opened prematurely.

In localities where irrigation facilities exist, even a very limited supply of water could be utilized to great advantage in bringing the cotton crop through to maturity. Where water is to be had in the winter, but without facilities for summer storage, winter irrigation may be practiced as a preparation for the cotton crop, the water being retained in the soil by the same methods of tillage as in dry farming. There is an unfortunate tendency in irrigated districts to apply water to the growing plants too early in the season. The result is to stimulate an undesirable vegetative growth and make the crop late, thus increasing the danger of weevil injuries.

In the drier districts of southern and western Texas the farmer depends more upon the moisture already stored in the soil than upon rain that falls during the growing season. To raise a crop of cotton without any rain on the plants would seem an impossibility in many humid regions, but this can often be done in dry regions if the previous rainfall has been conserved in the soil by proper tillage. Indeed, it is possible to have too much water stored in the soil and thus make the plants too luxuriant, just as it is possible to have too much rain.

Under such conditions there is the less reason to urge the importance of very early planting. In experiments with successive plantings of Triumph cotton at San Antonio, Tex., in 1906, the April and May plantings grew quite as large as the March plantings, showing a practical equality of the available supply of soil moisture, which was the limiting factor in this experiment. The surface of the soil becomes drier as the season advances, so that recourse to previous wetting of the seed or to somewhat deeper planting may become necessary to secure a good stand, but the easier cultivation and greater freedom from weeds in dry weather more than compensate for extra precautions in sowing.

LATER PLANTING IN BLOWING SOILS.

In addition to the loss of moisture and the checking of the plants by weather too cold for growth to be made, early planting increases the danger of the "blowing out" of the seedlings in some of the sandy districts of southern Texas that are otherwise well adapted for cotton. The surface soil may be drifted away and the plants broken down by the wind or the young stems may be actually cut away by the blowing sand. The winds are said to be much more severe as a rule in March than in April, and in districts where this is true it might be better if all plantings could be deferred till the later month. Even though the winds were as severe in April as in March the crop is less likely to be injured if the period of exposure is shortened. It is also easier to keep the soil from blowing before the cotton is planted, by throwing the surface of the field into ridges.

In addition to the possibility of avoiding injury from the wind, the April plantings are likely to have the advantage of more continuous growth. This not only favors an earlier and larger crop, as already explained, but tends at the same time to increase the length and the uniformity of the lint. The proportion of aberrant plants that are likely to appear in a variety of cotton depends to a considerable extent upon whether the plants are severely checked in the early stages of development or make uninterrupted growth.

LIMITATIONS OF LATE PLANTING.

If whole communities could be organized so that all the cotton could be planted at the same time and all the plants destroyed in the fall, so that none would survive the winter, later planting would become more feasible than at present; but other interests of the crop forbid very late planting.

In the northern districts of the cotton belt it is not safe to shorten the season by deferred planting, and even in places where the season is long enough the habits of the cotton plant set limits to late planting. If the weather is too hot during the early stages, the fertility of the plants suffers through a change in the habits of growth. Fruiting branches are not produced so near the ground as in earlier plantings, but are replaced by more numerous upright vegetative branches. With plenty of moisture such plants become large and bushy and produce a late crop, at the mercy of the weevils. Or if dry weather cuts off the supply of moisture the growth of the late plants is checked before the fruiting stage is reached, so that little or no crop can be set.

Under conditions of drought, the tendency to excessive vegetative growth of the young plants may be restricted by lack of water in the surface soil. This is another reason why late plantings are more likely to be successful in seasons when the drought is severe enough to check the multiplication of weevils. Thus at Palestine, Tex., in the season of 1909, some fields of cotton planted in June, after the harvesting of a crop of potatoes, developed normally and gave larger yields than neighboring fields planted much earlier, in April or May. In a wet season such late plantings might be a complete failure. The fruiting stage would probably not be reached until the weevils had time to multiply and destroy the whole crop.

Varieties differ in the readiness with which their characters are changed in response to differences of cultural conditions, some being more suitable for late planting than others. The tendency to deferred fruiting and to the production of excessive numbers of vegetative branches is still stronger in the Egyptian cotton than in the Upland series of varieties. Early planting of Egyptian cotton has been found necessary in Arizona as a means of controlling the growth of the plants, though no weevils exist.

Planting too late also interferes with the early destruction of the stalks, a most desirable measure for reducing the number of weevils that survive the winter. The earlier this work can be done the more successful it is likely to be, for the principal object is to deprive the weevils as early as possible of food and of facilities for breeding. If this work is postponed until the plants are killed by frost, much of the advantage of removing the stalks is lost, though it may still be very important to destroy the unripe bolls, which sometimes carry many weevil larvæ through the winter. In some districts the pasturing of the cotton fields in the fall is very useful, for the cattle eat the buds and green bolls with the weevils and larvæ that might otherwise be left in the fields.

Another factor that tends to limit late planting in Texas is the prevalence of root-rot. As the attacks of this disease are often deferred till the latter part of the season, the plants that are killed may not represent a total loss. Some of their bolls may be ripe before the plants are killed, and the remainder are opened prematurely by drying, so that the lint, though often weak and worthless, can be picked and sold with the rest of the crop. In some parts of Texas fields are often seen with half the plants dead from root-rot before the middle of September, though half or three-quarters of the crop may be already mature. If the crop were to be deferred by late planting, root-rot injuries might involve a total loss. In such cases the root-rot, rather than the boll weevil, may be said to determine the necessity for early planting.

RELATION OF DROUGHT TO WEEVIL-RESISTANT HABITS OF GROWTH.

Recognition of the importance of dry weather brings a new factor into the question of weevil-resistant habits of growth. If it be considered a matter of first importance to lessen the number of weevils that go into hibernation in the autumn, it appears to be essential to use the earliest and most determined varieties, so that the crop can be completed at the earliest possible date, and thus leave the weevils without opportunity to breed for as long a period as possible before winter. It happens, however, that some of the best of the early varieties, such as the Triumph cotton of Texas and the Kekchi cotton of Guatemala, have low, compact habits of growth that undoubtedly tend to interfere with the beneficial effects of dry weather in killing the weevil larvæ. Fallen squares are much more effectively shaded by a low, compact plant than by one that bears its foliage farther up so that all of the ground under the plant is exposed directly to the sun during at least a part of the day. Plants that stand well up from the ground and allow the sun to reach and dry out the fallen squares and kill the weevil larvæ are able to secure in this way a distinct advantage over the low, compact plants that shade the fallen squares and protect them from the dry winds.

Many of the experimental plats at San Antonio in 1909 consisted of Triumph cotton. The low, compact form of the plants was well calculated to shade fallen buds lying under them, though even in such buds the weevils did not appear to prosper under conditions of very extreme drought. But an adjacent planting of a newly acclimatized Mexican type of Upland cotton gave much less shelter for the weevils. No leafy branches were developed at the base of these plants until after fruiting had begun, so that the early foliage was borne well up from the ground.

This Mexican variety had not been supposed to have any specialized weevil-resisting characters, although it had given very favorable results under weevil conditions. The contrast in behavior between this variety and the Triumph was very striking, the Mexican cotton having much less tendency to put out branches from the lower joints of the stem.

Partly as a result of later planting and partly because of its different habits of growth, this cotton continued to develop slowly during the dry weather of May and June and was ready when rain finally came in July to put on very quickly a good crop of bolls. The tendency to ripen all of the bolls at one time has been shown in several other experiments and is to be reckoned as a very desirable characteristic of this type of cotton. It lessens the labor of picking and allows the fields to be cleaned of the old stalks early in the fall.

The behavior of this Mexican type of cotton may be contrasted in many ways with that of the Kekchi cotton from Guatemala. The Kekchi cotton has several definite weevil-resisting adaptations not possessed by the Mexican cotton, such as hairy stems and leaves that restrict the movements of the weevils, large, hairy, well-closed bracts that impede the access of the weevils to the young buds, and long pendent or creeping basal branches, the buds and bolls of which are seldom attacked because of the strong instinct of the weevils to climb up the plants instead of remaining on the lower branches or crawling downward. But in southern Texas, where most of the experiments with cotton have been made, some of the weevil-resisting characters have cultural disadvantages. Although the lower branches often continue to produce buds and bolls long after the weevils have halted all the other types of cotton, the additional bolls are borne so near the ground that they are often soiled by blowing sand or muddied and rotted by rain. Bolls produced underneath the plant often rest on the ground and are also subject to mildew and other diseases. An attempt is being made to avoid these disadvantages by selecting more erect forms of the Kekchi cotton that carry their bolls clear from the ground and thus enable the several desirable features of this type of cotton to be utilized. In addition to the weevil-resisting characters, some of the acclimatized strains of the Kekchi cotton have shown themselves very early and productive, and with lint of good Upland quality.

It is easy to understand that a variety with a rapid-fruiting habit like the Mexican cotton would be even more likely to have definitely determinate growth than an early-flowering variety like the Kekchi. The small size of the plants of early varieties may be ascribed to the fact that vegetative growth is less rapid after fruiting commences and if dry weather ensues an extra early variety may mature and cease to grow even under the same conditions that permit another variety with later fruiting habits to continue its development. Determinate habits of growth, like other desirable things, may be carried to excess. If selection for earliness be directed solely to the question of early flowering or early opening of bolls the effect on yield may be adverse. Very early flowering or very early opening of some of the bolls is not in itself a guarantee of the practical weevil-resisting value of a variety. Varieties that flower very early may develop more slowly or attain a precocious maturity if exposed to dry weather or to other unfavorable conditions that interrupt the growth of the plants.

IMPORTANCE OF DRY WEATHER IN HUMID REGIONS.

In cooler and more humid regions the importance of the drought factor must of necessity decline. Unless the weather is hot and dry enough to interfere with the propagation of the weevil larvæ, the direct advantage secured from drought in a dry climate is not obtained. A humid climate with heavy dews may allow unimpeded development of weevils, even in the absence of rain. Yet there is a very important indirect advantage in a period of dry weather, even though the conditions are not severe enough to destroy the weevils. Too much moisture interferes with the development of the cotton plant, either by stunting its growth or by causing the shedding of buds and young bolls. In a district where there are no weevils such a shedding may do little damage, for the plants continue to produce buds and can soon replace the loss, but with the weevils present the loss of the early crop by shedding becomes a much more serious matter.

In a continuously humid climate the early buds must be expected to furnish the crop, for all the later buds are likely to be destroyed by the weevils. There must be no delay in the development of the cotton if a crop is to be set before the insects become destructively numerous. The closer the race becomes between the cotton and the weevils, the more important it is that the plants lose no time in development and that the crop receive no setback by the shedding of buds or bolls. Every precaution that favors the quickest possible development becomes worthy of careful consideration, such as the planting of the cotton in dry, well-drained soil, thorough preparation and cultivation, and the application of fertilizers.

One limitation must be recognized in all such efforts. It is possible in some regions to stimulate the cotton into an excessive vegetative growth, and thus defeat the object of securing an early crop. If the plants make too rank a growth at first, fruiting is likely to be deferred, the lower fruiting branches being replaced by vegetative limbs.[1]

DIFFERENT TYPES OF EARLINESS IN RELATION TO WEEVIL RESISTANCE.

The ideal form of earliness for varieties that are to be grown in humid regions is not extreme precocity in showing the first flowers or the first ripe bolls, but the production of the crop as rapidly as possible after fruiting begins. Even the early varieties are not so early in humid regions as in dry, for abundance of moisture conduces to more vigorous vegetative growth and to the production of vegetative limbs near the base of the plant instead of fruiting branches. In a continuously humid region an early-fruiting variety would have no advantage over one that began to fruit a little later unless the later variety were attacked by weevils bred on the early variety, in case both were planted in the same locality.

If all the cotton in a humid district began to bud and blossom somewhat later but had the rapid-fruiting habit, it would have two advantages over an early-fruiting variety in relation to the weevils. A smaller number of weevils would survive until the late variety began to fruit and the late variety would be able to set the same amount of crop in a shorter period, after it had once begun to fruit. Late varieties that differ from early varieties in completing a larger amount of vegetative growth before they begin to fruit should be able to produce fruit more rapidly after fruiting has once begun.

Rapid fruiting, rather than early flowering or early opening of bolls, represents the most effective form of weevil resistance under conditions of continuous humidity. Other things being equal, there is more reason to expect fruiting to go on rapidly in varieties that begin to bud and flower rather late than in those that flower very early. A variety that begins to flower very early is likely to require more time to produce the same number of bolls than a later flowering variety. The relatively small size of the plants of all the early-flowering types may be taken as evidence that the very early production of fruit tends to check vegetative growth. In other words, earlier flowering may lead to slower fruiting, if account be taken of the total number of bolls or the quantity of cotton ripened within a given period.

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[1] See "Dimorphic Branches in Tropical Crop Plants," Bulletin 198, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911.

A later date in flowering is not to be reckoned as a lessening of weevil resistance if a variety sets its fruits with sufficient rapidity after flowering has begun. Until the flower buds are about half grown the weevils can not begin to reproduce. The rapidity with which bolls are developed within a specified time after the buds are large enough to allow the weevils to begin to breed would serve as a measure of weevil resistance in experiments with varieties in humid regions. It is important to establish such standards and to apply them to all varieties that are to be grown under weevil conditions, whether the weevils are already present or not.

In attempting to determine the rate of setting of the crop in different varieties, special precautions must be used. It is not sufficient to compare the yield in early pickings, for this will give an undue advantage to the factor of early opening in small-bolled varieties. Neither is it sufficient to determine the tendency to fruit production by the daily counting of flowers on experimental rows or plats representing the different varieties. Allowance must be made for the fact that a big-boll variety does not need to produce as many flowers in order to set the same amount of crop in the same number of days as a small-boll variety. Daily countings of the numbers of flowers on adjacent rows of different varieties may also be rendered unreliable by differences in shedding, some varieties dropping their buds and young bolls much more readily than others.

The counting of the full-grown bolls at different dates would give an indication of the crop-setting habits if there were any ready means of determining when the bolls have reached full size. For the most accurate determination it would be desirable to make counts of the bolls as fast as they became large enough to escape weevil injury, though it would still be necessary to take into account the differing amounts of cotton represented by the same numbers of bolls of different varieties.

It may be that the rapidity with which the bolls are opened corresponds to that with which they are set, but there is no definite information on this point. It has been noticed in some plantings of Mexican cotton that the bolls seemed to open more nearly together than those of the Triumph cotton and other United States Upland varieties grown in the same places. The rate of opening of the bolls depends very largely on the weather at the time when the bolls reach maturity, but these experiments were made under dry conditions, with equal opportunities for opening.

It was generally assumed at first that small-boll varieties must have a distinct advantage in weevil resistance because of earlier flowering and earlier opening of the bolls. Large importations of seed of the King and other small-boll varieties from the Carolinas were brought in to replace the Texas big-boll sorts in weevil-infested districts. Nevertheless, the small-boll cottons have not gained any general popularity in Texas, most farmers having returned to the native big-boll varieties. Additional familiarity with the factors that determine production under weevil conditions makes it possible to understand why the big-boll varieties do not show any such serious disadvantage in weevil resistance as at first expected.

The larger bolls require longer periods for full development, but during most of the time they are beyond the danger of weevil injury. The growth of the bolls continues longer after the crucial stage of weevil infestation has been reached. A big-boll variety that could produce as many flowers and set as many bolls in the same number of days as a small-boll variety could yield a larger crop in proportion to the increased size of the bolls, or larger bolls may make up for a deficiency in the number of flowers. The few observations that have been made do not indicate that big-boll varieties fall very seriously below the small-boll sorts in their rates of flowering and boll setting. The production of flowers and young bolls may not make larger demands on a big-boll variety than on a small-boll type. If the weevils are to prevent any further boll setting after a certain date, a big-boll variety has the advantage of being able to produce more cotton in each of the bolls that reaches maturity.

In districts where the season of growth is very short, early opening of the bolls may be necessary to avoid the danger of frost, but in a large part of the cotton belt the lapse of a few more days before the bolls begin to open is not to be considered as a serious disadvantage and is not likely to outweigh the stormproof qualities, easier picking, and other desirable features of the big-boll varieties. It is quite possible that the Texas big-boll type of cotton may be found less satisfactory in humid regions and that special selection may be necessary under the new conditions to establish local strains with uniform expression of earliness and other desirable characters. In the drier regions of central and southern Texas, where the growth of the plants is usually limited by drought, the same general tendency to early fruiting appears in the big-boll and small-boll types, but greater differences may be shown where more abundant moisture provides for more luxuriant growth.

IMPORTANCE OF RECOGNIZING FACTORS OF WEEVIL RESISTANCE.

Too much stress can be laid upon early varieties as well as upon early planting, because both these factors lose in effectiveness if pushed to extremes. Cotton planted too early may develop more slowly than cotton planted later, and varieties that begin fruiting too soon may take longer to develop a full crop. These considerations are well-nigh self-evident when once pointed out, especially when viewed in relation to the dry-weather factor. If the benefits exerted by dry weather are ascribed to early planting alone there is danger that the farmer may rely too much upon the date of planting and fail to appreciate the still greater importance of tillage and other means for securing an uninterrupted development of the crop.

That the production of cotton has been maintained in Texas has been taken generally to mean that the weevil menace was exaggerated. This may be true to the extent that the susceptibility of the insect to dry weather was not at first appreciated. In some localities the first seasons of weevil infestation were unusually wet. The destruction wrought by the weevils in the wet seasons was expected to continue every year, and the very existence of the cotton industry seemed to be threatened. At present the tendency is rather to the other extreme of optimism, on the assumption that the same results are to be expected over the whole cotton belt as in Texas. Such reasoning may prove erroneous, especially in regions that are subject to continued rain or damp weather in the early part of the growing season. Continued wet weather is always unfavorable to the cotton crop, no matter how satisfactory the other conditions may be. The losses occasioned by wet weather become the more serious if weevils are present to prevent the setting of any later crop of bolls.

In many cotton-growing districts the soils are so heavy and adhesive that the fields can hardly be entered for two or three days after each rain. In localities where the soils are varied much can be gained by choosing the driest and best drained land for cotton, but rain may still interfere with the cultivation of the fields and prevent the gathering of the weevil-infested squares.

Even in places where good yields can be obtained in favorable seasons the growing of cotton may become unpopular if the crop becomes too precarious. In the more humid sections of the coast belt of Texas, for example, some of the most progressive farmers consider the future of cotton culture as doubtful. Those who have been careful to clear their fields and destroy their stalks early in the fall and give their land good preparation and tillage have found it possible to raise good crops of cotton in spite of the weevils. In other seasons, when too much rain interfered with cultivation and the plants grew too large and shaded the ground before the bolls were set, the crop was seriously reduced or became a total loss. Nevertheless, the prevailing high prices have encouraged the taking of larger chances on the cotton crop, even by farmers who previously declared their intention of abandoning cotton altogether.

EARLIER LONG-STAPLE VARIETIES.

The practical questions of weevil resistance vary in different regions, like other cultural problems. In the Texas short-staple districts an immediate advantage was obtained by the use of earlier short-staple varieties. In long-staple districts the need of earlier varieties is still more acute. The introduction of the early short-staple varieties into the long-staple districts is not calculated to preserve the long-staple industry. There can be little doubt that the difficulty of producing the long staples is increased by the growing of the short-staple varieties in the same neighborhood. More weevils are bred early in the season in the short-staple fields. There is also more danger of admixture of the long-staple with the short-staple varieties, either by cross-fertilization in the fields or by the mixing of seed at the public gins.

Even before the weevils came, the manufacturers complained that the long-staple varieties were deteriorating, because the fiber was becoming less uniform. This has been ascribed to the fact that more and more of the ginning has been done in recent years at large public gins where the seed of the whole community becomes mixed, instead of at the smaller private plantation gins which gave much less opportunity for such admixture. If the long-staple varieties continue to decline in uniformity at the same time that the yield is being cut down by the presence of the weevils, there is less prospect of an ultimate survival of the long-staple industry.

The need of quick-fruiting long-staple varieties has been recognized in advance in the cotton-breeding work of the Department of Agriculture. Two such varieties have been developed and distributed, the Columbia cotton, originated by Dr. H. J. Webber, in South Carolina, and the Foster cotton, bred by Dr. D. A. Saunders for the Red River Valley of Louisiana and northeastern Texas. These varieties are not only distinctly earlier, but are also more productive than the older long-staple sorts. In their habits of growth they are much more similar to short-staple Upland varieties and they seem to yield at least equally well. Some of the Columbia cotton raised in the season of 1910 has been reported as selling as high as 24 cents a pound. While this price may be considered exceptional, there can be no doubt that a very general increase in the value of the cotton crop could be secured by replacing the present short and variable stocks with such varieties as the Columbia and the Foster.

The early-maturing characteristics of these varieties give them almost the same advantages of weevil resistance as the early short-staple varieties that are now being grown in former long-staple districts. The chief difference is that prolonged drought is a greater danger to the long-staple crop than to short staples. The difference is not so much in the ability of the plants to withstand dry weather as in the requirement of continuous growth, if uniform length and strength of fiber are to be secured. If the growth of the plants be checked during the fruiting season, shorter and weaker fiber is the result and the whole crop is injured by the lack of uniformity. The higher requirement of uniformity limits the production of long-staple cotton to districts where the soil moisture is adequate or is supplemented by irrigation. The irrigation facilities being developed in many localities in southern Texas may make it possible to extend the cultivation of long-staple varieties to a new region.

It remains to be seen whether cotton-growing communities can be organized to take full advantage of early long-staple varieties that have been developed. The size of the crop and the uniformity of the product may both be increased if whole communities, instead of scattered individual planters, can devote their time to the production of long-staple varieties. The preservation of the necessary uniformity of the long-staple varieties will become much easier if no short-staple types of cotton are grown in long-staple communities. The deterioration of varieties through cross-fertilization in the field and by the mixing of seed at gins can both be avoided in well-organized communities that limit themselves to one superior variety of cotton.

DIFFICULTY OF DIRECT TESTS OF WEEVIL RESISTANCE.

One of the chief obstacles in the study and general application of the factors of weevil resistance lies in the great difficulty of making any comparative tests that will definitely determine the actual values even of factors that have obvious practical importance. It is not reasonable to disregard these factors because of the difficulties of testing them. Fortunately there is no possible conflict between the cultural methods that are advised for purposes of weevil resistance and those that are calculated to secure maximum production, even without weevils.

In the case of early and late varieties the planting of the two side by side is likely to give an exaggerated idea of the benefits of earliness. It is certainly to be expected that a row of late cotton will suffer much more by being planted next to an early row infested with weevils than if there were no early cotton in the neighborhood. But if the plantings are made in separate fields to avoid the danger of weevils from adjacent rows, the equality of other experimental conditions can not be assured. Differences of yields at the end of the season can not be ascribed with any confidence to weevil differences alone. The soil may differ in fertility or in the content of moisture and cause wide fluctuations of the crop, even in regions that have no weevils. All other considerations are likely to be overshadowed and forgotton when the weevils are at hand. Nor does the use of isolated fields give any assurance of equality in the numbers of weevils. Even in parts of the same field the extent of damage from weevils usually shows wide variations, often 50 per cent and upward, especially in the early parts of the season before the period of total infestation is reached.

The planting of the two kinds of cotton side by side insures unfair conditions for the late cotton by breeding an extra supply of weevils close at hand. But if the experiment is made in isolated fields the usual inequalities of infestation may give an unfair advantage to either planting.

A field of late cotton planted by itself might appear at no such disadvantage in relation to weevil injury as would be expected from experiments with early and late rows planted close together. As a matter of fact, it often happens that a late-planted field suffers less from the weevils than fields a mile or two away that were planted a month or six weeks earlier.

But as soon as we begin to compare the different fields more in detail it becomes apparent that many other elements may modify our conclusions. More fertile soil or more favorable temperatures that enable the plants to make more rapid and uninterrupted growth may be the cause of a larger yield, instead of any particular factor of weevil resistance that might have been under investigation and that might have very definite importance in another case. In short, the problem of weevil resistance is not to be separated from other complex cultural problems. The factors of weevil resistance have to be studied and applied from the standpoint of the local conditions that determine the choice of varieties and methods of cultivation.

CONCLUSIONS.

The presence of the boll weevil introduces another factor of uncertainty into problems of cotton production in addition to the usual differences of soils and seasons. The effects of special methods of culture and the special characteristics of varieties should be taken into account in attempting to grow cotton in weevil-infested regions.

Weevil-resisting characters and methods of cultivation are more useful in dry regions or in dry seasons, because the propagation of the weevils is less rapid and the weevil-resisting factors are effective for longer periods. In dry regions the same factor that restricts the growth of the plants also tends to prevent the propagation of the weevils. In humid regions, on the other hand, the growth of the plants may be impeded by wet or cloudy weather that does not restrict the propagation of the weevils.

Wet weather not only favors the rapid multiplication of the weevils, but also interferes with the application of cultural expedients for avoiding weevil injury. Even the weevil-resistant characters of earliness, quick fruiting, and determinate habits of growth are likely to diminish or to disappear when the plants are grown under extreme conditions of heat and humidity.

Smaller injuries from weevils lend a relative advantage in dry regions and in dry seasons. It is not safe to assume that improved cultural methods, earliness of varieties, or special weevil-resisting characters will have the same value in humid regions that they may have shown in dry seasons in Texas. In the absence of the limiting factor of drought, it is not safe to apply the analogies drawn from Texas to the more eastern States.

The problem of weevil resistance is especially acute in the humid bottom lands of Louisiana and Mississippi, the chief centers of production of the long-staple Upland varieties. Every possibility of weevil resistance in the long-staple district is worthy of careful investigation, because special conditions of soil and climate make it possible to produce superior grades not generally obtainable in other parts of the cotton belt.

Earlier maturing long-staple varieties that have been bred in the United States or acclimatized from abroad may replace the present long-staple varieties whose late-maturing habits render them more susceptible to injury by the boll weevil, especially when grown in the same localities with early short-staple varieties.

Two additional measures of weevil resistance are also worthy of careful consideration in humid regions, the development of quick-fruiting long-staple varieties and the better organization of cotton-growing communities so that only one type of cotton shall be grown in the same locality.

While the use of early-fruiting varieties and the early planting of the crop are important in avoiding weevil injuries, both of these policies have distinct limitations. Very early varieties may be relatively unproductive, and too early planting may check the growth of the seedlings, delay their development, and postpone the fruiting period. The chief object is to secure the most rapid setting of a good crop rather than the earliest opening of flowers or bolls.

The early production of flowers or of ripe bolls does not prove that a variety has the most effective form of earliness for purposes of weevil resistance, especially if this precocious fruiting tends to restrict the growth of the plant. Rapidity of fruiting after fruiting has once commenced is more important than absolute earliness, as shown by the dates of the first flowers or the first open bolls. The setting of a crop of bolls in the shortest time after the flower buds begin to appear is the ideal form of earliness from the standpoint of weevil resistance. This requirement of rapid fruiting should be taken into account in the breeding of weevil-resistant varieties, as well as in devising improved methods of culture for weevil-infested regions.

As the weevils are restricted for food to the pollen of the cotton plant and are unable to begin to breed until the production of flower buds has begun, breeders of new varieties for weevil conditions should consider that plants may gain rather than lose if the formation of fruit buds can be deferred till the roots and other vegetative parts have made considerable progress, especially if this preliminary growth allows the more rapid formation of fruit buds when fruiting has once commenced.

Though later flowering varieties might appear to suffer more from the weevils than the early-flowering varieties if the two were planted side by side, the true agricultural value of a late-flowering variety would not be settled by such an experiment. It is obvious that somewhat later flowering would not be a disadvantage if it shortened the period of setting the crop. Nor would a somewhat later opening of the first bolls be undesirable, especially if there were a tendency for the whole crop to open more nearly together.

The practical value of rapid-fruiting long-staple varieties would also be increased if they were planted by whole communities. The exclusion of earlier short-staple varieties might be expected to give the long-staple varieties less exposure to weevil injuries, and at the same time it would help to maintain the uniformity of the crop by avoiding cross-pollination by bees and admixture of seed in public gins.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 221.

B. T. GALLOWAY, *Chief of Bureau.*

DIMORPHIC LEAVES OF COTTON AND ALLIED PLANTS IN RELATION TO HEREDITY.

BY

O. F. COOK,

Bionomist in Charge of Crop Acclimatization and Adaptation Investigations.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., April 28, 1911.

Sir: I have the honor to transmit herewith a paper entitled "Dimorphic Leaves of Cotton and Allied Plants in Relation to Heredity," by Mr. O. F. Cook, Bionomist in Charge of Crop Acclimatization and Adaptation Investigations of this Bureau, and to recommend its publication as Bulletin No. 221 of the Bureau series.

Numerous agricultural applications of the facts of dimorphism have been described in Bulletin No. 198 of this Bureau, entitled "Dimorphic Branches in Tropical Crop Plants: Cotton, Coffee, Cacao, the Central American Rubber Tree, and the Banana." The present paper reports additional information regarding the dimorphic characters and variations of cotton and other plants and points out their relation to problems of heredity and breeding. It is believed that more definite knowledge of the characters and habits of growth of our cultivated plants will be of assistance in many lines of agricultural investigation.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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DIMORPHIC LEAVES OF COTTON AND ALLIED PLANTS IN RELATION TO HEREDITY.

INTRODUCTION.

Parallel series of variations in the forms of the leaves can be traced through numerous species of cotton and also in other genera of Malvaceæ, such as Hibiscus, Abelmoschus, and Ingenhousia. The parallel variations appear as characters of different cultivated varieties and are also represented by dimorphic specializations of leaf forms in different parts of the same plant.

Though this class of variations has received little attention hitherto, the facts are of interest in relation to general questions of heredity and to the practical problems of breeding superior varieties and maintaining their uniformity by selection. Recognition of dimorphism of the leaves and branches in cotton and related plants enlarges the range of characters that may be used in distinguishing varieties and in determining the influence of environment upon the expression of characters.

The cotton plant affords unusually good opportunities for the study of environmental modifications, but it is essential that the characters and habits of the various cultivated forms be well known if the differences of behavior in different conditions are to be correctly understood. Studies of environmental differences or of correlations of characters that do not take into account the normal diversity in the structure of the different parts of the plant may give very misleading results.

Though different kinds of leaves or branches represent very definite facts of heredity, yet the expression of such characters can be influenced by external conditions. Thus it has been found that new conditions may seriously disturb the expression of characters in the cotton plant, even to the extent of a complete suppression of the fruiting branches, so that the plants remain completely sterile, although showing a high degree of vegetative vigor. The behavior of such plants may be compared with that of sterile hybrids. In both cases there is a failure to bring the full series of normal characters into expression.[1]

[1] Cook, O. F. Dimorphic Branches in Tropical Crop Plants: Cotton, Coffee, Cacao, the Central American Rubber Tree, and the Banana. Bulletin 198, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911, pp. 18–27.

For the purposes of the selection that has to be maintained in order to keep a superior stock in a condition of uniformity, it is quite as important to recognize varieties by the characters of their leaves and branches as by those of the bolls and seeds. Indeed, selection by vegetative characters can be made even more efficient than selection by fruit characters because it enables degenerate variations to be recognized and removed early in the season, thus avoiding the danger of spreading inferior characters through cross-pollination.[1]

Selection is our means of keeping undesirable characters from coming into expression, but it does not prevent the transmission of such characters. Even though all the lines of descent that show tendencies to the expression of undesirable characters be rejected, the possibilities of such expression remain in the other lines and are likely to be reawakened if selection be relaxed. One of the most important problems in the selective breeding of cotton and other seed-propagated field crops is to make selection more efficient by more adequate knowledge of the characteristics and behavior of the plants, so that deviations from a type can be more easily recognized and removed from the stock and the exciting causes of such deviations avoided.

DIMORPHISM A PHENOMENON OF ALTERNATIVE EXPRESSION.

The most important of the general facts or principles of heredity that may be illustrated by the phenomena of dimorphism is the fundamental distinction between expression and transmission. Unless this distinction is appreciated it is impossible to understand the measures of selective breeding that are required to preserve the uniformity and maintain the agricultural value of superior varieties of cotton and other seed-propagated crop plants. Many efforts are being made to solve the problem of heredity by seeking in the protoplasm of germ cells for microscopic organs or mechanisms that are supposed to transmit the characters from the parents to the offspring. While the discovery of such a mechanism would be of great scientific interest, the facts of heredity that promise to be of most value from the standpoint of agricultural application are facts of expression. Even without determining the mechanism of transmission it is possible to investigate the effects of breeding and environment upon the expression of characters.[2]

The doctrine elaborated by Weismann that there is a fundamental distinction between the germ plasm and the protoplasm of the somatic or vegetative tissues has doubtless tended to prolong the

[1] Cook, O. F. Cotton Selection on the Farm by the Characters of the Stalks, Leaves, and Bolls. Circular 66, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911.

[2] Cook, O. F. Transmission Inheritance Distinct from Expression Inheritance. Science, n. s., vol. 25, 1907, p. 911.

confusion of the facts of expression with those of transmission. The phenomena of inheritance have been supposed to center exclusively in the germ cells, the assumption being that all the characters that are to be shown in the adult are determined beforehand in the germ cells. The facts of dimorphism suggest that the phenomena of heredity and breeding can be studied in the vegetative parts of the plants as well as in the floral or reproductive organs or in the protoplasmic mechanism of the germ cells.

The production of a succession of different kinds of internode individuals by vegetative propagation shows that characters may be brought into expression and then suppressed and replaced by other characters without the necessity of new conjugations to form new germ cells. In all the higher plants the expression of the characters is changed repeatedly during the growth of each individual. This may be one of the reasons why the processes of heredity appear to be more susceptible to environmental influences in plants than in animals.

That the leaves and other vegetative parts of many plants do not have the power of regenerating or bringing the characters of the other parts into expression does not demonstrate a fundamental difference between the germinal and somatic protoplasm. In some plants, such as the Begonia, it is evident that all of the tissues inherit all of the characters, since new plantlets are able to bud out freely from the leaf blades, petioles, and stalks.

In Bryophyllum also young plantlets are produced from the leaves, but only from particular points along the margins instead of from the whole surface of the leaf. But even with the most definite limitations of expression there may be evidences of complete transmission. Thus lateral branches of coffee, though apparently quite unable to produce upright shoots from vegetative buds, are certainly able to transmit all the characters of the species, for all the fruit is produced on the lateral branches.

If there were a complete correspondence between expression and transmission, so that the transmitted characters of a variety could be fully known from a single individual or from a generation of uniform individuals, the characters of a pure-bred uniform variety might be expected to remain fixed for all time and further selection would be entirely unnecessary, as assumed in some theories. But in reality no such permanent uniformity has been found to exist. No refinement of the breeder's art establishes an unchanging expression of characters in any seed-propagated plant, or even in those that are increased by vegetative propagation. It is easy to understand that selected strains of wheat or other plants adapted to self-fertilization may show greater and more permanent uniformity than varieties of cross-fertilized plants like cotton and corn, but the idea of an absolutely fixed or constant expression of characters does not accord with the facts of biology.

The successive formation of the different organs of the plant represents a series of changes in the expression of the characters, often as definitely contrasted as differences between varieties or species. Even in purely vegetative organs like the leaves specialized dimorphic changes of expression may be established in some species, instead of more gradual or continuously varied changes that appear in related species or even in other varieties of the same species.

In the study of heredity, as in many other fields of scientific exploration, there is a tendency to give special values to evidence drawn from remote or difficult sources and to overlook the significance of familiar facts or of those that are capable of easy and direct observation. Yet it must be recognized that any underlying principles or general facts of heredity that are to be of practical use must have relation to readily visible external characteristics of our most familiar domestic animals and plants. The more familiar the facts, the more ready and reliable should be the interpretation, were it not for the greater interest generally secured by more remote and more doubtful considerations.

Though some of the facts described in this paper may not have been previously recorded in connection with the cotton plant and its relatives, similar facts are common enough in other genera and families of plants. The dimorphic leaves and branches of cotton and other related plants do not represent extreme types of specialization, but this may give them the greater interest from the standpoint of heredity because of the intermediate position between the more definite and less definite forms of alternative inheritance.

It is usual to think of plants as simple individuals, but in reality they are compound individuals built up by the association of many individual internodes or metamers, each of which may be capable of an independent existence. The internode individuals are not all of one kind. In addition to the specialization of some of them as floral organs definite differences are often to be found among the vegetative metamers. The fact that many plants seem to lack definite specializations among the vegetative internodes only renders such peculiarities the more interesting when they occur, for they throw another light on the facts of evolution and heredity.

The development of any individual plant may be viewed as a progressive change of expression of characters, the juvenile characters giving place to the adult, but the changes are generally so gradual as to suggest no analogy with the Mendelian form of definitely contrasted alternative inheritance. Abrupt changes from juvenile to adult forms of foliage have long been known in such cases as junipers and eucalypts, but these have not been considered as of the same nature as the contrasted inheritance of Mendelian characters. In the case of the cotton and Hibiscus, however, it appears that Mendelian relations exist in characters that are also subject to abrupt change during individual development. Mendelian inheritance is associated with other contrasted changes in the expression of characters. The same characters that show contrasted expression in Mendelian hybrids may be as definitely contrasted, in related plants, in the growth of each individual. Mendelism, like the dimorphic differences, may be looked upon as representing alternative expression of characters instead of alternative transmission.

ABRUPT CHANGES OF LEAF FORMS IN HIBISCUS CANNABINUS.

A very pronounced example of dimorphism of leaves was observed in Egypt, in May and June, 1910, in *Hibiscus cannabinus*, the so-called Deccan or Ambari hemp, a plant commonly grown along the borders of cotton fields. The object of planting the hemp with the cotton is to avoid the injuries of the plant lice, which are usually severe on the more exposed margins of the fields. Though the hemp plant is a rather close relative of the cotton, it is much less susceptible to the attacks of the insects and grows up more rapidly. The cotton field is protected against the drier outside air that might otherwise enable the plant lice to destroy the outer rows. Moreover, a bast fiber extracted from the Hibiscus is made into a coarse cordage used for many agricultural and domestic purposes.

Variations of leaf forms in the hemp plant show a curious parallel with cotton. In addition to the entire or very broadly lobed leaves comparable to those of ordinary Upland varieties of cotton, there are other varieties with deeply divided narrow leaves, like the so-called "okra" varieties of cotton in the United States, and some with leaves parted to the base into narrow digitate segments, a condition also known in some of the tropical varieties of cotton. (Pls. I, II, and V.)

Further similarity was found in the fact that the Egyptian variety of *Hibiscus cannabinus* with the lobed leaves produced entire leaves at the base of the stalk, as also happens with the narrow-lobed "okra" varieties of Upland cotton. The Hibiscus leaves show a very abrupt transition from the broad, simple form of leaves on the lower part of the stalk to the narrow, deeply lobed form on the upper part (fig. 1); this abrupt change in the characters of the leaves seemed the more worthy of notice on account of the fact that Mendelian segregation of the broad and narrow forms of leaves has been found to occur in the second generation of crosses between varieties of cotton representing two corresponding types of leaves. The hemp plants with the two kinds of leaves represent a segregation of characters among the internode members of the same plant.

The leaves of the upper part of the stem are all deeply lobed, while those of the lower part are without lobes. The transition is usually quite abrupt, though the leaves that are close to the transition are often slightly different from others of the same class. A premonition of the change may be found in the larger marginal teeth of the last of the undivided leaves (fig. 2), or the last simple leaf may have a prominent angle on one or both sides (fig. 3). A more definitely intermediate condition appears when a leaf is divided on one side

FIG. 1.—Growing tips of stalks of *Hibiscus cannabinus*, showing changes from simple to lobed leaves. (Natural size.)

but not on the other. (See Pl. II.) In such cases there is usually a very pronounced difference between the two sides of the leaf, so that the change from the entire to the lobed condition is still quite abrupt in comparison with the very gradual changes shown in many plants in passing from the large basal or radical leaves to those of the upper part of the stalk.

Specimens to illustrate the abrupt nature of the transition from the entire to the lobed form of leaf (Pl. I) were taken quite at random, except for the necessity of seeking plants that had uninjured leaves at the nodes where the transition took place. Many of the leaves were badly mutilated by the bites of insects. It was also necessary to search a little farther to find examples of more gradual transition from the entire to the divided state. (See Pl. II.)

Those who prefer mathematical statements of such facts might measure the depths of the incisions of the leaves and construct curves or other numerical expressions of the differences of form, but the nature of the differences is apparent in the photographic reproductions. It is evident from the abruptness of the transition that curves representing measurements of the divisions of the leaves would show two very distinct and well-separated modes, quite as distinct as those that would represent the expression of contrasted characters in cases of Mendelian segregation in the second generation of a hybrid.

FIG. 2.—Four leaves from successive internodes of the same stalk of *Hibiscus cannabinus*, showing slight differences among the simple leaves and abrupt change to the divided form. (Natural size.)

It is difficult to imagine that any practical advantage can be secured by the plants by changing the form of the leaves thus abruptly part way up the stalk. Yet it is possible that the different forms of the leaves may be connected with the fact that there is a difference of function among the internodes of the stalk. The internodes of the upper part of the stalk produce fruit or fruiting branches, while those of the lower part do not. Some of the lower internodes of the cotton stalk give rise to large vegetative limbs with the same functions as the stalk, while other internodes produce only small abortive branches or none at all. Several of the barren internodes usually intervene between the highest of the vegetative limbs and the lowest of the functional fruiting branches, as though it were difficult to change abruptly from one form of branches to the other.

In Deccan hemp and the okra plant the fruits are borne directly at the axils of the main stalk without the intervention of fruiting branches. It may be that the divided leaves indicate in advance the internodes that are to produce flowers and fruit. Change of leaf form marks the approach of the fruiting condition in such plants as *Hedera helix* and *Ficus repens,* but in such cases the change of leaf forms does not occur on the same axis of growth. The creeping stems of the juvenile stage represent an adaptive condition intercalated into the life histories of these plants, like the larval stages of insects.

The joints of the stalk of the cotton plant may also be considered as dimorphic with reference to the two kinds of branches that they produce, but it is a further step in hereditary specialization if the joints prove to be differentiated also by the forms of leaves that subtend the two kinds of branches. The external conditions often appear to influence the number of vegetative branches, but it is not yet known whether such changes are caused by direct transformations in buds already formed or are previously determined in the growth of the primary stalk. It may be that differences in the forms of the leaves will help to show when the characters of the branches are determined.

FIG. 3. Leaves from adjacent internodes of *Hibiscus cannabinus*, showing transition from the simple to the divided form, but with the lobes indicated in the simple leaf by prominent angles. (Natural size.)

In Upland varieties of cotton the fruiting branches are produced closer to the base of the plant than in the Egyptian cotton, and the seedlings of Upland cotton also begin to produce lobed leaves at earlier stages than Egyptian seedlings. The second or third leaves of Upland cotton often show distinct lobes, and in some varieties, such as "Willet's Red Leaf," even the first leaf may be lobed. In the Egyptian cotton, where the vegetative branches are more numerous and the fruiting branches begin farther up the stalk, the seedlings usually produce from five to seven entire leaves before the lobed leaves begin to appear. In luxuriant plants the vegetative branches continue farther up the stalk than the entire leaves, but under other conditions the vegetative branches are less numerous. Fruiting branches have been found on the Egyptian cotton in Arizona as low as the seventh node, as reported by Mr. Argyle McLachlan.

LEAF FORMS OF VARIETIES OF HIBISCUS CANNABINUS.

At least two varieties of the Deccan hemp are grown in Egypt, one with deeply divided, finely toothed leaves (Pls. I and II) and the other with more coarsely toothed, undivided leaves (figs. 1, 2, 3, and 4). It does not appear that either of these Egyptian varieties has been introduced into the United States, but a third variety with digitately parted leaf blades, not seen in Egypt but supposed to come from India, has been grown experimentally in Louisiana. (Figs. 5 and 6.)

Fig. 4.—Simple-leaved Egyptian variety of *Hibiscus cannabinus*. (Natural size.)

The variety with the dimorphic leaves is much more generally planted in Egypt, but plants with broader, undivided leaves are often found growing with the others. At Tanta, to the north of Cairo, separate plantings of the broad-leaved variety were seen. The plants seemed larger, coarser, and of a darker green color than those of the narrow-leaved type growing in the same locality. The leaves are distinctly larger and with the margins much more coarsely toothed. A tendency to the lobed form of leaf seemed to be indicated in this variety only by the somewhat larger teeth at the ends of the largest of the oblique veins. There may be a general correlation between the shape of the leaf and the size of the marginal teeth. The teeth seem to be larger in the undivided leaves of the dimorphic variety than in the lobed leaves. The smallest teeth are found on the specimens with the very narrow digitate lobes. (See figs. 5 and 6.)

Examples of transition forms of leaves seem to be more common on plants with rather small, narrow-pointed, sharply dentate leaves than in plants with larger leaves and less numerous teeth. (See Pl. II, *A*, *B*, *C*, and *D*.) It is not impossible that these differences represent distinct varieties or strains. There is no reason to suppose that the Egyptian varieties of this plant have been subjected to any more close or careful selection than the Egyptian varieties of cotton, which were found to exhibit a wide range of diversity.

FIG. 5.—Three-lobed leaf of narrow-lobed variety of *Hibiscus cannabinus*, grown in Louisiana. (Natural size.)

In Hooker's "Flora of British India" the leaves of *Hibiscus cannabinus* are described in two slightly different ways, once "Lower leaves entire, upper lobed," and again "Lower leaves cordate, upper deeply palmately lobed, lobes narrow serrate." The narrow-lobed variety shown in figures 5 and 6 would seem to conform most nearly to this description, though none of the lower leaves are shown in the pressed specimens of this variety in the Economic Herbarium of the United States Department of Agriculture. The species seems not to be represented in the National Herbarium. The leaves of the Egyptian varieties would hardly be described as cordate, though some of those in Plate II show a slight reentrant angle at the base.

The lobing of the leaves of the dimorphic Egyptian variety is not unlike that of the plant depicted as *Hibiscus cannabinus* in Roxburgh's "Plants of the Coast of Coromandel" (vol. 2, pl. 190), except that some of the upper leaves are shown with five lobes. Though no such leaves were seen on the Egyptian plants in July it is quite possible that they occur later in the season. Roxburgh also gives a separate figure of a simple narrowly lanceolate leaf and states that this form occurs at the top of the full-grown plants. According to Wester a similar reduction of the later leaves is shown in the roselle plant (*Hibiscus sabdariffa*).[1]

[1] Wester, P. J. Roselle: Its Culture and Uses. Farmers' Bulletin 307, U. S. Dept. of Agriculture, 1907, p. 7. "The leaves on the young plants are entire; as the plant increases in size the leaves change to palmately five parted; later the leaves in whose axils the flowers are borne are three parted."

PARALLEL LEAF FORMS IN COTTON.

The dimorphism of the leaves of *Hibiscus cannabinus* is the more interesting because a closely parallel series of leaf forms appears in the cotton plant. Entire or broad-lobed leaves are found in all varieties of cotton, at least during the early stages of growth, the lobes becoming more pronounced with maturity. (Figs. 7 and 8.) Narrow-leaved varieties of Upland cotton, popularly known as "okra" cotton, show a dimorphism corresponding quite closely to that of the dimorphic-leaved Egyptian variety (fig. 9), and others have a still more deeply divided, strongly digitate form, like the variety of *Hibiscus cannabinus* grown in Louisiana (fig. 10). Young plants of okra cotton have, at first, entire or broad-lobed leaves like the seedlings of other varieties of Upland cotton, but whether the change is gradual or abrupt has not been noticed.

FIG. 6.—Five-lobed leaf of narrow-lobed variety of *Hibiscus cannabinus*, grown in Louisiana. (Natural size.)

Individual plants with narrow-lobed leaves appear occasionally as mutative variations in broad-lobed varieties. Thus the narrow-lobed leaf shown in figure 9 represents a variety called "Park's Own," said to have originated as a variation of the King variety. (See fig. 8.) Several other mutations have been observed in experimental plantings of the King cotton in Texas showing different degrees of expression of the tendency to narrow lobes.

Transitions from entire to broadly lobed leaves are to be found on nearly every plant of Upland cotton, though entire leaves are more abundant on some varieties. Vegetative branches often have small, entire leaves, like those of young seedlings, on the short basal internodes. The proportion of entire leaves also seems to differ in varieties and is influenced by conditions of growth, humid greenhouse conditions having a distinct tendency to produce more of the entire leaves and to reduce the lobes of the others.

An individual plant of Triumph cotton found in a field at San Antonio, Tex., in September, 1910, showed a marked variation toward the simple form of leaves. The seed, unfortunately, had all been picked, so that the inheritance of the variation could not be tested. The plant appeared unusually vigorous, but had the advantage of standing at the end of the row. Most of the leaves were simple and entire (fig. 11), only a few being three lobed and these with the lobes unusually short. A count showed 152 simple leaves and 41 with lobes. Some of the wild species of cotton have all the

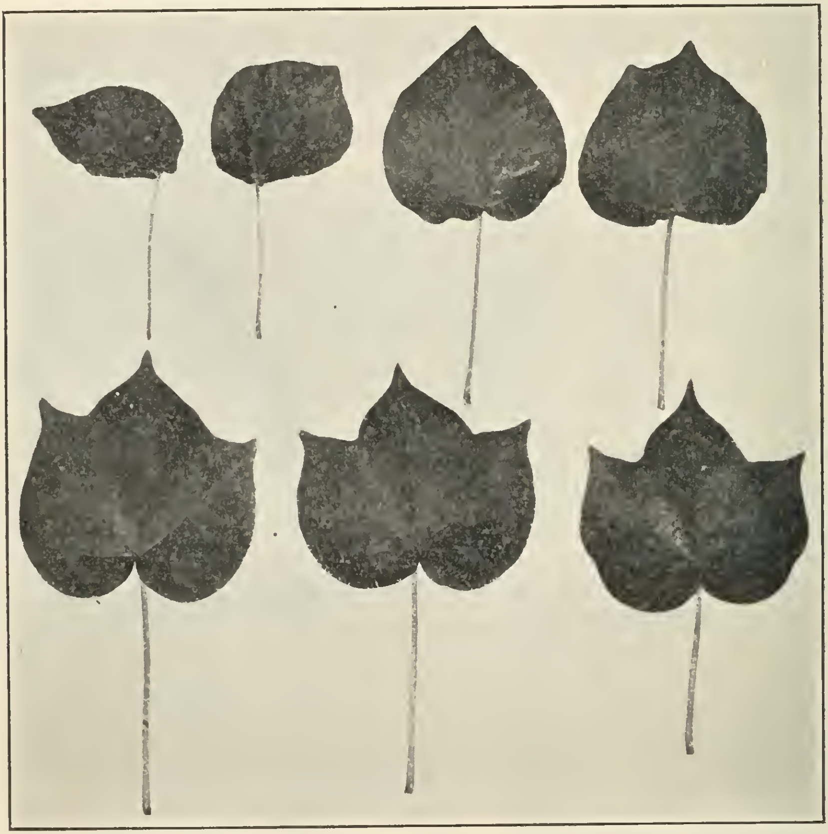

FIG. 7.—Leaves of Upland cotton seedling from first seven nodes above the cotyledons, showing changes of form. (Natural size.)

leaves simple, and thus complete the correspondence with the simple-leaved Egyptian variety of *Hibiscus cannabinus*.

The tendency to reduction of the lobes under greenhouse conditions represents another phase of the general parallelism of leaf forms. This tendency seems to be very general, not only in different varieties of Upland cotton, but also in the Egyptian and Sea Island types that in open-air conditions have the lobes more highly developed than those of Upland cotton. The fruiting branches of greenhouse plants of Egyptian cotton have many of the leaves of the fruiting branches quite simple, a character that appears very seldom in open-air plants. A comparison of figure 12 with figure 14 will give an idea of the range of variation in leaf forms on the fruiting branches of the Egyptian cotton and of the extent to which the expression of the characters may be modified by external conditions. It may also be noted that the entire leaf of the Egyptian cotton grown under greenhouse conditions is broader and less pointed than that of the Upland cotton grown in Texas under open-air conditions. As the figure also shows, the texture of the entire Egyptian leaf is much more delicate than that of the Upland leaf, which is not true in outdoor plants of Egyptian cotton.

The greater tendency of the Egyptian cotton to produce entire leaves is also apparent in the early stages of growth. Lobed leaves develop on young plants of Upland cotton from lower joints than in Egyptian cotton, as already noted. Hybrids between Upland and Egyptian cotton, grown at Bard, Cal., in 1911, were intermediate in this respect and usually began to show lobed leaves on the third joint above the cotyledons. The transition from the entire to the lobed form of leaves was much more gradual among the hybrids than in pure Egyptian plants. Very large luxuriant seedlings of the Egyptian cotton, with vegetative branches already pushing from the nodes of the cotyledons, seemed to show less definite transitions in leaf form than the somewhat smaller and more normal plants where the buds in the axils of the cotyledons had remained dormant. Failure of the normal specialization of leaf forms would correspond with abnormalities in the formation of the branches that occur very frequently in the Egyptian cotton under conditions of too luxuriant growth.

FIG. 8.—Mature leaf of "King" Upland cotton, parent of "okra-leaved" variations. (Natural size.)

TWO TYPES OF DIMORPHISM OF LEAVES IN COTTON.

The dimorphism of leaves in Hibiscus is of the same type as that of the narrow-leaved "okra" cottons, as already indicated. But there is another type of dimorphism of leaves in cotton, connected with a definite dimorphism of the branches. The leaves of the fruiting branches of cotton are smaller than those of the main stalk and vegetative branches and often have nectaries on only one or two of

FIG. 9.—Leaf of "Park's Own," an "okra" variety of American Upland cotton. (Natural size.)

the principal veins, even when the leaves of the main stalk and vegetative branches have three nectaries with much regularity.

The dimorphism is not so easily recognized in the blades of the leaves, because of the general freedom of variation in sizes and shapes, but appears much more definite when attention is given to the stipules. On the main stalk and the vegetative branches the leaves have the two stipules equal in size and narrowly lanceolate or strap shaped (fig. 13), while on the fertile branches of the same plant one stipule may be much broader than the other (fig. 14). Broadening of one of the stipules is a usual and apparently quite normal characteristic of the Egyptian cotton. (Pl. III.) It also appears in a related African type from the Niam Niam, in the upper valley of the White Nile. On the other hand, the enlargement of the stipules and the corresponding reduction of the petiole and blade of the leaf sometimes represents a distinctly abnormal tendency, accompanied by frequent abortion of the flower buds. In such cases the leaves of the fruiting branches become reduced and more or less intermediate in form between the normal leaves of the fertile branches and the involucral bracts that inclose the flower buds. (Pl. IV.)

Fig. 10.—Leaf of "Ratteree's Favorite," an "okra" variety of American Upland Cotton. (Reduced.)

These abnormal intermediate forms of leaves illustrate the nature of the transformation that has taken place in the specialization of the involucre of the cotton plant. Each of the three bracts that compose the external involucre represents a leaf with the blade much reduced, the petiole entirely suppressed, and the stipules greatly enlarged and united with the blade. In the abnormal intermediate forms of leaves a reduction of the petiole and blade is usually accompanied by a corresponding increase of the stipules, though one is generally much larger than the other. (Fig. 15.)

In contrast with the other leaves of the plant, the bracts might be considered as an extreme case of dimorphism, since the differences of form are much greater than those of the different types of foliage leaves. The occurrence of the intermediate forms between bracts and foliage leaves is also quite rare. Under some conditions of growth such intermediate forms seldom or never occur, but under other conditions, or at the end of the season, the normal specializations of inheritance seem to relax and the abnormal intermediate forms begin to appear. They are much more common in the Egyptian cotton than in the Upland and have shown themselves most frequently in a peculiar fastigiate variety of the Egyptian cotton introduced into Arizona under the name of "Dale," perhaps the same as the variety called "Bamieh" in Egypt.

Other series of abnormalities serve to connect the outer involucre of the cotton flower with the inner involucre, or so-called calyx, as though

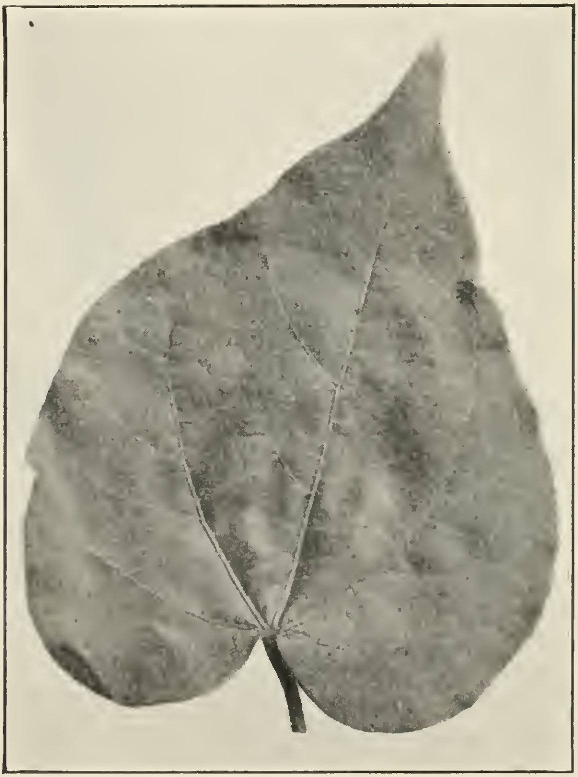

FIG. 11.—Cotton leaf without lobes, a variation of the Triumph variety. (Natural size.)

this organ were formed from another type of reduced and specialized leaves. The petals, on the contrary, seem to represent specialized stamens rather than specialized leaves. They are inserted on the base of the staminal column. Their development from stamens is also suggested by the small, expanded, petal-like organs that are sometimes found on the staminal column above the true petals. In such a case the petals or the stamens might be said to be dimorphic, or it might be considered that there has been a failure of the normally complete change in the expression of the characters in passing from the petals to the stamens.

PARALLEL LEAF FORMS IN OKRA.

The similarities of variations of leaf form in cotton and Deccan hemp do not exhaust the series of parallelisms. The okra plant (*Abelmoschus esculentus*) also shows the same general range of forms of leaves. Some varieties have broad leaves with very short, rounded

FIG. 12.—Simple leaf of fruiting branch of Egyptian cotton, produced under greenhouse conditions. (Natural size.)

lobes; others have rather narrow lobes, separated to below the middle, and there is a third type with very narrow segments digitately divided to the base. Though attention has not been paid to the nature of the transition from broad to narrow leaves, it is probable that varieties differ considerably in this respect, for Mr. W. R. Beattie informs the writer that broad-leaved varieties will sometimes show a few deeply divided leaves late in the season. Two general types of pods are recognized, but there seems to be no very definite relation between the form of the leaf and that of the pods. Long, narrow pods are not confined to narrow-leaved varieties, but

FIG. 13.—Young leaf from vegetative branch of Egyptian cotton, with five lobes and equal stipules. (Natural size.)

are shared by broad-leaved sorts. Broad-leaved varieties seem to produce the thickest pods, but some of the narrow-leaved sorts have short pods.[1]

The prevalence of the broad-leaved forms of okra in Egypt is doubtless the explanation of the fact that the name Bamieh or

[1] Beattie, W. R. Okra: Its Culture and Uses. Farmers' Bulletin 232, U. S. Dept. of Agriculture, 1905. pp. 12-16.

"okra" cotton is given in Egypt to a variety having unusually broad and heavy leaves, the direct opposite of the variation to narrow-lobed leaves that characterizes the so-called "okra" cottons of the United States. The occurrence of broad-leaved varieties in Egyptian cotton corresponds to the narrow-leaved variations in Upland cotton. The normal foliage of the Egyptian cotton is of the same general form as some of the narrow-leaved or "okra" variations of the Upland type of cotton.

There is a popular idea in Egypt that the Bamieh or broad-leaved type of Egyptian cotton originated from natural crossing of cotton with okra, the same explanation that is given for narrow-leaved variations of Upland cotton in America. The Egyptian Bamieh cotton also produces all of its bolls close to the main stalk, like the okra plant. American Upland varieties of the "okra" type do not have this short-branched habit.

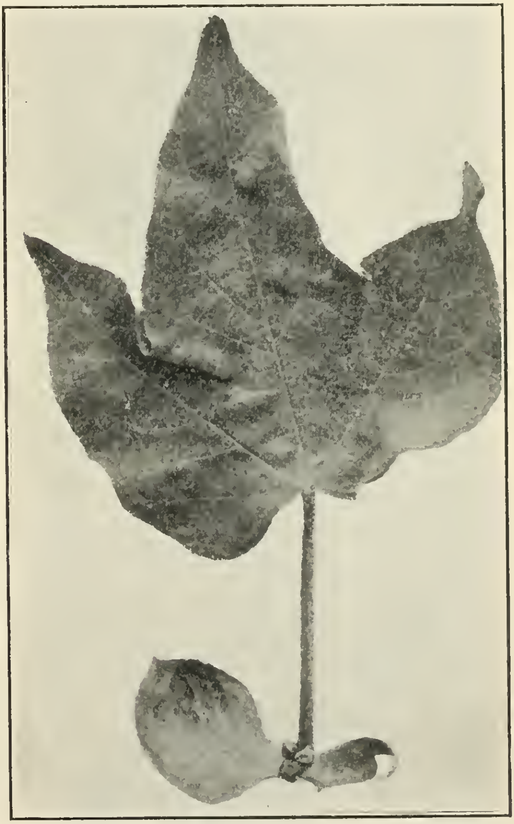

FIG. 14.—Young leaf from fruiting branch of Egyptian cotton, with three lobes and unequal stipules. (Natural size.)

The parallelism of leaf characters between cotton and okra extends even to the presence of a distinct red spot at the base of the leaf at the junction with the petiole. The presence of such a spot on the leaves of a cotton plant is reckoned in Egypt as a distinctive character of the inferior Hindi type that is responsible for a serious deterioration of the Egyptian stock. The leaves of the Hindi cotton are also a distinctly lighter shade of green than those of the Egyptian cotton, matching the color of the okra leaves very closely. These similarities are doubtless responsible for another popular theory, that the Hindi contamination of the Egyptian cotton is due to crossing with the okra plant.

The presence of the red basal spot in the okra and other relatives of cotton is of interest from the standpoint of heredity, in view of the fact that this character shows a somewhat contrasted or Mendeloid expression in hybrids of Egyptan with Hindi or Upland arieties. The contrasting variations of color are not confined to the hybrids, but may appear in the different stages of the same plant.[1]

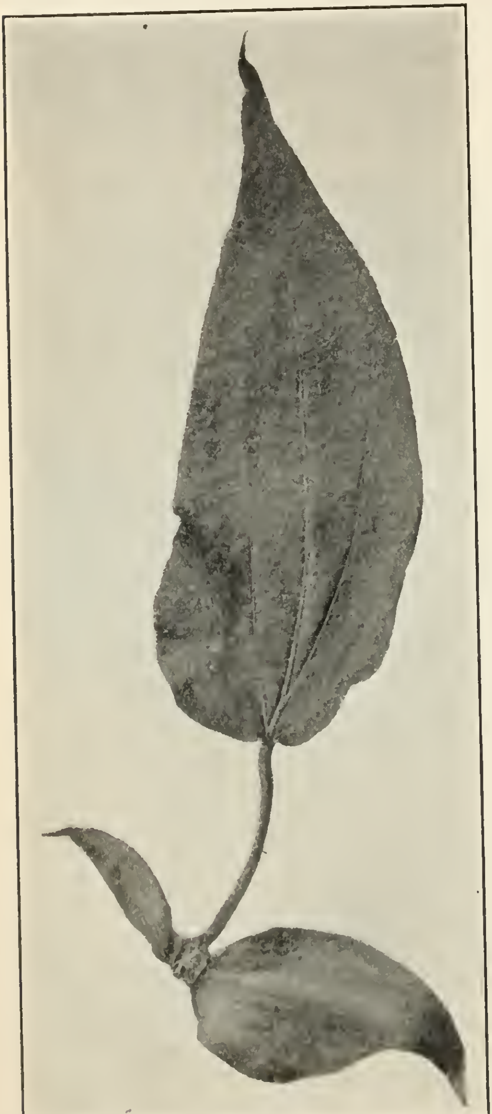

Fig. 15.—Leaf of fruiting branch of Egyptian cotton, with abnormally reduced blade and enlarged, bractlike stipule. (Natural size.)

Varieties of okra with the intermediate or narrow-lobed leaves seem to be most common in the United States, but in Egypt, where this crop is much more important than with us, broad-leaved varieties are grown almost exclusively. Okra, as well as *Hibiscus cannabinus,* is commonly planted with cotton in Egypt; but usually to take the place of hills of cotton that have ailed to grow, instead of being confined to the borders of the fields.

The only narrow-lobed okra plants noticed in Egypt were a few near Medinet, in the Fayum Oasis. Very little of this variety was said to be planted. The fruits are considered more delicate, but are smaller than those of the broad-leaved plants. In the narrow-lobed variety there was an abrupt change from the broad-lobed leaves of the lower part of the stem to the adult form of leaves, but even the broad-lobed leaves were more deeply divided than those of

[1] Cook, O. F. Mutative Reversions in Cotton. Circular 53, Bureau of Plant Industry, U. S. Dept. of Agriculture, March, 1910, p. 10.

a broad-lobed variety included in the same planting. In the latter the lower leaves were almost entire, as often occurs in broad-lobed types of cotton.

SIGNIFICANCE OF PARALLELISM IN THE STUDY OF HEREDITY.

The parallel series of leaf forms of cotton and related plants are of interest in connection with many problems of heredity and breeding. In view of the fact that the same wide range of diversity in leaf forms exists in Gossypium, Hibiscus, and Abelmoschus, it becomes easier to look upon such differences as within the usual range of variation for this group of plants. Changes of characters to wider or narrower leaves do not require us to believe that a new character has originated or that hybridization with a different type of cotton has occurred.

FIG. 16.—Plant of *Ingenhousia triloba*, showing transition from entire to deeply divided leaves. (Reduced.)

The theory of hybridization as a cause of diversity of leaf forms is rendered the more unnecessary because the wide range of leaf differences appears not only in the same species or variety, but on the same individual plant. This is well shown in a wild relative of cotton, *Ingenhousia triloba*, native in Arizona. (Fig. 16.) The young plants have entire and broad-lobed leaves, while the leaves of adult plants have long narrow lobes. The branches of Ingenhousia, grown under greenhouse conditions, do not show the same tendency as in cotton to return to simple leaves, but the three-lobed leaves at the base of the branches have very short and broad lobes, quite unlike the tapering long-pointed lobes of subsequent leaves of the same shoot. The upper leaves have five lobes, as in cotton, okra, and *Hibiscus cannabinus*.

The fact that a wide variation in leaf forms occurs on the same individual plants in primitive wild species makes it entirely unnecessary to resort to the idea that variations in such characters in cultivated stocks must be due to previous hybridization. Some writers consider that uniform expression of characters, as in a carefully selected line-bred variety, represent the normal condition of heredity, and assume that this condition is found in wild species. The diversities that appear through variation are ascribed to hybridization, to the disturbing influence of the environment, or to mutative transformation into new species. Yet diversity is always found among the members of wild species as soon as the observer gains sufficient familiarity. The uniformity found in "pure-bred" varieties is an artificial product established and maintained by selection. The inferior variations that appear in selected strains of Upland cotton show the same range of diversity that is found among the members of primitive, unselected stocks. Such variations may reasonably be considered as reversions.

The return of latent characters to expression should not be looked upon as rare or exceptional, but as a normal phenomenon of heredity. Uniform expression of characters is rare and exceptional because the tendency to reversion is so general and persistent. Transmission is permanent, not variable like expression. Characters that have been suppressed for thousands of generations, like the incisor teeth of cattle, continue to be transmitted. Students of embryology recognize permanence of transmission by the law of recapitulation. The development of the embryo of a higher animal does not take a straight course from the egg toward the adult form, but remains closely parallel with the courses followed in lower groups. Many primitive characters are brought into slight or temporary expression, though they may disappear entirely before even the embryonic development is complete.

In view of the continued transmission of primitive characters, the tendency of the diversities of the wild types of cotton and other plants to reappear in selected varieties is more easily understood. In a diverse, unselected type each individual inherits and transmits from its many ancestors a large number of characters that are not expressed in its own body, and this transmission of latent characters continues even in the most carefully selected variety. Though opposed by selection, the natural tendency to alternation in expression also continues and becomes effective in the occasional individuals that show mutative variations.

It is true that examples of mutative reversion are usually not frequent enough to affect statistical investigations of other forms of expression of characters, but they are of essential importance in many questions of heredity and breeding. If the possibility of reversion and suppression of characters be left out of account, every definite change of characters must be considered as the production of a new elementary species.

Mutative departures of occasional individuals from the characters of the parent stock are not uncommon in cotton, and differences in the forms of the leaves are one of the most readily distinguishable types of variation. Most of the variations that produce small bolls can be recognized in advance by their smaller and narrower leaves, or by other differences of vegetative characters.[1]

RELATION OF PARALLELISM TO CLASSIFICATION.

The importance of recognizing the fact of a general parallelism of variation in leaf form running through the different types of cotton and related plants is shown also in the field of classification. The genus Gossypium contains a large number of locally different forms of cultivated cotton, as well as numerous wild types. The classification of these into species and varieties is a difficult task of systematic botany. Failure to recognize the parallelism of variations has allowed the possession of narrow leaves to be taken as a sufficient proof of relationship. Narrow-leaved forms that are probably quite unrelated have been associated in the same species, while broad and narrow leaved forms of the same type of cotton have been treated as distinct species. These difficulties are well illustrated in a most elaborate monograph on the classification of cotton by Sir George Watt. The okra-leaved variations of American Upland cotton are repeatedly referred to in this work and add not a little to the complexities of the system of classification. Indeed, they are treated quite differently in different parts of the book and are even assigned to different botanical species.

The first suggestion is that the American okra-leaved forms represent a variety of an Asiatic species, *Gossypium arboreum*. This variety is alleged to have been introduced into North America at an early date and afterwards discarded from cultivation, as the following statements will show:

> It was not until well into the seventeenth century that we possessed any trustworthy evidence of the Asiatic cottons having been carried to the New World. The Levant cotton (*G. herbaceum*) was the first to be taken to the United States and grown in Virginia. The Indian cottons (*G. obtusifolium*, various races) were conveyed to the States by the East India Co., and the Chinese and Siamese cotton (*G. nanking*) was carried by the French colonists to Louisiana about 1758. *G. arboreum* proper does not seem to have been successfully acclimatized anywhere in the New World, though the most important Asiatic (? hybrid) form derived from that species (*G. arboreum* var. *neglecta*) was early carried to America and the West Indies by the East India Co., and is known in the United States to-day under the name of "Okra" cotton.
>
> There can thus be no doubt that Indian cottons were at an early date introduced into the West Indies and into the United States of America as well, and therefore

[1] Cook, O. F. Cotton Selection on the Farm by the Characters of the Stalks, Leaves, and Bolls. Circular 66, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1910.

very possibly this particular form, as also the far-famed Dacca cotton, stands every chance to have been carefully investigated in the New World. But the fact that *G. arboreum* var. *neglecta* has preserved in the United States, during probably close on 300 years of cultivation, identical characteristics to those it possesses under the widely different environment of India, argues strongly against the structural peculiarities by which it is recognized being viewed as merely geographical and climatological features, that change or disappear under altered conditions. * * *

But with reference to the survival of this presumably Indian plant in America and elsewhere (after its cultivation had been abandoned), it may be observed that once a particular species or race of cotton had been introduced into a favorable cotton-growing country, even though its regular cultivation might chance to be discontinued, it would be no great stretch of imagination to believe that a specially hardy stock, such as the present plant, might survive for centuries. * * * The fact, however, remains that *G. arboreum* var. *neglecta* has been repeatedly recorded as met with in the United States of America, and in the examples seen by me the plants in question could not possibly be separated botanically from the corresponding Indian stocks.[1]

It has not been found possible to produce hybrids between our American Upland varieties and the Asiatic species, though large numbers of experiments have been made in both India and the United States. In view of the failure to produce hybrids the Asiatic cottons can not be considered as close relatives of the American Upland type, though they show the same general range of variations of leaf forms. That the close similarity of leaf form should have led Watt to refer an American Upland cotton to an Asiatic species may be considered as a further testimony to the complete parallelism of variation.

Another okra-leaved variation of Upland cotton was considered by Watt to represent a hybrid of *Gossypium punctatum* or *G. hirsutum* and *G. schottii*, the last being a new species described by Watt as a wild plant in Yucatan. The idea that the narrow-leaved condition could be reached as a "natural sport" or mutative variation from a broad-leaved variety like the King is tacitly rejected in the following paragraph:

G. schottii, as defined by me above, must of necessity be a wild plant, since its inferior grade and low yield of wool would never justify its cultivation. It, however, matches sufficiently closely a hybrid found in a field of King's Improved cotton at Richmond, Va. (recently sent to me by Mr. Lyster H. Dewey of the Bureau of Plant Industry in the United States of America), as to countenance the belief that the so-called sport in question may have originated through the hybridization of *G. punctatum* or of *G. hirsutum* with the present species. The specimen came to me under the vernacular name of *okra*—a name that it will be recollected had on a former occasion been given to an American sample of *G. arboreum* var. *neglecta*. It is suggestive of the West Indian name *ochro* (*Hibiscus esculentus*) and possibly thus denotes the deeply dissected condition of the leaves. From the remark on the attached label of the present specimen it may be inferred that the American authorities were induced to believe that, though widely different from King's Improved, it was per-

[1] Watt, G. The Wild and Cultivated Cotton Plants of the World, 1907, pp. 81, 101, and 102.

haps but a natural sport. "Thousands of plants were grown from the seed, and but very few reverted to the broad-leaf type." [1]

In a later paragraph of the discussion of *Gossypium schottii* still another interpretation of the okra-leaved variations is proposed:

The bulk of the Upland American stock of present-day cultivation might be described, and accurately so, as consisting of forms of *G. mexicanum*. We read that repeated fresh supplies of seed have been procured direct from Mexico. It would thus be no great stretch of imagination to assume the possibility of hybridization of the cultivated stock of Mexico with the Yucatan *G. schottii* or some other allied form. Hence it is quite probable that King's Improved may itself be a hybrid of this nature, the split-leaved plant which appeared as if a saltatory variation being a recessive manifestation of the *G. schottii* characteristics. It is equally possible, however, that the fresh seed, imported from Mexico, may have been mixed and that the split-leaved plant had survived in the States for some years (and even got hybridized there) before its presence was recognized, just as the "Hindi weed cotton" of Egypt is reproduced year after year. In fact it might be possible to be a cultivated state of *G. schottii* in which no hybridization existed whatever, a weed of not sufficient importance to attract attention, which, once mixed, the seeds could not very readily be picked out from the supply reserved for future sowings.

If the narrow-leaved variations were a result of recent importations from Mexico they might be expected to appear more frequently in the Texas big-boll type of cotton and other varieties that Watt assigns to *Gossypium mexicanum* than in the King and other eastern small-bolled varieties that Watt holds to be more related to *Gossypium punctatum* and *G. hirsutum*. In reality the okra-leaved variations seem to be confined to the King and other small-boll types. They are certainly very rare in the big-boll varieties, if they occur at all.

For American readers it is hardly necessary to add that the theory of the existence of *Gossypium schottii* or any other wild type in the cotton-growing districts of the United States is not known to have any warrant of fact. There is a wild cotton in southern Florida, perhaps the same as that which has been described from the West Indies as *Gossypium jamaicense*. A specimen recently received from Mr. T. Ralph Robinson, collected by Mrs. Robinson on Terraceia Island in the lower part of Tampa Bay, indicates that the wild cotton of Florida extends farther to the north than has been supposed hitherto. Yet it would be a mistake to assume that it represents a close relative of our cultivated Upland varieties. The petals are yellow and have purple spots like those of the Egyptian or Sea Island cottons, instead of the white, spotless petals of the Upland varieties.

As a further example of the extent to which parallelism of leaf form may confuse classification, mention may be made of a curious, small-bolled, narrow-leaved cotton found by Messrs. G. N. Collins and C. B. Doyle at Tuxtla Gutierrez in southern Mexico, under the vernacular

[1] Watt, G. Op. cit., p. 207.

name "Culluche." The species has not been definitely identified, but Mr. F. L. Lewton suggests that it may represent Todaro's *Gossypium microcarpum* variety *rufum*. The leaves of the Culluche cotton are extremely variable in form, and many of them are quite simple. But instead of being broadly cordate like the simple leaves of Upland or Egyptian cottons, the simple leaves of the Culluche cotton are fusiform or lanceolate, much like the abnormal leaves of the Egyptian cotton shown in Plate IV and text figure 15. One of the simple leaves of the Culluche cotton is shown in figure 17. Comparison of this with the illustrations of the Egpytian cotton previously mentioned will show how close a resemblance of leaf forms may arise in species of cotton that are widely different in other respects.

Fig. 17.—Simple leaf of Culluche cotton from Tuxtla Gutierrez, Mexico. (Natural size.)

RELATION OF DIMORPHISM TO MUTATION.

Viewed as a phenomenon of heredity, dimorphism of leaves presents an analogy with mutative variation. The fact that the abrupt change or contrast of characters occurs in the same individual plant instead of in separate plants should increase the interest attaching to such variations, especially if it appears that they are of the same general nature as the mutations that give rise to new varieties.

The change of characters involved in the production of dimorphic leaves has the most direct analogy with the rather rare phenomenon of bud mutation. Cases are known in which the expression of characters is changed in a single bud of a tree. A single branch of a tree shows a definite peculiarity not found in other branches or other trees of the same variety. A bud mutation of coffee seen in Guatemala some years ago had leaves as definitely unlike the remainder of the tree as any of the numerous seminal mutations of coffee that had been previously studied.

The most obvious difference between such a variation and the dimorphic branches and leaves of coffee, cotton, or cacao lies in the fact that the bud mutations are of rare and irregular occurrence, while the changes of characters shown in dimorphism are regularly repeated during the development of each individual plant or tree. The production of fertile branches in the cotton plant involves a mutative change of characters away from those that are expressed in the main stalk and the vegetative branches. But instead of producing normally only the one kind of branches with rare mutations to other kinds, the regular course of development for the cotton plant involves the production of two forms of branches, the vegetative form near the base and the fertile form farther up the stalk. In the Triumph variety of Upland cotton there may be said to be a double dimorphism, resulting in three fórms of branches. The internodes of the lower fruiting branches are very short, like those of the branches of "cluster" varieties, though branches with internodes of normal length are produced farther up.

De Vries has proposed to associate bud variations with the form of alternative expression of characters shown in accommodations to external conditions (dichogeny). Accommodations and mutations are alike in the general sense that both may be considered as phenomena of alternative expression, but the changes of expression are evidently determined in different ways in the two cases. Bud variations represent definitely determined changes in the expression of the characters, like seminal mutations, but in the condition of dichogeny there is no such definite determination of expression on the part of the plant. Changes of expression continue to be dependent on the external conditions and are readily reversible if the conditions are changed.

The analogy between bud variations and dimorphic branches is much stronger, for both of these changes of expression are determined by the plant instead of depending on changes of environment and after the changes are made they are not readily reversible. It is also to be noted that all the three kinds of changes of expression shown in accommodations, dimorphism, and bud mutations take place during the processes of vegetative growth without any apparent relation to the special organs of the germ cells that have been supposed to control the process of heredity.

For purposes of the study of heredity a very definite distinction is to be made between changes of expression of characters that arise by mutation and those that appear in response to differences of external conditions. The increase in the proportion of simple leaves on cotton plants grown under greenhouse conditions is not the same, from the standpoint of heredity, as the variation toward simple leaves in an individual plant of Triumph cotton growing under field conditions, as already described on page 17. In the latter case the simple leaves were not induced by the external conditions, or the effect was limited to a single individual that must be supposed to represent an unusually susceptible condition. And in such cases of individual variation the change of expression is much more definite and permanent than when the change is shared by a whole series of plants or by plants of different kinds. The production of simple leaves on fruiting branches of Egyptian cotton in the greenhouse represents a general tendency to reduction of lobes manifested in many kinds of cotton under such conditions.[1]

This distinction does not turn, primarily, on the amount of difference or the extent of the change of expression, but upon the manner and permanence of the change, and the same is true of the changes of expression that constitute the phenomena of dimorphism. The result in both cases is the production of entire leaves; but one case probably represents a definite mutative variation, the other a readily reversible environmental accommodation. Dimorphism and bud mutations may also appear to accomplish the same result, in that two definitely different kinds of branches are produced on the same plant, but in the mutation the change is permanent, whereas the dimorphic changes belong to the series of regular alternations, though maintained by the plants themselves instead of being induced by changes of external conditions.

The substitution of vegetative limbs for fertile branches, as often occurs in the cotton plant, indicates that the external environment is a factor in modifying expression even in distinctly dimorphic characters, though it is not definitely known whether increase of vegetative branches results from the formation of a different kind of buds in the first place or represents a transformation of buds that had a previous tendency to produce fruiting branches. There are indications that both kinds of changes occur, depending on the time when the external conditions are changed. Although the normal course of development follows regular steps it is often influenced profoundly by external conditions, even with respect to characters that are known to be subject also to mutative changes of expression, such as the "cluster" character in cotton. The occurrence of mutative variation has also been found to be influenced by external conditions, mutations being much more numerous in some localities than others, in fields planted with the same selected stock of seed.

[1] Attention has been called by Mr. T. H. Kearney to the fact that similar modifications in oak leaves growing in shaded positions have been pointed out by Brenner in a paper on "Climate and Leaf in the Genus Quercus." Flora, vol. 90, 1902, pp. 114-160.

The two kinds of leaves borne by the two kinds of branches of the cacao tree, for example, are probably much more different than any mutations that have ever been reported. Changes of expression in dimorphic specializations are as great as or greater than in those that give rise to distinct mutative varieties or sports. Dimorphism not only covers at least an equal range of variation, but affects the same kinds of characters as mutative variations. This is shown very definitely in the Upland type of cotton, where cases of okra cottons with dimorphic leaves arise as mutative variations from broad-leaved varieties. The dimorphic condition, at least in such cases, has to be looked upon as a direct product of mutative variation.

Another form of mutation, more common in Upland cotton than mutations to narrow leaves, is the shortening of the internodes of the fruiting branches, as in the so-called "cluster" varieties. This variation also has relation to dimorphism. The shortening of the internodes of the branches, which characterizes the "cluster" varieties, affects only the fruiting form of branches. The vegetative limbs of "cluster" cottons grow quite as long as those of other varieties. The expression of the cluster character is accompanied by the expression of the other characters of the fruiting branches, like the peculiarities that come into expression in only one sex of an animal though capable of transmission through the other sex. Breeders consider that special egg-laying or milk-producing qualities are transmitted by male animals as well as by females.

A further analogy between mutations and dimorphic changes of expression of characters may be found in the fact of coherence. Dimorphic branches do not differ in one character alone. One form of branch differs from another in all of its parts. A whole group of characters clings together, as it were, in expression. In a similar way a mutative change usually involves a large group of characters. The fact of coherence is of practical importance in relation to selection, for it enables mutative variations to be much more easily recognized than if each detail of structure or color were free to change independently. In dimorphism, as well as in Mendelism and mutation, there seems to be a tendency to contrasted expression instead of to blended or graded expression. In other words, these phenomena may be said to be free from the law of regression enunciated by Galton. Contrasted characters not only maintain themselves in expression, but the contrast gains reenforcement by combination with other alternative characters.

When hybrids are made between different species, such as the Upland and Egyptian cottons, it becomes evident that some characters have much more freedom of combination than others. For example, the purple spot at the base of the petal of the Egyptian cotton may appear in plants which otherwise bring only Upland characters into expression. But the expression of the yellow color of the petals of the Egyptian cotton depends very closely upon the predominance of Egyptian characters in other parts of the plants. Egyptianlike hybrids often have white flowers, but Uplandlike plants with yellow petals are of very rare occurrence and are usually infertile or otherwise abnormal.[1]

RELATION OF DIMORPHISM TO MENDELIAN INHERITANCE.

Dimorphic leaf characters seem to have the same intimate relations with Mendelian inheritance as with the phenomenon of mutation. Indeed, this might be expected from the fact that characters that appear as mutations generally show Mendelian inheritance when crossed with other varieties not affected by the same mutation.

The leaves that follow each other on the same stalk of a plant of Deccan hemp are as definitely different as those that appear on different plants in the second (perjugate) generation of crosses between broad-leaved cottons and narrow-leaved "okra" varieties. A cross of this kind between a narrow-leaved mutation of King and a Texas variety called Edson has been studied by Dr. D. N. Shoemaker and found to represent an ordinary case of Mendelism. In the first or conjugate generation the leaves were quite uniformly intermediate, while the perjugate generation showed all three types of leaves—broad-lobed, narrow-lobed, and lobes of intermediate width like those of the conjugate generation. Deviations from the Mendelian proportions were not greater than could reasonably be ascribed to the effects of cross-fertilization.[2]

Hybrids between another broad-lobed Upland variety of cotton (Keenan) and an "okra" variety (Ratteree's Favorite) have been made by Mr. H. A. Allard in Georgia in connection with his experiments to determine the extent of natural crossing. Photographic illustrations of the leaves of the parent varieties and the conjugate hybrid are shown in Plate V, from some of Mr. Allard's specimens kindly furnished for this purpose. All of the plants of the conjugate generation, 84 in number, had leaves of intermediate form. The behavior of the characters in the perjugate generation has not been reported, but Mr. Allard states that a definite segregation of the parental leaf forms was shown.[3]

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[1] Cook, O. F. Suppressed and Intensified Characters in Cotton Hybrids, Bulletin 147, Bureau of Plant Industry, U. S. Dept. of Agriculture, April, 1909, p. 16; and Hindi Cotton in Egypt, Bulletin 210, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911, pp. 28-33.

[2] Shoemaker, D. N. A Study of Leaf Characters in Cotton Hybrids. Proceedings of the American Breeders Association, vol. 5, p. 116.

[3] Allard, H. A. Preliminary Observations concerning Natural Crossing in Cotton. American Breeders Magazine, vol. 1, 1910, p. 247.

As the illustrations of the leaves of *Hibiscus cannabinus* have shown, the transition from the entire to the divided leaves is not equally abrupt on all plants, but neither is it usual for the two types represented in a Mendelian progeny to have the contrasted characters equally expressed in all individuals. Narrow-leaved mutations from the broad-leaved varieties of cotton are not all equally narrow leaved, nor do the narrow-leaved members of a series of perjugate hybrids all have leaves with lobes of the same width. The range of variation in the perjugate generation is not only vastly greater in total extent than in the first or conjugate generation, but also seems to be greater among the perjugate plants that represent the narrow-leaved group. It is to be expected, however, that these general differences in the range of expression will also be found to vary in different hybrid combinations, just as there may be differences in the abruptness of the transition from one type of leaves to the other in different varieties.

In progenies raised from the seed of okra-leaved mutations grown in fields of the parent variety and subject to natural crossing, both broad and narrow leaves appeared, rather than leaves of intermediate form. Thus the progeny of a narrow-leaved mutation grown by Dr. Shoemaker at Waco, Tex., in 1906, showed the narrow-lobed type of leaves in only about a quarter of the plants, the remainder appearing to be normal broad-leaved examples of the King variety. The progeny of another okra-leaved mutation of the King, selected at San Antonio, Tex., in 1907 and tested at the same place in 1908, showed 20 plants out of 34 with broad leaves, 13 plants with leaves like the parent mutation, and 1 plant with a more extreme expression of the narrow-lobed tendency, as though another mutative step had been taken.[1]

The second type of dimorphic leaves in cotton, that connected with the dimorphism of the branches, is similarly related with Mendelian inheritance as well as with mutative variation. Branch characters show Mendeloid expression of characters in hybrids, as well as leaf characters. Crosses between cluster and noncluster cottons of the Upland type do not manifest the cluster habit in the conjugate generation, but the cluster character returns to definite expression in the perjugate generation.[2]

The interest of the dimorphic leaves of *Hibiscus cannabinus* in relation to Mendelism is to show that a change of characters quite as extensive and abrupt as those that characterize Mendelian hybrids

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[1] Cook, O. F. Local Adjustment of Cotton Varieties. Bulletin 159, Bureau of Plant Industry, U. S. Dept. of Agriculture, September, 1909.

[2] Cook, O. F. Suppressed and Intensified Characters in Cotton Hybrids. Bulletin 147, Bureau of Plant Industry, U. S. Dept. of Agriculture, April 7, 1909, pp. 22–23.

may take place in adjoining internodes of the stalk of the same individual plant. There can be no question, in such a case, regarding the separate transmission of the units of the two contrasted characters to different plants. The same plant not only inherits both of the contrasted characters, but brings them both into expression. Such facts may be considered as additional reasons for believing that Mendelian inheritance may be looked upon as a phenomenon of alternative expression of characters. It no longer seems necessary to predicate an alternative transmission of characters, as often assumed in the study of Mendelism.

That the phenomena of Mendelian inheritance are of much significance in the study of heredity need not be questioned, but what the significance may be is still in doubt. It is possible to interpret the facts of Mendelism in at least two very different ways. The mathematical relations of Mendelism are equally well explained, whether ascribed to an alternative transmission of contrasted characters or to alternative expression. Neither transmission nor expression is understood in its essential nature—that is, as a physiological process—but this only makes it the more desirable not to confuse the two processes in attempting to understand them. The importance of distinguishing between expression and transmission is not so obvious, perhaps, as long as investigation is limited to cytological and statistical studies of typical cases of Mendelism, but collateral evidence of other kinds should not be neglected. On this question plants seem to afford better evidence than animals because of their habits of growth by the vegetative multiplication of internodes. Among the internode members of the same plant body there can be no question of differences of transmission, yet definitely contrasted expression remains the rule of development. Not only are there abrupt transitions from one class of internodes to another, but the tendency to contrasted expression is accentuated by dimorphic specializations within the same class.

DIFFERENT TYPES OF DIMORPHIC SPECIALIZATION.

If the internodes of plants be thought of as individuals, the definite differences that exist between the various kinds of internodes of the same plant appear closely analogous to the contrasted characters of the sexes of the higher animals or the several castes that compose the highly organized colonies of bees, ants, and termites.

Species that are composed of two or more sexes, castes, or other distinct kinds of individuals have been called "ropic," a term that denotes a definite tendency to contrasted expression of the characters, as though the relations that determine the expression of the characters had a definite polarity or repulsion so that the contrasted extremes of a series are manifested rather than the intermediate degrees. Arropic species, on the other hand, are composed of individuals of only one kind, manifesting individual variations, of course, but with no definite tendency to the contrasted forms of expressions shown in sexual or dimorphic characters.[1]

On the basis of these distinctions the cotton plant and its relatives would be reckoned as arropic species, since there is no sexual or other differentiation into distinct types within the species. At the same time it is obviously desirable to have a ready means of designating different forms of structural specialization in plant individuals whether they belong to ropic or to arropic species. Plants that show obvious differences of leaves and flowers are sometimes called heterophyllous or heteranthous, but these terms record merely the fact of diversity, which is often indiscriminate or intergraded, without any definitely established tendency to contrasted expression of characters.

For the designation of cases of definite dimorphic or polymorphic specialization the word "ropic" may be used in combination with other terms to indicate the part affected. Thus the variety of *Hibiscus cannabinus* with the definite dimorphism of the leaves may be described as phylloropic. Cotton, coffee, cacao, and the Central American rubber tree (Castilla) may be described as cladoropic, since they all show definite specialization of two or more forms of branches. Cacao and some varieties of cotton are phylloropic as well as cladoropic, for the two types of vegetative branches are accompanied by definitely different types of leaves, which do not appear in coffee. According to Went[2], Castilla also has two kinds of leaves.

The banana plant and the Indian corn are familiar illustrations of a dimorphic condition of the flowers and may be termed anthoropic, each plant bearing two definitely different kinds of flowers. A more complicated case of specialization of floral differences appears in the Central American rubber tree. The male or staminate individuals bear only one kind of flowers, but the female or pistillate trees bear two kinds, each pistillate inflorescence being subtended by two small staminate inflorescences, not of the same form as those that are found on the purely staminate trees. The species as a whole shows a definite specialization of the sexes, but the female trees may be described as anthoropic because of the two definitely different kinds of flowers.

Many terms are used by students of plant pollination to indicate whether the stamens and pistils are present together in the same

[1] Cook, O. F. Aspects of Kinetic Evolution. Proceedings of the Washington Academy of Sciences, vol. 8, 1907, p. 369.

[2] Went, F. A. F. C. Der Dimorphismus der zweige von Castilloa elastica. Ann. Jardin Botanique Buitenzorg, vol. 14, pp. 1–17.

inflorescences, separated in different flowers of the same plant or on different plants, or whether these organs are alike or different among themselves or ripen at the same or at different times. Yet these terms do not indicate whether the different conditions arise by gradual changes in the expression of the characters or whether the other floral parts are different, as well as the stamens and pistils.

Technical terms can often be avoided in describing the details of structure or behavior in any one species or genus of plants, but they become a practical necessity in the scientific task of comparing and contrasting the behavior of different types of plants. Distinctions need to be carefully drawn so as to recognize as definitely as possible the different kinds of diversity that arise because of the different ways in which the expression of the characters is determined. In some cases it is plain that the external conditions are able to influence the expression of characters during the development of a branch, while in other cases determination of characters of branches and leaves seems to be entirely independent of the environment. It is desirable, therefore, to review briefly the terms that have been applied by morphologists to the structural diversities that most nearly resemble the present cases of dimorphic leaves and branches.

Goebel refers to upright shoots of conifers and similarly specialized trees as orthotropes, and lateral or horizontal shoots as plagiotropes; he also considers that the specialization of the lateral shoots (laterality) is of two kinds, called "labile induction" when the lateral branches are able to assume the functions of uprights, as in Picea, and "stabile induction" when such substitutions can not be made. There is also a distinction to be drawn between two kinds of "stabile induction" of laterality. In some cases the lateral branches are readily able to regenerate upright shoots from lateral buds, as in cotton, while in other cases the lateral branches seem to have no power of replacing the uprights, even from latent buds. This extreme type of specialization shown in coffee, Castilla, and cacao has also been demonstrated by Goebel in *Phyllanthus lathyroides*.[1]

The terms clinomorphy and anisophylly have been used by Wiesner for adaptive modifications of leaf forms connected with differences of position or exposure, but not in relation to dimorphism or contrasted expression of characters as a definite fact of heredity.[2]

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[1] Goebel, K. Einleitung in die Experimentelle Morphologie der Pflanzen, 1908, pp. 86–88.

[2] In Biologie der Pflanzen, Vienna, 1889, Wiesner states: "Many formative processes in plants are induced by the inclination of the organs to the horizon. All phenomena of development induced through position, not explainable through the effects of gravitation alone, should be comprehended under the name clinomorphy. Clinomorphy appears if an organ in the course of its development is so inclined to the horizon that one can distinguish an upper and an under side, and consists in the fact that the upper half takes another form than the lower." (P. 28.)

"Anisophylly is only an inequality of the foliage of the shoot in relation to position and is shown in the under leaves of a shoot becoming larger and heavier than the upper." (P. 33.)

Goebel considers Wiesner's definition of anisophylly too narrow, and would include cases where the leaves on the under side of the shoot are smaller than those on the upper side, as the following statements will show:

By anisophylly we mean that leaves of a different size and of different quality appear on the different sides of plagiotropous shoots; the leaves which stand upon the upper side are usually smaller than those upon the under side, but the converse is also sometimes the case. * * * All the examples have this in common, that the anisophylly occurs exclusively upon plagiotropous shoots and that it is a *character of adaptation* which has an evident relation to the direction of the shoot and especially to its position with regard to light. * * * Herbert Spencer in 1865 first directed attention to the anisophylly of lateral shoots in plants with decussate leaves, as well as to the connection of the anisophylly of higher plants with external factors, especially with light. * * * The term has come to us from Wiesner, although his definition, which is as follows, is too narrow: "I mean by anisophylly that the leaves lying upon the upper side of prone shoots have smaller dimensions than those upon the under side, whilst the lateral ones are intermediate." We know, however, that the leaves on the under side may be smaller, as is the case in the foliose Jungermannieæ and in *Lycopodium complanatum.* [1]

An excellent example of anisophylly is found in the common paper mulberry (Broussonetia), as shown in figure 18. Indeed, Broussonetia may be said to combine two phenomena, for in addition to the distinctly smaller size of the leaves that arise from the upper side of the branch there is a wide range of diversity in the forms of the leaves, which constitutes heterophylly.

Anisophylly is to be considered as a physiological phenomenon, rather than morphological. The inequalities in the size of the leaves are supposed by Wiesner and Goebel to arise by direct accommodation to the position in which they happen to be formed. An accident to a tree that changes the position or exposure of a growing shoot affects the condition of anisophylly by rendering the leaves more or less unequal than they otherwise would have been. Yet the interpretations that have been placed upon anisophylly do not seem to be altogether consistent. In some cases it is considered that the larger size of some of the leaves is connected with better exposure to light, but in Broussonetia it would seem that the light must be supposed to restrict growth, for the smaller leaves are produced from the upper side of the branch. Some writers look upon the small leaves as specially adapted to fit in among the large ones and thus utilize all the surface of exposure. In this view Broussonetia would seem to have overshot the mark. Figure 18 indicates that much

[1] Goebel, K. Organography of Plants, Especially of the Archegoniatæ and Spermaphyta, pt. 1, 1900, pp. 99–100.

Additional cases of anisophylly in tropical plants from the Malay region have been reported by Heinricher in a paper that concludes with a list of several other papers on the subject. (See Heinricher, E. Beitraege zur Kenntnis der Anisophyllie, Annales du Jardin Botanique de Buitenzorg, sup. 3, pt. 2, 1910, pp. 649–664, and pl. 25.

more space is lost between the rows of small leaves and the large ones than between the leaves in the rows.

When a definite dimorphism exists the differences in the leaves or branches are not merely physiological, but morphological. There are two kinds of leaves or of branches, not merely two conditions of the same kind. Anisophylly presupposes only one kind of leaves, but with a wide range of accommodation to external conditions. Inequalities of leaves due to differences of exposure to sunlight may be considered as a weaker form of the same kind of accommodation shown in amphibious plants that produce either an aquatic or an aerial form of foliage, depending on the medium in which they happen to grow.

Fig. 18.—Lateral branch of the paper mulberry (Broussonetia), with leaves unequal in size (anisophylly) and diverse in form (heterophylly). (Reduced.)

A term that has a more definite signification from the standpoint of heredity is dichogeny, defined by De Vries as follows:

> I mean [by dichogeny] all those cases where the nature of an organ is not yet decided during the early stages of its development, but may yet be determined by external influences. Thus, under normal conditions the runners of the potato plant form at their tips the tubers, but on being exposed to light, or when the main stem has been cut off, they develop into green shoots. * * *
>
> In such cases it is clear that the possibility of developing in either of two different directions is dormant in the young primordia. For this very reason I should like to apply the name *dichogeny* to this phenomenon. And it evidently depends upon external influences what direction is taken. Therefore, a selection must take place from among the available hereditary characters of the species, and this selection may be influenced by artificial interference. For the theory of hereditary characters such experiments are therefore of the highest interest.[1]

[1] De Vries, H. Intracellular Pangenesis (translated from the German by C. Stuart Gager, Chicago), 1910, pp. 15–16.

The phenomena of dimorphism of leaves and branches show a general contrast with the phenomena of dichogeny, since they appear to arise from a definite polarity or determination of expression or nonexpression of certain characters that may not be subject to change through the influence of external conditions. In such cases as the dimorphic branches of coffee, cacao, and the Central American rubber tree (Castilla), it is evident that the nature of the organ is definitely predetermined even in the earliest stages of its development. From a bud in a certain position on the internode only one kind of a branch can arise, while another kind of branch comes quite as regularly from another bud in a different position. The lateral or fruiting branches not only do not transform themselves into vegetative limbs but may even be unable to produce new vegetative shoots from buds. In the cotton plant vegetative shoots can be regenerated from axillary buds of the fruiting branches, but in coffee the fruiting branches can produce only inflorescences or other fruiting branches. The same is true of Castilla, except that the fruiting branches nearly always remain simple. In the cacao tree two kinds of branches are even more definitely specialized in their vegetative characters and functions, though both kinds bear inflorescences.

The word "ropogeny" may serve as a general term to cover such cases of definitely predetermined alternative expression of characters resulting in dimorphism or polymorphism in the branches, leaves, or flowers of the same plant. Ropogeny is to be contrasted with dichogeny, in which the expression of the characters is not definitely determined in the early stages but remains subject to change by environmental influences during the development of the plant.

Dichogeny and ropogeny, used in these senses, are strictly physiological terms. One of the problems in the physiology of reproduction is to understand, as far as possible, how the characters are determined and brought into expression. It is evident from the facts of dichogeny and ropogeny, as well as from the general nature of the processes of development in plants, that expression is differently determined in different plants and even in different parts of the same plant. Not only is there a general distinction to be drawn between transmission and expression of characters, but different forms of alternative expression have to be recognized.

The extent to which expression has been modified by specialization does not appear to have any direct relation to the method of predetermination of the characters. In some cases all gradations may be traced between normal foliage leaves and minute bracts or bud scales, while in other cases there are definite differences between two kinds of large, expanded foliage leaves as shown in the cacao tree and still more strikingly in the related species *Theobroma bicolor*.

These facts may explain why some of the more definite but less striking differences have been overlooked, notwithstanding the attention that has been given to the study of the more reduced and apparently more specialized forms of leaves.

In addition to bud scales and prophylla, special names have been given to the reduced leaves of underground shoots (kataphylls) and to those that subtend flowers or inflorescences (hypsophylls), but these terms seldom, if ever, refer to examples of definite dimorphic differences like those that sometimes exist among true foliage leaves, nor do they serve to distinguish gradual changes of characters from those that are more definite and abrupt.

It is convenient to use a general term (hypophyll) to cover all forms of reduced leaves, since nearly all plants have such leaves, in addition to the true foliage leaves (trophophylls) and the floral leaves (anthophylls). Most hypophylls are formed by the reduction or suppression of the blade and petiole of the leaf, while the sheath or the stipules are retained or enlarged, as in the involucral bracts of the cotton plant. Both the hypophylls and anthophylls may be disregarded in the study of differences among the true foliage leaves.

The terms that have reference to various kinds of differences among the leaves and branches of the same individual plant may be summarized briefly as follows:

Heterophylly, a general term covering all kinds of diversity of leaf forms on the same plant without regard to whether the differences are definite or adaptive.

Clinomorphy, a general term for differences of form arising through oblique or horizontal position.

Laterality, a general name for special characters of lateral branches as distinguished from those of an upright trunk or branches.

Anisophylly, inequality of leaves on upper and lower sides of horizontal or oblique shoots, as in Broussonetia. (See fig. 18.)

Hypophylly, the production of rudimentary or reduced leaves, including prophylls, bud scales, bracts, and other less common conditions, such as the scale leaves above the cotyledons of seedlings of *Persea gratissima* and *Citrus trifoliata* and those near the ends of upright shoots of *Theobroma cacao.*

Phylloropy, production of two or more definitely different kinds of foliage leaves on the same plant, as in the cacao tree and in narrow-leaved varieties of cotton, okra, and *Hibiscus cannabinus.*

Cladoropy, production of two or more definitely different kinds of branches on the same plant, as in cotton, coffee, cacao, and Castilla.

Cladoptosis, the self-pruning habit or spontaneous falling off of specialized temporary branches, as in Populus, Quercus, and Castilla.

Heteroblasty, the production of a distinct type of juvenile foliage as in Eucalyptus, Juniperus, Pinus, Hedera, and Ficus.

Homoblasty, the absence of a distinctive juvenile form of foliage.

Dichogeny, expression of characters not completely determined in early stages, allowing different characters to come into expression as a result of accommodation to different conditions, as in *Solanum tuberosum*, *Ranunculus aquatilis*, etc.

Ropogeny, expression of characters completely determined in the early stages, not subject to modification by differences of external conditions, as in the fruiting branches of coffee, cacao, and Castilla that are unable to regenerate vegetative shoots.

RELATION OF DIMORPHISM TO SEXUAL DIFFERENTIATION OF PLANTS.

Abrupt changes of characters during the development of plants are not limited to these more or less exceptional cases of dimorphic specialization of different kinds of leaves. Even where the leaves are all of one type numerous changes in the expression of characters are required to form the different kinds of floral organs. This requirement of numerous changes of characters during the process of development renders the phenomena of heredity in the higher plants somewhat different from those that are shown in the higher animals, especially when viewed from a physiological standpoint.

The fact that many of the higher plants are self-fertilized is often taken to mean that the principle of sexuality is less important with plants than with animals, but this idea represents only a partial view of the facts. The pollen grains and ovules of plants are not only as definitely differentiated as the sex cells of animals, but they are produced by plant individuals that have a sexual differentiation quite as definite as that of the higher animals.

The plant individual is constituted in a different way from the individual animal, being made up of a large number of internodes or joints often capable of independent existence, if cut apart, or even provided with natural means of separation. In other words, the plant is to be considered as a compound individual or social organization of numerous internode individuals. The stamens and pistils also represent separate members of the series of internodes that make up the compound plant body.

The process of conjugation in plants involves the union of sex cells derived from different individuals, no less than in animals. Self-fertilization simply means that crossing is confined to germ cells produced by members of the same plant colony. The close association of stamens and pistils in the same flower should not be allowed to conceal the fact that these two types of organs are entirely unlike, not only with respect to their products of pollen grains and ovules, but in other characters. The same freedom of change and contrast of characters apparent in the external visible features may be supposed to exist in internal characteristics of the germ cells.

Plants that produce both stamens and pistils in the same flowers are often described as hermaphrodite, but this normal bisexual condition should not be confused with an abnormal, partial, or intermediate expression of the characters of both sexes in the same individual, as sometimes occurs among sexually differentiated animals. In normally bisexual plants, on the contrary, the characters of both of the sexes are fully expressed in the separate individual members of the colony. Abnormal hermaphroditism, like that of animals, is shown in plants in the rare cases of malformed organs intermediate between stamens and pistils. The abnormal organs heretofore mentioned (p. 22) as intermediate between stamens and petals represent a similar failure of complete change in the expression of contrasted characters, as also occurs in abnormal intermediate forms of branches.

Morphologists may object that the higher animals, as well as the higher plants, have a segmental or metameric structure in the sense that their bodies are made up by the union of structural elements corresponding to the more distinctly segmental bodies of the lower groups of animals. But whatever stress may be laid upon this idea from the standpoint of morphological theories, it is evident that the physiological differences are profound, involving different relations among the primitive segments and different requirements for changes in the expression of the hereditary characters during the processes of development. The processes of heredity, as shown in the formation of the segments, might be described as simultaneous in animals and successive in plants.

The segmental growth of the animal body is determinate at a very early stage, long before the growth in size is completed. In the higher animals the determinate condition is shown most definitely in the female sex, the whole complement of ovules being formed while the animal is still in an embryonic stage of development. In bees and related insects the male sex is more determinate than the female. The plant body, on the other hand, begins with only one or two segments and adds the others gradually during the process of growth. The individual stamen or pistil of a plant is determinate, but most plants can produce an indefinite succession of stamens and pistils as well as of vegetative internodes.

Plants grow chiefly by successive additions of segmental units. The striking fact about the successive additions of new structural units to the plant body is that they are not all alike but are capable of very abrupt and very extensive changes of characters. After forming, it may be, several kinds of vegetative internodes, the young plant begins suddenly to make floral or reproductive internodes, each kind of internode involving a practically complete change of characters. The idea that plants could produce the slight changes of characters shown in bud mutations has seemed highly improbable to those who have not witnessed such changes, though more extensive changes regularly take place in the development of each plant.

Beginning with the formation of cotyledons or seed leaves, the plumule of the embryo has already provided for an abrupt change to the ordinary form of leaves. Some seedlings show more gradual transitions from the cotyledons to the ordinary leaves, and some have specialized reduced leaves between the cotyledons and the ordinary foliage leaves, as in *Persea gratissima* and *Citrus trifoliata*. The cacao tree often produces similarly reduced scalelike leaves on many internodes near the ends of the upright shoots in addition to two kinds of functional leaves, the ordinary leaves of the upright shoots being different from those of the lateral or whorled branches. Many plants have small entire leaves like those of seedlings at the base of each new shoot, as in the vegetative branches of cotton. In grasses and palms the basal joint of each branch or inflorescence bears a small bladeless sheath, called the prophyllum, similar to the first leaves of seedlings. Pines, junipers, and eucalypts have a distinct juvenile type of foliage in young plants that entirely disappears in adults, though it is recalled to expression when growth is forced from dormant buds after severe cutting back.

Many herbaceous plants have the so-called radical leaves at the base of the stalk much larger and of a very different form from those farther up, a condition that doubtless passes by numerous gradations into the more definite types of dimorphism shown in Hibiscus and Gossypium.

The erect fruiting branches of the English ivy are upright and bushy and have more rounded leaves than the familiar creeping stems. De Vries has shown that the so-called variety arborea represents merely rooted cuttings of the fruiting branches that continue the upright habit of growth. De Vries also found that the seedlings of such a plant were of the usual creeping form, and came to the conclusion that the upright habit was "not inherited." He states:[1]

> In 1893 I sowed the berries of an older plant of this kind, in this case an ivy bush of about 2 meters, and obtained over a thousand seedlings. These still grow in our garden and have made, up till now, exclusively creeping stems and branches. The arborea form is evidently not inherited.

In the same way it might be said that the characters of butterflies are not inherited, since they do not appear in the caterpillar stage

[1] De Vries, H. The Mutation Theory, 1909, vol. 1, p. 44.

of the progeny. Or beards might be considered as not inherited because they are not developed in children. In all such cases there is a temporary latency or postponement in the expression of characters, but no failure of inheritance in the sense of transmission. The adult characters remain latent during the larval or juvenile stages, and the juvenile characters are suppressed in turn during the adult stages. In the development of each individual plant several such changes in the expression of the characters are regularly required for the formation of the different kinds of vegetative and reproductive organs.

In the cotton plant six different forms of leaf organs may be recognized, the cotyledons, the entire or broad-lobed leaves at the base of the stalk, the more divided leaves farther up, the smaller, narrower leaves of the fruiting branches, and the two still more reduced and specialized forms that compose the outer and inner involucres. To form the petals, stamens, and pistils requires three other changes of characters, making nine changes altogether during the course of development of each plant.

The familiarity of the facts makes an adequate appreciation difficult, but if the individuality of the internodes and their method of development, one after another, be recognized, it becomes plain that the changes of characters that take place during the growth of the plant are much more profound than those that are required in the postembryonic development of an animal. The whole complex of characters expressed in one internode individual may give place to the expression of an entirely different complex in the very next internode. Without any opportunity for new conjugations, segregations of characters in different germ cells, or changes in the numbers of chromosomes, one complex of characters after another is called into expression and the previous complex retired to a latent condition.

Failure to effect the full change of expression results in the development of abnormal organs of intermediate form, as in the case of abnormal intermediate branches in the cotton plant. Such branches are usually sterile, or their flower buds are abortive, as in abnormal hybrids or hermaphrodites. The power to complete the various alternations in the expression of the characters determines the possibilities of development in the individual plant, in the same way that the evolutionary progress of a species is determined by evolutionary changes of characters.

The phenomena of alternative expression have been studied largely from the standpoints of environmental modifications and diversities in hybrids. These groups of phenomena are only a small part of the field of alternative expression, which includes also the endless changes of characters that appear during the ordinary processes of development. Even evolutionary changes appear to depend largely upon the power of alternative expression. After a character has once been acquired transmission seems to be permanent. Characters that are discarded from expression are not dropped from transmission, but may be transmitted in latent or rudimentary form for thousands of generations, as the facts of recapitulation and reversion have shown. The transmission of latent characters should not be considered as a rare or exceptional phenomenon, but as the normal, universal condition.

The internal agencies of the cells, that determine the expression of characters, remain active and capable of profound readjustments during the life history of each individual plant. The changes of characters shown in mutative variations are considered as very important phenomena of heredity, and yet they are far exceeded by the changes that regularly take place during the development of every normal plant. Even the metamorphoses of insects hardly constitute such profound modifications of form and structure as the differences among the internode members of the same plant.

Though the facts of plant development seem to afford little ground for the application of Weismann's idea of a fundamental distinction between the germ plasm and the somatic tissues, a distinction is at least to be made between the processes of inheritance in plants and animals. The unknown internal mechanism that controls the expression of the characters evidently remains in a much more active state during the development of a plant than in the case of an animal. This consideration may help to explain the generally recognized fact that the characters of plants are much more readily modified by changes of environment than those of animals. A recent writer has proposed to explain the greater adaptability of plants and lower animals to changes of environment by framing general laws of diminishing environmental influences in passing from lower to higher groups.[1]

A study of the methods of reproduction and development followed in the various groups may reveal biological facts underlying this generalization. The higher animals, that show the least susceptibility to environmental modification, not only have a more nearly simultaneous determination of the expression of the characters, but their warm-blooded bodies are able to maintain constant temperatures and thus protect themselves against the fluctuations of heat and cold that represent one of the most disturbing factors in the development of plants.

Consideration should also be given to the possibility that the sudden and complete changes of characters involved in the production of the

[1] Woods, F. A. Laws of Diminishing Environmental Influences. Popular Science Monthly, April, 1910, p. 313.

different kinds of internodes may influence the germ cells and the process of conjugation. The phenomena of sexuality are closely connected with contrasted expressions of characters. Sexuality is primarily a physiological fact, and only secondarily morphological. The physiological value of sexual differentiation must be sought finally in a greater efficiency of the process of conjugation.

In the higher groups of plants and animals there is a double differentiation of sexual characters. The male and female germ cells not only become more and more unlike as the scale of organization is ascended, but sexual inequalities also become more and more developed in the organisms that produce the two kinds of germ cells. Not only the inequalities of the germ cells but also the sexual differentiation of the parent organisms must be supposed to relate in some unknown manner to an increased efficiency of conjugation. Many of the secondary sexual characters of plants and animals are like dimorphic differences in having no direct or obvious use in relation to the external environment, but they may have relation to the internal functions of heredity. Even if considered as mere reflections or anticipations of divergent tendencies of expression embodied in the germ cells, secondary sexual characters would still have physiological significance as showing the fundamental tendency toward alternative expression of characters.

In view of these and other indications that diversity and alternative expression of characters among the members of species have physiological functions in increasing the efficiency of reproduction, it becomes reasonable to consider the possibility that the series of sudden and complete changes in the expression of characters involved in the development of the successive types of internode individuals in plants may also be a factor of heredity. If contrasted parental characters and changes of external conditions affect the vigor of organisms, why may not frequent changes of characters during the process of development be supposed to have a similar advantage? The specialization of two or more different kinds of leaves, branches, or flowers on the same plant may be compared with the alternative inheritance shown in the sexes and castes of animals, and both classes of specialization may have similar relations to the physiology of reproduction. Frequent conjugations between germ cells representing different lines of descent may be rendered less necessary in plants because of the numerous changes of characters that take place during the ordinary processes of growth.

CONCLUSIONS.

A definite dimorphism of the leaves exists in an Egyptian variety of the Deccan hemp (*Hibiscus cannabinus*). The leaves of the upper part of the stalk are deeply three lobed, while those of the lower part are without lobes. The change from one form of leaves to the other is usually quite abrupt.

The various types of cotton and okra show the same general range of diversities of leaf forms as the Deccan hemp, and some of the varieties have the same tendency to dimorphic expression of the leaf characters. In other words, there is a general parallelism of variation in leaf characters extending through the many species and varieties of cotton, as well as the related genera of plants.

The definite changes of characters involved in passing from one form of leaves or branches to another are analogous to the abrupt transformations that take place in mutative variations. The facts of dimorphism and of bud variation indicate that mutative changes of characters are not necessarily connected with conjugation or with the early stages of sexual reproduction from new germ cells.

Dimorphic differences and mutations show that abrupt changes of characters are to be considered as phenomena of alternative expression. It is obvious that such changes are not determined by alternative transmission, as often alleged for Mendelian segregation of contrasted characters. The same kinds of characters show dimorphic specialization in individual plants and Mendelian segregation in hybrids. Dimorphism and Mendelism may both be interpreted as phenomena of alternative expression.

The general interest of such phenomena is in their relation to the recognition of a fundamental distinction between transmission and expression as a general law or principle of heredity. The facts of heredity and breeding can be better understood if transmission be considered as including the whole ancestral series of characters. Transmission inheritance is a comprehensive process, while expression inheritance is partial and alternative, different characters being expressed in different individuals or in different stages of individual development.

The facts of dimorphism are worthy of being taken into account in breeding, as affording additional varietal characters and as one of the means of recognizing variations from the standard or typical form of a select variety. Dimorphism must also receive attention in the study of the influence of environmental conditions on the expression of characters. In cotton and other tropical crop plants the modification of dimorphic differences represents one of the most serious disturbances of normal heredity induced by external conditions.

DESCRIPTION OF PLATES.

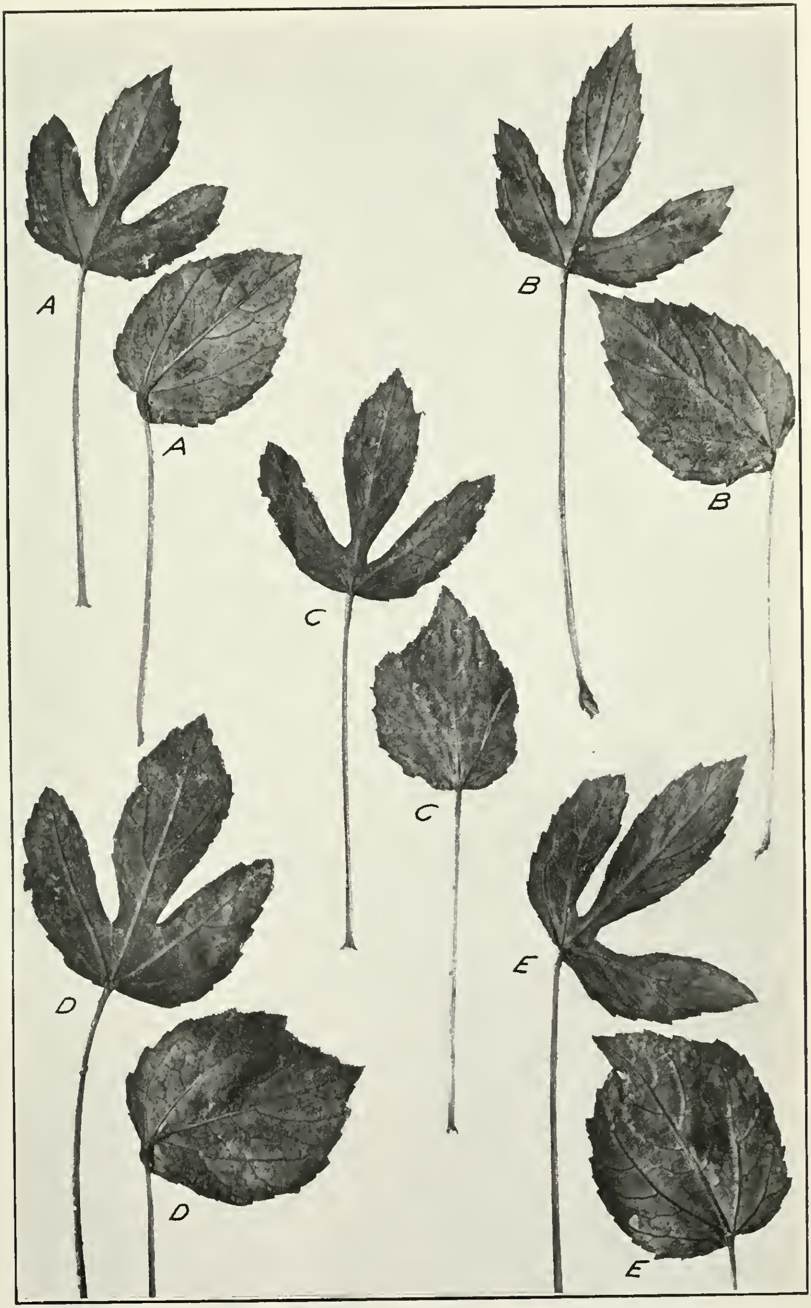
Plate I. Dimorphic leaves from adjacent internodes of five plants (*A*, *B*, *C*, *D*, *E*) of *Hibiscus cannabinus*, two leaves from each plant, the highest of the simple leaves and the lowest of the divided leaves, showing the very abrupt change of form. (Natural size.)

Plate II. Dimorphic leaves from adjacent internodes of four plants (*A*, *B*, *C*, *D*) of *Hibiscus cannabinus*, four leaves from plant *A* and three leaves from each of the others, showing the more gradual changes of characters. The plant leaves shown in this and the preceding plate were collected from plants grown on the borders of cotton fields at Gizeh, Egypt, July, 1910. (Natural size.)

Plate III. End of fruiting branch of Egyptian cotton with normal leaves, stipules, and involucral bracts. Photograph from living plant grown at Sacaton, Ariz., in 1910. (Natural size.)

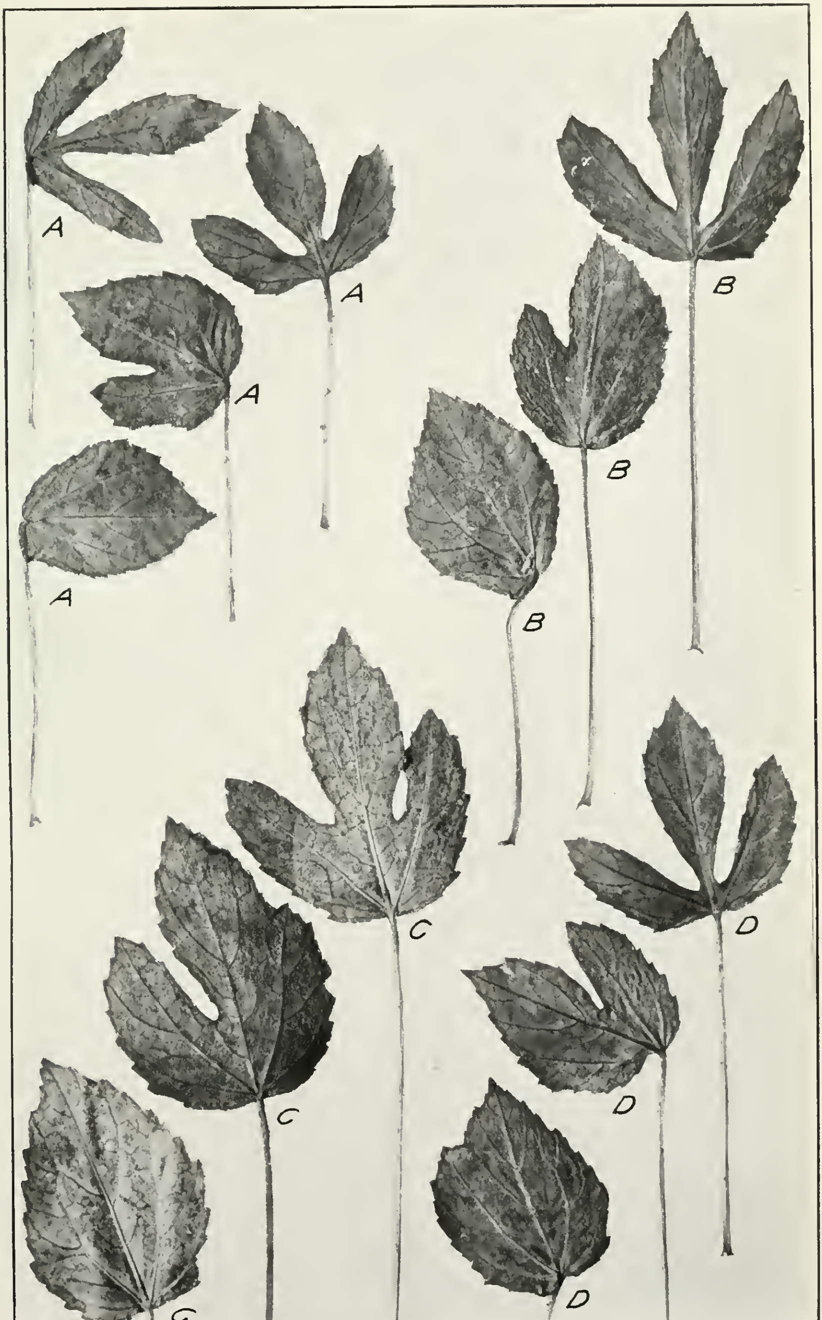
Plate IV. End of fruiting branch of Egyptian cotton with abnormally enlarged stipules and reduced leaf blades, without lateral lobes. Photograph from living plant, Sacaton, Ariz., 1910. (Natural size.)

Plate V. Hybridization of broad-leaved and narrow-leaved varieties of cotton: *A*, Leaf of Keenan variety; *B*, Ratteree's Favorite; *C*, hybrid. Photograph from dried specimens grown by Mr. H. A. Allard at Thompson's Mills, Ga. (Reduced.)



DIMORPHIC LEAVES FROM ADJACENT INTERNODES OF FIVE PLANTS (*A*, *B*, *C*, *D*, AND *E*) OF HIBISCUS CANNABINUS, SHOWING VERY ABRUPT CHANGES OF FORM.

(Natural size.)



DIMORPHIC LEAVES FROM ADJACENT INTERNODES OF FOUR PLANTS (*A*, *B*, *C*, AND *D*) OF HIBISCUS CANNABINUS, SHOWING SOMEWHAT GRADUAL CHANGES OF FORM.

(Natural size.)

END OF FRUITING BRANCH OF EGYPTIAN COTTON WITH NORMAL LEAVES, STIPULES, AND INVOLUCRAL BRACTS.

(Natural size.)

END OF FRUITING BRANCH OF EGYPTIAN COTTON WITH ABNORMALLY ENLARGED STIPULES AND REDUCED LEAF BLADES, WITHOUT LATERAL LOBES.

(Natural size.)

HYBRIDIZATION OF BROAD-LEAVED AND "OKRA" VARIETIES OF COTTON: (*A*) LEAF OF KEENAN VARIETY, (*B*) RATTEREE'S FAVORITE, AND (*C*) HYBRID.

(Reduced.)

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 222.

B. T. GALLOWAY, *Chief of Bureau.*

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LETTER OF TRANSMITTAL.

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Office of the Chief,
Washington, D. C., May 10, 1911.

Sir: I have the honor to transmit herewith a paper entitled "Arrangement of Parts in the Cotton Plant," by Messrs. O. F. Cook, bionomist, and Rowland M. Meade, scientific assistant, of this bureau, and to recommend its publication as Bulletin No. 222 of the bureau series.

Notwithstanding the great agricultural importance of the cotton plant, its peculiarities have received very little study from the botanical standpoint. This bulletin describes the general structure and habits of the plant as affected by differences in the number, position, and arrangement of the various parts.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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ARRANGEMENT OF PARTS IN THE COTTON PLANT.

INTRODUCTION.

The basis of all scientific study of cotton, as of other agricultural plants, is the recognition and comparison of differences. Whether experiments are being made for the breeding of better varieties or to determine the most favorable conditions or methods of culture, account must first be taken of the differences that are shown in the characters and behavior of the plants. The scientific interest and practical value of the results must depend very largely upon the ability of the experimenter to recognize such differences and to understand their relation to the development of varieties and to cultural problems.

Two principal kinds or classes of differences may be recognized in the study of such a plant as cotton. The component parts, such as the joints, leaves, flowers, or fruits, may differ, or there may be differences in the number and arrangement of parts that are otherwise alike. The body of the plant may be looked upon as a compound structure or colony built of several kinds of structural units, commonly called joints or internodes. Changes of behavior that are of serious economic importance may be brought about by changing the number and arrangement of the parts of the plants, even without altering the characteristics of the leaves, flowers, or other component units of structure.

Not only do the parts of an individual plant stand in relation to other parts of the same plant, but all the individuals of a pure strain or variety have the same system of arrangement of parts, though variously modified under different conditions of growth. The leaves and branches have definite positions on the stems, and the parts of the flowers and fruits have characteristic numbers and places, in addition to their peculiarities of form and color. Hybrids, mutations, and reversions usually show differences in arrangement of parts as well as in other characters. Differences in arrangement are often the most obvious and assist the breeder in recognizing the superior individuals and rejecting the inferior.

ARRANGEMENT OF THE LEAVES ON THE MAIN STALK OF THE COTTON PLANT.

The leaves of the cotton plant are not set at random along the stalks and branches, but are regularly arranged in ranks and spirals. In plants of normal growth it is usually easy to see that each leaf is directly above or below some other leaf and that there are three, five, or eight of these vertical ranks of widely separated leaves.

The regular spiral arrangement of the leaves is found on the main stalk and the vegetative branches. It is not apparent on the fruiting branches, for these have the joints twisted so that the leaves appear to stand in two rows.

The spiral arrangement of the leaves around a main stalk or a vegetative branch can be understood by considering the relation of any given leaf to the one next higher on the stalk. An imaginary line that would connect the insertions of the leaves would form a regular spiral, since it continues around the stalk in the same direction, to the right on some plants and to the left on others. On plants with three-ranked leaves the spiral makes one turn around the stalk in going from any given leaf to the next leaf that is directly above it. If the leaves are in five ranks the spiral makes two turns in going up to the next leaf on the same rank, while with eight-ranked leaves three turns are made.

Many individual plants will be found with their stalks so bent or twisted that no regular leaf arrangement is apparent, but in the majority of cases it is easy to ascertain which of the systems is followed. The regularity of the spiral is also destroyed if the growth of the stalk has been interrupted by dry weather or other injuries that cause the formation of very short joints. In such cases the direction of the spiral may even appear to be reversed.

Instances of such irregularities have been brought to our attention in cotton raised at Palestine, Tex., in the season of 1909, by Dr. D. N. Shoemaker, of the Bureau of Plant Industry. Some of the stalks had two or three sections of shortened joints and apparent reversals of the spirals. A possible explanation may be found in the fact that boll weevils, which were unusually abundant in the early part of the season, often eat out the terminal buds of the young plants. If the growth of the stalk were continued by an axillary bud it might be expected that the direction of the spiral would often be reversed, for the vegetative branches often differ from the main stalk in the direction of the spiral.

Botanists who have made special studies of the arrangement of leaves have found it convenient to describe the different systems by fractional numbers. The numerator of the fraction shows the number of turns that the spiral makes in passing from any given leaf to the next member of the same rank, while the denominator indicates the whole number of vertical ranks of leaves. The fraction as a whole indicates the part of the circumference of the stalk included between two successive leaves of a spiral. The most frequent arrangement of the leaves of the cotton plant is in the three-eighths spiral. This means that the leaves stand in eight ranks, that three turns around the stem are made by the spiral in passing from any particular leaf to the next that is directly above it, and that successive leaves along the spiral are separated by three-eighths of the circumference of the stalk.

NEW WORLD COTTONS WITH THREE-EIGHTHS SPIRALS.

The arrangement of leaves in three-eighths spirals appears to be a normal characteristic of all pure strains of cotton belonging to the Upland and Sea Island species (*Gossypium hirsutum* and *G. barbadense*) and to the nearly related types that are natives of tropical America. This normal arrangement appears with much regularity in varieties introduced from tropical America, when planted for the first time in the United States. With the advance of acclimatization, the leaf arrangements are varied by frequent examples of one-third and two-fifths spirals, and similar irregularities are found among native Upland varieties. Pure stocks are much more likely to have the regular three-eighths arrangement than those not carefully bred.

Variations in the arrangement of the leaves were first noticed in Egyptian-Upland hybrids, but were found later in all hybrid stocks, including many crosses between different Upland types. Hybrid plants may have a one-third, two-fifths, or even a five-thirteenths spiral arrangement, although both parents may have had the normal three-eighths arrangement, or hybrids may have the normal arrangement of the parents. The very general prevalence of the three-eighths spiral among American types of cotton warrants the suspicion that any plant without the normal three-eighths arrangement is of hybrid origin or the result of recent mutative variation.

On the other hand, there is a possibility that the regularity of the three-eighths arrangement in the newly imported stocks may represent one of the tendencies of reversion that are very frequently shown in other characters of the plants. The simpler forms of spirals may be correlated with the smaller size and more fertile habits of growth of acclimatized stocks, but if this be true some varieties should be found with the simpler spirals as a regular feature. The systems of arrangement followed by the foreign cottons in their native countries must also be ascertained before definite conclusions can be drawn regarding the effects of new conditions and acclimatization.

Mutative stocks, as far as known, differ from hybrid stocks in that all the plants of a stock have the same leaf arrangement. This may be like the stock from which the type mutated or it may be different. The only type of Upland cotton that seems to show a regular deviation some varieties the axillary branches are represented only by small rudiments or mere dormant buds, or they may die and drop off, leaving only minute scars, often difficult to detect in mature plants. When the limbs are produced they usually take a more upright position than the fruiting branches and often attain a height as great or greater than that of the main axis of the plant. In plants that have been injured or pruned or that have had their growth interrupted by dry weather; limbs may develop late in the season, either from basal joints of the stem or from joints that have already produced fruiting branches. At the base of the plant the vegetative branches usually grow more rapidly than the limbs, so that the latter may be forced to one side or their development arrested, but near the middle of the plant a limb and a fruiting branch may occur at the same node and may develop to about the same extent. In the Upland types of cotton the vegetative branches seldom occur above the fifth node from the base of the plant. The Egyptian cotton has a much stronger tendency to produce vegetative branches.[1]

Vegetative branches often grow as tall or taller than the main stalk and are generally larger than the limbs when both are produced on the same plant. They usually develop only at the base of the plant, but are often quite numerous and may even replace the fruiting branches over the whole plant, as often occurs in the first generation of foreign cottons introduced into the United States. Plants that develop only vegetative branches are rendered completely sterile. Having no fruiting branches they are unable to form any flower buds. This condition of sterility is to be distinguished from another that is still more common in unacclimatized stocks. Although fruiting branches are present the flower buds may all be abortive in the early stages, so that no flowers are produced. Moreover, plants that are able to produce an abundance of flowers may still fail to set any bolls.

Hybrids may also be rendered sterile in the same ways. An important step in the improvement of all cottons by selection is the removal of all plants showing a tendency to multiply vegetative branches at the expense of fruiting branches. Even though large branching plants may produce large quantities of cotton, seed from such plants should not be selected; furthermore, the crop ripens late and the yield per acre is generally less than can be secured from small plants. The presence of the boll weevil greatly increases the disadvantage of growing late varieties.

A special study of the branching habit of Egyptian cotton in Arizona has been made by Mr. Argyle McLachlan, of the Bureau of Plant

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Industry, who finds that the vegetative branches are produced for 12 to 14 nodes from the base of the main stalk in plantings of newly imported seed, whereas in acclimatized strains the number of vegetative branches is distinctly reduced and the production of fruiting branches usually begins five or six joints closer to the ground.

Weather that is dry enough to retard the growth of the plants also discourages the formation of limbs and vegetative branches, while humid conditions favor the production of both. After a prolonged drought at San Antonio, Tex., during the season of 1909, no plants of either New World or Old World cottons could be found with limbs, except as short rudiments, though many of the basal extra-axillary vegetative branches were well developed. The dry weather was apparently able to suppress the limbs without seriously restricting the growth of the extra-axillary vegetative branches that had begun to develop early in the season.

With an abundant supply of water the limbs may be forced into vigorous growth and may gain a predominance over the vegetative branches, as was well illustrated at Del Rio, Tex., during the same season. There the cotton from the same stocks as those in the San Antonio experiment received a plentiful supply of water, and limbs were much more numerous than vegetative branches. The vegetative branches usually outnumber the limbs unless the latter have been forced into growth late in the season.

ARRANGEMENT OF THE LEAVES ON THE LIMBS AND VEGETATIVE BRANCHES.

The arrangement of the leaves and buds on both the axillary limbs and the vegetative branches is the same as on the main stalk of the cotton plant. If the main stalk has the normal three-eighths arrangement all the limbs and vegetative branches follow the same system, no matter how many branches the plant may have. Deviations from the normal spiral on the main stalk are also accompanied by abnormal arrangements on the vegetative branches.

There seems to be little or no regularity in the directions of the leaf spirals on either the vegetative branches or the limbs. Often several succeeding vegetative branches will turn their spirals in the same (right or left) direction, while again they seem to alternate their direction with some regularity. The direction of the spirals of the vegetative branches often appears to agree with that of the main stalk in cases where the vegetative branches are few in number, but if the branches are numerous, differences in the direction of the spirals can usually be found. If a limb and a vegetative branch develop at the same node, their spirals may follow the same direction or may be opposed.

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ARRANGEMENT OF THE FRUITING BRANCHES.

The fruiting branches of the cotton plant are developed from the extra-axillary buds that stand slightly above and at one side of the axillary buds of the main stalk and the vegetative branches. Fruiting branches are very seldom produced from the lowest nodes of the main stalk or the vegetative branches. Even when no limbs or vegetative branches are developed at the base of the plant, the fruiting branches usually do not appear below the fourth or fifth joint of the stalk. When vegetative branches are present there is often an interval between them and the fruiting branches, a condition found by Mr. McLachlan to be especially prominent in the Egyptian cotton in Arizona.

FIG. 2. Two internodes of a fruiting branch of Upland cotton. (Natural size.)

The node at which the fruiting branches are first produced on the plant varies considerably, not only in the different varieties and types, but also in different conditions of growth. In Egyptian cottons this zone is from the eighth to the fourteenth nodes, while in the Upland cottons it is from the fourth to the fifth. In Upland cotton fruiting branches may begin to be formed very low down, only one or two nodes above the cotyledons, while in Egyptian cottons they generally begin much higher up, between the tenth and the fourteenth nodes. When the vegetative growth is very luxuriant the fruiting branches may be still higher up, or they may fail altogether, all being replaced by branches of the vegetative sort, as already noted.

Fruiting branches have a nearly horizontal instead of a vertical or ascending position. The basal joints are also longer than those of the vegetative branches, and the other joints are usually shorter, twisted, and more or less zigzag. (Fig. 2.)

ARRANGEMENT OF THE LEAVES AND FLOWERS ON THE FRUITING BRANCHES.

As previously stated, the leaves of the fruiting branches do not show the definite leaf arrangement of those on the main stalk and vegetative branches. The twisting of the joints of the fruiting branches brings the flower buds into an upright position and allows the leaves to stand out in two alternate rows along the sides of these branches. If one joint of the fruiting branch is twisted to the right, the next is twisted to the left, and so on in regular alternation, bringing every second leaf nearly in line with the one two nodes distant.

The direction of the twist of the basal joint also appears to have a regular relation to the position of the branch on the main stalk. Branches that come out at the right of the leaf axil usually have the basal joint twisted to the right; others to the left. The twisting brings the first leaf of the fruiting branch opposite the leaf on the main stalk, at the base of the branch. This alternation suggests the possibility that the fruiting branch may represent a specialized branch from the base of the axillary limbs.

The leaves of the fruiting branches, unlike those of the main stalk and vegetative branches, are often irregular in outline. If there is an odd number of lobes those on the side of the blade away from the branch are usually much larger than those alongside of the branch. These leaves often have two nectaries, or only one, instead of the three nectaries common to the leaves of the main stalk, one borne on the midvein and the second on the primary vein subtending the large lobe on the side of the blade away from the branch.

The flower buds do not come out from the axils of the leaves, but often appear to be separated by almost half the diameter of the stem. In cluster cottons, or others that have abnormal branches, the pedicel, or stem of the flower, appears as a continuation of the joint of the fruiting branch and lacks the usual absciss-layer that allows the blasted buds to fall off or the bolls to separate at maturity. This may indicate that the fruiting branches have what botanists describe as the sympodial method of growth, as though each joint were terminated by the flower and the next joint formed by the development of a new lateral bud.

In addition to the bud that continues the growth, there are buds in the axils of the leaves of the fruiting branches, and if these develop they may produce vegetative branches of the usual form. In other cases the axillary buds of the fruiting branch may produce very short vegetative branches, and these may give rise in turn to very short fruiting branches, so that one joint of a fruiting branch may appear to bear two or three bolls in an exceptionally fertile plant. Careful examination will show that only one boll is borne directly on the joint and that the others come from branches of the short axillary.

In the Asiatic species the flowers are often pendent and are borne somewhat on the sides of the branch, more nearly opposite the leaves. The leaves are arranged the same as those of the Upland and nearly related types of cotton.

ARRANGEMENT OF THE INVOLUCRAL BRACTS AND BRACTLETS.

Each flower bud of the cotton plant is protected by an involucre composed of three specially reduced and modified leaf-like organs, technically called bracts. Inside the involucre, between the bracts and the bud proper, still smaller leaf-like organs, the so-called bractlets, may occur. Both the bracts and the bractlets give indications of regular arrangement.

Two of the bracts are of equal size and are often appreciably larger than the third. The small bract is always borne on the side of the flower that faces outward, toward the end of the branch. (Fig. 3.) Bractlets are most likely to be associated with this small bract. If only two bractlets are present, as frequently happens, they stand at either side of this small outer bract. In the Kekchi cotton and other Central American types the bractlets often occur in pairs, alternating with the bracts, though it is rather unusual to find a complete set of six bractlets.

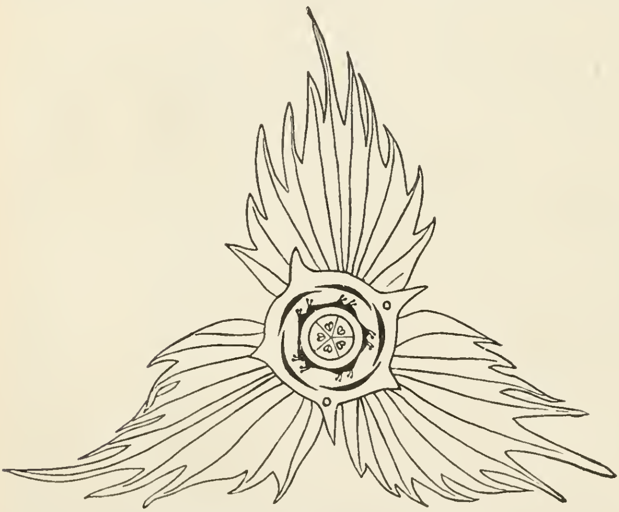

Fig. 3.—Diagram showing the relation of parts in the cotton flower. (Bracts and calyx teeth natural size.)

When a fourth involucral bract occurs, it develops at one side of the smaller bract, the side that is toward the leaf of the same node. This additional fourth bract has always been found to be smaller than the third and is even more likely to be accompanied by bractlets.

The laciniæ, or teeth, of the younger bracts are often bent or twisted in one direction and overlap those of another bract, completely inclosing the young bud. (Fig. 4.) At one node the laciniæ twist in one direction and at the next the direction is reversed. This twisting is opposite in direction to that of the internode which bears the flower and in the same direction in which the petals of the same flower overlap.

ARRANGEMENT OF THE LOBES OF THE CALYX.

The calyx of the cotton flower is usually very small, the usual function of the calyx, to protect the young bud, having been assumed by the much larger involucral bracts. The calyx forms in most kinds of cotton merely a shallow cup around the bases of the petals. The margin of the cup is more or less divided or produced into five lobes, sometimes short and broad, sometimes long and pointed. The assumption that these lobes represent as many sepals or bracts of some ancestral relative is warranted by their position and by the fact that a transparent line is also sometimes to be seen, extending from the sinus between two lobes to the base of the calyx.

Seldom, if ever, is a calyx found with lobes of uniform size. Usually there are two large lobes, two small lobes, and one of intermediate size. In the Egyptian cotton and in some of the Asiatic species, calyxes are found with the margin almost evenly truncate, but it is usually possible to distinguish the five lobes and to see that they are of unequal size.

FIG. 4.—Bracts of Upland cotton inclosing bud, showing twisted teeth. (Natural size.)

One of the small lobes stands between the two large lobes and is always on the outer face of the calyx, that is, opposite to the small outer bract of the involucre. (Fig. 5.) The other small lobe is between one of the large lobes and the intermediate lobe, but it may be on either side of the intermediate lobe. The position of the second of the small lobes with reference to the intermediate lobe has a constant relation to the twisting of the other parts of the flower. If the petals twist to the right the intermediate lobe is at the right of the small lobe, and vice versa. These relations can usually be ascertained without much difficulty, though abnormal calyxes are occasionally found, especially in connection with irregularities in the petals and other floral organs.

In view of the fact that organs of intermediate form are often found, it is not unreasonable to consider the so-called calyx as belonging to the same series of modified leaf organs as the outer involucral bracts. In other words, the so-called calyx may be looked upon as the inner involucre rather than as a true calyx. This view seems to give a better understanding of the arrangement of parts. It would explain, for example, the further fact that the smallest lobe, on the outer (distal) side of the calyx, seems to stand directly opposite to the small outer bract of the involucre, whereas none of the other lobes appears opposite to the bracts. The small outer involucral bract would commence and the smallest lobe of the calyx would complete one whorl or series of eight leaves in the usual system of leaf arrangement.

The two large lobes of the calyx alternate with two of the involucral bracts, and each of these lobes is usually provided with a nectary. The intermediate lobe and the remaining small lobe do not appear to be definitely alternate or opposite to any of the bracts. (Fig. 6.) Often the intermediate lobe approaches the size of the large lobes, especially in the Upland varieties. It then appears more nearly alternate with the involucral bracts and usually has a nectary at its base, like the other large lobes. In other cases the nectary is usually absent.

Fig. 5.—Flower of Upland cotton, from the side, showing the position of the small calyx lobe opposite the smallest bract. (Natural size.)

ARRANGEMENT OF THE INTRACALICARY ORGANS.

Inside of the calyx of the cotton flower, between the calyx and the petals, a series of small, greenish, oboval or spatulate organs may often be found. (Fig. 7.) The complete number of these organs is five and they are arranged in regular alternation with the lobes of the calyx. The size is extremely variable, so that the full number is seldom to be seen by the naked eye. Some of them are usually represented by minute rudiments visible under a lens as small tufts of hairs at the base of the calyx. When very large they may extend to the margin of the calyx, and in rare cases may project slightly above it.

That these organs are arranged in alternation with the lobes of the calyx is rendered the more apparent by the fact that they stand in front of faint transparent lines that mark the sutures between the component parts of the calyx. This was first observed in the Willet's Red Leaf variety of Upland cotton, where the deep-red color of the outside of the calyx makes the transparent lines more distinct. These lines are often very faint, but they seem to be generally present.

The intracalicary organs may be free from the calyx to near the base or they may be united with the calyx at the back, along the sutures which separate the calyx lobes. They are somewhat thickened and fleshy at the base, but become very thin toward the apex. Like other parts of the calyx they are well spotted with oil glands and have faint veinlets radiating from a transparent median line.

The fact that these organs are frequently adherent to the calyx lobes and that they often have a transparent median line, somewhat like the sutures that separate the lobes, suggests that they may represent ingrown margins of the calyx lobes. Or they may be considered as stipular elements of the calyx lobes, brought into expression in an irregular manner, like the bractlets that appear on the outside of the calyx. If viewed as independent organs, apart from the calyx, it is necessary to suppose that they represent rudimentary internodes or joints of the floral branch, intercalated between the calyx and the corolla, perhaps analogous to the suppressed or rudimentary branches that occur from the interval between the vegetative branches and the fruiting branches.

Fig. 6.—Flower of Upland cotton, from below, with bracts removed, showing the arrangement of calyx lobes, petals, and nectaries. (Natural size.)

If reckoned as parts of the calyx, the intracalicary organs add to the morphological analogies between the calyx and the involucre. If supposed to represent independent metamers, the intermediate position of the intracalicary organs would indicate that the so-called calyx is really a part of the involucre, since it is separated from the corolla by the intracalicary organs, which might even be considered as rudiments of the true calyx. It is possible that a study of the irregularities in the formation of the involucre in relation to different systems of phyllotaxy would give more definite indications regarding some of the morphological questions. The three bracts and the five calyx lobes would represent one complete whorl in a three-eighths system, but not in a two-fifths or a one-third system.

ARRANGEMENT OF THE PETALS.

The five petals of the cotton flower stand in alternation with the five lobes of the calyx and are inserted on the base of the staminal column, one petal at the base of each of the five lobes or ridges of the column. Abnormal flowers sometimes occur with six or more petals or with small petal-like organs on the base of the staminal column, above the large petals—another indication of the relation of the petals to the staminal column.

The arrangement of the five petals of the cotton flower in the bud may be described as convolute; that is, each petal overlaps the next. Sometimes the petals overlap to the right, sometimes to the left. If the internode that bears the flower twists to the right, the petals of the flower overlap to the left, and vice versa.

Fig. 7.—Calyxes of Cochin China Upland cotton, showing intracalicary organs alternate with calyx lobes. (Slightly enlarged.)

Looking into the flower, it appears that the petals and the stamens twist in the same direction. The direction of the twisting of the petals is reversed in each succeeding flower, as is the case with the internode of the fruiting branch which bears the flower. Finally, the petals twist in the same direction as the teeth of the bracts and stamens of the same flower. (Fig. 8.)

ARRANGEMENT OF THE STAMENS.

The cotton flower has a large cluster of stamens, often as many as 90, all inserted on a tubular sheath of tissue known as the staminal column. This surrounds and covers the pistil, allowing only the stigmas and part of the style to project beyond the cluster of stamens. If the style is long, as in the Egyptian cotton, the stigma may be carried well above the stamens, so that insects may be required for fertilization. In the Upland cottons the style is generally shorter and the stigmas may remain buried among the stamens, insuring self-fertilization.

Though the stamens may at first appear to have no regularity of arrangement, it is usually possible to see that they spring from five vertical ridges of the staminal column, often ending in as many teeth or lobes. The position of these ridges is opposite to that of the petals. Often there appear to be two rows of stamens on each ridge, one on either side. All of the filaments are usually bent in the direction of the twist of the petals and stigmas of the same flower.

The staminal column is reckoned by botanists as one of the peculiar characteristics of the mallow family, to which the cotton belongs. Some of the relatives of the cotton have only 5 or 10 stamens and little or no development of the staminal column. Abnormal cotton flowers are sometimes found with the column very short or split to the base into five separate lobes that may represent as many original stamens. On some plants all gradations may be found between this form of separate short lobes bearing few stamens, sometimes only two, and the elongated column of ridges bearing an indefinite number of stamens. In other words, the staminal column may be looked upon as composed of the united filaments or bases of the many stamens that are separated only at the end. The presence of partly divided anthers and of branched filaments, bearing two, three, or four anthers, also suggests the possibility that the large number of stamens now present in a normal cotton flower may have been attained by the subdivision or branching of an originally small ring of stamens. This would explain why the staminal tube has been developed as a common base for all the stamens instead of having them separately inserted, as in most of the families of plants that have numerous stamens.

FIG. 8.—Flower of Upland cotton, from above, showing the position of petals, stigmas, and stamens. (Natural size.)

ARRANGEMENT OF THE CARPELS.

The number of stigmas of the cotton flower is the same as that of the carpels, or "locks," of the ripe seed pod or "boll." In contrast with the generally constant number of bracts, calyx lobes, and petals, the number of carpels is always varied, even among the flowers of the same plant. No variety of cotton is known to have a constant number of carpels. In Upland cotton four-locked and five-locked bolls are the rule; in Egyptian and Sea Island varieties the bolls are three locked and four locked. Three-locked bolls are occasionally found in Upland cotton, and two-locked bolls in Egyptian. Six-locked bolls are of rare occurrence. Abnormal bolls with still larger numbers of locks result from fasciation, especially in the "cluster" varieties of Upland cotton.

When the number of carpels is less than five it does not appear that they have any regularity of arrangement with reference to other parts of the flower, but when five carpels are present they appear to stand in alternation with the lobes of the staminal column and the petals and opposite the calyx lobes. The stigmas are not usually twisted, but sometimes they are bent in the direction taken by the stamens and petals.

ARRANGEMENT OF THE HAIRS ON THE SURFACE OF THE SEED COAT.

Although not to be considered in detail in the present paper, the distribution of the hairs on the surface of the cotton seed is another subject worthy of study from the standpoint of position and arrangement. In most of the different species and varieties of cotton the seed produces two distinct kinds of hairs. The long hairs represent the commercial fiber, or lint, and the shorter, finer hairs represent the fuzz left on the seed after ginning. The fuzz may be white like the lint, but is often green or brown. If no fuzz is produced the seeds are left black and naked after ginning. Naked-seeded variations are quite common in some varieties of Upland cotton and are very undesirable because the absence of fuzz is nearly always accompanied by a serious reduction in the amount of lint. In a few cases plants have been found with neither fuzz nor lint. Though the presence of fuzz seems to be correlated with abundance of lint, very fuzzy seeds sometimes have very few of the long lint fibers; sometimes none at all.

In the Upland type of cotton the two kinds of hairs are mixed together over the whole surface of the seed, but in other sorts there are definite differences in the position of the lint and fuzz. In the Egyptian cottons there is a strong tendency to restrict the fuzz to the ends of the seed and the lint to the intermediate position. A peculiar form of Sea Island cotton found in a locality called San

Lucas, in eastern Guatemala, between Cajabon and Senahu, shows the most extreme specialization of the two kinds of hairs on the seed. The lower half of the seed is without lint, but has a dense, velvety covering of bright-green fuzz. The upper half of the seed produces lint but no fuzz.

In addition to the positional relation of the fuzz and lint there are also differences in the lengths of the lint fibers on different parts of the seed. Some varieties of Upland cotton have a strong tendency to have the fibers of the upper part of the seed distinctly longer than those of the lower part, so that when the lint is parted and combed out from the seed a "butterfly" outline is formed. The butterfly tendency is undesirable because inequality in the lengths of the fibers lessens the commercial value of the cotton for spinning purposes. Even when the long fibers are not all restricted to the upper part of the seed, the lower part may show an evident preponderance of shorter fibers.

ARRANGEMENT OF THE ROOTS AND UNDERGROUND SHOOTS.

The central stalk of the cotton plant extends into the ground to form the taproot. The lateral roots arise in four rows from four shallow vertical grooves, one on each side of the taproot. The regularity of arrangement is often obscured by the bending and twisting of the taproot, as well as by the fact that the lateral roots take different directions and develop very unequally. But most plants show definite indications of an arrangement of the roots in rows, and in occasional individuals, where all the roots happen to project at right angles, the four-ranked character of the root system is very plain, even in old plants. (Fig. 9.)

In addition to the various kinds of buds and branches already described, the cotton plant is able to produce underground shoots from the same grooves as the roots. The underground shoots have at first a rounded or irregular form, like root nodules or galls, and may represent modified root primordia. The nodules grow to various sizes, sometimes attaining a diameter of nearly an inch before showing the leafy bud that develops into a vegetative branch. The similarity to crown galls may prove interesting and even worthy of study from the standpoint of pathological tissues.

Subterranean shoots seem to be developed much more freely in the Egyptian cotton than in Upland varieties. They seemed to be generally distributed over a whole field of several acres of Egyptian cotton at Bard, Cal., where nearly all of the plants were killed down to the ground in the winter of 1910–11. The roots of all the plants that were dug up in different parts of the field were found to be alive and showed in May, 1911, many different stages of development of the subterranean shoots. Several of the lower leaves of such branches were small and distorted, but normal leaves were produced on shoots that had emerged from the ground.

FIG. 9.—Taproot of Egyptian cotton, showing the arrangement of lateral roots and underground shoots.

In cases where the plants had not been killed too far down, new shoots had been formed at the axils of the cotyledons and no subterranean shoots or nodules were found. If the buds in the axils of the cotyledons had developed into limbs in the previous year, new adventitious buds were produced from the swollen bases of the limbs. The branches from such buds were very small and slender at first, quite unlike the large, fleshy excrescences that gave rise to the underground shoots. The lower part of the stalk, representing the hypocotyl of the seedling, between the cotyledons and the surface of the ground, seems to have no power of producing adventitious buds. Nor did any of the nodules appear upon the lateral roots of any of the plants that were dug up. They seem to be entirely confined to the same lines or grooves which give rise to the normal lateral roots, and often show very clearly the same arrangement in four vertical rows. (Fig. 9.)

CONCLUSIONS.

Plants are compound organisms built up by many units of structure, the internodes or metamers. In studying the anatomy of a plant like cotton, two principal classes of differences may be taken into account: (1) Differences in the characteristics of the component parts of the plant and (2) differences in the number or the arrangement of the component parts.

The leaves and branches of the cotton plant have a regular arrangement in spirals. The normal arrangement in the Upland, Sea Island, and Egyptian varieties of cotton and nearly related types is in three-eighths spirals. Old World cottons, on the other hand, have the leaves and branches in a one-third spiral.

Hybridization produces deviations from the normal number of spirals of the parent stocks. Among the Old World types of cotton, hybrids show a tendency to produce plants with the more complicated arrangement of leaves, while among the Upland hybrids the tendency is to arrangements simpler than normal. Mutative variations may agree in leaf arrangement with the parent stock or may show different arrangements.

The cotton plant has two kinds of branches, differing in arrangement as well as in other characters. Fruiting branches develop laterally from extra-axillary buds at the side of the axillary buds, which produce the limbs. Extra-axillary buds may develop into vegetative branches and replace fruiting branches, but no normal fruiting branches are produced by axillary buds.

The leaves of the limbs and vegetative branches of the cotton plant have the same spiral arrangement as those of the main stem, though the direction of the spiral on the limbs and vegetative branches may be opposed to that on the main stalk. Each internode of the fruiting branch is twisted in the opposite direction from the one preceding, bringing the leaves in two alternating series along the sides of the branch and the flowers into an upright position.

The involucre of the cotton flower is composed of three bracts, two of equal size and one smaller. The small bract is always on the outer or distal side of the flower, toward the end of the branch. Two bractlets frequently appear on either side of the small bract in United States Upland varieties, while in certain Central American types a complete series of six is sometimes developed, one on either side of the three bracts. The teeth of the bracts when twisted follow the same direction as the overlapping of the petals

The calyx of the cotton flower has five lobes distinctly unequal in size, two large, two small, and one intermediate. One of the small lobes stands opposite the small bract of the involucre, between two large lobes. The arrangement of the other lobes varies in relation to that of other parts of the flower.

Small flaplike organs are often inserted between the calyx and the petals, arranged in alternation with the calyx lobes. These intracalicary organs may be considered as supernumerary calyx lobes or as representing free stipular elements of the calyx lobes. In either case they support the view that the calyx lobes are homologous with the bracts of the outer involucre. In other words, the calyx of the cotton plant may be looked upon as an inner involucre.

The petals of the cotton flower are opposite the lobes of the staminal column and overlap in the same direction as the stamens are bent. This direction conforms to the twisting of the internode of the branch bearing the flower and is reversed in the flowers at each succeeding node.

The stamens are arranged on the staminal column in five vertical rows, about the pistil, opposite the petals, and turn in the same direction as the overlapping of the petals. The paired positions and frequent branching of the stamens suggest the development of the compound staminal column by the subdivision of a few primitive stamens.

There is a persistent irregularity in the number of carpels, in the flowers and fruits of the same plant. The range of normal variation is from two to four carpels in the Egyptian cotton and from three to five carpels in the Upland cotton. When the number is five, the stigmas and carpels alternate with the petals and the lobes of the staminal column.

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 223.

B. T. GALLOWAY, *Chief of Bureau.*

SEEDS AND PLANTS IMPORTED

DURING THE PERIOD FROM JULY 1 TO SEPTEMBER 30, 1910:

INVENTORY No. 24; Nos. 28325 TO 28880.

ISSUED NOVEMBER 27, 1911.

WASHINGTON:
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Chief of Bureau, BEVERLY T. GALLOWAY.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 6, 1911.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 223 of the series of this Bureau the accompanying manuscript, entitled "Seeds and Plants Imported during the Period from July 1 to September 30, 1910: Inventory No. 24; Nos. 28325 to 28880."

This manuscript has been submitted by the Agricultural Explorer in Charge of Foreign Seed and Plant Introduction with a view to publication.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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SEEDS AND PLANTS IMPORTED DURING THE PERIOD FROM JULY 1 TO SEPTEMBER 30, 1910: INVENTORY NO. 24; NOS. 28325 TO 28880.

INTRODUCTORY STATEMENT.

No satisfactory test can be made of a new plant to determine its economic value until many months, or even years, have passed since its introduction. To emphasize those included in this inventory before they are tested may therefore appear somewhat premature, but it seems warranted for the reason that while in the printed descriptions new plants which arrive may seem much alike and equally interesting, to those who see all the correspondence which has led up to their introduction some of the new arrivals stand out as of special promise.

Those interested in the cover-crop problem of the California orange growers will notice the importation of a half ton of seed of the Palestine kirsenneh (*Vicia ervilia*, No. 28761) and 500 pounds of seed of another Palestine legume (*Lathyrus sativus*, No. 28762), and will note also the opinion expressed by Mr. Aaron Aaronsohn that the Lathyrus will make a quicker growth in the California orange orchards than *Vicia ervilia* and will have an advantage over the fenugreek that is now used there in that seed can be obtained cheaper.

The unusual interest in the mango in Florida, Porto Rico, and Hawaii has made it desirable to get the best East Indian varieties as rapidly as possible to increase the collection, which now numbers more than a hundred sorts. Some of these are early and others late ripening sorts; others have unusual keeping qualities; while still others are in the form of seeds imported for the purpose of originating new varieties. As pointed out by Mr. Walter T. Swingle in his citrus work, seeds like the mango, which are polyembryonic, are likely to give rise through the unfertilized embryos to strains of the original variety, which are characterized by increased vigor and productiveness.

So much interest has been aroused in the possibilities of the oriental persimmon through the introduction of the Tamopan variety and the perfection by Mr. H. C. Gore, of the Bureau of Chemistry, of new methods by which the tannin can be rendered insoluble in a practical way and the fruit hold its firm texture that a special search is being made for all the species of Diospyros which may in any way be of value for breeding purposes or as a stock. Special interest may attach to *Diospyros peregrina* (No. 28584), from Sibpur, Calcutta, from the fact that the expressed juice when boiled with powdered charcoal is used on a large scale for paying the bottoms of boats and that an excellent glue is made from the juice by the natives of the Malabar coast. *Diospyros montana cordifolia* (No. 28684), a tree which is found from the Himalayas to Australia and which bears small fruits the size of cherries, and *Diospyros microcarpa* from Australia (No. 28343) have also been secured.

Two strains of maize from the Kalahari Desert region of South Africa (Nos. 28614 and 28615) and a form from Zomba, Nyasaland Protectorate (No. 28661), may interest the corn breeders.

Dr. A. Weberbauer, whose collections in the Peruvian Andes are well known, has sent two wild forms of Solanum from the region about Lima. One, which he believes to be *Solanum maglia*, is from the cool, cloudy Loma region and the other from the same vegetation zone is an undetermined form (Nos. 28656 and 28657).

Western China is known to have many wild species of Rubus, some of which are reported to bear fruit of unusual excellence. The vigor of the Chinese brambles and the early-ripening habit of certain of those already introduced have attracted the attention of plant breeders in this field, and the introduction of a species from the top of Mount Omei, on the Upper Yangtze, described by the sender, Dr. Edgar T. Shields, of Yachow, as "a delicious large yellow raspberry" can scarcely fail to attract their attention.

Two of the best fruits of the Malay Archipelago are the ramboetan and the kapoelasan, species of Nephelium. A Wardian-case shipment has been made from Java, containing three varieties of the latter (Nos. 28332 to 28334) and seven varieties of the former (Nos. 28335 to 28341), and an attempt will be made to propagate these on various stocks for distribution in Porto Rico, Hawaii, and the Panama Canal Zone.

Dr. L. Trabut, the veteran experimenter of Algiers, has sent in seeds of the remarkably alkali-resistant grass *Festuca fenas* (No. 28355) from the Shott Khreida.

A collection of medicagos and trifoliums from Beirut, Turkey, containing six species (Nos. 28788 to 28793) will be of use to those breeding these leguminous plants.

The khat plant of Yemen, on the west coast of Arabia, has been in cultivation for generations. Its fresh leaves are chewed by the Arabs almost universally in that region. To them life and hard work would be unendurable without khat, and every coolie, even the poorest, buys the leaf. The plant yields a marketable crop the second year, is grown from cuttings, and is considered one of the most valuable cultures of the country. Plants have been secured and are now growing both from the Edinburgh Botanic Gardens and also direct from Aden, Arabia, through Mr. C. K. Moser, the American consul, who has furnished an interesting report on the industry. It is quite probable that this plant will grow in our southwestern country, but until the chemists and animal physiologists have closely examined the action of the alkaloid it contains, it will not be distributed to experimenters.

Picea breweriana of Oregon and California, which because of its appearance may be called the veiled spruce, is one of the rarest of all the spruces, and the seeds, though sought after many times, have so rarely been obtained that the distribution of more than a pound of fresh seed, received from Miss Alice Eastwood, is of unusual interest.

The nomenclature in this inventory and the notes on geographical distribution have been prepared in the Office of Taxonomic and Range Investigations by Mr. H. C. Skeels, under the direction of Mr. Frederick V. Coville. The inventory was prepared by Miss Mary A. Austin, of this office.

David Fairchild,
Agricultural Explorer in Charge.

Office of Foreign Seed and Plant Introduction,
Washington, D. C., April 24, 1911.

INVENTORY

28325 and 28326. AGAVE spp. **Zapupe.**

From Tampico, Mexico. Purchased from Mr. Mordelo L. Vincent. Received July 5, 1910.

Suckers of the following:

28325. AGAVE LESPINASSEI Trelease.

Vincent. "A fiber-producing agave, similar in appearance to sisal, with leaves 4 to 5 feet long, light green, armed with reddish marginal spines. Yields its first crop of leaves for fiber three to five years after planting and annual or semiannual crops thereafter for three to five years. The fiber is of the same class as the sisal of commerce, but is finer and more flexible.

"This variety, developed on the island of Juana Ramirez, is regarded as one of the best of the half-dozen different kinds of zapupe cultivated in that region. It can be cultivated successfully only in places free from severe frost in winter." (*Lyster H. Dewey.*)

28326. AGAVE ZAPUPE Trelease.

Estopier. "A fiber-producing agave, similar in appearance to the henequen cultivated in Yucatan, but with more slender leaves. The leaves are 4 to 5 feet long, glaucous, and with dark-reddish marginal spines. The first crop of leaves may be cut three to five years after planting and annually or semiannually thereafter for three to five years, when the plant will send up a flower stalk bearing bulbils and then die. It may be propagated by both bulbils and suckers. The fiber is similar to sisal and may be used for the same purposes, viz, binder twine and other hard-fiber twines.

"Cultivated most extensively in the vicinity of Tuxpam, Vera Cruz, Mexico, where it is called '*zapupe azul*' because of its bluish leaves. The variety *Estopier* has been improved somewhat by cultivation. Like all of the agaves cultivated for the production of fiber, it requires a climate practically free from frost." (*Lyster H. Dewey.*)

28327. CATHA EDULIS Forsk. **Khat.**

From Edinburgh, Scotland. Presented by the regius keeper, Royal Botanic Garden. Received July 5, 1910.

Plants. See No. 24714 for previous introduction, and No. 28825 for description.

28328 to 28330.

From Kandawglay, Rangoon, Burma, India. Presented by the secretary of the Agri-Horticultural Society of Burma. Received July 2, 1910.

Seeds of the following:

28328. PHYLLANTHUS EMBLICA L. **Emblic myrobalan.**

See No. 25724 for description.

28329. TERMINALIA BELLERICA (Gaertn.) Roxb. **Belleric myrobalan.**

See No. 25541 for description.

28330. TERMINALIA CHEBULA Retz. **Black myrobalan.**

See No. 25542 for description.

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28331. ANDROPOGON SQUARROSUS L. f. **Cuscus grass.**

From Peradeniya, Ceylon. Presented by Mr. M. Kelway Bamber, government chemist. Received July 2, 1910.

Clumps.

"This plant grows in large dense tufts, with stout, spongy, aromatic roots, which are sparingly branched. It is grown to a considerable extent in the hills of Jamaica for the purpose principally of binding loose soils and forming embankments on steep hillsides to prevent washing by rains.

"In India the roots are used in making aromatic-scented mats, and also fans, baskets, and other articles. The roots also when distilled with water yield a fragrant oil which is used as a perfume. Used also as medicine in case of fever and bilious complaints." (*Extract from Botanical Department of Jamaica Bulletin B. S. vol. 7, 1900, pp. 152–153.*)

Distribution.—Throughout the plains and lower hills of India and Burma, rising to an elevation of 4,000 feet, and in Ceylon and Java, and tropical Africa.

28332 to 28341. NEPHELIUM spp.

From Buitenzorg, Java. Presented by the Director of Agriculture. Received July 2, 1910.

Plants of the following; notes by Mr. F. W. J. Westendorp in "Teysmannia," 1910:

28332 to 28334. NEPHELIUM MUTABILE Bl. **Kapoelasan.**

28334. *Si babat.* "Dark colored, almost black; not so common as some other varieties."

28335 to 28341. NEPHELIUM LAPPACEUM L. **Ramboetan.**

28335. *Atjeh lebak boeloes.* "This variety, a ramboetan of the second rank, is handled in large quantities."

28336. *Atjeh goela batoe.* "A variety of the first class, but can not be obtained in large quantities."

28337. *Atjeh tangkoeweh.*

28338. *Atjeh si konto.* The same remarks apply to this as to No. 28335.

28339. *Atjeh lengkeng.* **28340.** *Si njonja.*

28341. *Atjeh matjan.*

"The two preceding ramboetans are of the first class and are the best commercial varieties."

For a general note on these fruits, see Nos. 25163 and 25165.

28342. COMBRETUM APICULATUM Sonder.

From Komati Poort, Transvaal, South Africa. Presented by Prof. J. Burtt Davy, government agrostologist and botanist, Transvaal Department of Agriculture, Pretoria. Received July 5, 1910.

"Seed collected by me at an altitude of 600 feet. The climate is almost tropical and free from frost, the tamarind being grown there. I am not aware that this Combretum has any economic value beyond the fact that it is ornamental; it would be of interest in a tree collection in Florida, Louisiana, or southern California." (*Davy.*)

Distribution.—In the woods in the vicinity of Magaliesberg, in the Transvaal region of South Africa.

28343. DIOSPYROS MICROCARPA (Jacq.) Gurke.

From Sydney, New South Wales. Presented by Prof. J. H. Maiden, director and government botanist, Botanic Gardens. Received July 6, 1910.

"A large shrub or tree 20 to 40 or even 100 feet high; trunk sometimes 2 feet in diameter. Leaves oblong or oval, alternate, palish green, especially beneath. Flowers diœcious, tetramerous (or rarely trimerous). Fruit globular or ovoid, ½ to ⅔ inch thick, fuscous and glabrescent when ripe; edible; ultimately one-celled and one-seeded. Slender-growing tree with elongated trunk and elegant, rigid foliage. Wood close, very tough and firm." (*Extract from Hiern's Monograph of Ebenaceæ, in Transactions of the Cambridge Philosophical Society, vol. 12, p. 246.*)

Distribution.—In the forest region along the coast in New South Wales and Queensland, Australia.

28344. CROTALARIA CANDICANS Wight and Arnott.

From Poona, Bombay, India. Presented by Mr. P. S. Kanetkar, superintendent, Empress Botanical Gardens. Received July 9, 1910.

"This crop is used for green manuring in the Madras Presidency. Out of that presidency it is not known." (*Kanetkar.*)

"A copiously branched undershrub, attaining 4 feet in height, with short-petioled leaves and panicles of bright-yellow flowers, produced in great profusion at the beginning of January. It thrives in any fair garden soil and is propagated by seed." (*Extract from Woodrow's Gardening in India, p. 277.*)

Introduced for experimental growing as a cover crop, for breeding purposes, and as an ornamental in our Southern States.

Distribution.—Slopes of the Nilgiri and Madura Hills, in the southern part of India.

28345. VICIA FABA L. **Horse bean.**

From Dongola Province, Egypt. Presented by Mr. S. E. Durant, inspector of agriculture, at the request of the Director of Agriculture and Lands, Sudan Government, Khartum. Received July 7, 1910.

"This grain is never used for stock feed, but it is ground into flour and mixed with wheat flour, then baked into bread. The straw is fed to stock, the only preparation being that the grain is first thrashed out by hand. The natives do not consider that bean straw forms such a valuable fodder as that of wheat." (*Durant.*)

28346 to 28350. ORYZA SATIVA L. **Rice.**

From Philippine Islands. Received through Mr. William S. Lyon, Manila, July 1, 1910.

Seeds of the following; native names and notes as given by Mr. Lyon:

28346. *Inaplaya.* Matures in 4½ months.

28347. *Inita.* One of the earliest; often matures in 100 days.

28348. *Dinalaga.* Late; matures in 4 to 4½ months.

28349. *Minalit.* Very late; matures in 5 or more months.

28350. *Pimling-berto.* Medium; matures in 4 to 4½ months.

28351. DIOSPYROS DISCOLOR Willd. **Mabola.**

From Buitenzorg, Java. Presented by the Director of Agriculture. Received July 14, 1910.

Seeds. See No. 26112 for description.

28352. Diospyros sp.

From Baroda, Madras Presidency, India. Presented by Mr. B. S. Cavanaugh, superintendent, State Gardens. Received July 14, 1910.

Seeds.

28353. Passiflora edulis Sims. **Passion flower.**

From Madras Presidency, India. Presented by Mr. P. S. Kanetkar, superintendent, Empress Botanical Gardens, Poona, Bombay, India. Received July 14, 1910.

"Edible passion fruit grown for culinary purposes." (*Kanetkar.*)

28354. Terminalia chebula Retz. **Black myrobalan.**

From Baroda, India. Presented by Mr. B. S. Cavanaugh, superintendent, State Gardens. Received July 5, 1910.

See No. 25542 for description.

28355 and 28356.

From Algeria. Presented by Dr. L. Trabut, Algiers. Received July 5 and 11, 1910.

Seeds of the following; notes by Dr. Trabut:

28355. Festuca fenas Lagasca.

"Grows in the very alkaline regions of Shott Khreida. This grass has a very remarkable resistance to alkalinity."

Distribution.—Southwestern Europe, extending from central Spain and southern France eastward to Croatia.

28356. Vicia faba L. **Horse bean.**

"Grows wild on the plateau of Sersou, Algeria."

28357. Melilotus segetalis (Brot.) Ser.

From Maison Carree, Algeria. Presented by the Botanic Garden. Received July 5, 1910.

"This is a small, sparsely leaved annual melilot, native of Mediterranean Europe and Africa. It was originally described from Portugal. In former tests carried on by the Office of Forage-Crop Investigations of the Bureau of Plant Industry it has attained a height of only 10 to 15 inches and its small growth makes it of doubtful value for the United States. This melilot has been received previously under S. P. I. Nos. 17003 and 27473." (*H. N. Vinall.*)

28358. Crotalaria candicans Wight and Arnott.

From Sibpur, Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received July 14, 1910.

See No. 28344 for description.

28359. Medicago sativa L. **Alfalfa.**

From Ecuador. Procured by Mr. Herman R. Dietrich, consul general, Guayaquil. Received July 14, 1910.

Guaranda.

28360 to 28363.

From Port Louis, Mauritius. Presented by Mr. G. Regnard. Received July 7, 1910.

Seeds of the following; notes by Mr. Regnard:

28360. Erythroxylon laurifolium Lam. **"Mauritius torchwood."**

Distribution.—A branching shrub common in the woods in the islands of Mauritius and Reunion and the Seychelles.

28361 and 28362. (Undetermined.) (Liliaceæ.)

28361. "Blue fruited." **28362.** "White fruited."

28363. (Undetermined.)

"Forest tree bearing scarlet berries."

28364. Gossypium sp. **Cotton.**

From Honduras. Presented by Mr. F. S. Chaffee, Trujillo, Honduras. Received July 8, 1910.

"This is supposed to be wild cotton from the Aguan River, 25 miles east of here (Trujillo). I found it three years ago while hunting in that vicinity. At that time it was a tree some 8 or 9 inches in diameter and 25 or 30 feet high and full of bloom. It stood out in the middle of a savannah in a sand and gravel soil with no other trees around it and fully a mile from any house. No one in that vicinity has any knowledge of its origin or how long it has been there; but last fall it was burned down by a savannah fire. These bolls were taken from the sprouts that have come up from the roots. There are also two or three other trees about a mile apart located in the heavy forest." (*Chaffee.*)

28365. Triticum aestivum L. **Wheat.**

From near the shore of Lake Van, a few miles from Bitlis, Turkey in Asia. Presented by Mr. Hamilton King, American minister to Siam, who procured it from Miss A. C. Ely. Received July 12, 1910.

"This is sown in drills and does not need to be irrigated. The soil is sandy, mixed with volcanic ashes, and probably some moisture percolates from the near-by lake. This is a rather inferior sample." (*Ely.*)

28367 and 28368.

From Marash, Turkey. Purchased from Mr. Paul N. Nersessian. Received July 16, 1910.

Seeds of the following; notes by Mr. Nersessian:

28367. Lathyrus sativus L.

"*Agh jilban* (white jilban). For cultivation, soil, and time and manner of sowing, see No. 28368."

28368. Vicia ervilia (L.) Willd. **Bitter vetch.**

"*Koushne.* They do not cultivate these plants for green manuring but only for seeds which they use for cattle feed. The seed is sown here from about the middle of September until near the end of November. It sprouts or stools some in the fall and remains that way during the winter. In the spring it sprouts more, covers the ground perfectly, grows about a foot high, and is ripe enough to harvest in these days (about June 1?). Usually it is sown on poor or exhausted fields from which a good crop of grain can not be expected. Of course it does

28367 to 28368—Continued.

better in richer ground and especially in ground where potash predominates. The usual practice in sowing it around here is to irrigate the grain stubble field if there has not been rain enough, to sow nearly a bushel of seed to an acre right on the stubble and just cover the seeds with the old native plow, and then drag a pole over the field to smooth it somewhat, which of course helps the seeds to come up more evenly and also decreases the surface evaporation. It is sown broadcast. It likes the ground well drained, either naturally or artificially, and the earlier it is sown the better it is, within the time mentioned."

28369. BAMBOS ARUNDINACEA Retz. **Bamboo.**

From Sibpur, Calcutta, India. Purchased from Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received July 16, 1910.

"This bamboo does not spread rapidly and it is seldom necessary to keep the plant in check. It never becomes a troublesome weed, and it can be extirpated without difficulty, if desired." (*Gage.*)

See No. 21317 for further description.

28370. PICEA BREWERIANA S. Watson. **Veiled spruce.**

From near Kerbyville, which is reached by stage from Grants Pass, Oreg. Collected by Mrs. A. J. Adams; purchased from Miss Alice Eastwood, Gray Herbarium, Harvard University, Cambridge, Mass. Received July, 1910.

"This is one of the rarest and most unique of all the spruces. It grows only on the summit of the Siskiyou Mountains of northern California and southern Oregon. I saw some small trees on Canyon Creek in Trinity County and I should call the tree the veiled spruce rather than the weeping spruce. It grows to quite a height, 70 or 80 feet, and with a diameter of 1 to 2 feet. The drooping branches are clothed with long pendent, slender branchlets. The tree is delicate and graceful in outline, but not funereal or sad. The cones resemble those of the Norway spruce." (*Eastwood.*)

Distribution.—Dry mountain ridges and peaks near the timber line on both slopes of the Siskiyou Mountains on the boundary between California and Oregon at an elevation of 7,000 feet, and on the Oregon coast ranges at the headwaters of the Illinois River, at an elevation of 4,000 to 5,000 feet.

28371 to 28531.

The following material presented by Dr. Walter Van Fleet to the Plant Introduction Garden, Chico, Cal. Numbered July, 1910. Notes by Dr. Van Fleet.

A collection made by Dr. Van Fleet, at Little Silver, N. J., and selected by him out of many thousands as especially valuable for breeding purposes in the various groups represented. Many of them are his own hybrids or crosses. The technical descriptions of the various species have been omitted for the sake of brevity.

28371. ALBIZZIA JULIBRISSIN Bovin.

(P. I. G. No. 6460.) "Seedlings from a tree 20 feet high growing in Monmouth County, N. J., little injured by winter temperatures as low as −12° F. Evidently a hardy type."

Distribution.—Mountains of northern Persia, India, northern China, and Japan; cultivated as an ornamental tree in Asia, southern Europe, northern Africa, and the United States.

28371 and 28531—Continued.

28372. Antholyza sp.

(P. I. G. No. 6225.) "Received from Natal, South Africa, as *Gladiolus* sp., possibly *Antholyza paniculata.*"

28373. Aquilegia oxysepala × canadensis.

(P. I. G. No. 6222.) "A hardy and long-lived hybrid, dwarf and early blooming; flowers wine red and white."

28374. Zantedeschia elliottiana × pentlandii.

(P. I. G. No. 6534.) "A weak-growing hybrid; spathes pure golden yellow."

28375. Zantedeschia rehmanni × pentlandii.

(P. I. G. No. 6533.) "Vigorous hybrids with lanceolate, spotted foliage; spathes pale yellow or white, overlaid with purple and rose shadings."

28376. Zantedeschia rehmanni × pentlandii.

(P. I. G. No. 6299.)

28377. Azalea nudiflora × sinensis.

(P. I. G. No. 6442.) "Vigorous hybrids with profuse cream, rose and salmon colored blooms.

28378. × Berberis stenophylla Lindl.

(P. I. G. No. 6493.) "A very ornamental evergreen variety."

28379. Berberis thunbergii × vulgaris.

(P. I. G. No. 6302.)

28380. Berberis thunbergii × vulgaris.

(P. I. G. No. 6494.) "Third-generation plants from original hybridization."

28381. Castanea pumila × sativa.

(P. I. G. No. 6227.) This introduction had previously been assigned No. 26233, so the number 28381 will be discarded and 26233 used.

28382. Celastrus articulatus Thunb.

(P. I. G. No. 6425.) *Distribution.*—In the provinces of Chihli, Shantung, Kiangsu, Kiangsi, Hupeh, and Kwangtung in China, in Chosen and the Korean and Nansei archipelagoes, and in the vicinities of Kiushu, Nagasaki, Yokosuka, Shimoda, and Hakodate in Japan.

28383. Citrus trifoliata L.

(P. I. G. No. 6447.) "Taken from a tree growing in Monmouth County, N. J. Has endured −8° F. without injury."

28384. Deutzia scabra × discolor.

(P. I. G. No. 6549.) "One-year seedlings."

28385. Fragaria filipendula Hemsl. (?)

(P. I. G. No. 6566.)

28386. Fragaria indica Andrews.

(P. I. G. No. 6567.)

28387. Fragaria moschata Duchesne. (?)

(P. I. G. No. 6573.)

28388. Fragaria sp.

(P. I. G. No. 6568.) *Alfonso × filipendula.*

28389. Fragaria sp.

(P. I. G. No. 6219.) *Alfonso XIII × President.*

28371 to 28531—Continued.

28390 to 28396. Freesia refracta (Jacq.) Klatt.

28390. (P. I. G. No. 6211). "× *Freesia arbutus* (*F. leichtlinii* × *armstrongi*)."

"An undisseminated hybrid; has large, sweet-scented, rosy lilac blooms, disposed in a conspicuous 2-ranked scape."

28391. (P. I. G. No. 6414.) "*F. armstrongi* × commercial *Refracta alba*."

28392. (P. I. G. No. 6385.) "*F. armstrongi* × *Purity* (*Refracta alba*)."

28393. (P. I. G. No. 6224.) "*F. aurea* × (*chapmani* × *armstrongi*)."

28394. (P. I. G. No. 6450.) "*F. chapmani* (*F. aurea* × *refracta*)."

"The finest yellow-flowered Freesia; raised in England."

28395. (P. I. G. No. 6196.) "*F. refracta* × *armstrongi* (selected)."

28396. (P. I. G. No. 6213.) "*F. refracta* × *armstrongi* (good variety)."

28397. Gerbera jamesoni Bolus.

(P. I. G. No. 6461.) See No. 25513 for description.

28398. Gladiolus alatus L.

(P. I. G. No. 6206.) *Distribution.*—The southwestern provinces of Cape Colony and in Namaqualand, South Africa.

28399. Gladiolus alatus × cardinalis.

(P. I. G. No. 6215.)

28400. Gladiolus alatus × colvillii (*Delicatissima*).

(P. I. G. No. 6378.)

28401 to 28429. "Various undisseminated hybrid gladioli and parent species."

28401. Gladiolus alatus × primulinus.

(P. I. G. No. 6536.)

28402. Gladiolus alatus × primulinus (*Goldbug*).

(P. I. G. No. 6535.)

28403. Gladiolus alatus × tristis.

(P. I. G. No. 6208.) "Green flowered."

28404. Gladiolus byzantinus Miller.

(P. I. G. No. 6207.) Variety *albus*. *Distribution.*—The countries bordering on the Mediterranean Sea.

28405. Gladiolus byzantinus (*albus*) × primulinus.

(P. I. G. No. 6199.)

28407. Gladiolus cardinalis Curtis.

(P. I. G. No. 6214.) *Queen Wilhelmina.*

28408. Gladiolus cardinalis × grandis.

(P. I. G. No. 6203.)

28409. Gladiolus cardinalis × primulinus.

(P. I. G. No. 6386.)

28410. Gladiolus colvillii (*Bride*) × purpureo-auratus (*Klondike*).

(P. I. G. No. 6201.)

28371 to 28531—Continued.

28401 to 28429—Continued.

28411. Gladiolus cruentus Moore.

(P. I. G. No. 6524.) *Distribution.*—Known only from Natal on the east coast of South Africa.

28412. Gladiolus cruentus × a selected dark-red seedling.

(P. I. G. No. 6528.)

28413. Gladiolus grandis × alatus.

(P. I. G. No. 6198.)

28414. Gladiolus grandis × primulinus.

(P. I. G. No. 6200.)

28415. Gladiolus papilio × "*Precious.*"

(P. I. G. No. 6529.)

28416. Gladiolus primulinus × "*Goldbug.*"

(P. I. G. No. 5527.)

28417. Gladiolus primulinus × grandis.

(P. I. G. No. 6537.)

28418. Gladiolus sp. (No. 74) × primulinus.

(P. I. G. No. 6384.)

28419. Gladiolus psittacinus × "*Very Odd.*"

(P. I. G. No. 6530.)

28420. Gladiolus purpureo-auratus (*Klondike*) × cardinalis (*Delicatissima*).

(P. I. G. No. 6538.)

28421. Gladiolus quartinianus A. Rich.

(P. I. G. No. 6526.) *Distribution.*—Mountains of tropical Africa from Abyssinia southward to Zambesia, Matabeleland, and Angola, rising to an elevation of 8,000 feet in Kassailand.

28422. Gladiolus quartinianus × (?).

(P. I. G. No. 6531.)

28423. Gladiolus ramosus (*Ne plus ultra*) × colvillii (*Express*).

(P. I. G. No. 6379.)

28424. Gladiolus salmoneus Baker.

(P. I. G. No. 6525.) *Distribution.*—Occurs at an elevation of 4,800 feet on the mountain slopes in the vicinity of Kokstad, in Griqualand, eastern part of Cape Colony.

28425. Gladiolus salmoneus × quartinianus.

(P. I. G. No. 6204.)

28426. Gladiolus tristis × colvillii.

(P. I. G. No. 6377.)

28427. Gladiolus tristis × vittatus.

(P. I. G. No. 6451.)

28428. Gladiolus vittatus × primulinus.

(P. I. G. No. 6197.)

28429. Gladiolus watsonius × grandis.

(P. I. G. No. 6202.)

28371 to 28531—Continued.

28430. Hibiscus syriacus L.

(P. I. G. No. 6546.) "A single-flowered, pure white seedling."

28431. Hemerocallis aurantiaca (major) × citrina.

(P. I. G. No. 6519.)

28432. Hemerocallis magnifica Hort.

(P. I. G. No. 6300.)

28433. Hemerocallis magnifica × florham.

(P. I. G. No. 6298.)

28434. Hippeastrum rutilum × vittatum.

(P. I. G. No. 6423.) "Fine, red-flowered varieties, blooming when foliage is fully developed."

28435. Hippeastrum vittatum × (?).

(P. I. G. No. 6413.)

28436. Iris atropurpurea atrofusca Baker.

(P. I. G. No. 6397.)

28437. Iris atropurpurea Baker.

(P. I. G. No. 6458.) *Distribution.*—Imported from Syria.

28438. Iris bartoni Foster.

(P. I. G. No. 6469.) *Distribution.*—The vicinity of Kandahar in the southern part of Afghanistan.

28439. Iris bismarckiana Baker.

(P. I. G. No. 6402.) *Distribution.*—The province of Lebanon, on the coast of the Mediterranean Sea, in Asiatic Turkey.

28440. Iris cristata Soland.

(P. I. G. No. 6459.) *Distribution.*—Rich woods from Maryland to Georgia and westward to Ohio, Indiana, and Missouri.

28441. Iris delavayi × sibirica.

(P. I. G. 6517.)

28442. Iris fulva Ker.

(P. I. G. No. 6516.) "A very large-flowered copper iris, bred by selection from the wild plant."

Distribution.—In swamps from Kentucky and Illinois southward to Missouri.

28443. Iris gracilipes A. Gray.

(P. I. G. No. 6466.) *Distribution.*—In damp meadows in Nambu and in the vicinity of Hakodate on the island of Hokushu (Yezo), Japan.

28444. Iris grant-duffii Baker.

(P. I. G. No. 6523.) *Distribution.*—Along the banks of the River Kishon in Palestine.

28445. Iris helenae Barbey.

(P. I. G. No. 6396.) *Distribution.*—In the vicinities of El Arish, Ouadi-el-Gradi, Ouadi-Cheriah, and Nachel Aboukeila, in the desert between Egypt and Palestine.

28446. Iris hexagona × missouriensis.

(P. I. G. No. 6463.)

28371 to 28531—Continued.

28447. Iris himalaica Hort.

(P. I. G. No. 6470.) Received in 1908 from Mr. W. R. Dykes, England. Not bloomed. This is probably *Iris clarkei* Baker, a native of Sikkim, India.

28448. Iris laevigata Fisch.

(P. I. G. No. 6303.) *Distribution.*—In the vicinity of Yokosuka, Shimoda, and Hakodate in Japan; in the province of Shengking, China, and near Port Chusan in Chosen (Korea). Also extensively cultivated in other countries.

28449. Iris korolkowi Regel.

(P. I. G. No. 6401.) *Distribution.*—Sent alive by Gen. Korolkow to St. Petersburg in 1870 from Turkestan.

28450. Iris paradoxa × pumila.

(P. I. G. No. 6421.) "Very meritorious hybrids. Plants vigorous, free blooming, and of easy culture."

28451. Iris lacustris Nutt.

(P. I. G. No. 6467.) *Distribution.*—Gravelly shores of Lakes Huron, Michigan, and Superior.

28452. Iris lortetii Barbey.

(P. I. G. No. 6399.) *Distribution.*—On the slopes of the Lebanon range of mountains at an altitude of 2,000 feet, between Mais and Hussin, in the province of Lebanon, Asiatic Turkey.

28453. Iris milesii × tectorum.

(P. I. G. No. 6380.)

28454. Iris milesii × tectorum.

(P. I. G. No. 6464.)

28455. Iris monnieri DC.

(P. I. G. No. 6518.) *Distribution.*—The islands of Rhodes and Crete, in the eastern part of the Mediterranean.

28456. Iris obtusifolia Baker.

(P. I. G. No. 6520.) *Distribution.*—The province of Mazanderan, on the southern shore of the Caspian Sea, in Persia.

28457. Iris pallida Lam.

(P. I. G. No. 6462.) *Distribution.*—The islands of Crete and Rhodes, and in Palestine, Syria, and Morocco, rising to an elevation of 7,000 feet in the Atlas Mountains.

28458. Iris nigricans Hort.

(P. I. G. No. 6400.)

28459. Iris paradoxa × sambucina.

(P. I. G. No. 6465.)

28460. Iris sibirica × (?).

(P. I. G. No. 6446.)

28461. Iris sibirica × (?).

(P. I. G. No. 6521.)

28462. Iris sibirica × delavayi.

(P. I. G. No. 6301.)

28371 to 28531—Continued.

28463. Iris sofarana Foster.

(P. I. G. No. 6398.) *Distribution.*—On the Lebanon Mountains in the vicinity of Ain Sofar, Asiatic Turkey.

28464. Iris straussi Leichtl.

(P. I. G. No. 6515.) *Distribution.*—The vicinity of Sultanabad, in the province of Irak Ajemi, western Persia.

28465. Iris suaveolens × lutescens statellae.

(P. I. G. No. 6220.)

28466. Iris tectorum Maxim.

(P. I. G. No. 6522.) *Distribution.*—The provinces of Shantung, Hupeh, Ichang, Hunan, Shensi, Kansu, and Szechwan, in China, and in the vicinity of Yokohama, in Japan.

28467. Iris tectorum × milesii.

(P. I. G. No. 6221.)

28468. Iris tenax Dougl.

(P. I. G. No. 6514.) *Distribution.*—Northwestern America, where it is common in open places from British Columbia southward to Oregon.

28469. Iris tenax × versicolor.

(P. I. G. No. 6452.)

28470. Iris verna L.

(P. I. G. No. 6468.) *Distribution.*—Wooded hillsides from Pennsylvania to Kentucky and southward to Georgia and Alabama.

28471. Iris versicolor L.

(P. I. G. No. 6445.) *Distribution.*—In swamps from Newfoundland to Manitoba and southward to Florida and Arkansas.

28472. Juglans cordiformis Maxim.

(P. I. G. No. 6449.) *Distribution.*—In the vicinity of Yokohama and of Hakodate on the island of Hokushu (Yezo), Japan.

28473. Juglans cordiformis × regia.

(P. I. G. No. 6511.)

28474. Juglans sieboldiana Maxim.

(P. I. G. No. 6448.) *Distribution.*—In forests on the mountains in Kiushu and in the vicinity of Tokyo, Yokohama, Kamakura, Yokosuka, and Hakodate, in Japan.

28475. Lachenalia pendula Ait.

(P. I. G. No. 6192.) *Distribution.*—Along the coast of Cape Colony in the vicinity of Hout Bay and Cape Flats.

28476 to 28478. Lachenalia pendula × tricolor.

28476. (P. I. G. No. 6191.) *Cowslip.*

28477. (P. I. G. No. 6193.) *Delight.*

28478. (P. I. G. No. 6194.) *Rector of Cawston.*

28479. Lachenalia tricolor Jacq.

(P. I. G. No. 6195.) *Distribution.*—Along the coast of Cape Colony at Malmesbury, near Cape Town, Saldanha Bay, Cape Flats, and Port Elizabeth, South Africa.

28371 to 28531—Continued.

28480. Lathyrus latifolius L.

(P. I. G. No. 6491.) *Leichtlin Extra White.*

28481. Lilium henryi × speciosum.

(P. I. G. No. 6553.)

28482. Lilium henryi × superbum.

(P. I. G. No. 6498.) "The largest flowered Hemerocallis."

28483. Lilium maculatum × martagon.

(P. I. G. No. 6552.)

28484. Lilium philippinense × longiflorum.

(P. I. G. No. 6562.)

28485. Lilium puberulum × linifolium.

(P. I. G. No. 6297.) "Very characteristic hybrids bearing large scarlet blooms of great substance, the small centers being yellow, dotted brownish purple. The other cross-pollinated lilies, as far as bloomed, do not show evidence of hybridity."

28486. Lilium speciosum Thunb.

(P. I. G. No. 6381.) Variety *magnificum.*

28487. Lilium speciosum × henryi.

(P. I. G. No. 6551.)

28488. Lilium sp.

(P. I. G. No. 6382.) *Ellen Wilmot.*

28489. Malus baccata × sylvestris.

(P. I. G. No. 6547.) "Malus baccata × '*Baldwin*' × '*Yellow Transparent.*' Second-generation hybrids of considerable vigor."

28490. Narcissus incomparabilis × poeticus.

(P. I. G. No. 6209.)

28491. Paeonia suffruticosa Andr.

(P. I. G. No. 6453.)

28492. Paeonia sp.

(P. I. G. No. 6454.) Seedling varieties.

28493. Philadelphus coronarius × microphyllus.

(P. I. G. No. 6495.)

28494. Philadelphus coronarius L.

(P. I. G. No. 6492.)

28495. Platycodon grandiflorum (Jacq.) DC.

(P. I. G. No. 6432.) Variety *Mariesi macranthum.*

28496. Prunus simonii × americana.

(P. I. G. No. 6548.)

28497. Pyrus chinensis × communis.

(P. I. G. No. 6510.) Chinese varieties, *Kieffer*, *Le Conte*, and *Golden Russet*, pollinated with *Bartlett*, *Angouleme*, *Anjou*, *Seckel*, and *Lawrence.*

28498. Quamasia leichtlinii × cusickii.

(P. I. G. No. 6223.)

28371 to 28531—Continued.

28499 to 28503. Promising hybrids between native gooseberry species and European garden varieties.

28499. Ribes cynosbati × reclinatum.

(P. I. G. No. 6565.)

28500. Ribes missouriense × reclinatum.

(P. I. G. No. 6217.)

28501. Ribes missouriense × reclinatum.

(P. I. G. No. 6563.)

28502. Ribes missouriense × reclinatum × rotundifolium.

(P. I. G. No. 6218.)

28503. Ribes reclinatum × rotundifolium

(P. I. G. No. 6564.)

28504. Rosa chinensis Jacq.

(P. I. G. No. 6443.) *Distribution.*—The provinces of Hupeh and Kwangtung, in China, and the island of Formosa.

28505. Rosa laevigata × *Frau Karl Druschki.*

(P. I. G. No. 6422.) "Attractive hardy hybrids bearing large semidouble sweet-scented blooms, blush white in color."

28506. Rosa ferruginea × *Paul Neyron.*

(P. I. G. No. 6456.) "Nearly thornless variety with reddish foliage; bloom very double, medium in size, bright rose pink in color."

28507. Rosa lutea × *Harrison's Yellow.*

(P. I. G. No. 6543.) "Very striking; buds nasturtium scarlet; blooms when opening light orange, turning to white and then to blush pink; semidouble, 2 inches across."

28508. Rosa multiflora × lutea.

(P. I. G. No. 6455.)

28509. Rosa rugosa × chinensis.

(P. I. G. No. 6539.) *Victor Hugo.* "Profuse, large, double, sweet-scented blooms, fiery scarlet-crimson in color. Apparently the best *Rosa rugosa* hybrid."

28510. Rosa rugosa (alba) × chinensis (*Devoniensis*).

(P. I. G. No. 6540.) "Good double white Rugosa, resembling Mad. Georges Bruant."

28511. Rosa rugosa × *Ards Rover.*

(P. I. G. No. 6497.)

28512. Rosa rugosa × ?.

(P. I. G. No. 6305.)

28513. Rosa rugosa × ?.

(P. I. G. No. 6541.) *Souvenir de Pierre Lepredieux.*

28514. Rosa soulieana Crepin.

(P. I. G. No. 6569.) *Distribution.*—In the vicinity of Tatsienlu, in the province of Szechwan, western China.

28515. Rosa sp.

(P. I. G. No. 6544.) "Hybrids of *Crimson Rambler.*"

28371 to 28531—Continued.

29516. Rosa sp.

(P. I. G. No. 6545.) *Lyon.*

28517. Rosa sp.

(P. I. G. No. 6417.) "*Lyon × President Carnot.*"

28518. Rosa sp.

(P. I. G. No. 6542.) *Richmond.*

28519. Rosa sp.

(P. I. G. No. 6496.) *Victor Hugo.* (Hybrid *Remontant.*)

28520. Rosa spp. Miscellaneous fruits.

(P. I. G. No. 6304.)

28521. Rosa spp. Seeds of hardy roses.

(P. I. G. No. 6428.)

28522. Rosa spp. Miscellaneous fruits.

(P. I. G. No. 6444.)

28523 and 28524. "Promising crossbred garden raspberries."

28523. Rubus neglectus × idaeus.

(P. I. G. No. 6571.)

28524. Rubus neglectus × strigosus.

(P. I. G. No. 6572.)

28525. Tritoma northiae (Baker) Skeels.

(*Kniphofia northiae* Baker, Jour. Bot., vol. 27, p. 43, 1889.)

(P. I. G. No. 6509.)

28526. Tritoma tuckii (Baker) Skeels.

(*Kniphofia tuckii* Baker, Gard. Chron., ser. 3, vol. 13, p. 68, 1893.)

The generic name Kniphofia was applied by Moench in 1794 (Meth., p. 632) to *Aletris uvaria* L., a species belonging to the same genus as the two given above, but Kniphofia had been published by Scopoli in 1777 (Introd., p. 327) as a generic name for *Terminalia catappa* L., and was therefore invalid as a designation for the other and later genus.

The next earliest name available for this genus is Tritoma, which was published by Ker-Gawler in 1804 (Botanical Magazine, vol. 20, pl. 744), based on *Tritoma sarmentosa* (Andrews) Skeels (*Aletris sarmentosa* Andrews), a South African species belonging to the same genus as the two listed above. These species are therefore recognized under the name given to the genus by Ker-Gawler, a name perhaps more frequently applied to them in horticultural literature than Kniphofia.

These plants are both indigenous to Cape Colony, *Tritoma northiae* occurring near Grahamstown, in the Albany division of the coast region, and *Tritoma tuckii* in the Colesberg division of the central region.

28527. × Tritonia "*Prometheus.*"

(P. I. G. No. 6427.)

28528. Vitis vinifera × (aestivalis × labrusca).

(P. I. G. No. 6418.) *Black Hamburgh × Gold Coin.*

28371 to 28531—Continued.

28529. Yucca filamentosa L.

(P. I. G. No. 6419.) Variety *variegata*.

Distribution.—In dry and sandy soil from North Carolina to Florida and Mississippi.

28530. Yucca flaccida Haw.

(P. I. G. No. 6306.) *Distribution.*—On dry or sandy slopes in or near the mountains from North Carolina to Alabama.

28531. Zephyranthes sulphurea Hort.

(P. I. G. No. 6216.)

28532. Medicago carstiensis Wulfen.

From Edinburgh, Scotland. Presented by Dr. Isaac Bayley Balfour, director, Royal Botanic Garden. Received July 21, 1910.

See No. 27794 for previous introduction.

28533 to 28536. Carica papaya L. **Papaya.**

From Empire, Canal Zone, Panama. Presented by Mr. W. G. Ross, at the request of Mr. H. F. Schultz. Received July 21, 1910.

Seeds of the following:

28533. "Fruit cylindrical in shape, very rich flavor, heaviest one here weighing 16½ pounds." (*Ross.*)

"This variety has a very small seed cavity and less seeds than most others." (*Schultz.*)

28534. "Fruit oblong in shape, extra size, 10½ pounds, and having an excellent flavor." (*Ross.*)

28535. "Fruit oblong and slightly tapering in shape, above medium in size, and having very sweet meat." (*Ross.*)

28536. "Fruit pear shaped. Tree was planted three years ago and produced 30 papayas last year, all very large and of very fine flavor." (*Ross.*)

28537. Tricholaena rosea Nees.

From Benguela, Angola, Portuguese West Africa. Presented by Mr. T. W. Woodside, A. B. C. F. M. Received July 20, 1910.

"A grass that grows spontaneously in old worn-out fields. Grows often to the height of 2½ or 3 feet. It is very succulent and sweet, and cattle like it very much. From the fact that it grows in old abandoned fields I would judge that it does not require rich soil." (*Woodside.*)

28538 and 28539. Medicago sativa L. **Alfalfa.**

From the Bombay Presidency, India. Presented by Mr. P. S. Kanetkar, superintendent, Empress Botanical Gardens, Poona, Bombay, India. Received July 23, 1910.

Seeds of the following:

28538. "From the Surat district, a few miles from the sea and at sea level. It is grown in fields in which sugar cane was grown in the rains and harvested in October. The seed is sown in November. No cuttings for green fodder are taken, but the crop is allowed to run to flower and seed. The crop is harvested at the end of March. The cultivators near Surat have only recently taken

28538 to 28539—Continued.

to growing lucern for seed only. The crop from this seed, however, is not as lasting a one as from the seed of the following (S. P. I. No. 28539)." (*Kanetkar.*)

28539. "From Poona, which is situated at a height of 1,900 feet and is distant 80 miles from the sea. The soil is loamy and responds to manure and irrigation treatments readily. The lucern crop in Poona is kept for three years, the cuttings which are taken every four to five weeks being fed to cattle and horses. The plants are allowed to run to seed in March every year. The seeds are sold at about triple the price of seed of the preceding (S. P. I. No. 28538). A quart bottleful is sold at from 2 to 2½ rupees, a rupee being equal to 16 pence." (*Kanetkar.*)

28540 to 28550.

From Pretoria, Transvaal, South Africa. Presented by Prof. J. Burtt Davy, government agrostologist and botanist, Transvaal Department of Agriculture. Received July 23, 1910.

Seeds of the following:

28540. Trichloris mendocina (Phil.) Kurtz.

See No. 26651 for previous introduction.

28541. Cervicina undulata (L. f.) Skeels.

See No. 27520 for previous introduction.

28542. Eragrostis lappula divaricata Stapf.

Distribution.—On the Pellat Plains, between Matlareen River and Takun, in Bechuanaland, South Africa.

28543. Trisetum spicatum (L.) Richter.

Distribution.—Alpine regions and in the Arctic and Antarctic zones.

28544. Chaetochloa nigrirostris (Nees) Skeels.

See No. 26653 for previous introduction.

28545. Eragrostis plana Nees.

Distribution.—In the Kalahari district and along the eastern coast of Cape Colony and Natal in South Africa.

28546. Panicum maximum hirsutissimum Nees.

(*Panicum hirsutissimum* Steud.)

Distribution.—The coast region of Natal and Cape Colony.

28547. Spinifex hirsutus Labill.

Distribution.—Sandy shores of New Zealand, Tasmania, and southern Australia.

28548. Trichloris mendocina (Phil.) Kurtz.

See No. 28540 for previous introduction.

28549. Eragrostis gummiflua Nees.

Distribution.—South Africa; in the Kalahari region and along the eastern coast of Cape Colony and Natal.

28550. Acacia robusta Burchell.

"This is a characteristic tree of the dry bush veldt below 4,500 feet altitude (i. e., in the subtropical zone of the Transvaal).

28540 to 28550—Continued.

"I have not been able to learn much about the wood, beyond the fact that it is sometimes used for fence posts when the rarer and harder sorts, such as *Olea verrucosa*, are not available." (*Davy*.)

Distribution.—In the vicinity of Litakun, Bechuanaland, and at Magaliesberg in the interior of Cape Colony.

28551. MANGIFERA INDICA L. **Mango.**

From Monrovia, Liberia, West Africa. Presented by Mr. E. L. Parker, Commissioner of Agriculture. Received July 20, 1910.

Sierra Leone.

28552 to 28555. MANGIFERA INDICA L. **Mango.**

From Poona, Bombay, India. Purchased from Mr. P. S. Kanetkar, superintendent, Empress Botanical Gardens. Received July 20, 1910.

Seeds of the following:

28552. *Alphonse.*
28553. *Kadarapasant.*
28554. *Pakria.*
28555. *Totafari.*

28556 to 28563. MANGIFERA INDICA L. **Mango.**

From Sibpur, Calcutta, India. Purchased from Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received July 20, 1910.

Seeds of the following:

28556. *Alphonso.*
28557. *Baromassia.*
28558. *Bhadoorea.*
28559. *Large Malda.*
28560. *Small Malda.*
28561. *Paranay.*
28562. *Peters.*
28563. *Soondershaw.*

28564 to 28568. MANGIFERA INDICA L. **Mango.**

From Colombo, Ceylon. Purchased from Dr. C. Drieberg, secretary, Ceylon Agricultural Society. Received July 22, 1910.

Seeds of the following; descriptive notes by Dr. Drieberg:

28564. *Dampara.* "Prolific; fruit small in size, of second quality, rather fibrous; skin yellow brown; seed small; ripens early and keeps fairly well. The tree is a free grower and is hardy. It is not much cultivated."

28565. *Heart.* "This is also called *Bombay* and is the commonest variety found on the market. Prolific; fruit medium in size, not much longer than broad, of second quality; skin golden yellow; seed of medium size; ripens early and is a fair keeper. The tree is a free grower and is hardy."

28566. *Jaffna.* "The favorite variety here. Prolific; fruit medium in size, twice as long as broad, of first quality; skin green; seed of medium size; ripens early and is a fair keeper. The tree is a fairly free grower and is hardy."

28567. *Parrot.* "Fairly prolific; fruit medium to small, of second quality; skin dark green; seed of medium size; ripens late and is a fair keeper. The tree is a free grower and is hardy. This variety has a slight turpentine flavor and is not very common."

28564 to 28568—Continued.

28568. *Rupee.* "This is also called '*Two-Shilling.*' It is a sparse bearer; fruit the largest of local (Ceylon) varieties, of first quality; skin pale green; seed small compared to size of fruit; ripens late and is not a good keeper. The tree is not a free grower and is tender. This variety is scarce and expensive. Requires very careful ripening."

28569 to 28582. MUSA spp. **Banana.**

From Paramaribo, Surinam. Presented by Mr. Goldsmith H. Williams, manager, United Fruit Co. Received July 21, 1910.

Suckers of the following; notes by Mr. Williams:

28569 to 28580. MUSA sp.

28569. "*Bas Joe.* From southern China. Has seeds in very small fruit."

28570. "*Cinerea Sahramphur.* Short, slim-pointed fruit of good flavor."

28571. "*Congo.*"

28572. "Dwarf banana, frequently called *Cavendishii.*"

28573. "Jamaica banana."

28574. "Large *Horse* banana. Sweeter than the plantain. Very good fried or roasted."

28575. "*Pisang Ambon.* A trifle better than the *Horse* banana of Florida and much the same shape."

28576. "*Pisang Celat.* Small, sweet fruit with 13 to 16 hands on a bunch."

28577. "*Pisang Kudjo.* Red banana."

28578. "*Pisang Siam.* Much like the *Horse* banana of Florida."

28579. "*Pisang Susa.* Similar to the ordinary *Apple* banana."

28580. "*Rubra India Sapientum Dacca.* One of the silver-skin varieties. What we term silver skin is a fruit that is like the red banana in shape and flavor, but with a clear, yellow skin."

28581. MUSA ROSACEA Jacq.

"Variety *Chittagong.* Very small, with seeds. New York Botanical Garden No. 9636."

Distribution.—The lower slopes of the eastern Himalayas in Chittagong, upper Burma, and in the Konkan region on the western coast of India; said to have been introduced from Mauritius in 1805.

28582. MUSA ZEBRINA Van Houtte.

"Reddish leaves. Very small worthless fruit, with seeds. Good as an ornamental plant."

28583. ARRACACIA XANTHORRHIZA Bancroft. **Arracacha.**

From Caracas, Venezuela. Presented by Señor Antonio Valero Lara. Received July 26, 1910.

See No. 3511 for description.

28584. Diospyros peregrina (Gaertn.) Guerke.

From Sibpur, Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received July 26, 1910.

"A dense, evergreen, small tree with dark-green foliage and long, shining leaves; common throughout India and Burma except the arid and dry zone in the Punjab and Sind. Distributed to Ceylon, Siam, and the Malay Peninsula; very abundant in Bengal. It is a beautiful tree; the fruit is eatable, but excessively sour. Its principal use is for paying the bottoms of boats. It is beaten in a large mortar and the juice is expressed. This is boiled, mixed with powdered charcoal, and applied once a year to the outside of the planks. The wood is of little value. The fruit is largely used in tanning, being a powerful astringent. The juice of the unripe fruit is used in medicine as an astringent. The tree produces a round fruit as big as a middle-sized apple, green when unripe, rusty yellow when ripe, and in the later stages containing a somewhat astringent pulp, in which the seeds are embedded. When ripe it is eaten by the natives, but is not very palatable. The leaves are also eaten as a vegetable. Ainslie mentions that the carpenters of the Malabar coast use the juice of the fruit as an excellent glue." (*Watt, Dictionary of the Economic Products of India, vol. 3, p. 145.*)

Seeds.

28585 to 28593.

From Domäne Niemiercze, Podolia, Russia. Presented by Messrs. K. Buszczynski and M. Lazynski. Received July 22, 1910.

Seeds of the following:

28585 to 28587. Avena sativa L. **Oat.**

28585. *Earliest*, or *Sixty-Day*.

28586. *Ligovo*.

28587. The new oats (cross between *Ligovo* and *Earliest*).

28588 to 28592. Triticum aestivum L. **Wheat.**

28588. Brown bearded.

28589. *Crossed Wheat No. 1.*

28590. *Improved Banat.*

28591. *Triumph of Podolia.*

28592. White bearded.

28593. Triticum durum Desf. **Wheat.**

White spring.

28594 and 28595.

From Spain. Presented by Mr. R. L. Sprague, American consul, Gibraltar, Spain. Received July 7, 1910.

Seeds of the following; notes by Mr. Sprague:

28594. Vicia ervilia (L.) Willd. **Bitter vetch.**

"*Yero.* This vetch is sown throughout Andalusia, but never plowed under for green manure. When the crop is ripe it is gathered and given to cattle during the winter months."

28595. Lathyrus sativus L.

"*Alverjones.* These are used for green manure and can be procured in larger quantities than the preceding (S. P. I. No. 28594). At about the same price the practical result is considered better."

28596. HORDEUM sp. **Barley.**

From Maison Carree, Algeria. Presented by Dr. L. Trabut, Algiers, Algeria. Received July 27, 1910.

"Smooth-bearded black barley. This barley appeared as a mutation in some black barley from Australia; it is very early and very resistant to drought. Curious on account of its absolutely smooth beards." (*Trabut.*)

28597. ALEURITES MOLUCCANA (L.) Willd. **Candlenut.**

From Manila, Philippine Islands. Presented by Mr. William S. Lyon. Received July 21, 1910.

See No. 24351 for description.

28598 to 28603. ALLIUM CEPA L. **Onion.**

From Puerto de Orotava, Teneriffe, Canary Islands. Presented by Mr. Solomon Berliner, American consul, Teneriffe. Received July 27, 1910.

Seeds of the following:

28598 to 28600. From Wildpret Bros. (Specially selected seed.)

28598. *Bermuda Red.*
28599. *Bermuda White.*
28600. *Crystal Wax.*

28601 to 28603. From Mr. T. M. Reid.

28601. *Bermuda Red.*
28602. *Bermuda White.*
28603. *Crystal Wax.*

28604. CICER ARIETINUM L. **Chick-pea.**

From Byers, Colo. Procured by Mr. H. N. Vinall from Mr. Edelen. Received July 29, 1910.

"Mr. Edelen says the original seed of these peas was given to him by an Italian. He claims they yielded 2,500 pounds of grain per acre last season, and in the face of an extremely dry season this year he is counting on 1,000 pounds per acre. From the looks of his field I should judge that 500 or 600 pounds is nearer what the correct yield will be. Chick-peas are very drought resistant and hail does them little injury, as the plant itself is tough and fibrous." (*Vinall.*)

28606. CROTALARIA CANDICANS Wight and Arnott.

From Peradeniya, Ceylon. Presented by Dr. J. C. Willis, director, Botanic Garden. Received August 2, 1910.

See No. 28344 for description.

28607. DENDROCALAMUS STRICTUS (Roxb.) Nees. **Bamboo.**

From Sibpur, near Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received August 5, 1910.

See Nos. 21548, 22819, and 23476 for previous introductions.

28609. MYRICA NAGI Thunb.

From Kiayingchau, China. Presented by Mr. George Campbell. Received July 25, 1910.

Seeds. See Nos. 25908 and 26905 for previous introductions.

28610 and 28611. Anona spp.

From Redland Bay, Queensland, Australia. Presented by Mr. James Collins. Received August 2, 1910.

Cuttings of the following:

28610. Anona sp.

"As far as I know this variety has never been named. It is a giant and far superior to any of the other anonas. It often attains a weight of 6 pounds, 'being a veritable custard.' It originated here about 30 years ago." (*Collins.*)

28611. Anona cherimola Mill. **Cherimoya.**

28612 and 28613. Mangifera indica L. **Mango.**

From Poona, Bombay, India. Purchased from Mr. P. S. Kanetkar, superintendent, Empress Botanical Gardens. Received August 4, 1910.

Seeds of the following:

28612. *Pyrie.* **28613.** *Kala Hapoos.*

28614 and 28615. Zea mays L. **Corn.**

From the Kalahari, about 30 miles east of Kuruman, on the Kaapscheberg, South Bechuanaland, Africa. Presented by Prof. J. Burtt Davy, government agrostologist and botanist, Transvaal Department of Agriculture, Pretoria, Transvaal, South Africa. Received August 2, 1910.

Seeds of the following; notes by Prof. Davy:

"*White Botman* flint maize. This seed was procured from a very dry region, of shallow limestone soil, cold and dry in winter. It struck me that these strains might do for the extreme southwest of the corn belt of the United States (northwestern Texas)."

28614. "Donovan's strain (red cob) has been grown by him without selection or change of seed for 10 years, and came originally from a still drier region, Daniels Kuil, at the southeast end of the Kuruman Hills."

28615. "Mayer's strain, from the same vicinity as the preceding (S. P. I. No. 28614)."

28616. Trichilia dregeana E. Meyer.

From Durban, Natal, South Africa. Presented by Dr. J. Medley Wood, director, Botanic Gardens. Received July 26, 1910.

"A handsome evergreen shade tree." (*Wood.*)

Distribution.—In woods in the vicinity of Durban in South Africa.

See No. 9482 for previous introduction.

28617. Vigna unguiculata (L.) Walp. **Cowpea.**

From Para, Brazil. Presented by Mr. Walter Fischer, acting director, Campo de Cultura Experimental Paraense. Received August 4, 1910.

"Probably identical with the *Blackeye* variety; I grew them on the campo and harvested them just two months after sowing. This cowpea could hardly be called a forage variety, at least not here in this soil, where it soon goes to seed, but bears heavily." (*Fischer.*)

28618 to 28625.

From Russia. Received through Mr. Frank N. Meyer, agricultural explorer, July 25, 1910.

28618 to 28625—Continued.

Seeds of the following:

28618. LATHYRUS SATIVUS L.

From Vladikavkaz, Caucasus, Russia. "(No. 1334a, May 4, 1910.) A legume very rarely seen, said to come originally from Russia. The seeds are used locally as a human food, being boiled in soups or mixed with chick-peas in stews. Suitable for trial as a forage crop in regions with a moderately light summer rainfall." (*Meyer.*)

28619. PISUM SATIVUM L. **Field pea.**

From Vladikavkaz, Caucasus, Russia. "(No. 1335a, May 4, 1910.) A very small pea, apparently an offspring from a cross between *Pisum sativum* and *Pisum arvense*. Used locally as a food, being more appreciated than the large-seeded varieties and consequently more expensive. Perhaps of value as a forage or food crop in the intermountain regions." (*Meyer.*)

28620. CICER ARIETINUM L. **Chick-pea.**

From Baku, Caucasus, Russia. "(No. 1336a, May 23, 1910.) A large variety of chick-pea, obtained from a Persian seed dealer and said to come from Persia. Chick-peas are much used by the orientals, preferably boiled with mutton in soups and stews." (*Meyer.*)

28621. VICIA FABA L. **Horse bean.**

From Baku, Caucasus, Russia. "(No. 1337a, May 23, 1910.) A horse bean, said to come from Persia. Used by the orientals both in the fresh green and in the dried state as a vegetable. Ground horse beans are a well-known and excellent feed for draft animals; perhaps they may be grown advantageously as a winter crop in the mild-wintered regions of the United States and as a summer crop in the intermountain regions." (*Meyer.*)

28622. TRITICUM DURUM Desf. **Wheat.**

From Baku, Caucasus, Russia. "(No. 1338a, May 23, 1910.) A good hard wheat, said to come from Persia." (*Meyer.*)

28623. TRITICUM DURUM Desf. **Wheat.**

From Vladikavkaz, Caucasus, Russia. "(No. 1339a, May 4, 1910.) An excellent hard wheat, coming from Persia and called '*Tatuch*.'" (*Meyer.*)

28624. HORDEUM sp. **Hull-less barley.**

From Baku, Caucasus, Russia. "(No. 1340a, May 23, 1910.) A naked barley of superior quality, said to come from Persia. Much imported into this country, where it is roasted and mixed with coffee. The beverage produced from this is very agreeable." (*Meyer.*)

28625. LENS ESCULENTA Moench. **Lentil.**

From Baku, Caucasus, Russia. "(No. 1341a, May 23, 1910.) A large variety of lentil, said to come from Persia. Much used by the orientals in soups and stews. Recommended as a crop in semiarid regions." (*Meyer.*)

28626. OPUNTIA sp.

From Nice, France. Presented by Dr. A. Robertson-Proschowsky. Received at the Subtropical Plant Introduction Garden, Miami, Fla., in the spring of 1909. Numbered for convenience in recording distribution on August 12, 1910.

"This Opuntia is easily propagated by cuttings of the pads. After being severed from the plant, they should be left in the sun for two or three days to dry up the

28626—Continued.

wound and then be planted rather deeply in the ground in comparatively dry soil. Because of the value of its fruits it seems that this species is likely to prove a very valuable one for dry soils where other plants are not likely to thrive." (*Robertson-Proschowsky, Journal d'Agriculture Tropicale.*)

28627 to 28631. MANGIFERA INDICA L. **Mango.**

From India. Purchased from Mr. P. S. Kanetkar, superintendent, Empress Botanical Gardens, Poona, Bombay. Received August 8, 1910.

Seeds of the following:

28627. *Amin.* From Madras Presidency.

28628. *Borsha.* From Poona.

28629. *Fernandez.* From Goa.

28630. *Peter pasant.* From Madras Presidency.

28631. *Shendrya.* From (Kothrud) Poona.

28632 and 28633. CAPSICUM ANNUUM L. **Pepper.**

From Sibpur, near Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received August 2, 1910.

Seed of *Nepal* peppers from northern India, as follows:

28632. Red. 28633. Yellow.

28634 to 28636.

From Chile. Received through Mr. José D. Husbands, Limavida, Chile, August 3, 1910.

Seeds of the following; descriptive notes by Mr. Husbands:

28634. CHENOPODIUM QUINOA Willd. **Quinoa.**

"(No. 585.) A grain said to produce 1,000 for 1. After rubbing and washing well to remove its bitterness it is eaten boiled, toasted, and ground into flour, used in soups, etc. The ashes of the plant contain an extra amount of potash and are used in soap making."

28635. MYRTUS sp.

"(No. 590.) A new class of '*Arrayan*,' a Myrtus that flowers in the fall, has crimson seed berries, and seeks the altitude of the driest arid hills; the fragrance is about the same as of that which flowers in the spring and only grows in wet or moist places. A dense, evergreen, ornamental treelet or bush worthy of cultivation."

28636. PERSEA MEYENIANA Nees.

"(No. 584.) '*Lingue*' of central Chile."

28637 to 28642. VITIS VINIFERA L. **Grape.**

From Elqui, Chile. Received through Mr. José D. Husbands, Limavida, Chile, August 11, 1910.

28637 and 28638. "*Italia.* This is the finest raisin grape known." (*Husbands.*)

28637 to 28642—Continued.

28637 and 28638—Continued.

28637. Seeds. **28638.** Cuttings.

"While I can not speak authoritatively upon the subject, I will give my opinion, which I believe will be found substantially correct upon investigation. Elqui raisins are made from the 'Italia' grapes. These are lemon yellow in color, long-oblong in shape, agreeably sweet, exquisitely flavored, have thin skins and semitransparent, long, slender bunches, a fruit which makes excellent raisins even when left hanging on the vine after maturity. The seeds vary. Some fruits are seedless; others in the same bunch have chaff seeds; others one, two, three, and rarely, but sometimes, more. I think neither machines nor shade are employed in drying raisins in Chile, nor are they steeped in boiling water or any sort of lye, nor are they dried on the plant. They are simply picked and sun-dried upon mats, trays, or shallow baskets. Their flexibility is natural and not due to sweating. The natural dryness of the climate is quite sufficient to dry them to perfection either in the shade or sun. The latter method is quicker and better, as it leaves the raisins softer. These vines are prolific bearers and the grapes are highly esteemed as extra fine and juicy table grapes.

"In view of the fact that all fruits, grains, etc., of a similar appearance are vulgarly called the same, I have an idea that the Elqui Italia is, or may be, a class by itself, a Chile strain of the Italias introduced from Italy. I have seen very many kinds of Italia grapes grown in central Chile, principally for consumption while fresh. There are other classes preferred for wines and brandy. All these have the same general appearance and are called alike, but show marked differences in plant and fruit. The Elqui grape for making raisins, however, is above competition." (*Husbands.*)

28639 and 28640. "*Pastilla.* It is from these grapes that the famous Chile brandy called 'Pisco' is distilled." (*Husbands.*)

28639. Seeds. **28640.** Cuttings.

"Pisco originated at a seaport just south of Callao, Peru, named Pisco. The liquor was sold in a jar about 30 inches high, mouth about 6 inches in diameter made so that it could not stand up. This jar was made by the Spanish upon models of the Incas. The brandy was placed within this piece of pottery new and unrefined; often buried as a refining process. I believe the plants came originally from Peru." (*Husbands.*)

28641 and 28642. "*Negra* (black). It is from these grapes that the celebrated Elqui red wine is made."

28641. Seeds. **28642.** Cuttings.

28643 and 28644.

From the Andean Highlands near Cuzco, Peru. Presented by Mrs. Franklin Adams, Washington, D. C. Received August 10, 1910.

Seeds of the following:

28643. Zea mays L. **Corn.**

28644. Chenopodium quinoa Willd. **Quinoa.**

See No. 28634 for previous introduction.

28645. Vicia faba L. **Horse bean.**

From Paris, France. Purchased from Vilmorin, Andrieux & Co. Received August 12, 1910.

Winter.

28646. Medicago sativa tunetana Murbeck.

From Oued Zenati, Algeria. Presented by Mr. A. Clavé. Received August 13 1910.

"The plants from which this seed was taken were found in a single, very limited place on calcareous and uncultivated ground. I had to watch carefully to save from the sheep, which are very fond of this excellent forage, a few flowering stems and a few seeds. It was impossible for me to get a larger quantity because of the great scarcity of this species in this region." (*Clavé.*)

Distribution.—Pine woods on both sandy and calcareous soil in the mountainous region of central Tunis and at Oued Zenati and Tebessa in the province of Constantine in Algeria.

28648 and 28649.

From Turkestan. Received through Mr. Frank N. Meyer, agricultural explorer, August 13, 1910.

28648. Tulipa sp. **Tulip.**

From mountains near Bachar-den, Turkestan. "(No. 790, June 5, 1910.) A tulip growing on sunburned mountain sides in decomposed rock soil. Flowers apparently red." (*Meyer.*)

28649. Eremurus sp.

From near Kulikalan, in the province of Samarkand, Turkestan. "(No. 789.) A very robust, ornamental Eremurus, having spikes of flowers that grow 4 feet tall and are rosy pink in color. Found at an altitude of about 7,000 feet in rich, blackish soil. Of value as an ornamental plant in fairly dry climes; apparently able to stand low temperatures." (*Meyer.*)

28653. Eragrostis lehmanniana Nees. (?)

From Mowbray, Cape Colony, South Africa. Presented by C. Starke & Co. (Ltd.). Received August 13, 1910.

Distribution.—Central and eastern South Africa, extending from the Graaff Reynet region and Natal southward to the Cape.

Seeds.

28655. Triticum turgidum L. **Wheat.**

From Valencia, Spain. Presented by Mr. Robert Frazier, jr., American consul. Received July 12, 1910.

"Irrigated wheat, the typical variety grown in this vicinity. Usually planted from the end of November to the middle of December." (*Frazier.*)

28656 and 28657. Solanum spp.

From Peru. Presented by Dr. A. Weberbauer, German Legation, Lima. Received August 16, 1910.

Tubers of the following; notes by Dr. Weberbauer:

28656 and 28657—Continued.

28656. SOLANUM sp.

"Tubers of an undoubtedly wild Solanum that I collected myself. I found the plants on the hills near Lima, between crumbled rocks in the so-called Loma formation, 200 meters above sea level. The specimens were very young, in the beginning of their growing period, but one of them already had blooms. These were deep violet, almost the color of *Viola odorata*. The plants were very similar to the potato, but were not *Solanum tuberosum*, but the *Solanum maglia* which I collected (formerly) near Mollendo.

"Lima, considering its latitude, has very low temperatures; from June to October the average monthly temperature is 15.9° to 16.7° C.; sometimes the temperature sinks to 12° C. From November to May there is practically no precipitation. From June to October, however, it is cloudy almost continuously, and slight rains dampen the ground so that the previously bare hills are covered with a green carpet of plants (chiefly annual plants, such as tuberous and bulbous plants). This vegetation is called Loma."

28657. SOLANUM sp.

"Tubers of another Solanum species related to the potato. This, too, was found at 200 meters above sea level and between crumbled rocks in the Loma. The plant has pale-lilac blooms and is distinguished from *Solanum tuberosum*, among other things, by the narrow leaf lobes." (*Weberbauer.*)

28658. RUBUS sp. **Raspberry.**

From the top of Mount Omei, Szechwan Province, China. Presented by Dr. Edgar T. Shields, Yachow, Szechwan Province, China. Received July 23, 1910.

"Seed of a most delicious, large, yellow raspberry." (*Shields.*)

28659. VICIA FABA L. **Horse bean.**

From Yachow, Szechwan Province, China. Presented by Dr. Edgar T. Shields. Received July 23, 1910.

"These are very prolific and are used extensively in feeding horses and cows. They are also eaten by the poorer people, boiled and roasted in oil." (*Shields.*)

28660. MAGNOLIA CAMPBELLII Hook. f. and Thoms.

From Erfurt, Germany. Purchased from Haage & Schmidt. Received August 17, 1910.

A large deciduous-leaved tree, whose rosy flowers, often 10 inches in diameter, open before the leaves appear. The leaves are 12 inches long by 4 inches wide, smooth above and silky pubescent below.

Distribution.—In the forests on the slopes of the Himalayas, at an elevation of 8,000 to 10,000 feet, in Sikkim and Bhutan, northern India.

28661. ZEA MAYS L. **Corn.**

From Zomba, Nyasaland Protectorate, Africa. Presented by Mr. E. W. Davy, agriculturist, Agricultural and Forestry Department. Received August 13, 1910.

"Seed of a native-grown type of Nyasaland. I have carried out selection work on it for only one year at present, and it will take some years to get a very true and improved type fixed. The results of even the first year show a marked improvement, the yield being at the rate of 4,550 pounds of dried husked corn per acre. I would recommend you to test it in your Southern States with a good rainfall." (*Davy.*)

28662 and 28663.

From South Africa. Presented by Prof. J. Burtt Davy, government agrostologist and botanist, Transvaal Department of Agriculture, Pretoria. Received August 1, 1910.

Seeds of the following:

28662. Acacia litakunensis Burchell.

"This was collected 70 miles southeast of the type locality. I have not been able to learn that the wood has any special economic value, but the tree is ornamental and stands considerable drought, with some frost." (*Davy.*)

Distribution.—The vicinity of Litakun in Bechuanaland, South Africa.

28663. Lebeckia cuspidosa (Burch.) Skeels.

(*Spartium cuspidosum* Burchell, Travels, vol. 1, p. 348, 1822.)

(*Genista cuspidosa* DC., Prodromus, vol. 2, p. 147, 1825.)

(*Stiza psiloloba* E. Meyer, Commentariorum de Plantis Africae Australioris, p. 32, 1835.)

(*Lebeckia psiloloba* Walp., Linnæa, vol. 13, p. 478, 1839.)

This South African leguminous shrub is reported by Harvey (Flora Capensis, vol. 2, p. 84, 1861–62) from "Near Uitenhage," and it was originally described from between "Gattikamma" (white water) and "Klaarwater," now known as Griquatown, and apparently near the latter locality. Burchell says in regard to it: "In one part, toward the end of our journey, we passed abundance of a handsome shrub, from 5 to 7 feet in height, covered with showy yellow flowers, but quite destitute of leaves, and even by this light easily to be distinguished as a plant which had not been anywhere seen before. It was completely armed at all points, its green leafless branches being terminated by a spine as sharp as a needle."

De Candolle in the Prodromus restricted the use of the generic name Spartium to a single species of the Mediterranean region, *S. junceum*, and referred this South African plant to Genista. The species was apparently again described by E. Meyer under the name *Stiza psiloloba*, and since Stiza is not recognized as distinct from the earlier Lebeckia, Meyer's plant was placed in that genus by Walpers. The original specific name published by Burchell, though long in disuse, is here restored.

"This is a nearly leafless, dense shrub, about 6 feet high, bearing ornamental yellow flowers. It is very spiny and should be suitable for hedges. It comes from the Kalahari, near Kuruman, and is likely to suit dry, warm reigons." (*Davy.*)

28665. Solanum tuberosum L. **Potato.**

From Temuco, Chile. Presented by Mr. D. S. Bullock. Received August 19, 1910.

"*Damma.* An early variety." (*Bullock.*)

Tubers.

28667 to 28672.

From Mauritius. Presented by Mr. Gabriel Regnard. Received July 29, 1910.

Seeds of the following:

28667. Aphloia theaeformis (Vahl) Bennett.

"*Bois Goyave* or *Bois Viliau.* A glabrous, much-branched shrub; leaves oblong, obtuse, or acute, entire or toothed, 1 to 4 inches long. Flowers yellowish. Fruit ovoid-ampullæform ¼ to ½ inch long; 10 to 12 seeded." (*Regnard.*)

28667 to 28672—Continued.

Distribution.—Frequent in the woods on the islands of Mauritius, the Seychelles, Rodriguez, and Madagascar.

28668. Elaeocarpus sp.

28669. Ehretia acuminata R. Br.

"An Indian tree of the boraginaceous family yielding a tough, light, and durable wood. It bears bunches of tiny white flowers and red seeds the size of a small pea. Is a very showy and ornamental tree." (*Regnard.*)

Distribution.—Slopes of the subtropical Himalayas and the adjacent plains from Gurhwal to Bhutan in India, and in Java, Australia, and Japan.

28670. Mimusops imbricaria Willd.

"A large tree with gray, glabrous branches. Leaves oblong, glabrous, shining. Fruit a drupe, globose, the size of a small apple, one to four seeded." (*Regnard.*)

Distribution.—Thick woods in the interior of the islands of Mauritius and Reunion.

28671. Tambourissa amplifolia (Tul.) DC.

"Branchlets stout. Leaves alternate, oblong, ½ to 1 foot long. Bud of female perianth black, apiculate, 1½ inches thick, globose, with conical fruits ½ inch long." (*Regnard.*)

Distribution.—In the forests on the slopes of the Pouce and other mountain ranges on the island of Mauritius.

28672. (Undetermined.)

"A forest shrub (?)." (*Regnard.*)

28673 to 28675.

Plants of the following, turned over to the Department for distribution by Dr. J. N. Rose, associate curator, Division of Plants, United States National Museum, Washington, D. C., August, 1910.

28673. Echeveria hoveyi Rose *n. sp.*

"Usually stemless, but when old developing a short stem; leaves forming a loose spreading rosette, pale green with broad pinkish or white margins and these more or less wavy or sometimes colored throughout; flowering stem a secund raceme bearing 6 to 12 flowers; corolla pinkish.

"The origin of this form is unknown. It is probably some horticultural sport or hybrid, but does not closely resemble any of our common cultivated forms, although it may be said to belong to the group of species in which *Echeveria secunda* and *Echeveria glauca* are found." (*Rose.*)

28674. Parmentiera cereifera Seem. **Candle tree.**

"This is one of the most remarkable trees of the Tropics, a native of Panama. It grows 30 to 40 feet high and produces from its stem and old branches a profusion of almost sessile campanulate flowers; these are followed by yellowish cylindrical, smooth points, 12 to 18 inches long, which appear exactly like wax candles, as the botanical name implies. So close is the resemblance that travelers, seeing the tree in fruit for the first time, are liable to be temporarily puzzled as to whether the candles of shops are made in factories or grow on trees. The candlelike fruits are suspended from the bare stem and branches by short slender stalks; dangling in the air, they readily give the impression of a chandler's shop. This impression is intensified as night falls and the numerous fireflies move among the fruits. It is not, perhaps, surprising that the inex-

28673 to 28675—Continued.

perienced traveler should not infrequently be informed that the fireflies perform the duty of lighting up these 'candles' when required by the denizens of the jungle. The fruits are fleshy and juicy and have a peculiar applelike odor. They are eaten by certain tribes, and also by cattle. The tree belongs to the natural order Bignoniaceæ." (*Rose.*)

28675. ZINZIBER sp. **Wild ginger.**

"From near Tampico, Mexico. Sent in by Dr. Edward Palmer." (*Rose.*)

28676 and 28677. MANGIFERA INDICA L. **Mango.**

From San Jose, Costa Rica. Presented by Mr. A. R. Guell, Louisiana State University, Baton Rouge, La. Received August 22, 1910.

Cuttings of the following:

28676. "Our common fiberless variety." (*Guell.*)

28679 to 28683.

From Richmond, New South Wales, Australia. Presented by Mr. H. W. Potts, principal, Hawkesbury Agricultural College. Received August 2, 1910.

Seeds of the following:

28679. ANDROPOGON PERTUSUS (L.) Willd.

Distribution.—Southern Europe and Asia, extending from Sicily to India, in tropical Africa, and in Queensland and New South Wales in Australia.

28680. ANDROPOGON REFRACTUS R. Brown.

Distribution.—Eastern Australia, at Port Essington in North Australia, along the Brisbane River in Queensland, at Port Jackson in New South Wales, and at Mitta-Mitta in Victoria.

28681. DICHELACHNE CRINITA (L. f.) Hook. f.

Distribution.—Throughout Australia and in Tasmania and New Zealand.

28682. EUCALYPTUS ROBUSTA Smith. **Swamp mahogany.**

Distribution.—New South Wales in Australia, extending from Port Jackson to the Blue Mountains.

28683. STERCULIA DIVERSIFOLIA G. Don. **Kurrajong tree.**

Distribution.—Australia, in the provinces of Queensland, New South Wales, Victoria, and Western Australia.

28684. DIOSPYROS MONTANA CORDIFOLIA (Roxb.) Hiern.

From Lahore, Punjab, India. Presented by Mr. W. R. Mustoe, superintendent of the Government Gardens. Received August 23, 1910.

A tree with short spines occasionally on the trunk and older branches; young branches and leaves softly pubescent; leaves narrowly ovate, slightly heart shaped at the base; fruit globular and about the size of a large cherry. The wood is yellowish gray and soft, but durable. It is used for making carts and tools and would be suitable for furniture.

Distribution.—India, from the Himalayas to Ceylon and Tenasserim, through the Malay Archipelago to tropical Australia.

28685. Prunus mume Sieb. and Zucc. **Japanese apricot.**

From Yokohama, Japan. Purchased from the Yokohama Nursery Co. Received August 24, 1910.

See Nos. 9211 to 9216 for description.

28686 and 28687.

From Washington, D. C. Presented by Mr. W. R. Smith, superintendent, National Botanic Garden. Numbered for convenience in recording distribution August 25, 1910.

Plants of the following:

28686. Actinidia kolomikta (Maxim.) Rupr.

See Nos. 20360 and 22593 for description.

28687. Passiflora capsularis L.

"A climbing vine with leaves dividing below the middle into two oblong lanceolate lobes; flowers greenish white, the filament crown pale yellowish green surrounding a double white cup, anthers and stigmas yellow. Fruit about 2 inches long, oblong, and six-angled." (*Adapted from Botanical Magazine, vol. 55, pl. 2868.*)

Distribution.—Mirador in southern Mexico and southward to Ecuador and Brazil.

28688 and 28689.

From Paraguay, South America. Presented by Mr. C. F. Mead, Piropo, Paraguay. Received August 20, 1910.

Seeds of the following:

28688. Psidium guajava L. **Guava.**

"In Spanish called '*Guayaba grande*' and in Guarany '*araza-guaza.*' It is the same class of fruit as the small guayaba, except that it is much larger, about the size of a hen's egg, and is borne on a tree which in five years attains a height of 20 to 25 feet and a diameter of 8 to 10 inches. The wood of this tree is hard, tough, and impossible to split." (*Mead.*)

28689. Bromelia sp. **"Caraguata."**

"This plant in Guarany is called 'caraguata'. It grows in camp hereabouts especially in barren spots. Every year in the fall the center leaves turn bright red and it bears a cluster of pink and white flowers, similar to tuberoses. The fruits, which are used here for preserves only, are borne in a cluster 10 to 15 inches long and 4 to 6 inches in diameter; they are the size of a small plum and are bright yellow when ripe. The plant has a bad name, owing to the difficulty of exterminating it when it is well started." (*Mead.*)

28690. Widdringtonia whytei Rendle. **Mlanje cypress.**

From Zomba, Nyasaland Protectorate, Africa. Presented by Mr. J. M. Purves, chief forest officer. Received August 25, 1910.

"The seed germinates quickly, usually in three or four weeks, in moist and slightly shaded soil, with a mean temperature of from 65° to 70° F. The tree occurs in about 17° south latitude at elevations of from 5,000 to 6,000 feet. Above the latter it becomes very stunted in growth. It exhibits a preference for deep gullies and ravines, and seems to detest very strong winds. The soil varies considerably, and fine trees often occur in the crevices of the decomposing granite rocks, of which the mountain chiefly consists. The rainfall will vary from 70 to 90 inches, and in the dry months the

28690—Continued.

forests are subject to heavy mist and fog, with the result that the undergrowth never dies and is always very moist. The rains fall in the hot months, October to April, and herein will lie your chief difficulty in establishing the tree in the Northern Hemisphere. In the south of England it is grown with difficulty, as it makes its new growth in the same months as at Mlanje, with the result that it does not ripen off before the advent of frosts. At elevations of 3,000 feet in Nyasaland, where the conditions of climate are more xerophytic, it makes a nice ornamental tree, but it begins to die out suddenly after 10 or 12 years. It seems to thrive best in its native habitat when it is slightly intermixed with other leaf-shedding trees and evergreens, typical of mountain forests, as the decaying foliage, etc., helps to form a better layer of humus." (*E. W. Davy, acting chief forest officer, Agricultural and Forestry Department, Zomba, Nyasaland Protectorate, Africa.*)

28691 to 28703. MANGIFERA INDICA L. **Mango.**

From Seharunpur, India. Purchased from Mr. A. C. Hartless, superintendent, Government Botanic Gardens. Received August 23, 1910.

Seeds of the following:

28691. *Sanduria.*
28692. *Singapuri.*
28693. *Gopalbhog.*
28694. *Ennurea.*
28695. *Faizan.*
28696. *Tamancha.*
28697. *Sunahra.*
28698. *Sharbati* (brown).
28699. *Bulbulchasm.*
28700. *Calcutta Amin.*
28701. *Hathijhul.*
28702. *Chickna.*
28703. *Faquirmala.*

28704. ROLLINIA sp.

From Port Louis, Mauritius. Presented by Mr. G. Regnard. Received August 26, 1910.

"Tree 30 feet; leaves 7 inches long; fruit heart shaped, with prominent eyes of a yellowish color when ripe; edible." (*Regnard.*)

28705 to 28707. SOLANUM spp. **Wild potato.**

From Marseille, France. Presented by Prof. Edouard Heckel, director, Botanic Gardens. Received August 29, 1910.

Tubers of the following:

28705 and 28706. SOLANUM MAGLIA Schlecht.

28705. White and violet.

28706. Fifth generation.

28707. SOLANUM COMMERSONII Dun.

Half wild.

28708 to 28710. **Willow.**

From Limavida, via Molina, Chile. Presented by Mr. José D. Husbands. Received August 30, 1910.

Cuttings of the following:

28708. SALIX VITELLINA L.

"(H. No. 609.) *Yellow Mimbre.* An industrial plant of value, introduced into Chile from Europe by the Spaniards. Grows in waste spots along the edge of canals, creeks, ravines, etc. It is used to make extra strong baskets for holding fruit, potatoes, or corn and for general farm and factory uses; also to tie fences, thatches, etc." (*Husbands.*)

28708 to 28710—Continued.

28709. SALIX HUMBOLDTIANA Willd.

"(H. No. 611.) *Sauce.* A Chilean willow that grows wild, principally in the sands of the river-bottom lands. Its greatest use is for live fence posts in wet or water-covered lands. Cuttings when planted take root quickly and grow very rapidly. Its form varies and it is not a uniform growth like 'castilla' or the weeping varieties. The bark is used in medicine as an astringent, febrifuge, etc., and is a valuable remedy; it also gives a white crystallized substance called 'salicina,' used in fevers as quinine." (*Husbands.*)

28710. SALIX HUMBOLDTIANA Willd.

"(H. No. 610.) Variety *fastigiata.* The Chilean castilla. These trees grow perfectly straight and attain a great height. All the branches grow up close to the trunk, like a well-trimmed Populus. I have seen these trees growing in the worst arid clays, perfectly dry." (*Husbands.*)

28711. GOSSYPIUM sp. **Cotton.**

From Manly, near Brisbane, Queensland, Australia. Presented by Mr. Daniel Jones. Received August 30, 1910.

"Seed of a hybrid, naturally crossed, found in a field; it is of good quality and a good bearer. So far we are not sure whether it will maintain its present standard, but we are experimenting with it. This sample is from a 3-year-old shrub. We hope to fix a type by breeding. Frequently 1 to 2 pounds of cotton are obtained from a shrub of this variety, and in one instance a 2-year-old plant gave us 4 pounds; this is abnormal, however. Mascote (tree cotton) types frequently give up to 6 pounds per shrub." (*Jones.*)

28712. MORAEA BICOLOR (Lindl.) Steud.

From Glasnevin, Dublin, Ireland. Presented by Mr. F. W. Moore, M. A., director, Royal Botanic Gardens. Received August 29, 1910.

"A South African flowering bulb having a flower 2 inches across, yellow, with beautiful brown spots on the outer segments; style crests yellow." (*Extract from Bailey, Cyclopedia of American Horticulture.*)

Distribution.—The coast region of Cape Colony between the Olifant's and Kei rivers.

28713. BERBERIS FREMONTII Torrey. **Barberry.**

From Tucson, Ariz. Presented by Mr. J. J. Thornber, botanist, University of Arizona. Received August 29, 1910.

"Native barberry from northern Arizona. A very drought-resistant species, and promising as an ornamental." (*Thornber.*)

See No. 12242 for previous introduction.

Distribution.—Slopes of canyons in western Texas, New Mexico, Arizona, and southern California.

28714. ANONA CHERIMOLA Miller. **Cherimoya.**

From Lima, Peru. Presented by the director of the National School of Agriculture and Veterinary Surgery, through Mr. Edw. J. Habick. Received through Rev. V. M. McCombs, Callao, Peru, August 30, 1910.

28715 to 28730.

From Durban, Natal, South Africa. Presented by Prof. J. Medley Wood, director, Botanic Gardens. Received July 25, 1910.

Seeds of the following trees and evergreen shrubs:

28715. Assonia spectabilis (Bojer) Kuntze.

Distribution.—In the Mozambique district of East Africa, and in Madagascar and Mauritius.

28716. Bauhinia galpini N. E. Brown.

Distribution.—Along the coast of southeastern Africa, in the Makua district of Mozambique, and in the vicinity of Barberton in the Transvaal.

28717. Bauhinia petersiana Bolle.

Distribution.—The vicinity of Senna in Zambesiland, at the foot of Mount Moramballa and in the Manganya Hills in the Mozambique district of tropical Africa.

28718. Bauhinia picta (H. B. K.) DC.

Distribution.—The valley of the Magdalena River, in the northern part of Bolivia.

28719. Boscia undulata Thunb.

Distribution.—In the primitive woods in the vicinity of Uitenhage and district of George in Cape Colony; also in the island of Mauritius.

28720. Brunsfelsia americana L.

28721. Calpurnia aurea (Lam.) Benth.

Distribution.—In Abyssinia, the highlands of Huilla and Golungo Alto in Lower Guinea, and in the vicinity of Durban in Natal.

28722. Carissa grandiflora (E. Mey.) DC.

See Nos. 11734 and 13239 for previous introductions.

28723. Dovyalis caffra (Hook. and Harv.) Warb.

Distribution.—The eastern districts of Cape Colony and in Kafirland, South Africa.

See No. 3724 for description.

28724. Dracaena rumphii (Hook.) Regel.

Distribution.—In woods along the eastern coast of Cape Colony, from near Uitenhage northward to Pondoland.

28725. Indigofera sp.

28726. Mimosa rubicaulis Lam.

Distribution.—Afghanistan and India, rising to an elevation of 5,000 feet in the western Himalayas.

28727. Moraea iridioides L.

See No. 13732 for previous introduction.

Distribution.—Tropical and South Africa, extending from the valley of the River Umba in German East Africa and from British Central Africa southward to Cape Colony.

28728. Tecoma berteroi DC.

Distribution.—On the island of Haiti in the West Indies.

28715 to 28730—Continued.

28729. Ophiobostryx volubilis (Harvey) Skeels.

(*Bowiea volubilis* Harvey; Hooker, Botanical Magazine, vol. 93, pl. 5619. 1867.)

The original generic name given this curious liliaceous plant is invalid since it had been used by Haworth 43 years earlier (Philosophical Magazine, vol. 64, p. 299, 1824) for another proposed genus belonging to the same family. No other name has been applied to the later genus Bowiea, and Ophiobostryx is therefore proposed, in allusion to the leafless asparaguslike branches suggesting snaky locks, such as supplanted hair on the head of the monster Medusa, according to classical mythology. The genus has only one species, *O. volubilis*.

Ophiobostryx volubilis was first sent to the Royal Gardens, Kew, by Henry Hutto, of Grahamstown, South Africa, and has since been found at Katberg in the Stockenstrom division of the coast region, in the Orange River Colony and Transvaal, in the Kalahari region, and near Transkei, Kokstad, and Durban, in the eastern part of Cape Colony.

28730. Mondia whiteii (Hook. f.) Skeels.

(*Chlorocodon whiteii* Hook. f., Botanical Magazine, pl. 5898, 1871.)

The generic name *Chlorocodon*, "in allusion to the bell-like green flowers," was applied to this plant in 1871 by Sir Joseph Hooker (Botanical Magazine, vol. 97, pl. 5898), who was doubtless unaware that the name had been used by Fourreau in 1869 (Annales de la Société Linnéenne de Lyon, n. s., vol. 17, p. 113) for a proposed genus of ericaceous plants. No other name appears to have been used for the later genus known as Chlorocodon, and since a new name is necessitated Mondia is proposed, this being an adaptation of the native name "Mondi," or "Mundi," applied to this plant.

Mondia whiteii was originally described from Fundisweni, Natal, but has since been collected at Yaunde in Kamerun; Bumbo, Pungo Ndongo, and other places in Angola; also at Karagwe and Bukoba in German East Africa, and in Nyasaland.

28731 and 28732. Solanum maglia Schlecht. **Wild potato.**

From Marseille, France. Presented by Dr. Edouard Heckel, director, Botanic Garden. Received September 1, 1910.

28731. Fourth generation, violet.

28732. Fourth generation, violet.

Distribution.—See No. 28705.

28733 to 28738.

From Fort Hall, Nairobi, British East Africa. Presented by Mr. J. McClellan, Provincial Commission. Received July 29, 1910.

Seeds of the following:

28733. Andropogon sorghum (L.) Brot. **Sorghum.**

"This lot represents a mixture of two of the East African sorghum types, probably durras, one with white seeds and one with red. Such mixtures are commonly received from central East Africa and from Abyssinia, but the varieties have always proved too late to mature in this country." (*Carleton R. Ball.*)

28734. Cajan indicum Spreng.

28733 to 28738—Continued.

28735. CHAETOCHLOA ITALICA (L.) Scribn.

28736. DOLICHOS LABLAB L. **Bonavist bean.**

28737. ELEUSINE CORACANA (L.) Gaertn. **Ragi millet.**

28738. PENNISETUM AMERICANUM (L.) Schum. **Pearl millet.**

28739. CERATONIA SILIQUA L. **Carob.**

From the estate of the Comte de Puerto Hormosa, at Pizarra, near Malaga, Spain. Received through Mr. R. S. Woglum, September 6, 1910.

"These cuttings were taken from the best carob tree I saw in Spain. A magnificent tree, fully 30 feet high and noted for being very prolific in fruit." (*Woglum.*)

28740 to 28744.

From Mauritius. Presented by Mr. G. Regnard, Port Louis. Received September 2, 1910.

Seeds of the following; quoted notes by Mr. Regnard:

28740. PECTINEA PAUCIFLORA (Thouars) Skeels.

(*Erythrospermum pauciflorum* Thouars, Veg. Iles Austr. Afr., p. 67, pl. 21, fig. 1, 1806.)

(*Erythrospermum mauritianum* Baker, Flora of Mauritius and Seychelles, p. 10, 1877.)

The genus Pectinea was published by Gaertner in 1791 (De Fructibus et Seminibus Plantarum, vol. 2, p. 136, pl. 111, fig. 3), with *P. zeylanica* as the only species, while the name Erythrospermum, often applied to this genus, appears to have been used no earlier than 1792 or 1793 on a plate published by Lamarck (Encyclopédie Méthodique, pl. 274). No description accompanied this plate and the text explaining it was not published until even a later date. The first publication of a description of the genus under the name Erythrospermum appears to have been effected in 1806 by Thouars (Histoire des Végétaux Receuillis dans les Isles Australes d'Afrique, p. 65), who states that Lamarck's figure only had appeared. There is apparently no reason, therefore, why Post and Kuntze, Lexicon Generum Phanerogamarum, should not be followed in the restoration of Gaertner's name, Pectinea, published 15 years earlier than Erythrospermum.

Pectinea pauciflora was originally described by Thouars from Mauritius and is still unknown elsewhere in an indigenous state.

"*Bois Manioc* or *Bois Cochon.* Small tree. Fruit globose, hard, ¼ to 1 inch thick. Found in mountain woods in Mauritius."

28741. EUGENIA GLOMERATA Lam.

"*Bois de Pomme.* Berry as large as a pea. Frequent in mountain woods in Mauritius; also in Madagascar."

28742. (Undetermined.)

"*Bois Maigre. Bois sans écorce. Bois Bigaigon.* Berry ½ inch long. Found in Mauritius in dense woods; also in Reunion."

28743. MERIANA sp.?

"From Pouce Mountain, Mauritius. Pink color."

28744. VOANDZEIA SUBTERRANEA (L.) Thouars. **Woandsu.**

"Bambara ground nuts. Nuts are eaten boiled and are very rich and nourishing. From Africa."

See No. 23453 for further description.

28745. Prunus sp. **"Plumcot."**

From Harput, Turkey. Presented by Mr. William W. Masterson, American consul. Received August 26, 1910.

"An unusually fine-tasting fruit that might be called a 'plumcot.' It was about the size of a greengage plum, of a light-yellow color, and had a decided apricot flavor, indicating that it was a hybrid between the plum and the apricot." (*Masterson.*)

28746. Solanum commersonii Dun. **Wild potato.**

From Montevideo, Uruguay. Presented by Mr. Fred W. Goding, American consul. Received September 6, 1910.

Tubers.

28747. Solanum sp. **Wild potato.**

From Asuncion, Paraguay. Presented by Mr. T. R. Gwynn. Received September 6, 1910.

"The wild potato is here in profusion. The plant and leaf are almost exactly like the cultivated varieties, but the roots are very different. It puts forth a long underground stem to the end of which the potatoes are attached. These are sometimes as large as a walnut, hull and all, though generally much smaller." (*Gwynn.*)

28748 to 28751. Mangifera indica L. **Mango.**

From Poona, Bombay, India. Purchased from the Empress Botanical Gardens. Received August 31, 1910.

Seeds of the following:

28748. *Badsha.*
28749. *Fernandez.*
28750. *Gudbeli.*
28751. *P'ote* (?).

28752 to 28760. Mangifera indica L. **Mango.**

From Seharunpur, India. Purchased from the Government Botanic Gardens. Received August 31, 1910.

Seeds of the following:

28752. *Gola.*
28753. *Khaparia.*
28754. *Langra.*
28755. *Bombay* (green).
28756. *Fajri* (round).
28757. *Fajri* (long).
28758. *Lamba Bhadra.*
28759. *Malda.*
28760. *Najibabadi.*

28761 and 28762.

From Palestine. Purchased from Mr. Aaron Aaronsohn, director, Jewish Agricultural Experiment Station, Haifa, Palestine. Received August 22, 1910.

Seeds of the following:

28761. Vicia ervilia (L.) Willd. **Bitter vetch.**

28762. Lathyrus sativus L.

"I think that *Lathyrus sativus* will make a quicker growth in the California orange orchards than *Vicia ervilia*, and for this reason I believe it will be better adapted as a green manure. Furthermore, I believe it will make a heavier growth and give a bigger yield than *Vicia ervilia;* at least, this is its behavior in Palestine, where I have had experience with both species. In my opinion *Lathyrus sativus* is in no way inferior to the fenugreek, which has been used so successfully in the orange orchards in Cali-

28761 and 28762—Continued.

fornia. There might be a possible advantage in trying *L. sativus* in place of fenugreek, inasmuch as the seed is cheaper." (*Aaronsohn.*)

28763. ANONA MONTANA MacFayden.

From Mayaguez, Porto Rico. Presented by Mr. W. E. Hess, assistant horticulturist, Agricultural Experiment Station, through Mr. P. J. Wester. Received August 23, 1910.

"A small tree indigenous to the West Indies; the fruit is subglobose, muricate, and the flesh dry and unedible.

"Introduced for trial as a stock for the cultivated anonas." (*Wester.*)

28764. ZIZIPHUS JUJUBA Miller.

From Las Cruces, N. Mex. Presented by Mr. David Griffiths. Received September 8, 1910.

"The trees from which these seeds were obtained were loaded with fruit. There are only two alive; one is 12 feet high. The trees are probably about 12 to 15 years old, but have had very poor conditions and are badly crowded." (*Griffiths.*)

28765. PHASEOLUS MAX L.

From Port of Spain, Trinidad. Presented by the assistant secretary of the Board of Agriculture at the request of Mr. R. B. Dickson. Received August 23, 1910.

28766. HELYGIA PADDISONI (Baker) Skeels.

(*Parsonsia paddisoni* R. T. Baker, Proc. Linn. Soc. N. S. Wales, vol. 24, p. 385, 1899.)

The original use of the generic name Parsonsia was by Patrick Brown in 1756 (Natural History of Jamaica, p. 199, pl. 21, fig. 2), for a species later published by Linnæus as *Lythrum parsonsia*, a plant of the family Lythraceæ. The genus Parsonsia as proposed by Brown was recognized in 1763 by Adanson (Familles des Plantes, vol. 2, p. 234), whose description and citation completed the technical publication of the name. Parsonsia is therefore the valid name for Cuphea, the genus to which *Lythrum parsonsia* was later referred. This original use of Parsonsia by Patrick Brown and Adanson invalidates its use by Robert Brown in 1809 (Memoirs Wernerian Natural History Society, vol. 1, p. 64) for the apocynaceous genus to which the species given above belongs. Several other generic names have been proposed for various species of this genus, and the earliest of them, Helygia, published by Blume in 1826 (Bijdragen tot de flora van Nederlandsch Indië, vol. 2, p. 1043) with *H. javanica* as the type, is recognized as the valid name for the group, and the species under consideration is accordingly transferred to it.

Helygia paddisoni was originally described from New Angledool, New South Wales, and is not known to occur elsewhere.

From Sydney, New South Wales, Australia. Presented by the curator, Department of Public Instruction, Technical Education Branch, Technological Museum. Received August 30, 1910.

"A glabrous woody climber. Leaves opposite, glabrous on both sides. The stem is about 1 inch in diameter a foot or so above the ground, the bark being of a quite corky nature.

"Stock are very fond of the leaves, so that this plant should be ranked as a fodder. My attention was first drawn to this plant by Mr. A. Paddison, of New Angledool, who

28766—Continued.

sent for identification a large tuber or 'yam' weighing about 10 pounds, stating that similar 'yams' were eaten both by settlers and aborigines. The interior is composed of a whitish substance, the chemical analysis of which shows only 4½ per cent of carbonaceous principles. It tastes very much like a turnip, both in the raw and cooked condition. The color and consistency of the largest specimens resemble those of the common mangel-wurzel." (*R. T. Baker.*)

"A vine generally found growing at the foot of and twisting itself around some small tree, and that tree in nine cases out of ten a 'wilga' (*Geijera parviflora* Lindl.). The top 'yam' of the plant we dug was 4 inches from the surface, and the deepest that we could find was 21 inches from the surface. We dug up all that we could find, carried them home, and weighed each one separately, 29 'yams' in all. The total weight was 101¼ pounds; the heaviest one weighed 12¼ pounds." (*A. Paddison.*)

28767 and 28768. MELINIS MINUTIFLORA Beauv. **Molasses grass.**

From Sao Paulo, Brazil. Purchased from Mr. H. M. Lane, Mackenzie College. Received September 3, 1910.

Seeds of the following:

28767. "*Negro Head.*" **28768.** Ordinary variety.

See Nos. 23201 and 23381 for previous introductions.

28770. SOLANUM JAMESII Torr. **Wild potato.**

Collected in the Chiricahua National Forest. Presented by Mr. Arthur H. Zachau, forest supervisor, Portal, Ariz., through the Forest Service. Received September 15, 1910.

28771. SOLANUM sp. **Wild potato.**

From Zacatecas, Mexico. Collected by Mr. F. E. Lloyd. Presented by Dr. J. N. Rose, associate curator, United States National Museum, Washington, D. C. Received September 10, 1910.

(Rose No. 08.219.)

28772 to 28779.

From Chile. Received through Mr. José D. Husbands, Limavida, via Molina, Chile, September 2, 1910.

Seeds of the following; notes by Mr. Husbands:

28772. GEVUINA AVELLANA Molina.

"(H. No. 595.) *Avellano.* These are fresh seed from the South and therefore hardier than those sent heretofore from central Chile (S. P. I. No. 25611)."

28773. DRIMYS WINTERI Forster.

"(H. No. 599.) *Canelo del Sur.*"

Distribution.—Damp slopes of the exposed valleys in the vicinity of the Strait of Magellan in southern Chile.

28774. GERANIUM ROBERTIANUM L.

"(H. No. 601.) *Alfilerillo* single."

28775. ERODIUM sp.

"(H. No. 602.) *Alfilerillo* double."

28776. ARISTOTELIA MACQUI L'Herit.

"(H. No. 603.) White maqui."

See No. 26306 for previous introduction.

28772 to 28779—Continued.

28777. (Undetermined.)

"(H. No. 605.) A beautiful evergreen lumber tree; name unknown to me."

28778. Melica violacea Cav.

"(H. No. 606.) A wild grass from the south of Chile. Is eaten by animals."

Distribution.—The vicinity of Talcahuano on the coast of central Chile.

28779. Sanguisorba minor Scop.

"(H. No. 607.) A wild grass from the south of Chile. Is eaten by animals."

See No. 25040 for previous introduction.

28780. Dioscorea sp.

From Paraguay. Presented by Mr. C. F. Mead, Piropo. Received September 17, 1910.

"This will stand the same amount of frost as tomato vines. The tubers above ground are very similar to potatoes, but the color is dark, from yellow to red. There are also white tubers below the ground, the same as regular potatoes, but these are very small. It may be possible by selection or crossing to induce the plant to bear marketable potatoes, both below and above ground. It is not as heavy a cropper as the regular potato, and the necessity for a trellis upon which it can climb makes its economic value doubtful. It should be planted in the same manner as the potato. Will probably thrive in regions favored by sugar cane and oranges." (*Mead.*)

28781. Melocanna baccifera (Roxb.) Skeels. **Muli bamboo.**

(*Bambusa baccifera* Roxb., Pl. Corom., vol. 3, p. 37, pl. 243, 1819.)
(*Melocanna bambusoides* Trin., in Spreng., Neue Entdeckungen im Ganzen Umfang der Pflanzenkunde, vol. 2, p. 43, 1821.)

The genus Melocanna was established by Trinius in 1821 (Spreng., Neue Entdeckungen im Ganzen Umfang der Pflanzenkunde, vol. 2, p. 43), based on the single species *Bambusa baccifera* Roxburgh. Unfortunately the original specific name was changed and in consequence the species has since been known as *Melocanna bambusoides* Trin. The earlier specific name of Roxburgh is here restored.

The species was described by Roxburgh from the Chittagong Mountains in the southwestern part of Upper Burma, India, where it was called "Payu-tullu," and it is now known to occur on the Khasi and Garrow Hills in Assam, and in Arakan and Tenasserim, in India.

From Sibpur, Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Gardens. Received September 19, 1910.

See No. 21347 for description.

28782. Secale cereale L. **Rye.**

From Schlanstedt, Saxony, Germany. Purchased from Mr. W. Rimpau. Received September 19, 1910.

"*Old-breeding.*"

28783. Argania spinosa (L.) Skeels. **Argan.**

(*Sideroxylon spinosum* L., Sp. Pl., vol. 1, p. 193, 1753.)
(*Argania sideroxylum* Roem. and Schult., Syst., vol. 4, p. 502, 1819.)

The genus Argania was established by Roemer and Schultes in 1819 (Linn. Systema Vegetabilium Secundum Classes, Ordines, Genera, Species, vol. 4, p. 502) and contained the single species *Sideroxylon spinosum* L., but in transferring the species to

28783—Continued.

the new genus the specific name was changed and the species has since usually been known as *Argania sideroxylum* Roem. and Schult. The original specific name is here restored in accordance with the now nearly universal custom.

The name *Sideroxylon spinosum* as used by Linnæus in the Species Plantarum appears to have included two distinct plants, the one under consideration here and that usually recognized as the type, being the one represented by the Plukenet synonym, but not the Malabar plant referred to by the Rheede citation. The species seems to have been originally described by Linnæus in his Hortus Cliffortianus from a garden plant, and he is in error in ascribing India as its habitat. The species is known in an indigenous state only in Morocco.

From Tangier, Morocco. Procured by Mr. R. L. Sprague, American consul, Gibraltar, Spain. Received September 17, 1910.

See No. 3490 for description.

28784. CORCHORUS CAPSULARIS L. **Jute.**

From Shanghai, China. Presented by Mr. Nicholas Tsu. Received September 17, 1910.

See No. 1963 for description.

28785. PIRATINERA UTILIS (H. B. K.) W. F. Wight. **Palo-de-vaca.**

The "cow tree of South America" was first named *Galactodendrum utile* by Humboldt, Bonpland, and Kunth (Nova Genera et Species, vol. 7, p. 163) in 1825. In 1830 David Don (Sweet, Hortus Britannicus, ed. 2, p. 462) placed the species in the genus Brosimum, giving it the name *B. galactodendron*, which in 1880 was corrected by Karsten (Deutsche Flora, p. 498) to *Brosimum utile*. The generic name Brosimum was published by Swartz (Nova Genera et Species Plantarum, p. 12) in 1788, with two species, *B. alicastrum* and *B. spurium*. In 1775, however, Aublet (Plantes de la Guiane Françoise, vol. 2, p. 888, pl. 340, fig. 1) published the genus Piratinera with one species, *P. guianensis*, which is considered to be congeneric with *Brosimum alicastrum* Swartz. The change of name from *Brosimum galactodendron* to *Piratinera utilis* was made by Mr. W. F. Wight in the Century Dictionary and Cyclopedia (vol. 12, p. 934, 1909) under "palo," subhead "palo-de-vaca."

From Caracas, Venezuela. Presented by Mr. Antonio Valero Lara. Received September 20, 1910.

"This tree grows here in the wooded mountains and highlands as well as along the seacoast." (*Lara.*)

28786 and 28787. CITRUS spp.

From Buitenzorg, Java. Presented by the director, Department of Agriculture. Received September 22, 1910.

Seeds of the following:

28786. CITRUS AURANTIUM L.

Variety *macrocarpa*.

28787. CITRUS MACRACANTHA Hassk.

28788 to 28793.

From Beirut, Turkey. Presented by Mr. Alfred E. Day, through Miss Lanice B. Paton, Hartford, Conn. Received September 20, 1910.

28788 to 29793—Continued.

Seeds of the following:

28788. Medicago hispida denticulata (Willd.) Urb. **Bur clover.**

28789. Medicago orbicularis (L.) All.

28790. Medicago sp.

28791. Trifolium agrarium L.

28792. Trifolium clypeatum L.

Distribution.—In the countries along the eastern part of the Mediterranean from Crete to Syria and Palestine.

28793. Trifolium scutatum Boiss.

Distribution.—On the hills in the vicinity of Smyrna, and in Syria and Palestine.

28794. Talauma mutabilis Blume.

From Buitenzorg, Java. Presented by the director, Department of Agriculture. Received June 3, 1910. Numbered September, 1910.

Variety *splendens.*

Distribution.—Along the banks of the rivers in the interior of the province of Bantam, Java.

28796 and 28797.

From Port Louis, Mauritius. Presented by Mr. G. Regnard. Received September 23, 1910.

Seeds of the following:

28796. Artocarpus communis Forst.

See No. 26936 for previous introduction.

28797. Mimusops sp.

28798. Gossypium sp. **Wild cotton.**

From Riviere du Rempart, Mauritius. Presented by Mr. G. Regnard, Port Louis, Mauritius. Received September 26, 1910.

See Nos. 28879 and 28880 for note.

28799 and 28800. Feronia lucida Scheffer.

From Buitenzorg, Java. Presented by the director, Department of Agriculture. Received September 16, 1910.

"This plant is known as *Kawis watoe* in Javanese and *Kawista-batoe* in Malayan. It differs from the wood-apple (*Feronia elephantum*) (S. P. I. No. 25888) in having yellowish petals and anthers instead of reddish as that has; also calyces linear-laciniate instead of ovate-acute as in the latter. Occurs in the province of Rembang, Java." (*Extract from Scheffer in Natuurk. Tijds. Ned. Ind., vol. 31, p. 19. 1870.*)

28801 to 28809.

From Batum, Caucasus, Russia. Received through Mr. Frank N. Meyer, agricultural explorer, March 31, 1910.

Seeds of the following:

28801. Amygdalus communis L. **Almond.**

"A very small almond, but with thin shell and of good flavor. Said to come from Persia." (*Meyer.*)

28801 to 28809—Continued.

28802. Amygdalus communis L. **Almond.**

"A large almond with a very hard shell. Said to come from Persia." (*Meyer.*)

28803. Corylus avellana L. **Hazelnut.**

"A hazelnut called '*Trepizond.*' A very popular variety and much grown in this section of the Caucasus. Quantities of them are exported to England and America. Selling at 6 and 7 rubles per pood (36 pounds)." (*Meyer.*)

28804. Corylus maxima Miller. **Filbert.**

"A small filbert, quantities of which are sold locally." (*Meyer.*)

28805. Corylus maxima Miller. **Filbert.**

"A filbert called '*Kerasund.*' Grown quite extensively and exported to England and America. Sells at 8 rubles per pood (36 pounds)." (*Meyer.*)

28806. Elaeagnus angustifolia L. **Oleaster.**

"Sold sparingly as a sweetmeat. Said to come from Turkestan." (*Meyer.*)

28807. Pistacia vera L. **Pistache.**

"A very white pistache, of rather poor quality. Said to come from Persia." (*Meyer.*)

28808. Prunus domestica L. **Plum.**

"These plums when dried are used stewed with meats and in soups. Said to come from Persia." (*Meyer.*)

28809. Prunus cerasus L. **Cherry.**

"Said to come from Gori, central Caucasus." (*Meyer.*)

28810. Canarium luzonicum (Blume) Gray. **Pili nut.**

From Nueva Caceres, Philippine Islands. Presented by the Hon. P. M. Moir, judge, 8th judicial district, Province of Ambos Camarines. Received September 22, 1910.

"These nuts grow in the southern part of Luzon and nowhere else in the Philippines. The tree is quite large and fairly pretty. The nut is the richest in flavor of any nut I have ever eaten, and all the Americans in the Philippines think it the finest nut grown. When the nuts are roasted, if you touch a lighted match to one it will burn like a lamp, it is so rich in oil. I think you will have to have them planted in Florida, southern Louisiana, or Mississippi, where the climate is warm and damp, as that is the kind of climate we have in the southern part of Luzon, and our rains are very frequent and abundant. The ground should be well drained. The trees are male and female, and it will take five or six years for them to bear nuts." (*Moir.*)

See Nos. 21860 and 23536 for previous introductions.

28811. Psidium guajava L. **Guava.**

From Tlacotalpan, Vera Cruz, Mexico. Presented by Mr. Edward Everest. Received September 26, 1910. To be grown in connection with the guava-breeding work.

"An evergreen, arborescent shrub, 10 to 20 feet tall, indigenous to the tropical mainland of America whence it has been introduced to practically all parts of the Tropics. The fruit is round, oblong, or pyriform, the best forms attaining a weight of 8 to 10 ounces. The surface is smooth, yellowish, and the flesh, in which the numerous seeds are embedded, whitish, yellowish, or reddish and usually very aromatic. The quality and flavor vary exceedingly, certain types being flat and insipid, others very sweet, and still others more or less acid. The sweet and subacid sorts may be eaten

28811—Continued.

with cream as a dessert fruit, with sometimes sugar added. From the acid fruits a superior jelly is manufactured. By-products obtained in its manufacture are guava marmalade and guava cheese.

"The guava succeeds practically on all classes of land, even poorly drained land, if it is properly cared for and fertilized. Where the temperature during the winter frequently drops below 26° F., its cultivation ceases to be profitable.

"The seed should be sown thinly in flats and the young plants pricked off about 2 to 3 inches apart; keep dry to prevent damping off. When the plants are 6 inches tall they may be transplanted to the nursery, and they are ready for budding when the stems are hardly half an inch in diameter. If the operation is performed during the winter or spring the plants may readily be budded, using the method of shield budding. To obtain the best results, well-ripened budwood from the current year's growth should be used and the buds tied with grafting tape. With good care the plants are ready for planting in the field nine months after insertion of the bud. Twenty to twenty-five feet apart is a good distance at which to plant the guava." (*P. J. Wester.*)

Seeds.

28812. Furcraea sp.

From Nice, France. Presented by Dr. A. Robertson-Proschowsky. Received September 29, 1910.

Bulbils. For description see No. 29320.

28813 to 28815.

From the Gaucin district, Spain. Procured by Mr. R. L. Sprague, American consul, Gibraltar, Spain. Received September 29, 1910.

Seeds of the following:

28813 and 28814. Lathyrus sativus L.

28813. Large seeded. **28814.** Small seeded.

28815. Vicia ervilia (L.) Willd. **Bitter vetch.**

28816 to 28822. Mangifera indica L. **Mango.**

From Lal-Bagh, Bangalore, India. Procured from Mr. G. H. Krumbiegel, economic botanist with the Government of Mysore, Government Botanic Gardens. Received September 26, 1910.

Seeds of the following; notes by Mr. Krumbiegel:

28816. "*Amini.* Weight 12 to 15 ounces; size 7 by 3½ inches; color yellowish white with a light-red shade; shape long, with thin seed. Skin thin; pulp yellow and juicy; taste sweet."

28817. "*Badami.* Weight 10 to 12 ounces; size 4 by 3½ inches; skin greenish yellow with reddish-orange shoulder; pulp fine, dark-cream color, of the finest piquant and delicate flavor. The keeping qualities of this fruit are excellent, and it is generally admitted to be the best of the mangos."

28818. "*Mulgoa.* Weight 16 to 25 ounces; size 7 by 5 inches; color yellow and green; pulp pale yellow; fiberless; very sweet; thin stone and thick skin. One of the latest varieties. Keeps for a long time; a good variety for shipping; one of the best."

28819. "*Puttu.* Weight 12 to 18 ounces; size 5 by 4½ inches; color dark green; thick skin; orange-white pulp; stone very small as compared with the size; taste not very sweet; juicy and fiberless."

28816 to 28822—Continued.

28820. "*Raspuri.* Weight 12 to 15 ounces; size 6 by 4½ inches; color greenish yellow with dark spots and red shade; pulp yellow, fiberless; thin skin; taste good; flavor pleasant. Profusely fruiting. One of the earliest varieties."

28821. "*Romani.* Weight 10 to 14 ounces; size 4 by 3½ inches; skin very thin; pulp pale yellow; color varying from pale yellow with reddish spots to golden yellow; taste sweet; stone very small. Fruits on trees look like apples from a distance. A long-keeping variety, quite fit for long journeys."

28822. "*Sundersha.* Weight 15 to 20 ounces; size 8 by 4½ inches; color yellowish red; pulp white; stone thin and flat; skin thick; unripe ones are also sweet; shape long, with a pointed curve like that of a parrot's bill. A late variety."

28823 and 28824.

From Oregon. Presented by Mr. George R. Schoch, R. R. No. 1, Forest Grove, Oreg. Received August 26, 1910.

Seeds of the following:

28823. Lathyrus polyphyllus Nutt.

From northwestern Oregon, altitude 800 feet. Crop of 1910.

"A perennial species with violet-colored flowers, abundant in the open coniferous woods throughout western Washington and western Oregon. The plants appear in early spring and become fully mature and dry in July. Stock are not fond of the plant when green, but eat the hay readily." (*C. V. Piper.*)

28824. Vicia gigantea Hook. **Giant vetch.**

From northwestern Oregon, latitude 45° 32′, longitude 46° 8′, altitude 1,000 feet. Crop of 1910.

"A perennial vetch with ochroleucous flowers, growing along the Pacific coast from Sitka to middle California. It grows to a great size, the vines being often 8 to 10 feet long and producing a great abundance of plants and pods. The seeds, however, are ordinarily destroyed by insects. Stock ordinarily will not eat the plants while green and are not particularly fond of the hay. The entire plant turns black on drying." (*C. V. Piper.*)

28825. Catha edulis Forsk. **Khat.**

From Aden, Arabia. Procured by Mr. Charles K. Moser, American consul. Received August 24, 1910.

"Khat is the Arabic name for *Catha edulis*, a shrub grown commercially in only two localities in the world, the Yemen and near Harrar in Abyssinia. The word is said to be derived from another Arabic word, kût, meaning food or sustenance, and refers to the most salient property of the plant, that of sustaining one who eats of its leaves under the most extraordinary bodily labor. The Arabs say that life and hard work would be unendurable in their country without khat.

"The shrub is found only in certain localities in the mountains from 3,500 to 5,000 feet above sea level. It will not grow, even in highlands, near salt water, or in any soil containing sand. The height of a full-grown plant varies from 5 to 12 feet, apparently more according to the nature of the climate than to the quality of the soil, as has been demonstrated by the Arabs. It appears that its chief requirements for cultivation are a fair amount of water, a cool but not cold climate, and a soil composed largely of disintegrated stone, well manured with sheep and goat droppings. A peculiarity of the plant is that it will not thrive in soil manured with camel or cattle dung.

28825—Continued.

"In appearance khat is a dark-green shrub of thick foliage, its elliptical leaves varying greatly in size, color, and texture in individual plants. In general the mature leaves will average from $1\frac{1}{4}$ to $1\frac{5}{8}$ inches in length, and from three-eighths to five-eighths of an inch in width, according to the locality in which they are grown.

"Khat is grown altogether from cuttings. Cultivation of it is simple and original. The field is first flooded until the soil has absorbed all the water it can hold; care is taken that the water brings in no sand with it. It is then well mixed with sheep and goat manure and left to 'ripen' for a few days. When the ground is sufficiently dry and 'ripe' they set out the cuttings in shallow holes from 4 to 6 feet apart, with space enough between the rows for pickers to pass easily (usually $2\frac{1}{2}$ to 3 feet). The cuttings grow rapidly and spread widely. They are given shallow hoeing for the first year, by which time the shrub is about 2 feet high, with a spread of perhaps 18 inches. Soft earth is then piled up about the base to conserve all moisture, and the leaves become more numerous. Though it is customary to begin picking the leaves when the plant is a year old, this may not always occur. The Arab follows a different rule. When he sees the leaves being eaten by the birds, he knows they are ripe and of good flavor for the market.

"The khat caravans arrive daily at Aden about 11 a. m. The British Government provides rooms for the storage and sale of the shrub, which later is taxed according to weight. On every 25 pounds of the high-grade kinds the tax is $0.3244; on the low-grade product (which is used by the common people) the tax is $0.3244 for every 20 pounds. The only reason advanced for the higher tax being placed on the cheaper khat is that its use is more common and therefore the more to be discouraged.

"Khat is used universally throughout all Arabia. There is no coolie too poor to buy his daily portion of this plant. It is the great fact, next to their religion, in the everyday life of the people. The expense to the native is out of all intelligible proportion to his income, and can only be explained as the Arabs explain it, to wit: that without khat they would not consider life worth living, nor would they ever achieve the energy to do any sustained or arduous work.

"The Arab of Aden who earns 30 cents per day spends at least half of it for khat. In Hodeida the man earning the same wage will average 10 cents per day for the support of his family and expend the other 20 cents wholly on khat. Among the better class the proportion of expenditure is not so high, but it is at least 25 per cent of their incomes, and some of the wealthy will spend several dollars per day for their favorite passion. The fresh leaves and tender stems are always chewed, never brewed or made into any sort of beverage. Nothing is known in Arabia of the chemical constituents of khat." (*Moser.*)

See No. 24714 for previous introduction.

28826. PASSIFLORA EDULIS Sims. **Passion flower.**

From Melbourne, Australia. Presented by Mrs. Alexander Graham Bell, Washington, D. C. Received September 29, 1910.

"Passion fruit will grow in the States; it prefers a loose sandy-loam soil, but must be high enough up to be out of the reach of frosts, and near the sea for preference, within, say, 10 miles. It requires plenty of manure and should be grown on a wire trellis, that is, an ordinary fence with posts 15 feet apart. In place of having the wire as in the fence, nail a crosspiece about 18 inches long on the top of each post and run two wires along this crosspiece. Train the vine up by the main stem until the wires are reached, then run an arm out each side along the wires. The lateral growths will hang down like a curtain and the fruit bears on this lateral growth. Plant vines 15 feet apart, one between each two posts; train vines up a stick until they reach the wire. Rows to be 15 feet apart. The best manure for them is composed of 7 hundredweight

28826—Continued.

of bone dust, 5 hundredweight of superphosphate, and 3 hundredweight of potash, making 15 hundredweight to an acre. If the winter is fairly warm a winter crop can be grown by cutting off the lateral growth a foot below the wires in the late spring or early summer and then manuring, but if the winter is not mild I would simply go in for the natural summer crop—prune as above late in winter and manure early in spring. The vines are raised in seed boxes from the seed. Simply wash the pulp out of the fruit and dry the seed; plant out when about 6 inches high. Do not allow any lateral growth until the wires are reached. We plant in Australia about the end of September or the beginning of October. Shelter young plants until they get started. Some fruit will be obtained the first season and a full crop the second season. The vines are about done in four years. The passion flower does wonderfully well in the sandstone country around Sydney, yet it grows almost wild in the semitropical climate of the northern rivers of New South Wales." (*James Moody, Toomuc Valley Orchards, Melbourne, Australia.*)

See Nos. 1906 and 12899 for description.

28827 and 28828.

From Puerto de Orotava, Teneriffe, Canary Islands. Presented by Dr. George V. Perez. Received September 16, 1910.

Seeds of the following:

28827. CYTISUS PROLIFERUS L. **Tagasaste.**

Variety *palmensis.* "This is a splendid forage plant and very drought resisting. The failures with it are due to ignorance of farmers and to not cutting back the plant. Cattle and horses have to learn to eat it; they relish it ever after. In the island of Palma (Canary Islands), where it is native from time immemorial, it has been used with the greatest success possible. It is quite as nutritious as lucern and does not want irrigation. I know of nothing that will fatten cattle and horses so much. In Palma there are large districts planted with it where cattle and even pigs eat it at liberty. Chaffed and mixed with straw it is excellent. The seed must be scalded in boiling water before sowing." (*Perez.*)

28828. ECHIUM SIMPLEX DC.

"The so-called *Pride of Teneriffe*, a lovely, showy, native plant, remarkable for its single tall spike of white flowers reaching from 2 to 3 yards high. From what I have seen and observed I have come to the conclusion that besides being a very ornamental plant it could be turned into a most valuable fodder, beating the prickly comfrey, over which it has the advantage, like all plants of the Canary flora, of being drought resistant. The idea is entirely my own after watching in one of my properties how greedily my cows eat it." (*Perez.*)

28829 to 28832.

From Togo, Africa. Presented by Mr. G. H. Pape, through Mr. A. B. Conner, scientific assistant, Chillicothe, Tex. Received September 29, 1910.

Seeds of the following:

28829. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

Tan.

28830 to 28832. VOANDZEIA SUBTERRANEA (L.) Thouars. **Woandsu.**

28833 to 28874.

From Ventimiglia, Italy. Presented by Mr. Alwin Berger, La Mortola. Received September 6, 1910.

Seeds of the following:

28833. Acer oblongum Wall. **Maple.**

"Tree up to 50 feet in height, with glabrous, entire ovate-lanceolate leaves, coriaceous and glaucous beneath." (*Bailey.*)

See No. 8659 for previous introduction.

Distribution.—Slopes of the temperate Himalayas at an altitude of 2,000 to 5,000 feet, extending from Kashmir to Sikkim in India, and in the vicinity of Hongkong, China, and in the Nansei Islands.

28834. Althaea sulphurea Boiss. and Hohen.

Distribution.—Lower slopes of the mountains in northern Persia, Afghanistan, and Sungaria.

28835. Asparagus acutifolius L.

See No. 17981 for description.

Distribution.—The countries bordering on the Mediterranean Sea from Portugal and Spain through Italy and Greece to Syria, and in northern Africa.

28836. Ballota pseudodictamnus (L.) Benth.

"A white-woolly, herbaceous plant, wool densely floccose, leaves orbiculate, entire or obscurely crenate, base broadly cordate, petiole short, corolla white spotted with red, upper lip cut at the apex, bearded within." (*Willkomm and Lange, Prodromus Florae Hispanicae.*)

Distribution.—In waste places and dry fields in Greece and the island of Crete.

28837. Ballota hispanica (L.) Benth.

"An herbaceous plant, stem white woolly, leaves broadly ovate, obtuse, velvety above, floccosely woolly below, corolla whitish." (*Willkomm and Lange, Prodromus Florae Hispanicae.*)

Distribution.—Dry and stony places in Spain, Italy, Sicily, and Dalmatia.

28838. Benincasa cerifera Sav.(?)

28839. Berberis napaulensis (DC.) Spreng. **Barberry.**

"The fruit of this evergreen species is edible. The plant is hardy to latitude 59° 55′ in Norway (Schuebeler)." (*Von Mueller.*)

See No. 8853 for previous introduction.

Distribution.—On the lower slopes of the Himalayas at an elevation of 4,000 to 8,000 feet from Gurhwal to Bhutan in northern India, and on the Khasi Hills in southern India.

28840. Buddleia brasiliensis Jacq.

"An evergreen tender shrub with orange flowers." (*Johnson's Gardeners' Dictionary.*)

A shrub with ovate leaves united around the square stem, native of Brazil.

28841. Buddleia globosa Hope.

See No. 1576 for description.

28833 to 28874—Continued.

28842. Celtis occidentalis L. **Hackberry tree.**

"Height reaching to 80 feet. Will grow tolerably well even on the poorest soil. (*B. E. Fernow.*) Hardy as far north as Christiania. Wood rather soft, difficult to split." (*Von Mueller.*)

28843. Cistus albidus × crispus.

28844. Clematis integrifolia L.

"Herbaceous, erect, becoming 2 feet high; leaves rather broad; flowers solitary, blue. Blooms from June to August." (*Bailey.*)

Distribution.—Central Europe and Asia, extending from Austria and Hungary eastward through central Russia and Siberia.

28845. Crataegus crenulata Roxb.

"Shrub with branchlets and petioles rusty pubescent, at length glabrous; leaves oblong to oblanceolate, leathery, bright green and glossy above; corymbs glabrous; fruit globose, bright orange-red; blooms in May and June." (*Bailey.*)

Distribution.—Dry places on the slopes of the Himalayas at an altitude of 2,500 to 8,000 feet, between Sirmur and Bhutan, northern India.

28846. Crataegus sp.

28847. Crotalaria capensis Jacq.

"Stout, much-branched shrub, 4 to 5 feet high. Cultivated in Florida." (*Bailey.*)

Distribution.—Common in the eastern districts of Cape Colony, extending northward to Durban.

28848. Eucalyptus crebra Muell. **Narrow-leaved ironbark.**

"A tall tree. Bark persistent throughout, dark, almost blackish, ridged, and deeply furrowed, solid; timber heavy, hard, elastic, and durable; used for railroad ties, piles, fence posts, and in the construction of bridges and wagons; also suitable for splitting into palings." (*Bailey.*)

See No. 769 and 1622 for previous introductions.

Distribution.—Between the Flinders and Lynd Rivers in North Australia, in the vicinity of Moreton Bay in Queensland, and along the Hastings River in New South Wales.

28849. Eucalyptus lehmanni (Schauer) Preiss. **Lehmann's gum.**

"A tall shrub or small tree; bark coming off in irregular sheets, roughish and reddish; flowers greenish yellow. A valuable ornamental tree. Blooms July to September.

Distribution.—West Australia, extending along the southern coast east to King George Sound, and on stony hills from Bald Island and Stirling Mountains eastward to Cape Arid.

28850. Podachaenium eminens (Lag.) Baill.

"A tall shrub; on account of the grandeur of its foliage in requisition for scenic effects." (*Von Mueller.*)

Distribution.—Southern Mexico and Central America, extending from Orizaba southeastward through Guatemala to Costa Rica.

28851. Iris albopurpurea Baker (?)

Received in a shipment from Japan without any information as to the locality from which it came.

28833 to 28874—Continued.

28852. Iris attica Boiss. and Heldr.

"Stem short or almost none; leaves wide, falcate, equaling or longer than the spathe; limb violet or yellow, external segments slightly shorter, reflexed, bearded within." (*Bailey.*)

Distribution.—In stony places on the lower slopes of Mount Parnassus and in the province of Attica in Greece.

28853. Iris cengialti Ambrosi.

"Resembles *Iris pallida*, of which it is probably merely a dwarf variety; leaves 6 inches long, stem about as long as leaves, flowers bright lilac, outer segments with a white beard. Blooms May and June." (*Bailey.*)

Distribution.—Slopes of the Tyrolese Alps in southern Austria and northern Italy.

28854. Iris spuria daenensis Kotschy.

Distribution.—This subspecies comes from the southern part of Persia.

28855. Iris foetidissima L.

"This plant is very distinct and is easily recognized by the odor of the broken leaves. The capsules remain on the plant in the winter, bursting open and displaying rows of orange-red berries. The flowers are rather inconspicuous." (*Bailey.*)

Distribution.—Central and southern Europe and eastward to Afghanistan and in Algeria.

28856. Iris germanica L.

"Leaves 1 to 1½ feet long; stem 2 to 3 feet high; spathe valves tinged with purple; outer segments obovate-cuneate, 2 to 3 inches long; beard yellow; inner segments as large, obovate, connivent. Blooms in early May and June." (*Bailey.*)

See No. 9103 for previous introduction.

Distribution.—Throughout central and southern Europe.

28857. Iris halophila Pallas.

"Leaves pale green, 1 to 1½ feet long; stem stout, terete, 1½ to 2 feet long, often bearing one to two spicate clusters below the end one; limb pale yellow; outer segments with an orbicular blade one-half to three-fourths of an inch broad, shorter than the claw, which has a bright-yellow keel and faint lilac veins; inner segments shorter, erect." (*Bailey.*)

Distribution.—Eastern Europe and southern Asia, extending from Austria eastward through Turkey, Asia Minor, and the Caucasus region to Mongolia and Kashmir.

28858. Iris chamaeiris italica (Parl.) Baker.

"Leaves 3 to 4 inches long, one-half inch broad; stem very short, flowers dark violet; outer segments obovate-cuneate, tinged and veined with brown; inner segments oblong. Blooms in May." (*Bailey.*)

Distribution.—Southern Europe, extending from southern France and northern Italy through Dalmatia.

28859. Iris lutescens Lam.

"Leaves 6 to 9 inches long; stem equaling the leaves; flowers pale yellow; outer segments obovate-cuneate, 2 to 2½ inches long, pale yellow, streaked with pale brown, undulate; inner segments broader, suddenly narrowed to a claw which is streaked with purple, crenulate." (*Bailey.*)

Distribution.—Stony mountainous slopes in the southern part of France.

28833 to 28874—Continued.

28860. Iris sibirica L.

"Compact, tufted; leaves green, not rigid, 1 to 2 feet long; stem slender, terete, fistulous, much overtopping the leaves, simple or forked, bearing several clusters of flowers; limb bright lilac blue; outer segments $1\frac{1}{2}$ to 2 inches long, with orbicular blade gradually narrowed to a slender claw, veined with bright violet, whitish toward the claw; inner segments shorter, erect. The plants form large compact clumps producing many long flowering stems from the center." (*Bailey.*)

See Nos. 9104 and 13232 for previous introductions.

Distribution.—Throughout central and southern Europe and eastward to eastern Siberia.

28861. Iris missouriensis Nutt. (?)

28862. Iris chamaeiris olbiensis (Henon) Baker.

Same as No. 28858 except "flowers are bright yellow." (*Bailey.*)

Distribution.—Northern Italy and southern France and eastward through Dalmatia.

28863. Iris orientalis Miller.

Variety *gigantea.*

Distribution.—Asia Minor and Syria, and the island of Samoa.

28864. Iris paradoxa Stev.

"Plants dwarf; leaves linear; flowers large, outer segments reduced to a mere claw, dark, covered with pile; inner segments 2 inches long, orbicular, lilac to white. A flower with singular combinations of color. Grows in dry situations, but requires shelter in winter." (*Bailey.*)

Distribution.—Dry sandy places in the Transcaucasian region of southern Russia and in northern Persia.

28865. Iris prismatica Pursh (?).

28866. Iris ruthenica Dryand.

"Leaves 5 to 12 inches long, in crowded tufts; stem slender, 3 to 6 inches long, but often obsolete; tube twice as long as the ovary; outer segments with an oblong blade rather shorter than the claw, lilac, violet scented. Blooms in April and May." (*Bailey.*)

Distribution.—Eastern Europe and central Asia, extending from Austria eastward through Russia and Siberia to eastern China and Mongolia.

28867. Iris setosa Pall. (?)

Distribution.—Eastern Siberia, Japan, and in northwestern North America.

28868. Iris halophila sogdiana (Bunge) Skeels.

(*Iris sogdiana* Bunge, Academie de St. Petersbourg, Memoires des Savants Etrangers, vol. 7, p. 507, 1850–54.)

(*Iris gueldenstaedtiana sogdiana* Baker, Irideae, p. 14, 1892.)

The name *Iris gueldenstaedtiana* was published by Lepechin (Acta Academiae Petropolitaniae for 1781, pt. 1, p. 292, pl. 8) in 1784. But Pallas in 1773 (Reise durch Verschiedene Provinzen des Russischen Reichs, vol. 2, p. 733) had published the name *Iris halophila* for the same species. The earlier name should be used for the species, which necessitates transferring the subspecies published by Baker to *I. halophila.*

Same as No. 28857 but "with gray-lilac flowers (Bailey)."

Distribution.—Throughout Asia, from Asia Minor and the Caucasus region eastward to Kashmir and Mongolia.

28833 to 28874—Continued.

28869. Iris unguicularis Poir.

"Leaves about six in a tuft, finally 1½ to 2 feet long, bright green; tube 5 to 6 inches long, filiform, exserted from the spathe; limb bright lilac, rarely white; outer segments 2½ to 3 inches long, 1 inch broad, with a yellow keel, streaked with lilac on a white ground at the throat; inner segments oblong. Blooms in January and February. Not hardy." (*Bailey.*)

Distribution.—A fragrant-flowered species coming from Algeria.

28870. Iris xiphium L. **Spanish iris.**

"Leaves about 1 foot long, stem 1 to 2 feet high; pedicel long; tube obsolete; outer segments 2 to 2½ inches long; violet-purple, yellow in the center; inner segments as long, but narrower. Blooms in late June." (*Bailey.*)

Distribution.—Spain and southern France, ascending to an elevation of 6,000 feet, and in northern Africa.

28871. Moraea sp.

Note.—This was received as *Moraea aurantiaca* Eckl., which seems never to have been described.

28872. Pistacia lentiscus L.

See No. 3011 for description.

Distribution.—The countries bordering on the Mediterranean from Spain through Italy, Greece, and Asia Minor to Syria, and in northern Africa.

28873. Salvia sclarea L.

"A plant of exceptional interest. Cultivated for its culinary and medicinal value and also for ornament, but its ornamental value lies not in the flowers, which are pale purple or bluish, but in the colored bracts or floral leaves at the tops of the branches." (*Bailey.*)

Distribution.—Southern Europe and western Asia, extending from Germany eastward through Austria, Italy, Turkey, and southern Russia to Persia, and in northern Africa.

28874. Viburnum tinus L.

See No. 2192 for description.

Distribution.—Southern Europe, extending from Portugal and Spain through southern France and Italy to Dalmatia, and in northern Africa.

28875. Belou marmelos (L.) W. F. Wight. **Bael.**

From Pusa, Bengal, India. Presented by Dr. A. Howard, of the Agricultural Research Institute, through Maj. A. T. Gage, Royal Botanic Gardens, Sibpur, Calcutta, India. Received September 28, 1910.

Dalsing Serai.

See No. 24450 for description of this species.

28876. Vitis sp. (?)

From Hollywood, Cal. Presented by Mr. E. D. Sturtevant. Received September 29, 1910.

"Native of the southern part of the state of Vera Cruz, Mexico. Said to bear beautiful scarlet flowers. It is hardy here, but does not bloom. It might do so in south Florida." (*Sturtevant.*)

28877. Cynara scolymus L. **Artichoke.**

From Maison Carree, Algeria. Presented by Dr. L. Trabut, Mustapha-Alger, North Africa. Received September 29, 1910.

Violet Provence.

28878. Passiflora edulis Sims. **Passion flower.**

From Patras, Greece. Grown by Mrs. Crowe. Presented by Dr. A. Donaldson Smith, American consul, Aguascalientes, Mexico. Received September 29, 1910.

"I have tasted the passion fruit in many places, but the fruit from which these seeds were taken was the best." (*Smith.*)

See No. 25874 for distribution of this species.

28879 and 28880. Gossypium sp. **Wild cotton.**

From Mauritius. Presented by Mr. G. Regnard, Port Louis, Mauritius. Received September 26, 1910.

Seeds of the following:

28879. From Yemen, Black River. **28880.** From Carcenas, Black River.

"These cottons (see also No. 28798) grow particularly at the NNE. and NW. of the island at different altitudes and under different soil and climatic conditions without varying in growth and shape." (*Regnard.*)

PUBLICATION OF NEW NAMES.

28525. Tritoma northiae (Baker) Skeels.
28526. Tritoma tuckii (Baker) Skeels.
28526 (in note). Tritoma sarmentosa (Andr.) Skeels.
28663. Lebeckia cuspidosa (Burch.) Skeels.
28673. Echeveria hoveyi Rose n. sp.
28729. Ophiobostryx volubilis (Harvey) Skeels.
28730. Mondia whiteii (Hook. f.) Skeels.
28740. Pectinea pauciflora (Thouars) Skeels.
28766. Helygia paddisoni (Baker) Skeels.
28781. Melocanna baccifera (Roxb.) Skeels.
28783. Argania spinosa (L.) Skeels.
28868. Iris halophila sogdiana (Bunge) Skeels.
19897. × Assonia cayeuxii (Andre) Skeels.

(*Dombeya cayeuxii* Andre, Revue Horticole, vol. 69, p. 545, 1897.)

The name Dombeya (Cavanilles, 1787) seems to have been quite generally used to designate a genus of sterculiaceous shrubs or small trees, but as the same name was originally used (L'Heritier, 1784) for a genus belonging to the family Bignoniaceæ, for which the name Tourretia (Fougeroux, 1787) was later proposed, it should not be applied to the genus established by Cavanilles. In fact, the latter author on a previous page of the same work in which he published Dombeya established the genus Assonia with the single species *A. populnea* (Tertia Dissertatio Botanica, p. 120, pl. 42, fig. 1, 1787). This species is now recognized as congeneric with the various species referred to Cavanilles's Dombeya, and Assonia should therefore be considered the valid name for the genus in question. It should be noted that both the names Assonia and Dombeya were proposed by Cavanilles in 1786 (Secunda Dissertatio Botanica, app.), but without mention of species.

Cuttings of the species listed were received in 1907 as "*Dombeya spectabilis*(?)" and were later distributed. Dr. Franceschi of the Montarioso Nursery, Santa Barbara, Cal., who received some of the cuttings, called attention to the identity of the plant with *Dombeya cayeuxii* Andre.

INDEX OF COMMON AND SCIENTIFIC NAMES, ETC.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 224.

B. T. GALLOWAY, *Chief of Bureau.*

TIMOTHY RUST IN THE UNITED STATES.

BY

EDWARD C. JOHNSON,

Pathologist in Charge of Cereal Disease Work,
Office of Grain Investigations.

ISSUED AUGUST 4, 1911.

WASHINGTON:
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LETTER OF TRANSMITTAL

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of Chief of Bureau,
Washington, D. C., May 26, 1911.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 224 of the series of this Bureau the accompanying manuscript, entitled "Timothy Rust in the United States," by Mr. Edward C. Johnson, of the Office of Grain Investigations of this Bureau.

Timothy rust, first reported in the United States in 1882, has become an important problem in recent years. In 1906 it was abundant in the timothy-breeding plats at the Arlington Experimental Farm, near Washington, D. C. Since then it has become widespread, causing considerable damage in many localities, and its ultimate distribution over all timothy-growing regions where conditions are favorable to rust development is to be expected. This paper discusses the present known distribution and relationships of the rust of timothy and summarizes previous investigations of this disease in Europe and America. New information on its physiological specialization and methods of winter survival and on the resistance of timothy strains and varieties to rust is also presented.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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TIMOTHY RUST IN THE UNITED STATES.

DISTRIBUTION OF THE RUST OF TIMOTHY.

Rust of timothy was reported in this country by Trelease as early as 1882.[1] Farlow and Seymour, on the basis of this report, mentioned *Puccinia graminis* on *Phleum pratense* L. from the United States in their "Host Index of the Fungi of the United States" (1888). Rust of timothy was reported as causing considerable damage in the experimental plats at the Iowa experiment station in 1891.[2] From 1891 to 1906 the parasite seems to have been little in evidence throughout the country, and the writer has been unable to find any mention of it during those years.

In 1906 the rust became epidemic in the experimental plats at the Arlington Experimental Farm. In 1907 it was epidemic at points in New York and Virginia; it was also reported from Delaware, West Virginia, and Ontario, Canada. In 1908 this rust was widespread and caused much damage in New York, Pennsylvania, Delaware, Maryland, and Virginia; it was also reported from West Virginia, Ohio, Michigan, Wisconsin, and Minnesota. In 1909 the rust was common in many of the States mentioned and in addition was reported from Indiana, Kentucky, Iowa, and Maine. In 1910 it was observed in many States from which it had been previously reported, and in considerable quantity in Virginia, New York, Michigan, and Minnesota. In the last State it was collected at both New Richland and Owatonna, and in August was exceedingly abundant in timothy pastures around Crookston. Thus, from being only locally observed in 1906, this rust was widespread in 1909 and 1910, having been reported from Maine to Ontario and northern Minnesota, and south to Iowa, Kentucky, and Virginia.[3]

[1] Trelease, William. Parasitic Fungi of Wisconsin. Transactions of the Wisconsin Academy of Sciences, 1882, p. 131. A specimen collected in Wisconsin was kindly sent to us for examination by Dr. Trelease from the Missouri Botanical Gardens. It was rather unsatisfactory, as it consisted of only one rusted leaf, and thus may have been inaccurately determined, leaving some doubt as to the authenticity of this early report.

[2] Wilson, J., Curtis, C. F., and Kent, D. A. Time of Sowing Grass Seed. Bulletin 15, Iowa Agricultural Experiment Station, 1891, pp. 285–286.

[3] The writer is indebted to botanists and plant pathologists at the various agricultural experiment stations and to J. J. Davis, M. W. Evans, E. M. Freeman, R. A. Harper, Frank D. Kern, W. J. Morse, C. V. Piper, H. N. Vinall, H. J. Webber, and others who have answered letters of inquiry in regard to the rust on timothy or have given information as to its prevalence in various localities.

DESCRIPTION OF TIMOTHY RUST.

The timothy rust is very similar in general appearance and morphological characteristics to *Puccinia graminis* Pers. on wheat. It attacks both leaf and stem, forming long, yellowish-brown uredo pustules and dark-brown to black teleuto pustules, which rupture the epidermis. At times it also attacks the head, often preventing the formation of seed. The uredospores are most prevalent, while the teleutospores are less abundant.

The uredospores are 18 to 27 μ in length and 15 to 19 μ in width; the teleutospores, 38 to 52 μ in length and 14 to 16 μ in width. This is the same range as that of the corresponding spores of *Puccinia graminis* Pers. on wheat, but the variation is not quite as great as in the wheat rust. The teleutospores are constricted in the middle and have a much thickened, round or pointed apex and pedicels of medium length, and closely resemble those of the typical *Puccinia graminis* Pers.

RELATIONSHIP AND PHYSIOLOGICAL SPECIALIZATION OF TIMOTHY RUST.

In 1908 and 1909 inoculation experiments on various grasses were undertaken at Washington, D. C., to determine the relationship of the rust of timothy to rusts of other hosts in this country and to ascertain whether or not it is the same form as that which occurs in Europe. Collections were made at the Arlington Experimental Farm, and fresh material in the uredo stage was kept growing in the greenhouses at Washington, D. C. All inoculations were made on young, fresh leaves of the host plants growing in pots. The plants were kept moist for 48 hours after inoculation by placing the pots in moist chambers consisting of large bell jars placed in pans containing sand and a little water. In this way a thin film of water soon condensed on the leaves and remained as long as the plants were covered. This gave ideal conditions for spore germination and for infection. The results of these inoculations are reported in Table I.

TABLE I.—*Results of experiments in inoculating various grasses with uredospores of rust.*

Serial No.	Date of inoculation.	Source of inoculating material.	Varieties of plants inoculated.	Number of leaves inoculated.	Number of successful infections during incubation period of 17 to 21 days.
1	Jan. 25, 1908	Phleum pratense	Triticum vulgare	10	0
2	Feb. 3, 1908	Triticum vulgare	Phleum pratense	25	0
3	Jan. 25, 1908	Phleum pratense	Hordeum vulgare	10	0
4	do	do	Avena sativa	10	6
5	Feb. 18, 1908	do	do	20	11
6	Feb. 3, 1908	Avena sativa	Phleum pratense	23	0
7	do	Phleum pratense	do	25	19
8	Jan. 25, 1908	do	Secale cereale	5	1
9	Feb. 18, 1908	do	do	36	7
10	Feb. 7, 1908	do	Festuca elatior	24	6
11	Feb. 4, 1909	do	do	42	0
12	Feb. 20, 1908	do	Dactylis glomerata	22	6
13	Jan. 23, 1909	do	do	25	1
14	Feb. 4, 1909	do	do	16	6
15	Feb. 13, 1909	do	do	59	9
16	Feb. 20, 1908	do	Arrhenatherum elatius	18	0
17	Jan. 27, 1909	do	do	18	6
18	Feb. 4, 1909	do	do	3	2
19	do	do	Poa compressa	18	6
20	Feb. 8, 1909	do	do	29	7
21	do	do	Poa pratensis	33	0
22	Feb. 7, 1908	do	Elymus virginicus	60	0
23	Jan. 27, 1909	do	do	33	0
24	Feb. 4, 1909	do	do	10	0
25	Jan. 23, 1909	do	Elymus canadensis	25	0
26	Feb. 8, 1909	do	do	9	0
27	Mar. 7, 1908	do	Elymus robustus	16	0
28	Feb. 20, 1908	do	Agropyron occidentale	14	0
29	do	do	Hordeum jubatum	24	0
30	Mar. 7, 1908	do	Phalaris arundinacea	17	0
31	do	do	Holeus lanatus	28	0
32	Feb. 4, 1909	do	Hystrix hystrix	44	0
33	Feb. 8, 1909	do	Agrostis alba	31	0
34	Feb. 13, 1909	do	do	11	0
35	Jan. 23, 1909	do	Bromus unioloides	40	0
36	Jan. 27, 1909	do	do	7	0

The rust rather easily transferred to *Avena sativa* (17 out of 30 inoculations), *Secale cereale* (8 out of 41 inoculations), *Festuca elatior*[1] (6 out of 66 inoculations), *Dactylis glomerata* (22 out of 122 inoculations), *Arrhenatherum elatius* (8 out of 47 inoculations), and *Poa compressa* (13 out of 47 inoculations). Inoculations on other grasses produced no infection. Similar results were obtained by Eriksson[2] in inoculation experiments with this rust on *Avena sativa*, *Secale cereale*, and *Festuca elatior*.[1] No inoculations on *Dactylis glomerata*, *Arrhenatherum elatius*, or *Poa compressa* are cited in his report. Direct inoculation on *Triticum vulgare* and *Hordeum vulgare* gave negative results in 10 trials each, thus corresponding to the negative results in numerous similar trials of Eriksson.[2] From these

[1] The tall meadow fescue was used in our work. It is probable that the same variety was used by Eriksson, as this is the common form known by that name in Sweden.

[2] Eriksson, Jakob. Ist der Timotheengrasrost eine selbständige Rostart oder nicht? Öfversigt af Kongliga Svenska Vetenskaps-Akademiens Förhandlingar, no. 5, 1902, pp. 193–196.

experiments it may be concluded that the rust in the United States and the rust in Europe are identical, and the statement by Eriksson [1] that it is not a well-fixed species is substantiated. Although timothy rust can easily be transferred to *Avena sativa*, Eriksson [1] and Carleton [2] have shown that the uredo of *Puccinia graminis avenae* Erikss. and Henn. can not be made to grow on timothy. This rust, however, can easily be transferred to *Dactylis glomerata* and *Arrhenatherum elatius*.[2] Timothy rust also transfers to these hosts (Table I). These rusts, therefore, although not identical, have many characteristics in common, which indicates that there probably is a very close relationship between the two.

A small number of experiments to test whether or not the timothy rust can be transferred by means of bridging hosts to various cereals which are not successfully infected directly from timothy were tried and it was found that by using *Avena sativa* as a bridging host the rust easily transferred to *Hordeum vulgare* (4 times in 10 trials); by using *Festuca elatior* it transferred to *Hordeum vulgare* (twice in 10 trials) and to *Triticum vulgare* (once in 10 trials); and by using *Dactylis glomerata* it transferred to *Triticum vulgare* (once in 5 trials). By the use of the bridging hosts the rust undoubtedly could be made to transfer to many grasses on which it will not grow when coming directly from timothy, but on which it might continue to grow after such a transfer. That this to some extent takes place in nature is very probable, and these trials, together with recent experiments of a similar nature on the rusts of grains,[3] throw much light on the possible origin of many of the so-called "physiological species" of rust.

ÆCIDIAL STAGE AND NOMENCLATURE OF TIMOTHY RUST.

The æcidial stage of the rust is not definitely known. Eriksson and Henning [4] noticed that the timothy in the neighborhood of barberries was not affected, while other grasses in the same locality were rusted. In two trials in 1891 they were unable to secure infection on timothy with æcidiospores from *Berberis vulgaris*. In 1892–3 æcidia on *Berberis vulgaris* were obtained by them after inoculation with teleutospores of timothy rust once in nine trials, and that in only one place of inoculation against 92 places inoculated with negative results. This one positive result may have been due to accidental infection from some other source, as two leaves on the same bush

[1] Loc. cit.

[2] Carleton, Mark Alfred. Cereal Rusts of the United States. Bulletin 16, Division of Vegetable Physiology and Pathology, U. S. Dept. of Agriculture, 1899, pp. 61–62.

[3] Freeman, E. M., and Johnson, Edward C. The Rusts of Grain in the United States. Bulletin 216, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1911, p. 16.

[4] Eriksson, Jakob, and Henning, Ernst. Die Haupt-Resultate einer neuen Untersuchung über die Getreideroste. Zeitschrift für Pflanzenkrankheiten, vol. 4, 1894, p. 140.

which had not been artificially inoculated also produced æcidia.[1] In 1895 Eriksson again made inoculation experiments on the barberry with the teleutospores of this rust, but in 25 inoculations none was successful.[2] In this country Kern[3] in 1908 observed eight unsuccessful inoculations on the barberry.

From their results Eriksson and Henning concluded that timothy rust does not form its æcidial stage on the barberry, while Kern[3] says that "The one positive result mentioned ought, it seems, [to] be accorded more weight than all the negative ones together, and proves that it [timothy rust] does, even if with difficulty, form its æcial stage upon the barberry." Eriksson and Henning regard the rust as a distinct species and name it *Puccinia phlei-pratensis*, while Kern considers it "a race of *Puccinia poculiformis* (*graminis*) or a so-called physiological species." Evans accepts the name *Puccinia phlei-pratensis*,[4] and in a discussion of the development of the uredo mycelia of the cereal rusts shows that there are differences in the details of infection of this rust and *Uredo graminis*, which, although slight, are well marked. In a later paper Kern[5] states that he is still of the opinion that this rust is not entitled to specific rank and would include it under "*Puccinia poculiformis* (Jacq.) Wettst.," i. e., *Puccinia graminis* Pers. He modifies his previous statement as to its being a physiological species and thinks it might better be considered a variety or subspecies, "since it does, as previously pointed out, possess some slight morphological differences from the typical form, particularly in the smaller æcial cups and the more delicate uredinial mycelium."

From the physiological specialization of this rust, as shown in experiments above reported; from its distinctive method of infection from the uredospore, as described by Evans; from the difficulty with which it produces its æcidium on barberries, as shown by Eriksson and Henning; and from the delicacy of the mycelium of the uredo stage as compared with the typical *graminis* form, as cited by Kern, it is evident that the rust of timothy has many distinctive characteristics, and, even if not well fixed, is highly specialized. Whether or not it should be regarded as a distinct species is, perhaps, debatable.

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[1] Eriksson, Jakob, and Henning, Ernst. Die Getreideroste, 1894, p. 137.

[2] Eriksson, Jakob. Ist der Timotheengrasrost eine selbständige Rostart oder nicht? Öfversigt af Kongliga Svenska Vetenskaps-Akademiens Förhandlingar, no. 5, 1902, p. 191.

[3] Kern, F. D. The Rust of Timothy. Torreya, vol. 9, January, 1909, p. 4.

[4] Evans, I. B. Pole. The Cereal Rusts. The Development of Their Uredo Mycelia. Annals of Botany, vol. 21, no. 84, 1907, pp. 446–448. "The substomatal vesicle is a very definitely shaped body closely resembling that of *Uredo graminis*, but narrower * * *. It differs from *Uredo graminis* chiefly in the fact that the end from which the hypha springs does not cling to the head of the guard cell."

[5] Kern, F. D. Further Notes on Timothy Rust. Proceedings of Indiana Academy of Science, 1909, pp. 417–418.

Some method of differentiating this rust in literature from the common *graminis* forms is necessary, however, and unless further experiments should show that it can produce its æcidium on the barberry, and until such experiments have been performed, the writer favors the use of the specific name *Puccinia phlei-pratensis* Erikss. and Henn.

WINTER SURVIVAL OF TIMOTHY RUST.

In 1908 an effort was made to determine how the rust survives the winter at the Arlington Experimental Farm. Timothy plants were removed from the field on January 19 and March 12 and were immediately potted and placed in a greenhouse at Washington, D. C., where they could be carefully watched and any further development of rust noted. Table II shows the results of these experiments.

TABLE II.—*Results of experiments on the winter survival of the rust of timothy.*

Serial No.	Placed in greenhouse.	Observations.					
		Date.	Result.	Date.	Result.	Date.	Result.
	1908.	1908.		1908.		1908.	
1	Jan. 20	Jan. 22	Four unopened pustules near tip of one leaf, several flecks in center.	Jan. 28	Pustules near tip not open, three fresh open pustules at center where flecks occurred.	Feb. 3	End of leaf dried, numerous fresh pustules over remainder of leaf.
2	...do....	...do....	No rust pustules, no flecks.	...do....	No rust...........	...do....	No rust.
3	...do....	...do....	Seven unopened pustules on upper side of one leaf, several on lower.	...do....	Several fresh open pustules on both sides of leaf, several new pustules.	...do....	Leaf covered with vigorous pustules.
4	...do....	...do....	Six pustules near tip on upper side of one leaf, six on lower.	...do....	Six pustules on upper side of leaf, six on lower near tip, vigorous; three fresh pustules on upper side; three on lower near center, two of them open.	...do....	New pustules still forming, old ones vigorously producing spores.
5	...do....	...do....	One pustule on middle of upper side of one leaf, leaf partly dried.	...do....	Leaf drying.......	...do....	Leaf almost dead, no new pustules.
6	Mar. 13	Mar. 13	Several pustules at base of one leaf.	Mar. 19	No further development of rust.	Mar. 25	No further development of rust.
7	...do....	...do....	Unopened pustules at base of one leaf, other leaves flecked.	...do....	Three fresh pustules on leaf; more than 2 per cent of the spores from these pustules germinated in water.	...do....	Three fresh pustules on leaf, and several fresh pustules on leaves which were flecked.
8	...do....	...do....	Unopened pustules on many leaves.	...do....	Two open pustules on one leaf.	...do....	Fresh open pustules on many leaves.
9	...do....	...do....	One pustule on each side of one leaf near tip.	...do....	No further development of rust.	...do....	No further development of rust.
10	...do....	...do....	Leaves with several unopened pustules.	...do....	.....do............	...do....	Do.

It is seen that some of the plants brought in on January 19 and March 12, notably Nos. 1, 3, 4, 7, and 8, continued to produce uredospores. At Arlington, in 1908, fresh rust pustules on new growth of timothy were common after March 15. Undoubtedly the old rust mycelium living in the plants had produced these pustules. Spores collected on January 20 and March 13, 1908, were found to be viable.

Similar conditions undoubtedly prevail in other localities of the same latitude and similar climate where this rust is found. How the rust winters farther north has not been determined, but in the light of recent investigations [1] it is very probable that it lives through the winter in the uredo stage much farther north than the latitude cited. As shown by specimens sent to the Office of Grain Investigations, it seems that teleutospores of this rust are more abundant in northern latitudes than at the Arlington Experimental Farm, where they were very scarce in 1907 and 1908. At the latter place the parasite *Darluca filum* (Biv.) Cast. largely prevents the formation of the teleuto stage, as almost every pustule ready to produce teleutospores is attacked by this fungus and further development is prevented. However, as the æcidial stage, if present, is undoubtedly rare in this country, the teleuto stage is of doubtful importance in the wintering and dissemination of the rust.

METHODS OF DISTRIBUTION OF TIMOTHY RUST.

The rapid distribution of timothy rust in recent years is doubtless due to the dissemination of the uredospore by the usual agencies. Insects have been shown to be carriers of spores,[2] birds and other animals may carry them from place to place, they may be transferred from one region to another by man through the shipment of rusted timothy hay, etc., but most important is the agency of the wind. It has been shown probable [3] that the uredospores of rusts are distributed by the wind not only from field to field, but, rising into the upper air, are carried by currents for hundreds of miles. With a quantity of uredospores on hand in various localities early in the spring, their distribution thus becomes an easy matter and the general dissemination of rust over large areas is accounted for. Undoubtedly, in the course of a few years, the distribution of this rust is to be expected over all timothy-growing sections where conditions are favorable for its development.

With the ultimate dissemination of rust over the greater part of the timothy area a practical certainty, methods of preventing any

[1] Freeman and Johnson, loc. cit.

[2] Johnson, Edward C. Floret Sterility of Wheats in the Southwest. Phytopathology, vol. 1, 1911, p. 18.

[3] Freeman and Johnson, loc. cit.; and Klebahn, H., Die wirtswechselnden Rostpilze, 1904, pp. 68–72.

considerable damage to the timothy crop from this parasite become necessary. Only one method at present known can be employed against it with any promise of success, and that is the development of varieties of timothy resistant to rust. To this end work has been commenced.

RESISTANCE OF VARIETIES OF TIMOTHY TO RUST.

A fair opportunity was offered to study the resistance of varieties of timothy to rust and to make selections for rust resistance at the Arlington Experimental Farm during 1908 and 1909, as the disease was plentiful in those years. Mr. W. J. Morse, of the Office of Forage-Crop Investigations, who had charge of timothy-breeding work at that place, says in an unpublished report:

> By July 30 (1908) no timothies were found to be entirely free from rust. * * * The rust resistance varied greatly, ranging from zero to 98 per cent. In some instances a few small rust spots appeared on the culms and no rust on the leaves. Several selections made no growth at all, the rust appearing to stunt the growth. In other instances the plants made some growth, but the production of seed was prevented. In 1909 the rust attack at the Arlington Experimental Farm was even more severe than in 1908, although the rust did not appear to any extent until the middle of May. This severe attack brought to light the fact that many of the strains marked "resistant" in 1908 appeared to be much less resistant in 1909. It was noticeable, however, that the relative resistance of the different strains was very little different in 1909 from what it was in 1908.

In 1910 the rust attack on the same farm was not nearly so severe as in the two preceding years. Under such conditions the distinction between resistant and nonresistant strains is not nearly as well marked as when rusts are abundant. As a result many strains failed to retain in their resistance percentages the same relative position which they occupied in 1908 and 1909. This corroborates the experience of the writer that the value of rust-resistance figures obtained in years when the rust is not abundant or at places where the rust attacks are not severe is questionable and shows that the notes taken at such times and places may often be misleading. Dependable data can be secured only either in "rust years" or in places where vigorous rust attacks occur or are artificially produced every year.[1]

In order to determine whether or not the figures on rust resistance obtained in the field during seasons when rust is abundant are comparable to data secured where different strains are placed under identical conditions and subjected to artificial inoculation, experiments were undertaken in 1909 in the greenhouses at Washington, D. C. Seed of various strains of timothies from the 1908 selections at the Arlington Experimental Farm was planted in 4-inch pots.

[1] Freeman and Johnson, loc. cit.

When the timothy was about 2 inches high, it was thinned to 10 plants or less in a pot and the first leaf of each plant was inoculated by placing on it, by means of a flattened inoculating needle, a small quantity of fresh uredospores. The pots were placed in a moist chamber for 48 hours, as described on page 8 of this paper, and were then removed and allowed to stand for 17 to 21 days, when final notes were taken. The percentage of noninfection from uredospore inoculations of timothy selections and the rust-resistance percentages of these selections in the field during 1908 and 1909 are shown in Table III.

TABLE III.—*The percentage of noninfection from uredospore inoculations of timothy selections and the rust-resistance percentages of these selections in the field during 1908 and 1909.*

Serial No.	Date of inoculation.	Timothy selections.	Leaves inoculated.	Leaves pustuled.	Days of incubation.	Leaves not infected.	Resistance in field.	
							1908	1909
	1909.		*Number.*	*Number.*	*Number.*	*Per cent.*	*Per cent.*	*Per cent.*
1	Jan. 2	965-25	28	10	17	64	98	50
2	....do	965-15	18	4	17	77	80	30
3	....do	965-22	12	6	17	50	0	(1)
4	....do	952-'04	19	12	17	37	60	....
5	....do	952-'06	5	5	17	0	70	20
6	Jan. 9	965-18	11	6	18	46	60	....
7	....do	29-A	14	4	18	71	98	....
8	....do	45-B	14	9	18	36	90	30
9	....do	967-16	11	1	18	91	0	(1)
10	Jan. 15	52-B	16	13	18	19	0	....
11	....do	50-B	14	13	18	7	90	40
12	Jan. 20	965-'03	8	8	21	0	98	40
13	....do	967-16	8	6	21	25	0	(1)
14	....do	967-15	13	11	21	16	90	40
15	....do	16	8	6	21	25	70	....
16	....do	967-35	7	6	21	14	0	10
17	....do	49	18	15	21	17	98	40
18	....do	75-C	17	17	21	0	0	(1)
19	....do	43-A	19	15	21	21	60	10
20	....do	81	6	6	21	0	60	70
21	....do	45-A	11	9	21	18	90	40
22	....do	37-A	18	12	21	34	75	....
23	Jan. 23	49-A	14	7	18	50	60	20
24	....do	952-'06	8	3	18	63	70	20

1 Discarded.

The percentages of inoculated leaves which did not develop rust do not correspond with the rust-resistance figures obtained in the field. This is accounted for by the fact that even the most rust-resistant varieties of both grasses and cereals will develop rust to some extent when carefully inoculated in the greenhouse with the rust most common on the respective hosts. It is always noticeable, however, that although every inoculated leaf of a rust-resistant strain may be affected, the rust infection is much less severe on them than on susceptible varieties. Therefore in making observations on rust resistance not only the percentage of leaves developing rust pustules but also the severity of the infection must be considered. Although such observations are not noted in Table III it was found that, in so far as the vigor of the infection was concerned, the relative rust resistance of strains as obtained in the field was fairly well maintained in the greenhouse experiments and that the differences in resistant and susceptible strains were marked.

Having determined, then, that there are wide differences in timothy strains with regard to resistance and susceptibility to rust, the problem in timothy-rust prevention is one of breeding. This may not be as difficult as it appears at first, since up to the present time timothies have not been highly bred and there are not only great differences between varieties but apparently unusual variations within a variety. Response to selection, therefore, may be both rapid and well marked. Such breeding, however, to be of any value must be carried on in places where the rust is abundant or where either naturally or artificially a rust attack occurs every year.

SUMMARY.

Timothy rust was reported in the United States as early as 1882. It was reported from Iowa in 1891. From 1891 to 1906 no mention of the parasite has been found. In 1906 the rust became epidemic at the Arlington Experimental Farm, near Washington, D. C., and since then has been found to be widespread, having been reported from Maine to Ontario and northern Minnesota and south to Iowa, Kentucky, and Virginia.

Timothy rust is similar in general appearance and morphological characteristics to *Puccinia graminis* Pers. on wheat.

Inoculation experiments with timothy rust at Washington, D. C., show that it can be transferred easily to various grasses. Similar results have been obtained by Eriksson in Europe. This demonstrates that the rust in the United States and the rust in Europe are identical. That it is not a well-fixed species is substantiated. By using bridging hosts timothy rust can be made to transfer to various cereals which it will not attack directly. That such transfers take place in nature to some extent is probable.

The æcidial stage of this rust is not definitely known. Eriksson and Henning in numerous inoculations with the teleutospores on barberries obtained negative results except in one instance. On this basis they consider the rust a distinct species, naming it *Puccinia phlei-pratensis*. Kern has observed several unsuccessful inoculations on the barberry in this country. From the one apparently positive result of Eriksson and Henning, however, he believes that the rust is not entitled to specific rank and should be included under *Puccinia graminis* Pers. Evans accepts the name *Puccinia phlei-pratensis* and shows that there are well-marked differences in the details of the infection from the uredospore of this rust and the *graminis* form on

cereals. From the physiological specialization of the rust, from its distinct method of uredospore infection, from the numerous negative results of inoculations with the teleutospore on barberries, and from the delicacy of the uredo mycelium, as compared with typical *graminis* forms, it is evident that this rust has many distinctive characteristics. Unless further experiments should show that the rust can produce its æcidium on the barberry and until such experiments have been performed, the writer favors the use of the specific name *Puccinia phlei-pratensis* Erikss. and Henn.

At the Arlington Experimental Farm the rust mycelium lives through the winter. It is very probable that it lives over winter in the uredo stage much farther north than the latitude cited. As the æcidial stage, if present, is undoubtedly rare in the United States the teleuto stage is of doubtful importance in the wintering and dissemination of the rust.

The rapid distribution of timothy rust in recent years is undoubtedly due to the dissemination of the uredospores by the usual agencies, namely, insects, birds, animals, man, surface winds, and upper air currents. Its ultimate distribution over all timothy-growing sections favorable to it is to be expected, and methods of preventing any considerable damage to the timothy crop become necessary.

In a study of the resistance of varieties of timothy to rust in 1908 and 1909, W. J. Morse found that the resistance "varied greatly, ranging from zero to 98 per cent." The resistance of different strains relative to each other varied little during the two years. Under a less severe rust attack in 1910 these strains in many instances failed to retain the same relative position as in previous years. This tends to show that dependable data can be obtained only when vigorous rust attacks occur.

In greenhouse experiments where strains which had been tested in the field were subjected to similar inoculation and identical conditions during the period of incubation, the percentage of inoculated leaves which did not become infected did not correspond with the figures on rust resistance obtained in the field. When the severity of infection and not the percentage of leaves developing pustules was considered, however, the relative resistance of strains as obtained in the field was fairly well maintained in the greenhouse.

As there are wide differences in timothy strains with regard to rust resistance, the problem in timothy-rust prevention becomes one of breeding. This may not be as difficult as it appears at first. Such work, however, to be of value must be carried on when the rust is abundant and where either naturally or artificially a rust attack occurs every year.

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U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 225.

B. T. GALLOWAY, *Chief of Bureau.*

A SPOT DISEASE OF CAULIFLOWER.

BY

LUCIA McCULLOCH,

Scientific Assistant, Laboratory of Plant Pathology.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 31, 1911.

Sir: I have the honor to transmit herewith a manuscript entitled "A Spot Disease of Cauliflower," by Miss Lucia McCulloch, scientific assistant in the Laboratory of Plant Pathology, and recommend its publication as Bulletin No. 225 of the series of this bureau.

This paper deals with a disease which is shown to be of bacterial origin and which has not been reported hitherto.

The investigations of this disease have been carried out according to the advice and suggestions of Dr. Erwin F. Smith.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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A SPOT DISEASE OF CAULIFLOWER.

INTRODUCTION.

In April and again in May, 1909, diseased cauliflower plants were sent to the Laboratory of Plant Pathology from a farm in southeastern Virginia. In both lots the leaves were closely covered with brownish to purplish gray spots 1 to 3 millimeters in diameter (Pl. I). There were also larger diseased areas due to the coalescing of spots. All parts of the leaves were affected. Where the midribs and veins were badly attacked the tissues had contracted, giving a puckered appearance to the leaves (Pl. II). From the spots a bacterium was secured in pure cultures by means of petri-dish poured plates on agar, and subcultures from colonies thus obtained were used for inoculating healthy cauliflower plants.

The cauliflower heads from the same plants were not in good condition, but no success attended the efforts to secure from them the same kind of bacterium that was found in the leaf spots.

What appears to be the same disease was also received once on cauliflower from Florida.

INOCULATIONS.

All inoculations were made by spraying the plants with pure cultures of the bacterium suspended in water (24 to 48 hour agar slants washed off in sterile water). Young, healthy cauliflower plants 6 to 10 inches high were used, some being kept in infection cages and some merely on a bench in the greenhouse.

The infection shows first on the lower surface of the leaves as sunken water-soaked spots.[1] These are visible on the third day after inoculation. In 4 or 5 days the spots are dark purplish-gray and show on both surfaces. In transmitted light the centers are thin, almost colorless, and surrounded by a dark border. In size they vary from mere points to spots 1.5 millimeters in diameter. In shape they are irregularly angled; the spread of the disease appears to be stopped or hindered by the veins of the leaf. The individual

[1] Some infections from old cultures that had probably lost much of their virulence were first indicated after 6 to 8 days by tiny water-soaked elevations. As the disease progressed the tissues collapsed and a sunken spot resulted.

spots do not become more than 2 to 3 millimeters in largest diameter, though where crowded the spots usually coalesce, forming diseased areas of considerable size.

When only the upper surface of leaves was subjected to the inoculating spray very few infections resulted, while inoculations on the lower surface gave numerous infections (Pl. III). So far as observed in sections the infection takes place only through stomata, and mostly from the lower surface. The older and the very young leaves appear to be partially or even completely immune, while those of intermediate age (on the same plant) may be seriously affected.

The diseased leaves become yellow and fall off in from three to five weeks. The younger leaves and new growth are healthy. Under our rather dry hothouse conditions in no case was there evidence of infection on any but the inoculated leaves.

From spots developing on leaves inoculated with the original culture the organism was repeatedly isolated by means of petri-dish poured plates, and subcultures from colonies were again used for inoculations, always with the production of the characteristic infection.

The checks in all cases remained healthy; also numerous other cauliflower plants in the same greenhouse.

Cabbages inoculated with this organism became infected in the same manner as the cauliflower with one exception, viz, the spots were darker. From spots appearing on the inoculated cabbages the organism was isolated and tested on cauliflower, with the result of the production of the disease.

During May and June of 1909 all inoculations resulted in successful and typical infections.

On July 10, 1909, seven plants were inoculated in the usual manner and, contrary to expectations, no infections resulted. The conditions were the same as in previous inoculations, except that the temperature was higher at this time, 26° to 34° C. (78° to 93° F.). Subsequent experiments show that the bacterium causing the disease refuses to grow in artificial media at 29° C. (84° F.) or above. It is probable, therefore, that in this case the high temperature prevented infection.

After July no more plants were available for inoculation until January 24, 1910, when 10 plants were inoculated. No infections resulted. On February 2, 1910, 10 more plants were inoculated and no infections resulted. All conditions seemed favorable, and loss of virulence in the culture was suspected as the cause of failure to infect. The cultures used for inoculation were descended through numerous transfers made during the winter. An agar-stock culture which had not been transferred since September, 1909, was then tried. Fresh agar-slant cultures were made from the September stock and used when 24 hours old (February 12, 1910) for inoculating cauliflower plants. This time infections resulted. The infections were very slight, however, and the spots too few in number to cause any noticeable injury to the plants, but the bacteria plated from these spots produced typical colonies on agar and characteristic growth in artificial media. Cauliflower plants inoculated with this new strain became very generally infected, which fact seems to indicate that the organism had increased in virulence by passage through the host.

On December 6, 1910, cabbage, cauliflower, turnip, rutabaga, radish, and mustard were inoculated in cages by spraying with sterile water to which had been added agar-streak cultures 3 days old. All of these plants were young. There were two to four of each sort. The material for inoculation was obtained from a cauliflower inoculated November 22, 1910. Infections were obtained on cabbage and cauliflower (six days), but not on the other plants. Sections of the spots made on the tenth day showed them to be full of bacteria.

On March 4, 1911, three cauliflower plants were again inoculated by spraying with sterile water to which had been added 2-day-old agar-slant cultures. These plants were about 8 inches high and very healthy. They were kept in an infection cage for two days. At the end of 10 days there were very small dark specks on each of the plants. These specks were in the center of a small semitransparent elevation. A microscopic examination showed bacteria present in these spots. The flower stalks of plant 104 also showed elongated water-soaked spots, darker in the center. These also contained bacteria and plates made from them yielded the organism in pure culture. The flowering part of plant 104 bore no spots, although it had been drenched with the spray. The check plant remained healthy.

Several attempts to inoculate the heads of the cauliflower gave no satisfactory results. Growing heads were copiously inoculated and kept under moist conditions, but no infections occurred. Infection spots similar to those on leafstalks and midribs occurred on some of the larger stalks of the flower head, while the flowering parts remained free from infection. Mature heads from the market were also inoculated, but as decay of the tender surface was general in the checks as well as in the inoculated heads, the results are not conclusive.

DESCRIPTION OF THE CAULIFLOWER LEAF-SPOT ORGANISM.

MORPHOLOGY.

The organism is a short rod, forming long chains in some media. Ends rounded. Size from leaf 1.5 to 2.4 μ by 0.8 to 0.9 μ. Size in 24-hour beef-agar culture, temperature 20° to 25° C., 1.5 to 3 μ by 0.9 μ. No spores are produced. The organism is actively motile by means of one to five polar flagella, which are two to three times the length of the rod. (Stained by Van Ermengem's method; also by Hugh Williams's method.) Motility occurs in most artificial media. In beef-bouillon cultures grown and kept at 0.5° to 1.5° C. for four months the organism is still motile. Involution forms were found in alkaline beef bouillon (−17 on Fuller's scale). Pseudozoogloeæ occur in Uschinsky's solution and in acid beef bouillon.

REACTION TO STAINS.

The organism does not stain by Gram. Modified Gram, using amyl alcohol, gives a deep blue stain. It stains readily and strongly with carbol fuchsin, with an alcoholic solution of gentian violet, and with a stain obtained from Dr. Kinyoun which contains methylene blue, silver nitrate, azure I, and azure II. It is not acid fast.

CULTURAL CHARACTERS.

Agar plates (+15 peptonized beef bouillon with 1 per cent agar).—The colonies are visible on the second day as tiny white specks (temperature 23° C.).

In three to four days the colonies are 1 to 3 millimeters in diameter, white (opalescent in transmitted light), round, smooth, flat, shining, and translucent, with edges entire. Structure, under hand lens, coarsely granular with internal reticulations. Buried colonies small, lens shaped. With age the colonies become dull to dirty white, slightly irregular in shape, the edges undulate, slightly crinkled, and with indistinct radiating marginal lines. The internal reticulations disappear and the coarsely granular appearance changes to finely granular. In thinly sown plates 7-day-old colonies are 6 to 8 millimeters in diameter; 15-day-old colonies are 12 to 15 millimeters in diameter.

Agar stabs.—The surface of the agar is covered in two days (22° to 24° C.) by a thin white growth. For several days the stab shows a moderate growth in the upper 8 to 10 millimeters, but this does not continue. Finally, the stab is almost, if not quite, invisible. Crystals appear in the stab and on the surface.

Agar slants.—In smear cultures the surface is covered in two days (temperature 19° to 21° C.) with a thin white growth, glistening, coarsely and irregularly pitted. White sediment in the V.

In streak cultures in two days (temperature 19° to 21° C.) the streak is 3 to 5 millimeters wide, white, margins slightly undulate. The internal reticulations seen in colonies on plates are present in the streak cultures. At right angles to the streak are fine lines extending from center to margin.

Agar cultures become slightly greenish.

Beef bouillon.—Peptonized beef bouillon +15 held at 24° to 25° C., if inoculated from young, vigorous bouillon cultures, clouds thinly in 6 hours and is moderately to heavily clouded in 24 hours. The growth is best at the surface, where a white layer is formed. This is not a true pellicle, as it disintegrates when the cultures are handled.[1] No zoogloeæ are present. There is no rim. In two days there are heavy clouds and a moderate amount of white flocculent precipitate. After several weeks the precipitate is white and slimy, moderate in quantity, and with small crystals in it. The medium becomes slightly greenish. After several months the precipitate is viscid.

Acid bouillon.—In neutral beef bouillon plus vegetable acids, growth occurs until an acidity of +34 for oxalic acid and +36 for malic and citric acids (Fuller's scale) is reached. There is no rim or pellicle. Occasionally pseudozoogloeæ are formed in the more acid media.

Microscopic examination shows most of the organisms greatly reduced in length, some so short as to be spheroidal. That these were not contaminations was proved by plating out and by tests on other culture media.

Alkaline bouillon.—In alkaline beef bouillon (NaOH used) the organism grew well in −17, −19, −22, less in −23, and not at all in −25, −26, and −28 (Fuller's scale). Involution forms and filaments were present in −17 beef bouillon when two weeks old.

Bouillon with sodium chlorid.—In beef bouillon plus 2 per cent NaCl the growth is as good as in plain beef bouillon. With the addition of more NaCl the growth gradually lessens until it is scarcely noticeable in a 5 per cent solution. When grown in a 4 per cent solution, the organism is not motile. In a 2 per cent solution, the organism is motile, but less so than in beef bouillon without NaCl.

Beef bouillon over chloroform.—For the first 24 hours the growth is somewhat retarded. By the end of 48 hours no difference could be seen between cultures over chloroform (5 c. c. of chloroform with 10 c. c. of beef bouillon not shaken) and those in plain beef bouillon.

Loeffler's blood serum.—Growth of stroke is moderate, smooth, shining; color creamy; margins finely crinkled. No liquefaction. After three months the whole medium was slightly browned.

Cohn's solution.—Moderate clouding and white precipitate; no rim, pellicle, or zoogloeæ; no fluorescence. After some weeks featherlike crystals of considerable size (5 to 10 by 2 to 6 mm.) are formed.

Fermi's solution.—Moderate clouding at first. Precipitate moderate to abundant, white, flocculent. Pellicle white, tender, sinking in strings and masses. Finally the medium is densely clouded and

[1] Old cultures kept for several months at 0.5° to 1.5° C. had a delicate pellicle.

pale green-fluorescent (between water green and greenish glaucous, Repertoire de Couleurs, Paris, 1905); more precipitate than in beef bouillon.

Nutrient gelatin (+10 on Fuller's scale).—The stab cultures liquefied in 8 to 10 days (temperature 17° to 18° C.). Growth from surface crateriform. Slight, white, granular precipitate. Slight green fluorescence.

The plate cultures showed no signs of growth in 24 hours at 17° to 18° C. In three days well-isolated colonies vary from mere points to round growths 2 millimeters in diameter. The gelatin is liquefied in cuplike hollows. Margin of smaller colonies entire, of larger colonies fimbriate. Thickly sown plates entirely liquefied in two days at 15° to 16° C.

Litmus milk.—The medium becomes dark blue at the surface in 12 to 24 hours. The darkening proceeds downward in definite layers until in 8 to 10 days the whole medium is dark blue with a slight white precipitate. During six months' observation the medium remained dark blue (reflected light) and liquid. Finally by evaporation the medium becomes thickened, but there is at no time any separation into curd and whey.

A few cultures showed a trace of reduction of litmus at the bottom.

Milk.—As in the litmus-milk cultures, growth and color-change in the milk begin at the surface, proceeding downward in definite layers. In 15 to 20 days the whole tube (10 c. c. of milk) is yellow (near Ridgway's Naples yellow, but somewhat duller and with a greenish tinge) and translucent. No separation into curd and whey. Fat not changed. In four months the medium is quite dark (reddish-brown) and somewhat thick (evaporated to about 5 c. c.). Small tyrosin crystals are formed. These are distinctly visible only with a lens.

Uschinsky's solution.—Growth moderate to copious; pellicle white, tender, breaking and sinking easily. Pseudozoogloeæ are present. There is a greenish fluorescence. The old cultures are much like those in Fermi's solution.

OTHER CHARACTERISTICS.

Fermentation tubes.—The organism is aerobic and does not form gas. It was tested in fermentation tubes in the presence of dextrose, saccharose, lactose, maltose, glycerin, and mannit, each of these carbon compounds being added to a basal solution consisting of 1 per cent of Witte's peptone dissolved in water. It did not grow in the closed end of the fermentation tubes in the presence of any of these substances.

Ammonia production.—Moderate.

Nitrates.—Nitrates are not reduced.

Indol.—Indol production is feeble.

Hydrogen sulphid.—Hydrogen sulphid is not formed in cultures on beef-peptone agar, potato cylinders, turnip cylinders, or in beef bouillon or milk.

TEMPERATURE RELATIONS.

Thermal death point.—The thermal death point is 46° C. The following tests were made: Newly inoculated beef-bouillon (+15) cultures in tubes were suspended in a hot-water bath where they were kept for 10 minutes at a constant temperature, then removed to room temperature (20° to 24° C.). First, temperatures ranging from 40° to 50° C. were tried, and, the thermal death point seeming to lie about halfway between, trials were again made of 45°, 46°, and 47° C. More than half of the cultures exposed to 45° C. for 10 minutes clouded in 3 to 5 days. Of cultures exposed to 46° C. 1 out of 12 clouded after 11 days. The others never clouded. Of 20 cultures exposed to 47° C., none clouded.

Optimum temperature.—The optimum temperature for growth is 24° to 25° C.

Maximum temperature.—The maximum temperature for growth is very low, viz, 29° C.

Minimum temperature.—The minimum temperature for growth is below 0° C.

The organism was dead after exposure for 3½ days at 33° to 36° C. in beef bouillon.

EFFECT OF DESICCATION.

When young, well-clouded beef-bouillon cultures were dried on cover glasses and kept in a dark place at temperatures of 22° to 25° C., 75 per cent were killed in 24 hours and 90 per cent in 48 hours. All were dead in five days.

EFFECT OF SUNLIGHT.

Four minutes' exposure to sunlight killed all organisms in thinly sown agar poured plates exposed bottom up on ice, one-half of each plate being covered as a check.

EFFECT OF FREEZING.

Freezing by means of salt and pounded ice for two and five hours in +15 beef bouillon had no effect in reducing the number or the vitality of the organisms, as shown by poured-plate cultures made before and after freezing.

Beef bouillon (10 c. c.) inoculated and at once frozen and kept at temperatures of −4° to −18° C. (average −12° C.) for nine days showed no growth during this period, but clouded moderately three days after removal to temperature of 18° to 20° C., and plates from this tube gave pure cultures of the cauliflower organism. Plates poured before and after 10 days' freezing showed considerable reduction in the numbers of organisms, but the growth of the living ones was not retarded. Some tubes of beef bouillon, inoculated with a 3-millimeter loop from a 48-hour bouillon culture and kept frozen for seven days, clouded within 48 hours after removal to a temperature of 18° to 20° C. Another frozen for 22 days did not cloud after removal to temperatures of 18° to 20° C. The check clouded. The organism grows readily at low temperatures, e. g., beef-bouillon cultures clouded in seven days when kept at temperatures of 0° to 1° C.

VITALITY ON CULTURE MEDIA.

This organism remains alive for six to eight months at temperatures varying from 18° to 24° C. on beef agar, Loeffler's blood serum, and potato cylinders, and in peptonized beef bouillon (+15), beef gelatin (+10), milk, Uschinsky's, Fermi's, and Cohn's solutions. Evaporation was not prevented in these cultures and the media became concentrated, often dry, and yet the organism was frequently alive. Beef-agar and beef-gelatin cultures at temperatures of 12° to 15° C. and subject to less evaporation (in refrigerator) were dead after eight months. In media less favorable for the growth of this organism, as beef bouillon plus salt, alkali, or acid, the bacteria live but two to three months.

GROUP NUMBER.

The group number, according to the descriptive chart of the Society of American Bacteriologists, is 211.3332023.

NAME OF ORGANISM.

This organism appears to be an undescribed form, and because of the characteristic spotting of the affected leaves the name *Bacterium maculicolum* (n. sp.) is suggested.

LATIN DIAGNOSIS.

BACTERIUM MACULICOLUM (N. SP.).

Baculis in hospite brevibus, cylindricis, apicibus rotundatis, solitariis, saepe binis (in agar-agar quandoque 10–30 baculis in filamenta conjunctis); baculis 1.5–3.0 μ x 0.8–0.9 μ; 1–5 flagellis polaribus mobilibus; aerobiis, asporis.

Habitat in foliis vivis Brassicae oleraceae in maculis 1–3 mm. latis, purpureo-griseo colore. Coloniae gelatinam liquefacientes. Coloniae in agar-agar rotundae, albae, nitentes. Si baculi in petri-vasibus rare seruntur, in septimo die colonae 6–8 mm. diam. sunt. Baculi methodo Gram non colorantur. Nitrum non redigitur. Lac sterile alcalinum fit; initio translucidum, flavum pallidum demum opacum, brunnen et gelatum; casein non segregatur. Inter temperaturam 29° C. et temperaturam −5° C. culturae crescunt. Si culturae novae in infusione carnis ¼ horam in temperatura 46° C. tenentur, moriuntur. Inter temperaturas −5° C. et −15° C. per decem dies non moriuntur. Si baculi siccantur vel soli exponuntur, celeriter moriuntur. In foliis vivis Brassicae oleraceae aspergendo inoculatis, maculae in 3–4 diebus producuntur. Contagium in stomatibus fit.

SUMMARY.

The leaf-spot disease of cauliflower described in the preceding pages is due to a bacterial organism, which was secured in pure culture from the leaf spots and inoculated into healthy cauliflower plants, with production of the disease. Healthy cabbages inoculated with the organism also showed similar infection.

Inoculations during July, 1909, were unsuccessful because of the higher temperature.

The heads of cauliflower gave no satisfactory results when inoculated with the organism.

The name *Bacterium maculicolum* has been suggested for this organism. It is a schizomycete, pathogenic to crucifers, causing numerous small spots on cauliflower and cabbage. Entrance by way of the stomata. Organism white, but causing a greenish fluorescence in some media (beef bouillon +15, beef gelatin +10, beef agar +15, Uschinsky and Fermi). Motile by means of one to several polar flagella. A short rod (1.5 to 3 μ by 0.9 μ), single or in chains in some media (10 to 30 μ long on agar; 10 to 24 μ long in beef bouillon plus 4 per cent sodium chlorid). Does not stain by Gram; stains deeply with amyl Gram.

No spores. Involution forms (found in alkaline beef bouillon) and pseudozoogloeæ. Aerobic. Liquefies gelatin slowly. Does not liquefy Loeffler's blood serum. Not gas forming. Feeble production of ammonia, indol, and hydrogen sulphid. Nitrates not reduced. Tolerates acids, citric and malic to +36 and oxalic to +34 (Fuller's scale). Tolerates sodium hydroxid in beef bouillon to −25 (Fuller's scale).

Optimum temperature 24° to 25° C. Thermal death point 46° C. Will not grow in beef bouillon (+15) or on agar (+15) at 29° C. Grows at 0° C. and below. Grows well in bouillon over chloroform. Grows in Cohn's solution. Blues litmus milk.

The most striking facts about the organism are its ability to grow at temperatures below freezing and its failure to grow at a common summer temperature (85° F.).

The leaves of the attacked plants fall off.

O

UPPER SURFACES OF CAULIFLOWER LEAVES FROM VIRGINIA, SHOWING NATURAL INFECTION WITH BACTERIUM MACULICOLUM. PHOTOGRAPHED MAY 4, 1909.

UNDER SURFACES OF CAULIFLOWER LEAVES FROM VIRGINIA, SHOWING MIDRIBS SPOTTED BY NATURAL INFECTION WITH BACTERIUM MACULICOLUM. PHOTOGRAPHED MAY 4, 1909.

UNDER SURFACES OF CAULIFLOWER LEAVES FROM HOTHOUSE; INOCULATED BY SPRAYING ON MAY 19, 1909, WITH BACTERIUM MACULICOLUM. PHOTOGRAPHED JUNE 2, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 226.

B. T. GALLOWAY, *Chief of Bureau.*

A PLANT-DISEASE SURVEY IN THE VICINITY OF SAN ANTONIO, TEXAS.

BY

FREDERICK D. HEALD AND FREDERICK A. WOLF,

Experts.

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BUREAU OF PLANT INDUSTRY.

Chief of Bureau, Beverly T. Galloway.
Assistant Chief of Bureau, William A. Taylor.
Editor, J. E. Rockwell.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 5, 1911.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 226 of the Bureau series the accompanying manuscript entitled "A Plant Disease Survey in the Vicinity of San Antonio, Texas," submitted with a view to publication by Mr. W. A. Orton, Pathologist in Charge of Cotton and Truck-Crop Diseases and Sugar-Plant Investigations.

This bulletin gives the results of work done by the authors, Dr. Frederick D. Heald, professor of botany, University of Texas, and Mr. Frederick A. Wolf, tutor in botany, University of Texas. The work was undertaken at the request of Mr. C. S. Scofield, Agriculturist in Charge of Western Agricultural Extension, who desired a preliminary survey of the plant diseases of this region to be made as a part of the work of the San Antonio Experiment Farm.

Respectfully,

Wm. A. Taylor,
Acting Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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A PLANT-DISEASE SURVEY IN THE VICINITY OF SAN ANTONIO, TEXAS.

INTRODUCTION.

During the summer and fall of 1909 and the winter and spring of 1910 a plant-disease survey was made of a portion of Texas in the vicinity of San Antonio. The object of this work was to determine the diseases which were prevalent with a view to a later and more detailed investigation of those which are either new or imperfectly known.

The emphasis has been placed upon the diseases of plants due to bacteria, fungi, or other parasites, but environmental factors have not been overlooked. The field is an exceedingly fruitful one, since but little has been published concerning the parasitic fungi or plant diseases of this part of the country. Besides the report of Jennings (34),[1] issued some years ago, and a short list by Cooke (9), but few scattered records of Texas fungi exist. It will not be surprising, then, if a detailed examination of a restricted area should show many new and interesting forms.

The work outlined in this report was carried out by the writers, with headquarters at the University of Texas. Acknowledgment is here made of the helpful suggestions of Mr. W. A. Orton. Mrs. F. W. Patterson, and Miss E. C. Field, of the Department, have very kindly assisted in working over the doubtful specimens and in the determination of most species which appeared to be new, with the exception of the Uredinales, which were submitted to Mr. F. D. Kern, Lafayette, Ind. Several specimens were also referred to Prof. C. H. Peck, Albany, N. Y. In addition, the senior writer visited the herbaria at Washington and the New York Botanical Garden in order to compare our material with their collections which are rich in type specimens.

Specimens have been deposited in the herbarium of the University of Texas, at Austin, while duplicates, including type specimens,

[1] The serial numbers in parentheses used in this bulletin refer to the index to literature, pp. 107–108.

have been placed in the herbarium of pathological collections, Bureau of Plant Industry, Washington, D. C. New species have been described as such in different numbers of Mycologia.

TERRITORY COVERED BY THE SURVEY.

The territory covered by this survey is included within a circle having a radius of 100 miles from San Antonio. One trip was made to the south of this region, and collections were made at Falfurrias and Alice, outside of the territory described. The accompanying map (fig. 1) shows the territory studied, and all of the points at which collections were made are indicated by name and solid black circle. It will be observed that more attention was paid to the eastern and southeastern portions of the territory than elsewhere. The explanation for this will be evident by reference to the discussion of crops, native vegetation, and topography of the region.

PHYSIOGRAPHY AND SOILS.

The region studied occupies the coastal plain of Texas in the south and east and extends into the Edwards Plateau and Llano country in the northwest. It is traversed diagonally, beginning in the northern part, by the Colorado, Guadalupe, San Antonio, Medina, Frio, and Nueces Rivers, most of which rise in the edge of the Edwards Plateau and cross the coastal plain to the gulf. A gradual rise characterizes the elevation from the low coastal prairie in the southeast to the rough mountain country of the Edwards Plateau in the northwest. Table I shows the elevations for different stations.

Table I.—*Elevation for principal stations.*

Less than 250 feet.	250 to 500 feet.	500 to 1,000 feet.	Over 1,000 feet.
Beeville, 225. Cuero, 177. Hallettsville, 235. Victoria, 187.	Flatonia, 465. Gonzales, 299. Luling, 418. Runge, 308.	Austin, 593. Georgetown, 750. Hondo, 901. New Braunfels, 720. Sabinal, 964. San Antonio, 701. San Marcos, 588. Uvalde, 937.	Blanco, 1,350. Boerne, 1,412. Fredericksburg, 1,742. Kerrville, 1,650. Llano, 1,040.

The region under consideration includes part of the three units of the coastal plain. In the extreme southeastern portion, in Victoria, Goliad, and Bee Counties, may be found the interior border of the coast prairie region, which is flat, low lying, and generally treeless, with the exception of the river valleys. In parts of this area the mesquite and other timber is encroaching upon the prairies where its natural spread is not held in check by agricultural development.

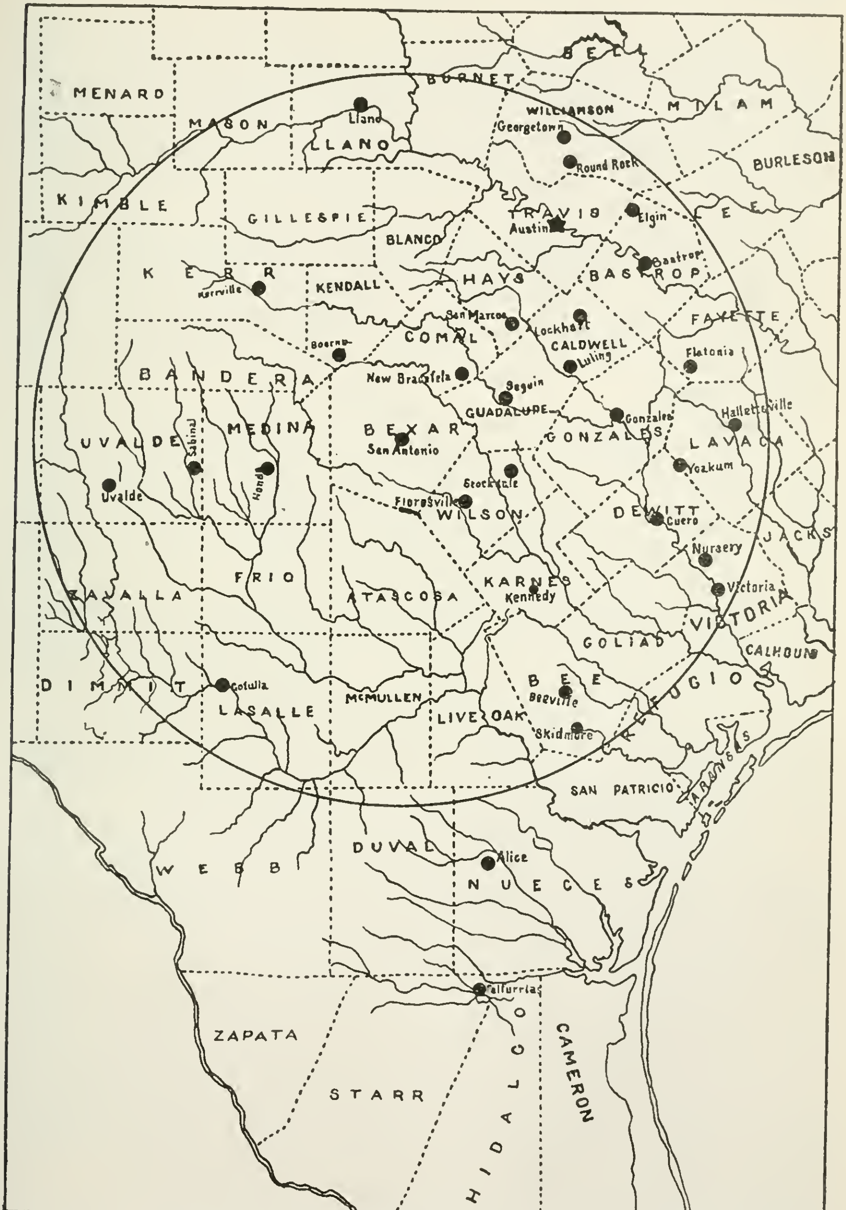

Fig. 1.—Map of a part of the State of Texas, showing the territory covered and places visited in connection with the plant-disease survey.

The prevailing soils in this area except in the bottom lands are stiff, waxy clays, generally with an impervious clay subsoil, and ranging in color from black to chocolate. They are of residual origin.

The coast prairie region is succeeded by the Tertiary forested area, which extends from Bastrop County in the northeast to the southwest. It includes a considerable part of the post-oak lands of the lignitic belt. The region is much more hilly than the coast prairies, and the rise in elevation is gradual. The southern portion is level or only slightly rolling and less forested than the more hilly northern part.

The soils in this area are mainly residual, varying according to the character of the underlying formation. In various localities may be found sands and sandy loams well adapted to truck crops, as in portions of Bastrop, Caldwell, Gonzales, and Wilson Counties. Clays and clay loams may also be found, while rich alluvial soils occur along the river valleys.

A narrow extension of the rich Cretaceous prairies of northern Texas extends southward through Williamson, eastern Travis, Hays, Comal, and Bexar Counties. The typical soil is black and waxy, derived from the underlying Cretaceous chalks, clays, and marls. The land is exceedingly fertile and produces good yields of cotton and corn when there is sufficient rainfall.

The region investigated includes a small part of the Llano country, in the northwest along the Colorado and Llano Rivers and north of the Edwards Plateau. The region is rough and hilly, with low mountains, the elevations ranging from 1,000 to 1,800 feet. The underlying rocks are largely granite. In many places they are sparsely covered with soil, but the valleys in many localities have fertile soils suitable for the culture of a variety of crops.

The northwestern portion of the region south of the Llano country is occupied by the southern extension of the Edwards Plateau. The region extends west and northwest from the Balcones escarpment, a line of cliffs or hills which terminate abruptly just west and north of a line connecting Austin, San Antonio, and Uvalde. In contrast to the Llano country, the region is essentially a limestone country and is rough and rugged, being cut by the rivers which have their source in this region. The rivers which cross the area under investigation either originate in the Edwards Plateau or rise at the base of the escarpment. The Edwards Plateau is poorly adapted to agriculture, since it is a rugged, hilly country, with scant soil in many places and a rainfall which ranges from 20 to 25 inches.

CLIMATOLOGY.

RAINFALL.

The rainfall of the territory under investigation decreases progressively from the eastern border to the northwest and southwest, reaching the lowest limit in the southwest. The average annual rainfall in Lavaca County in the extreme eastern portion of the section is more than 30 inches, while at Llano, in the low mountain country in the northwest, the average annual rainfall is only about 22 inches. In the extreme southwestern portion some localities report as low an average as 20 inches or somewhat less.

TABLE II.—*Annual precipitation for 1909 in the region of San Antonio, Tex.*

Stations.	Total precipitation.	Departure from normal.	Stations.	Total precipitation.	Departure from normal.
	Inches.	*Inches.*		*Inches.*	*Inches.*
Austin	20.57	−13.78	Kerrville	26.02	− 3.83
Beeville	30.81	+ 1.25	Luling	21.26	− 7.93
Blanco	24.13	− 5.31	Marble Falls	21.14	....
Boerne	25.76	− 6.11	New Braunfels	19.66	−10.45
Cuero	23.43	−10.66	Rossville	16.59	....
Falfurrias	25.42	....	Runge	18.94	−11.29
Flatonia	28.42	....	Sabinal	19.34	....
Fredericksburg	21.86	− 6.52	San Antonio	14.92	−11.91
Georgetown	19.68	−15.79	San Marcos	29.81	− 1.51
Gonzales	24.53	....	Taylor	20.72	−14.75
Hallettsville	31.93	− 1.22	Uvalde	18.19	....
Hondo	17.54	−10.53	Victoria	33.58	− 2.96

Table II shows that the total rainfall for the year varied from 14.92 inches at San Antonio to 33.58 inches at Victoria. All stations except Beeville show less rainfall than normal, the departure varying from about 4 to 15 inches in the greater portion of the territory.

For the year 1909 only a narrow strip of territory about 25 miles in width, occupying the extreme southeastern portion, had a rainfall slightly over 30 inches. (See fig. 2.) The greater part of the territory north of Bexar County had a rainfall of 20 to 30 inches, while a strip 25 or 30 miles wide lying just west of the more humid southeastern portion had a rainfall similar to the northern half. In a small area at the extreme north in Williamson County the rainfall was only 10 to 20 inches. The extreme west and the entire southwest had a rainfall of 10 to 20 inches with the exception of a small part of Zavalla and Dimmit Counties, where it dropped to less than 10 inches. From the above it may be seen that about one-half of the entire area had a total annual precipitation ranging from 10 to 20 inches.

TEMPERATURE.

Table III shows an average mean temperature for the year ranging from 66.1° in the low mountain country of the Edwards Plateau to 72° in the southern portion.

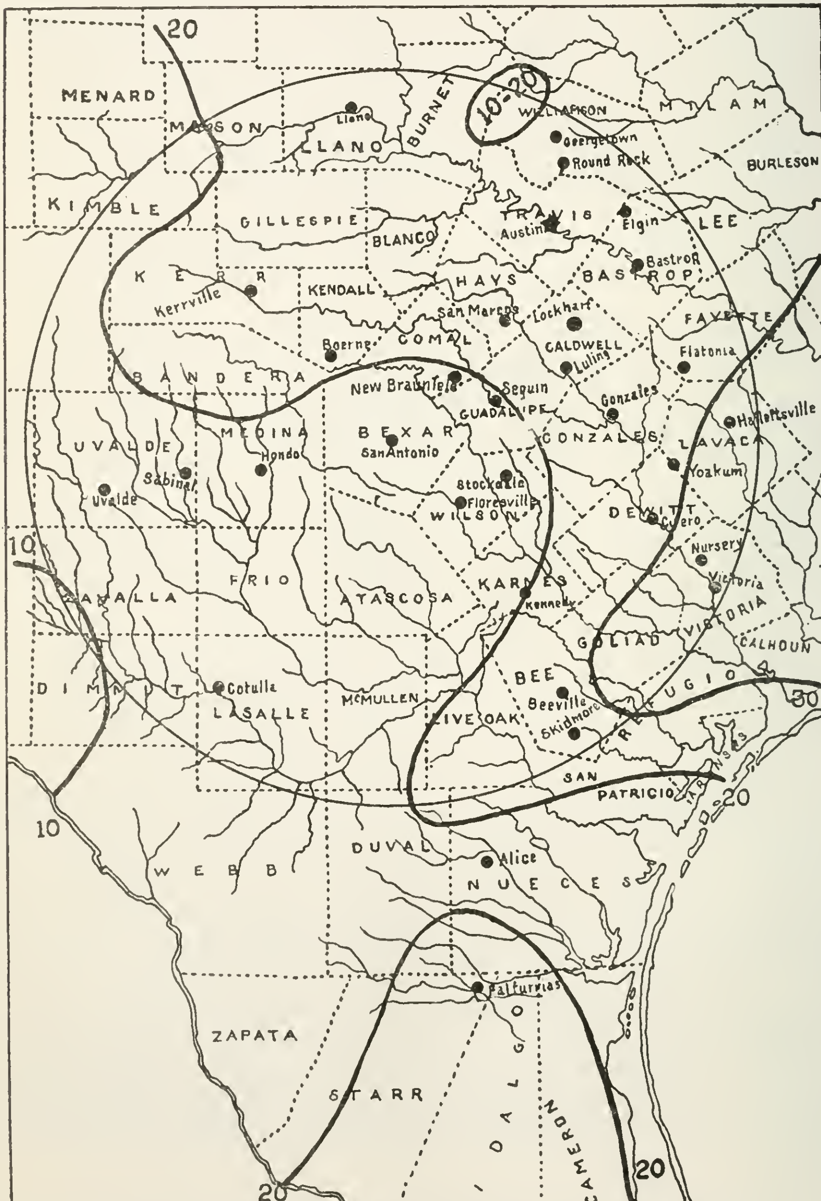

FIG. 2.—Map of that part of the State of Texas presented in figure 1, showing the rainfall for 1909.

TABLE III.—*Maximum, minimum, and mean temperatures for 1909 in the region of San Antonio, Tex.*

Station.	Maximum.		Minimum.		Mean.
	Date.	Temperature.	Date.	Temperature.	
		°F.		°F.	°F.
Austin	Aug. 19	102	Jan. 11	19	67.9
Beeville	...do....	106	...do.....	23	72.0
Blanco	Aug. 18	107	Jan. 12	14	66.1
Boerne	Aug. 19	109	Feb. 16	14	67.5
Cuero	Aug. 20	109	Jan. 12	21	71.2
Falfurrias	Aug. 18	107	Feb. 16	23	74.1
Flatonia	...do....	107	Jan. 12	18	70.5
Fredericksburg	...do....	104	...do.....	11	66.8
Georgetown	...do....	112	...do.....	16	67.4
Hallettsville	Aug. 20	104	Jan. 11	20	71.0
Hondo	Aug. 18	108	....	....	....
Kerrville	Aug. 19	105	Feb. 16	11	66.6
Luling	Aug. 18	105	{Jan. 12 / Feb. 15}	19	69.5
New Braunfels	Aug. 19	105	Jan. 12	19	69.5
Rossville	...do....	108	Dec. 19	20	72.1
Sabinal	Aug. 4	110	{Jan. 12 / Feb. 16}	21	72.0
San Antonio	Aug. 20	107	Jan. 12	20	70.3
San Marcos	Aug. 18	105	{..do.... / Feb. 15}	19	68.4
Taylor	...do....	109	Jan. 12	15	68.0
Uvalde	...do....	110	{Jan. 13 / Feb. 16}	21	71.6
Victoria	...do....	101	Feb. 15	22	71.0

The month of August was marked by excessive heat, some localities showing a temperature as high as 110° to 112° F. The continuance of the high temperature for several days following or subsequent to the maximum recorded was general for the entire territory. The continued high temperatures and the lack of the customary amount of rainfall caused a very considerable decrease in crop yields. Throughout the area cotton did not make half a crop, many fields of corn were a total failure, and other vegetation suffered in a corresponding degree.

EVAPORATION.

The relative total evaporation for the vicinity of San Antonio is high, with a rate between that of a desert center and a deciduous forest.

Table IV shows the average daily evaporation in inches for the year 1909, and the first three months in 1910, at the San Antonio Experiment Farm. The data were obtained from Mr. C. S. Scofield, who recorded the daily evaporation from an open-air tank.

TABLE IV.—*Average daily evaporation at San Antonio Experiment Farm.*

Month.	Evaporation.	Average for—	Month.	Evaporation.	Average for—
1909.	*Inch.*		1909.	*Inch.*	
January	0.103	Entire month.	October	0.182	Entire month.
February	.149	Do.	November	.127	Do.
March	.188	Do.	December	.092	Do.
April	.235	26 days.[1]			
May	.237	Entire month.	1910.		
June	.331	First 27 days.	January	.090	First 24 days.
July	.357	Last 25 days.	February	.103	Last 26 days.
August	.274	First 30 days.	March	.191	Entire month.
September	.241	Entire month.			

[1] No records for Apr. 17, 18, 19, 20.

CROPS AND NATIVE VEGETATION.

The climatological character of the San Antonio area excludes certain crops which are extensively grown in more northern localities and in regions of greater rainfall, but makes possible the culture of some crops which are characteristic of semitropic conditions.

FRUITS.

Apple orchards conducted on a commercial scale are excluded. In a few localities small numbers of trees are to be found in family orchards which generally appear to be seriously affected with black-rot. In the sheltered valleys in the low mountain country to the northwest the most favorable conditions for the growth of apples are found. Several nurseries in the territory grow large quantities of apple stock for shipment to old Mexico, Arizona, and the Pecos country in Texas. The young trees in the nursery were unusually exempt from diseases.

Pears are more successfully grown than apples, but commercial orchards are rare. Most of the small pear orchards have been very seriously neglected, and it is not surprising to find them affected with such diseases as black-rot and bitter-rot. With proper care and cultivation pears could be more extensively grown, since they are much freer from fire-blight than in the more humid coast country.

Peaches are common in the eastern half of the territory and are grown to some extent in the sheltered valleys to the west and northwest. The crop for 1909, however, was a complete failure, owing to the severe freezes of the previous winter. The sudden drops in temperature following warm periods which had started vegetative activity killed many peach trees. This condition will explain the rarity of such diseases as brown-rot and peach freckle (*Cladosporium carpophilum*), which are very abundant when there is an average crop. The entire absence of the peach leaf-curl which is so common farther north may be noted. Present records give only a single instance of this disease in Texas, and that from the northern part of the State (34). The die-back appears to be the most serious disease.

Apricots are grown to some extent where peaches are found, but are rather rare. Plums are not uncommon, but they are grown less than peaches. The crop for 1909 was a failure, and this will explain why the common brown-rot is not reported. The failure of the crop is not, however, the explanation for the absence of "plum pockets," since this disease appears to be absent during normal seasons. Black-knot was not found in any of the localities visited, either on wild or cultivated species. No cherries are grown in this territory, and apparently the only portions of the State where they can be successfully grown are the Panhandle country, the Llano Estacado, and portions of the Red River Valley.

Persimmons are not uncommon, especially in the eastern half of the territory. The various Japanese varieties do well, but the limited demand has prevented their extensive planting. Figs are grown throughout the eastern and more humid portion of the region, although more favorable conditions are found in the humid coast country extending from Beaumont to Brownsville. In many localities visited the fig trees were killed back to the ground by the severe winter, but they generally sprouted up again from the roots. Most of the trees which were not killed failed to produce fruit on account of the abnormally dry season. In many places the half-ripened fruit dried up on the tree. For this reason no information is at hand concerning the prevalence of fig diseases which attack the fruit. Citrus fruits are grown to a limited extent in the extreme southeastern portion, in Victoria and Bee Counties, while some nurseries farther north are growing large quantities of *Citrus trifoliata* stock which is used for the propagation of the Satsuma orange, the variety most commonly grown. Most of the plantings of citrus varieties are only a few years old (33). The date palm is planted to some extent in the citrus-fruit territory, but none of the trees are more than a few years old.

Grapes are quite generally grown throughout most of the territory, and adapted varieties do well when properly cared for. The black-rot is generally prevalent and is apparently responsible for many of the failures which are attributed to drought. Strawberries can be grown in most of the region in sufficient quantity for home consumption, but the main strawberry region lies to the east in the more humid section. In much of the drier portion of this area the plants die out during the long dry period of the summer unless specially protected or grown under irrigation. Blackberries are grown to some extent, but they are relatively rare as compared with dewberries, which are extensively grown throughout the entire area.

Raspberries, currants, and gooseberries are practically unknown in any part of the area studied.

The pecan is a common nut crop in favorable localities. It is native throughout the area, and many large trees may be found along the fertile valleys of the Llano, Colorado, Guadalupe, and Nueces Rivers. Most of the crop is obtained from the natural growth, but some groves have been planted along the river valleys where the rich, deep soil is adapted to their growth.

TRUCK CROPS.

The main truck-growing section of the State lies farther to the east, in Smith, Cherokee, Anderson, Henderson, Rusk, and Angelina Counties, or in the Brownsville district to the south, but nearly all kinds of truck crops are grown to some extent throughout the territory. In nearly all of the localities west of the ninety-eighth meridian truck crops grown without irrigation are uncertain, and most of the localities in the western half of the region do not supply even a sufficient quantity for home consumption.

The principal truck crops which are grown extensively for shipment to northern markets are potatoes, watermelons, and onions. La Salle County produces large quantities of onions, but Webb County, just to the south and beyond the limits of our area, has a much larger acreage. Watermelons are grown commercially in the sandy soils of Bastrop County and in smaller quantities in many other sections. Most of the home gardens have an abundance of okra and peppers and other common vegetables, such as peas, beans, lettuce, radishes, and eggplants. The Kentucky Wonder bean is grown more extensively than any of the wax-podded varieties, and the black-eyed pea (*Vigna unguiculata*) is common in the vegetable garden, being frequently substituted for the less hardy Phaseolus varieties. Cabbage and spinach are grown on a commercial scale in several localities from Austin southward. Spinach is marketed throughout the entire winter even as far north as Austin. The tomato is a common crop in all of the irrigated sections, but produced a light yield during 1909 on account of the excessive heat in the early part of the season, followed by a long period of drought. The greater number of the irrigated truck patches suffered heavy losses from nematodes, and tomatoes were more seriously affected than any other crop. Cucumbers and squashes are quite generally grown, the main varieties of squash being the cushaw and the small bush varieties (cymlings). Asparagus is rare, the only large field observed being at Austin. Its limited culture is apparently due to the lack of demand for this article in the local markets.

FIELD CROPS.

Cotton and corn constitute the main field crops throughout all of the agricultural portion of the region. The western half of the area contains but a small acreage adapted to these crops, and only small yields are obtained even in the more fertile valley lands. In the black-land regions of Williamson County, eastern Travis County, and much of Hays and Comal Counties may be found continuous fields of cotton and corn, with but little land devoted to forage or other crops. Oats is the principal small grain, but wheat is grown to some extent in the more elevated sections of the west and northwest. But little rice is now planted in this area. In recent years the limits of the rice-growing country have been gradually pushed more into the coast region or into the more humid territory to the east.

FORAGE CROPS.

The semiarid conditions which prevail throughout the greater part of the area make the different sorghum varieties the principal crops cultivated for forage. Cane, Kafir corn, and milo maize are extensively grown. In the region surrounding Austin, especially to the north and east, may be found extensive meadows of Johnson grass. Cane and Johnson grass are the most common kinds of hay on the local markets. Alfalfa is grown only to a very limited extent in any portion of the region. In a few localities it is grown without irrigation, but under irrigation it is a very profitable crop, some fields yielding as high as 7 to 8 tons per acre. In some localities in the southern part of the region a number of weedy grasses are cut for hay. Among these may be mentioned *Panicum texanum*, *Echinochloa colona*, and *Eleusine indica*. In some places the weedy grasses grow so abundantly in cornfields that a crop of hay is obtained following the harvesting of the corn. The western half of the area is devoted very largely to stock raising, and many of the 300 species of Texas native and introduced grasses may be found within the territory studied. The most important of the native species are *Bulbilis dactyloides*, *Bouteloua curtipendula*, and various species of Bouteloua and Andropogon. In certain portions of the more eastern part pastures of Bermuda grass are common, and in some places bur clover (*Medicago arabica*) furnishes valuable winter and early spring forage in the same pastures. Bermuda grass is the only species used extensively for lawns.

NATIVE GROWTH.

The greater portion of the territory lying west of the Colorado and west of a line connecting Austin, San Antonio, and Uvalde is a part of the low mountain country of the Edwards Plateau. A general idea in regard to the character of the vegetation may be obtained from the following quotation (4):

> Its structure and habits indicate that it is a xerophytic or dry-climate vegetation; but though this is true of it as a whole, conditions vary enough to give in some places, as in well-watered and sheltered canyons, a relatively luxuriant growth, while in other situations, as upon stony, arid slopes, there is the scantiest vegetation.

One of the most characteristic features of this area is the extensive cedar brakes along the Colorado from Austin to the northwest and along the upper waters of the Llano, Guadalupe, Medina, Nueces, and Frio Rivers.

The greater part of the region lying south of a line connecting Uvalde, San Antonio, and Skidmore is more level country, much of which was formerly occupied by extensive, open grasslands, but which now shows over much of the territory dense thickets of mesquite, cat's-claw, haujilla, huisache, whitebrush, platyopuntias, cylindropuntias, and similar types of vegetation (5 and 8).

It will thus be seen that the most productive portion of the territory lies largely to the east of a line connecting Austin, San Antonio, and Skidmore, which includes the southern extension of the black-land prairie and the timber belt of east Texas and extends through the Fayette Prairie to the edge of the coast prairie on the southeast.

RELATION OF DISEASES TO ENVIRONMENTAL FACTORS.

The direct relationship between the environmental factors, both edaphic and climatological, and the presence or absence of diseased conditions of the vegetation is very evident. No one condition due, perhaps, to the character of the soil is more noticeable than chlorosis. It affects practically the entire vegetation, being more evident in the truck fields, nurseries, and peach orchards. No appreciable effect on cotton and corn was noted. Since this chlorotic condition is limited very largely to the Cretaceous prairies and the lime soils of the Edwards Plateau, it is probably a lime chlorosis (38). It is known, too, that continued droughts cause plants to become chlorotic. This would explain in part the greater prevalence of this condition during the past year.

The downy and powdery mildews, which are quite common in the States farther north, are much less evident. The intense sunlight and the high temperatures are no doubt responsible for this. The spores of certain members of the Peronosporaceæ are known to germinate with difficulty in daylight and to exist only in shaded places where the temperatures are excessive. The amount of sunlight can be indicated and partially appreciated from the fact that the actual number of clear or partly cloudy days ranged during 1909 from

203 to 324 and the cloudy days from 41 to 162 (6) in various parts of the territory.

Injury to truck crops and nursery stock was especially severe where irrigation was practiced. Nematodes, which thrive best with an abundant supply of moisture, caused the formation of galls and the consequent improper functioning of the root system. While injury from this source is very general over the territory, it is more pronounced in irrigated fields. In similar places Rhizoctonia was abundantly present on potatoes, tomatoes, okra, and eggplants.

The excessive drought together with the high temperatures produces a languid condition in the aerial parts of the vegetation and thus renders them more susceptible to the attacks of fungi. This would account for the prevalence of leaf-inhabitating fungi, of which the genus Cercospora is an abundant representative. While it is not known that any correlation exists between the presence of this genus and high temperatures, yet it seems more than a coincidence, since Cercospora diseases are not nearly so abundant in the Northern States even in arid places or during seasons of drought.

PLAN OF THE WORK.

The collections for this survey were begun in the fall of 1908. These were entirely in the immediate vicinity of Austin, as were those of a part of the following season. The greater part of the work, of necessity, was performed in the months of July, August, and September, 1909, with a less amount during the succeeding months of that year. Then again, in the spring of 1910 a very considerable proportion of time was given to the field work.

Attention was given primarily to the diseases of cultivated plants, with an attempt to cover all the varieties of field, truck, nursery, and orchard crops. As much time as was possible was given to the consideration of greenhouse and ornamental plants, with reasonable emphasis upon shade and forest trees. The natural vegetation could not be entirely left out of account, however, because of the fact that the same organism may be the cause of diseased conditions in both wild and cultivated forms.

Notes on the symptomatology from field conditions were carefully made in the field at the time of collection. The value of accurate observations in the field in regard to the symptoms attending the progress of the various diseases can not be overestimated. Actual determinations of the causal organism would have been impossible in many instances without them.

Many of the facts which must be incorporated in our future pathologies can not be obtained from dry herbarium specimens, but must be recorded in the field while the patients are still alive and not after they are dead and have been stored away in herbarium sepulchres (30).

Within a few days after the collections were made a preliminary diagnosis was made in the laboratory and the notes were completed, accompanied by drawings and actual measurements when it was deemed advisable. In working over the material at a later date it was occasionally found necessary to change the previous determination. The time available permitted only a limited amount of culture work.

It is not to be supposed that the list is by any means complete. The territory, comprising over 30,000 square miles, is too large to be covered in the time which has been devoted to the work. In view of the diversity of crops grown in the various sections and the fact that similar crops may reach the same stage of maturity over a very considerable range at the same time, and that it has not been possible to make the work continuous throughout an entire year, the incompleteness will be properly emphasized. Enough, however, has been done to be very suggestive and indicative of the profitableness of further work.

DISEASES OF FRUIT TREES.

APPLE.

Black-rot (*Sphaeropsis malorum* Pk.).—This is the most common and serious disease of the apple (*Malus sylvestris* Miller) in this section. The foliage of the young plants in the nurseries was abundantly spotted and many twigs and limbs of the trees in orchards were seriously affected or entirely dead.

Specimens collected: Austin, 460, 1270, 1911; Kerrville, 1598; Boerne, 1651, 1652; Nursery, 2552; Stockdale, 2626; Gonzales, 2659, 2660.

Crown-gall (*Bacterium tumefaciens* Erw. Sm. and Townsend).—Trees about 8 years old were found seriously affected in one locality. A chlorotic condition preceded the death of the tree in each case.

Specimens observed: Llano, 1772.

Leaf-spot (*Cercospora mali* Ell. and Ev.).—The spots caused by this fungus are circular or subcircular, 2 to 5 mm. in diameter, silver gray on the upper surface with a narrow brown border, while on the under surface they are of a uniform brown. Badly affected leaves turn yellow and fall from the trees, or they may show extended brown areas of dead tissue in which the gray spots are quite conspicuous. The conidial tufts are very abundant and conspicuous on the gray centers of the upper surface, showing as minute black specks; they are inconspicuous on the brown ground of the under surface, but are fairly abundant. It may be noted that the original description characterizes the fungus as "epiphyllous" (18), while a careful examination of our specimens reveals the fact mentioned above. The range in size of the spores may be extended from 60 to 70 by 2 to 2.5 μ to 30 to 75 by 2 to 3 μ.

Specimen collected: Gonzales, 2660.

Powdery mildew (*Podosphaera leucotricha* (Ell. and Ev.) Salm.).—Apparently this disease is not common in this territory. The perithecia were abundant on the stems and leaves of the shoots growing from the base of trees.

Specimen collected: Austin, 1273.

APRICOT.

Die-back (*Valsa leucostoma* (P.) Fr.).—Pustules are formed on the apricot (*Prunus armeniaca* L.) just beneath the outer bark. At maturity these heaps rupture the bark and are exposed. While it has been reported on several species of the genus Prunus, Rolfs (42) mentions its occurrence also on the apricot. Our specimens show only the *Cytospora* stage.

A small orchard of plums, peaches, and apricots at Round Rock was seriously affected with this disease. The trees were about 8 years old. Some had been completely killed, while others were in a badly crippled condition.

Specimen collected: Round Rock, 2424.

Shot-hole (*Cylindrosporium padi* Karst).—The symptoms are the same as for the cherry "shot-hole," the foliage becoming perforated with circular openings.

Bacteria were present in abundance in the dead tissue of the spots, and were apparently responsible for the shot-hole effect. Only a few spores of the fungus were present.

Specimens collected: Austin, 1441; Nursery, 2551.

DATE PALM.

Smut (*Graphiola phoenicis* (Moug.) Poit.).—The smut of the date palm (*Phoenix dactylifera* L.) is confined to the leaves. It produces small protuberances, the sporocarps, on both surfaces. The entire leaflets or considerable portions from the tips downward may be brown and dead in case of severe infections. The sporocarps are dark gray or black, 0.2 to 0.8 mm. in diameter; when mature they rupture and extrude a mass of pale chocolate-brown spores. (Pl. VIII, fig. 1.)

An examination of the herbaria at Washington and at the New York Botanical Garden shows that it has previously been collected in Florida, Georgia, California, and Texas, and in conservatories in various Northern States. It has presumably been introduced from the Mediterranean countries where it is not uncommon (26).

Specimens collected: Beeville, 1849; Victoria, 2525; Falfurrias, 2453.

FIG.

Die-back (*Diplodia sycina* Mont. var. *syconophila* Sacc.).—Trees of the fig (*Ficus carica* L. var.) on which this disease is present have dead branches sometimes extending well down toward the trunk.

Underneath the bark, and often breaking through, are densely aggregated, black pycnidia, 350 to 400 μ in diameter, containing oval to elliptical, brown, two-celled spores, 18 to 35 by 9 to 14 μ.

Specimens collected: Beeville, 1843, Luling, 2242.

Leaf-blotch (*Cercospora fici* Heald and Wolf, 32).—This trouble appears late in the summer, forming large angular or irregular spots on the leaves. The spots are dirty brown above with a darker border and uniformly yellowish brown below. They vary in size from 1.5 to 10 mm., and when confluent may exceed this measurement. The conidiophores are borne in dense fascicles on the upper surface, 24 by 4 μ, and are dilute brown. The conidia are clavate, brown, 60 to 180 by 3 to 4.5 μ, and many septate. (Pl. II, fig. 8.)

The disease was very abundant in several localities, involving half the leaf surface and causing the leaves to fall.

Specimens collected: Victoria, 2501; Cuero, 2593 (type specimen); Flatonia, 2711; Hallettsville, 2784.

Root-knot (*Heterodera radicicola* (Greef) Mül.).—Both mature trees in the orchard and cuttings in the nursery are affected. Sometimes the roots near the surface of the ground are abundantly covered with the galls. On the older trees it is productive of no apparent injury.

Specimens collected: Beeville, 1848; Nursery, 2555.

Root-rot (*Ozonium omnivorum* Shear).—This trouble was observed in two nurseries in which it was very common and productive of serious loss among the cuttings.

Specimens collected: New Braunfels, 1678; Beeville, 1851.

Rust (*Physopella fici* (Cast.) Arth.).—The circular yellowish-brown sori about 1 mm. in diameter are produced in great numbers on the lower surface of the leaves. This disease appears in such abundance in late summer as to cause the yellowing of the leaves and much defoliation.

Specimens collected: Austin, 458; Falfurrias, 2458.

Rusty-leaf (*Cercospora bolleana* (Thm.) Speg.).—Small yellowish-brown spots 1 mm. or less in diameter appear on the foliage. The spots are more prominent and more yellow on the under surface than on the upper. When the spots are abundant a considerable amount of yellowing of the foliage results. This fungus is responsible for much early defoliation of fig trees. (Pl. II, fig. 7.)

Specimens collected: Austin, 1907; Luling, 2243; Seguin, 2320; Georgetown, 2363; Victoria, 2333; Cuero, 2601; Stockdale, 2643; Gonzales, 2674; Hallettsville, 2787.

ORANGE AND LEMON.

Damping-off (*Phoma* sp.).—This is the most serious trouble of the young plants of *Citrus trifoliata* L. in the nursery. Often a large percentage of the plants will be yellow or completely dry and dead. Near the ground level will be found a sunken area, 12 to 19 mm. long, on which are black dots, the pycnidia. These pycnidia are 150 to 200 μ in diameter and the spores are 5 to 7 by 3 μ. Several plants in the row may be dead and the adjacent plants apparently unaffected. The manner in which the fungus gains entrance is not known. Where the ground has been allowed to remain wet in low places the loss is greatest.

It is not possible definitely to assign this Phoma to any of the many species of Phoma described as occurring on citrus hosts.

Specimens collected: On *Citrus trifoliata* L.—Beeville, 1847; Floresville, 2855.

Leaf-spot (*Cercospora aurantia* Heald and Wolf, 32).—This fungus forms large spots, 6 to 10 mm. in diameter, and suborbicular except when they are marginal. They are dark brown in color with a lighter brown center, and are surrounded by a region of yellow which fades out into the green of the leaf. The conidiophores are formed on the under surface in small groups, brown, septate, 100 to 180 by 5 to 6 μ, showing plainly the points of attachment of the conidia. The conidia are dilutely colored, clavate, 75 to 135 by 4 to 5 μ, and many septate. (Pl. I, fig. 8.)

Specimen collected: On *Citrus aurantium sinensis* L.—Falfurrias, 2446 (type specimen).

Twig-blight (*Diplodia aurantii* Catt.).—The ends of the branches are killed and the black pycnidia which are formed beneath the bark at length protrude.

Specimens collected: On *Citrus trifoliata* L.—Nursery, 2546; Falfurrias, 2447.

Twig-blight (*Sphaeropsis malorum* Pk.).—This fungus has been found on blighted twigs and less frequently on the leaves of *Citrus trifoliata* L. The trouble was observed at the Austin station in a hedge which stood adjacent to some apple trees which were very seriously infected with black-rot.

Specimen collected: On *Citrus trifoliata* L.—Austin, 1324; Cuero, 2596; Falfurrias, 2447; Gonzales, 2677; Nursery, 2544.

Wither-tip (*Colletotrichum gloeosporioides* Penz.).—Both leaves and twigs are attacked. The leaves form brown areas which become somewhat grayish when the epidermis has been ruptured by the protruding acervuli.

The twigs may be killed back from the tip or along one side, causing the branches to be angular. Some trees were observed on which the disease had worked well down on the trunk.

Specimens collected: (1) On *Citrus limonum* Risso.—Austin, 1443. (2) On *C. aurantium sinensis* L.—Beeville, 1846 (doubtful).

PEACH.

Crown-gall (*Bacterium tumefaciens* Erw. Sm. and Townsend).—Just to what extent this trouble is present on the peach (*Amygdalus persica* L.) is not known. It was observed in two places only.

Specimens collected: Uvalde, 1939; Round Rock.

Die-back (*Valsa leucostoma* (P.) Fr.).—This is the most widely distributed and most serious trouble of the peach. (See also plum and apricot.) The entire tree may be killed or only the smaller branches. Orchards were observed in which nearly all the trees were dead, giving them a very characteristic silvery appearance. The bark is elevated in wartlike nodules covering dark-brown or black pustules. These at length are exposed on the surface. Our specimens show only the Cytospora stage.

Specimens collected: San Antonio, 1368, 3170; Kerrville, 1594, 1596; Boerne, 1644; Beeville, 1825; Elgin, 1873; Bastrop, 2038; Lockhart, 2080; San Marcos, 2122; Seguin, 2288; Round Rock, 2423; Victoria, 2521; Nursery, 2557; Stockdale, 2625; Gonzales, 2670; Flatonia, 2731; Yoakum, 2756.

Freckle (*Cladosporium carpophilum* Thm.).—This disease is general wherever the peach is grown, but was collected only a few times, since the peach crop was almost a complete failure in our territory.

Specimens collected: Austin, 1440; Beeville, 1838; Elgin, 1892; Georgetown, 2362.

Rust (*Tranzschelia punctata* (P.) Arth.).—The rust of the peach shows on the upper surface of the leaves as definite, circular, or subcircular, yellow spots which average about 1 mm. in diameter. The color of the spot on the under surface is the same, but the center of each is occupied by a minute yellowish-brown sorus.

This rust is abundant on peach foliage in some localities and causes defoliation in the latter part of the growing season.

Specimens collected: Austin, 202, 210, 454, 468; San Marcos, 2100; Nursery, 2560.

Shot-hole and leaf-spot (*Bacterium pruni* Erw. Sm.).—This disease is characterized in its typical condition by small, irregular or angular, purplish-brown spots, 2 to 5 mm. in diameter, which are crowded full of bacteria. In some of our collections the spots are less angular and lack the purple coloration, and the leaves show more or less chlorosis, but only bacteria were found in the dead spots. The diseased tissue frequently drops out, leaving perforations with dead marginal tissue. Rorer (43) has recently shown that the bacterium on the peach is probably identical with the one on the fruit and leaves of the plum, and we have collected the bacterial spots of both hosts from adjacent trees.

Specimens collected: San Antonio, 1365, 1399; Kerrville, 1592; Beeville, 1863; Elgin, 1888; Uvalde, 1933; San Marcos, 2101; Nursery, 2553; Gonzales, 2671.

Twig-blight.—In one locality peach trees were badly blighted, but no indication of die-back was observed. The dead twigs and branches showed an abundance of erumpent pustules which we have referred to *Fusarium sarcochroum* (Desm.) Sacc. It is not probable that this fungus was responsible for the disease.

Specimen collected: Falfurrias, 2456.

PEAR.

Bitter-rot canker (*Glomerella rufomaculans* (B.) Spaul. and Von Schr.).—The cankers caused by this fungus on the pear (*Pyrus communis* L.) have been found in both young and old orchards, and the disease is responsible for a considerable amount of injury. The specimens collected represent rather young twigs, and the cankers show as circular, elliptical, or irregular areas, 1 to 3 cm. long, or they may girdle the twig. In the young stages of development the bark is yellowish brown and slightly tumid and at length cracks away around the margin of the spot, leaving the dead bark more or less isolated. As the spots become older, more or less irregular ruptures are formed; these ruptures are frequently concentrically disposed, while the whole spot becomes somewhat sunken. Only the conidial stage of the fungus was found.

Specimens collected: Kerrville, 1599; Nursery, 2570; Gonzales, 2666; Flatonia, 2714.

Black-rot (*Sphaeropsis malorum* Pk.).—This disease has been observed to cause the characteristic cankers on the branches and the rotting of the fruit.

Specimens collected: Boerne, 1650; Austin, 2219; Georgetown, 2399(a); Nursery, 2572; Stockdale, 2629; Hallettsville, 2786.

Crown-gall (*Bacterium tumefaciens* Erw. Sm. and Townsend).—Collected in an orchard 6 or 8 years old, where about 75 per cent of the trees were dead.

Specimen collected: Llano, 1771.

Fly-speck (*Leptothyrium carpophilum* Pass.).—Minute black specks appear on the fruit, rendering it unattractive.

Specimens collected: Cuero, 2599; Hallettsville, 2794.

Fire-blight (*Bacillus amylovorus* (Burr.) Trev.).—This trouble is rather common in our territory and is responsible for a very considerable amount of damage to the pear trees, blackening the leaves and twigs.

Specimens collected: Austin, 1319; Brenham, 1460; Boerne, 1657; Elgin, 2001; Lockhart, 2081; San Marcos, 2123; Nursery, 2571; Cuero, 2600; Stockdale, 2628; Flatonia, 2713; Hallettsville, 2785.

Leaf-blight (*Cercospora minima* Tracy and Earle.)—This fungus produces irregular angular areas 1 to 10 mm. or more in diameter, brown or sometimes showing a grayish color in older portions, and frequently bounded by the principal veins. Spots may be few in number, or they may be sufficiently abundant to coalesce and nearly cover the leaf. Affected leaves frequently show a considerable amount of chlorosis, and many fall from the tree. In several localities the pear trees were nearly defoliated by this disease.

Specimens collected: Victoria, 2511; Nursery 2541; Cuero, 2605; Gonzales, 2707; Flatonia, 2712; Hallettsville, 2775; Falfurrias, 2454.

Leaf-spot (*Fabraea maculata* (Lev.) Atk.).—These spots are grayish brown, circular, and about 2 to 4 mm. in diameter. The black pycnidia are sparsely present on the upper surface.

Specimens collected: Austin, 364; New Braunfels, 1705; Llano, 1761; Stockdale, 2630.

Rust-spot (*Gymnosporangium* sp?).—These are the Phyllosticta-like infections of a rust. Small circular spots about 2 or 3 mm. in diameter are formed. They are brown with a very dark border and a central dark cluster of spermagonia.

Specimen collected: New Braunfels, 1689.

PERSIMMON.

Black leaf-spot (*Cercospora fuliginosa* Ell. and Kellerm.).—Affected leaves of the persimmon (*Diospyros* sp.) show circular or subcircular spots, 1 to 5 mm. in diameter, on the upper surface black with yellow border; on the under surface purplish black with indefinite border. With maturity of spots the centers on both surfaces may become brown or gray. In some cases the leaves turn yellow and fall, while in others extended brown, dead areas may be produced before the leaf is cast.

Our specimens differ from the original description only in the size of the spots (1 to 2 mm.).

Specimens collected: On *Diospyros kaki* L.—New Braunfels, 1706; Georgetown, 2361; Victoria, 2537; Stockdale, 2642. All specimens except 2361 are immature infections.

Leaf-spot (*Cercospora kaki* Ell. and Ev.).—The spots caused by this fungus (16) are yellowish brown below, with a very dark, almost black border, angular, 2 to 5 mm. in diameter or occasionally larger, the veins frequently marking the edge of the spot. On the upper surface the spots are darker brown with definite dark border, the center becoming grayish and showing numerous black conidial tufts. The affected leaves become chlorotic and fall.

The conidial tufts are epiphyllous, very abundant, almost black, and are composed of a dense aggregate of dark-brown, septate hyphæ, which extend 30 to 45 μ above the leaf surface and produce an aggregate having the appearance of a pseudoparenchyma for an equal distance below the leaf surface. Spores densely fasciculate, olivaceous, nearly straight, 3 to 5 septate, slightly clavate, cells sometimes two guttulate, 45 to 60 by 3 to 4 μ. (Pl. VII, fig. 3.)

Our specimens differ from the type in the size and character of the conidiophores and the colored, definitely septate spores.

The disease was very abundant in the localities where it was observed.

Specimens collected: On *Diospyros kaki* L.—Gonzales, 2651; Hallettsville, 2778.

Leaf-spot and fruit-rot (*Phyllosticta biformis* Heald and Wolf, 32).—The Mexican persimmon is affected by a fungus which produces black pycnidia in clusters upon the upper surface of the leaves. At first they are surrounded by the green tissue, but later a dark-margined spot 2 to 5 mm. in diameter is formed which is grayish with the black pycnidia distinctly visible. The pycnidia show on the fruit as minute pustules or slightly sunken spots, but are not very evident on account of the dark color of the fruit.

The pycnidia on the leaves are globose, 150 μ in diameter, ostiolate, and produce an abundance of hyaline, densely granular spores, 6 by 9 μ. (Pl. V, fig. 8.) The pycnidia on the fruit are much more flattened, are covered by the very thick epidermal wall, and contain spores similar to those on the leaf except that they are dilute brown in color. (Pl. V, fig. 9.)

Specimens collected: On *Diospyros texana* Scheele—Llano, 1739; Austin, 1548, 2896 (type specimen).

PLUM.

Bacterial leaf-spot (*Bacterium pruni* Erw. Sm.).—This is very probably the same organism which has been described in this report as occurring on the peach. It produces on the plum (*Prunus* spp.) irregular dark areas which sometimes show somewhat of a shot-hole effect. This diseased tissue, however, is crowded with bacteria.

Specimens collected: Uvalde, 1934; San Marcos, 2132.

Bacterial twig-canker.—The first indication of the disease on the twigs is the swollen longitudinal ridges of the cortex. In cross section this ridge shows numerous radial rifts extending outward to just below the epidermis. Eventually these radial rifts extend outward through the epidermis, and open longitudinal slits are produced. Bacteria are abundantly present in the cankered tissue. This may be the same organism which attacks the leaves and fruits. It has been previously reported (29) on the twigs. This is a very general trouble of the plums of this section. (Pl. VIII, fig. 3.)

Specimens collected: San Antonio, 1400; Austin, 1433; Seguin, 2290.

Die-back (*Valsa leucostoma* (P.) Fr.).—The symptomatology is identical with a trouble described under the same name as occurring on the peach. This, too, is present to a very considerable extent.

Specimens collected: Austin, 1439; Kerrville, 1597; Beeville, 1862; Seguin, 2285; Round Rock, 2422; Victoria, 2522; Stockdale, 2627; Gonzales, 2669.

Leaf-spot (*Phyllosticta congesta* Heald and Wolf, 32).—On the upper surface of the leaf are very numerous brown areolæ bounded by the veins of the leaf. The lower surface may not be discolored. These minute spots, 0.5 to 0.8 mm. in diameter, fuse. Each contains at its center a single black pycnidium 50 to 125 μ in diameter. The pycnidia contain globular or slightly oval clear spores 6 to 9 μ in diameter.

Specimen collected: Boerne, 1554 (type specimen).

Rust (*Tranzschelia punctata* (P.) Arth.).—The sori are frequently so abundant as to make the leaf seem uniformly chocolate brown. In one orchard the trees were very seriously affected.

Specimens collected: Austin, 450, 467; Cuero, 2595.

Shot-hole (*Cylindrosporium padi* Karst.).—This is the most general trouble of the plum, producing brown, circular areas which drop out, giving the " shot-hole " effect.

Specimens collected: Austin, 449, 1279, 1431; San Antonio, 1387; Brenham, 1461; Kerrville, 1593; Boerne, 1655; New Braunfels, 1704; Llano, 1758; Beeville, 1839, 1850; Elgin, 1882; Bastrop, 2039; Luling, 2244; Seguin, 2291; Georgetown, 2364; Round Rock, 2404; Victoria, 2508; Nursery, 2550; Cuero, 2598; Stockdale, 2620; Gonzales, 2672; Flatonia, 2734; Hallettsville, 2781.

Silver-twig.—The bark on the twigs becomes silvery in appearance. It is found to be infested with the brown septate filaments of a fungus, which grow just beneath the epidermis. The surface cells are raised so as to admit air, thus producing the silvery coloration.

Specimen collected: Falfurrias, 2457.

DISEASES OF SMALL FRUITS.

BLACKBERRY.

Leaf-spot (*Septoria rubi* Westd.).—This disease was observed in only two localities, as the blackberry (*Rubus* sp.) is not commonly cultivated in this section. The foliage was very copiously spotted.

Specimens collected: Llano, 1765; Floresville, 2857.

DEWBERRY.

Leaf-spot (*Septoria rubi* Westd.).—This fungus produces on the dewberry (*Rubus* sp.) purple-margined, grayish-centered spots, 1 to 2 mm. in diameter. It is abundantly present everywhere on both wild and cultivated forms.

Specimens collected: Austin, 375, 1268, 1318; San Antonio, 1364, 3150; Brenham, 1464; Boerne, 1658; New Braunfels, 1693; Luling, 2271; Seguin, 2323; Georgetown, 2360; Victoria, 2514; Gonzales, 2675; Flatonia, 2728.

Leaf-spot (*Cercospora rubi* Sacc.).—Large, brown, irregularly outlined areas characterize this disease. It is perhaps as generally present as the other leaf-spot and as destructive.

Specimens collected: Elgin, 1871; Bastrop, 2058; San Marcos, 2116; Luling, 2246; Round Rock, 2411; Victoria, 2504; Nursery, 2554; Cuero, 2594; Flatonia, 2728; Yoakum, 2763; Hallettsville, 2782.

GRAPE.

Black-rot (*Guignardia bidwellii* (Ell.) Viala and Ravaz).—This is the most common and most destructive disease of the grape (*Vitis* spp.). On the leaves it produces conspicuous, circular, brick-red spots, 2 to 8 mm. in diameter. Embedded in these areas are the black pycnidia. It also occurs very abundantly on the fruit, and in several cases observed the crop was a total failure, leaving dry, wrinkled mummies in place of the normal fruits. It was observed on several varieties of cultivated grapes, among them Thompson's Seedless and the Mission, also on several wild species, as *Vitis cinerea* Engelm., *V. candicans* Engelm., and *V. monticola* Buckl.

Specimens collected: Austin, 1276, 1326, 1412, 1560, 3056, 3062; San Antonio, 1336, 1391; Brenham, 1463; Hempstead, 1499; Kerrville, 1622; Boerne, 1645; Beeville, 1815, 1834, 1835; Bastrop, 2047; Luling, 2231, 2255; Georgetown, 2382; Round Rock, 2405; Gonzales, 2665; Flatonia, 2717; New Braunfels, 1696; Elgin, 1880; Lockhart, 2084; Yoakum, 2758; Hallettsville, 2776.

Downy mildew (*Plasmopara viticola* (B. and C.) Berl. and De T.).—A white, downy coating is produced in spots on the under surface of the affected leaves. It is not at all common in this section, having been observed but once.

Specimen collected: Austin.

Leaf-spot (*Cercospora viticola* (Ces.) Sacc.).—This fungus causes the formation of large, dark-brown, almost black, spots on the upper surface of the leaf which show below as much fainter brown areas. They are somewhat circular in outline and 2 to 10 mm. in diameter. (Pl. VIII, fig. 2.) The conidia formed on the lower leaf surface are clavate, more or less curved, brown, and 42 to 60 by 5 to 7 μ. (Pl. III, fig. 8.)

It becomes very abundant in the late summer, causing the leaves to be badly spotted and producing considerable defoliation. The disease is present on both wild and cultivated forms.

Specimens collected: Austin, 251; Tyler, 1551; Boerne, 1645; New Braunfels, 1695; Llano, 1762; Beeville, 1864; Bastrop, 2027; San Marcos, 2108; Luling, 2250; Seguin, 2306; Victoria, 2513; Nursery, 2561; Cuero, 2591; Stockdale, 2633; Gonzales, 2657, 2692; Flatonia, 2732; Hallettsville, 2777, 2791, 2793; Floresville, 2852.

Sooty mold (*Fumago vagans* (?) P.).—The upper leaf surface is coated over with a black, sooty covering. Observed in only a single locality.

Specimen collected: Luling, 2263.

STRAWBERRY.

Leaf-spot (*Mycosphaerella fragariae* (Tul.) Lindau).—When the spots first appear on the leaves of the strawberry (*Fragaria* sp.) they are brownish or reddish, becoming circular, 3 to 6 mm. in diameter, with a dead white or grayish center and a broad, purplish margin.

Specimens collected: Austin, 1314; Beeville, 1845.

DISEASES OF TRUCK CROPS.

ASPARAGUS.

Blight (*Cercospora asparagi* Sacc.).—On the cladophylls and branches of asparagus (*Asparagus officinalis* L.) diffuse grayish-brown spots are produced. Densely clustered over these areas are dark fascicles of conidiophores and conidia. Large branches, especially on the older parts of the plant, are killed.

Specimens collected: Victoria, 2505; Floresville, 2853.

Rust (*Puccinia asparagi* DC.).—The rust of asparagus was observed in only one locality. This can be explained by the fact that asparagus is rarely cultivated in the territory covered by this survey.

Specimens collected: Austin, 383, 1916, 2946.

BEAN.

Anthracnose (*Colletotrichum lindemuthianum* (Sacc. and Magnus) Briosi and Cav.)—The anthracnose is generally prevalent on beans (string or snap bean, *Phaseolus vulgaris* L.) throughout our territory. Only a few specimens were collected, since the bulk of our field work was done after most of the crop had been harvested. Records from pickings in one garden (Golden wax) in Austin were obtained with the following result: Picking May 17, no anthracnose; May 21, 4.35 per cent; May 26, 100 per cent.

The rapid increase between May 21 and 26 was favored by an abundance of rain.

In some localities the Kentucky Wonder, a climbing variety with green pods, is seriously affected. The foliage is little affected by this disease, but bacterial blight is often present and may be erroneously diagnosed as anthracnose.

Specimens collected: Austin; San Antonio, 1395; Llano, 1764.

Stem anthracnose (*Colletotrichum caulicolum* Heald and Wolf, 32).—A destructive disease of the Kentucky Wonder bean, observed in a single locality, was found to be due to this fungus. A superficial examination of the affected field showed a considerable number of plants which were completely dead, others were dying, while still others that were less affected exhibited more or less chlorosis of the foliage. An examination of the root system showed it to be in normal condition, while the only deviation from normal in the foliage was the marked chlorosis.

An examination of the stems showed that brown, depressed cankers were present an inch or more above the ground level. The cankers were longitudinally elongated (20 to 40 mm.), more or less irregular, rough and frequently somewhat fissured or open. On the chlorotic plants the canker occupied one side of the stem, on the plants that were dying the stem was nearly girdled, and on all dead plants examined the canker had completely encircled the stem. (Pl. VI, fig. 8.)

Acervuli do not occur on the young cankers, but nearly mature or complete cankers show a few which are visible to the naked eye as small black specks (Pl. VI, fig. 8 (*a*), while they become much more abundant on the stems of plants which have been dead for a few days.

Acervuli scattered, black when mature, low convex, 150 to 250 μ in diameter (Pl. VI, fig. 6); setæ abundant, brown, septate, blunt pointed or sometimes tapering, 60 to 120 by 3.5 to 4 μ; conidiophores nearly half the length of the setæ, cylindrical, hyaline, generally one or two septate; spores falcate, hyaline, granular, and 18 to 30 by 3.5 to 4 μ. (Pl. VI, fig. 7.)

Two species of Colletotrichum have previously been reported as occurring on Phaseolus species. *Colletotrichum lindemuthianum* (Sacc. and Magnus) Briosi and Cav. is the cause of the common anthracnose. It may be noted that this species is still retained under the genus Gloeosporium by Lindau (37), since the production of setæ is of such rare occurrence. It is known to attack seeds, pods, leaves, and stems. *Colletotrichum lagenarium* (Pass.) Ell. and Hal., has been reported as occurring on different species of beans by two different writers (28 and 50). The report rests on the assumption by Halsted that the two above-mentioned species are identical.

The identity of these two species is not considered sufficiently established (37), so they must still be treated as separate. A comparison of our species with the two mentioned may be made as follows:

TABLE V.—*Comparison of characters of species of Colletotrichum.*

Characters.	C. caulicolum.	C. lindemuthianum.	C. lagenarium.
Conidiophores.	30 to 60 by 3 μ	45 to 50 μ	15 to 20 by 3 to 5 μ.
Spores	Falcate, pointed, 18 to 30 by 3.5–4 μ.	Oblong, straight or slightly curved, rounded ends, 15 to 19 by 3.5 to 5.5 μ.	Ovate oblong, often inequilateral, rounded ends, 16 to 18 by 5.6 μ.
Setæ	Abundant, terete, generally blunt pointed.	Few or absent, terete, fusoid	Few or absent, terete, fusoid.

A comparison of the above characters will make it plain that our specimens represent a new species, which has been described in Mycologia (32).

Specimen collected: Uvalde, 1963 (type specimen).

Bacterial blight (*Bacterium phaseoli* Erw. Sm.).—This disease is common on the foliage of both string and Lima beans, but the symptomatology is somewhat different in each. On the leaves of string beans it causes extended, brown, dead areas which appear near the margin or tip and advance into the leaf, or the original foci may be removed from the margin and so cause a conspicuous spotting which is generally accompanied by more or less chlorosis. On the Lima bean the progress of the disease is often marked in the same way, but frequently small circular or somewhat irregular reddish pustules are present. These pustules are found filled with an abundance of bacteria. This symptom has been observed by the senior writer, in Nebraska, and a somewhat similar condition is reported by Clinton (7). A bacterial rot of the pods, due to the same organism which affects the leaves, and affecting both green-podded and yellow-podded varieties, has been observed. It appears first as small watery or pellucid areas along the sutures, which spread and give an opportunity for the inroads of fungi. This bacteriosis of the pods is especially favored by frequent and abundant rains.

Specimens collected: (1) On *Phaseolus vulgaris* L.—San Antonio, 1406 (leaves and pods); Austin, 1427; Stockdale, 2641. (2) On *P. lunatus* L.—Austin, 1540; San Antonio, 1784; Uvalde, 1932.

Chlorosis.—In one truck garden Kentucky Wonder beans were found suffering from chlorosis to a marked extent. The plants were decidedly chlorotic and had made only a stunted growth. The roots were sound, and neither fungous nor bacterial lesions could be found on the aerial portions. A general examination of the field showed, however, that the hypocotyls extended 4 to 6 inches below the surface of the ground. This abnormal length was due to deep planting with subsequent ridging of the rows to provide irrigation furrows between rows. It seems probable that this abnormal depth of the roots, combined with excessive irrigation was the cause of this trouble.

Specimen observed: Uvalde, 1965.

Leaf-spot (*Cercospora canescens* Ell. and Martin).—A leaf-spot disease of the Lima bean caused by the above fungus was observed in a single locality. The spots are subcircular or angular, 1 to 5 mm., with a gray center surrounded by a narrow, definite, reddish-brown border, slightly less pronounced upon the under surface. The spots are isolated, either few or abundant, and do not cause chlorosis to any extent. (Pl. IX, fig. 3.)

Conidiophores are equally abundant on both surfaces, densely cespitose (Pl. II, fig. 5), brown below, becoming hyaline tipped, several septate, irregular, nodose in distal portion, 60 to 105 by 3 to 4.5 μ; spores hyaline, slender club shaped, straight or curved, one to many septate, 100 to 210 by 3 to 4.5 μ, or sometimes as short as 30 μ and rarely equaling 6 μ in diameter. (Pl. II, fig. 6.)

Six different species of Cercospora have been described as affecting the various species of Phaseolus. The sizes of the spores of these species are as follows: *Cercospora phaseolina* Speg., 20 to 45 by 3 to 3.5 μ; *C. phaseolorum* Cke., 40 to 50 by 4 μ; *C. columnaris* Ell. and Ev., 40 to 60 by 5 μ; *C. cruenta* Sacc., 60 to 80 by 4 μ; *C. canescens* Ell. and Martin, 100 to 120 by 5 to 6 μ; *C. olivascens* Sacc., 130 to 150 by 4 to 4.5 μ.

It may be noted that our specimens show a size of spore different from that recorded for *C. canescens* Ell. and Martin, but an examination of the specimens in the herbarium of the New York Botanical Garden shows that they should be referred to this species.

Specimen collected: Georgetown, 2365.

Powdery mildew (*Erysiphe polygoni* DC.).—This fungus forms a dense white coating on the leaves causing them to become yellow and dry. A crop grown in September was a total loss, and the June crop was seriously affected in the one locality where it was observed.

Specimen collected: San Antonio, 3149.

Root-rot (*Ozonium omnivorum* Shear).—This trouble caused the death of a large portion of a plat of snap beans in a truck garden in a single locality. Black-eyed peas occupied an adjacent plat, and the disease affected portions of both, beginning at the end and advancing to form a distinct semicircular area, about half of the semicircle being occupied by each species.

Specimen collected: Uvalde, 1944.

Root-rot (*Rhizoctonia* sp.).—A few plants of "frijole" beans in an irrigated field were affected with this disease.

Specimen collected: On Brack ranch, 30 miles west of Cotulla, 2185.

Rust (*Uromyces appendiculatus* (P.) Lk.).—This disease was observed in an irrigated truck garden, and also in the University garden at Austin. The maximum development of the trouble was not reached till after most of the crop had been harvested, so that only a small amount of loss resulted.

Specimens collected: Uvalde, 1947, 1948; Austin, 3129.

BEET.

Leaf-spot (*Cercospora beticola* Sacc.).—The presence of the subcircular, dry, pallid blotches on the leaves of the beet (*Beta vulgaris* L.) was very commonly observed. The disease was not, however, sufficiently abundant to cause a great amount of injury.

Specimens collected: Austin, 369, 1322, 1429, 3042; San Antonio, 1376, 3177; New Braunfels, 1716; Sabinal, 1967; Georgetown, 2366.

Root-knot (*Heterodera radicicola* (Greef) Mül.).—This trouble was quite common, especially in irrigated gardens or low moist ground, but was not serious.

Specimens collected: Austin, 3137; San Antonio, 3148.

CABBAGE.

Leaf-spot (*Cercospora bloxami* B. and Br. (?)).—The fungus which is the cause of this leaf-spot on the cabbage (*Brassica oleracea capitata* L.) produces pale, subcircular areas 1 to 5 mm. in diameter surrounded by a slightly raised, faintly purple border. Conidial tufts amphigenous, more conspicuous in the center of the spots. Conidiophores densely tufted, pale brown, sparingly septate, 60 to 120 by 4 to 4.5 μ. Conidia long-clavate, tapering, straight or much curved, hyaline or faintly smoky, many septate, 3 to 5 by 100 to 270 μ. Our specimens are somewhat doubtfully referred to this species, since the published descriptions include no information concerning size of conidiophores or spores, and the original specimens showed no spores (10). Present only on languid leaves and not sufficiently abundant to cause any material injury.

Specimen collected: Georgetown, 2367.

CARROT.

Rhizoctonia root-rot (*Corticium vagum* B. and C. var. *solani* Burt.).—The roots of the carrot (*Daucus carota* L.) become covered by white, ropy strands of the fungus. No serious rotting was observed to result.

Specimen collected: San Antonio.

CASABA.

Sooty mold (*Fumago vagans* (?) P.).—The mycelium on casaba (*Cucumis melo* L.) forms a black or brown sooty crust on the leaves, most abundant on the upper surface. Plant lice were abundant on the foliage.

Specimen collected: New Braunfels, 1725.

CUCUMBER.

Root-knot (*Heterodera radicicola* (Greef) Mül.).—Vines of the cucumber (*Cucumis sativus* L.) which were affected remained stunted and later were killed. In one field about one-third of the plants were dead by the time they should have been bearing.

Specimens collected: Austin, 3138; San Antonio, 3146.

EGGPLANT.

Fruit-rot (*Gloeosporium melongenae* Ell. and Hals.).—The fruits of the eggplant (*Solanum melongena* L.) affected with fruit-rot show brown, sunken areas over which are scattered the black acervuli. With the progress of the disease the fruits are completely rotted.

Specimens collected: Austin, 1906; Uvalde, 1943.

Fruit-rot (*Colletotrichum* sp.).—On the diseased areas are very dense aggregates of black acervuli, varying in diameter from 100 to 250 μ. Brown, taper-pointed, septate setæ, 100 to 150 by 5 μ project profusely from all parts of the acervulus. The conidiophores are slightly club shaped, 12 to 15 by 3 to 4 μ, and the spores are 30 to 36 by 3 to 4 μ, clear, guttulate, falcate, frequently blunt on one end. This has not been definitely associated with any described species and may represent a new species. *Gloeosporium melongenae* was also present on the same fruits, which were completely destroyed by the combined action of the two fungi.

Specimens collected: Austin, 1915, 2430.

Root-rot (*Rhizoctonia* sp.).—The plants which are affected remain dwarfed for a time and then wilt and die. The stems up to the ground level and a little above are sunken and have little wartlike nodules. The loss was quite serious in an irrigated garden where it was observed.

Specimen collected: San Antonio, 1329.

GLOBE ARTICHOKE.

Leaf-spot (*Cercospora obscura* Heald and Wolf, 32).—The presence of this disease on the globe artichoke (*Cynara scolymus* L.) is made manifest by the circular gray spots, varying in diameter from 1 to 2 mm., which appear on the upper surface of the leaf in great numbers. Each spot has a faint brown border, with the tufts of conidiophores on the upper surface. Since the lower surface of the leaf is covered by a silvery tomentum the spots appear as slightly darker areas.

The conidiophores are in groups of from four to seven, epiphyllous, nonseptate, varying in length from 50 to 80 μ, and in width from 4 to 5 μ, brown, with a hyaline tip. The conidia are cylindrical in shape, 40 to 74 by 3 to 4 μ, three to four septate, dilutedly colored, and straight or curved. (Pl. III, fig. 6.)

Specimen collected: Beeville, 1861 (type specimen).

MUSKMELON.

Anthracnose (*Colletotrichum lagenarium* (Pass.) Ell. and Hals).—The appearance of large, dead, brown patches on the leaf of the muskmelon (*Cucumis melo* L.) marks the presence of this fungus.

Specimen collected: Beeville, 1827.

Leaf-blight (*Alternaria brassicae* (B.) Sacc. var. *nigrescens* Pegl.).—Large brown spots are formed on the foliage, attaining 1 cm. in diameter. When numerous the leaves turn brown and curl. It was observed to be sufficiently abundant in one field to cause a very serious loss, and has been reported to be a very destructive blight south of our territory.

Specimens collected: Austin, 1425, 3136; Hallettsville, 2904.

Root-knot (*Heterodera radicicola* (Greef) Mül.).—This trouble was observed in an irrigated garden where the plants remained stunted for a time, and at length succumbed. The crop was an entire loss. (Pl. IX, fig. 2.)

Specimens collected: San Antonio, 1327; Austin, 3135.

OKRA.

Root-knot (*Heterodera radicicola* (Greef) Mül.).—This disease is common on okra (*Abelmoschus esculentus* Moench.), but was observed to be the cause of serious loss only in an irrigated garden.

Specimens collected: San Antonio, 1394; Llano, 1770; Stockdale, 2631; Yoakum, 2768.

Root-rot (*Ozonium omnivorum* Shear).—Observed in a single locality where the plants were stunted and chlorotic.

Specimens collected: New Braunfels, 1711, 1712.

Root-rot (*Rhizoctonia* sp.).—This fungus caused the destruction of the smaller roots and the constriction of the stem at the ground level.

Specimen collected: San Antonio, 1330.

PARSLEY.

Root-knot (*Heterodera radicicola* (Greef) Mül.).—This trouble was observed on parsley (*Petroselinum sativum* Hoffm.) in a single locality.

Specimen collected: San Antonio, 3144.

Root-rot (*Ozonium omnivorum* Shear).—This diseased condition is characterized by the same symptomatology as when this fungus is present on other herbaceous hosts.

Specimen collected: San Antonio, 3143.

PARSNIP.

Rhizoctonia root-rot (*Corticium vagum* B. and C. var. *solani* Burt).—The white strands of fungous filaments surround the roots of the parsnip (*Pastinaca sativa* L.), but do not cause any material loss.

Specimen collected: San Antonio.

PEA.

Powdery mildew (*Erysiphe polygoni* DC.).—This fungus forms a white coating on the leaves and pods of the pea (*Pisum sativum* L.), causing them to become brown and dry. It is probably quite common throughout the territory.

Specimen collected: Austin, 3130.

PEPPER.

Anthracnose (*Colletotrichum nigrum* Ell. and Hals.).—The fruit of the pepper (*Capsicum annuum* L.) sometimes shows large, brown, sunken areas. The black acervuli are either scattered over the diseased spot or zonately arranged.

Specimen collected: Uvalde, 1951.

Bacterial leaf-spot.—The leaves have small, elevated, brown spots from 0.5 to 1 mm. in diameter. The leaf tissue between them is more or less chlorotic. Each pustule is crowded full of bacteria. No record has been found of a pepper disease due to these organisms.

Specimen collected: Uvalde, 1950.

Fruit-spot.—The sweet pepper is very commonly spoiled by the formation of large, dry, brown, more or less sunken areas on the side exposed to the sun. An Alternaria was found to be present, but inoculations into healthy fruits failed to reproduce the spots. This would suggest that the trouble is physiological and that the fungus associated with it is merely a saprophyte.

Specimens collected: Austin, 1536; San Antonio, 1783; New Braunfels, 1683.

Leaf-spot (*Cercospora capsici* Heald and Wolf, 32).—Leaves infested with this fungus form spots 1 to 7 mm. in diameter, mostly circular or subcircular. The spots are raised on the upper surface, brown at first, later becoming grayish brown. They are margined by a very definite darker zone, outside of which is a more or less extended halo of yellow. Where the spots are abundant, the leaves become chlorotic, then wilt and fall. The conidiophores are borne on both surfaces, brown, grouped in clusters of 10 to 15, 30 to 60 by 4.5 to 5.5 μ, and are occasionally septate. The conidia are borne on the tips, are dilutely brown, 75 to 125 by 4 to 5 μ, clavate, generally straight, and several septate. (Pl. IV, fig. 7.)

Specimen collected: Cuero, 2592 (type specimen).

POTATO.

Early blight (*Alternaria solani* (Ell. and Martin) J. and G.).—This was observed to be abundant on the potato (*Solanum tuberosum* L.) in several localities, producing large, irregular, brown spots.

Specimens collected: San Antonio, 1402, 3145; Kerrville, 1601; Austin, 3134.

Rhizoctonia disease (*Corticium vagum* B. and C. var. *solani* Burt).—The stems are cankered and have the characteristic pustules. The tubers also are very frequently destroyed, especially in irrigated gardens, during a rainy period. (Pl. X, fig. 2.)

Specimen collected: San Antonio, 3147.

Scab (*Oospora scabies* Thax.).—Observed in a single locality.

Specimen collected: San Antonio, 1402a.

RADISH.

Powdery mildew (*Erysiphe polygoni* DC.).—The leaves of the radish (*Raphanus sativus* L.) at first are covered with a powdery coating, becoming chlorotic and at length entirely dry.

Specimen collected: Cotulla, 2931.

SPINACH.

Leaf-spot (*Cercospora beticola* Sacc.).—This fungus on spinach (*Spinaciæ oleracea* L.) forms numerous subcircular areas, 1 to 3 mm. in diameter, with a slightly raised margin. The dark, amphigenous conidiophores cause the larger part of the diseased area to be brown. No record has been found of the occurrence of a Cercospora on this host, but as the symptomatology and size of conidiophores and spores are similar to *C. beticola*, and as the hosts are closely related, it is in all probability the same species.

Specimen collected: Austin, 3039.

SQUASH.

Anthracnose (*Colletotrichum* (?) *nigrum* Ell. and Hals.).—This fungus was found on squash (*Cucurbita* spp.) in the same field with the Colletotrichum, which was attacking sweet peppers, and agrees with it morphologically. From this it may be inferred that it is probably the same. On the fruits are formed numerous dark acervuli, often concentrically arranged.

Specimen collected: On cymling (*Cucurbita pepo* L.)—Uvalde, 1941.

Fruit-rot (*Botrytis cinerea* P.).—In one field the young fruits were seriously affected with this fungus. It apparently starts on the decaying flower and in a few days the entire fruit is destroyed and covered by a black, fungous growth. (Pl. X, fig. 3.)

Specimen collected: On cymling (*Cucurbita pepo* L.)—Austin.

Leaf-spot (*Macrosporium* sp.).—Rounded dry areas surrounded by an area of yellow are formed on the leaves. The center may become grayish with age. We were not able definitely to associate the fungus with any given species.

Specimen collected: On cushaw (*Cucurbita moschata* Duch.)—Beeville, 1840.

Leaf-spot (*Cercospora cucurbitae* Ell. and Ev.).—Rounded brown spots 1 to 4 mm. in diameter, becoming whitish with an elevated border, appear on the foliage. The characters of the conidiophores and conidia agree with the original description (17), except in size, the conidiophores being sometimes 150 μ long and the conidia reaching 300 μ and being plainly multiseptate.

Specimen collected: On cushaw (*Cucurbita moschata* Duch.)—Hempstead, 1498.

Rhizoctonia root-rot (*Corticium vagum* B. and C. var. *solani* Burt).—A very considerable loss in an irrigated field was due to this fungus, the entire root system being destroyed.

Specimen collected: On cymling (*Cucurbita pepo* L.)—San Antonio, 3151.

Root-knot (*Heterodera radicicola* (Greef) Mül.).—This was observed in only two localities, but it is probably quite widely distributed.

Specimens collected: On cymling (*Cucurbita pepo* L.)—New Braunfels, 1685; San Antonio, 3152.

SWEET POTATO.

White-rust (*Albugo ipomoeae-panduranae* (S.) Swingle).—This fungus on the sweet potato (*Ipomoea batatas* (L.) Poir.) produces clusters of white pustules on the under surface of the leaves. In young infections the leaves show yellow spots on the upper surface, and as the disease progresses the tissue becomes brown and dead. In severe infections the leaves may show considerable chlorosis in the young stages and in later stages extended brown areas which have been killed.

Specimens collected: San Antonio, 1781; Llano, 1752; Beeville, 1821; Elgin, 2015; Uvalde, 1953; Nursery, 2562; Yoakum, 2765.

Root-rot.—According to the reports of gardeners, root-rot is very prevalent and destructive in certain localities. All field work was done previous to the harvesting of the crop, and no specimens were obtained, hence it is impossible to say which of the various rot-producing fungi are prevalent.

TOMATO.

Leaf-spot (*Septoria lycopersici* Speg.).—This trouble on the tomato (*Lycopersicon esculentum* Mill.) was observed to be especially serious in seed beds. The young leaves become thickly covered with small angular spots having a grayish center and a darker colored border. The disease was not so serious on mature plants.

Specimens collected: Austin, 370, 1307; Llano, 1766; Uvalde, 1952, 1956; Nursery, 2556.

Rhizoctonia disease (*Corticium* sp.?).—The symptomatology is very much the same as in diseases of other hosts caused by the same organism.

Specimens collected: San Antonio, 1380, 3142; Austin, 3139.

Root-knot (*Heterodera radicicola* (Greef) Mül.).—Probably this is a very general trouble. In several large fields about one-third of the plants had been killed and the others were so stunted that the crop was a complete failure. This is the most serious trouble on tomatoes in the irrigated truck gardens. (Pl. IX, fig. 1.)

Specimens collected: San Antonio, 1328, 3141; Llano, 1769; Beeville, 1842; Elgin, 2011; Uvalde, 1949; Austin, 3132.

TURNIP.

Downy mildew (*Peronospora parasitica* (P.) De By.).—The oldest leaves of the affected turnip plants (*Brassica rapa* L.) were dry and dead, while those higher up on the plant were chlorotic either entirely or in part. Such leaves are copiously downy white on the lower surface. This disease was very abundant in a truck garden, the only place where it was observed.

Specimen collected: Austin, 3040.

Powdery mildew (*Erysiphe polygoni* DC.).—This fungus causes the characteristic white appearance of the leaves, which at length become yellow and dry.

Specimen collected: Cotulla, 2930.

WATERMELON.

Blossom-end blight and rot.—A very common and destructive disease of the watermelon (*Citrullus vulgaris* Schrad.) is characterized by the blighting and atrophy of the blossom end of the fruit followed by the rotting of the entire fruit. The blossom end turns brown, dries more or less, and remains smaller than the remainder of the fruit. (Pl. X, fig. 1.) The trouble may begin very soon after the blossom stage and the affected fruit may never reach any considerable size, or the trouble may begin later and the fruit may reach nearly normal size before it is destroyed. In some cases observed it was impossible to find any fungus present in the blighted portion, but in the majority of cases the fruit was invaded by a Fusarium which transformed the melon into a soft, rotting mass.

The Fusarium present comes to the surface on the side of the melon in contact with the soil, and in specimens kept in a damp atmosphere conspicuous pinkish spore tufts are produced over the surface. Only macroconidia, 18 to 24 by 3 μ, falcate, and two septate, have been observed.

The definite etiology of this disease is not known, and it can only be suggested that the blighting is due first to the excessive transpiration at times when root activity is not sufficient to meet the loss, and that the fungus gains an entrance into the dead tissue and then spreads throughout the remainder of the fruit.

This is the most serious trouble of the watermelon and is generally prevalent. The loss may be from 25 to 75 per cent in many cases. The very general prevalence of this disease is such that a more detailed investigation should be undertaken.

Specimens collected: New Braunfels, 1690; Austin, 1870; Beeville, 1817 (collections do not represent the prevalence).

Leaf-spot (*Cercospora citrullina* Cke.).—The oldest leaves of the plant are the first to show these circular spots, 2 to 4 mm. in diameter.

Each is bordered by a dark-brown or purplish zone beyond which is an area of faint yellow. The mature spots have grayish centers.

Specimens collected: Hempstead, 1487; Beeville, 1816; Luling, 2245; Victoria, 2338; Alice, 2494; Nursery, 2545; Stockdale, 2634; Flatonia, 2733; Yoakum, 2764; Hallettsville, 2903.

Sooty mold (*Capnodium* (?)).—The stems, petioles, and leaves become covered over with a sooty, black coating, more abundant on the older parts of the plant. On the late crop in some localities it results in the death of the entire plant. Probably the injury is mostly due to plant lice and the fungus is merely secondary. Dark-brown pycnidia 90 to 120 μ are formed on the surface. The spores are clear, elongated, 5 to 6 by 3 μ, and stream out in tortuous, rope-like strands.

Specimens collected: Elgin, 2000; Bastrop, 2048; Cotulla, 2202.

DISEASES OF CEREALS.

BARLEY.

Covered smut (*Ustilago hordei* (P.) Kellerm. and Swingle).—This smut was present in considerable quantities in barley (*Hordeum* sp.) grown near San Antonio in 1909.[1]

Loose smut (*Ustilago nuda* (Jens.) Kellerm. and Swingle).—Barley is not grown as a field crop in the territory covered by this survey, and this material was collected from a plat on the University campus. The brown spore masses occur on the spikelets, which fall away, leaving only the naked rachilla.

Specimens collected: Austin, 3099, 3118.

Rust (*Puccinia graminis* P. var. *hordei* Freeman and Johnson).—This rust was prevalent on barley near San Antonio in 1909.[1]

CORN.

Rust (*Puccinia sorghi* S.).—This disease on corn (*Zea mays* L.) is quite general in its distribution but was not observed to be sufficiently abundant to cause any serious loss except in one field of late corn at Flatonia.

Specimens collected: Austin, 1557; Kerrville, 1584; Boerne, 1649; New Braunfels, 1679; San Antonio, 1782; Elgin, 1893; San Marcos, 2102; Gonzales, 2676; Flatonia, 2719; Yoakum, 2751.

Smut (*Ustilago zeae* (Beckm.) Ung.).—No loss of any consequence can be attributed to smut, as it was rarely found in abundance. At Uvalde a field of corn was observed which had 40 to 50 per cent of the ears destroyed, but in all other localities smut was rare.

Specimens collected: Austin, 1450; Kerrville, 1583; New Braunfels, 1709; Uvalde, 1962; Hondo, 1997; Cotulla, 2216; Seguin, 2299; Flatonia, 2720.

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[1] Notes from E. C. Johnson, Bureau of Plant Industry, U. S. Dept. of Agriculture.

OATS.

Crown-rust (*Puccinia coronata* Cda.).—Rust on oats (*Avena sativa* L.) was not uncommon, but most of our field work was completed after harvest time. Collected from a single locality.

Specimen collected: San Antonio, 1389.

Stem-rust (*Puccinia graminis* P. var. *avenae* Eriks. and Henn.).—Also collected in a single locality.

Specimen collected: San Antonio, 1359.

Smut (*Ustilago avenae* (P.) Jens.).—The loose smut of oats is not uncommon in this territory. Extensive loss has been reported from some sections. Fields were observed with 10 to 15 per cent of the heads destroyed. Inquiry revealed the fact that seed treatment is not practiced to any great extent.

Specimens collected: Austin, 1001, 3117; San Antonio, 1358; San Marcos, 974.

RYE.

Leaf-rust (*Puccinia rubigo-vera* (DC.) Wint. var. *secalis* Carl.).—Rye (*Secale cereale* L.) is not generally grown in this region. Leaf-rust was abundant on plats at the San Antonio Experiment Farm in 1908 and 1909.[1]

WHEAT.

Floret sterility (*Stemphylium tritici* Patterson).—This disease was found abundantly in 1909 on the leaves and sterile spikelets of wheat (*Triticum aestivum* L.) near San Antonio. It is closely associated with rusts in causing floret sterility of wheats.[1]

Leaf-rust (*Puccinia rubigo-vera* (DC.) Wint. var. *tritici* Carl.).—This rust is abundant on wheat almost every year in the locality of San Antonio and was especially prevalent in 1908 and 1909.[1]

Leaf-spot (*Cladosporium graminum* Cda.).—This causes brown to black spots on the leaves of wheat and is often found in sterile florets. It was abundant in the San Antonio region in 1908 and 1909.[1]

Loose smut (*Ustilago tritici* (P.) Jens.).—The dusty olive-brown spore masses appear on the heads or spikelets, destroying them entirely and leaving only the naked rachis.

Specimen collected: Austin, 3115.

Stem-rust (*Puccinia graminis* P. var. *tritici* Eriks. and Henn.).—Wheat is not extensively grown in this section, but the rust was found abundantly present on it wherever it was grown.

Specimens collected: San Antonio, 1366; Kerrville, 1602.

Stinking smut (*Tilletia tritici* (Bjerk.) Wint.).—Found sparingly near San Antonio in 1909.[1]

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[1] Notes from E. C. Johnson, Bureau of Plant Industry, U. S. Dept. of Agriculture.

DISEASES OF FORAGE CROPS.

ALFALFA.

Leaf-spot (*Cercospora medicaginis* Ell. and Ev.).—This disease on the leaves of alfalfa (*Medicago sativa* L.) shows as dark-brown, circular or subcircular areas, 1 to 5 mm. in diameter. The spots on a single leaflet may vary in number from one to nine and with a predominant size of 2 to 3 mm. When the spots are few in number each is surrounded by an indefinite zone of yellow, and when abundant the entire intervening areas become yellow. Many of the affected leaflets fall from the plant, thus producing considerable defoliation.

This disease was first reported from College Station, Tex., in 1891 (20), and has been reported more recently from New York (49).

Specimens collected: San Marcos, 2103; Victoria, 2528; Gonzales, 2700.

Leaf-spot (*Pseudopeziza medicaginis* (Lib.) Sacc.).—Observed only in a single locality, at which place it was very abundant in an irrigated field.

Specimen collected: San Marcos, 970.

Root-rot (*Ozonium omnivorum* Shear).—This disease is caused by the same fungus which produces the well-known root-rot of cotton. It was observed only in a single field, where it caused a loss of 25 to 30 per cent.

Specimen collected: Beeville, 1841.

Rust (*Uromyces medicaginis-falcatae* (DC.) Wint.).—This disease causes the formation of minute circular or elongated pustules of a reddish-brown color. The epidermis is ruptured and the spore mass is surrounded by the irregular lacerated remains. Only uredo pustules have been observed in our specimens and these are more abundant on the under surface than upon the upper surface of the leaflets (27). Freeman does not mention the occurrence of the pustules upon the upper surface of the leaflets. A single leaflet may show 20 to 60 pustules and still retain its green color in portions not occupied by the pustules, while others having a lesser number of pustules may show considerable yellowing. The disease does not cause serious damage since only a slight degree of defoliation results. It is apparently the least injurious of the three leaf diseases in this territory.

Specimens collected: Collins's Garden, San Antonio, 1390; Brack ranch, Cotulla, 2204.

COWPEA.

Leaf-spot (*Cercospora vignae* Racib.).—This is probably the most common disease of the cowpea (*Vigna unguiculata* (L.) Walp.) in this territory. It produces on the foliage large, circular, brown spots

1 to 2 cm. in diameter. The spots are most commonly isolated, but they may become confluent and irregular. With the abundant production of conidiophores and conidia the areas become dirty gray in color. It causes a serious defoliation of the plants. It was originally described from Java (41), and no mention has been found of its occurrence in this country. (Pl. I, fig. 1.)

Specimens collected: Austin, 1543, 2428; Beeville, 1826; Elgin, 1889, 2006; Uvalde, 1946; Victoria, 2529; Nursery, 2549; Cuero, 2604; Gonzales, 2673; Flatonia, 2730; Yoakum, 2767; Floresville, 2854; Hallettsville, 2902.

Leaf-spot (*Cercospora cruenta* Sacc.).—The large, indefinite, vague spots which this fungus produces characterize the disease. The tissue on the upper leaf surface is paler green or somewhat chlorotic, and the profuse production of conidiophores and conidia on the lower surface renders it dirty gray in color. The spots are largely confluent, often involving the entire leaf and causing its destruction. (Pl. I, fig. 2.)

Specimens collected: Beeville, 1860; Luling, 2259, 2260; Flatonia, 2729; Yoakum, 2752; Austin, 3131.

Root-rot (*Ozonium omnivorum* Shear).—The symptomatology of this disease is the same as that of the cotton root-rot.

Specimens collected: Beeville, 1837; Uvalde, 1945.

Rust (*Uromyces appendiculatus* (P.) Lk.).—This trouble was observed in only one locality where it was not the cause of any serious loss.

Specimen collected: Luling, 2260.

PEANUT.

Leaf-spot (*Cercospora personata* (B. and C.) Ell.).—This disease on the peanut (*Arachis hypogaea* L.) is so common on the mature plants that farmers consider it time to harvest when the leaves are badly spotted. The spots are chestnut brown, beginning as minute specks and increasing to about 4 mm., often, however, to as large as 10 mm. The margin of the spot is yellowish, paling out into the green of the leaf. The conidiophores are present on both surfaces, being more abundant below. The conidia are frequently 100 μ in length. In the original description (14) the fungus is said to be hypophyllous and the conidia may reach a maximum of 50 μ. (Pl. III, fig. 9.)

Specimens collected: Brenham, 1465; Elgin 2019; Luling, 2235; Nursery, 2566; Stockdale, 2624; Hallettsville, 2905.

DISEASES OF WILD AND CULTIVATED GRASSES.

BERMUDA GRASS.

Leaf-spot (*Helminthosporium giganteum* Heald and Wolf, 32).—This disease on Bermuda grass (*Capriola dactylon* (L.) Kuntze) is characterized by the presence of numerous yellowish or pale straw-colored spots, 0.5 to 1 mm. wide by 1 to 4 mm. long, longitudinally elongated, and with a narrow brown border. The spots are generally absent from the leaf sheath, and when numerous they may become confluent on the laminæ and thus cause somewhat extended dead areas.

The conidiophores are dark brown, many septate, 9 to 12 by 200 to 400 μ, with a slightly bulbous base (Pl. VII, fig. 6); the spores are elongated, cylindrical, with slightly tapering ends, five septate, pale brown, densely granular contents, 15 to 21 by 300 to 315 μ. (Pl. VII, fig. 7.)

Specimen collected: Falfurrias, 2440 (type specimen).

CRAB-GRASS.

Gray-spot (*Piricularia grisea* (Cke.) Sacc.).—Circular or slightly elongated spots appear on crab-grass (*Syntherisma sanguinalis* (L.) Dulac). These spots are dirty yellow or grayish in color, 1 to 5 mm. in diameter, with prominent purple borders. Very frequently the areas are confluent so that the entire leaf tip becomes dry.

Specimen collected: Uvalde, 1936.

Rust (*Uromyces* sp.).—Observed in but a single locality. Affected leaves showed an abundance of sori.

Specimen collected: Falfurrias, 2490.

FEATHER GRASS.

Balansia blight (*Balansia hypoxylon* (Pk.) Atk.).—This fungus on feather grass (*Stipa leucotricha* Trin.) destroys the entire spike, forming around the vascular tissue of the spikelets a pseudosclerotium which is grayish or bluish black on the outside, whitish within, and 4 to 15 mm. in length. (Pl. XI, fig. 1.) The black pulvinate stromata project prominently from this sclerotium. These stromata contain the flask-shaped perithecia. This blight is quite common during the last part of April and the first part of May. When this species was made the basis of a study by Atkinson (2) the host plant of the Texas material was undetermined.

Specimen collected: Austin, 3071.

Smut (*Ustilago hypodytes* (Schl.) Fr.).—The internodes of the inflorescence beginning at their bases are enveloped for the greater part of their length by a dusty, dark-brown spore mass, and the spikelets are destroyed.

Specimens collected: Austin, 2950, 3098.

GRAMA GRASS.

Rust (*Puccinia jamesiana* (Pk.) Arth.).—This rust on grama grass (*Bouteloua* sp.) was observed in a single locality, where it was not abundant.

Specimen collected: Falfurrias, 2481.

JOHNSON GRASS.

Leaf-blight (*Helminthosporium turcicum* Pass.).—The diseased areas on Johnson grass (*Andropogon halepensis* (L.) Brot.) are dark purple, often almost black, from 5 to 10 mm. in diameter, and are elongated parallel to the veins. They are frequently flattened on the side of the veins and show a pronounced zonation. These spots become confluent, resulting in the death of the leaf tips.

Specimens collected: Bastrop, 2024; Luling, 2232; Elgin, 2010; San Antonio, 1409; Sabinal, 1983; Austin, 3036. (The last three are mixed infections, Colletotrichum being present.)

Leaf-blight (*Septoria pertusa* Heald and Wolf, 32).—The diseased areas are elongated parallel to the veins and are 1 to 2 cm. in length without a definite margin. The brownish center is surrounded by a yellow zone which pales out into the green. These areas become confluent so that whole leaves are dry and yellowish brown in color. The flask-shaped pycnidia are very abundant on both surfaces and protrude by a short papilla. (Pl. VI, fig. 16.) The conidia are clear, straight, or slightly curved, slightly clavate, 60 to 75 by 3 μ, guttulate, and are extruded so abundantly as to make a white coating. (Pl. VI, fig. 17.)

Specimens collected; Luling, 2270; Flatonia, 2722 (type specimen).

Leaf-spot (*Cercospora sorghi* Ell. and Ev.).—No definitely limited spots are produced by this fungus. The affected areas are reddish purple with a tinge of red along the border. The production of conidiophores and conidia renders the center of these areas somewhat brown.

Specimens collected: Flatonia, 2741; Hallettsville, 2800; Gonzales, 2668. (Immature specimens, Colletotrichum being also present.)

Leaf-spot (*Colletotrichum lineola* Cda. var. *halepense* nov. var.).—This fungus on the leaf blades produces circular or slightly elongated spots which have an average length of about 2 mm., but may reach 5 mm. or more in length. The spots have a bright-red border with a gray or dirty-yellow center, bearing a central cluster of black acervuli. The acervuli are on both surfaces and few in each spot. The spores are falcate, acute pointed, hyaline, 20 to 27 by 4 to 5 μ, and frequently show one to three large granules. The conidiophores are short, 15 μ long, and nonseptate. The setæ are pointed, with slightly bulbous base, 1 to 2 septate, and reach 75 μ in length. (Pl. VI, fig. 15.) Our specimens agree with *C. lineola* Cda. in size of spores and setæ and with *C. andropogonis* Zimm.[1] in symptomatology.

One field was observed where the disease was sufficiently developed to cause the death of the grass.

Specimens collected: Round Rock, 2410 (type specimen), 2427; Falfurrias, 2441, 2727; Yoakum, 2753; Floresville, 2844; Austin, 3036.

Rust (*Puccinia purpurea* Cke.).—This rust occurs so abundantly on the leaves that they are purple, the color being caused by the closely clustered, elongated sori which rupture the epidermis on both leaf surfaces.

Specimen collected: Austin, 121.

JUNGLE RICE.

Gray-spot (*Piricularia grisea* (Cke.) Sacc.).—Circular or oval yellowish areas with purple margins appear on the blades of jungle rice (*Echinochloa colona* (L.) Link). These spots are from 1 to 5 mm. in diameter and become grayish below. The intervening tissues are killed and the leaf tips become dry. (See under "Crab-grass.")

Specimen collected: Uvalde, 1938.

PANICUM.

Black-blotch (*Phyllachora graminis* (P.) Fckl.).—The leaves of Panicum (*Panicum* spp.) become infested with black, shining, stromatic blotches. These are small, mostly less than 1 mm. in diameter, and often confluent. The affected leaves become brown between these spots.

Specimens collected: Austin, 859; Elgin, 1895.

Gray-spot (*Piricularia grisea* (Cke.) Sacc.).—Small elongated or lenticular spots are formed. They are grayish brown with a brown border, and are most abundant toward the tip of the leaf. Chlorosis accompanies this spotting, and large parts of the leaves turn brown.

Specimen collected: On *Panicum texanum* Buck.—Kennedy, 2834.

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[1] Dr. Zimmerman, to whom duplicates of our specimens were sent, reports that they are identical with *C. andropogonis* Zimm. Edgerton, who is making a careful study of the Colletotrichums, is of the opinion that *C. lineola* Cda., *C. andropogonis* Zimm., *C. cereale* Manns, and *C. falcatum* Went. may be identical.

REED-GRASS.

Leaf-spot (*Hendersonia arundinacea* (Desm.) Sacc.).—This fungus produces brown, elongated spots on the leaves of reed-grass (*Phragmites vulgaris* (Lam.) B. S. P.). The spots are 1 to 2 cm. in length, most commonly confluent, causing the drying of the leaves. The upper surfaces of the affected areas at maturity become grayish with a brown margin.

Specimen collected: San Marcos, 2109.

SAND BUR.

Smut (*Sorosporium syntherismae* (Pk.) Farl.).—This smut destroys the complete inflorescence of the sand bur (*Cenchrus* sp.).

Specimen collected: Skidmore, 2807.

SILVER BEARD-GRASS.

Black-blotch (*Phyllachora graminis* (P.) Fckl.).—This parasite on silver beard-grass (*Andropogon argyraeus* Schult.) produces on the leaves black, shining blotches. The spots are small, oblong, prominent, sometimes confluent, with a rugulose surface. The fructification is not mature until the leaves are dead and decaying.

Specimens collected: Austin, 297, 356.

Smut (*Tolyposporella brunki* (Ell. and Gall.) Clint.).—The leaf sheaths inclose a black, powdery mass of spores, which has taken the place of the inflorescence.

Specimen collected: Austin, 1727.

SORGHUM.

Bacterial blight (*Bacillus sorghi* Burr.).—This trouble is very generally present on all the varieties of sorghum (*Andropogon sorghum* (L.) Brot.) grown in this section, such as milo maize, Kafir corn, and cane. It produces on the leaves elongated purplish or dark-brown patches quite commonly confluent, so that large portions of the leaf are discolored. Many of the specimens represent mixed infections of Colletotrichum spots and bacterial blight.

Specimens collected: Boerne, 1653; New Braunfels, 1691, 1701; Sabinal, 1968; Hondo, 1993; Bastrop, 2020; Lockhart, 2067; Cotulla, 2161, 2203; Seguin, 2298; Stockdale, 2612; Flatonia, 2723; Floresville, 2848.

Head-smut (*Sphacelotheca reiliana* (Kuhn.) Clint.).—The head-smut is not uncommon on the various varieties of sorghum, but is not so generally abundant as the kernel smut.

Specimens collected: San Antonio, 1794; Uvalde, 1926; Bastrop, 2051; San Marcos, 2104; Seguin, 2292; Victoria, 2350; Stockdale, 2636; Gonzales, 2701; Hallettsville, 2799.

Kernel smut (*Sphacelotheca sorghi* (Lk.) Clint.).—The smut was present in the majority of fields examined.

Specimens collected: New Braunfels, 1700; Llano, 1750; San Antonio, 1795; Uvalde, 1925; Sabinal, 1978; Hondo, 1991; Bastrop, 2052; Luling, 2249; Seguin, 2294; Victoria, 2500; Gonzales, 2702.

Leaf-blight (*Helminthosporium turcicum* Pass.).—Very large irregular areas frequently appear on the leaves. They are usually brown with a narrow border of reddish purple. Quite commonly they have a tendency to be formed on the leaf margin or to advance from the leaf tip, so that large portions become involved. Isolated central spots may be found. An Alternaria was very commonly associated with this fungus.

Specimens collected: Sabinal, 1971; Luling, 2237; Falfurrias, 2493; Stockdale, 2638.

Leaf-spot (*Colletotrichum lineola* Cda.).—This disease is characterized by the formation of numerous oval spots, 1 to 5 mm. in length, with pink center and reddish-purple border, which becomes red on the outer border. The pink centers show the black acervuli in groups, or even a single acervulus, but in many cases acervuli may be entirely absent. The spots may become very abundant and confluent and kill the leaf generally from the tip back. The dead portion turns brown and the affected spots show as darker areas. (Pl. XI, fig. 2.) The disease was very abundant and severe in some localities.

Acervuli black, amphigenous; setæ 75 to 150 by 4.5 to 6 μ, base enlarged, very dark throughout, many septate, pointed and generally showing a marked constriction at some point above the base; basidia short, 15 to 20 by 3 to 6 μ, hyaline (Pl. VI, fig. 13); spores falcate, hyaline, granular or guttulate, and 20 to 30 by 4 to 6 μ (Pl. VI, fig. 14).

Our specimens are doubtfully referred to *C. lineola*. They are similar to many of the specimens which American mycologists have assigned to this species. It seems, however, that *C. lineola* Cda. and *C. andropogonis* Zimm. have not been clearly differentiated. (See footnote under "Johnson grass," p. 52.)

Specimens collected: Skidmore, 2806; Victoria, 2349; Nursery, 2564; Kerrville, 1586; Beeville, 1865; Gonzales, 2703; Yoakum, 2754.

DISEASES OF FIBER PLANTS.

COTTON.

Angular leaf-spot (*Bacterium malvacearum* Erw. Sm.).—The angular leaf-spot of cotton (*Gossypium herbaceum* L.) was observed in the great majority of fields examined. Pellucid spots were observed on the bolls in several cases either in connection with anthracnose or distinct from it, which are probably due to the same bacterium.

Specimens collected: San Antonio, 1410; Boerne, 1637; Beeville, 1822; Elgin, 1883; Bastrop, 2045; Lockhart, 2066; San Marcos, 2094; Sabinal, 1974; Hondo, 1994; Luling, 2240; Seguin, 2301; Georgetown, 2386, 2387; Round Rock, 2414; Victoria, 2348; Nursery, 2543; Cuero, 2584; Stockdale, 2613; Gonzales, 2680; Flatonia, 2726; Yoakum, 2759; Hallettsville, 2797; Falfurrias, 2436, 2438.

Anthracnose (*Glomerella gossypii* (South.) Edgerton, 12).—The anthracnose of the cotton bolls is not very abundant in this territory. Bolls were collected which showed only one or two small sunken anthracnose spots, while others were nearly completely covered. No fields were observed where the disease was sufficiently abundant to cause any material injury.

Specimens collected: Bastrop, 2050; Lockhart, 2079; Luling, 2280; Seguin, 2331; Victoria, 2517; Stockdale, 2639; Gonzales, 2708; Yoakum, 2772.

Leaf-spot (*Cercospora gossypina* Cke.; *Sphaerella gossypina* Atk.).—Only the Cercospora stage of this fungus was observed. The spore size ranges from 70 to 150 by 3 to 4 μ, which is in excess of the measurements recorded by Saccardo (45). This disease is not as abundant in this territory as the angular leaf-spot and affected leaves are not as seriously injured.

Specimens collected: Sabinal, 1973; Luling, 2261; Victoria, 2344; Alice, 2495; Nursery, 2573; Gonzales, 2661; Flatonia, 2715; Skidmore, 2801; Kennedy, 2840.

Leaf-spot (*Macrosporium* sp.?).—A leaf-spot of cotton was obtained in a single locality which differed from the angular leaf-spot or the Cercospora spot. It is characterized by the presence of numerous brown spots, 3 to 5 mm. in diameter, which show more or less concentric zonation. The tissue adjacent to the spots is frequently colored a pronounced purple. The fungus present is apparently a Macrosporium, but the spores are much larger than those of *Macrosporium nigricantium* described by Atkinson (1).

The spores of our species are 90 to 150 by 12 to 16 μ, long-stipitate, the stipe equaling the body of the spore in length; spore cells uniseriate or muriform, constricted at cross partitions, body cells 4 to 7, pale brown.

Specimen collected: Nursery, 2542.

Texas root-rot (*Ozonium omnivorum* Shear).—The common root-rot of cotton is prevalent throughout the entire extent of this territory. In some fields 25 to 75 per cent of the plants were killed. In this connection it may be noted that the same fungus has been collected on the following hosts in addition to cotton: Alfalfa, althæa, bean, black locust, cowpea, fig, okra, parsley, and umbrella China tree.

Specimens collected: Boerne, 1633; Beeville, 1823; Elgin, 1884; Bastrop, 2035; Lockhart, 2068; San Marcos, 2095; Sabinal, 1966; Hondo, 1992; Luling, 2238;

Seguin, 2295; Georgetown. 2388; Victoria, 2342; Cuero. 2583; Stockdale, 2646; Gonzales, 2683; Flatonia, 2727; Yoakum, 2760; Hallettsville. 2798; Falfurrias, 2450. 2466; Alice, 2497; Skidmore, 2499.

Root-rot.—This is a new disease. which is characterized by the dying of the affected plants, the dead plants exhibiting much the same general appearance as in the case of the well-known Texas root-rot. The patches may be small or they may reach nearly an acre in extent. A few plants may persist within the affected areas. At the circumference of the area of dead plants may be found living plants which are affected with the disease, but have not yet succumbed. These diseased plants show frequently a slight chlorosis of the foliage and a diseased condition of the root; others that are affected will show about normal foliage, and the only indication of the presence of the disease is the abnormal condition of the root. Many of these affected plants may wilt down and die in the course of a few hours.

The roots of diseased plants show a marked constriction at the crown, and the root remains apparently smaller from that point downward. An examination of the surface shows many delicate brown hyphæ aggregated in strands or making loosely interwoven masses; numerous small wartlike pustules also appear on the main root as well as on the branches. These wartlike nodules are sclerotal aggregates of fungous tissue which are slightly protruding from the cortex (Pl. XI, fig. 3).

The mycelium shows some Rhizoctonia characters, and fruits were found in the field in two cases, which may be connected with the fungus present. The systematic position of the fungus has not yet been determined, but cultural work is in progress which should throw light upon its relationship. The cultures up to the present time have failed to produce spores upon any media, but cultural characters show that the fungus is not a Rhizoctonia.

Specimens collected: Falfurrias, 2433, 2434, 2466.

Rust (*Aecidium gossypii* Ell. and Ev.).—The spots produced by this fungus show on the upper surface of the leaf as circular or subcircular areas, 3 to 5 mm. in diameter, with reddish-purple or dark-brown centers, slightly depressed and surrounded by a narrow zone of yellow or orange. The under surface of the spot is slightly hypertrophied and contains numerous cluster cups, 150 to 260 μ in diameter, which have a bright yellow or orange color. From one to three or four spots occurred on a single leaf. While the fungus was general throughout the fields where it was observed, it was not abundant, and caused but little injury. This fungus was first reported from California (22) and no records of its occurrence in other parts of the United States have been found.

Specimens collected: Falfurrias, 2435, 2452.

Sore-shin (*Corticium vagum* B. and C. var. *solani* Burt).—No field notes are at hand regarding the extent of the losses caused by this organism upon the young plants. It is probably generally present and the cause of a very considerable loss in warm, rainy springs.

Specimen collected: Austin, 2895.

DISEASES OF TREES AND SHRUBS.

ALTHÆA.

Root-rot (*Ozonium omnivorum* Shear).—The fungus which causes this trouble on althæa (*Hibiscus syriacus* L.) is the same as the one which produces the root-rot of cotton. The attendant symptoms are essentially similar. The disease was observed only in nurseries, where it killed all the plants in certain sections of the nursery rows.

Specimens collected: Austin, 1924; New Braunfels.

ASH.

Leaf-spot (*Cercospora fraxinites* Ell. and Ev.).—The spots caused by this fungus on the leaves of ash (*Fraxinus* spp.) are subcircular or somewhat irregular, dark gray above, with many minute black heaps of conidia and conidiophores, and are margined by a zone of brown fading out into the green tissue which may show a certain amount of chlorosis; the affected areas are pale brown below with a slightly darker, definite margin, and show fewer and less conspicuous conidial tufts. The spots are 4 to 10 mm. in diameter. Sometimes they are confluent, causing larger dead areas along the margins of the leaflets or removed from the margin. It is stated in the original description of this species (16) that the spots are 3 to 4 mm. in diameter, but the agreement of spore measurements and other characters indicate that our species is *C. fraxinites* Ell. and Ev.

At the time specimens were collected, September 1, little or no defoliation had resulted, but nearly all leaves were affected, each leaflet showing 1 to 13 spots.

Specimen collected: Victoria, 2340.

Leaf-spot (*Cylindrosporium viridis* Ell. and Ev.).—On the upper surface of the leaf the numerous spots are dark purple in color, ranging in diameter from 1 to 4 mm. with a definite margin. The affected areas are more dilute on the under surface, often brownish, and concealed in part by the abundant heaps of white or pinkish spores. The acervuli are immersed, globular or somewhat flattened, 150 μ or less in diameter, and become erumpent only on the lower surface.

According to the original description (19) the acervuli are from three to six in number on each spot and open above. The spores are cylindrical, fusoid, 30 to 36 by 3 to 4 μ. This measurement of width is in excess of the original description (2.5 μ).

Where the spotting is abundant the leaves become yellow and fall.

Specimen collected: Gonzales, 2652.

Leaf-spot (*Septoria submaculata* Wint.).—As a result of the attacks of this fungus definitely margined spots 1 to 2 mm. in diameter are formed. In the early stages they are circular and purple with a whitish center; later they become brown and angular, 3 to 4 mm. in diameter and are limited by the veins of the leaf.

On the upper surface are black pycnidia, embedded in the leaf tissue. The spores are 20 to 30 by 1 to 2 μ. hyaline and cylindrical.

Although the leaves were abundantly spotted, no defoliation was seen.

Specimen collected: Austin, 1546.

BLACK HAW.

Leaf-spot (*Hendersonia foliorum* Fckl. var. *viburni* Sacc.).—This fungus produces angular spots, 2 to 5 mm. in diameter upon the leaves of the black haw (*Viburnum prunifolium* L.) The pycnidia are sparsely scattered over the upper surface of the spots which are gray or dirty yellow with a darker border. The spots may be few in number on each leaf, or as many as 15.

Specimen collected: Austin, 331.

BLACK LOCUST.

Leaf-spot (*Cylindrosporium solitarium* Heald and Wolf. 32).—This disease of black locust (*Robinia pseudacacia* L.) is characterized by the presence of minute brown spots upon the leaflets. In the early stages of the disease the leaflets have their normal green color, and the spots show as circular areas, 0.5 to 1 mm. in diameter, which have a pale-brown center and a narrow, darker brown border, surrounded by a faint zone of chlorotic tissue. As the disease progresses the entire leaflet turns to a bright-yellow color with the exception of narrow zones of pale green which persist around the circumference of the brown spots. In this stage the spots show an outer zone of green, a middle zone of dark brown, and a central area of light-brown or grayish tissue. (Pl. XIII, fig. 4.) Affected leaflets may show from 1 to 40 spots, and these are generally isolated, although they may be somewhat clustered. The leaflets fall soon after they assume the yellow color and sometimes even before the complete chlorotic stage has been reached. In many cases considerable defoliation results.

Each spot shows one and occasionally two acervuli, which occupy the middle of the light-brown, central area. A straight or curved mass of spores may be seen extruded from the acervulus, which is immersed in the tissue of the under surface. The spores are 45 to 60 by 3 to 4 μ, 3 to 6 septate, generally slightly curved, nearly cylindrical but sometimes tapering, and hyaline. (Pl. VI, fig. 4.)

The disease was observed during the season of 1908 in a much more severe form than in 1909. In all cases it was observed only on nursery trees which were badly crowded.

Specimens collected: Austin, 459, 1909 (type specimens); Georgetown, 2354.

Root-rot (*Ozonium omnivorum* Shear).—This disease was found in a nursery where it had destroyed a small group of young trees (5 or 6 years old). The disease had spread across all of the rows and when observed was advancing along the rows. Roots removed from the soil showed the characteristic yellowish-brown filaments.

Specimen collected: Georgetown, 2351.

BOX.

Leaf-blight (*Macrophoma candollei* (B. and Br.) Berl. and Vogl.).—The leaves of box (*Buxus sempervirens* L.) become entirely dry, with scattered black pycnidia 250 to 300 μ in diameter on both surfaces. The conidia are 36 to 40 by 10 to 11.5 μ, hyaline, and densely granular.

Specimens collected: New Braunfels, 1666; Georgetown, 2357.

BOX ELDER.

Leaf-spot (*Gloeosporium negundinis* Ell. and Ev.).—As a result of the attack of this fungus on box elder (*Acer negundo californicum* (T. and G.) Sarg.), circular or subcircular straw-colored spots 3 to 5 mm. in diameter are formed. Most commonly they are so abundant as to result in the formation of larger dead areas, due to the fusion of spots. The yellow color is more pronounced on the under surface.

The acervuli are 125 to 200 μ in diameter, brown or blackish, and more abundant on the upper surface. The spores are oval, guttulate, and 15 to 20 by 5 to 7 μ. *G. negundinis* Ell. and Ev. on the twigs of the box elder, as determined from measurements of spores from specimens in the mycological herbarium of the Bureau of Plant Industry, shows a range of spore size from 5.9 to 6.6 by 16.5 to 19 μ.

Specimen collected: Lockhart, 2060.

Leaf tip-blight (*Septoria marginata* Heald and Wolf, 32).—The tips and margins of the leaves are killed, the dead areas being brick red, light brown to straw colored, or nearly gray in some cases, and confined to a narrow zone at the leaf tip or margin, or extending back until nearly the whole leaflet is involved. The advancing edge of the affected area is bordered by a narrow zone of yellow.

The pycnidia are very abundant, brown or black, on both surfaces, in surface view subcircular or somewhat irregular, 87 to 140 μ, flask shaped, with a slightly protruding ostiole. Spores clear, 40 to 60 by 2.5 to 3 μ, straight or slightly curved, three to several septate.

The spore measurements are identical in size with *Cylindrosporium negundinis* Ell. and Ev. (21), and the fungus was first referred to this species by the writers, since the extrusion of the spores from the pycnidia simulated acervuli in external appearance. An examination of type specimens shows that the two species are distinct.

This disease results in considerable defoliation, giving the tree the appearance of having suffered from drought.

Specimens collected: Beeville, 1859; Lockhart, 2060; San Marcos, 2113 (type specimen); Luling, 2279; Seguin, 2286; Austin.

BUCKEYE.

Leaf-blight (*Phyllosticta aesculi* Ell. and Martin).—Leaves of the buckeye (*Aesculus octandra* Marsh) affected by this fungus have large marginal areas of yellowish-brown or brown tissue with a region of yellow toward the advancing edge so that the spots are not definite margined. The pycnidia are very numerous on the lower surface and few on the upper surface. In the original description (24) they are said to be hypophyllous. They are minute, measuring from 40 to 50 μ, dark, and contain an abundance of oblong, hyaline spores 3 to 4 by 1 μ.

Apparently it is the cause of a complete defoliation of the trees in the middle of summer. It was collected in only two localities, but it was observed in several other places.

Specimens collected: Seguin, 2307; Austin, 3128.

BUMELIA.

Leaf-spot (*Cercospora lanuginosa* Heald and Wolf, 32).—This disease on *Bumelia lanuginosa* Michx. first appears as indefinite-margined dark-brown spots on the upper surface of the leaf. At length these areas become 1 to 3 mm. in diameter, irregular in outline, with a definite brown margin and a grayish center. Owing to the woolly coating on the lower leaf surface, the leaf spots show through only faintly as brown spots. Scattered over the upper surface of the spot are very dense clusters of conidiophores, 15 μ in length. The spores are cylindrical to slightly clavate, pale smoky, 45 to 54 by 5 μ, and three to four septate. (Pl. II, fig. 2.)

Specimens collected: Luling, 2222 (type specimen); Flatonia, 2742.

Leaf-spot (*Phyllosticta bumeliifolia* Heald and Wolf, 32).—This causes the formation of definite, pale-brown spots on the leaves. These spots vary in diameter from 3 to 6 mm. when circular or subcircular, but often the areas have fused so that much larger, irregular spots are produced. The color is less intense on the lower surface. Numerous black pycnidia, ranging from 125 to 150 μ, open to the upper surface. The spores are globular, granular, with one or more guttulæ, 9 to 15 μ in diameter. In severe cases half of the leaf tissue may be involved.

Specimens collected: Austin, 1549 (type specimens); 3032.

Sooty mold (*Fumago vagans* (?) P.).—The interlacing filaments give the effect of a black crust on the entire upper surface of the leaf.

Specimen collected: Austin, 253.

BUTTONBUSH.

Leaf-spot (*Ramularia cephalanthi* (Ell. and Kellerm.) Heald).—This fungus on the buttonbush (*Cephalanthus occidentalis* L.) produces numerous circular, brown spots 0.5 to 2 mm. in diameter, surrounded by a narrow, slightly elevated, darker brown border, which is in turn surrounded by a zone of bright red, 1 to 2 mm. wide, irregular margined, and fading out into the green. The spots are uniformly brown on the under surface. Conidia are produced only when the brown centers become somewhat gray. The spots may be very abundant and become confluent, causing the death of large areas of the leaf, or considerable chlorosis may precede the browning.

The size of the spores and the general symptomatology indicate that the fungus is *Cercospora cephalanthi* Ell. and Kellerm. (23), but the formation of the spores in chains (Pl. V, fig. 4) places it with Ramularia. Our specimens show spores which are apparently mature, 18 to 30 by 3 μ, and hyaline or faintly smoky. The change in size and color given for mature specimens (17) is probably based on the examination of a true Cercospora.

Specimens collected: Uvalde, 1930; Cotulla, 2148.

Leaf-blight (*Cercospora perniciosa* Heald and Wolf, 32).—When this disease is present the entire foliage of the tree is seriously affected. Isolated spots are about 1 cm. in diameter, reddish brown, with a darker border. Often the spots have narrow rings of this darker brown tissue, rendering them zonate.

Most commonly these spots are irregular in outline, as the diseased areas have fused, causing a large part of the leaf to become dry. The lower surface of the leaf is much more dilutely colored. On the upper surface the profusion of conidiophores and conidia renders the spots grayish. The conidiophores are densely fasciculate, clear or dilutedly colored, 40 to 50 by 3 to 4 μ. The spores are clavate, guttulate, 45 to 105 by 3 to 4 μ, and obscurely septate. (Pl. III, fig. 3.)

Where the disease has been observed the trees were almost entirely deprived of their leaves.

Specimens collected: Victoria, 2539 (type specimens); Austin, 2869.

CAPE JASMINE.

Sooty mold (*Fumago vagans* (?) P.).—The upper surface of the leaves of the Cape jasmine (*Gardenia jasminoides* Ellis) is entirely covered by a black, filmy crust. Plant lice were also present.

Specimen collected: Austin, 216.

CATALPA.

Leaf-blight.—Nursery trees and older trees of catalpa (*Catalpa* sp.) are frequently sufferers from a severe leaf-blight in which a species of Cercospora probably plays a secondary part. In some cases irregular, dead, brown areas occur along the margin and extend downward between the prominent radiating veins; or isolated brown spots, small or of considerable size, may occupy a similar position. In some spots the Cercospora may be mingled with an Alternaria, or Cercospora may be the only fungus present, and in one case Alternaria with little or no Cercospora was observed. In the specimens which showed the most severe development of the disease, with large dead areas involving in some cases nearly half of a leaf, much concentric zonation was characteristic; scattered over the brown, dead areas were numerous subcircular gray or white spots, 1 to 2 mm. in diameter, which produced central conidiophore tufts on both surfaces.

Conidiophores densely clustered, brown, becoming lighter toward the apex, few septate, irregular nodose tips, 60 to 75 by 3 to 4 μ, with occasional individuals of double the average length. Spores slender clavate, straight or only slightly curved, hyaline, few to many septate, and 42 to 130 by 3 to 4.5 μ.

The Cercospora on our specimens differs from *Cercospora catalpae* Wint., especially in having much longer and more slender spores, and also by producing amphigenous conidial tufts, but they should probably be referred to this species.

In the territory covered by this report the species of catalpa make a poor and frequently crippled growth and the foliage shows the effect of excessive transpiration in the early part of the season. The position and characteristics of the dead areas indicate that the trouble is largely physiological and that the fungi present find an easy growth in the dead or languid tissues.

Specimens collected: New Braunfels, 1674, 1681; Luling, 2239; Falfurrias, 2464.

CAT'S-CLAW.

Rust (*Ravenelia versatilis* (Pk.) Diet.).—The affected leaflets of cat's-claw (*Acacia greggii* A. Gray) have minute (scarcely large enough to be noticeable) brown pustules surrounded by chlorotic tissue. The leaflets become yellow and drop off.

Specimen collected: Uvalde, 1957.

CEDAR.

Cedar rust (*Gymnosporangium exiguum* Kern).—This is a new species of Gymnosporangium which has recently been described from Texas (35). Previous to the formation of telia on the cedar (*Juniperus sabinoides* Nees) the presence of the infected twigs can be detected only by the brown or yellow cast of the scale leaves. The minute chestnut-brown telia are formed in the month of March or early in April, and protrude from between the scale leaves. (Pl. XVIII, fig. 2.) The affected twigs are killed and are later cast from the tree. The fungus is frequently present in sufficient quantity to give the tree a marked scorched appearance after the telia have matured and disappeared.

Specimens collected: Austin, 754, 855.

Cedar-apples (*Gymnosporangium* (?) *globosum* Farl.).—This species of Gymnosporangium produces brown galls varying in size from minute globular enlargements to somewhat nodose structures an inch or more in diameter. The gall is similar to that produced by *G. juniperi-virginianae*, but shows marked depressions between the telial areolæ. The telia are flattened rather than terete, and show pointed truncate or notched apices.

Our specimens were sent to Mr. F. D. Kern, Purdue University, Lafayette, Ind., who referred them to *G. globosum* Farl. The specimens show no indication of a perennial character, and in this respect appear to be quite similar to *G. juniperi-virginianae*, but the spores are similar to those of *G. globosum*.

Specimens collected: Austin, 497, 666, 758, 854.

Whitening of the cedar (*Cyanospora albicedrae* Heald and Wolf).—The mountain cedar is frequently attacked by a fungus (31) which produces extended white patches upon the bark of trunk or branches and upon the surface of branches or twigs which have apparently been corroded by the action of the fungus. The white areas may completely encircle the branches, or they may be confined to one side. Darker oval nodules, 1 to 2 mm. long by about 1 mm. wide, containing the perithecia, are scattered over the whitened areas. Each nodule contains one or more perithecia, which open to the surface by excentrically located ostioles. On the bark these nodules are flattened, while on the twigs from which the cortex has been corroded they stand out more prominently, owing to the fact that the surrounding wood tissue has been more corroded than the wood tissue which constitutes the stromatic nodule. The stromatic nodules on the decorticated twigs are also more nearly black, while those on the bark are dark gray.

This fungus is so constantly present on the mountain cedar that the occurrence of white patches on the bark has been given as one of the characteristics of this species of cedar (3). The fungus which causes this trouble has been under investigation by the writers for some time, and it seems probable that it represents a new and undescribed species and genus. A more detailed consideration has been published in Mycologia.

A study of the affected cedars under field conditions indicate that the fungus is a true parasite. Affected trees frequently show a large quantity of dead decorticated twigs and branches.

Specimens collected: Austin, 306, 1434, 2865. Coextensive with the distribution of the mountain cedar.

COTTONWOOD.

Leaf-spot (*Septoria musiva* Pk.).—Numerous small, angular areas are formed on the leaves of the cottonwood (*Populus deltoides* Marsh), which are brown, but may become grayish. The pycnidia, containing hyaline, curved spores 30 to 35 μ long, appear on the upper surface.

Specimens collected: Lockhart, 2076; San Marcos, 2117.

Leaf-spot (*Septoria populicola* Pk.).—This species differs mainly from the above in the fact that the pycnidia open on the lower surface and the spores are 60 to 75 by 3 to 4 μ. The amount of defoliation is only slight.

Specimens collected: Austin, 413, 1426, 1432, 2910; Victoria, 2339; Gonzales, 2656.

Rust (*Melampsora medusae* Thm.).—Observed only in a single locality, where it was causing no serious damage.

Specimens collected: Austin, 162, 414.

CRAPE MYRTLE.

Leaf-spot (*Cercospora lythracearum* Heald and Wolf, 32).—Circular to subcircular indefinite-margined areas appear on the foliage of the crape myrtle (*Lagerstroemia indica* L.). These spots, varying in size from 2 to 8 mm., are uniformly yellowish brown below and dark brown above with a zone of limiting yellow tissue paling out into the green tissue.

The conidiophores are densely clustered, 15 to 20 by 3 μ, continuous, diluted brown in color, and are present on both surfaces, mostly epiphyllous, however. The spores are 30 to 42 by 3 μ, 4 to 5 septate, clavate or subcylindrical, and dilutedly colored. (Pl. I, fig. 6. See also "Pomegranate".)

Specimen collected: Austin, 466 (type specimen).

Leaf tip-blight.—This trouble begins as a drying of the leaf tips, which become brownish in the dead portions. An extended zone of chlorotic tissue gradually fading into the green marks the advancing edge. The entire leaf may become dry and fall, exhibiting all the appearances of a physiological trouble. Three fungi (*Phyllosticta lagerstroemia* Ell. and Ev., *Pestalozzia guepini* Desm., and *Cercospora lythracearum* Heald and Wolf) were present.

Specimens collected: Beeville, 1857; Flatonia, 2748; Luling, 2254.

DOGWOOD.

Leaf-spot (*Cercospora cornicola* Tracy and Earle).—Very abundant, indefinite-margined, irregular, brown spots are formed on the foliage of the dogwood (*Cornus* sp.). The margin is quite commonly purplish. The entire foliage becomes seriously affected.

Specimens collected: Austin, 351; San Antonio, 1778; San Marcos, 2107; Seguin, 2304; Victoria, 2534; Gonzales, 2706; Flatonia, 2749; Hallettsville, 2788, 2795.

ELDERBERRY.

Leaf-spot (*Cercospora catenospora* Atk.).—The spots on the leaves of elderberry (*Sambucus canadensis* L.) caused by this fungus are yellow at first, becoming gray with age. They are rounded or elongated in the direction of venation and 3 to 6 mm. in greatest length. They are often so numerous as to be confluent, resulting in the chlorosis and subsequent fall of the foliage.

Specimen collected: San Marcos, 2114.

ELM.

Blight.—The small-leaved elms (*Ulmus* spp.) frequently show a blight or scald of the foliage which is characterized by the death of the leaf tips. The dead, brown area advances downward until the whole leaf may be involved. The brown area is generally bordered by a zone of chlorotic tissue. In some cases the dead areas are not terminal or marginal, but show as definite spots. This is true for our specimens of *Ulmus crassifolia*. In some cases an Alternaria is present, but it is not sufficiently constant to be definitely connected with the disease.

Specimens collected: (1) On *Ulmus alata* Michx.—Gonzales, 2699; Kennedy, 2823. (2) On *U. crassifolia* Nutt.—New Braunfels, 1719.

Leaf-scab (*Gnomonia ulmea* (Sacc.) Thm.).—Elm leaves affected with this fungus show minute spots scattered over the surface. These spots, which are 1 to 3 mm. in diameter, show on the upper surface a central cluster of small black pustules surrounded by a border of dead tissue, white or gray in color; or the black pustules may be somewhat concentrically arranged. In the early stages of development the spot will not be noticeable on the under surface, but in the later development the under surface shows a definite brown area of dead tissue opposed to the white zone of the upper surface. In this stage the epidermis of the under surface is elevated in numerous pustules and ruptured to some extent by the protruding beaks of the perithecia. The late fall collections show only immature perithecia. The white zone bordering the perithecial pustules is caused by the accumulation of large quantities of crystals in the epidermal cells (Pl. XIII, fig. 1).

In many of the collections, especially upon the late collections of *Ulmus alata*, a Coniothyrium is present. The pycnidia of this fungus may be present on either surface of the spots and produce an abundance of oval, brown spores 3.5 to 4 by 6 μ. It is possible that this represents a pycnidial stage of the Gnomonia, but proof of a definite connection must be obtained by cultures. It may be noted in this connection that a Phoma-like pycnidium has been observed in connection with Phomatospora (25), a genus belonging to the Gnomoniaceæ.

Some specimens of *Ulmus alata* show a third type of fruit. These fruits show as minute erumpent papillæ scattered abundantly over the under surface, while the upper surface shows a marked yellow punctate appearance. The spores produced are two to three septate, 21 to 39 by 4 μ, and hyaline. These spores may be the only form present on the leaves at a given time, or they may be found in connection with the perithecial stage of Gnomonia. These spores and pycnidia show a marked similarity to *Phleospora ulmi* (Fr.) Wallr. (36), and it seems probable that they represent a stage in the life history of our Gnomonia, since Klebahn (36) has proved a similar connection between *Phleospora ulmi* (Fr.) Wallr. and *Mycosphaerella ulmi*, another genus of the Sphæriales.

Specimens collected: (1) *Ulmus alata* Michx.—Austin, 255, 256, 338; Llano, 1749. (2) *Ulmus crassifolia* Nutt.—New Braunfels, 1675; Uvalde, 1928; Seguin, 2312; Elgin, 1874. (3) *Ulmus americana* L.—Round Rock, 2419.

Leaf-spot (*Cylindrosporium tenuisporum* Heald and Wolf, 32).—The small-leaved elm is affected by a leaf-spot which shows as brown circular or slightly irregular areas, 2 to 10 mm. in diameter, generally with a gray center and a narrow yellow border. The under surfaces of the spots are more uniformly brown and show minute black specks, the acervuli of the fungus. In a few cases the acervuli may be found on the upper surface.

The spores are very narrow, cylindrical, hyaline, continuous, straight or slightly curved, 15 to 24 by 0.75 to 1 μ.

Specimen collected: On *Ulmus crassifolia* Nutt.—Austin, 307 (type specimen).

Mistletoe (*Phoradendron flavescens* (Pursh.) Nutt.).—The small-leaved elm (*Ulmus crassifolia*) is one of the many trees attacked by mistletoe.

Specimen collected: On *Ulmus crassifolia* Nutt.—Llano, 1737.

Powdery mildew (*Uncinula* sp.).—Powdery mildew was collected in a single locality on the cork-winged elm (*Ulmus alata*). It was found only in the conidial stage and was not abundant. Since two species of Uncinula have been described for this host, a definite specific determination can not be made.

Specimen collected: On *Ulmus alata* Michx.—Llano, 1753.

ENGLISH IVY.

Anthracnose (*Colletotrichum gloeosporioides* Penz. var. *hederae* Pass.).—Irregular, brown, raised, definite-margined areas are formed on the leaves of the English ivy (*Hedera helix* L.). Often they are confined to the tips of the lobes, but at times they are central. The acervuli are formed abundantly over the entire diseased areas.

Specimens collected: San Antonio, 1403; Gonzales, 2685; Flatonia, 2747.

Leaf-blight (*Phyllosticta concentrica* Sacc.).—This disease begins on the leaf tips or centrally and results in the formation of dark-brown, dead areas which may extend until the whole leaf is involved. Some spots have a blackish tinge, due to the numerous pycnidia, which in some cases are arranged so as to show concentric zonation. The spores are ovoid, 10 by 7 μ, hyaline, guttulate, and embedded in a mucilaginous matrix. This blight in one locality was observed to have destroyed about half the foliage; so it is the cause of serious harm.

Specimens collected: Austin, 1313; New Braunfels, 1667; Stockdale, 2637.

Leaf-spot (*Ramularia hedericola* Heald and Wolf, 32).—Large irregular spots, grayish brown above and brown below, appear on the leaves. The margin of the diseased area is elevated, with the fungus fruits on the upper leaf surface. Conidiophores 60 to 120 by 4 μ, septate. Conidia clear, 9 to 15 by 2.5 μ. (Pl. V, fig. 5.)

Specimen collected: San Marcos, 2130 (type specimen).

EUONYMUS.

Anthracnose (*Colletotrichum griseum* Heald and Wolf, 32).—This is one of the most common diseases of *Euonymus japonicus* Thunb. for this region. It forms on the leaves indefinite-margined, yellow blotches 1 to 4 mm. in diameter. These increase in size until the diseased areas are sometimes 8 to 10 mm. across; a definite, brown, elevated border is formed, and the center of the spot becomes gray. Scattered over this gray area are numerous black acervuli, either zonate or more or less scattered, usually concentrically arranged. Often the spots are marginal, or the disease may apparently work back from the tip of the leaf. (Pl. XII, fig. 2.)

The twigs and larger branches are also affected, resulting in the formation of gray cankers 1 to 8 mm. in diameter.

These gray patches drop away, leaving the brown, cankered area exposed. The acervuli are immersed, varying in shape from globular to quite flat, 250 to 300 μ in diameter, the margin of the opening being set with numerous brown setæ, 40 to 60 by 5 μ, quite uniform in diameter or sometimes taper pointed. (Pl. VI, figs. 1, 2.) The spores are straight or only slightly curved, hyaline, densely granular, or with several guttulæ, 14 to 17 by 4 μ, and rarely marked by a single transverse septum which does not divide the cell into equal halves. (Pl. VI, fig. 1.)

Specimens collected: Austin, 1280 (type specimen); San Antonio, 1404; Lockhart, 2110; Georgetown, 2353, 2376.

Leaf-spot (*Exosporium concentricum* Heald and Wolf, 32).—This fungus produces on the leaves circular areas 0.5 to 2 cm. in diameter which may show concentric zonation. This zonation is due to concentric regions of brown and grayish yellow. The acervuli are confined to the grayish-yellow regions. In other cases the spots may be uniformly grayish yellow with a narrow brown border. Usually only one spot is present on each leaf, but occasionally there are several, which fuse. (Pl. XII, fig. 1.) The affected leaves may show considerable yellowing beyond the diseased areas, and in severe cases much defoliation follows.

The acervuli, 100 to 150 μ in diameter, are dark and either concentrically arranged or scattered. They are at first covered and at length protrude, causing that portion of the leaf to become grayish because the rupture of the epidermis has admitted the air. The spores are nearly hyaline, clavate cylindrical, 25 to 45 by 2.5 to 3 μ, one to several septate. (Pl. VII, fig. 5.)

Specimens collected: San Marcos, 2129; Georgetown, 2375; Austin, 2867 (type specimen).

HACKBERRY.

Leaf-spot (*Cylindrosporium defoliatum* Heald and Wolf, 32).—The common hackberry of this region (*Celtis laevigata* Willd.) is quite generally affected with a serious leaf blight which first produces irregular gray blotches 1 to 2 cm. in diameter. These blotches sometimes coalesce and involve a large part of the leaf. (Pl. XIV, fig. 1.) In early stages of the disease the adjacent leaf tissue may remain green, but later a considerable amount of yellowing is produced, and the affected leaves fall from the tree.

The acervuli are amphigenous, but more abundant upon the upper surface, 60 to 75 μ, immersed. (Pl. VI, fig. 10.) The spores accumulate on the surface of the leaf, where they are visible as minute white tufts. The spores are hyaline, cylindrical, straight, or curved, 30 to 42 by 3 to 3.5 μ, and three to five septate. (Pl. VI, fig. 9.) This species is clearly distinct from *Cylindrosporium celtidis* Earle, which has been described as forming small spots on *C. laevigata* in Alabama (11).

Specimens collected: (1) On *Celtis laevigata* Willd.—New Braunfels, 1673; Austin, 1728, 1905 (type specimen); Elgin, 1890; Bastrop, 2049; Lockhart, 2073; San Marcos, 2099; Cotulla, 2180; Luling, 2256; Seguin, 2317; Georgetown, 2377; Victoria, 2509; Cuero, 2578; Stockdale, 2615; Gonzales, 2689; Flatonia, 2709; Yoakum, 2771. (2) On *Celtis reticulata* Torr.—Beeville, 1855; Sabinal, 1975.

Leaf-spot (*Ramularia celtidis* Ell. and Kellerm.).—Very numerous small white spots form on the leaves. They are circular in outline and about 2 mm. in diameter. The margin is brown or yellow and slightly raised.

Specimens collected: (1) On *Celtis reticulata* Torr.—Austin, 464; Beeville, 1814; Luling, 2265; Gonzales, 2690; Kennedy, 2835. (2) On *C. laevigata* Willd.—Austin, 1539; Lockhart, 2062; Georgetown, 2355; Hallettsville, 2779.

Mistletoe (*Phoradendron flavescens* (Pursh.) Nutt.).—This parasitic plant is present on the hackberry throughout the territory covered by this survey. It is often so abundant that the winter aspect makes the tree appear in full foliage.

Powdery mildew (*Uncinula polychaeta* B. and C.).—The mycelium forms a white, felty coating on both leaf surfaces, generally forming patches and not covering the entire leaf.

Specimens collected: On *Celtis reticulata* Torr.—Austin, 415; Georgetown, 2392; Cuero, 2587.

HAWTHORN.

Blotch (*Hendersonia foliorum* Fckl.).—On the leaves of the hawthorn (*Crataegus* spp.) large, brown, irregular blotches appear, and on these blotches black dots (the pycnidia) are formed. Each pycnidium contains brown spores, 15 by 6 μ, and three septate. It is probably merely associated with a physiological languor, coming in as a saprophyte.

Specimen collected: Gonzales, 2698.

Leaf-spot (*Cercospora crataegi* Heald and Wolf, 32).—This fungus causes the formation of large, dark-brown, irregular areas from 5 to 10 mm. or more in diameter. The spots are darker above than below, and when as many as 20 to 25 in number are confluent, involving large areas, with chlorotic tissue surrounding them. The upper surface is broken by the numerous brown tufts of conidiophores and conidia. The conidiophores are closely aggregated, 24 to 30 by 5 to 6 μ, brown and nonseptate. The conidia are clavate, straight or curved, 120 to 180 by 5 to 7 μ, many septate with prominent guttulæ. (Pl. IV, fig. 2.)

Specimen collected: Gonzales, 2697 (type specimen).

Rust (*Gymnosporangium globosum* Farl.).—The cluster cups of this rust were found abundantly present on the leaves and twigs of *Crataegus crus-galli* L. (See under "Cedar.")

Specimens collected: Austin, 1312, 1444 (cluster cups).

Rust (*Gymnosporangium* sp.).—Several species of Crataegus have been found whose leaves are covered by reddish-yellow areas, with a group of black spermagonia at the center.

Specimens collected: Elgin, 2009; Lockhart, 2069.

HEMP TREE.

Leaf-spot (*Cercospora viticis* Ell. and Ev.).—Irregular, suborbicular, rusty spots, 2 to 4 mm. in diameter are formed on the hemp tree (*Vitex agnus-castus* L.). The margin of the area is elevated and darker, with a paler center as the spots become old.

Specimen collected: Nursery, 2569.

JAPANESE IVY.

Leaf-spot (*Phyllosticta labruscae* Thm.).—The spots produced on the Japanese ivy (*Psedera tricuspidata* (Sieb. and Zucc.) Rehder) by this fungus are subcircular, 5 to 8 mm. in diameter, reddish brown, with a narrow dark border. The black pycnidia open to the upper surface.

Specimen collected: Austin, 3103.

LILAC.

Leaf-blight (*Cercospora macromaculans* Heald and Wolf, 32).—This blight on the lilac (*Syringa* sp.) is characterized by the presence of large, brown, dead patches 1 cm. or more in diameter, which are more or less irregular and either central or marginal. The center of the spots is frequently gray, and sometimes an evident zonation is exhibited, due to the concentric arrangement of the dark conidial tufts.

Conidiophores amphigenous, densely fasciculate, many septate, dark brown, 60 to 75 by 6 μ; spores slender clavate, tapering gradually to the end, few to many septate, hyaline, 70 to 187 by 2.8 to 3 μ. (Pl. I, fig. 7.)

This blight causes the death of many leaves and much defoliation.

Specimens collected: Austin, 463, 1910; Kerrville, 1603 (type specimen).

Powdery mildew (*Microsphaera alni* (Wallr.) Wint.).—The lilac is only rarely used in this region as an ornamental shrub, and so the mildew is not common.

Specimen collected: Austin, 1308.

LIPPIA.

Leaf-spot (*Cylindrosporium lippiae* Heald and Wolf, 32).—This fungus produces on lippia (*Lippia ligustrina* (Lag.) Britton) three to four circular spots 2 or 3 mm. in diameter to each leaf. The spots have gray centers with narrow brown borders edged with a tinge of yellow, and show in the center numerous white conidial tufts.

Acervuli amphigenous, 30 to 100 μ in diameter, more on the upper surface; spores hyaline, straight or generally curved, continuous or one to three septate, 24 to 54 by 3 μ, nearly cylindrical. (Pl. VI, fig. 5).

Specimen collected: Llano, 1756 (type specimen).

MAGNOLIA.

Leaf-spot (*Coniothyrium olivaceum* Bon. var. *grandiflorae* Sacc.).—This fungus on the magnolia (*Magnolia grandiflora* L.) occurs on circular or subcircular, definite-margined spots, 1 to 5 mm. in diameter, which are yellowish brown above with a narrow limiting zone of darker brown and uniformly brown on the under surface, but of a darker shade. There may be from a few to a dozen or more spots to each leaf, but the fungus is not responsible for any defoliation.

The pycnidia are on the lower surface and are uniform in color with the spot, and consequently are not visible to the naked eye. They are globular, 100 μ in diameter, which is much less than the recorded size (300 to 350 μ), but the spores are of similar dimensions.

Specimen collected: Georgetown, 2374.

MAPLE.

Leaf tip-blight (*Gloeosporium* sp.?).—The maple (*Acer saccharinum* L.) is not indigenous to this section, and occurs only rarely under cultivation. This leaf disease causes a browning of the tips of the lobes. The acervuli are sparsely present on the lower surface. We were unable definitely to associate this fungus with any of the ten species described as occurring on species of Acer.

Specimens collected: Victoria, 2520; Flatonia, 2716.

MESQUITE.

Anthracnose (*Gloeosporium leguminum* (Cke.) Sacc.).—The pods of the mesquite (*Prosopis glandulosa* Torr.) are quite generally affected by a Gloeosporium, which produces irregular slightly sunken areas on one side of the pods or completely encircling them. The spots show numerous black acervuli, which are generally aggregated and frequently confluent on a gray ground, and the whole area is surrounded by a narrow zone of brown. Seriously affected pods fall from the tree before they reach maturity.

Specimens collected: Austin, 17; San Antonio, 1360; Beeville, 1796; Elgin, 1891; Uvalde, 1961; Hondo, 1996; Bastrop, 2046; Lockhart, 2061; San Marcos, 2096; Cotulla, 2184; Luling, 2253; Seguin, 2314; Stockdale, 2609; Gonzales, 2662; Floresville, 2843.

Blight.—The affected leaves in the early part of the growing season show a pronounced yellow color on the upper surface, while large numbers of minute yellowish heaps cover the under surface. The affected leaves soon fall, and by midsummer they have entirely disappeared. Thus far it has been impossible to associate the trouble with any known organism.

Specimens collected: San Marcos, 926; Austin, 1065.

Galls.—The large limbs and smaller branches of the mesquite sometimes show abnormal enlargements which are frequently globular or sometimes elongated and sometimes greatly exceed the diameter of the branch on which they are produced. (Pl. XV, figs. 2 and 3.) Specimens have been obtained ranging from 1 to 8 or 10 inches in diameter. The gall is produced by an abnormal growth of the wood, and cross sections of galls always show small brown specks where the wood cells are more or less disintegrated. These are distributed throughout the entire woody region.

These galls are not of insect origin, and cultural work attempted has as yet failed to connect either bacteria or fungi with the disease, although both have been obtained.

Specimens collected: Austin, 1294; Llano, 1746; Beeville, 1858; Cotulla, 2218; Runge, 2923.

Mistletoe (*Phoradendron flavescens* (Pursh.) Nutt.).—The American mistletoe is not uncommon on the mesquite. In some regions having a scarcity of forage it is pruned from the trees and fed to cattle.

Specimens collected: Llano, 1737; Cotulla, 2183; Luling, 2277; Seguin, 2297.

Leaf-blight (*Cercospora prosopidis* Heald and Wolf, 32).—This disease is characterized by the presence of irregular, angular, brown patches which occupy one side of the midrib of the leaflets or extend across the whole leaflet and are generally bounded by a narrow, brown border. The spots may be either terminal or removed from the apex of the leaflets, and they frequently advance until the whole leaflet is killed or drops from the tree. In some cases it is very abundant and causes considerable defoliation. Its greatest development may be found in the dense mesquite thicket.

The conidiophores are amphigenous, densely fasciculate, uniformly brown, continuous, 18 to 30 by 3 to 4 μ; spores straight, cylindrical to slightly club shaped, brownish, 20 to 70 by 4 to 5 μ, and one to many septate. (Pl. III, fig. 2.)

Specimens collected: Uvalde, 1959 (type specimen); Luling, 2264; Falfurrias, 2468; Gonzales, 2663; Kennedy, 2824; Floresville, 2847.

Powdery mildew (*Erysiphe* sp. ?).—The young mesquites are frequently affected with powdery mildew, but it is rare on older trees. It produces no apparent injury and is abundant only near the end of the growing season. Immature perithecia were found in one locality, but all other collections represent only the conidial stage. Salmon in his monograph does not record a powdery mildew for this host, hence the specific determination can not be made.

Specimens collected: Austin, 200, 2917; Beeville, 1867; Uvalde, 1960; San Marcos, 2091; Cotulla, 2172; Luling, 2278; Seguin, 2315; Farfurrias, 2491; Cuero, 2579; Stockdale, 2610; Gonzales, 2684; Skidmore, 2815; Kennedy, 2837; Floresville, 2841; Hallettsville, 2900.

Rust (*Ravenelia arizonica* Ell. and Ev.).—This rust is very inconspicuous, producing a few minute brown sori on both surfaces of the leaflets. There was no other discoloration of the leaves in the specimens collected. Specimens obtained from a single locality.

Specimen collected: Falfurrias, 2492.

MULBERRY.

Die-back (*Myxosporium diedickei* Syd.).—The branches of young mulberry plants (*Morus* spp.) in the nursery rows were covered with whitish or pink pustules protruding through the epidermis. The terminal portions of the twigs had apparently been killed by this fungus.

Specimen collected: On *Morus alba* L.—Georgetown, 2359.

Eye-spot (*Cercospora moricola* Cke.).—This fungus produces circular or subcircular spots 3 to 7 mm. in diameter on the leaves. The center is tan colored, with a very dark outer zone and outside of this a halo of yellowish brown, paling out into the green. (Pl. XIII, fig. 2.) The conidiophores, densely tufted, pale yellow, 20 to 25 by 3 to 3.5 μ, are on the lower surface. The conidia are clavate, 30 to 75 by 4 to 4.5 μ, slightly colored, two to eight septate, guttulate. (Pl. IV, fig. 6.) This is a common disease on both wild and cultivated forms.

Specimens collected: On *Morus rubra* L.—Llano, 1747; Luling, 2273; Seguin, 2282; Victoria, 2512; Nursery, 2558, 2568; Stockdale, 2607; Hallettsville, 2796.

Leaf-spot (*Cercospora missouriensis* Wint.).—Large, orbicular, dark-brown spots are formed on the leaves. They vary in size from 3 to 7 mm. and usually have a slightly darker border. The conidiophores are borne on the lower surface in dense tufts.

This species is listed by Saccardo (44) under *C. pulvinulata* Sacc. and Wint.

Specimens collected: On *Morus rubra* L.—Austin, 465, 469; Beeville, 1844; Falfurrias, 2459; Cuero, 2597; Floresville, 2842.

Leaf-spot (*Cercosporella mori* Pk.[1]).—This diseased condition of the foliage is characterized by the formation of irregular, circular or angular spots 1 to 8 mm. in diameter. The areas are brown in color, with a darker border. A conspicuous cushionlike cluster of white or pinkish conidia is extruded near the center, or they may be scattered over the surface of the spots. These acervuli are for the most part on the under surface of the leaf, and are 50 to 100 μ in diameter. The conidiophores are faintly smoky. The conidia are slightly clavate, several septate, hyaline, 35 to 75 by 3 to 4 μ. (Pl. VII, fig. 8.)

Specimens collected: On *Morus alba* L.—New Braunfels, 1684, 1721; Beeville, 1832; Seguin, 2330; Austin, 3184.

OAK.

Ball moss (*Tillandsia recurvata* L.).—This lives epiphytically on the oak (*Quercus* spp.) throughout the entire range except the extreme western and northwestern portions covered by this survey. It is quite commonly considered as parasitic, since it occurs so abundantly and is so apparent on dead trees. Death is probably due to shading of the foliage in addition to edaphic and climatic factors.

Leaf-spot (*Marsonia quercus* Pk.).—The spots, 1 to 2 mm. in diameter, are whitish or grayish brown above and brown below. The areas are often bordered by a narrow purplish zone.

Specimens collected: Elgin, 2008; Victoria, 2502; Stockdale, 2644; Flatonia, 2735.

[1] This fungus has been determined as *Cercosporella mori* nov. sp. by Prof. C. H. Peck, to whom specimens were sent for identification.

Spanish moss (*Dendropogon usneoides* (L.) Raf.).—This epiphyte forms long pendent festoons and is very commonly distributed. It is most abundant, however, along the watercourses, while the ball moss is more abundant on the higher ground.

Tar-spot (*Rhytisma erythrosporum* B. and C.).—Thin, black blotches, usually about 4 mm. in diameter, but sometimes as large as 8 mm., are formed on the upper surface of the leaves of the live oak. (Pl. XIII, fig. 3.)

Specimens collected: On *Quercus virginiana* Mill.—Austin, 176, 496, 547, 2936.

OLEASTER.

Leaf-spot (*Cercospora elaeagni* Heald and Wolf, 32).—In this disease the leaves of the oleaster (*Elaeagnus* sp.) show on the upper surface an abundance of circular or subcircular spots 1 to 2 mm. in diameter with a definite brown border and a whitish or brown center. The spots are inconspicuous on the under surface on account of the dense, silvery tomentum. There is generally some yellowing beyond the spot and in many cases a pronounced yellowing of the whole leaf.

Conidiophores amphigenous, densely fasciculate, dark brown, 40 by 3.5 to 4 μ, more abundant on the upper surface; spores clavate, straight or slightly curved, nearly hyaline, 28 to 150 by 2.5 to 4 μ, and one to several septate. (Pl. IV, fig. 4.)

Specimen collected: On imported host (species not known)—Floresville, 2861 (type specimen).

OSAGE ORANGE.

Blight (*Sporodesmium maclurae* Thm.).—No definite spots are produced on the foliage of the Osage orange (*Toxylon pomiferum* Raf.). The under surface acquires a diffuse dirty-brown coloration, not so abundant, however, on the upper surface. Considerable chlorosis accompanies this disease, and a subsequent defoliation results. (Pl. V, fig. 6.)

Specimens collected: Austin, 1922; Seguin, 2319.

Cottony leaf-spot (*Ovularia maclurae* Ell. and Langl.).—This leaf disease is characterized by the cottony appearance of the lower surface of the affected areas. The upper surface of the spots is circular to irregular, rusty brown, and they vary in size from 3 to 10 mm.

Specimen collected: Gonzales, 2694.

PECAN.

Leaf-blight (*Septoria caryae* Ell. and Ev.).—Some of the trees of the pecan (*Hicoria pecan* (Marsh.) Britt.) in the vicinity of Austin show a large amount of leaf-blight characterized by the presence of large, irregular, chestnut-brown areas on the under surface of the leaflets, while the upper surface is somewhat paler. The minute black pycnidia are very numerous on the under surface, but are absent from the upper surface. It may be noted that the description of Saccardo (47) gives the pycnidia as amphigenous. There is also a considerable amount of yellowing of the leaf tissue adjacent to the spots, and more or less defoliation results.

Specimens collected: Austin, 238, 2908.

Leaf-spot (*Clasterosporium diffusum* Heald and Wolf, 32).—This fungus produces circular or irregular, indefinite-margined, brown spots, 5 to 10 mm. in diameter, which are uniformly brown on both surfaces of the leaflets.

The fungus produces dark-brown hyphæ which run throughout the dead tissue, or creep over either surface of the affected area, or are sometimes aggregated to produce clusters of erect conidiophores. Spores curved-clavate, many septate, brown, 45 to 135 by 4 to 5 μ. (Pl. VII, fig. 4.)

Specimens collected: Victoria, 2536; Gonzales, 2695 (type specimen); Yoakum, 2770; Hallettsville, 2783.

Scab (*Fusicladium effusum* Wint.).—This disease first produces minute brown spots on the under surface of the leaflet which increase in size until they reach 3 to 5 mm. in diameter. The spots are circular or subcircular, and in severe infections they may become confluent. In the earlier stages the spots are confined to the lower surface, but finally the leaf tissue is killed and the spot becomes dark brown on the upper surface. It does not show the velvety appearance of the under surface, since the conidiophores are entirely hypophyllous. The scab spots occur also on the petioles.

Specimens collected: Kerrville, 1570; Uvalde, 1927; Seguin, 2309.

POISON OAK.

Rust (*Pileolaria toxicodendri* (B. and Rav.) Arth.).—The small chocolate-brown sori are formed in abundance on the upper surface of the leaves of the poison oak (*Rhus toxicodendron* L.).

Specimen collected: Austin, 347.

POMEGRANATE.

Leaf-spot (*Cercospora lythracearum* Heald and Wolf, 32).—This fungus on the pomegranate (*Punica granatum* L.) produces angular—more or less rounded—brown spots with an indefinite margin below, 1 to 4 or 5 mm. in diameter, sometimes larger. Exceedingly dense aggregates of conidiophores are present on both surfaces, 20 to 30 by 3 μ, clear or only faintly yellowish; conidia clavate, 30 to 56 by 3 to 3.5 μ, clear, septate. (Pl. I, fig. 5.)

This is apparently the same species of Cercospora which we have described as causing a leaf spot of crape myrtle (p. 64), a closely related host, and the difference in the conidiophores is no more than might be expected from growth upon different hosts.

Specimens collected: Beeville, 1829; Falfurrias, 2472; Victoria, 2510, 2515; Cuero, 2589; Flatonia, 2738.

PRICKLY ASH.

Rust (*Accidium xanthoxyli* Pk.).—Cluster cups were found on the leaves of prickly ash (*Zanthoxylum clava-herculis* L.); especially abundant in the vicinity of Austin.

Specimens collected: Elgin, 1872; Austin, 3114.

Sooty mold (*Fumago vagans?* P.).—This forms a sooty coating on the foliage.

Specimen collected: Austin, 419.

PRIVET.

Leaf-spot (*Cercospora adusta* Heald and Wolf, 32.)—This forms on the privet (*Ligustrum* spp.) dark-brown areas involving large spots, frequently extending from the tip downward or from the margin inward. Rarely are the spots removed from the margin. The older diseased parts become very dark and the newer, brown, with a gradual shading out into the chlorotic tissue. Conidiophores 100 to 150 by 4 to 5 μ, brown and septate, appear on both surfaces in small clusters. The conidia are densely granular, clear, multiseptate, and 85 to 160 by 3 to 4 μ. (Pl. III, fig. 1.)

Alternaria is abundantly present on the spots, probably as a saprophyte.

Specimens collected: On *Ligustrum ovalifolium* Hassk.—Falfurrias, 2471 (type specimen); Floresville, 2851.

Leaf-spot (*Cercospora ligustri* Roum.).—Somewhat circular or irregular spots, sometimes as large as 7 mm., are formed. They are brown with a grayish center above and brown below. The margin is purplish or darker brown. (Pl. XV, fig. 1.)

Specimen collected: On *Ligustrum japonicum* Thunb.—Austin, 1316.

Leaf-spot (*Phyllosticta ovalifolii* Brun.).—Small circular brown spots 2 or 3 mm. in diameter, with a darker margin, occur on the leaves. The black pycnidia are few in each area.

Specimen collected: On *Ligustrum ovalifolium* Hassk.—San Antonio, 1405.

REDBUD.

Leaf-spot (*Cercospora cercidicola* Ell.).—In the beginning small brown spots appear on the leaves of the redbud (*Cercis occidentalis* Torr.). These spots become 2 to 4 mm. in diameter, angular, dark brown above and brown below, with a region of yellow tissue surrounding each spot. The leaves become badly spotted, and defoliation results.

Specimens collected: Kerrville, 1621; Austin, 1913; Georgetown, 2397.

RETAMA.

Sooty mold (*Dimerosporium parkinsoniae* Heald and Wolf, 32).—The leaves and smaller twigs and even the smooth bark of larger branches of retama (*Parkinsonia aculeata* L.) are sometimes covered with patches made up of dense aggregates of brown, septate hyphæ. The conidia are dark brown, one to four celled, and also muriform. (Pl. VII, fig. 2.) The asci are eight spored, 45 to 50 by 12 to 15 μ; spores hyaline, two celled, lower cell smaller, both biguttulate, and 15 to 18 by 4 to 6 μ. (Pl. VII, fig. 1.)

Specimens collected: Austin, 455; Seguin, 2311 (type specimen); Gonzales, 2658; Hallettsville, 2901.

SUMAC.

Leaf-spot (*Cercospora rhoina* Cke. and Ell.).—Circular or irregular brown or dark-brown, almost black, spots, 3 to 5 mm. in diameter, are formed on the leaves of sumac (*Rhus copallina lanceolata* Gray). They have a tendency to be marginal and extend inward, the outline being angular, due to the veins of the leaf.

Specimens collected: Austin, 218; Georgetown, 2399.

SWAMP CYPRESS.

Leaf-blight (*Pestalozzia funerea* Desm.).—In this disease the leaflets of the swamp cypress (*Taxodium distichum* (L.) Rich.) turn brown. Beginning at the tips, they become brown throughout, or show somewhat grayish, with an abundance of black acervuli. The foliage of affected trees was badly blighted. In one collection showing similar symptoms the Pestalozzia was not present, but an Alternaria species was found, so it may be possible that the Pestalozzia is only a secondary factor in producing the disease.

Specimens collected: Victoria, 2535; Gonzales, 2678.

SYCAMORE.

Blight (*Gloeosporium nervisequum* (Fckl.) Sacc.).—This blight, which is characterized by the formation of dead areas beginning at the margin of the leaf or the tips of the lobes and spreading throughout the leaf, is very destructive to the sycamore (*Platanus occidentalis* L.) in the more humid portion of this territory, but rare in the western and southwestern portion.

Specimens collected: Tyler, 1550; New Braunfels, 1723; Bastrop, 2056; San Marcos, 2118; Georgetown, 2371; Flatonia, 2710; Hallettsville, 2774; Falfurrias, 2470.

Leaf-blight (*Phleospora multimaculans* Heald and Wolf, 32).—Definite, irregular, circular or angular spots, dark brown or purple, and 1 to 3 mm. in diameter, are produced upon the upper surface of the leaves. They frequently show a brown center, and on the under surface the spot is brown throughout with a darker brown border. The spots frequently become confluent and produce dirty-brown, extended, dead areas. The spots may be very numerous, and in nurseries much defoliation results. (Pl. XIV, fig. 2.)

The pycnidia are hypophyllous; spores nearly cylindrical, straight or curved, hyaline, 30 to 50 by 3.5 to 5 μ, and two to three septate, sometimes four septate (Pl. V, fig. 7). (See also Walnut.)

Specimens collected: Austin, 1398, 1535; Brenham, 1462; New Braunfels, 1682 (type specimen); Llano, 1767; Victoria, 2503; Gonzales, 2655; Floresville. 2858.

SYMPHORICARPOS.

Powdery mildew (*Microsphaera diffusa* Cke. and Pk.).—Both the conidial and perithecial condition were abundantly present on *Symphoricarpos orbiculatus* Moench where this was observed. Causes little apparent injury.

Specimen collected: Austin, 1311.

TREE-OF-HEAVEN.

Shot-hole (*Cercospora glandulosa* Ell. and Kellerm.).—This disease on the tree-of-heaven (*Ailanthus glandulosa* Desf.) forms circular spots 1 to 3 mm. in diameter, brown, becoming gray above, with an elevated margin. The whitish conidial tufts are very conspicuous on the lower surface. The entire diseased area at length drops out, producing on the leaves a "shot-hole" effect.

Specimens collected: New Braunfels, 1698; Austin, 2862.

TRUMPET CREEPER.

Leaf-mold (*Cercospora sordida* Sacc.).—On the lower surface of the leaf of trumpet creeper (*Tecoma radicans* (L.) Juss.) a diffuse, indefinite, brown or olivaceous coating is formed. This shows on the upper surface as a slight chlorosis of the tissue.

Specimens collected: Bastrop, 2023; Victoria, 2519.

Leaf-spot (*Septoria tecomæ* Ell. and Ev.).—The diseased areas are purplish throughout in the earlier stages of their development, 2 to 3 mm. in diameter, and with an indefinite outline. Later a minute, central, grayish patch is formed in which the pycnidia are produced.

Specimen collected: Austin, 1317.

TULIP TREE.

Leaf-blight (*Gloeosporium liriodendri* Ell. and Ev.).—The leaves of the tulip tree (*Liriodendron tulipifera* L.) may show extended, dead, brown patches which involve part or the whole of the leaf lobes, advancing from the tips or margins. The spots are light brown and darker at the advancing edges. *Gloeosporium liriodendri* is present, but it is impossible to say whether it is the entire cause of the blight.

Specimens collected: New Braunfels, 1680; Seguin, 2281.

Leaf-spot.—The leaves of the tulip tree in one locality showed a definite spotting which indicates a fungous trouble, although no fungus spores were found. The spots are irregularly circular, 4 to 8 mm. in diameter, dark brown or black, surrounded by a broad zone of yellow which fades out without a definite boundary. On the lower surface the spots are less pronounced and more of a purplish-black color. The affected leaves may show only a few spots or as many as 25, and in some cases extensive, dead, brown areas may be produced.

Specimen collected: Georgetown, 2370.

UMBRELLA CHINA TREE.

Root-rot (*Ozonium omnivorum* Shear.).—This was found on an umbrella China tree (*Melia azedarach* L.) in a nursery where the root-rot had killed the young trees of black locust in an adjacent plat.

Specimen collected: Georgetown, 2352.

VIRGINIA CREEPER.

Leaf-spot (*Cercospora pustula* Cke.).—This fungus produces on the Virginia creeper (*Psedera quinquefolia* (L.) Greene) dark-brown, purple, or almost black spots, subcircular or angular, 1 to 2 mm. in diameter or smaller, and generally surrounded by a zone of yellow. Colors are more dilute on the under surface.

The conidiophores are epiphyllous, fasciculate in rather sparse groups, continuous, 35 to 45 by 4 μ, uniformly yellowish brown; spores smoky, clavate, straight or curved, 28 to 72 by 4 μ, and two or three septate. (Pl. III, fig. 5.) Differs from *C. ampelopsidis* in having smaller spores, and epiphyllous conidiophores.

Specimens collected: Austin, 1277; New Braunfels, 1669.

Leaf-spot (*Phyllosticta ampelopsidis* Ell. and Martin).—Definite, circular, brown spots, 1 to 5 mm. in diameter, with a darker border, are characteristic of this trouble.

Specimens collected: Austin, 1547; New Braunfels, 1670.

WALNUT.

Leaf-spot (*Phleospora multimaculans* Heald and Wolf, 32).—The spots on the leaves of the walnut (*Juglans* sp.) produced by this fungus average about 1 mm. in diameter, are subcircular, dark brown with a darker border on the upper surface, and about a uniform brown on the under surface. The spots may be few in number, or they may be so numerous as almost completely to cover the leaf. It is very severe in some cases and causes much defoliation.

The pycnidia are hypophyllous, 30 by 45 μ; the spores are generally curved, hyaline, nearly cylindrical, 20 to 40 by 3 to 3.5 μ, and one to three septate. (Pl. V, fig. 11.) The general symptomatology and the close relationship of the hosts indicate that this is the same species as described on the sycamore (p. 79), although there are slight morphological differences.

Specimens collected: (1) On *Juglans nigra* L.—Austin, 1538, 2426; Victoria, 2337; Stockdale, 2621; Gonzales, 2682; Flatonia, 2721 (type specimen); Falfurrias, 2460. (2) On *Juglans regia* L.—Austin, 366; Falfurrias, 2461.

WILD CHINA TREE.

Leaf-spot (*Cylindrosporium griseum* Heald and Wolf, 32).—Very numerous grayish or whitish, circular or slightly angular spots are produced on both surfaces of the leaflets and the rachis of the wild China tree (*Sapindus drummondii* Hook. and Arn.) The spots vary in size from 1 to 5 mm. with a predominating size of 1 to 2 mm. and show more prominent veins owing to the shrinking of the tissue. They may become confluent and cause extended dead areas (Pl. XIX, fig. 1).

The acervuli are amphigenous, more abundant on the upper surface, and are located immediately over the prominent veins (Pl. VI, fig. 12); they may be nearly circular in outline or much elongated along the veins, pale when young, becoming darker with age. The spores are cylindrical, slightly curved or sometimes straight, hyaline, 90 to 135 by 3 to 4.5 μ, and seven to nine septate (Pl. VI, fig. 11).

Specimens collected: Kerrville, 1588; Llano, 1757 (type specimen); Bastrop, 2026; San Marcos, 2098.

Powdery mildew (*Uncinula circinata* Cke. and Pk.).—The mycelium of the fungus forms a very effuse coating, most abundant on the lower surface. The leaves first become yellow and later dry and brown. The scattered perithecia are produced on the lower surface, dark brown in color, 150 to 180 μ in diameter, with clear appendages about equal in length to the diameter of the perithecium. The asci are elongated 65 to 70 by 25 to 30 μ, containing six to eight ascospores 15 to 18 by 9 to 12 μ. This species is somewhat doubtfully referred to *U. circinata.* Salmon records it for species of Acer only.

Specimens collected: Austin, 315, 441.

WILLOW.

Leaf-spot (*Cercospora salicina* Ell. and Ev.).—Dark-brown, irregular, more or less confluent areas from 3 to 8 mm. in diameter are present on the leaves of the willow (*Salix* sp.). The greater part of the leaf becomes involved.

Specimens collected: New Braunfels, 1724; Victoria, 2530; Falfurrias, 2462; Floresville, 2856.

Rust (*Melampsora bigelowii* Thm.).—The yellow sori appear on the foliage, upon the under surface of the leaves.

Specimens collected: Austin, 83, 237.

WISTARIA.

Leaf-spot (*Phyllosticta wistariae* Sacc.).—This fungus on the wistaria (*Kraunhia* sp.) causes circular grayish or brown spots 2 to 5 mm. in diameter, with a narrow purple border. Pycnidia are not abundant, and on some of the spots a species of Alternaria is present. Affected leaves showed considerable chlorosis.

Specimen collected: Austin, 1304.

DISEASES OF ORNAMENTAL PLANTS.

BALSAM-APPLE.

Leaf-blight (*Ramularia momordicae* Heald and Wolf, 32).—In the early stages of this disease the leaves of the balsam-apple (*Momordica balsamina* L.) show irregular blotches of yellow. As the disease advances, circular to subcircular yellowish-brown areas, varying from 1 to 10 mm. in diameter, with a more or less evident zonation, are formed on the upper side of the leaf. On the lower surface these areas become depressed with a ridged margin and are dark brown in color, due to the abundance of conidiophores and conidia. The conidiophores, aggregated in tufts of 8 to 14, are 30 to 45 by 4 to 5 μ in size and brown in color. The spores are cylindrical, hyaline, 42 to 65 by 4 to 5 μ, and 1 to 5 septate. (Pl. V, fig. 1.) The spots are often so numerous as to be confluent, causing the leaves to curl and become dry. Much defoliation results.

Specimen collected: Falfurrias, 2482 (type specimen).

BEGONIA.

Bacterial leaf-spot (*Bacillus pyrocyanus* P. and D.) (?).—The first appearance of this trouble on the leaves of the begonia (*Begonia* sp.)

can be noted by the presence of purplish areas 1 to 2 mm. in diameter. These spots become depressed, often show concentric zonation, and increase in size to 4 to 8 mm., with a wide area of yellow, dead tissue around them. The yellow areas may fuse, thus involving a large part of the leaf, so that it is completely destroyed. (Pl. XVII, fig. 2.) This is probably the same disease that occurs in France, although it was not observed to attack the stems but only the leaves (40). The disease was observed in only a single locality, on greenhouse plants. No cultural work with the organism was attempted.

Specimens collected: San Antonio, 1411, 3176.

CANDYTUFT.

Dodder (*Cuscuta indecora* Choisy).—This parasite was observed on the candytuft (*Iberis* sp.) in only a single locality where it had spread to a considerable extent.

Specimen collected: San Antonio, 1372.

CANNA.

Leaf-blight.—A very serious leaf disease of the canna (*Canna indica* L.) appears at first as minute yellowish spots which become from 5 to 10 mm. in diameter, with brown centers. When isolated they are subcircular in outline, but when abundant they coalesce so that large irregular areas are involved. The brown parts show alternating concentric rings of lighter and darker areas of brown. Examination reveals no evidence of either fungi or bacteria, yet the trouble is apparently of fungous origin. In severe cases the entire leaf or leaf tip becomes dead and brown.

Specimens collected: New Braunfels, 1672, 1710.

CARNATION.

Root-rot (*Fusarium* sp.?).—This root disease was observed on the carnation (*Dianthus caryophyllus* L.) both in the greenhouse and in an irrigated garden. The smaller roots are destroyed and the larger ones become badly disintegrated.

Considerable loss results among young plants.

Specimens collected: San Antonio, 1385; Austin, 1914.

Rust (*Uromyces caryophyllinus* (Schrk.) Schrt.).—This fungus was collected in a greenhouse in a single locality. The brown sori were formed on the leaves and stems, but were not sufficiently abundant to cause serious harm.

Specimens collected: Austin, 2941, 3059.

CASTOR BEAN.

White leaf-spot (*Cercospora ricinella* Sacc. and Berl.).—On the foliage of the castor bean (*Ricinus communis* L.) this fungus causes the formation of small circular spots from 1 to 2 mm. in diameter. These spots are gray on both surfaces and have a well-defined, raised, purple margin. When the spots are abundant the leaves become yellow.

Specimens collected: Falfurrias, 2443; Flatonia, 2737; Hallettsville, 2780; Austin, 2921.

CENTURY PLANT.

Blight (*Stagonospora gigantea* Heald and Wolf, 32).—The disease begins on the tips or margin of the leaves of the century plant (*Agave americana* L.) and advances toward the base. (Pl. XVI, fig. 1.) The diseased tissue becomes dry, gray, and zonate, marking the periodic growth of the fungus. The pycnidia are on both leaf surfaces, covered at first, and at length protruding. They vary from 500 to 600 μ in diameter. (Pl. XVI, fig. 2.) The spores are large, hyaline, cylindrical, and slightly clavate, densely granular and frequently with many guttulæ, three septate and 72 to 115 by 13 to 15 μ. (Pl. V, fig. 3.) Our species differs from *S. macrospora* (Dur. and Mont.) Sacc., principally in having much larger spores, and also larger pycnidia.

This disease was very serious, blighting the plants in all the localities where it was observed.

Specimens collected: Austin, 1283 (type specimen); San Antonio, 1377; Boerne, 1648.

CHINA ASTER.

Stem-rot (*Fusarium* sp.?).—This fungus on the China aster (*Callistemma chinensis* (L.) Skeels) was the cause of a very considerable loss in the one locality in which it was observed. The young plants in the benches remain without any apparent growth for a time, then wither and die, with a serious disintegration of the stem near the ground.

Specimen collected: Austin, 1445.

CHRYSANTHEMUM.

Leaf-spot (*Septoria chrysanthemi* Allesch.).—This leaf-spot of chrysanthemum (*Chrysanthemum stipulaceum* (Moench) W. F. Wight) has been collected twice from greenhouses. In some cases it causes a considerable amount of defoliation, especially on the lower part of the plant.

Specimens collected: Austin, 380; Georgetown, 2368.

Root-knot (*Heterodera radicicola* (Greef) Mül.).—Observed in only a single locality. Affected plants were much dwarfed.

Specimen collected: Austin, 1921.

COLUMBINE.

Leaf anthracnose (*Gloeosporium aquilegiae* Thm.).—Large marginal spots, usually irregular in outline, are formed on the leaves of the columbine (*Aquilegia* sp.). These diseased areas are yellowish brown in color with a brown border and often a yellowish zone toward the advancing edge of the affected tissue. The lower surface shows the same colors except that they are more dilute. On the upper surface are numerous little dots, the acervuli. Observed in greenhouses only.

Specimens collected: Beeville, 1866; Austin, 2864.

CYCAS.

Blight (*Ascochyta cycadina* Scalia).—The leaflets of *Cycas revoluta* Thunb. turn yellow at the tips, and as the trouble advances the older diseased portions become brown. The pycnidia, black and more or less scattered, form on the upper surface. Observed in a single locality where it was abundantly present and apparently the cause of considerable injury.

Specimen collected: Beeville, 1852.

DAISY.

Dodder (*Cuscuta indecora* Choisy).—This was observed on the daisy (*Chrysanthemum* sp.) in a garden at San Antonio.

Specimen collected: San Antonio, 1664.

Leaf-spot (*Cercospora chrysanthemi* Heald and Wolf, 32).—The diseased areas are raised above and sunken below, and vary in size from 2 to 10 mm. They have very definite elevated borders, are subcircular or irregular in outline and brown in color, becoming grayish with age. The conidiophores, present on both surfaces, are densely fasciculate, brown, septate, 45 to 75 by 4 μ. The conidia are clavate, 40 to 120 by 4 μ, many septate, and dilutedly colored. (Pl. III, fig. 4.)

When the spots are abundant the leaf becomes brown between the diseased areas.

Specimen collected: San Antonio, 1659 (type specimen).

ELEPHANT'S-EAR.

Leaf-spot.—On the upper surface of the leaves of elephant's ear (*Colocasia esculenta* (L.) Schott.) the spots are circular in outline, 5 to 15 mm. in diameter, with a brown center and a surrounding zone of yellow, shading out into the green tissue without a definite boundary. On the lower surface the spots are more definite in outline, with a brown center, surrounded by a yellowish-brown area with often a zone of diffuse white bordering the spot. This zone is 1 to 2 mm. wide, and probably marks the advance of the fungus. Only sterile fungous filaments were found. The affected leaves become chlorotic.

Specimen collected: New Braunfels, 1668.

FOUR-O'CLOCK.

White-rust (*Albugo platensis* (Speg.) Swingle).—This species of white-rust has been found on the common four-o'clock (*Mirabilis jalapa* L.). Sori were very abundant on the leaves which turned brown and shriveled, while those in which the disease was not so far advanced showed a marked chlorosis. Wilson (51) does not record this species for the four-o'clock, although it is common on other species of the Allioniaceæ.

Specimens collected: Austin, 3019, 3101.

GERANIUM.

Bacterial leaf-spot.—Geraniums (*Pelargonium* sp.) have been found to suffer in the greenhouse from what is apparently a bacterial spot. The affected leaves show numerous subcircular, brown or somewhat pellucid areas which are crowded full of bacteria. With the advance of the disease the intervening leaf tissue turns brown, and extensive dead, wrinkled areas result which show the original foci as darker spots scattered over the dead portions. Affected leaves generally show more or less chlorosis and may fall before they turn brown. (Pl. XVII, fig. 1.) Young plants in the same house were affected with a stem-rot which was probably also of bacterial origin.

Specimens collected: Austin, 374, 474, 1920.

HOLLYHOCK.

Leaf-spot (*Cercospora althaeina* Sacc.).—The numerous small circular or angular spots 1 to 5 mm. in diameter produced on the leaves of the hollyhock (*Althaea rosea* (L.) Cav.) by this fungus are reddish brown with a darker border and often a lighter center. The entire area is raised on the upper surface and depressed on the lower.

Specimen collected: Austin, 1904.

IRIS.

Leaf-blight (*Heterosporium gracile* (Wallr.) Sacc.).—This blight on the iris (*Iris* sp.) produces an abundance of spots which make their appearance first on the distal portions of the leaves. The young spots show a yellow center surrounded by a zone of watery tissue. The older spots which have produced tufts of conidiophores are circular or elliptical, reaching 3 to 8 mm. in length, and show a gray center surrounded by a zone of brown, bordered by a narrow, watery area. The fungus is much more abundant toward the tips of the leaves and proceeds downward, the terminal portions of the leaves often becoming brown and dead, with the more or less zonate spots still conspicuous. In serious infections the leaf tissue turns yellow in advance of the fungus, and many leaves may be completely killed.

Specimens collected: On Peace variety—Austin, 457, 1323, 1436.

MAY-APPLE.

Rust (*Kuehneola hibisci* (Syd.) Arth.).—This rust on the May-apple (*Malvaviscus drummondii* T. and G.) produces very abundant, almost punctiform sori upon the under surface of the leaves and causes more or less browning of the upper surface.

Specimen collected: Austin, 372.

MEXICAN BLUEBELL.

Leaf-mold (*Cercospora nepheloides* Ell. and Holw.).—Diffuse olive-green patches appear on the leaves of the Mexican bluebell (*Eustoma russellianum* (Hook.) Griesb.) At first these patches are more or less circular, gradually spreading over large portions of the leaf, with considerable chlorosis. In the advanced stages of the disease the conidiophores and conidia have become evenly distributed over the brown, dead tissue.

Conidiophores 30 to 42 by 3 to 4 μ, brown, in dense fascicles; conidia 30 to 60 by 3 to 4 μ, brown, clavate, several septate. (Pl. II, fig. 3.) Both leaf surfaces are equally attacked, the lower leaves being most affected.

Our specimens agree with *C. nepheloides* Ell. and Holw. on *E. silenifolium* Salisb. No published descriptions of this species have been found, and the determination was made by a comparison of our specimens with one issued by S. B. Parish under the above name, labeled "Santa Barbara, Cal., Sep. '94."

Specimen collected: Austin, 1556 (type specimen).

PERIWINKLE.

Dodder (*Cuscuta indecora* Choisy).—This parasite on periwinkle (*Vinca rosea* L.) had run rampant in a garden.

Specimen collected: San Antonio, 1663.

ROSE.

Cane canker (*Coniothyrium fuckelii* Sacc.).—On the rose (*Rosa* spp.) canes or stems brown, sunken patches, 1 to 4 or 5 cm. in length, are formed. The stem may be girdled as the filaments extend through the cortex. Sometimes the open cankers are not so evident, the fungus being more diffuse. The pycnidia are formed just beneath the epidermis, at length protruding.

Specimens collected: Austin, 1282; San Antonio, 1384.

Dodder (*Cuscuta indecora* Choisy).—This was present in a garden where it had grown on several other hosts.

Specimen collected: San Antonio, 1374.

Leaf-blotch (*Actinonema rosae* (Lib.) Fr.).—This fungus has been observed in gardens and nurseries and produces a considerable amount of defoliation, especially in the nurseries.

Specimens collected: Austin, 20, 379, 1278, 1919, 2939; Victoria, 2336; Stockdale, 2640; Falfurrias, 2463.

Leaf-spot (*Cercospora rosicola* Pass.).—The spots produced by this fungus are circular, 1 to 5 mm. in diameter, with a pronounced purple border and a brown or grayish center. More or less yellowing of the foliage and defoliation occur when the spots are abundant.

Specimens collected: Austin, 371, 381, 1442; Brenham, 1456; Seguin, 2328; Georgetown, 2373; Victoria, 2524; Gonzales, 2687.

Powdery mildew (*Sphaerotheca humuli* (DC.) Burr. and *S. pannosa* (Wallr.) Lev.).—The first of these is the greenhouse form and is not so common as the latter. Early in the summer roses are very commonly completely defoliated by the ravages of *S. pannosa.*

Specimens collected: (1) (*S. humuli*)—San Antonio, 1370. (2) (*S. pannosa*)—Austin, 1275, 2940.

Rust (*Phragmidium disciflorum* (Tode) James).—The æcial stage was so abundantly present that the leaves were very conspicuously chlorotic above, while the orange-colored æciospores covered the lower surface.

Specimens collected: Austin, 3119; San Antonio, 3181.

STANDING CYPRESS.

Powdery mildew (*Sphaerotheca humuli* (DC.) Burr.) (?).—This mildew was very abundant in one locality where standing cypress (*Gilia rubra* (L.) Heller) was cultivated in large beds. The lower leaves were attacked first and many were completely killed. No perfect fruits were found. The mildew showed an abundance of a species of Cicinnobolus.

Specimens collected: Austin, 1309, 1437.

SWEET ALYSSUM.

Dodder (*Cuscuta* sp.?).—Sweet alyssum (*Konia maritima* (L.) R. Br.) infested with dodder was found in one locality. Not flowering.

Specimen collected: San Antonio, 1372.

SWEET PEA.

Dodder (*Cuscuta indecora* Choisy).—This parasite was present on the sweet pea (*Lathyrus odoratus* L.) and also on several other kinds of plants growing near.

Specimen collected: San Antonio, 1375.

VIOLET.

Leaf-spot (*Alternaria violae* Gall. and Dorsett).—This disease occurs on the leaves of the violet (*Viola odorata* L.), commencing with small yellowish spots. The spots are somewhat circular, 1 to 5 mm. in diameter, and become yellowish white at maturity. They frequently spread so that large areas are involved.

Specimens collected: San Antonio, 1383, 1662, 3180; Uvalde, 1964.

Leaf-spot (*Cercospora violae* Sacc.).—Numerous small pale spots are formed on the leaves. They vary in size from 1 to 3 mm., and are margined by a zone of brown.

Specimens collected: Beeville, 1856; Austin, 1917; Lockhart, 2131; Seguin, 2329; Victoria, 2334, 2523; Georgetown, 2372; Cuero, 2577; Flatonia, 2739; San Antonio, 3178.

ZINNIA.

Leaf-spot (*Cercospora atricincta* Heald and Wolf, 32).—This disease on the leaves of the zinnia (*Crassina elegans* (Jacq.) Kuntze) is characterized by the presence of irregular, angular, gray spots with a brown border. When the spots are abundant this border is narrow and the spots are small, 1 to 2 mm. in diameter. When they are few they may be 4 mm. in diameter, with a broad marginal zone of purplish or dark brown. The conidiophores are found on both surfaces in small groups, brown in color, septate, 45 to 70 by 3.5 to 4.5 μ.

The conidia are dilute brown, many septate, clavate, 100 to 200 by 4 to 4.5 μ. (Pl. I, fig. 4.)

This is quite common in gardens.

Specimens collected: San Antonio, 1381, 1660; Victoria, 2506 (type specimen).

DISEASES OF WILD PLANTS.

ARROW LEAF.

Leaf-spot (*Cercospora sagittariae* Ell. and Kellerm.).—This disease on the arrow leaf (*Sagittaria* sp.) is characterized by the presence of grayish-brown, circular, or subcircular spots, 2 to 10 mm. in diameter, with a darker border and exhibiting more or less concentric zonation. In some cases adjacent foci become confluent, thus involving larger areas of the leaf. Some chlorosis is frequent in badly affected leaves.

Conidiophores on both surfaces, in clusters of 2 to 5, brown, straight, continuous or one septate, 6 by 60 μ; spores straight or curved, tapering, club shaped, four to five septate, contents homogeneous or distinctly two guttulate, hyaline, or faintly smoky, 120 to 140 by 5.5 to 8 μ. (Pl. IV, fig. 1.)

Our specimens differ from *C. sagittariae* Ell. and Kellerm. in the size of the spores, which are recorded as 60 to 80 by 3 to 4 μ (15).

Specimens of *Sagittaria lancifolia* L. are affected with the same Cercospora, which is not perfectly developed, since the spores are 50 to 80 by 3.5 to 5 μ, indistinctly septate, more nearly straight, and hyaline. The general symptomatology is similar.

Specimens collected: (1) On *Sagittaria lancifolia* L.—Collins's Gardens, San Antonio, 1386 (represents young infections with immature spores). (2) On *S. platyphylla* (Engelman) Sm.—New Braunfels, 1676; San Antonio, 3164; San Marcos, 2121 (shows mostly immature spores and imperfectly developed spots). (3) On *Sagittaria* sp.?—Lockhart, 2064 (has but few mature spots).

BLUEBONNET.

Powdery mildew (*Erysiphe polygoni* DC.).—The stem, leaves, and pods of the bluebonnet (*Lupinus texensis* Hook.) are covered by the powdery white network of fungous filaments. Affected plants are paler green, with yellow-margined leaves, some of which are dry.

Specimen collected: Austin, 3126.

BLUET.

Rust (*Aecidium oldenlandianum* Ell. and Tracy).—The affected leaves of the bluet (*Houstonia angustifolia* Michx.) show considerable chlorosis. Nearly all leaves are attacked, so that affected plants are rendered conspicuous by their yellow color. The yellowish cluster cups containing the orange-colored æciospores open to the lower surface of the leaves.

Specimens collected: Austin, 2947, 2951.

BOERHAVIA.

White-rust (*Albugo platensis* (Speg.) Swingle).—Blisterlike elevations, each of which contains a white, powdery mass of spores, are formed on the upper surface of the leaf of the Boerhavia (*Boerhavia* spp.). This disease is very widely distributed, but apparently causes little injury.

Specimens collected: San Antonio, 1371, 3175; New Braunfels, 1697; Bastrop, 2033; Lockhart, 2075; Cotulla, 2135; Seguin, 2318; Victoria, 2527; Nursery, 2574; Cuero, 2590; Stockdale, 2608; Gonzales, 2686; Kennedy, 2832.

BROOMWEED.

Rust (*Aecidium chrysopsidis* Ell. and Anders.).—On the stems and leaves (much more abundantly on the stems) of the broomweed (*Gutierrezia texana* (DC.) Torr. and Gray) are whitish or yellowish pustules, the cluster cups. They form in such numbers on the main stems and branches that these parts become brown and are killed.

This rust has been described (13) as occurring on *Gutierrezia euthamia* Torr. and Gray and is probably the same as the one on this species, although no note of the fact has been found.

Specimens collected: Victoria, 2538; Gonzales, 2679.

BULL NETTLE.

Leaf-spot (*Septoria jatrophae* Heald and Wolf, 32).—This causes the formation of very characteristic, brown, circular areas on the leaves of the bull nettle (*Jatropha stimulosa* Michx.). These spots vary in size from 1 to 5 mm. and are frequently somewhat irregular in outline. At first they are dark brown with a darker, almost black, border. Later the centers become tan and sometimes gray, but always with a definite dark margin. The pycnidia are 120 to 150 μ, brown and immersed wholly in the leaf tissues. The spores are rod shaped or slightly clavate, hyaline, 40 to 50 by 3 μ and few septate.

The spots frequently are so abundant that they fuse, causing the drying of large portions of the leaf.

Specimen collected: Austin, 2429 (type specimen).

CAROLINA CLOVER.

Rust (*Uromyces elegans* B. and C.).—The minute brown sori appear abundantly on the lower surface of the leaflets of Carolina clover (*Trifolium carolinianum* Michx.).

Specimen collected: Austin, 3060.

COCKLEBUR.

Leaf-spot (*Cercospora xanthicola* Heald and Wolf, 32.)—This fungus produces upon the leaves of the cocklebur (*Xanthium* spp.) numerous circular or subcircular spots, 0.5 to 2 mm. (1 mm. average size) in diameter, with dirty-gray or brownish centers surrounded by a narrow darker border. The number of infections on a single leaf may reach as high as 400 to 600, in which case the leaf shows more or less chlorosis, but frequently the spots are less numerous and the leaf shows little or no deviation from the normal color.

Conidiophores amphigenous, fascicles of 3 to 8, hyaline tipped, irregular-nodose for two-thirds the length, continuous or rarely septate, 3 to 3.5 by 60 to 100 μ. Spores 105 to 135 by 3 μ and reaching the length of 245 μ in some cases, very slender club shaped, tapering gradually from the base, generally somewhat curved, hyaline, and obscurely septate except in the basal portion. (Pl. II, fig. 4.)

Specimens collected: Luling, 2236; Georgetown, 2383 (type specimen); Nursery, 2567; Cuero, 2588; Gonzales, 2705; Yoakum, 2755; Hallettsville, 2790; Kennedy, 2836; Austin, 2871.

Rust (*Puccinia xanthi* S.).—The rust of the cocklebur is very common, producing numerous circular or slightly irregular spots on the leaves (minute to 1 cm. in diameter), pale yellow and sunken on the upper surface, dark brown with narrow yellow border on the under surface, and somewhat hypertrophied. Old spots frequently show gray centers on the under surface.

Specimens collected: Austin, 1413, 1545; Beeville, 1800; Lockhart, 2065; San Marcos, 2088; Hondo, 2251; Luling, 2241; Seguin, 2302; Georgetown, 2381; Victoria, 2343; Gonzales, 2664; Kennedy, 2822; Floresville, 2849.

CONVOLVULUS.

White-rust (*Albugo ipomoeae-panduranae* (S.) Swingle).—The white, blisterlike spots on the convolvulus (*Convolvulus hermanioides* Gray) were present on all parts of the plant. This disease is not recorded (51) as occurring on this species.

Specimens collected: Austin, 311, 814, 1265.

CORAL BEAD.

Leaf-spot (*Cercospora menispermi* Ell. and Holw.).—On the foliage of this climbing vine (*Cebatha carolina* (L.) Britton) very abundant dark-brown spots are present, 2 to 5 mm. in diameter. The margin of the spot pales out from a raised border which is almost black. With age the centers of the diseased areas become grayish. The spores are generally clavate, sometimes cylindrical, from 30 to 60 by 5 to 6 μ, brown, three to five septate.

No defoliation results.

Specimens collected: Sabinal, 1987; Bastrop, 2036; San Marcos, 2089; Luling, 2230; Seguin, 2313; Round Rock, 2409; Gonzales, 2681; Floresville, 2846.

CRANE'S-BILL.

Downy mildew (*Rhysotheca geranii* (Pk.) Wilson).—Very conspicuous, definite, downy, white areas are formed on the lower surface of the leaves of the crane's-bill (*Geranium carolinianum* L.). They may be small and isolated or may involve the entire surface. In the earlier stages the upper surface of the foliage becomes yellow, but finally the entire leaf becomes dead and dry.

Specimen collected: Austin, 2938.

CROTON.

Dodder (*Cuscuta indecora* Choisy).—This was very abundant on the plants of croton (*Croton* spp.) in a single locality.

Specimen collected: San Antonio, 1373.

Rust (*Bubakia crotonis* (Cke.) Arth.).—In this species of rust the sori are very abundant. In the majority of specimens collected the uredinia are more abundant than the telia. In some the telia are much more abundant than the uredinia, and occur on both surfaces of the leaves and on the petioles and stems. The telia on the leaves are black, swollen cushions, still covered by the epidermis, 0.5 to 1 mm. in diameter and very abundant, causing the edges of the leaf blade to roll upward and inward. The telia on the stems may be similar in size to those on the leaf surfaces, but they are generally much larger and may form elongated cushions 3 to 10 mm. in length, which are confined to one side of the stem or completely encircle it. When uredinia only are present the leaves may also be curled and rolled, and the sori are frequently surrounded by a narrow zone of yellow. Our collections represent various other species of Croton in addition to *C. texensis* (Kl.) Muell. Arg.

Specimens collected: Luling, 2258; Georgetown, 2380; Round Rock, 2418; Falfurrias, 2442, 2489; Victoria, 2526; Cuero, 2582; Stockdale, 2647; Flatonia, 2736; Yoakum, 2757; Skidmore, 2817; Austin, 2907. All except 2907 represent uredinia only.

CROWNBEARD.

Leaf-spot (*Cercospora fulvella* Heald and Wolf, 32).—This disease on the crownbeard (*Verbesina texana* Buckl.) is characterized by the presence of irregular, yellowish-brown areas, 5 to 10 mm. in diameter, which sometimes become confluent, causing the death of larger areas. The color is more dilute and the spots less definite on the under surface. The conidiophores are epiphyllous or sometimes amphigenous, fasciculate, brown, septate, 45 to 150 by 4 to 5 μ; spores clavate, straight, dilutedly colored, 40 to 60 by 4 to 5 μ, three to four septate. (Pl. III, fig. 7.)

Specimen collected: Austin, 406 (type specimen).

Leaf-spot (*Phyllosticta verbesinae* Heald and Wolf, 32).—This fungus produces numerous gray or whitish subcircular spots, 1 to 3 mm. in diameter and surrounded by an indefinite darker zone which fades out into the green. The pycnidia are numerous, epiphyllous, 36 to 45 μ in diameter; the spores are oval or elliptical, 4 to 6 by 2.5 to 3 μ.

Specimen collected: Seguin, 2310 (type specimen).

Rust (*Puccinia cognata* Syd.).—Punctiform telia and uredinia are produced upon the under surface of the leaves. Common.

Specimens collected: Austin, 178, 346, 361.

DAYFLOWER.

Rust (*Uromyces spegazzinii* (De T.) Kern. nov. comb.).—Observed in only one locality, where it was very abundant on the dayflower (*Commelina virginica* L.).

Specimen collected: Austin, 232.

DOCK.

Dodder (*Cuscuta indecora* Choisy).—Observed on dock (*Rumex berlandieri* Meisn.) in a low, moist field, where it had grown over other plants.

Specimen collected: San Antonio, 1776.

EVENING PRIMROSE.

Powdery mildew (*Erysiphe polygoni* DC.).—Found on the evening primrose (*Oenothera laciniata* Hill) in only a single locality.

Specimen collected: Austin, 1051.

EUPHORBIA.

Rust (*Uromyces euphorbiae* Cke. and Pk.).—The rust is very common on the euphorbias (*Euphorbia* spp.) of this section, forming on the leaves very abundant brown, circular pustules.

Specimens collected: San Antonio, 1397, 3174; Austin, 1420, 1908, 3102; Lockhart, 2077.

FALSE DANDELION.

Rust (*Puccinia pyrrhopappi* Syd.).—The sori are produced profusely on the stems, leaves, and involucres of the false dandelion (*Sitilias multicaulis* (DC.) Greene). This rust was observed to be exceedingly abundant in and about Austin, where it caused the death of the plants.

Specimens collected: Austin, 1073, 1264, 2948, 3061; Hempstead, 1515.

FIREWEED.

Leaf-spot (*Cercospora vernoniae* Ell. and Kellerm.).—This fungus on the fireweed (*Vernonia* spp.) produces irregular, rounded, or angular spots, 2 to 5 mm. in diameter, brown or grayish in color, with a slightly darker border, frequently surrounded by a zone of yellow. Sometimes the spots become confluent, causing the death of the leaves.

Specimens collected: Austin, 1558; Seguin, 2324; Georgetown, 2378.

Rust (*Coleosporium vernoniae* B. and C.).—Minute yellow pustules are very abundant on the lower surface of the leaves and cause a yellow, punctate appearance of the upper surface.

Specimen collected: Austin, 345.

FLEABANE.

Leaf-spot (*Septoria erigerontea* Pk.).—This disease on the fleabane (*Erigeron canadensis* L.) appears as distinct spots, 1 to 2 mm. in diameter, with a grayish center and brown border on the leaves, most abundantly on the lowermost. The black pycnidia show very plainly in the grayish center. The spores are 24 to 78 μ in length, which is in excess of the original description (39).

Specimen collected: Austin, 3033.

GAURA.

Rust (*Uromyces gaurinus* (Pk.) Long.).—The cluster cups on gaura (*Gaura coccinea* Pursh.) appear on both surfaces of the leaves and are so numerous that the leaves are destroyed.

Specimens collected: Austin, 2945, 3000.

GIANT RAGWEED.

Dodder (*Cuscuta indecora* (?) Choisy).—Found in only a single locality, where it was growing abundantly on the giant ragweed (*Ambrosia trifida* L.), as well as several other hosts.

Specimen collected: San Antonio, 1777.

Powdery mildew (*Erysiphe cichoracearum* DC.).—The collections of this fungus include only conidiospore specimens.

Specimens collected: San Marcos, 949; San Antonio, 3155.

Rust (*Puccinia xanthi* S. var. *ambrosiae* B. and Rav.).—This variety is quite similar to the rust on the cocklebur, but the sori are more abundant and generally smaller.

Specimen collected: Austin, 1415.

GOLDENROD.

Leaf-spot (*Cercosporella reticulata* Pk.).—Numerous brown spots with indefinite margins appear on the leaves of the goldenrod (*Solidago* spp.). The spots are often confluent and the leaf tips may become brown, the tissue adjacent to the areas being killed.

Specimen collected: Elgin, 2007.

GROUND-CHERRY.

Leaf-spot (*Cercospora physalicola* Ell. and Barthol.).—This fungus on the ground-cherry (*Physalis* sp.) produces circular brown spots 3 to 10 mm. in diameter, which show a marked concentric zonation. It was found on only the lower leaves which were more or less shaded.

Conidiophores amphigenous, few in each cluster, 130 to 150 by 5 μ, several septate. Spores 60 to 130 μ or reaching 188 by 4 to 5 μ, five to many septate, nearly hyaline. (Pl. IV, fig. 5.)

Our specimens differ from the type in having longer conidiophores, amphigenous instead of epiphyllous, septate instead of continuous, and larger, more numerously septate spores.

Specimen collected: New Braunfels, 1715.

HORSE NETTLE.

Leaf-spot (*Cercospora atro-marginalis* Atk.).—This disease appears on the leaves of the horse nettle (*Solanum carolinense* L.) as circular or somewhat angular dark-brown spots from 3 to 5 mm. in diameter. These spots frequently are concentrically zonate, with a dark margin. The conidiophores are densely fascicled and show as brown heaps when aggregated.

Specimen collected: Gonzales, 2667.

HYDROCOTYLE.

Leaf-spot (*Cercospora hydrocotyles* Ell. and Ev.).—Very numerous reddish-brown spots are produced on the leaves of hydrocotyle (*Hydrocotyle* spp.). They are circular or slightly angular, and 1 to 3 mm., mostly 2 mm., in diameter. The leaf tissue between the spots is at first yellow, turning brown, with the fungous foci darker. The conidia vary from 30 to 80 by 3 to 3.5 μ, exceeding the size given in the original description (16), which measurement is 30 to 40 by 3 μ.

Specimens collected: On *H. umbellata* L.—Von Ormy, 1117; San Antonio, 3165. On *H. verticillata* Nutt.—Georgetown, 2384.

Rust (*Puccinia hydrocotyles* (Lk.) Cke.).—The rust appears on the leaves of *H. umbellata* as minute circular brown pustules, often so closely clustered as to give the leaves a brown color and cause their death.

Specimen collected: On *H. umbellata* L.—Von Ormy, 1117.

INDIAN MALLOW.

Rust (*Puccinia heterospora* B. and C.).—This rust on the Indian mallow (*Abutilon texense* T. and G.) produces circular telia 0.5 to 3 mm. in diameter on the lower surface and punctiform telia above. Old or mature telia generally show a gray center.

Specimens collected: Austin, 24, 1421, 2884, 3113; San Antonio, 3160.

INDIGO PLANT.

Dodder (*Cuscuta* sp.).—The dodder was observed on the indigo plant (*Indigofera leptosepala* Nutt.) in only a single locality.

Specimen collected: Boerne, 1639.

KNOTWEED.

Leaf-spot (*Cercospora polygonacea* Ell. and Ev.).—This disease on the knotweed (*Polygonum* spp.) appears as suborbicular spots, 2 to 3 mm. in diameter, reddish brown above with a darker, raised margin and a dark zone of tissue beyond the elevated border. Areas become brown below and adjacent tissue becomes yellow.

Specimen collected: Cuero, 2586.

Powdery mildew (*Erysiphe polygoni* DC.).—Both leaf surfaces have a white, felty covering, due to the interlacing mycelium and the summer spores.

Specimens collected: San Marcos, 943; San Antonio, 1363, 3173; Austin, 3116.

Rust (*Puccinia polygoni-amphibii* P.).—The minute reddish-brown sori open to the under surface. Frequently they cause chlorosis and death of the leaves.

Specimen collected: San Marcos, 942.

MALLOW.

Leaf-spot (*Cercospora malachrae* Heald and Wolf, 32).—Circular or subcircular spots are produced upon the leaves of the mallow (*Malachra capitata* L.). They are 1 to 4 mm. in diameter, with yellowish-gray centers on which the conidial tufts are evident, surrounded by a dark-purple border. The spots are slightly less pronounced upon the under surface.

The conidiophores are amphigenous, in fascicles of few to a dozen, brown with slightly paler tips, nodose extremities, 90 to 120 by 4 to 5 μ, and several septate; conidia clavate, hyaline, slender pointed, 100 to 210 by 4 to 5 μ, many septate. (Pl. IV, fig. 3.) This species of Cercospora seems to be distinct from the many described for different species of the Mallow family. It agrees most nearly with *C. polymorpha* Bubák.

Specimen collected: Victoria, 2347 (type specimen).

MINT.

Powdery mildew (*Erysiphe galeopsidis* DC.).—Only the conidial stage of this mildew was observed on mint (*Stachys drummondii* Benth.).

Specimen collected: San Marcos, 947.

MORNING-GLORY.

Leaf-spot (*Phyllosticta ipomoeae* Ell. and Kellerm.).—The leaves of the morning-glory (*Ipomoea* spp.) develop conspicuous brown spots with a narrow dark margin. They are suborbicular and about 4 mm. in diameter, becoming grayish with age. A few black pycnidia are embedded in these areas.

Specimens collected: Austin, 378; Seguin, 2316; Victoria, 2507.

Rust (*Puccinia cassipes* B. and C.).—Both the cluster cups and teleutospores are abundantly present, often on the same leaves or stems.

Specimens collected: Austin, 192, 198, 330; San Marcos, 2105; Victoria, 2345, 2346; Flatonia, 2724.

White-rust (*Albugo ipomoeae-panduranae* (S.) Swingle).—White. blisterlike elevations are formed on the leaves and stems. When sufficiently abundant the foliage is apparently uniformly white. (Pl. XVIII, fig. 1.)

This trouble is very generally distributed. The wild morning-glories are common weeds in the cultivated fields and are affected by the same white rust which attacks sweet potatoes.

Specimens collected: Austin, 120, 420, 1305, 1306; New Braunfels, 1671; Sabinal, 1979; Lockhart, 2071; Seguin, 2296; San Marcos, 2093; Georgetown, 2369; Round Rock, 2415; Elgin, 1879; Flatonia, 2725; Stockdale, 2623; Gonzales, 2693; San Antonio, 3167.

MUSTARD.

White-rust (*Albugo candida* (P.) Rouss.).—The characteristic white, blisterlike heaps of conidia occur on both surfaces of the leaves of mustard (*Brassica nigra* (L.) Koch.), causing them to become yellow and dry.

Specimen collected: Austin, 3072.

NYMPHAEA.

Leaf-spot (*Phyllosticta orontii* Ell. and Martin).—The diseased areas on *Nymphaea advena* Soland are straw colored and several centimeters in length, generally elongated in the direction of the veins, and concentrically zonate. The lines marking the zones are slightly elevated and darker.

Specimens collected: Georgetown, 2385; Von Ormy, 1162.

PARTHENIUM.

Rust (*Puccinia xanthi* S. var. *ambrosiae* B. and Rav.).—The sori, produced on the lower surface of parthenium (*Parthenium hysterophorus* L.), are characteristically brown and aggregated in circular patches. The spots show a yellowish-brown coloration on the upper surface.

Specimen collected: Kennedy, 2838.

PEPPERGRASS.

Downy mildew (*Peronospora parasitica* (P.) De By.).—This fungus on the peppergrass (*Lepidium virginicum* L.) causes the under surface of the leaves to appear downy white in small spots or extended areas, while the upper surface of the diseased spots is pale yellow.

Specimen collected: Austin, 2952.

PIGWEED.

Leaf-spot (*Cercospora brachiata* Ell. and Ev.).—The spots on the pigweed (*Amaranthus* spp.) are first dark brown, becoming grayish brown, subcircular or irregularly rounded, 3 to 5 mm. in diameter. They become very abundant, causing the leaves to curl and dry.

Specimen collected: On *A. spinosus* L.—Kennedy, 2827.

White-rust (*Albugo bliti* (Biv.) Kuntze).—The formation of the white pustules on the under surface of the leaves marks the presence of this fungus.

Specimens collected: (1) On *A. albus* L.—Austin, 376. (2) On *A. retroflexus* L.—Austin, 1315; San Marcos, 2092; Uvalde, 1935; Luling, 2229; Victoria, 2516; Stockdale, 2635; San Antonio, 3179. (3) On *A. spinosus* L.—Llano, 1760; Lockhart, 2059; Falfurrias, 2448.

POKEWEED.

Leaf-spot (*Cercospora flagellaris* Ell. and Martin).—Circular or slightly irregular brown spots 2 to 5 mm. in diameter appear on the foliage of the pokeweed (*Phytolacca americana* L.). The spots have a dark-brown, elevated border and they become grayish when older. Frequently they are abundantly formed on the leaf tips, resulting in the drying of the affected portions. In some localities affected plants were completely defoliated and dead.

Specimens collected: Austin, 336; Brenham, 1458; New Braunfels, 1722; Elgin, 1885; Bastrop, 2025; San Marcos, 2115; Cuero, 2603; Stockdale, 2622; Gonzales, 2696; Flatonia, 2744; Yoakum, 2769.

PRICKLY PEAR.

Anthracnose (*Gloeosporium* sp.).—The prickly pears (*Opuntia* spp.) of this region are frequently attacked by this fungus, which produces generally circular or subcircular depressed areas, with grayish centers densely covered with minute black acervuli which become less abundant toward the periphery, which is limited by a zone of brown. The spots are most commonly 1.5 to 2.5 cm. in diameter, but they may be much larger in some cases. The isolated spots may coalesce and cause the complete death of a stem segment. The diseased area always extends completely through the stem segment, and the old dead tissue may persist or it may fall out. In all cases of spots of the average size mentioned the advance of the fungus is limited by a development of corky tissue at the periphery of the area. This same fungus produces on young fronds, under favorable conditions of temperature and moisture, a severe rotting, and the fungus may advance through an entire segment in a few days, starting from a single center of infection, and thus leave the segment brown and completely dead. In this stage an abundance of pale acervuli is generally produced at the center of the infected area. In such cases the frond is chlorotic some distance beyond the advance of the fungus, and there is frequently a marked gummy exudation from the spot.

Specimens collected: Austin, 562; Llano, 1773; Hondo. 2252; Georgetown, 2393; Round Rock, 2406.

Black-spot (*Perisporium wrightii* B. and C.).—This fungus produces superficial black spots, generally circular in outline and 5 mm. to 1 cm. in diameter, on the stem segments. They may be few in number, or they may be sufficiently abundant to coalesce and nearly cover the surface. The black color is due to the large numbers of spore fruits or perithecia. No instances have been observed where the fungus was causing any material injury.

Specimens collected: Austin, 1293; Elgin, 1875; Round Rock, 2408.

Scald (*Hendersonia* (?) *opuntiae* Ell. and Ev.).—Probably the most general and the most severe disease of the prickly pear is what is popularly called "sun scald" in this territory. The whole surface of the older fronds becomes covered with a yellowish-brown, scaly growth of a corky character. In this scaly growth may be seen numerous minute black specks, the fruits of the fungus. Large plants may be killed, but the fungus remains superficial and the injurious effect is apparently due to the corky covering which cuts off the light in part and prevents the aeration of the underlying tissue. The network of dark-brown fungous filaments may be found just beneath the epidermal layer and also to some extent deeper down and inclosed in the corky layers.

The pycnidia are produced at the openings of the stomatal chimneys, and an aggregate of hyphæ generally closes the opening. The spores are pale brown, straight or slightly curved, two to three septate, and 25 to 30 by 3 μ.

A species of Rhabdospora may sometimes be associated with the trouble, but it is apparently of secondary importance.

Specimens collected: Austin; Falfurrias, 2467; Round Rock, 2407.

PURSLANE.

White-rust (*Albugo portulacae* (DC.) Kuntze).—This species of white-rust has been found on two different species of Portulaca.

Specimens collected: (1) On *Portulaca oleracea* L.—Beeville, 1811; Bastrop, 2028; Luling, 2248; Cuero, 2585; Stockdale, 2632. (2) On *Portulaca lanceolata* Eng.—Falfurrias, 2439.

RAIN LILY.

Rust (*Puccinia cooperiae* Long).—On the leaves of the small rain lily (*Cooperia drummondii* Herb.) are formed oval or elliptical brown sori, often very abundantly aggregated.

Specimen collected: Austin, 493.

RIVINA.

Leaf-spot (*Cercospora flagellaris* Ell. and Martin).—The general symptomatology of this disease on *Rivina laevis* L. is the same as the leaf-spot of the pokeweed (p. 99). Since it also agrees in size of conidiophores and conidia, it is very probably the same fungus, the hosts being related.

Specimens collected: Austin, 303, 1419.

RUELLIA.

Rust (*Puccinia ruelliae* (B. and Br.) Lagerh.).—On *Ruellia tuberosa* L. an abundance of sori are produced, punctiform to 1 mm. in diameter, mostly upon the upper surface of the leaves.

Specimens collected: Austin, 34, 412, 439; Beeville, 1797.

SAGE.

Rust (*Puccinia farinacea* Long).—Minute, rounded, brown sori are formed on the upper surface of the leaves of sage (*Salvia farinacea* L.).

Specimen collected: Austin, 349.

SENNA.

Leaf-spot (*Ramularia cassiaecola* Heald and Wolf. Syn.—*Cercospora occidentalis* Ell. and Kellerm.)—This fungus on senna (*Cassia* sp.) first forms diffuse brown spots, circular, indefinitely margined, 1 to 5 mm. in diameter, and frequently bordered by a zone of yellow. In severe infections the entire leaflet may turn yellow, with the exception of the brown spots on which the fungus is located.

The conidiophores are amphigenous, but more abundant on the under surface, closely fasciculate, brown, continuous except in the aggregated basal portion, and 24 to 30 by 3 to 4.5 μ; the spores are 45 to 150 by 3 to 5 μ, olivaceous, nearly cylindrical, 1 to 5 septate, and when mature frequently guttulate. (Pl. V, fig. 2.)

An examination of Ravenel's specimens of *Cercospora occidentalis* and also of Ellis's collections of this species shows that they should have been referred to the genus Ramularia. Since there is already a valid *R. occidentalis*, the specific name can not be retained.

Specimens collected: On *Cassia occidentalis* L.—Beeville, 1868; Cuero, 2580; Stockdale, 2611; Yoakum, 2750; Hallettsville, 2773.

Rust (*Ravenelia longiana* Syd.).—The sori are formed on the lower surface of the leaves.

Specimen collected: On *Cassia roemeriana* Scheele—Llano, 1751.

SMILAX.

Leaf-spot (*Cercospora smilacina* Sacc.).—This is the most common leaf disease of the smilax (*Smilax bona-nox* L.). The foliage becomes thickly spotted with subcircular, reddish areas, with brown margins.

Specimens collected: New Braunfels, 1702; Llano, 1748; Elgin, 1876; Uvalde, 1929; Bastrop, 2037; Lockhart, 2063; Cotulla, 2179; Luling, 2226; Seguin, 2305; Georgetown, 2398; Round Rock, 2416; Gonzales, 2704; Flatonia, 2743; Yoakum, 2762; Hallettsville, 2792.

Leaf-spot (*Phyllosticta smilacis* Ell. and Ev.).—The diseased areas are conspicuously reddish brown or brown, circular or subcircular, and vary from 2 to 8 mm. in diameter. They have a very pronounced dark-brown border. The black, immersed pycnidia, 150 μ in diameter, are either scattered or peripheral and on both surfaces. Generally, however, they are on only one surface of a given spot. The spores are nearly spherical or slightly elongated, clear, granular, 10 to 14 by 7 to 9 μ. The spores in our specimens are smaller than in the type (15 to 20 by 7 to 9 μ).

Specimens collected: Austin, 360; Boerne, 1656; Round Rock, 2412, 2413; Hallettsville, 2789.

Rust (*Puccinia smilacis* S.).—The upper surface of the leaf is densely spotted with yellowish or brown circular spots from 1 to 2 mm. in diameter. On the under surface small brown sori have broken through the epidermis.

Specimens collected: Austin, 23; San Marcos, 2090.

SUNFLOWER.

Leaf-spot (*Cercospora pachypus* Ell. and Kellerm.).—Irregular, angular spots, 1 to 5 mm. in diameter, becoming dark brown, are formed on the foliage of the sunflower (*Helianthus* spp.). These areas fuse and, accompanied by more or less chlorosis, the leaves are killed.

Specimen collected: Hondo, 1989.

Powdery mildew (*Erysiphe cichoracearum* DC.).—Upon the upper side of the leaves appear conspicuous white patches, often covering the greater part of the leaf surface. Only the conidial stage was observed.

Specimen collected: San Antonio, 3159.

Rust (*Puccinia helianthi* S.).—The rust sori are formed in abundance on both wild and cultivated forms, frequently so as to render the under surface quite brown.

Specimens collected: San Antonio, 1357, 1388, 1392, 1780, 3162; Seguin, 2300; Cuero, 2576; Flatonia, 2718.

TICK TREFOIL.

Rust (*Uromyces hedysari-paniculati* (S.) Farl.).—The yellowish-brown sori on tick trefoil (*Meibomia* sp.) are very numerous on the lower surface of the leaves and sparse on the upper surface.

Specimen collected: Austin, 343.

TROMPILLO.

Dodder (*Cuscuta* sp. ?).—This parasite on the trompillo (*Solanum elaeagnifolium* Cav.) was not flowering, and consequently could not be identified.

Specimen collected: Bastrop, 2029.

Nematode leaf-curl (*Tylenchus* sp.).—This is quite common, causing the leaves to be curled and much hypertrophied. (Pl. XVIII, fig. 3.)

Specimens collected: Austin, 1262; Kennedy, 2833.

VINCETOXICUM.

Leaf-mold (*Cercospora bellynckii* (Westd.) Sacc.).—An olivaceous, brown, diffuse coating is formed on the leaves of vincetoxicum (*Vincetoxicum* spp.). The description (46) of the fungus states that it occurs on the lower leaf surface, but our specimen shows conidiophores on both surfaces. In other characters the agreement is satisfactory.

Specimen collected: Austin, 312.

Rust (*Puccinia gonolobi* Rav. and B.).—The sori are present on both stems and leaves. On the stems they are so numerous as to form a black crust. On the leaves they are scattered and on the lower surface.

Specimens collected: Austin, 334, 335, 1449.

VIRGIN'S-BOWER.

Leaf-blight (*Phleospora adusta* Heald and Wolf, 32).—This trouble on the virgin's-bower (*Clematis drummondii* T. and G.) is very general and very severe. The foliage has large, irregular, brown areas, generally beginning on the leaf tips. The entire leaves become dry and brown and more or less curled in the advanced stages of the disease.

The pycnidia are hypophyllous, 30 to 45 μ in diameter and sparse. The spores are cylindrical, hyaline, 18 to 36 by 3 to 3.5 μ, and one to three septate. (Pl. V, fig. 10.)

Specimens collected: New Braunfels, 1699; Austin, 1726 (type specimen); Llano, 1734; Beeville, 1833; Sabinal, 1976; Hondo, 1998; Bastrop, 2021; Seguin, 2303; Georgetown, 2390; Gonzales, 2654; Kennedy, 2825.

Rust (*Puccinia tomipara* Trel.).—Groups of yellowish-white cluster cups appear on the foliage in the spring and late fall. The telia and uredinia are reported as occurring on *Bromus* spp., but no collections have been made in our territory.

Specimens collected: Austin, 309, 438, 1424.

WATER CRESS.

Leaf-blight (*Cercospora nasturtii* Pass.).—The leaves of water cress (*Radicula nasturtium-aquaticum* (L.) Britten and Rendle) infested with this fungus show circular to subcircular straw-colored or dirty-yellow spots varying in size from 1 to 5 mm. There is generally more or less concentric zonation. The diseased plants are stunted and show a purple coloration of the foliage.

The conidiophores are continuous, 45 to 60 by 3.5 μ, and clear-tipped. The conidia are 65 to 115 by 3.5 μ, several septate, hyaline, and granular. (Pl. II, fig. 1.)

Specimen collected: Austin, 1448.

WATER WILLOW.

Leaf-spot (*Cercospora diantherae* Ell. and Kellerm.).—The affected leaves of water willow (*Dianthera americana* L.) show numerous gray or brown spots, 1 to 4 mm. in diameter, surrounded by a darker border. Extended areas of the leaf tissue may be killed and the spots show as lighter areas in a dark ground. In the earlier stages of the disease a considerable degree of chlorosis may be exhibited.

Specimens collected: Austin, 64, 2870.

WILD GOURD.

Leaf-spot (*Cercospora cucurbitae* Ell. and Ev.).—Dirty-yellow, subcircular or angular spots, 2 to 7 mm. in diameter, are produced on the wild gourd (*Cucurbita foetidissima* H. B. K.) by this fungus. The spores are 57 to 173 μ in length. This range of size is different from that given in the original description (48) (100 to 120 μ).

Specimens collected: New Braunfels, 1717; Llano, 1754; Elgin, 1877; Lockhart, 2086; Austin, 359, 1923; Sabinal, 1984; Luling, 2269; Seguin, 2289; Floresville, 2845; San Antonio, 3161.

WILD TOBACCO.

Leaf-spot (*Cercospora nicotianae* Ell. and Ev.).—This fungus on the leaves of wild tobacco (*Nicotiana repanda* Willd.) forms subcircular areas 5 to 10 mm. in diameter. Because of the production of conidiophores and conidia on both surfaces, the center of the affected areas is brown with a lighter border.

Specimen collected: Austin, 3034.

WIND FLOWER.

Rust (*Tranzschelia cohaesa* (Long) Arth.).—The densely aggregated cluster cups, yellowish or dilutedly brown, appear on the lower surface of the foliage of the wind flower (*Anemone caroliniana* Walt.). The margins of the cups show quite commonly four recurved rays. This rust is very common and very abundant during March.

Specimens collected: Austin, 2935, 2944.

Smut (*Urocystis anemones* (P.) Wint.).—The brownish-black pustules are formed on the stems, petioles, and leaf blades. These pustules are covered at first and vary in size from very small to 2.5 or 5 cm. in length when on the stems.

Specimen collected: Austin, 2942.

WOOD SORREL.

Smut (*Ustilago oxalidis* Ell. and Tracy).—The seeds of the wood sorrel (*Oxalis stricta* L.) are replaced by a mass of brown spores, and when the capsule dehisces these spores are forcibly ejected in clouds.

Specimens collected: Austin, 1261, 1263.

YUCCA.

Blight (*Cercospora floricola* Heald and Wolf, 32).—This disease produces on the yucca (*Yucca rupicola* Scheele) elongated grayish or brownish patches, which become darker with age and spread over the main scape, the flower pedicels, and the outer divisions of the perianth. The creamy-white outer perianth segments may be completely covered with the conidial tufts, which cause them to turn nearly black and to shrivel more or less. (Pl. XIX, fig. 3.) The fungus may spread over the whole segment from the tip downward. The perianth divisions may be attacked before the flower opens and the flower bud completely blighted (Pl. XIX, fig. 2), or the flower may expand to full size and open in a normal way, but blight completely a little later. In the locality where the disease was prevalent fruit formation did not take place.

Conidiophores in dense fascicles of many short, brown, continuous filaments, 30 to 45 by 5 to 6 μ; spores generally straight, cylindrical, or slightly clavate, hyaline or faintly colored, 18 to 69 by 5 to 5.5 μ, and one to five septate, commonly three septate. (Pl. I, fig. 3.)

Specimen collected: On *Yucca rupicola* Scheele—Austin, 1438 (type specimen).

Leaf-spot (*Pestalozziella yuccae* Karst. and Har.).—Grayish lenticular areas, 4 to 10 mm. in length, are produced on the leaves. Protruding through the epidermis are dark pustules, the acervuli containing oblong clear spores with four hairs at the apex.

Specimen collected: On *Yucca rupicola* Scheele—Austin, 1530.

Leaf-blight (*Kellermannia yuccogena* Ell. and Kellerm.).—The affected leaves become straw colored, the dead area advancing downward from the tip or showing as a narrow zone along the margin. The advancing edge of the dead area is generally bordered by a narrow zone of brown. Our observations indicate that this species of fungus is not strictly parasitic, but that it finds its entrance first into leaves which have been scorched by prairie fires.

The pycnidia are very abundant on both surfaces, showing as minute black specks, 345 to 500 μ in diameter. Spores hyaline, two celled, 33 to 45 by 9 to 10.5 μ, each with a colorless appendage from the end, 15 to 30 μ long.

Specimen collected: On *Yucca filamentosa* L.—Sabinal, 1988.

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DESCRIPTION OF PLATES.

All drawings show a magnification of 417 diameters unless otherwise indicated.

PLATE I. Species of Cercospora from various hosts, No. 1. Fig. 1.—Three spores of *Cercospora vignae* Racib. on cowpea (*Vigna unguiculata* (L.) Walp.). Fig. 2.—Three spores of *C. cruenta* Sacc. on *Vigna unguiculata* (L.) Walp. Fig. 3.—Conidiophores and spores of *C. floricola* Heald and Wolf on *Yucca rupicola* Sheele; also three spores above. Fig. 4.—Conidiophores and spores of *C. atricincta* Heald and Wolf on zinnia (*Crassina elegans* (Jacq.) Kuntze). Fig. 5.—Conidiophores and spores of *C. lythracearum* Heald and Wolf on pomegranate (*Punica granatum* L. and Var.). Fig. 6.—Conidiophores and spores of *C. lythraccarum* Heald and Wolf on crape myrtle (*Lagerstroemia indica* L.). Fig. 7.—Conidiophores and spores of *C. macromaculans* Heald and Wolf on *Syringa* sp. Fig. 8.—Conidiophores and spores of *C. aurantia* Heald and Wolf on orange (*Citrus aurantium sinensis* L.).

PLATE II. Species of Cercospora from various hosts, No. 2. Fig. 1.—Conidiophores and spores of *Cercospora nasturtii* Pass. on water cress (*Radicula nasturtium-aquaticum* (L.) Britten and Rendle). Fig. 2.—Conidiophores and spores of *C. lanuginosa* Heald and Wolf on *Bumelia lanuginosa* (Michx.) Pers. Fig. 3.—Conidiophores and spores of *C. nepheloides* Ell. and Holw. on Mexican blue-bell (*Eustoma russellianum* (Hook.) Griesb.). Fig. 4.—Conidiophores and spores of *C. xanthicola* Heald and Wolf on *Xanthium* sp. Fig. 5.—Diagram of a portion of a cross section of leaf showing abundance and distribution of conidial tufts of *C. canescens* Ell. and Martin on the Lima bean (*Phaseolus lunatus* L.) × 73. Fig. 6.—Conidiophores and spores of *C. cancscens* Ell. and Martin on the Lima bean (*P lunatus* L.). Fig. 7.—Spores of *Cercospora bolleana* (Thm.) Speg. on the fig (*Ficus carica* L.). Fig. 8.—Conidiophores and spores *Cercospora fici* Heald and Wolf on the fig (*F. carica* L.).

PLATE III. Species of Cercospora from various hosts, No. 3. Fig. 1.—Conidiophores and spores of *Cercospora adusta* Heald and Wolf on California privet (*Ligustrum ovalifolium* Hassk.). Fig. 2.—Conidiophores and spores of *C. prosopidis* Heald and Wolf on mesquite (*Prosopis glandulosa* Torr.). Fig. 3.—Conidiophores and spores of *C. perniciosa* Heald and Wolf on buttonbush (*Cephalanthus occidentalis* L.). Fig. 4.—Conidiophores and spores of *C. chrysanthemi* Heald and Wolf on *Chrysanthemum* sp. Fig. 5.—Conidiophores and spores of *C. pustula* Cke. on Virginia creeper (*Psedera quinquifolia* (L.) Greene). Fig. 6.—Conidiophores and spores of *C. obscura* Heald and Wolf on globe artichoke (*Cynara scolymus* L.). Fig. 7.—Conidiophores and spores of *C. fulvella* Heald and Wolf on crownbeard (*Verbesina texana* Buckl.). Fig. 8.—Spores of *C. viticola* (Ces.) Sacc. on *Vitis* sp. Fig. 9.—Conidiophores and spores of *C. personata* (B. and C.) Ell. on the peanut (*Arachis hypogaea* L.).

PLATE IV. Species of Cercospora from various hosts, No. 4. Fig. 1.—Conidiophores and spores of *Cercospora sagittariae* Ell. and Ev. on *Saggitaria* sp. Fig. 2.—Conidiophores and spores of *C. crataegi* Heald and Wolf on hawthorn (*Crataegus* sp.). Fig. 3.—Conidiophores and spores of *C. malachrae* Heald and Wolf on mallow (*Malachra capitata* L.). Fig. 4.—Spores of *C. elaeagni* Heald and Wolf on *Elaeagnus* sp. Fig. 5.—Conidiophores and spores of *C. physalicola* Ell. and Barthol. on ground-cherry (*Physalis* sp.). Fig. 6.—Conidiophores and spores of *C. moricola* Cke. on red mulberry (*Morus rubra* L.). Fig. 7.—Conidiophores and spores of *C. capsici* Heald and Wolf on pepper (*Capsicum annuum* L.).

PLATE V. Various genera of Fungi Imperfecti on different hosts. Fig. 1.—Conidiophores and spores of *Ramularia momordicae* Heald and Wolf on the balsam-apple (*Momordica balsamina* L.). Fig. 2.—Conidiophores and spores of *R. cassiaecola* Heald and Wolf on senna (*Cassia occidentalis* L.). Fig. 3.—Spores of *Stagonospora gigantea* Heald and Wolf on century plant (*Agave americana* L.). Fig. 4.—Spores of *Ramularia cephalanthi* (Ell. and Kellerm.) Heald on buttonbush (*Cephalanthus occidentalis* L.). Fig. 5.—Conidiophores and spores of *R. hedericola* Heald and Wolf on English ivy (*Hedera helix* L.). Fig. 6.—Spores of *Sporodesmium maclurae* Thm. on Osage orange (*Toxylon pomiferum* Raf.). Fig. 7.—Pycnidium and spores of *Phleospora multimaculans* Heald and Wolf on the sycamore (*Platanus occidentalis* L.). Fig. 8.—Section of a pycnidium of *Phyllosticta biformis* Heald and Wolf on leaf of Mexican persimmon (*Diospyros texana* Sheele). × 73. Fig 9.—Section of a pycnidium of *P. biformis* Heald and Wolf from the fruit of *D. texana* Sheele. × 73. Fig. 10.—Section of a pycnidium and spores of *Phleospora adusta* Heald and Wolf on virgin's-bower (*Clematis drummondii* T. and G.). Fig. 11.—Section of a pycnidium and spores of *P. multimaculans* Heald and Wolf on walnut (*Juglans* sp.).

PLATE VI. Species of Colletotrichum, Cylindrosporium, and Septoria on various hosts. Fig. 1.—Group of spores of *Colletotrichum griseum* Heald and Wolf on *Euonymus japonicus* Thunb. Fig. 2.—Portion of the acervulus of *C. griseum* Heald and Wolf on *E. japonicus* Thunb. Fig. 3.—A single acervulus showing distribution of setæ of *C. griseum* Heald and Wolf. × 73. Fig. 4.—Spores of *Cylindrosporium solitarium* Heald and Wolf on black locust (*Robinia pseudaeacia* L.). Fig. 5.—Spores of *Cylindrosporium lippiae* Heald and Wolf on *Lippia ligustrina* (Lag.) Britton. Fig. 6.—Acervulus of *Colletotrichum caulicolum* Heald and Wolf on bean (*Phaseolus vulgaris* L.) ×73. Fig. 7.—Conidiophores, conidia, and setæ of *C. caulicolum* Heald and Wolf. Fig. 8.—Distribution of acervuli (*a*) of *C. caulicolum* on stem of bean (*Phaseolus vulgaris* L.). Natural size. Fig. 9.—Acervulus of *Cylindrosporium defoliatum* Heald and Wolf on the hackberry (*Celtis laevigata* Willd.). Fig. 10.—Depressed acervulus bearing spores with two septate spores of *C. defoliatum* Heald and Wolf on *C. laevigata* Willd. Fig. 11.—Spores of *C. griseum* Heald and Wolf on wild China tree (*Sapindus drummondii* Hook. and Arn.). Fig. 12.—A small portion of a leaf showing acervuli (*a*) of *C. griseum* Heald and Wolf on the veins of *S. drummondii* Hook. and Arn.). × 73. Fig. 13.—Setæ, conidiophores, and conidia of Colletotrichum on sorghum (*Andropogon sorghum* (L.) Brot.). Fig. 14.—Spores of Colletotrichum on *A. sorghum* (L.) Brot. Fig. 15.—Portion of the acervulus and a group of spores of Colletotrichum on Johnson grass (*A. halepensis* (L.) Brot.). Fig. 16.—Several pycnidia of *Septoria pertusa* Heald and Wolf on Johnson grass (*A. halepensis* (L.) Brot.). × 73. Fig. 17.—A single pycnidium of *S. pertusa* Heald and Wolf. (*a*, Ostiole and protruding spores; *b*, a group of four spores.)

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PLATE VIII. Fig. 1.—Leaflet of the date palm (*Phoenix dactylifera* L.), showing numerous pustules of *Graphiola phoenicis* (Moug.) Poit. Fig. 2.—Leaf of grape (upper surface), showing numerous dark blotches due to *Cercospora viticola* (Ces.) Sacc. Fig. 3.—Bacterial twig-canker of the plum (*Prunus* sp.).

PLATE IX. Fig. 1.—The roots of a tomato plant (*Lycopersicon esculentum* Mill.) deformed by nematodes (*Heterodera radicicola* (Greef) Mül.). Fig. 2.—Root-knot of muskmelon (*Cucumis melo* L.) due to *Heterodera radicicola* (Greef) Mül. Fig. 3.—Leaves of the Lima bean (*Phaseolus lunatus* L.) affected with leaf-spot due to *Cercospora canescens* Ell. and Martin.

PLATE X. Fig. 1.—Young watermelons (*Citrullus vulgaris* Schrad.) affected with blossom-end blight and rot. Fig. 2.—Potato (*Solanum tuberosum* L.) with nodules formed by Rhizoctonia. Fig. 3.—A young cymling (*Cucurbita pepo* L.) almost destroyed by *Botrytis cinerea* P.

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PLATE XII. Fig. 1.—Leaves of *Euonymus japonicus* Thunb., showing the characteristic spotting caused by *Exosporium concentricum* Heald and Wolf. Fig. 2.—Leaves of *E. japonicus* Thunb., showing spots due to *Colletotrichum griseum* Heald and Wolf.

PLATE XIII. Fig. 1.—Leaf of winged elm (*Ulmus alata* Michx.) affected with scab due to *Gnomonia ulmea* (S.) Thm. Fig. 2.—Leaf of red mulberry (*Morus rubra* L.), showing eye-spot due to *Cercospora moricola* Cke. Fig. 3.—Tar-spot on the live oak (*Quercus virginiana* Mill.) due to *Rhytisma erythrosporum* B. and C. Fig. 4.—Leaflets of black locust (*Robinia pseudacacia* L.), showing the characteristic spotting due to (*Cylindrosporium solitarium* Heald and Wolf.

PLATE XIV. Fig. 1.—Leaves of the hackberry (*Celtis laevigata* Willd.), blighted by *Cylindrosporium defoliatum* Heald and Wolf. Fig. 2.—Leaf of the sycamore (*Platanus occidentalis* L.), blighted by *Phleospora multimaculans* Heald and Wolf.

PLATE XV. Fig. 1.—Leaf of the Japanese privet (*Ligustrum japonicum* Thunb.) affected with leaf-spot caused by *Cercospora ligustri* Roum. Fig. 2.—Small branch of mesquite (*Prosopis glandulosa* Torr.), showing three galls of possible bacterial origin. Fig. 3.—A single large gall on a small branch of mesquite.

PLATE XVI. Fig. 1.—Portion of a leaf of century plant (*Agave americana* L.) affected with blight due to *Stagonospora gigantea* Heald and Wolf. Fig. 2.—Portion of the margin of the same leaf slightly enlarged, showing the distribution of numerous pycnidia.

PLATE XVII. Fig. 1.—Leaves of geranium (*Pelargonium* sp.) affected with bacterial blight. Fig. 2.—Leaf of *Begonia* sp. affected with bacterial blight.

PLATE XVIII. Fig. 1.—A leaf of wild morning-glory (*Ipomoea* sp.) from the under surface, showing the abundant sori of the white-rust (*Albugo ipomoeae-panduranae* (S.) Swingle). Fig. 2.—A small branch of the mountain cedar (*Juniperus sabinoides* Nees.), showing the gelatinous sori of *Gymnosporangium exiguum* Kern. Fig. 3.—Leaf-curl of the trompillo (*Solanum elaeagnifolium* Cav.), due to the presence of nematodes (*Tylenchus* sp.).

PLATE XIX. Fig. 1.—Leaflet of the wild China tree (*Sapindus drummondii* Hook. and Arn.) affected with *Cylindrosporium griseum* Heald and Wolf. Fig. 2.—Buds of *Yucca rupicola* Scheele blighted by the attacks of *Cercospora floricola* Heald and Wolf. Fig. 3.—Small portion of the inflorescence of *Y. rupicola* Scheele with flowers blighted by *Cercospora floricola* Heald and Wolf.

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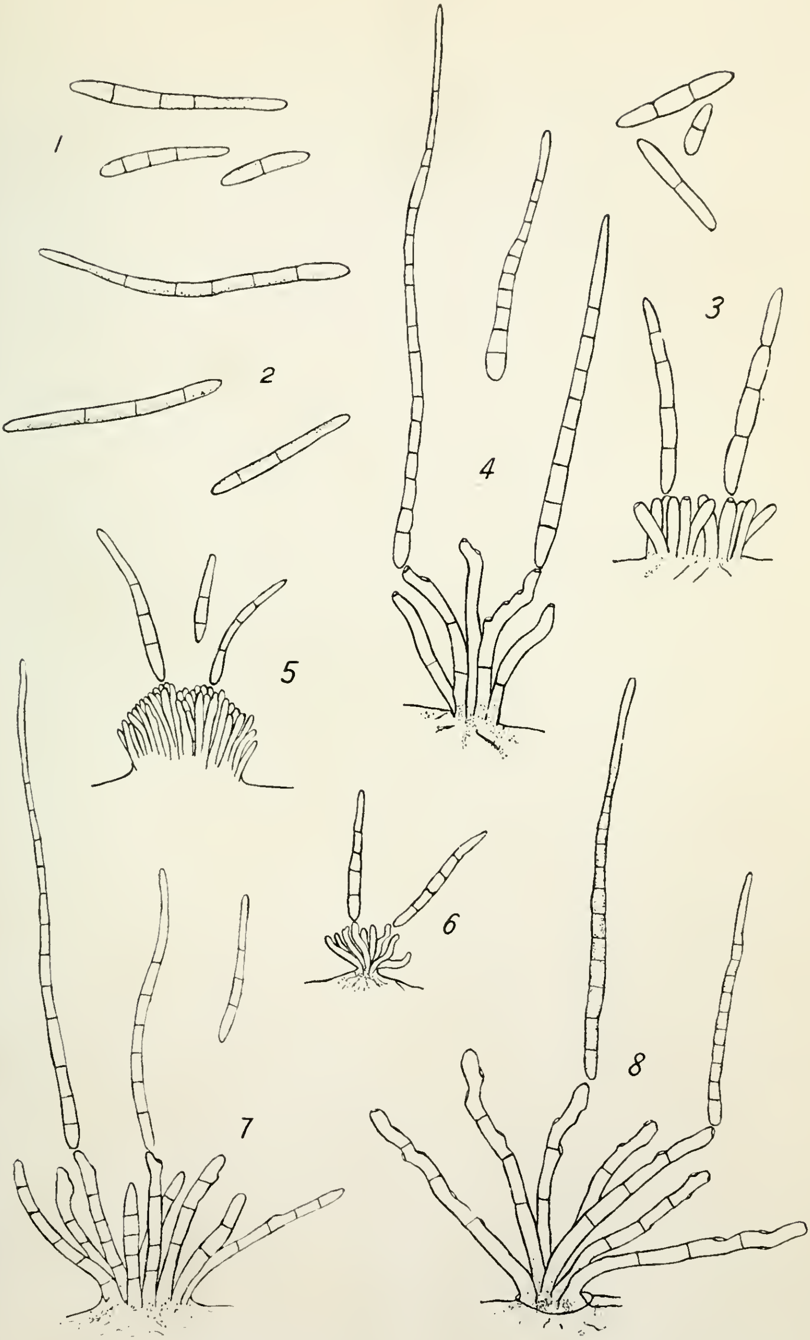

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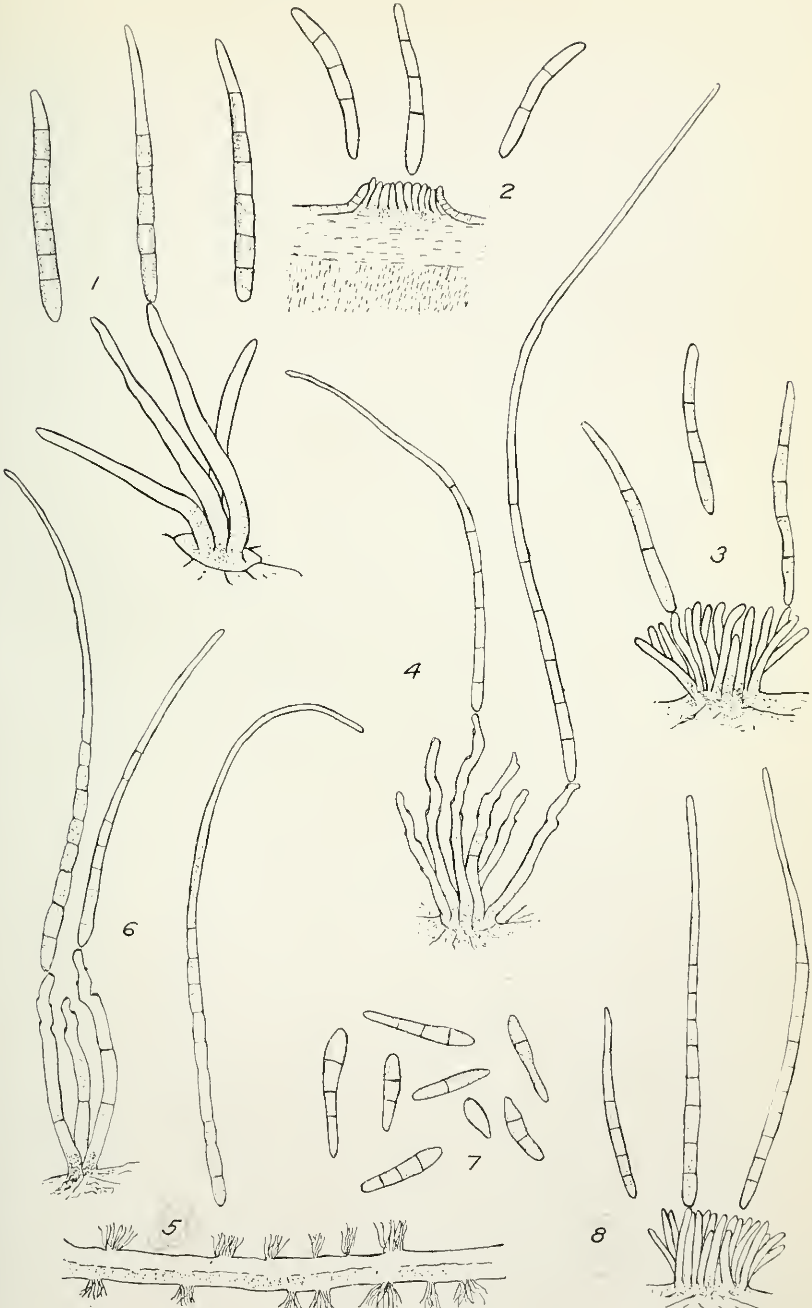

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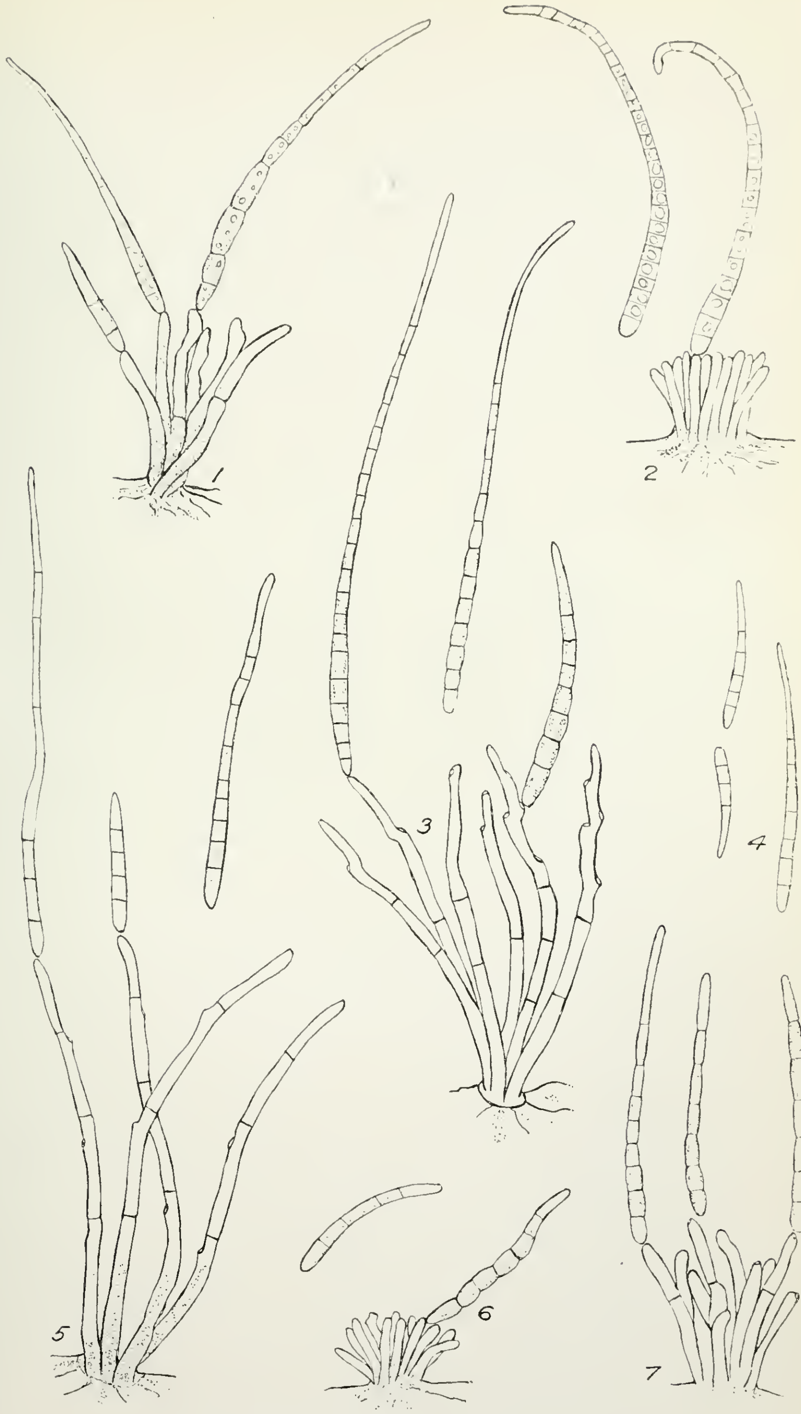

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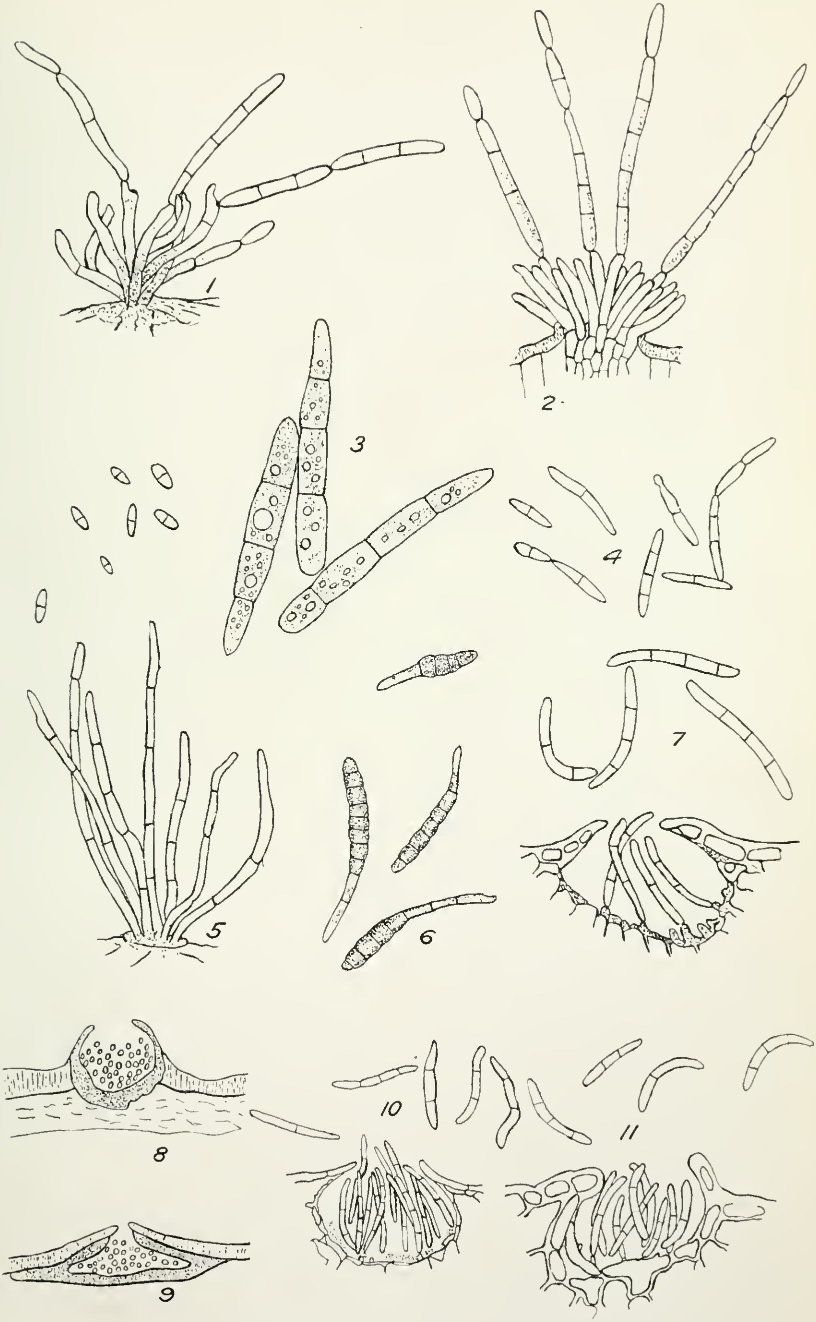
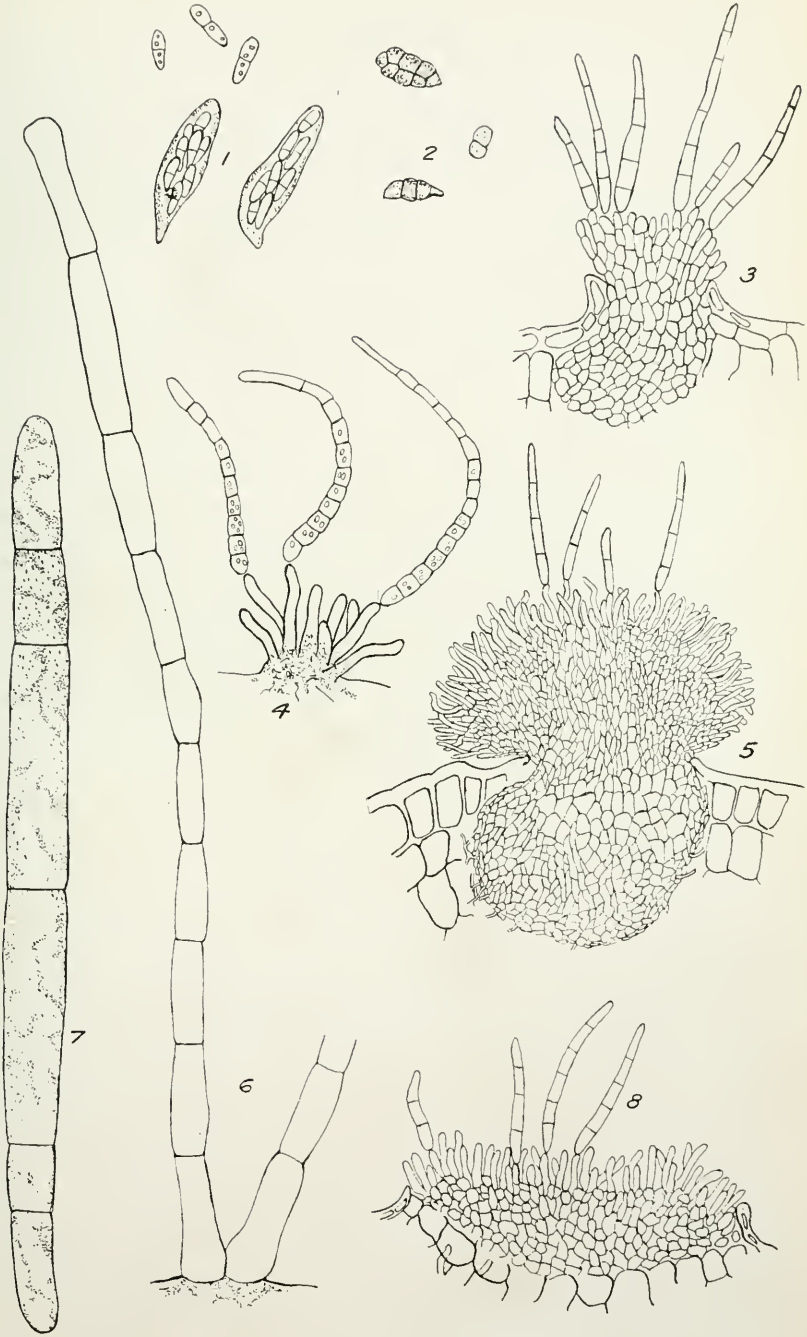
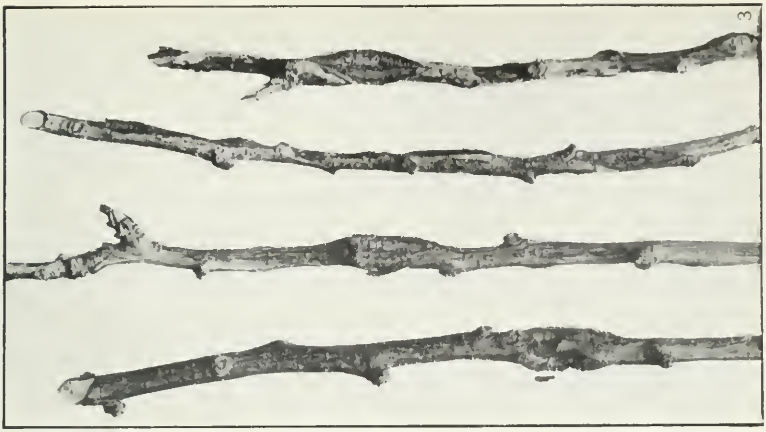


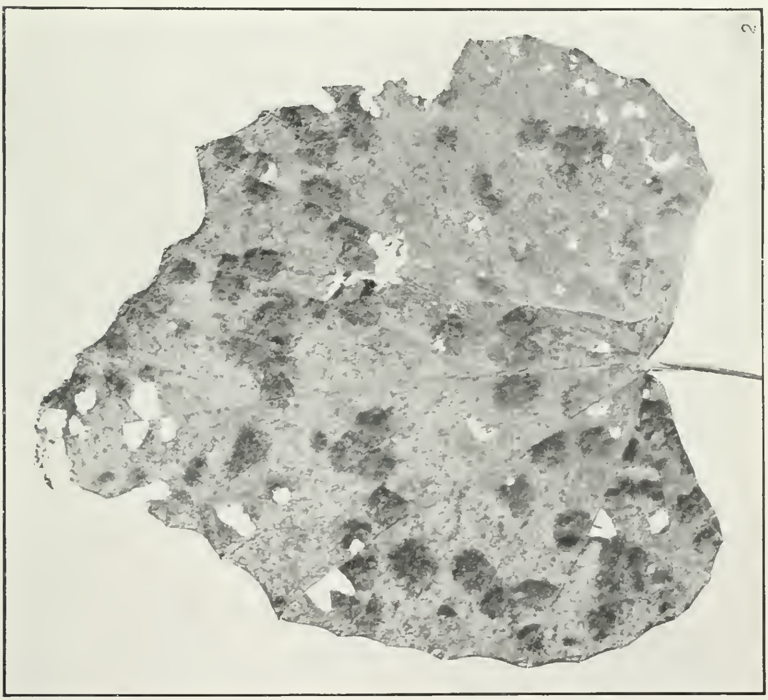
VARIOUS GENERA OF FUNGI IMPERFECTI ON DIFFERENT HOSTS.

SPECIES OF COLLETOTRICHUM, CYLINDROSPORIUM, AND SEPTORIA ON VARIOUS HOSTS.



FUNGI FROM VARIOUS HOSTS.





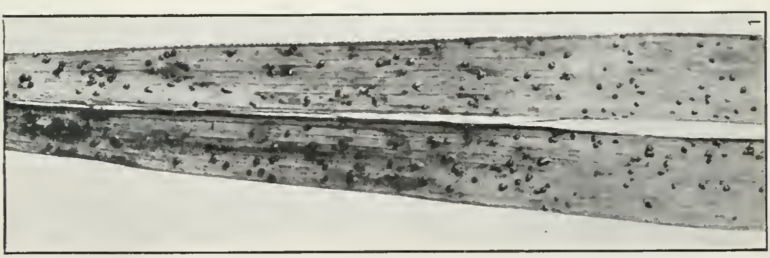


FIG. 1.—LEAFLET OF THE DATE PALM, SHOWING NUMEROUS PUSTULES OF GRAPHIOLA PHOENICIS.
FIG. 2.—LEAF OF GRAPE, SHOWING NUMEROUS BLOTCHES DUE TO CERCOSPORA VITICOLA.
FIG. 3.—BACTERIAL TWIG-CANKER OF THE PLUM.

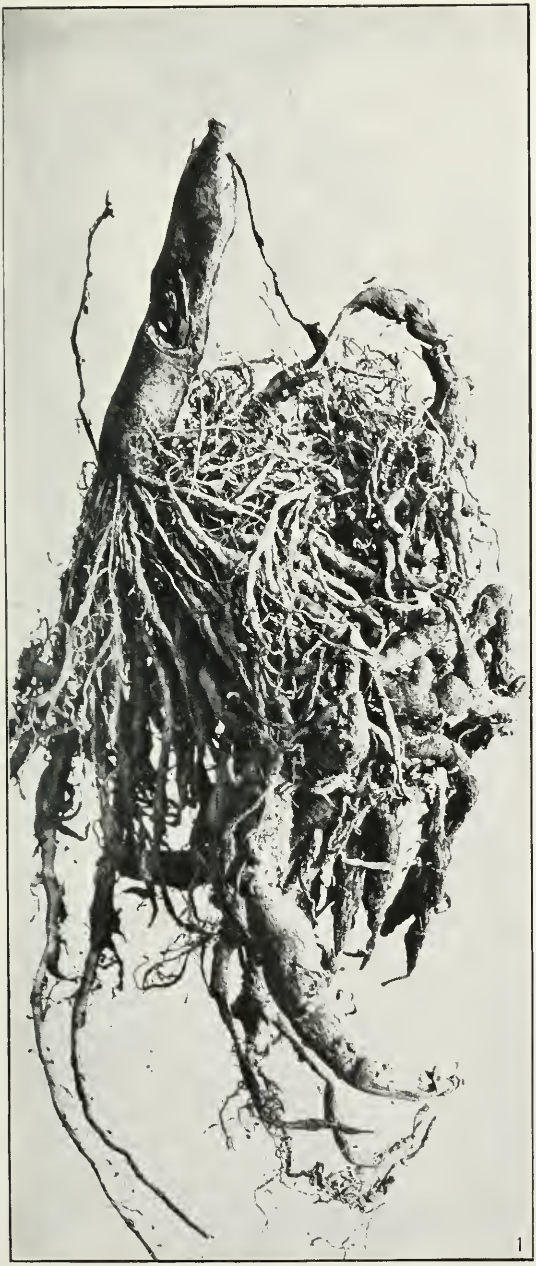


FIG. 1.—ROOTS OF TOMATO PLANT DEFORMED BY NEMATODES.
FIG. 2.—ROOT-KNOT OF MUSKMELON DUE TO NEMATODES.
FIG. 3.—LEAVES OF LIMA BEAN, SHOWING LEAF-SPOT DUE TO CERCOSPORA CANESCENS.

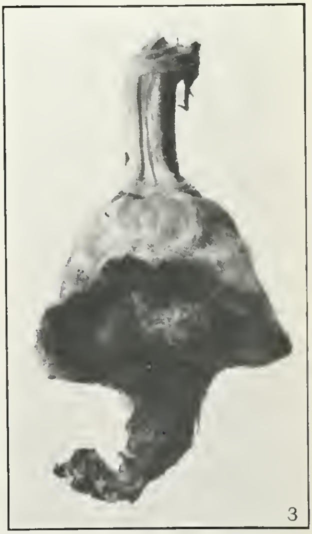
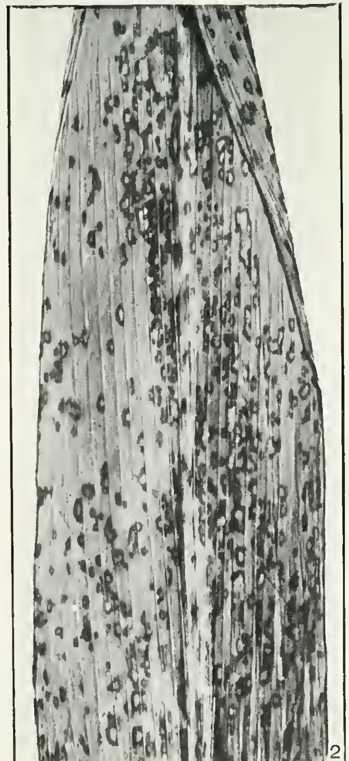


FIG. 1.—YOUNG WATERMELONS AFFECTED WITH BLOSSOM-END BLIGHT AND ROT.
FIG. 2.—TUBER OF POTATO, SHOWING NODULES FORMED BY RHIZOCTONIA.
FIG. 3.—CYMLING ALMOST DESTROYED BY BOTRYTIS CINEREA.



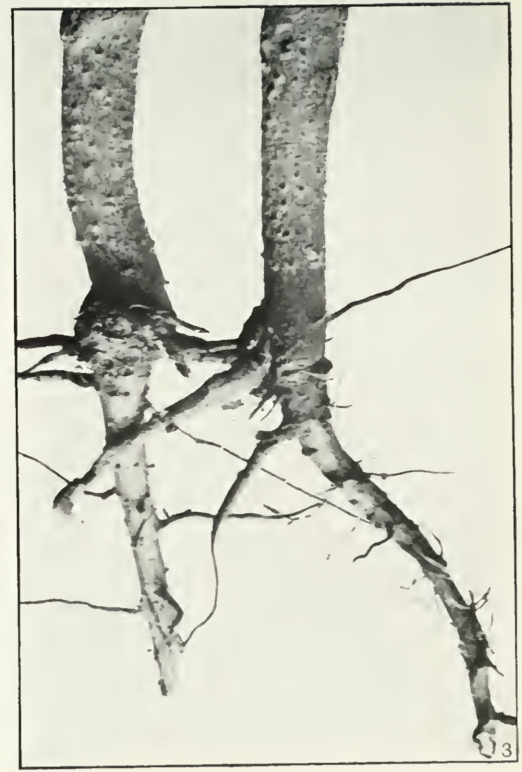


FIG. 1.—INFLORESCENCE OF FEATHER GRASS ATTACKED BY BALANSIA HYPOXYLON.
FIG. 2.—PORTION OF A LEAF OF SORGHUM AFFECTED WITH BLIGHT DUE TO COLLETOTRICHUM LINEOLA.
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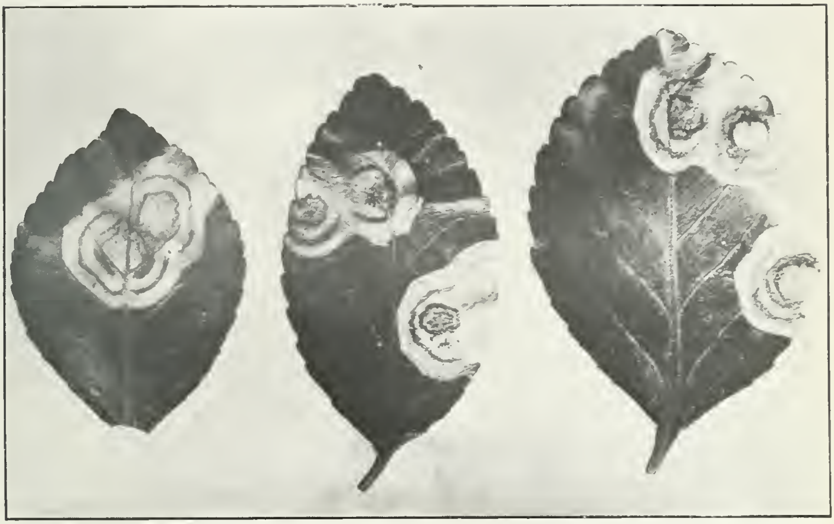
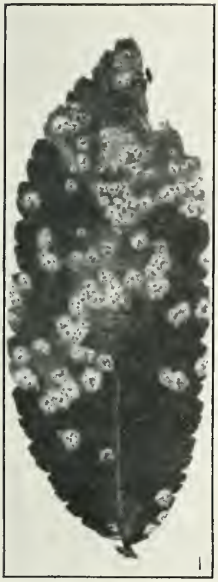
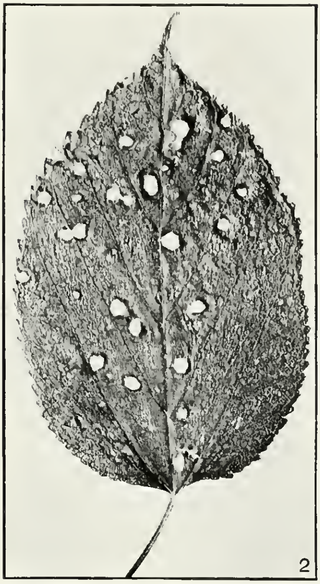
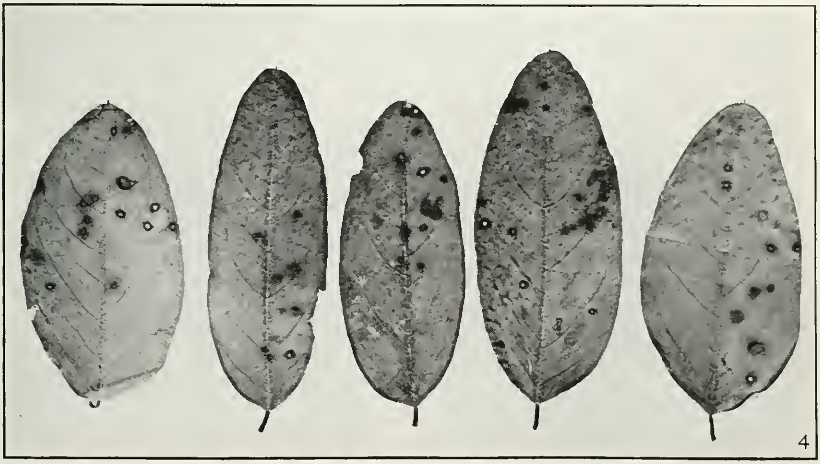


FIG. 1.—LEAVES OF EUONYMUS, SHOWING THE CHARACTERISTIC SPOTTING CAUSED BY EXOSPORIUM CONCENTRICUM.

FIG. 2.—LEAVES OF EUONYMUS, SHOWING SPOTS DUE TO COLLETOTRICHUM GRISEUM.







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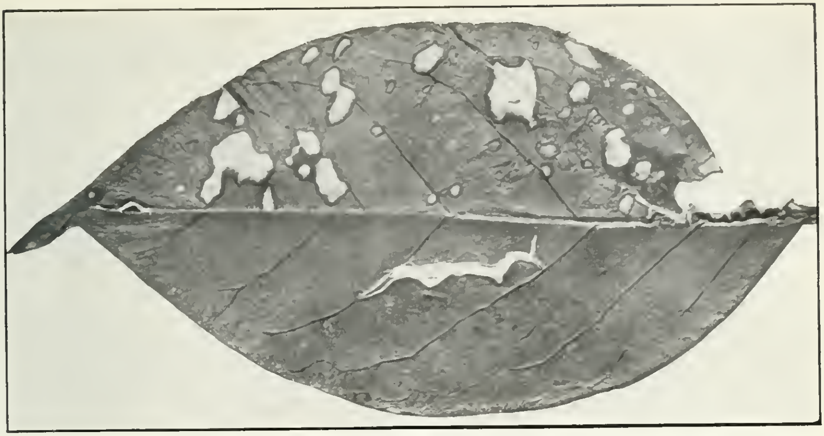


FIG. 1.—LEAF OF THE JAPANESE PRIVET AFFECTED WITH LEAF-SPOT DUE TO CERCOSPORA LIGUSTRI.

FIG. 2.—SMALL BRANCH OF MESQUITE, SHOWING THREE GALLS OF POSSIBLE BACTERIAL ORIGIN.

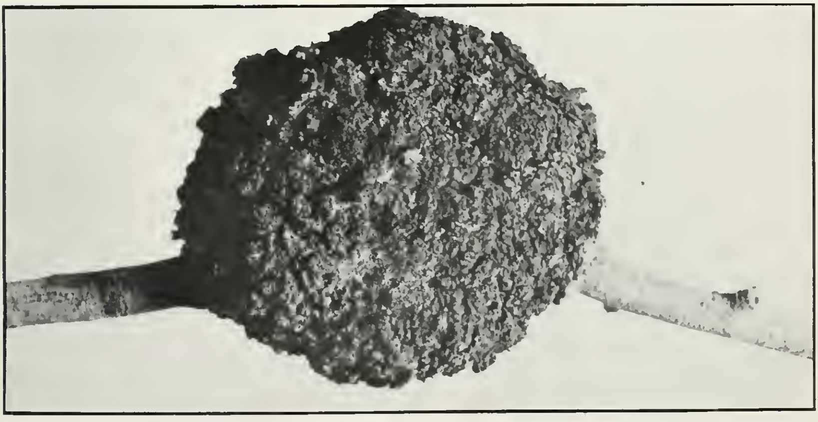


FIG. 3.—A SINGLE LARGE GALL ON A SMALL BRANCH OF MESQUITE.

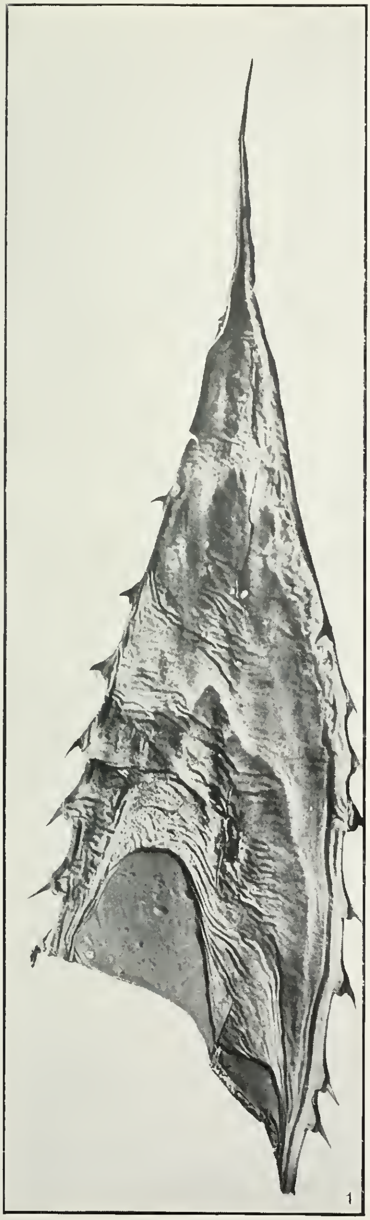


FIG. 1.—PORTION OF LEAF OF CENTURY PLANT AFFECTED WITH BLIGHT DUE TO STAGONOSPORA GIGANTEA.

FIG. 2.—MARGIN OF SAME LEAF SLIGHTLY ENLARGED, SHOWING THE DISTRIBUTION OF PYCNIDIA.

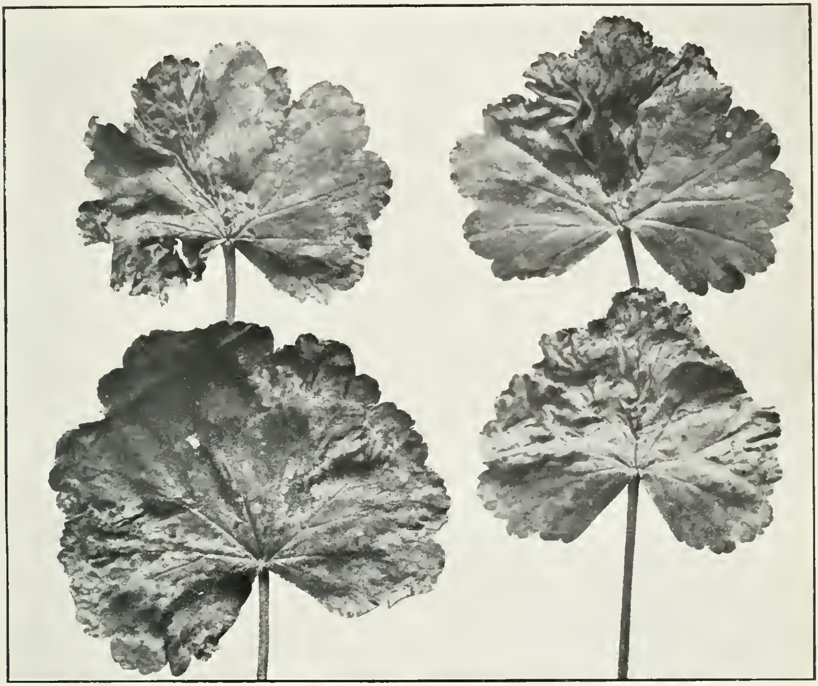
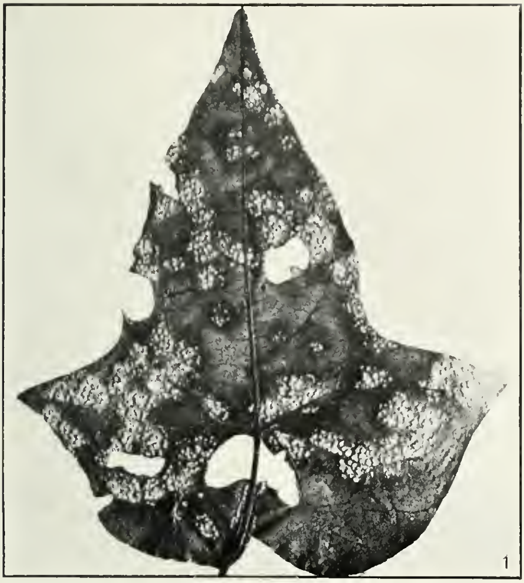


FIG. 1.—LEAVES OF GERANIUM AFFECTED WITH BACTERIAL BLIGHT.

FIG. 2.—LEAF OF BEGONIA AFFECTED WITH BACTERIAL BLIGHT.



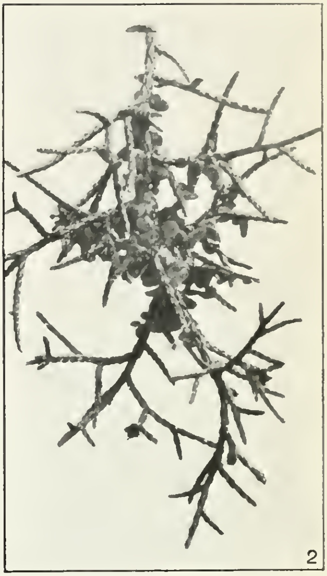


FIG. 1.—LEAF OF WILD MORNING-GLORY ATTACKED BY ALBUGO IPOMOEAE-PANDURANAE.
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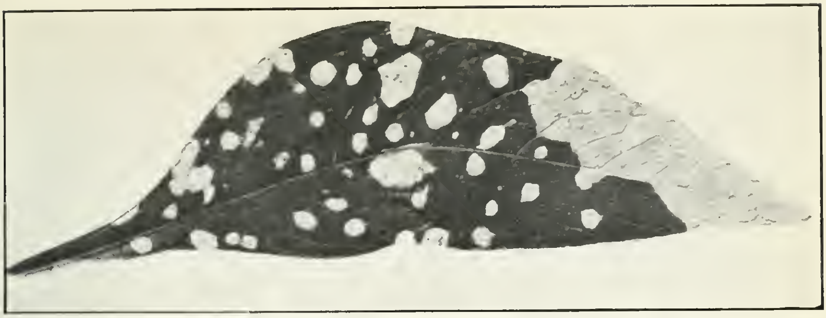

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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN NO. 227.
B. T. GALLOWAY, *Chief of Bureau.*

SEEDS AND PLANTS IMPORTED

DURING THE PERIOD FROM OCTOBER 1 TO DECEMBER 31, 1910:

INVENTORY No. 25; Nos. 28883 TO 29327.

Issued November 2, 1911.

WASHINGTON:
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BUREAU OF PLANT INDUSTRY.

Chief of Bureau, BEVERLY T. GALLOWAY.
Assistant Chief of Bureau, WILLIAM A. TAYLOR.
Editor, J. E. ROCKWELL.
Chief Clerk, JAMES E. JONES.

FOREIGN SEED AND PLANT INTRODUCTION.

SCIENTIFIC STAFF.

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Edward Simmonds, *Gardener, in Charge of Subtropical Plant Introduction Garden, Miami, Fla.*
John M. Rankin, *Expert, in Charge of Yarrow Plant Introduction Garden, Rockville, Md.*
Edward Goucher, John H. Allison, and W. H. F. Gomme, *Experts.*

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 16, 1911.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 227 of the series of this Bureau the accompanying manuscript, entitled "Seeds and Plants Imported during the Period from October 1 to December 31, 1910: Inventory No. 25; Nos. 28883 to 29327."

This manuscript has been submitted by the Agricultural Explorer in Charge of Foreign Seed and Plant Introduction, with a view to publication.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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SEEDS AND PLANTS IMPORTED DURING THE PERIOD FROM OCTOBER 1 TO DECEMBER 31, 1910: INVENTORY NO. 25; NOS. 28883 TO 29327.

INTRODUCTORY STATEMENT.

The present inventory includes the material collected during the period from June to September, 1910, by Mr. Frank N. Meyer, the only agricultural explorer in the field, who was exploring the region which lies along the Zerafshan Valley and in the vicinity of Samarkand, Tashkend, Old Bokhara, the oasis of Merv, Chartchui, Andijan, Guldscha, Terek-Dawan, Osh, Kostakos, Kizil-Kurgan, and Khokan in Russian Turkestan, and the cities of Kashgar, Kan-Shugan, Ulukshat, and Irkestan in Chinese Turkestan. Although Mr. Meyer was hindered from making several important side trips which had been contemplated, he still secured during his stay in this region 141 different specimens, some of which are of special importance. Among them is a hardy dwarf Prunus (Nos. 28943 and 28944) from the mountain slopes near Wishist at an altitude of 3,000 to 7,000 feet, which Mr. Meyer suggests may be of value in the breeding of bushy forms of the almond or as a stock for the almond in dry regions. Possibly the suggestion of an economic bush cherry may be realized by American breeders and Mr. Meyer's *Prunus prostrata* (No. 28945) and *Prunus microcarpa* (No. 28946) be utilized in the creation of such a fruit, while the various forms of *Prunus cerasifera divaricata* (Nos. 28948 to 28951 and No. 29224), called "Alitcha" in Turkestan, may be of distinct value to the plum breeders because of their early-fruiting character, their remarkable productiveness, and their resistance to drought and heat.

The apricot growers of Turkestan grow varieties which have sweet instead of bitter kernels, which they use for confectionery purposes just as we do the kernels of the almond. Mr. Meyer has imported 11 varieties of these (Nos. 28953 to 28962 and No. 29223) and recommends that the whole subject of the utilization of apricot kernels be studied. This may resolve itself into a comparison between the price of the kernels as a source of prussic acid and their price as a table delicacy.

Probably there is no work so extensive and successful in the binding of drifting desert sands as that carried on at Chartchui, Turkestan, by the Russian Government. The railroad, which was previously in continual danger of being covered by shifting sand dunes, has been completely protected by the use of certain drought and alkali resistant plants, seeds of which Mr. Meyer secured for similar experiments in this country (Nos. 28973 to 28977).

The oleaster is remarkable for its extreme hardiness and resistance to drought, and the importation by Mr. Meyer of a large-fruited form (No. 29225) will interest the horticulturists of the Northwest, who are beginning to see the possibilities of this plant as a hardy fruiting shrub.

The rose breeders will be interested in the wild roses from this region (Nos. 29251 to 29258); the melon growers, in an unusual collection of watermelons and muskmelons; the nut growers, in the almond and Afghanistan pistache; the currant breeders, in the black and red currants which Mr. Meyer has secured.

Of material sent in by correspondents, it is worth while to emphasize a new relative of the guava, *Psidium araça* (No. 28911), from Minas Geraes, which is said to be sweeter in taste than the guava; a new variety of alfalfa, which originated in Norway and which is reported to be hardier and larger than the ordinary types grown there (No. 28919); three distinct varieties of the Chinese jujube (Nos. 28926 to 28928); a remarkable citrus relative which lives on the seashore in mangrove swamps in India (No. 28933); a quantity of the wild wheat of Palestine for use in breeding drought-resistant varieties (No. 29026); a leguminous plant, *Cassia mimosoides*, from Assam, recommended as a cover crop in banana plantations to keep down the weeds (No. 29031); the kameel-doorn of South Africa, an extremely hard-wooded, drought-resistant tree (No. 29046); *Passiflora ligularis* (No. 29090), from Mexico, and a variety from Java (No. 29319), relatives of the southern maypop, for breeding experiments with this fruit; one of the largest of the large-leaved trees of the Chinese forests from Hupeh, central China (No. 29095); a new hybrid of the giant wild rose from Burma, *Rosa gigantea* (No. 29096); the Paraguayan tea plant, from which the maté of South America is made, a drink as highly prized by millions of South Americans as tea is by Europeans (No. 29097); four varieties of Japanese sugar cane for trial as a forage plant in the South (Nos. 29106 to 29109); four species of tropical persimmons, related to the edible oriental species, from the island of Ceylon (Nos. 29111 to 29114), for the breeders of this fruit; the yeheb-nut plant, a newly discovered leguminous shrub which occurs in the poor sandy soils of the dry regions of Italian Somaliland and produces nuts which are so sweet and nutritious that in their season the Somaliland natives live on them in preference to rice and dates; a spineless lime and a seedless lime from Trinidad (Nos. 29123 and 29124); the Aomori chestnut from Hokushu, Japan (No. 29132); the Sampson tangelo, a hybrid between the pomelo and the tangerine which has been originated by the Office of Crop Physiology and Breeding Investigations (No. 29159); and the Etonia or flowering citrange, a hybrid between the common orange and the hardy Japanese trifoliate orange which promises to be a remarkable ornamental tree, with its large white blossoms which nearly hide the foliage (No. 29160), also a product of the same office.

This inventory was prepared by Miss Mary A. Austin, and the botanical determinations are those of Mr. H. C. Skeels, working under the supervision of Mr. Frederick V. Coville, of the Office of Taxonomic and Range Investigations.

David Fairchild,
Agricultural Explorer in Charge.

Office of Foreign Seed and Plant Introduction,
Washington, D. C., May 16, 1911.

INVENTORY.

28883 and 28884.

From Teneriffe, Canary Islands. Procured by Mr. Ross J. Hazeltine, American vice consul, from Señor Luis Diaz. Received October 3, 1910.

Cuttings of the following:

28883. PRUNUS ARMENIACA L. **Apricot.**

Yellow.

28884. PRUNUS sp. **Plum.**

Yellow. "One of the finest I have ever seen." (*Hazeltine.*)

28885. HORDEUM SPONTANEUM Koch. **Barley.**

From Haifa, Palestine. Presented by Mr. Aaron Aaronsohn, director, Jewish Agricultural Experiment Station. Received October 3, 1910.

28886. SPONDIAS sp.

From Mauritius. Presented by Mr. G. Regnard, Port Louis, Mauritius. Received October 14, 1910.

"This is much like the species *dulcis* as regards appearance of the tree and fruit, but not the seeds. The only specimen in Mauritius grows at the Botanical Gardens, Pamplemousses; it has not been classified and seems not to have been noticed." (*Regnard.*)

28887. CARICA PAPAYA L. **Papaya.**

From Camp Overton, Mindanao, Philippine Islands. Presented by Maj. Charles H. Muir, Twenty-third Infantry, Fort Clark, Tex., through Mr. E. C. Green, in charge, South Texas Plant Introduction Garden, Brownsville, Tex. Received October 3, 1910.

"This seed is from the best variety of this fruit I have ever met with in either the Philippines or Cuba; it is spoken of as the *Dapitan* by some and as the *Java* by others." (*Muir.*)

28888 to 28893. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

From the Province of Para, near the town of Bragança, Brazil. Presented by Mr. Walter Fischer, acting director, Campo de Cultura Experimental Paraense, Para, Brazil. Received October 3 and 4, 1910.

Seeds of the following:

28888. Large brown eye.

28889. Pinkish clay-colored seeds.

28890. Brownish clay-colored seeds.

28891. Reddish brown.

28892. Under color brownish clay thickly marked with purplish lines or marblings.

28893. Like the preceding, except that the ground color is almost completely obscured by the purple marblings.

"The two preceding numbers (I believe one of them is a hybrid with some speckled variety) are said to give a luxuriant growth of foliage, but further than this I heard nothing." (*Fischer.*)

28894. RAJANIA PLEIONEURA Griseb. **"Waw-waw."**

From Dominica, British West Indies. Presented by Mr. J. Jones, curator, Botanic Station. Received October 6, 1910.

"The 'waw-waw' is a native of Dominica. It occurs wild in the forests and does best in the deep shade. It is not cultivated in this island, probably because an abundance of the yam can be obtained by digging in the forest.

"The 'waw-waw' is considered by many people to be superior to the yams produced by the dioscoreas." (*Jones.*)

Distribution.—Common in the woods on the island of Dominica, and in Cuba and Porto Rico.

28895 to 28898. COFFEA ARABICA L. **Coffee.**

From Reunion Island. Presented by Mr. G. Regnard, Port Louis, Mauritius. Received October 7, 1910.

Seeds of the following:

28895 and 28896. "*Cafe du Pays.*"

28895. From Campon. **28896.** From St. Louis.

28897 and 28898. "*Cafe le Roy.*"

28897. From Campon. **28898.** From St. Louis.

28899. SOLANUM MURICATUM Ait. **Pepino.**

From Grand Canary, Canary Islands. Presented by Mr. M. Moniz, American consular agent pro tem., at the request of Mr. Ross J. Hazeltine, American consul, Teneriffe. Received October 8, 1910.

See No. 23650 for description.

28900. DIOSPYROS DISCOLOR Willd. **Persimmon.**

From Iloilo, Panay, Philippine Islands. Presented by Mr. J. B. O. Colman, Bureau of Public Works. Received October 7, 1910.

"This is a species of persimmon which has a thick and pleasantly flavored meat. The fruits from which these seeds were taken were unusually large and perfect." (*Colman.*)

See No. 26612 for further description.

28901 and 28902. PITTOSPORUM spp.

From Greendale, Canterbury, New Zealand. Presented by Mr. T. W. Adams. Received October 14, 1910.

Seeds of the following:

28901. PITTOSPORUM RALPHII Kirk.

Distribution.—In the Patea district on the southern coast of North Island, and on the Great Barrier Island, off the northern coast of North Island, New Zealand.

28902. PITTOSPORUM TENUIFOLIUM Gaertn.

Distribution.—Along the eastern coasts of the islands of New Zealand extending from the northern island southward to the province of Otago.

"These are small, hardy trees that will bear 20 degrees of frost, but I suppose they will not be hardy at Washington, D. C. (*Adams.*)

28903 to 28905.

The following material presented by Dr. Walter Van Fleet to the Plant Introduction Garden, Chico, Cal., November 30, 1909. Numbered October 17, 1910.

28903. Berberis (vulgaris × thunbergii) × stenophylla. **Barberry.**

"An interesting blend, combining blood of four species: *Berberis stenophylla* Lindl., being a supposed hybrid of *B. empetrifolia* and *B. darwinii*, an evergreen species from southern Chile. One plant has light-purple foliage and the drooping habit of *B. thunbergii*. (P. I. G. No. 8395.)" (*Van Fleet.*)

Plants.

28904. Quamasia leichtlinii × cusickii.

"A fine, vigorous hybrid, intermediate between parent species. These bulbs are six years from seed. Grown at my place in Little Silver, N. J. (P. I. G. No. 6291.)" (*Van Fleet.*)

28905. Iris albopurpurea Baker.

"A beautiful large-flowered iris from Japan, allied to *I. laevigata*. Fall petals white, marbled blue. (P. I. G. No. 8394.)" (*Van Fleet.*)

28906. Stizolobium aterrimum Piper and Tracy. **Mauritius or Bengal bean.**

From Herbert River, Queensland. Presented by Mr. J. H. Maiden, director, Botanic Gardens, Sydney, Australia, who obtained them from the Macknade mill of the Colonial Sugar Refining Co. Received October 15, 1910.

"This species is considerably cultivated in the island of Mauritius, Brazil, New Zealand, and Australia. It much resembles the Florida velvet bean, but the vines grow larger and the seeds mature considerably later. This variety is so late, in fact, that it matures in this country only in the southern half of Florida." (*Piper.*)

28907. Saccharum spontaneum L.

From Sibpur, Calcutta, India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden. Received October 17, 1910.

"A coarse perennial grass, with long creeping roots, abundant throughout India and up to 6,000 feet in the Himalayas. This grass is largely used as a thatching material, and the leaves are manufactured into ropes, mats, etc. It is a favorite fodder for buffaloes and is also, when young, given to elephants. Native name, *Kans.*" (*C. V. Piper.*)

28908. Medicago sativa L. **Alfalfa.**

From Ti-tao, Kansu Province, western China. Presented by Mr. Berthold Laufer, Field Museum, Chicago, Ill., who procured them from Mr. D. P. Ekvall, an American missionary of Ti-tao. Received October 17, 1910.

28909 to 28911. Psidium spp.

From Theophilo Ottoni, Minas Geraes, Brazil. Presented by Mr. Fred Birch. Received October 17, 1910.

Seeds of the following; notes by Mr. Birch:

28909. Psidium guajava L. **Guava.**

"Seeds from an all-white guava. The tree bears only white fruits, which are about 2 inches in diameter."

28910. Psidium guajava L. **Guava.**

"Seeds from the largest and finest tasting guava I have ever seen or tried. It was nearly 3 inches in diameter, and the flesh and jelly were pinkish red as in the common varieties. The tree grows by a stream near Theophilo Ottoni, Minas Geraes, and most of the fruits have comparatively few seeds."

28909 to 28911.—Continued.

28911. Psidium araça Raddi. **Guava.**

"The araça grows to about 15 feet (the size of a hazel), and the very pleasant sweet fruits are about an inch or an inch and a quarter in diameter. With good cultivation I feel sure it could be improved. The fruits are just like small guavas, clear yellow when ripe. They taste sweeter, however, and would make excellent preserves."

See No. 26757 for previous introduction.

28912. Irvingia gabonensis (Aubry-Lecomte) Baill. **Oba.**

From Victoria, Kamerun, Africa. Presented by Mr. F. A. Deistel, director of the experiment station, at the request of the Imperial Colonial Office at Berlin, Germany. Received October 8, 1910.

This is a tree 30 to 50 feet high, with shining leaves, which produces edible fruit said to be about 2½ inches in diameter. The seeds are the source of "Dika butter." This is called "wild mango" by the English residents of Princes Island, where it grows. It is also reported from the Muni and Kamerun rivers in western Africa.

28913. Ipomoea tuberculata Ker.

Grown at Brookland, D. C., and presented by Miss Carrie Harrison, of the Bureau of Plant Industry, October, 1910.

"Last spring I purchased in the Center Market of Washington a promising young perennial plant said to be a passion flower. It was planted in a corner with a choice of tumbling over a wall, following wires and climbing a tree, or trailing on the ground; it did all three with a decided preference for trailing. About August it produced a few pinkish-violet, morning-glory blooms with a pansy-purple center, so far as I know the most decorative of the order.

"This species has been in cultivation since 1815, is from the East Indies, and probably reached the market from the Botanical Gardens in Washington, D. C., where they have some plants growing. It belongs to the group which contains the sweet potato.

"It has a large spiral root and sends out about 30 branches, each between 20 and 30 feet long. The enormous growth would make it a desirable forage plant, and as closely related species in India are used for this purpose the presumption is in its favor. The general aspect of leaves and branches is that of *Akebia quinata*. It will have to be grown from cuttings, quite an easy matter, as it roots at the leaf nodes, because it would not bear fruit out of doors north of Washington, D. C." (*Harrison.*)

Cuttings.

28914. Lapageria rosea R. and P. **Chilean bellflower.**

From Coquimbo, Chile. Presented by Mr. Andrew Kerr, consular agent. Received October 15, 1910.

See No. 14948 for previous introduction and description.

28915 to 28917. Solanum spp. **Wild potato.**

Collected by Mr. J. C. Blumer, Tucson, Ariz. Received October 27, 1910.

Tubers of the following; notes by Mr. Blumer:

28915 and 28916. "Collected October 5, 1910, on the steep northeast slope of the Santa Catalina Mountains, at an elevation of 7,800 feet, under white and Douglas fir, in fine humous loam. Vines fresh, succulent, and fruiting. Slope burned clean in June."

28917. "Collected October 17, 1910, on Rincon Mountains, at Spud Ranch camp site. Since potatoes were once cultivated here these purplish tubers may be escaped from cultivation."

28918 to 28922.

From Christiania, Norway. Presented by Prof. Dr. Wille, director, Botanic Garden. Received October 24 and 25, 1910.

Seeds of the following:

28918. MEDICAGO FALCATA L.

28919. MEDICAGO SATIVA L. **Alfalfa.**

Variety *malthei*. "This is a new variety which has not yet been described and which is larger and much hardier than the main variety. *Medicago sativa* is used very little in Norway for its economic importance, as it is not very hardy. A dealer in dyestuffs, O. Malthe, was very much interested in this question. He experimented and finally succeeded in discovering this variety and endeavored to disseminate it. The farmers, however, did not want to cultivate lucern because they find *Trifolium pratense* and *Phleum pratense* more profitable.

"I wish to call your attention to the fact that the seed of *M. sativa* var. *malthei* may possibly represent crosses with the closely related main variety; however, only to a limited extent. If all the seeds are planted some plants of the pure variety will likely be obtained." (*Wille.*)

28920. MEDICAGO SATIVA VARIA (Mart.) Urb. **Sand lucern.**

28921. MELILOTUS SULCATA Desf.

Distribution.—Throughout the Mediterranean region from Portugal and the Canary Islands to Palestine, and in the oases of the Libyan Desert.

28922. TRIGONELLA CAERULEA (L.) Ser.

See No. 27146 for previous introduction.

28923 to 28925. ASPARAGUS spp. **Asparagus.**

From Tunis, northern Africa. Presented by Mr. L. Guillochon, Jardin d'Essais de Tunis. Received October 27, 1910.

Seeds of the following:

28923. ASPARAGUS CRISPUS Lam.

Distribution.—In the coast region of Cape Colony in the vicinities of Hopefield, Table Mountain, Simons Bay, and in British Kaffraria.

28924. ASPARAGUS OFFICINALIS L.

28925. ASPARAGUS SPRENGERI Regel.

Distribution.—The vicinity of Port Natal in Natal, South Africa. Commonly cultivated in the United States as an ornamental house plant.

28926 to 28928.

From China. Presented by Mr. T. J. League, Tsingtau, China, who obtained them through Rev. G. E. Baker, English Baptist Mission, Tsingchowfu, Shantung, China. Received October 27, 1910.

Cuttings.

NOTE.—Three tubes were received in this shipment, although from Mr. League's letter it would appear that four different lots of material were sent. There were apparently no markings on either tubes or cuttings, so S. P. I. numbers could be assigned only to the three bundles. The notes on this material, furnished by Mr. League, appear on the following page.

28926 to 28928—Continued.

ZIZIPHUS JUJUBA Miller.

This being an unusual name for the common jujube, the following dates and synonyms are given to avoid confusion:

Ziziphus jujuba Miller 1768. (*Rhamnus zizyphus* L. 1753, *Z. sativa* Gaertn. 1788, *Z. vulgaris* Lam. 1789, not *Z. jujuba* (L.) Lam. 1789.) See No. 28129 for further information.

"*Ch'ang Hung tsao.* (Long red 'date' or jujube.)
Yüan Ling tsao. (Foremost honorable 'date' or jujube.)
Hsiao tsao. (The small 'date' or jujube.)"

DIOSPYROS sp. (?) **Persimmon.**

Juan tsao. "A wild persimmon on which, as a stock, they graft the edible persimmon."

28929. ARACHIS HYPOGAEA L. **Peanut.**

From Kia-ying chau, China. Presented by Mr. George Campbell. Received November 2, 1910.

"These seem to be more drought resistant than some received from the States. The plants also have a running habit." (*Campbell.*)

28930 to 28932.

From Costa Rica. Presented by Señor don Anastasio Alfaro, secretary of the Society of Agriculture, San Jose, through Mr. Lyster H. Dewey, Botanist in Charge of Fiber-Plant Investigations. Received October 4, 1910.

Notes on the following by Mr. Dewey:

28930. AGAVE FOURCROYDES Lem. **Henequen.**

"Bulbils and suckers from plants introduced in the garden of the Museum of San Jose, Costa Rica, supposed to have come from Mexico.

"These plants appear to be the same type as those cultivated for fiber production in Yucatan.

"The fiber from the leaves of this plant is called sisal in English-speaking countries. It is used more than all other fibers combined in the manufacture of binder twine. The true sisal plant, *Agave sisalana* Perrine, is a distinct species having a wider range but not so extensively cultivated."

Distribution.—The provinces of Yucatan and Campeche in Mexico. Cultivated in Tamaulipas, Sinaloa, and Chiapas in Mexico, in Cuba, and in German East Africa.

28931. AGAVE sp. **Agave.**

"Young plants collected on the island in the Gulf of Nicoya on the Pacific coast of Costa Rica.

"These plants belong to the narrow-leaved group of the large agaves and may be useful for the production of fiber."

28932. FURCRAEA sp. **Cabuya.**

"Bulbils and young plants from the garden of the Museum of San Jose, Costa Rica. Collected by Señor don Adolfo Tonduz.

"This species belongs to the group of furcræas that are being cultivated in Costa Rica for the production of fiber."

28933. Gonocitrus angulatus (Willd.) Kurz.

From India. Presented by Maj. A. T. Gage, superintendent, Royal Botanic Garden, Sibpur, Calcutta, India. Received October 31, 1910.

"This is a large shrub or small tree growing on the seashore in mangrove swamps and presumably able to endure a high degree of salinity in the soil. It is armed with ferocious spines half an inch long that usually occur in pairs at the side of the leaves. The fruit is most curious, being angled, and contains a few very large seeds embedded in a gum so sticky that Rumphius compared it to birdlime.

"The fact that this plant grows only along the seashore in mangrove swamps would lead us to believe that it possesses high powers of alkali resistance, since sea water contains over 3 per cent of dissolved salts and the mangrove and other plants growing in the mangrove swamps are able to withstand unusually large amounts of dissolved salts in the soil." (*W. T. Swingle.*)

Distribution.—In the mangrove swamps and tidal forests along the coasts from the mouths of the Ganges south of Calcutta eastward to the Molukka Islands.

28935 to 28939.

From Aintab, Turkey, Asia. Presented by Mr. H. H. Bakkalian, secretary to Mrs. F. A. Shephard. Received October 19, 1910.

Seeds of the following:

28935. Cicer arietinum L. **Chick-pea.**

28936. Lathyrus sativus L.

28937. Lens esculenta Moench. **Lentil.**

28938. Medicago falcata L.

28939. Vicia ervilia (L.) Willd.

28940 and 28941. Medicago falcata L.

From Copenhagen, Denmark. Presented by Mr. Axel Lange, curator, Botanic Garden, Copenhagen University. Received October 31, 1910.

28942 to 29012.

From Turkestan. Received through Mr. Frank N. Meyer, agricultural explorer, October 18, 1910.

Seeds of the following:

28942. Prunus sp. **Buckthorn almond.**

From Zerafshan Valley, near Sangar, Samarkand, Turkestan. "(No. 1342a, July 14, 1910.) A central Asian form of buckthorn almond, found on stony, sterile, sunburned mountain sides at elevations of 4,000 to 6,000 feet. Of possible value as a stock for almonds and peaches in dry and hot regions. Out of the bitter kernels, collected from the wild trees, the natives of Turkestan produce an oil which, after heating, can be used for culinary purposes." (*Meyer.*)

28943. Prunus lycioides (Spach) Schneider. **Buckthorn almond.**

From Zerafshan Valley, near Wishist, Samarkand, Turkestan. "(No. 1343a, July 14, 1910.) A spiny buckthorn almond of shrubby habits growing from 3 to 8 feet in height and found on stony and rocky mountain slopes and in cliffs at elevations of 3,000 to 7,000 feet above sea level. Of possible use in breeding a bushy type of almond or as a stock for almonds and peaches in dry, hot regions. Oil is produced from the kernel of this the same as from No. 28942." (*Meyer.*)

28942 to 29012—Continued.

28944. Prunus lycioides (Spach) Schneider. **Buckthorn almond.**

From Zerafshan Valley, near Wishist, Samarkand, Turkestan. "(No. 1344a, July 14, 1910.) A large-fruited variety of the preceding number, to which the same remarks apply." (*Meyer.*)

28945. Prunus prostrata Labil. **Bush cherry.**

From mountains near Stood and Peki, Samarkand, Turkestan. "(No. 1345a, July 9 to 11, 1910.) A bush cherry found on stony and sterile mountain slopes and in cliffs. Grows from 1 to 8 feet tall and bears multitudes of small red cherries of a sour taste that vary much in flavor and size on different plants. This cherry apparently stands a great deal of cold and drought. After some improvement it might be made into a fruit for the home garden in the more northern sections of the United States. It may possibly be hybridized with the large-fruited sweet and sour cherries and therewith give rise to a race of bush cherries suitable for growing in the drier sections of the United States. It may also be tested as a possible dwarfing stock for cherries in dry and sterile localities." (*Meyer.*)

See also remarks under No. 1331a (S. P. I. No. 28022).

28946. Prunus microcarpa C. A. Meyer. **Cherry.**

From mountains near Bacharden, Turkestan. "(No. 1346a, June 5, 1910.) A wild cherry growing into a tall bush up to 10 feet high. Found between stony débris in dry river beds and on rocky mountain sides. Apparently stands great drought. Perhaps of value as a stock for cherries in stony and dry localities." (*Meyer.*)

See also remarks under Nos. 473 (S. P. I. No. 27303) and 1266a (S. P. I. No. 27337).

28947. Prunus sp. **Cherry.**

From Askabad, Turkestan. "(No. 1347a, June 9, 1910.) A small, dark-red, sour cherry, very juicy; said to come from Persia. Used stewed in compotes, and in spirits. To be tried under irrigation in the dry and hot sections of the United States." (*Meyer.*)

28948. Prunus cerasifera divaricata (Ledeb.) Schneider. **Plum.**

From Askabad, Turkestan. "(No. 1348a, June 9, 1910.) A small sour plum, round, not larger than a marble, of green color, with red cheek, clingstone. Said to come from Persia. Used stewed in compotes and with meats. Called *Alitcha*. To be tried as a garden fruit under irrigation in the dry and hot sections of the United States." (*Meyer.*)

28949. Prunus cerasifera divaricata (Ledeb.) Schneider. **Plum.**

From Askabad, Turkestan. "(No. 1349a, June 9, 1910.) A small sour plum of green color, larger than the preceding number, but otherwise the same remarks apply to it. Called *Alitcha*." (*Meyer.*)

Note.—"These plums are apparently not grafted, but are raised from seed. Although small and sour, their early-fruiting capacities recommend them for hybridization work." (*Meyer.*)

28950. Prunus cerasifera divaricata (Ledeb.) Schneider. **Plum.**

From Old Bokhara, Turkestan. "(No. 1350a, June 20, 1910.) A small, red, round plum of very sweet taste, called *Alitcha*. Used fresh like ordinary plums. Of value like preceding numbers." (*Meyer.*)

28942 to 29012—Continued.

28951. Prunus cerasifera divaricata (Ledeb.) Schneider. **Plum.**

From Zerafshan Valley, near Wishist, Samarkand, Turkestan. "(No. 1351a, July 14, 1910.) A wild plum found sparingly along watercourses at an elevation of about 4,500 feet; grows as a dense shrub or small tree and bears in most remarkable quantities small, round, green plums with a reddish hue. Owing to their great productiveness and their resistance to long periods of drought and heat these plums may prove valuable in hybridizing work." (*Meyer.*)

28952. Prunus sp.

From near Kulikalan, Samarkand, Turkestan. "(No. 1352a, July 9, 1910.) An ornamental species of Prunus which grows to be a small tree; it has large light-green leaves and bears long racemes of small, scarlet, oval fruits of a sweet-bitter taste. Found along a watercourse in the mountains, altitude about 6,000 feet. Of value as an ornamental park and garden tree." (*Meyer.*)

28953 to 28962. "The following numbers of apricots should be sown to obtain some superior varieties of apricots with sweet kernels which would bring a much higher price on the market than the present bitter kernels do." (*Meyer.*)

28953. Prunus armeniaca L. **Apricot.**

From Askabad, Turkestan. "(No. 1353a, June 9, 1910.) A small pale-yellow apricot, flesh rather hard, freestone, kernel large and sweet. Said to come from Persia." (*Meyer.*)

28954. Prunus armeniaca L. **Apricot.**

From Askabad, Turkestan. "(No. 1354a, June 9, 1910.) A smooth-skinned apricot of pale-yellow color; looks like a nectarine. Said to have come from Geok-tepe, Turkestan." (*Meyer.*)

28955. Prunus armeniaca L. **Apricot.**

From Askabad, Turkestan. "(No. 1355a, June 9, 1910.) A waxy-white variety of apricot of a very sweet and melting taste; clingstone; sweet kernel. Said to come from northern Persia." (*Meyer.*)

28956. Prunus armeniaca L. **Apricot.**

From Askabad, Turkestan. "(No. 1356a, June 9, 1910.) A large orange-yellow apricot of a sweet melting taste; somewhat fibrous; semi-clingstone; kernel sweet. Said to come from Persia." (*Meyer.*)

28957. Prunus armeniaca L. **Apricot.**

From Askabad, Turkestan. "(No. 1357a, June 9, 1910.) A yellow apricot of remarkable clingstone properties." (*Meyer.*)

28958. Prunus armeniaca L. **Apricot.**

From Old Bokhara, Turkestan. "(No. 1358a, June 20, 1910.) A large pale-yellow apricot of very fine aromatic taste; freestone; kernel large and sweet." (*Meyer.*)

28959. Prunus armeniaca L. **Apricot.**

From Samarkand, Turkestan. "(No. 1359a, July 3, 1910.) A large smooth-skinned apricot of white color with a red cheek; looks totally unlike an apricot. Flesh melting and sweet." (*Meyer.*)

28960. Prunus armeniaca L. **Apricot.**

From Dirdar, Zerafshan Valley, Samarkand, Turkestan. "(No. 1360a, July 13, 1910.) A large pale-yellow apricot of melting flavor; flesh firm and sweet; freestone; kernel sweet." (*Meyer.*)

28942 to 29012—Continued.

28953 to 28962—Continued.

28961. PRUNUS ARMENIACA L. **Apricot.**

From Langar, Zerafshan Valley, Samarkand, Turkestan. "(No. 1361a, July 13, 1910.) An orange-yellow apricot; flesh firm and slightly subacid; kernels sweet. Locally much used dried." (*Meyer.*)

28962. PRUNUS ARMENIACA L. **Apricot.**

From Orono, Zerafshan Valley, Samarkand, Turkestan. "(No. 1362a, July 12, 1910.) A fine variety of apricot of pale-yellow color; flesh firm but sweet and melting; kernels sweet; freestone." (*Meyer.*)

28963. AMYGDALUS PERSICA NECTARINA Ait. **Nectarine.**

From Samarkand, Turkestan. "(No. 1363a, July 4, 1910.) A small nectarine of very firm flesh and of subacid flavor; red throughout; from a distance resembles a crab apple more than anything else. Said to come from Chartchui." (*Meyer.*)

28964. CUCUMIS MELO L. **Muskmelon.**

From Merv, Turkestan. "(No. 1364a, June 13, 1910.) A muskmelon said to be very sweet and early. Obtained from a native dealer in Merv. To be tried under irrigation in the hot and dry sections of the southwestern United States." (*Meyer.*)

28965. CUCUMIS MELO L. **Muskmelon.**

From Merv, Turkestan. "(No. 1365a, June 13, 1910.) A muskmelon said to be very sweet but later than the preceding number, otherwise the same remarks apply to it." (*Meyer.*)

28966. CUCUMIS SATIVUS L. **Cucumber.**

From Askabad, Turkestan. "(No. 1366a, June 7, 1910.) A Persian variety of greenish-yellow, medium-long cucumber, said to be early." (*Meyer.*)

28967. CUCUMIS MELO L. **Muskmelon.**

From Old Bokhara, Turkestan. "(No. 1357a, June 21, 1910.) A fine variety of muskmelon, being early, of greenish-yellow color, small size, and very sweet." (*Meyer.*)

28968. CUCUMIS MELO L. **Muskmelon.**

From Askabad, Turkestan. "(No. 1368a, June 7, 1910.) A muskmelon said to be of very fine quality and very sweet. Obtained from a Persian seed dealer. To be tried like No. 1364a (S. P. I. No. 28964)." (*Meyer.*)

28969 to 28971. CITRULLUS VULGARIS Schrad. **Watermelon.**

From Tarasowka, Podolsk, Russia. "(June, 1910.) The climate of Podolsk is very temperate and as these melons seem to be something out of the ordinary they should be carefully tested in a temperate section of the United States. They were obtained, through correspondence, from a former assistant." (*Meyer.*)

28969. "(No. 1369a.) A small-seeded watermelon, having red flesh and said to be of very fine quality." (*Meyer.*)

28970. "(No. 1370a.) Like the preceding number but with white flesh." (*Meyer.*)

28971. "(No. 1371a.) Like the preceding numbers but with yellow flesh." (*Meyer.*)

28942 to 29012—Continued.

28972. Capparis spinosa L. **Caper.**

From near Langar, Zerafshan Valley, Samarkand, Turkestan. "(No. 1372a, July 13, 1910.) The well-known caper plant, growing on the driest of sunburned mountain slopes and having roots that penetrate yards into the soil and between cracks in rock ledges. Roots sent from the Caucasus under No. 783 (S. P. I. No. 28126), which number see for further remarks." (*Meyer.*)

28973. Salsola arbuscula Pallas.

From Chartchui, Turkestan. "(No. 1373a, June 18, 1910.) A shrub of peculiar appearance, having no leaves but instead long, slender, green, drooping branches. Is used with much success in the sand-binding and desert-reclamation work along the central Asian railroads. Recommended for the dry and hot sections of the United States for various purposes: (1) For its sand-binding properties; (2) as an ornamental park and garden shrub; (3) as a fuel supply in desert regions.

"These seeds should be sown out in the fall and kept moist until the young plants appear above ground; after that they should be watered sparingly.

"Obtained from Mr. W. A. Paletsky, in charge of sand-binding operations along the railroads in central Asia." (*Meyer.*)

28974. Calligonum caput-medusae Schrenk.

From Chartchui, Turkestan. "(No. 1374a, June 18, 1910.) A shrub of very much the same appearance as the preceding number, only flowering quite beautifully toward the end of May and early June. Strongly recommended, therefore, as an ornamental park and garden shrub in desert regions where high summer temperatures prevail, but where the mercury does not drop below zero F. See preceding number for further remarks." (*Meyer.*)

28975. Calligonum aphyllum (Pall.) Guerke.

From Chartchui, Turkestan. "(No. 1375a, June 18, 1910.) A tall shrub like the preceding, but of more arborescent growth and somewhat less ornamental; otherwise all remarks made on preceding numbers apply also to this one." (*Meyer.*)

28976. Haloxylon ammodendron (C. A. Meyer) Bunge. **Saxaul.**

From Chartchui, Turkestan. "(No. 1376a, June 18, 1910.) The famous saxaul tree, one of the chief fuel supplies of the deserts and oases in central Asia. The wood, which is exceedingly heavy and compact, retails at 20 to 25 kopecks a pood (40 pounds). For possible uses and cultural remarks see preceding numbers; see also remarks under No. 1303a (S. P. I. No. 27802)." (*Meyer.*)

28977. Carex physodes Bieb.

From Chartchui, Turkestan. "(No. 1377a, June 18, 1910.) A rare species of sedge, native of the desert, used in sand-binding work along the central Asian railroads. To be tested for similar purposes in the arid sections of the southwestern United States; also, as a possible lawn sedge in the same regions. Obtained like the preceding numbers." (*Meyer.*)

28978. Rosa xanthina Lindl. **Rose.**

From near Kulikalan, Samarkand, Turkestan. "(No. 1378a, July 10, 1910.) A very spiny, shrubby rose, bearing in early summer an abundance of small, deep butter-yellow roses. Found on stony, sterile mountain slopes and in ravines at altitudes of 6,000 to 9,000 feet. Recommended for hybridization work to create perfectly hardy yellow roses and as an ornamental garden shrub for the northern United States." (*Meyer.*)

28942 to 29012—Continued.

28979. Rosa xanthina Lindl. **Rose.**

From near Pasroute, Samarkand, Turkestan. "(No. 1379a, July 11, 1910.) Apparently the same as the preceding, but no flowers could be found. Collected at 6,000 feet elevation." (*Meyer.*)

28980. Berberis sp. **Barberry.**

From near Kulikalan, Samarkand, Turkestan. "(No. 1380a, July 10, 1910.) A tall-growing ornamental barberry found at elevations from 5,000 to 10,000 feet, often on quite sterile places. Bears multitudes of large racemes of yellow flowers. Recommended as an ornamental park and garden shrub in the northern sections of the United States.

"These are last year's seeds and were collected from old bushes at an altitude of about 10,000 feet. In these regions the snow disappears by about the 15th of May, but returns again the last days of September." (*Meyer.*)

28981. Lonicera sp. **Honeysuckle.**

From near Kulikalan, Samarkand, Turkestan. "(No. 1381a, July 10, 1910.) A tall bushy honeysuckle growing on dry and rocky places, preferably between bowlders. Found at an altitude of about 6,000 feet above sea level. Bears yellow berries. Of value apparently as a park and garden shrub in the northern sections of the United States." (*Meyer.*)

28982. Lonicera sp. **Honeysuckle.**

From near Kulikalan, Samarkand, Turkestan. "(No. 1382a, July 10, 1910.) A tall bushy honeysuckle sometimes growing into a tree. Bears red berries. Found on dry and rocky places at elevations of 5,000 to 8,000 feet. Recommended like the preceding number." (*Meyer.*)

28983. Colutea sp.

From Zerafshan Valley, near Wishist, Samarkand, Turkestan. "(No. 1383a, July 14, 1910.) A Colutea found on very dry and rocky mountain slopes; bears yellow flowers and a multitude of large inflated pods. Of value as an ornamental garden and park shrub in the dry sections of the United States." (*Meyer.*)

28984. Colutea sp.

From near Bacharden, Turkestan. "(No. 1384a, June 4, 1910.) A Colutea found amidst stony débris and rocks on arid places. Of value like the preceding number." (*Meyer.*)

28985. Acacia sp.

From desert near Merv, Turkestan. "(No. 1385a, June 14, 1910.) A spiny weed growing here and there in large quantities in the desert. The pods seem to possess tanning capacities and should be tested for these qualities. If found to be possessed of sufficient tannin, this plant could be grown commercially in large sections of the southwestern United States." (*Meyer.*)

28986. Medicago minima (L.) Grufb.

From Baku, Caucasus, Russia, "(No. 1386a, May 26, 1910.) A bur clover growing here and there on very dry hill slopes. Recommended as a winter herbage for cattle in the moist mild-winter sections of the United States." (*Meyer.*)

28987. Trigonella sp.

From near Pasroute, Samarkand, Turkestan. "(No. 1387a, July 11, 1910.) Found along the edge of a wheat field at about 6,000 feet altitude. Of possible value as a fodder herb or as green manure in the mountainous sections of the United States." (*Meyer.*)

28942 to 29012—Continued.

28988. GLAUCIUM sp.

From near Bacharden, Turkestan. "(No. 1388a, June 5, 1910.) A wild plant with yellow red-spotted flowers. Of possible value as an ornamental garden annual." (*Meyer.*)

28989. DATURA STRAMONIUM L. **Jamestown weed.**

From Langar, Zerafshan Valley, Samarkand, Turkestan. "(No. 1389a, July 13, 1910.) The seeds of this plant are locally used by the Sart population as a remedy against headache, the seeds being heated in oil and pounded together with it into a pulp; this is then applied to the temples and is said to be very efficient." (*Meyer.*)

28990. PAPAVER SOMNIFERUM L. **Poppy.**

From Pendshikent, Samarkand, Turkestan. "(No. 1390a, July 7, 1910.) A pure-white variety of poppy seed, grown locally and used baked on cakes and in pastry; also expressed for the sweet, clear oil it contains, which is used for culinary purposes." (*Meyer.*)

28991. PAPAVER SOMNIFERUM L. **Poppy.**

From Old Bokhara, Turkestan. "(No. 1391a, June 22, 1910.) A white variety of opium poppy used for the same purpose as the preceding number." (*Meyer.*)

28992. PHASEOLUS RADIATUS L.

From Kizil-Arvat, Turkestan. "(No. 1329a, June 2, 1910.) The ordinary gram or mung bean, used by the population in central Asia as a food; boiled in soups, eaten boiled with rice, or ground into flour; mixed with flour of various cereals and baked into small hard cakes. This number is said to have been imported from Persia." (*Meyer.*)

28993. PHASEOLUS RADIATUS L.

From Old Bokhara, Turkestan. "(No. 1393a, June 22, 1910.) A rare local variety of mung bean with yellow seeds; used boiled in soups." (*Meyer.*)

28994. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

From Old Bokhara, Turkestan. "(No. 1394a, June 22, 1910.) A very large local variety of cowpea, used in soups and stews. To be tried under irrigation in the hot and dry sections of the southwest United States." (*Meyer.*)

28995. ANDROPOGON SORGHUM (L.) Brot. **Durra.**

From Merv, Turkestan. "(No. 1395a, June 13, 1910.) A good quality of djugara used by the native population for making flat loaves; also eaten boiled as a gruel. To be tried under slight irrigation in the hot and dry sections of the United States." (*Meyer.*)

28996. ANDROPOGON SORGHUM (L.) Brot. **Durra.**

From Old Samarkand, Turkestan. "(No. 1396a, June 30, 1910.) A good quality of local djugara used like the preceding number." (*Meyer.*)

"These represent the common djugara of Turkestan, a white durra differing from the ordinary form found in northern Africa and grown in the United States for many years in having a taller, heavier stalk and more compact heads, nearly all of them pendent. It has been introduced several times before." (*Carleton R. Ball.*)

28997. PANICUM MILIACEUM L. **Proso.**

From Old Samarkand, Turkestan. "(No. 1397a, June 30, 1910.) A large white-seeded local variety of proso, grown by the Sart population in the oasis of Samarkand. To be tested like preceding numbers." (*Meyer.*)

28942 to 29012—Continued.

28998. Panicum miliaceum L. **Proso.**

From Old Samarkand, Turkestan. "(No. 1398a, June 30, 1910.) A large whitish-seeded variety of proso. Other remarks on preceding number apply also to this." (*Meyer.*)

28999. Panicum miliaceum L. **Proso.**

From Old Samarkand, Turkestan. "(No. 1399a, June 30, 1910.) A large yellow-seeded variety of proso. To be tested like preceding numbers." (*Meyer.*)

29000. Chaetochloa italica (L.) Scribn. **Italian millet.**

From Old Samarkand, Turkestan. "(No. 1400a, June 30, 1910.) A white variety of millet." (*Meyer.*)

29001. Chaetochloa italica (L.) Scribn. **Siberian millet.**

From Old Samarkand, Turkestan. "(No. 1401a, June 30, 1910.) A red variety of millet.

"The remarks made on preceding numbers apply also to these." (*Meyer.*)

29002. Echinochloa frumentacea (Roxb.) Link.

From Old Samarkand, Turkestan. "(No. 1402a, June 30, 1910.) A local variety of Japanese millet, used as food by the poorest classes. This seed was sifted out of some rice seed and is apparently a weed." (*Meyer.*)

29003. Hordeum vulgare L. **Barley.**

From Merv, Turkestan. "(No. 1403a, June 13, 1910.) Winter barley grown with slight irrigation in the oasis of Merv. To be tested under irrigation in the dry and hot sections of the United States." (*Meyer.*)

29004. Hordeum vulgare L. **Barley.**

From Merv, Turkestan. "(No. 1404a, June 13, 1910.) Summer barley grown under irrigation in the oasis of Merv. To be tried like the preceding number.

"Barley, in central Asia, takes the same place that oats do with us and is fed everywhere to cart and riding horses, which apparently relish the food." (*Meyer.*)

29005. Triticum durum Desf. **Wheat.**

From Old Samarkand, Turkestan. "(No. 1405a, July 3, 1910.) A fine variety of winter wheat grown without irrigation in the oasis of Samarkand. Very much in favor with the people for bread making; apparently rich in gluten. To be tried in the drier sections of the United States." (*Meyer.*)

29006. Triticum sp. **Wheat.**

From Old Samarkand, Turkestan. "(No. 1406a, July 3, 1910.) A fine local variety of soft white wheat." (*Meyer.*)

29007. Triticum sp. **Wheat.**

From Old Samarkand, Turkestan. "(No. 1407a, July 3, 1910.) A good local variety of hard white wheat.

"The two preceding numbers should be tested like No. 1405a (S. P. I. No. 29005)." (*Meyer.*)

29008. Triticum aestivum L. **Wheat.**

From Pendshikent, Samarkand, Turkestan. "(No. 1408a, July 7, 1910.) A local variety of dark winter wheat grown on the mountain slopes without irrigation. To be tested in the semiarid sections of the United States." (*Meyer.*)

28942 to 29012—Continued.

29009. TRITICUM sp. Wheat.

From Pendshikent, Samarkand, Turkestan. "(No. 1409a, July 7, 1910.) A good local variety of hard winter wheat grown on the plains under irrigation." (*Meyer.*)

29010. TRITICUM sp. Wheat.

From Merv, Turkestan. "(No. 1410a, June 13, 1910.) A good local variety of winter wheat grown under irrigation in the oasis of Merv." (*Meyer.*)

29011. TRITICUM sp. Wheat.

From Old Bokhara, Turkestan. "(No. 1411a, June 22, 1910.) A fine variety of wheat said to come from Katti-Kurgan, Turkestan, which place is known for its good wheat.

"The husks of the Turkestan wheats seem to adhere very firmly to the seed, so that even when left in the field for months the grains do not fall out." (*Meyer.*)

29012. TRIFOLIUM sp.

From Kazelkovskaia, near Merv, Turkestan. "(No. 1412a, June 14, 1910.) A creeping species of white clover found along irrigation canals and on low places in the desert. Of possible value as a lawn clover, under slight irrigation, in the desert regions of the United States." (*Meyer.*)

29013. INGA EDULIS Mart. "Ingá cipó."

From Para, Brazil. Presented by Mr. Walter Fischer, acting director, Campo de Cultura Experimental Paraense. Received November 4, 1910.

"This is a somewhat choicer variety than the one (S. P. I. No. 27798) which I previously transmitted." (*Fischer.*)

29014. VIGNA UNGUICULATA (L.) Walp. Cowpea.

From Para, Brazil. Presented by Mr. Walter Fischer, acting director, Campo de Cultura Experimental Paraense. Received November 4, 1910.

"A variety of cowpea known here as *feijão manteiga* (my Macassar No. 2)." (*Fischer.*)

29015. ALHAGI MAURORUM Medic.

From Cairo, Egypt. Presented by Mr. Abdel Hamid Abaza, secretary general, Khedivial Agricultural Society. Received November 4, 1910.

"A thorny leguminous plant which yields the so-called *Alhagi-manna* or *terendjebin*. This is a sweet gummy substance which during the heat of the day exudes from the leaves and stems and hardens. It is collected by the Arabs and used as a sugar substitute, and as an ingredient for certain sweetmeats. It is a desert plant, growing spontaneously in South Africa, Egypt, Arabia, Asia Minor, and central India. It is imported into India from Kabul and Kandahar in considerable quantities, and has been valued at 30 shillings per pound. I do not think the plant suitable for southern Florida. If introduced it should be tried in our arid southwestern regions. In the hottest part of the year, when almost all other vegetation is shriveled up, it puts forth its leaves and flowers, which are fed to camels; hence it is sometimes called camel's thorn. In some places no manna is obtained from the plant; in no place is much obtained from a single plant. The gummy-looking substance is shaken off. It occurs in grains varying from the size of a mustard seed to that of a hemp seed, and is of a light-brown color and an agreeable saccharine sennalike smell. This substance if unprotected is probably attacked by weevils or other insects; hence it is said to breed worms." (*W. E. Safford.*)

29016. Osterdamia matrella (L.) Kuntze.

From Yokohama, Japan. Purchased from the Yokohama Nursery Co. Received November 5, 1910.

A valuable lawn grass.

Distribution.—Sandy shores of tropical Asia from India eastward through China and Japan to Australia.

29017 to 29019.

From Kuling, China. Presented by Mrs. John Berkin. Received November 5, 1910.

Seeds of the following:

29017. Actinidia chinensis Planch. Yangtaw.

"With regard to the yangtaw, the natives say they think all vines grow fruit, but a young vine never bears. They are usually 6 to 8 years old before they bear. So possibly these vines in time will produce fruit." (*Berkin.*)

See No. 21781 for further description.

29018. Prunus sp. Wild cherry.

29019. Vitis sp. Wild grape.

29020 and 29021.

From Mauritius. Presented by Mr. G. Regnard, Port Louis, Mauritius. Received November 4, 1910.

Seeds of the following:

29020. Elaeodendron orientale Jacq.

"*Bois d'olive.* A shrub 10 to 30 feet high, glabrous. Flowers in cymes one-fourth of an inch across. Drupe oblong, the size of a large Spanish olive; edible; seed two celled. Found in Mauritius, Rodriguez, and Madagascar." (*Regnard.*)

29021. Vangueria madagascariensis Gmelin.

"*Vavangue.* A glabrous shrub 10 to 15 feet high, with very large and long leaves; flowers in copious peduncles, greenish yellow, and having an awful odor. Globose drupe $1\frac{1}{2}$ inches thick with five large bony stones. The fruit is eaten only when quite ripe and of a light-brown color; the pulp is brown with a sweet acid flavor. Naturalized over Mauritius and the Indian Ocean islands." (*Regnard.*)

29022 and 29023. Iris tenax Dougl. Iris.

From Oregon. Presented by Mr. George R. Schoch, Forest Grove, Oreg. Received November 10, 1910.

Seeds of the following; notes by Mr. Schoch:

29022. "Flowers purple, penciled with yellow. Height of flower stems 6 to 12 inches."

29023. "Variety *alba.* Height of flower stems 6 to 8 inches."

"These bloom for about 30 days annually. They should develop attractive flag or carpet effects in extensive grounds, lawns, or parks. The herbage should not be mown, save once in the autumn. The seeds should be forced, as they germinate reluctantly.

"This plant endures the severest droughts; besides, it remains green when not subjected to severe freezes. It should find friends and admirers south of Tennessee."

29025. Irvingia gabonensis (Aubry-Lecomte) Baill. Oba.

From Botnaga, Kamerun, western Africa. Presented by Mr. Fred H. Hope. Received November 17, 1910.

See No. 28912 for description.

29026. Triticum dicoccum dicoccoides (Koern.) Asch. and Graebn. Wild wheat.

From Palestine. Presented by Mr. Aaron Aaronsohn, director, Jewish Agricultural Experiment Station, Haifa, Palestine. Received November 3, 1910.

See Bulletin No. 180, Bureau of Plant Industry, for description.

Note.—"I believe that you will do well to sow a part of this as winter wheat in the Southwest. The wild wheat sown at Bonn, Germany, last October survived the winter perfectly, as I could see for myself last May when I visited there." (*Aaronsohn.*)

29027. Passiflora ligularis Juss. Passion flower.

From near Ambato, Ecuador. Presented by Mr. Herman R. Dietrich, American consul general, Guayaquil. Received November 14, 1910.

"This granadilla fruit was grown a short distance from Ambato, Ecuador. It is frequently shipped to Guayaquil, where it is sold to consumers at about 3½ cents apiece, Ecuadorian currency." (*Dietrich.*)

29028 to 29030. Gossypium spp. Cotton.

From Marash, Turkey. Presented by Mr. Paul N. Nersessian. Received November 9, 1910.

Seeds of the following; notes by Mr. Nersessian:

29028. Gossypium herbaceum L.

"This branches out more and grows larger than No. 29030, the bolls are larger, and the lint cotton from a given weight of bolls is much more, but the yield of bolls from a given area is much less in this locality than the aforementioned variety. It may yield more bolls in another locality, or the cause of the short yield may be found and remedied; then of course it will be the best of all. This variety we call *Besny* or *Gaga.*"

29029. Gossypium hirsutum L.

"This variety we call *Constantinople.* It grows larger, branches out more like a tree, requires richer land, is sown about two weeks earlier, and matures earlier. It requires more water for irrigating than the others. The bolls open wide apart and shed out the lint cotton if not picked in time."

29030. Gossypium herbaceum L.

29031 to 29033.

From eastern Bengal and Assam, India. Presented by Mr. R. L. Proudlock, arboricultural expert. Received November 19, 1910.

Seeds of the following:

29031. Cassia mimosoides L.

"A leguminous plant which is splendid for covering ground and yet easy to root out. It does well in a moist tropical climate and will in my opinion be first-rate for keeping down weeds on rubber plantations." (*Proudlock.*)

Distribution.—India, extending from the Himalayas, where it grows at an altitude of 6,000 feet, southward to Ceylon; generally naturalized in the Tropics.

29031 to 29033—Continued.

29032. Diospyros peregrina (Gaertn.) Guerk. (?) Persimmon.

29033. Diospyros sp. Persimmon.

"These two species are grown in this district (Dacca) for their edible fruit. The fruits are rather astringent unless they are allowed to become almost dead ripe before they are eaten." (*Proudlock.*)

29034 to 29041. Phormium tenax Forst. New Zealand flax.

From Wellington, New Zealand. Presented by Mr. T. W. Kirk, director, Department of Agriculture. Received September 8, 1910. Numbered November 21, 1910.

Plants of the following varieties:

29034. *Arerowharawhara* from Taupo.
29035. *Awanga.*
29036. *Katiraukawa.*
29037. *Korokihi.*
29038. *Oue.*
29039. *Paretaniwha.*
29040. *Putaiore.*
29041. *Tihore.*

29042. Argania spinosa (L.) Skeels. Argan.

From Safi, Morocco. Procured by Mr. R. L. Sprague, American consul, Gibraltar, Spain. Received November 21, 1910.

See No. 28783 for previous introductions.

29043. Coffea macrocarpa Rich. Coffee.

From the island of Mauritius. Presented by Mr. G. Regnard, Port Louis, Mauritius. Received November 21 and 23, 1910.

"A small and very rare shrub of Mauritius, which grows on a soil rather poor, but wet." (*Regnard.*)

Distribution.—In the woods on the slopes of the Pouce and Savanne mountain ranges in the island of Mauritius.

29044. Citrus sp. Orange.

From Olokemeji, Western Province, Southern Nigeria. Presented by Mr. A. Harold Unwin, provincial forest officer. Received November 22, 1910.

"An orange, the skin of which remains green even after the fruit ripens." (*R. L. Beard, Winston Salem, N. C.*)

29045. (Undetermined.)

From Botnaga, Kamerun, western Africa. Presented by Mr. Fred H. Hope. Received November 18, 1910.

"*Mvut*, native name. These seeds are from a tree that grows 30 to 40 feet high and has a rough bark. The fruit is about 1 inch in diameter and 2 inches long. It grows in clusters like the grape and has a fuzz like the peach. The cluster grows out from the trunk of the tree and very often low. Generally found to do best in deep forests." (*Hope.*)

29046. Acacia giraffae Willd.

From South Africa. Presented by Prof. J. Burtt Davy, agriculturist and botanist, Department of Agriculture, Pretoria, Transvaal, South Africa. Received November 23, 1910.

"Seeds of the *kameel-doorn*. This is named after the camelopard, or giraffe, which is said to browse on the foliage; the Dutch word for giraffe is *kameel*. This tree used to be plentiful about Kimberley, but it has been largely destroyed for fuel. The wood is hard and heavy and the heartwood dark brown-red in color; Burchell (Travels) states that the Bechuanas used it for spoons, knife handles, etc. By white people it is chiefly used for fuel, as much as 10,000 tons of fuel, mostly of this species, having been taken to Vryburg alone during some years. Kimberley has also been responsible for the destruction of large quantities. In the early days of mining in Kimberley, when the kameel-doorn was plentiful in the vicinity, the hard heartwood, well oiled, was used as a support for machinery shafts. It is stated by Mr. Senator Marks, one of the old residents of Kimberley, that kameel-doorn, when well oiled, outlasted brass fittings for this purpose.

"This tree grows in a warm, dry, sandy country, with a minimum rainfall of about 15 to 20 inches and a dry winter; its growth is said to be very slow." (*Davy.*)

Distribution.—Dry and sandy deserts in the vicinity of Kimberley, Cape Colony, and northward to Bechuanaland.

29047. OLEA VERRUCOSA (R. and S.) Link. Wild olive.

From South Africa. Presented by Prof. J. Burtt Davy, government agrostologist and botanist, Department of Agriculture, Pretoria, Transvaal, South Africa. Received October 31, 1910.

See Nos. 25520 and 25521 for previous introduction and description.

29048. PASSIFLORA LIGULARIS Juss. Passion flower.

From Bolivia. Presented by Mr. Alexander Benson, chargé d'affaires ad interim, La Paz, Bolivia. Received November 22, 1910.

"These granadillas were purchased in the open market. As you doubtless are aware, La Paz is surrounded by desert, barren country, and all fruits which are brought to the market are brought in on the backs of donkeys from the Yungas country." (*Benson.*)

29049. SOLANUM sp. Potato.

Collected on the Morro Solar Mountain near Chorillos, near Lima, at about 200 meters altitude, among the rocks of a talus slope. Presented by Dr. A. Weberbauer, German legation, Lima, Peru. Received November 23, 1910.

"The plant from which these tubers were procured is closely related to *Solanum maglia*, differing from it, however, in that the flowers are not uniformly violet, but often bear violet stripes on a white ground." (*Weberbauer.*)

29050. PYRUS sp. Pear.

From Manchuria. Purchased from Mr. Edward C. Parker, agriculturist, Bureau of Agriculture, Industry, and Commerce, Mukden, Manchuria. Received November 25, 1910.

"Mixed varieties. Native habitat, Kwangning district, Manchuria, 42° N. lat. These varieties are very resistant to drying winds, sun scald, blight, etc. Valuable in America as hardy grafting stocks." (*Parker.*)

29051 and 29052.

From Russia. Received through Mr. Frank N. Meyer, agricultural explorer, October 18, 1910.

Seeds of the following:

29051. MEDICAGO RIGIDULA MORISIANA (Jord.) Rouy and Fouc. Bur clover.

From near Petrovsk, Daghestan, Caucasus, Russia. "(May 15, 1910.) A small annual bur clover found on level, sandy ground, also on stony slopes along the road. Of small growth. May be of value as a winter-forage plant in regions where the winters are mild and moist, or as a summer-forage plant in the cooler sections of the United States, notably in mountainous regions." (*Meyer.*)

Distribution.—Originally found in the islands of Corsica and Sardinia; apparently occurring with the species throughout southern Europe from Spain to Greece; in Asia Minor, Syria, and Persia; and in Egypt, Algeria, and Morocco.

29051 to 29052—Continued.

29052. PINUS LARICIO PALLASIANA (Lamb.) Endl. **Pine.**

From near Kirikinesh, Crimea, Russia. "(January 16, 1910.) A pine found growing wild along the coasts of the Crimea, occurring sometimes in the rockiest of situations where one would not believe a pine tree would grow. Of value as an ornamental park tree in regions where the winters are not too severe, but the summers hot and dry. Said to be used in reclaiming moving sand wastes in southern Russia." (*Meyer.*)

Distribution.—On the slopes of the mountains in the Crimean Peninsula and the adjacent shores of the Black Sea.

29054 to 29077. MUSA spp. **Banana.**

From Paramaribo, Surinam, South America. Presented by Mr. Goldsmith H. Williams, manager, United Fruit Co. Received November 19, 1910.

Suckers of the following; notes by Mr. Williams:

29054. Apple banana. From Surinam.

29055. Apple banana, large. From Demerara.

29056. Apple banana, large, extra acid. From Demerara.

29057. Apple banana, very long bunches, sweet. From Demerara.

29058. *Braka Bana*, a sort of cross between a plantain and banana. From Surinam.

29059. Fig, or lady's-finger, extra long bunches, usually 10 hands. From Demerara.

29060. Fig, *King of the Prawn*, tasteless but handsome. From New York Botanic Garden.

29061. Fig, *Soekroe*, very small fig banana, but quite sweet. From Surinam.

29062. Horse banana. From Demerara.

29063. Horse banana, *Camboure*, pink fleshed. From Oyapok River, French Guiana.

29064. *Lindo*, tree exactly like the Jamaica banana, but the fruit is not so sweet and resembles slightly a plantain in appearance and flavor. From Costa Rica.

29065. *Martaban Calcutta*, very much like the *Bumulan* from Manila. From Surinam.

29066. Plantain, common. From Surinam.

29067. *Palem Bang*, Malay Archipelago; small fingers, but has a good flavor.

29068. *Pisang Radja*, Siam. From Java.

29069. *Pisang Radja.* From Java.

NOTE.—There is some question as to whether or not this is *Pisang Radja*, as a mistake was made in labeling it.

29070. Plantain, *Vittata*, St. Thomas Island, West Africa.

29071. Red, medium size; light shade of red. From Demerara.

29072. *Uraba.* From Gulf of Darien.

29073. *Uraba No. 2.* From Windward Islands.

29074 to 29077.

NOTE.—These numbers were put on the plants from which the labels had become detached en route. They can not be identified until grown.

29078 to 29081.

From Addis Abeba, Abyssinia. Presented by Mr. Guy R. Love, American vice consul general. Received November 23, 1910.

Seeds of the following:

29078 and 29079. Cicer arietinum L. — **Chick-pea.**

29078. Brown seeded. **29079.** Black seeded.

29080. Pisum arvense L. — **Field pea.**

29081. Pisum sativum L. — **Field pea.**

29082 to 29086.

From Lyngby, Denmark. Presented by Mr. E. Lindhard, Experiment Station for Plant Culture, Tystofte Pr. Tjaereby, Denmark, who procured them from Mr. K. Hansen at Lyngby Experiment Station. Received November 26, 1910.

Seeds of the following; quoted notes by Mr. Lindhard:

29082 to 29084. Pisum arvense L. — **Field pea.**

29082. "Marbled winter variety."

29083. "Spotted winter variety."

29084. "Tawny winter variety."

"Winter varieties of the field pea are cultivated only on very limited areas in this country."

29085 and 29086. Vicia sativa L. — **Common vetch.**

29085. "Brown." **29086.** "Gray."

"Fall field vetches."

29087 and 29088.

From Gonda, United Provinces, India. Presented by Rev. N. L. Rockey, district superintendent of the missions of the Methodist Episcopal Church. Received November 23, 1910.

Seeds of the following:

29087. Anona reticulata L. — **Custard-apple.**

29088. Citrus decumana (L.) Murr. — **Pomelo.**

29089. Boehmeria nivea (L.) Gaud. — Ramie.

From Chekiang, China. Presented by Mr. R. J. Felgate, Mokanshan, China. Received November 26, 1910.

"This sample grew wild in a garden close by my house." (*Felgate.*)

29090. Passiflora ligularis Juss. — Passion flower.

From Acapulco, Mexico. Presented by Mr. Marion Letcher, American consul. Received November 29, 1910.

"This fruit is sold in season in this market, but is not grown in this immediate locality, being brought from the mountain section of the State. As to the quality of the fruit, I have to say that in my opinion it is inferior in flavor to its congener (maypop) of the cotton fields of the Southern States. The Mexican fruit has the advantage in size and in having smaller seeds. The local name for the fruit is *granada china*. I should judge from the name that it was introduced from China in the earlier days and is not an indigenous fruit, as supposed." (*Letcher.*)

29091. NICOTIANA TABACUM L. **Tobacco.**

Grown on the Santa Maria plantation, 12 miles east of the city of Pinar del Rio, and in the Vuelta Abajo, Cuba. Presented by Mr. H. H. Norton, Consolacion del Sur, Cuba. Received November 28, 1910.

"I believe there is only one variety of tobacco grown in Cuba and that the different types are the results of different soils, climate, and methods of cultivation and curing." (*Norton.*)

29092 and 29093. NICOTIANA TABACUM L. **Tobacco.**

From Cuba. Presented by Mr. Francisco A. Montero, Santa Clara, Cuba. Received November 28, 1910.

Seeds of the following:

29092. *Remedios.* From the district surrounding the town of this name in the province of Santa Clara.

29093. *Yara.* From the district in the vicinity of the town of this name in the province of Oriente, 16 miles east-southeast of Manzanillo.

29094 to 29096.

From Orleans, France. Presented by Léon Chenault & Son, nurserymen. Received November 29, 1910.

Plants of the following:

29094. CARRIEREA CALYCINA Franch.

"A deciduous tree 20 to 30 feet (sometimes 40 feet) high with a wide-spreading head of branches." (*Kew Bulletin, No. 9, 1909.*)

Distribution.—Slopes of the mountains in the northeastern part of the province of Szechwan, China, at an elevation of about 4,500 feet.

29095. TETRACENTRON SINENSE Oliv.

"According to Mr. E. H. Wilson this is among the very largest of the broad-leaved trees of the Chinese forests (that is, excluding conifers). It is often 80 feet high and upward, with a trunk 20 feet in circumference. It bears small yellowish flowers in slender spikes about 4 inches long." (*Kew Bulletin, No. 9, 1909.*)

Distribution.—The districts of Chienshih and Fang in the province of Hupeh, central China.

29096. ROSA GIGANTEA × (?). **Rose.**

"*Étoile du Portugal*, the new hybrid of *Rosa gigantea*. As this variety has not yet proved to be quite hardy it would be preferable to plant it in a cool greenhouse or in a conservatory, where it would grow beautifully." (*Chenault.*)

29097. ILEX PARAGUARIENSIS St. Hil. **Yerba maté.**

Grown near the boundary line of Brazil and Paraguay. Presented by Mr. C. F. Mead, Cahi Puente, Paraguay. Received November 30, 1910.

"This plant is known here as *yerba*, and the forests where it is found are called yerbales. There are many varieties hereabout, but I was lucky enough to be able to purchase seed of the best kind. I am sending the entire fruit. To get out the seed it must be soaked for 24 hours in warm water at about 45° C., or better still put in an incubator where a steady temperature can be maintained. There are five or six seeds to each fruit. The seed when planted will take three months to germinate, but if the whole fruit is planted, three years are necessary. Plant in the nursery first; then transplant, spacing 10 feet apart for square method. When full grown the tree is from 30 to 40 feet high. The yerba is the leaf, cut and prepared about once every three years if you own the tree, once every two years if you rent the yerbal. The extra year acts the same on the life of the tree as proper or improper pruning does on fruit trees. The general method here is to rent two or three yerbales and harvest one each year, the picking season of Paraguay being from June 15 to the end of August.

"As near as I can find out, the method of preparing for market is to pick the leaves, partly dry by a fire, finish drying in the sun, and then break up fine with a kind of flail, when it is ready to sack and market. The flavor of yerba is regulated by variety; the strength, by years of growth and methods of preparation. The yield of yerba is about 3 kilos per tree when three years old, 6 kilos per tree the second crop, and a gradual increase then until full grown, when you can cut 80 to 100 kilos (this is probably incorrect as most authorities agree that only 25 to 35 kilos can be cut every three years).

"Maté, or, yerba takes the place of tea and coffee south of Brazil, and its use is being widely extended. There are already companies in Britain for exploiting it, and the export to Mediterranean countries has attained some volume. It has the general reputation of being far less injurious than tea or coffee. When used constantly, however, you have the same craving as with the others, and the majority even go so far as to endow the use of yerba, especially 'amargo' (without sugar), with medicinal qualities, though experiments carried on in Buenos Aires go to prove that such claims are greatly exaggerated, and the 'cup of maté was not so good for Mary Anne' as the Buenos Aires Standard expressed it.

"Yerba is the name of the herb, but the tea is always spoken of as maté. Maté cocido is boiled yerba; this taken the same way as tea or coffee in cups is the 'gringo' style. For peons, a tin cup of maté and six small biscuits keep their speck of life until noontime. The general method of serving, however, is with maté and bombilla, the word 'maté' here meaning the small gourd used to hold yerba and the 'bombilla' the thin tube through which maté is sucked. The maté is about the size of a small cup. The yerba is placed inside and the resultant tea sucked out through the bombilla. The use of sugar is optional. On emptying the maté cup hot water is poured in again and it is passed to the next member of the ring around the fire; a very unsatisfactory and unsanitary method, to say the least, but the only way according to the natives, even though it is necessary to repeat the operation for about two hours to get enough. Maté cocido would be the only method for white people. Yerba sells in Buenos Aires for $1.15 in silver (about 50 cents in gold) per kilo." (*Mead.*)

See No. 25529 for previous introduction.

29098. POPULUS TREMULA L. **Poplar.**

From Tiflis, Caucasus, Russia. Presented by the Tiflis Botanic Garden. Received December 5, 1910.

"The wood of this tree is used almost exclusively in the match industry of Sweden. Undoubtedly the other species of Populus, i. e., *P. alba* and *P. canescens*, could be used to advantage for the same purpose but for the fact that the latter are not so abundant as *P. tremula*. *P. tremula* does not appear to have been noticed by botanists in America, although it is frequently found planted in our parks. It is readily recognized by its large dark-brown buds, 1 centimeter long and half as wide. These are rather blunt and not pointed, as in the case of the Lombardy and Carolina poplars. *P. tremula* was in all probability introduced into Maryland by the early settlers, as it and other species are frequently found about the old mansions." (*Extract from letter of Mr. I. Tidestrom, of the Bureau of Plant Industry, September 17, 1910.*)

29099. Stizolobium aterrimum Piper and Tracy. **Mauritius or Bengal bean.**

From the State of Minas Geraes, Brazil. Presented by Mr. Walter Fischer, acting director, Campo de Cultura Experimental Paraense. Received November 26, 1910.

See No. 28906 for description.

29100. Melinis minutiflora Beauv.

From Brazil. Presented by Dr. Orville A. Derby, Servico Geologico e Mineralogico do Brazil, Rio de Janeiro, Brazil. Received December 2, 1910.

"The species of grass named *Panicum melinis* (*Melinis minutiflora*) occurs in at least two distinct varieties: *Capim catingueiro roxo* and *Catingueiro claro*. The *Melinis minutiflora* is certainly but a synonym of the *Panicum melinis* and no distinct species. A variety has been found at Petropolis, but as I had no opportunity to see this variety, I think it is an adaptation to the different conditions of humidity in the mountains." (*Alberto Löfgren, director, Botanic Garden, Sao Paulo, Brazil.*)

29101 to 29105.

From China. Presented by Mr. T. M. Wilkinson, Foochow, China. Received November 28, 1910.

Seeds of the following; notes by Mr. Wilkinson:

29101. Citrus decumana (L.) Murr. **Pomelo.**

"This tree grows 200 miles north of Foochow. It is much like the orange, but coarser. The fruit weighs from 2 to 3 pounds; the casings of the pulp are very bitter; the skin is very thick in the large fruits, nearly half an inch. All casing and rind must be carefully removed before eating. It is semitart and of fine flavor. Grows on any good land. Season, September 15 to April."

29102. Diospyros kaki L. f. **Persimmon.**

"I am told that this tree grows as far north as Shanghai. The fruits are large, many of them being 2 inches in diameter; skin and pulp red; sweet and fine flavored. Grows from valley to mountain side."

29103. Crataegus pinnatifida Bunge. **Hawthorn.**

"*San cha.* In habit this fruit tree is very much like the American thornapple or hawthorn, but the fruit is much larger, being 1 to 1¼ inches in diameter. It is semitart and makes delicious sauce and preserves."

29104. (Undetermined.)

"Yellow bullet. This tree in habit and appearance is like litchi and linging. The fruit is russet in color, with skin like a grape and a translucent, semitart pulp. Season, August 10 to September 20."

29105. (Undetermined.)

"A doctor who lives 200 miles in the interior gave me the fruit this seed came from and said it seemed to grow wild. In appearance it was very much like a pawpaw, but the flavor was semitart; he was unable to learn the native name. Where this came from there is some snow in winter."

29106 to 29109. SACCHARUM OFFICINARUM L. **Sugar cane.**

From Japan. Purchased from the Yokohama Nursery Co., Yokohama, Japan. Received December 3, 1910.

Cuttings of the following:

29106. "*Chikusho.* Early variety."

29107. "Earliest variety from Kagawa Ken."

29108. "*Kikaigashima.* Early variety from Kagoshima Ken."

29109. "*Oshima.* Early variety from Kagoshima Ken."

See No. 28193 for purpose for which introduced.

29110. CITRUS LIMETTA Risso. **Lime.**

From Seharunpur, India. Received through Mr. R. S. Woglum, of the United States Department of Agriculture, December 5, 1910.

Sylhet.

29111 to 29115.

From Peradeniya, Ceylon. Presented by Dr. John C. Willis, director, Royal Botanic Gardens. Received December 5, 1910.

Seeds of the following:

29111. DIOSPYROS AFFINIS Thwaites.

Distribution.—Known only from the island of Ceylon.

29112. DIOSPYROS ATTENUATA Thwaites.

Distribution.—Known only from the island of Ceylon.

29113. DIOSPYROS INSIGNIS Thwaites.

Distribution.—In the damp forests on the slopes of the mountains of Ceylon up to an elevation of 2,000 feet, and on the Anamually Hills in southern India, to an elevation of 2,000 to 3,000 feet.

29114. DIOSPYROS MOONII Thwaites.

Distribution.—Known only from the island of Ceylon.

29115. MABA OBLONGIFOLIA Hiern.

A small tree closely allied to Diospyros.

Distribution.—Low moist regions up to an elevation of 1,000 feet in the island of Ceylon.

29116. DIOSPYROS sp. **Persimmon.**

From China. Presented by Mr. E. T. Williams, a member of the Division of Far Eastern Affairs, Department of State, through Dr. R. H. True. Received December 5, 1910.

"Some years since, when Mr. Frank Meyer was in China, he asked me to obtain for him if possible some seeds of the Chinese persimmon, which is for the most part seedless. I mentioned it at the time to a friend, who is now in Nanking and who has sent me these seeds just found in a persimmon. If he had sent a larger quantity an interesting experiment might have been made, since all Chinese persimmons are propagated by grafting upon the wild stock." (*Extract from letter of Mr. E. T. Williams, Dec. 1, 1910, to Dr. True.*)

29117 to 29121. Asparagus spp.

From Paris, France. Purchased from Vilmorin-Andrieux & Co. Received December 5, 1910.

Seeds of the following climbing varieties:

29117. Asparagus blampiedii Hort.

29118. Asparagus crispus Lam.

See No. 28923 for previous introduction.

29119. Asparagus comorensis Hort.

29120. Asparagus scandens deflexus Baker.

Distribution.—In woods on the lower slopes of the mountains in the Somerset division of the central region of Cape Colony and in the vicinity of Cape Town.

29121. Asparagus verticillatus L.

"Fruit red. Height 3 to 4 meters. Foliage ornamental from April to October."

Distribution.—Southeastern Europe and western Asia, extending from Turkey through the Caucasus region to the southern part of Siberia and northern Persia.

29122. Cordeauxia edulis Hemsl. **Yeheb nut.**

From Kew, England. Presented by Dr. David Prain, director, Royal Botanic Gardens. Received December 2, 1910.

"The yeheb plant grows in poor sandy soil in the dry regions of Italian Somaliland. The underground soil is said to be somewhat moist and at certain seasons of the year there are regular and plentiful rains in the localities where the plant grows.

"The yeheb forms an evergreen bush about 4 to 6 feet high and the seeds are an important article of food among the Somalis.

"Its seeds, called nuts, have a high food value, containing 21 per cent of cane sugar, 2 per cent of reducing sugars, 13 per cent of proteids, and 37 per cent of carbohydrates. They form an article of commerce and are brought to the coast by caravans. They are eaten by the native Dolbahanta Somalis in preference to rice and dates. Though the climate of Somaliland is not well known, the indications are that where this plant grows long periods of drought occur, but rains are abundant and regular at certain seasons of the year. Winter temperatures probably do not go below freezing. The plant quickly forms a long taproot, bears when only 4 feet high, has evergreen leaves which if crushed stain the fingers a magenta color, and grows into a large tree.

"At Kew seedlings have been raised without difficulty under moist tropical conditions, but it is hoped that it may be possible to establish the plant in dry regions where the soil is poor and the conditions are similar to those of its native country." (See Kew Bulletin, 1908, No. 1, pp. 36–44, and No. 3, p. 141.)

"I doubt very much if Florida will suit this plant, but the southern part of California seems more hopeful. It is evident, however, from its behavior with us that it is one of those desert plants which insist on having desert conditions so far at least as the surface is concerned, though I suspect it likes to be able to tap a deep supply of water. Perhaps a sand draw, provided such can be found in a region sufficiently hot, would be the ideal locality for it." (*Prain.*)

29123 and 29124. Citrus limetta Risso. **Lime.**

From Trinidad, British West Indies. Collected and presented by Mr. G. P. Wilder, of Hawaii. Received December 7, 1910.

Cuttings of the following; notes by Mr. Wilder:

29123. "Spineless lime, from St. Clair Experiment Station, Port of Spain. This lime had few seeds, juice was of fine quality, shape roundish and depressed. There are about 6 to 8 trees, very healthy and robust. The entire wood is free from thorns."

29123 and 29124. CITRUS LIMETTA Risso—Continued.

29124. "Potter seedless lime, from Tree River Estate, La Brea, Pitch Lake. These limes were excellent. I sampled over two dozen and did not find any signs of seeds. Skin greenish; rind thick, but as the location of the tree was a low, damp, fertile valley I am led to believe it would not produce such coarse-skinned fruits under different circumstances."

29125. NICOTIANA TABACUM L. Tobacco.

From Cuba. Presented by Mr. F. L. Cervantes, Havana, Cuba. Received December 8, 1910.

San Juan y Martines.

29126. NICOTIANA TABACUM L. Tobacco.

From Pinar del Rio, Cuba. Presented by Mr. Francisco A. Montero, Santa Clara, Cuba. Received December 12, 1910.

Vuelta.

29127 and 29128. NICOTIANA TABACUM L. Tobacco.

From Cuba. Presented by Mr. Robert M. Grey, superintendent, Harvard Botanical Experiment Station, Cienfuegos, Cuba. Received December 5, 1910.

Seeds of the following:

29127. *Remedios.* Grown one year in Manicaragua, the chief tobacco district in Santa Clara Province.

29128. *Vuelta.* From the city of Pinar del Rio, Vuelta Abajo district.

29129. RAJANIA PLEIONEURA Griseb. "Waw-waw."

From Cuba. Presented by Mr. Robert M. Grey, superintendent, Harvard Botanical Experiment Station, Cienfuegos, Cuba. Received December 8, 1910.

"A large tuber that was brought in by one of the Guajiros from the hills under the name '*Guagua ñame.*' It is also known here under the name of '*Alambrillo.*'" (*Grey.*)

See No. 28894 for previous introduction.

29130 and 29131. SACCHARUM OFFICINARUM L. Sugar cane.

From Cuba. Presented by Mr. Robert M. Grey, superintendent, Harvard Botanical Experiment Station, Cienfuegos, Cuba. Received December 8, 1910.

Cuttings of the following:

29130. *Caledonia Queen.*

29131. *Louisiana Purple.*

29132. CASTANEA CRENATA S. and Z. Chestnut.

From Japan. Presented by Prof. T. Minami, Agricultural College, Tokoku Imperial University, Hokushu, Japan. Received December 10, 1910.

Aomori. A variety of chestnut which is said to occur in the northern part of the north island of Japan.

29133. PHYTOLACCA ACINOSA Roxb.

From Japan. Purchased from the Yokohama Nursery Co., Yokohama, Japan. Received December 10, 1910.

Variety *esculenta.* "This is a perennial found wild only in moist mountain-forest undergrowth. The leaves are eaten boiled in miso soup by rural people; the root is somewhat poisonous and is used as a drug by the herb medical school; the berries are not edible." (*Yokohama Nursery Co.*)

Distribution.—Southeastern Asia, extending from northern India eastward through China to Japan.

29134. Ilex paraguariensis St. Hil. **Yerba maté.**

From Paraguay. Presented by Mr. C. F. Mead, Cahi Puente, Paraguay. Received December 10, 1910.

"Crop of 1910."

See No. 29097 for description.

29137. Persea americana Miller 1768. **Avocado.**

(*Persea gratissima* Gaertn. f. 1805.)

Material growing at the Subtropical Garden, Miami, Fla. Numbered December, 1910.

"Bud wood furnished by Mr. Andrew Hardie, Cocoanut Grove, Fla., who mailed a specimen of fruit to this office. The tree is a seedling of the *Trapp* variety, but differs from this sort in the shape of the fruit, which is slightly ovoid and of a very attractive purplish-red color. It is said to be quite prolific and promises to be one of the most valuable accessions to our avocado collection, not so much on account of superior quality but for its unusually attractive appearance and the fact that it ripens late, about Christmas. The fruit is medium to large size, possesses a very thick skin, and the meat is medium thick, yellow, and very tender. The seed is comparatively large but firmly inclosed by the meat." (*H. F. Schultz.*)

29138 to 29140. Medicago spp.

From India. Presented by Mr. F. Booth Tucker, Salvation Army, Simla, India. Received December 14, 1910.

Seeds of the following; notes by Mr. Tucker:

29138. Medicago hispida apiculata (Willd.) Urban.

From the Punjab Agricultural College (irrigated colonies). "This is known here as *Maina*. The Director of Agriculture tells me that this is an excellent fodder for cattle, and especially for milch cows, but that it is not suitable for horses."

28139. Medicago falcata L.

From Lahul, in the heart of the Himalayas, near Kashmir. "Lahul is a valley 10,000 to 11,000 feet above the sea, surrounded by glaciers and snowy mountains and covered with snow during the winter months."

29140. Medicago sativa L. **Alfalfa.**

From the Punjab Agricultural College (irrigated colonies). "The ordinary *Medicago sativa* as grown in the Punjab by horse breeders."

29141 to 29150.

Received through Mr. Frank N. Meyer, agricultural explorer, December 10, 1910.

Cuttings of the following:

29141. Ribes sp. **Red currant.**

From near Guldscha, Russian Turkestan. "(No. 791, October 10, 1910.) Found growing on a dry mountain side at an elevation of about 6,000 feet. Of vigorous growth, the tallest stems being 8 feet long. Of value in hybridization experiments and, when somewhat improved, as a hardy garden fruit for the northern sections of the United States." (*Meyer.*)

29142. Ribes nigrum L. **Black currant.**

From near Terek-Dawan, Russian Turkestan. "(No. 792, October 13, 1910.) Found growing in a cold, stony canyon at an elevation of over 9,000 feet above sea level. The Russians who live here and there in the mountains make a very palatable preserve from the ripe berries. This shrub may be of value as a garden fruit in the most northern sections of the United States." (*Meyer.*)

29141 to 29150—Continued.

29143. Salix sp. **Willow.**

From Guldscha, Russian Turkestan. "(No. 793, October 11, 1910.) A willow found on sandy alkaline flats; has long, very narrow leaves, and reddish twigs. The trunk, when getting old, assumes a black color and is often twisted and gnarled. The wood is harder than any other willow I ever saw. The trees grow only to a moderate size and may be of value as ornamental garden and park trees and as windbreaks in alkaline sections of the United States. The young twigs are very pliable and may be employed as a tying material." (*Meyer.*)

29144. Salix sp. **Willow.**

From Chinese Turkestan, near Irkestan. "(No. 794, October 15, 1910.) A shrubby willow with reddish twigs and very lanceolate leaves, found growing on very sandy and alkaline places. It has sand-binding qualities, while the young twigs are fit for tying purposes and for basket material. Of value in sandy and alkaline sections of the United States as a hedge plant and an arrester of moving sands." (*Meyer.*)

29145. Salix sp. **Willow.**

From Chinese Turkestan, near Irkestan. "(No. 795, October 15, 1910.) A tall shrubby willow having reddish young twigs, while the stems become quite white when older. Growing on alkaline flats on wind-swept places. Of value as a windbreak and hedge plant in alkaline sections of the northern United States." (*Meyer.*)

29146. Lonicera sp. **Honeysuckle.**

From Chinese Turkestan, near Irkestan. "(No. 796, October 15, 1910.) A shrubby honeysuckle, growing on remarkably dry, stony, and wind-swept places at altitudes often over 9,000 feet above the sea. It has small, somewhat downy leaves and bears yellow berries. Recommended as an ornamental garden shrub and as a possible hedge plant in the dry, cold sections of the United States." (*Meyer.*)

29147. Reaumuria sp.

From Chinese Turkestan, near Irkestan. "(No. 797, October 15, 1910.) A Tamarix-like shrub found on very sandy and alkaline flats at elevations of 8,000 feet and less. Recommended as a sand binder in sandy sections of the northern United States." (*Meyer.*)

29148. Populus sp. **Poplar.**

From Chinese Turkestan, near Irkestan. "(No. 798, October 15, 1910.) A poplar found here and there in clumps on sandy flats and on alkaline places. Leaves round, elliptical. Color of trunk and twigs gray white. The trees apparently do not grow very large. They may prove of value as shade trees and as windbreaks around gardens in alkaline sections of the northern United States." (*Meyer.*)

29149. Tamarix sp. **Tamarisk.**

From near Ulukshat, Chinese Turkestan. "(No. 799, October 16, 1910.) A low-growing tamarisk found on sandy and alkaline level places at elevations of 7,000 and 8,000 feet above sea level. Arrests blowing sands quite well and is recommended for this purpose in the colder sections of the United States." (*Meyer.*)

29150. Crataegus sp. **Hawthorn.**

From near Kan-Shugan, Chinese Turkestan. "(No. 800, October 17, 1910.) A hawthorn of dense growth, reaching the size of a small tree. Leaves large and deeply lobed; berries pale yellow. Found on stony places along water-courses at elevations of 7,000 and 8,000 feet above sea level. Of value as an ornamental park and garden tree in the northern sections of the United States." (*Meyer.*)

29151. Euphorbia canariensis L.

From Teneriffe, Canary Islands. Presented by Mr. R. J. Hazeltine, American vice consul. Received November 10, 1910.

See Nos. 3031 and 10693 for previous introductions.

Distribution.—A shrub or tree 12 to 20 feet high with 4 to 6 angled branches, native of the Canary Islands.

29152 and 29153.

From island of Mauritius. Presented by Mr. G. Regnard, Port Louis. Received December 9, 1910.

Seeds of the following:

29152. Northea seychellana Hook. f. **Capucin.**

This is a tree 60 to 80 feet high, with thick coriaceous leaves 5 to 9 inches long, and bearing inconspicuous flowers in small axillary clusters which produce large fruits with a seed the size of a hen's egg. It is a native of Three Brothers Island in the Seychelles Archipelago.

29153. Stadmannia oppositifolia Lam.

"*Bois de fer.*—This tree is scarce in our forests; it produces bunches of a fruit resembling *Nephelium longan* which are devastated before ripening by monkeys and bats. The pulp of these fruits makes excellent jelly and jam which recall those of quince. The tree is fine and its wood of an extreme tenacity." (*Regnard.*)

Distribution.—Found occasionally in the forests in the island of Mauritius.

29154 to 29160.

The following plants propagated by Mr. G. L. Taber, Glen St. Mary Nursery Co., Glen St. Mary, Fla., for distribution by the Office of Crop Physiology and Breeding Investigations. Numbered December 16, 1910.

Seedling plants as follows:

29154 to 29158. Citrus trifoliata × aurantium. **Citrange.**

29154. *Colman.* See No. 19609.

29155. *Morton.* See No. 16872.

29156. *Rusk.* See No. 13002.

29157. *Rusk.* Budded on sour stock.

29158. *Colman.* Budded on sour stock.

29159. Citrus decumana × nobilis. **Tangelo.**

Sampson. "This is a hybrid between the ordinary grapefruit or pomelo (female parent) and the *Dancey* tangerine (male parent). The color of the fruit is much like that of an orange. Its size is midway between the pomelo and tangerine. In flavor it is sprightly acid, but rather sweeter than the pomelo. Its most pronounced characters, however, are the looseness of the rind and the ease with which the segments can be separated; in these qualities it partakes of the nature of the tangerine. In short, the fruit is much like a high-flavored orange, but has a trace of the sprightly flavor of the grapefruit. The tree is an early and abundant bearer. The *Sampson* tangelo is of course no hardier than either parent and can be grown only in the orange belts of Florida and California." (*W. T. Swingle.*)

Note.—This *Sampson* tangelo is exactly the same as Nos. 13004 and 21596, except that it is grafted on *Citrus trifoliata* stock.

29154 to 29160—Continued.

29160. Citrus trifoliata × aurantium. Citrange.

Etonia or flowering citrange. "This is a hybrid between the common orange and the trifoliata, having the same parents as the *Colman*, *Morton*, and other standard citranges. So far it has borne almost no fruit. On the other hand, it flowers profusely in early spring and the flowers are very large in size, larger than those of either parent. They appear with the leaves and are often so abundant as almost to hide the foliage. This variety is being distributed on a small scale for trial in cities for dooryard planting, where an ornamental rather than a fruit tree is desired." (*W. T. Swingle.*)

29161. Persea americana Miller. Avocado.

From Barbados, British West Indies. Presented by Mr. A. S. Archer, Antigua, British West Indies. Received December 16, 1910.

"The fruits from which I obtained these seeds were purple and each weighed from 2 pounds 10 ounces up to 3 pounds 2 ounces; nothing better could have been desired. The seed cavity was small." (*Archer.*)

29162. Anona reticulata L. Custard-apple.

From Cairns, North Queensland, Australia. Presented by Prof. Howard Newport, instructor in tropical agriculture and manager of the Kamerunga State Nursery, Department of Agriculture. Received December 15, 1910.

Cuttings.

29163. Nicotiana tabacum L. Tobacco.

From the district of Mascota, in the State of Jalisco, on the west coast of Mexico. Presented by Dr. Pehr Olsson-Seffer, editor, American Review of Tropical Agriculture, Mexico City, Mexico. Received December 10, 1910.

"This seed is from the variety which supplies the cigar leaf of the locally well-known Mascota cigars, and is considered one of the best in this country." (*Olsson-Seffer.*)

29164. Agave sp. Agave.

From Costa Rica. Presented by Mr. Carlos Wercklé, through Prof. H. Pittier. Received December 15, 1910.

"These plants are of no value for the production of fiber, but the character of the leaves indicates that they are likely to be very attractive ornamentals and I suggest that they be distributed either to botanical gardens or to growers of succulent plants." (*L. H. Dewey.*)

29165. Citrus sp. Orange.

From Bahia, Brazil. Presented by Mr. Southard P. Warner, American consul. Received December 10, 1910.

"*Laranja da terra.*" Used as a stock. For description, see No. 30605.

29166. Andropogon sorghum (L.) Brot. Kowliang (?)

From Chillicothe, Tex. Grown by Mr. A. B. Conner, in charge of the Department experiment farm. Received December 12, 1910.

"Grown from No. 27764 which was secured from Mr. J. K. Freed, Scott City, Kans. This variety came from Mr. Freed as White Amber sorgo, but it is evidently a kowliang. It gives considerable promise, because of its earliness, as both a grain and a forage crop." (*Conner.*)

29167. ZEA MAYS L. **Corn.**

From near Ciudad del Maiz, State of San Luis Potosi, Mexico, the latitude being approximately 22° 20′ and the longitude being approximately 20 miles west of the line which runs exactly north and south through Mexico City. The elevation of the ranch is approximately 1,000 meters. Presented by Mr. Wilbert L. Bonney, American consul, San Luis Potosi, Mexico. Received December 16, 1910.

"This corn was grown by an American ranchman who selects his seed corn carefully, and this sample may be regarded as representing the best corn now grown in this State." (*Bonney.*)

29169 and 29170.

From Seharunpur, India. Received through Mr. R. S. Woglum, of the United States Department of Agriculture, December 20, 1910.

Seeds of the following:

29169. BAMBOS sp. **Bamboo.**

"Said to be seed of a bamboo which grows wild around Seharunpur." (*Woglum.*)

29170. LIMONIA ACIDISSIMA L.

"I found one tree of this species in the Botanical Garden at Seharunpur. Tree 25 to 30 feet tall and very healthy. Fruit ripening at this time of year (November 15). A small blackish fruit, almost half an inch in diameter, containing a small pit of roundish form." (*Woglum.*)

See No. 26496 for previous introduction.

29171. DIOSPYROS sp. **Persimmon.**

From Tampico, Mexico. Presented by Mr. Clarence A. Miller, American consul, who procured them from Mr. Mordelo Vincent. Received December 17, 1910.

"The fruits from which this seed was taken are not very large. They have green skins and black meat and resemble in contour the Japanese persimmon. They are very sweet but insipid and full of seed." (*Miller.*)

29172. NICOTIANA TRIGONOPHYLLA Dunal. **Wild tobacco.**

From the neighborhood of San Pedro de Ocampo, Mexico. Presented by Dr. Elswood Chaffey, Cerros, Mazapil, Zacatecas, Mexico. Received December 19, 1910.

Cimarron.

Distribution.—In sandy soil, Texas to California and southward to the vicinity of Coahuila in central Mexico.

29173. ZIZANIA LATIFOLIA (Griseb.) Stapf. **Wild rice.**

From Canton, China. Presented by Mr. G. W. Groff, Canton Christian College. Received December 20, 1910.

"*Woo kau* or *kau sun.*"

See No. 26760 for previous introduction.

29174 and 29175.

From Mexico. Secured by the Supervisor of Forests, Tucson, Ariz., from the Director General of Agriculture of Mexico. Received December 20, 1910.

Seeds of the following:

29174. Cupressus thurifera H. B. K. **Cypress.**

Distribution.—Wooded slopes of the mountains in the vicinity of Tasco and Orizaba, Mexico, at an elevation of 5,000 to 7,000 feet.

29175. Pinus montezumae Lamb. **Pine.**

Distribution.—Mountain slopes at an elevation of 3,500 to 12,000 feet from Chihuahua southward to the vicinity of Orizaba, Mexico.

29176 to 29197.

From Philippine Islands. Presented by Mr. H. M. Curran, Forest Service, Manila, P. I. Received December 12, 1910.

Seeds of the following; notes by Mr. Curran:

29176. Clitoria ternatea L.

"*Calocanting* (Tagalog). Rapid-growing vine with ornamental foliage and large, blue solitary flowers. Commonly cultivated in the Philippines."

29177. (Undetermined.) (Fabaceæ.)

"A vine found commonly by roadsides, ornamental."

29178. Casuarina equisetifolia Stickman.

"*Agoho* (Tagalog). A rapid-growing ornamental timber tree, suitable for planting on sandy exposed beaches."

29179. Carica papaya L. **Papaya.**

"Edible fruit, good flavor; cultivated and wild."

29180. Didymosperma sp.

"*Pugaham* (Tagalog). A large, rapid-growing, very ornamental palm."

29181. Intsia sp.

"*Ipil* (Tagalog). Large, rapid-growing, ornamental timber tree. Wood very durable. Grows near tidewater. Purple and white flowers."

29182. Cassia fistula L.

"*Cana fistula* (Tagalog). An ornamental rapid-growing timber tree; wood durable. Bears large clusters of yellow flowers, very showy. Fruit is used for medicine."

29183. Oroxylon indicum (L.) Vent.

"*Pincapincahan* (Tagalog). Ornamental medium-sized tree. Very rapid growing. Wood used for matches. Large purple flowers and conspicuous fruit."

Distribution.—Throughout India from the Himalayas, where it reaches an altitude of 3,000 feet, southward to Ceylon and Burma, and in Cochin China and the Malay Archipelago.

29184. Mezoneuron glabrum Desf.

"*Cabit-cabag* (Tagalog). A rapid-growing vine, bearing ornamental fruit."

Distribution.—The Province of Tenasserim in southern Burma, the island of Timor, and in the Philippines.

29185. Cassia sp.

"*Balacbac* (Tagalog). A low-growing shrub with conspicuous ornamental yellow flowers."

29176 to 29197—Continued.

29186. (Undetermined.) (Fabaceæ.)

"*Tagum* (Tagalog). A small tree, wood hard and durable, bears spikes of purple flowers."

29187. Erythrina indica Lam.

"*Dap-dap* (Tagalog). Ornamental seaside tree with conspicuous masses of showy red flowers which appear before the leaves. Plant deciduous during dry season."

See No. 26499 for previous introduction.

29188. Wallichia tremula (Bl.) Mart.

"*Dumayuca* (Tagalog). An ornamental low-growing palm. Midrib used for making brooms."

Distribution.—Known only from the Philippines.

29189. (Undetermined.)

"*Antipolo* (Tagalog). A large rapid-growing timber tree. Tree yields abundant white latex, used for birdlime. Immature fruit reported edible when cooked."

29190. Albizzia sp.

"*Malasampaloc* (Tagalog). An ornamental medium-sized timber tree; durable wood. Tree resembles *Tamarindus indica*."

29191. Pithecolobium acle (Bl.) Vidal.

"*Acle* (Tagalog). An ornamental timber tree. Mimosa-like white flowers; conspicuous fruits."

29192. (Undetermined.) (Asclepiadaceæ.)

"Ornamental vine. Large fruits; possible source of rubber. Abundant fiber, with seeds; possibly of commercial importance."

29193. Vigna unguiculata L. Cowpea.

"*Setar* (Tagalog). Cowpea cultivated by Negritos of Zambales."

29194. Toona calantas Merrill and Rolfe.

"*Calantas* (Tagalog). An ornamental timber tree furnishing the cigar-box cedar."

Distribution.—The islands of Luzon and Mindoro, in the Philippines.

29195. Diospyros kaki L. f. Persimmon.

"Chinese persimmon sold on the Manila market. Large red fruits, good flavor."

29196. (Undetermined.) (Apocynaceæ.)

"An ornamental vine, copious latex, possible source of rubber and fiber."

29197. Mespilus germanica L. Medlar.

"Medlar pear, sold on the markets of eastern Europe. Flesh soft, with much the color and taste of decayed apples."

29198 to 29203.

From Argentina. Procured by Prof. F. Lamson-Scribner from Mr. Carlos Girola, secretary of the Society Rural, Buenos Aires. Received October 17, 1910.

Seeds of the following:

29198. Cucumis melo L. Muskmelon.

From the American consul, Buenos Aires.

29198 to 29203—Continued.

29199. ORYZA SATIVA L. Rice.

"*Bolita.*" From Tucuman Province.

29200. ORYZA SATIVA L. Rice.

"*Negro.*" From Misiones Province.

29201. TRITICUM DURUM Desf. Wheat.

"*Anchuelo.*" From Entre Rios Province.

29202. TRITICUM TURGIDUM L. Wheat.

"*Medeah.*" From Jujuy Province.

29203. TRITICUM DURUM Desf. Wheat.

"*Candeal.*" From central part of La Pampa Province.

29206 to 29208. CHAYOTA EDULIS Jacq. Chayote.

From Kingston, Jamaica. Presented by Mr. William Harris, Superintendent of Public Gardens, Department of Agriculture. Received December 22, 1910.

Seeds of the following:

29206. Black (not black, however, but a dark green).

29207. Green (a light green).

29208. White (milky white).

29209. CUCURBITA PEPO L. Pumpkin.

From Florida. Presented by Mr. Lorenzo D. Creel, United States Indian Service, Fort Myers, Fla. Received December 22, 1910.

"Seeds of a pumpkin I found the Seminole Indians in the Everglades were growing and probably have been growing for a very long time. It is remarkable for its sweetness and good keeping quality." (*Creel.*)

29210. HIBISCUS SABDARIFFA L. Roselle.

From Mayaguez, Porto Rico. Presented by Mr. C. F. Kinman, horticulturist, Porto Rico Agricultural Experiment Station. Received December 29, 1910.

"Roselle does exceeding well here. The plants when set 3 or 4 feet apart branch freely, grow to be 6 to 9 feet tall, and produce 200 or more fruits. The fruit makes a delicious sauce which by one not familiar with roselle is mistaken for cranberry. At Thanksgiving the fruit is in demand here by Americans, but I am surprised at the little care they have for it except on that date. The Porto Ricans do not care for so tart a fruit, so the market for it here will continue to be very limited. The plants require so little attention and are so prolific that quantities of it would be raised were there any demand. It can be dried easily, and some experiments indicate that it will keep well, making it possible to supply a market at any time of the year.

"I can only guess as to the value of this plant in the Southern States where the soil is quite sandy and in some places dry, as my experience in growing roselle is limited to Porto Rico and Cuba, where the soil is a heavy clay and where the plants do well." (*Kinman.*)

29211. ANANAS SATIVUS Schult. f. Pineapple.

From Tjiomas, Java. Presented by the Director of Agriculture, Buitenzorg, Java. Received December 29, 1910.

"A large pineapple, mandaloeng, from Tjiomas. This is less fragrant than the common *nanas Bogor*, also from Tjiomas." (*Teysmannia, vol. 21, no. 3, 1910.*)

29213 to 29270.

Received through Mr. Frank N. Meyer, agricultural explorer, December 20, 1910.

Seeds of the following:

29213. AMYGDALUS COMMUNIS L. Almond.

From Khokan, Russian Turkestan. "(No. 1413a, September 28, 1910.) *Astachan badam.* A large thin-shelled variety of almond cultivated around Khokan and considered to be fine. As the climate around Khokan is semiarid with long, hot summers and medium-cold winters, while the soil is decidedly alkaline, these almonds may prove hardier and more alkali resistant than the varieties coming from southern Europe." (*Meyer.*)

29214. AMYGDALUS COMMUNIS L. Almond.

From Khokan, Russian Turkestan. "(No. 1414a, September 28, 1910.) *Kasan badam.* A large, medium, thin-shelled almond cultivated around Khokan, considered to be a fine variety. For further remarks see preceding number." (*Meyer.*)

29215. AMYGDALUS COMMUNIS L. Almond.

From Khokan, Russian Turkestan. "(No. 1415a, September 28, 1910.) *Khandak badam.* A small, round, semihard-shelled almond grown around Khokan. For climatological remarks see No. 1413a (S. P. I. No. 29213)." (*Meyer.*)

29216. AMYGDALUS COMMUNIS L. Almond.

From Khokan, Russian Turkestan. "(No. 1416a, September 28, 1910.) *Khandak badam.* A small soft-shelled variety of almond grown around Khokan. See No. 1413a (S. P. I. No. 29213) for further remarks." (*Meyer.*)

29217. AMYGDALUS COMMUNIS L. Almond.

From Khokan, Russian Turkestan. "(No. 1417a, September 28, 1910.) *Khandak badam.* A small soft-shelled variety of almond grown around Khokan. See No. 1413a (S. P. I. No. 29213) for further remarks." (*Meyer.*)

29218. AMYGDALUS COMMUNIS L. Almond.

From Khokan, Russian Turkestan. "(No. 1418a, September 28, 1910.) *Tash badam.* A medium-sized hard-shelled variety of almond grown around Khokan. See No. 1413a (S. P. I. No. 29213) for further remarks." (*Meyer.*)

29219. PISTACIA VERA L. Pistache.

From Khokan, Russian Turkestan. "(No. 1419a, September 28, 1910.) A good variety of pistache nut coming from northern Afghanistan." (*Meyer.*)

29220. PRUNUS ARMENIACA L. Apricot.

From Khokan, Russian Turkestan. "(No. 1420a, September 28,1910.) *Khandak uruk.* A small variety of apricot, exceedingly sweet, having a thin-shelled stone and sweet kernel, cultivated around Khokan." (*Meyer.*)

29221. PRUNUS ARMENIACA L. Apricot.

From Khokan, Russian Turkestan. "(No. 1421a, September 28, 1910.) *Mirshan djali uruk.* A large variety of apricot of very sweet taste. Stone large; kernel sweet. Cultivated around Khokan." (*Meyer.*)

29222. PRUNUS ARMENIACA L. Apricot.

From Khokan, Russian Turkestan. "(No. 1422a, September 28, 1910.) A large apricot of good quality, obtained in Khokan." (*Meyer.*)

29213 to 29270—Continued.

29223. Prunus armeniaca L. Apricot.

From Kashgar, Chinese Turkestan. "(No. 1423a, October 27, 1910.) Sweet-kerneled apricot stones sold on fruit stands in Kashgar. Eaten like almonds; also much used in cakes." (*Meyer.*)

29224. Prunus cerasifera divaricata (Ledeb.) Schneider (?). Plum.

From Khokan, Russian Turkestan. "(No. 1424a, September 28, 1910.) *Alitcha.* A small, very sour variety of plum of reddish or yellow color. Used by the native population in meat stews, making tough meat more digestible. May be of value as a stock for plums in semiarid regions where high summer temperatures and medium-cold winters prevail." (*Meyer.*)

29225. Elaeagnus angustifolia L. Oleaster.

From Andijan, Russian Turkestan. "(No. 1425a, October 4, 1910.) *Djigda.* A large-fruited variety sold on the market in Andijan and eaten as sweetmeats. Of value as an ornamental small tree and as a windbreak in alkaline sections in the mild-wintered semiarid parts of the United States." (*Meyer.*)

29226. Prunus domestica L. Plum.

From Kashgar, Chinese Turkestan. "(No. 1426a, October 27, 1910.) A blue plum much grown around Kashgar. Sold fresh and dried. Makes a fair preserve. Apparently the ordinary European prune. To be sown for identification purposes." (*Meyer.*)

29227. Amygdalus persica nectarina Ait. Nectarine.

From Samarkand, Russian Turkestan. "(No. 1427a, July 27, 1910.) A yellow clingstone nectarine of medium size; meat very firm and of medium-sweet taste, not melting. A rare variety." (*Meyer.*)

29228. Amygdalus sp. Peach.

From Tashkend, Russian Turkestan. "(No. 1428a, September 10, 1910.) A large flat peach having white meat, very juicy and sweet." (*Meyer.*)

29229. Ribes sp. Red currant.

From near Guldscha, Russian Turkestan. "(No. 1429a, October 10, 1910.) Found growing on a dry mountain side at an elevation of about 6,000 feet above sea level. For further remarks see No. 791 (S. P. I. No. 29141), under which cuttings were sent." (*Meyer.*)

29230. Ribes nigrum L. Black currant.

From near Terek-Dawan, Russian Turkestan. "(No. 1430a, October 13, 1910.) Found growing in a cold stony canyon at an elevation of over 9,000 feet above sea level. For further remarks see No. 792 (S. P. I. No. 29142), under which cuttings were sent." (*Meyer.*)

29231. Cucumis melo L. Muskmelon.

From Samarkand, Russian Turkestan. "(No. 1431a, July 22, 1910.) A fine muskmelon of round shape; rind drab-green; flesh yellowish colored, of very sweet and aromatic taste. To be tested under irrigation in the dry and hot sections of the southwestern United States." (*Meyer.*)

29232. Cucumis melo L. Muskmelon.

From Samarkand, Russian Turkestan. "(No. 1432a, July 23, 1910.) A muskmelon of round shape; medium size; rind greenish yellow; flesh of deep-green color and of very spicy flavor. To be tested like preceding number." (*Meyer.*)

29213 to 29270—Continued.

29233. Cucumis melo L. **Muskmelon.**

From Samarkand, Russian Turkestan. "(No. 1433a, July 28, 1910.) A fine muskmelon of flat-round shape; rind yellowish; flesh of rosy-green color; very sweet and aromatic. To be tested like No. 29231." (*Meyer.*)

29234. Cucumis melo L. **Muskmelon.**

From Tashkend, Russian Turkestan. "(No. 1434a, August 11, 1910.) A melon of oval shape; rind drab green; flesh thick and green; of delicious sweet taste and long-keeping qualities. To be tested like No. 29231." (*Meyer.*)

29235. Cucumis melo L. **Muskmelon.**

From near Tashkend, Russian Turkestan. "(No. 1435a, September 20, 1910.) A melon of oval form; greenish rind; salmon-red flesh; of fresh, sweet taste; has remarkably few seeds; possesses long-keeping qualities. Curiously called '*Amerikanski*' melon and believed to have come from America. To be tested like No. 29231." (*Meyer.*)

29236. Cucumis melo L. **Muskmelon.**

From Kostakos, Russian Turkestan. "(No. 1436a, September 24, 1910.) A melon of oblong shape; rind greenish; flesh white, very juicy, sweet, and aromatic. To be tested like No. 29231." (*Meyer.*)

29237. Cucumis melo L. **Muskmelon.**

From Tashkend, Russian Turkestan. "(No. 1437a, August 14, 1910.) A melon of round-oblong shape; rind golden yellow, slightly ribbed; flesh whitish and of remarkably sweet and aromatic flavor. To be tested like No. 29231." (*Meyer.*)

29238. Cucumis melo L. **Muskmelon.**

From Andijan, Russian Turkestan. "(No. 1438a, October 4, 1910.) A small very oblong-pointed melon; rind green; flesh of rosy color; taste fresh, sweet. A so-called winter melon; can be kept until New Year's Day. To be tested like No. 29231." (*Meyer.*)

29239. Cucumis melo L. **Muskmelon.**

From Andijan, Russian Turkestan. "(No. 1439a, October 4, 1910.) A melon of oval shape; rind greenish yellow, netted; flesh white, melting, and very sweet. Can be kept for several weeks. To be tested like No. 29231." (*Meyer.*)

29240. Cucumis melo L. **Muskmelon.**

From Andijan, Russian Turkestan. "(No. 1440a, October 4, 1910.) A melon of oblong-pointed form; rind drab green; flesh white and very firm. Can be kept for several months. Probably a good variety from which to make preserves. To be tested like No. 29231." (*Meyer.*)

29241. Cucumis melo L. **Muskmelon.**

From Osh, Russian Turkestan. "(No. 1441a, October 9, 1910.) A melon of large size and oval shape; rind yellow with green veins; flesh pale yellow, of a fine, fresh, sweet, and aromatic flavor. To be tested in somewhat cooler regions than No. 29231, as Osh is over 4,000 feet altitude." (*Meyer.*)

29242. Citrullus vulgaris Schrad. **Watermelon.**

From Samarkand, Russian Turkestan. "(No. 1442a, July 27, 1910.) A small watermelon having light-green rind, while the flesh is salmon red; taste fresh, sweet. Has small seeds and is an early ripener. To be tested like No. 29231." (*Meyer.*)

29213 to 29270—Continued.

29243. Citrullus vulgaris Schrad. **Watermelon.**

From Tashkend, Russian Turkestan. "(No. 1443a, August 2, 1910.) A small watermelon; rind light green; flesh salmon red, sweet and very juicy. To be tested like No. 29231." (*Meyer.*)

29244. Citrullus vulgaris Schrad. **Watermelon.**

From Tashkend, Russian Turkestan. "(No. 1444a, August 24, 1910.) A small-sized watermelon; rind dark green with light-green patches; flesh pale red, of fresh, sweet taste. To be tested like No. 29231." (*Meyer.*)

29245. Acer sp. **Maple.**

From near Kizil-Kurgan, Russian Turkestan. "(No. 1445a, October 11, 1910.) A maple of small size found on dry and stony mountain sides at elevations of 5,000 feet and over. Bears small leaves which vary much in shape, being found in all forms between trilobed and entire. Of value as a small ornamental tree in the drier sections of the United States." (*Meyer.*)

29246. Juniperus foetidissima Willd. **Juniper.**

From near Guldscha, Russian Turkestan. "(No. 1446a, October 10, 1910.) Found on very sterile and stony mountain sides at high altitudes. Generally of very gnarled and twisted shapes. Much used in the mountains for building purposes and for fuel. Native name, *Artchak*. To be tested in the intermountain sections of the United States." (*Meyer.*)

29247. Berberis sp. **Barberry.**

From near Kan-Shugan, Chinese Turkestan. "(No. 1447a, October 17, 1910. A very spiny barberry having dentate, somewhat undulate leaves and bearing racemes of coral-red berries. Found on sandy and sterile level places at elevations of about 8,000 feet above sea level. Of value as an ornamental garden and park shrub in the northern sections of the United States." (*Meyer.*)

29248. Berberis sp. **Barberry.**

From near Guldscha, Russian Turkestan. "(No. 1448a, October 10, 1910.) A tall-growing barberry found on dry, sandy, and sterile places; bears blue berries. Of value like the preceding number." (*Meyer.*)

29249. Cotoneaster sp.

From near Guldscha, Russian Turkestan. "(No. 1449a, October 10, 1910.) Found growing on dry and sterile locations at altitudes of 5,000 feet above sea level. Of value like preceding numbers." (*Meyer.*)

29250. Nitraria schoberi L. **Desert currant.**

From near Ulukshat, Chinese Turkestan. "(No. 1450a, October 15, 1910.) A spiny shrub found on alkaline and sandy places at elevations of 6,000 to 8,000 feet above sea level. It grows from 3 to 7 feet high and has small white foliage and erect racemes of small juicy black-violet berries. These are edible and of sweet saline taste, but this rather high alkaline property leaves an unpleasant aftertaste in one's mouth, while one's throat also feels the sharpness of the salt. The seeds occupy too much of the berry and the fruits have no value to the white races of men. This desert currant possesses great sand-binding qualities, however, and deserves to be tested for this purpose in the elevated and cool arid and semiarid regions of the United States." (*Meyer.*)

Distribution.—Southeastern Europe and central Asia, extending from the Caucasus region eastward through southern Siberia, northern Persia, and Mongolia to China.

29213 to 29270—Continued.

29251. Rosa sp. **Rose.**

From near Osh, Russian Turkestan. "(No. 1451a, October 9, 1910.) A small, shrubby wild rose, growing in stony and pebbly banks in a semiarid region. Apparently has red flowers. Of possible value as a garden and park shrub in the northern and in the semiarid sections of the United States." (*Meyer.*)

29252. Rosa sp. **Rose.**

From near Guldscha, Russian Turkestan. "(No. 1452a, October 11, 1910.) A wild rose, rather spiny, found on dry stony places. Apparently has reddish flowers. Of value possibly like the preceding number." (*Meyer.*)

29253. Rosa sp. **Rose.**

From near Guldscha, Russian Turkestan. "(No. 1453a, October 10, 1910.) A wild rose of spreading habits, found on dry and sandy places. Apparently has yellow flowers. Possibly of value like the preceding numbers." (*Meyer.*)

29254. Rosa sp. **Rose.**

From near Langar, Russian Turkestan. "(No. 1454a, October 9, 1910.) A wild rose, apparently bearing white flowers, found in rather sterile places. Is armed with an abundance of white spines. Of value possibly like the preceding numbers." (*Meyer.*)

29255. Rosa sp. **Rose.**

From near Terek-Dawan, Russian Turkestan. "(No. 1455a, October 13, 1910.) A wild rose found in a bleak, rocky, and dry canyon at an elevation of over 9,000 feet above sea level. Of possible value like the preceding numbers." (*Meyer.*)

29256. Rosa sp. **Rose.**

From near Irkestan in Chinese Turkestan. "(No. 1456a, October 15, 1910.) A wild shrubby rose found on dry stony banks along a watercourse. Altitude about 9,000 feet. Of value possibly like the preceding numbers." (*Meyer.*)

29257. Rosa sp. **Rose.**

From near Kok-su, Russian Turkestan. "(No. 1457a, October 14, 1910.) A wild rose found in sterile soil along a mountain stream at about 8,000 feet altitude. Of value possibly like the preceding numbers." (*Meyer.*)

29258. Rosa sp. **Rose.**

From near Kan-Shugan, Chinese Turkestan. "(No. 1458a, October 18, 1910.) A shrubby wild rose found in stony places. Has very large white spines. Of possible value like the preceding numbers." (*Meyer.*)

29259. Crataegus sp. **Hawthorn.**

From near Kan-Shugan, Chinese Turkestan. "(No. 1459a, October 17, 1910.) A hawthorn of dense growth. For further remarks see No. 800 (S. P. I. No. 29150), under which cuttings were sent." (*Meyer.*)

29260. Medicago sativa L. **Alfalfa.**

From near Kizil-Kurgan, Russian Turkestan. "(No. 1460a, October 11, 1910.) An alfalfa found in dry decomposed rock banks at an elevation of between 5,000 and 7,000 feet above sea level. Apparently the genuine wild form of the cultivated lucern." (*Meyer.*)

29261. Knautia sp.

From near Guldscha, Russian Turkestan. "(No. 1461a, October 10, 1910.) An ornamental dipsaceous perennial plant, growing from 2 to 4 feet high and bearing large flower heads of a purplish-blue color on stiff, erect stems. Found on a dry, fertile hill slope. Of value apparently as a garden perennial for the northern sections of the United States." (*Meyer.*)

29213 to 29270—Continued.

29262. Vigna unguiculata (L.) Walp. Cowpea.

From Khojend, Russian Turkestan. "(No. 1462a, September 28, 1910.) A large variety of cowpea used locally as a food for man and beast. Deserves to be tested under irrigation in the hot and dry sections of the United States." (*Meyer.*)

29263. Trifolium fragiferum L. Clover.

From near Kok-su, Russian Turkestan. "(No. 1463a, October 14, 1910.) A creeping perennial clover found along a watercourse on clayey alkaline soil at an altitude of 9,000 feet. Possibly of value as a forage and lawn plant in the cooler and intermountain sections of the United States." (*Meyer.*)

29264. Iris sp. Iris.

From near Kan-Shugan, Chinese Turkestan. "(No. 1464a, October 18, 1910.) An iris growing in enormous quantities on alkaline plains at elevations of 6,000 feet above sea level. The plants are a conspicuous feature of the landscape. Said to produce masses of light-blue flowers in early summer. Possibly of value as a ground cover in alkaline sections of the United States." (*Meyer.*)

29265. Glaucium sp.

From near Ulukshat, Chinese Turkestan. "(No. 1465a, October 15, 1910.) Found on dry stony mountain slopes at elevations of over 9,000 feet above sea level. Of possible use as an ornamental garden plant in the colder sections of the United States." (*Meyer.*)

29266. Statice sp.

From near Kostakos, Russian Turkestan. "(No. 1466a, September 24, 1910.) A remarkable perennial having very finely divided foliage and producing masses of flowers of a beautiful metallic-blue color. Found in alkaline places in the desert. Of decided value as a cut flower and as an ornamental garden plant in alkaline sections of the United States." (*Meyer.*)

29267. Vigna sesquipedalis (L.) W. F. Wight.

From Kashgar, Chinese Turkestan. "(No. 1467a, October 23, 1910.) A very long bean used by the local population as a green vegetable. Can also be dried and kept for winter uses. Able to withstand considerable alkali in the soil. Of value as a garden vegetable under irrigation in alkaline sections in the hot and dry parts of the United States." (*Meyer.*)

29268. Cucumis sativus L. Cucumber.

From Kashgar, Chinese Turkestan. "(No. 1468a, October 29, 1910.) A Chinese variety of cucumber, called *Huang kua*, of medium size; green color; good for pickling purposes. Able to withstand considerable alkali and may be tested like the preceding number." (*Meyer.*)

29269. Brassica pekinensis (Lour.) Skeels. Cabbage.

From Kashgar, Chinese Turkestan. "(No, 1469a, October 23, 1910.) A Chinese variety of autumn cabbage called *Ghai pai tsai*. Looking somewhat like Swiss chard. Leaves of dark green, having a very broad, white midrib. The plants do not make any head. They are able to withstand considerable alkali and deserve to be tested like preceding numbers." (*Meyer.*)

29270. Brassica pekinensis (Lour.) Skeels. Cabbage.

From Kashgar, Chinese Turkestan. "(No. 1470a, October 23, 1910.) A large variety of Chinese winter cabbage called *Tung pai tsai*. Of fine quality but requires a long season. Able to grow in quite alkaline soil and deserves to be tested like preceding numbers." (*Meyer.*)

29271 to 29310.

The following list represents some promising varieties of cowpeas grown at the Arlington Experimental Farm in 1910. Numbered in December, 1910.

Notes on the following by Prof. C. V. Piper:

29271 to 29275. VIGNA CATJANG (Burm.) Walp. **Catjang.**

29271. Originally found growing in No. 21569A at the Arlington Experimental Farm. A buff-seeded catjang of very peculiar habit and possibly a distinct species.

29272. Found mixed with guar, No. 18648, from Surat, India, and grown under temporary No. 0336. A catjang with brown-eyed yellowish seeds. A peculiar variety, but not of much agricultural value.

29273. Found mixed with adzuki bean, No. 17321, from Hankow, China, and grown under temporary No. 0927. A distinct variety of catjang, with pale-buff seeds marbled with dark brown. A prolific but not a tall variety.

29274. A single plant found at Arlington, Va., in 1909, in No. 21603 and grown under temporary No. 01446. A catjang with marbled seeds.

29275. Found growing in adzuki bean, No. 17321, from Hankow, China, and grown under temporary No. 0931. Seeds pink buff. A prolific catjang of good habit.

29276 to 29302. VIGNA UNGUICULATA (L.) Walp. **Cowpea.**

29276. From the Public Gardens, Jamaica. Grown under temporary No. 0145. A cowpea with black-eyed white seeds; prolific and of good habit.

29277. From Nairobi, British East Africa. Grown under temporary No. 0509. A peculiar variety of cowpea with small pods which tend to spread out horizontally. The seeds are buff, mostly clouded with purple. A prolific variety, but does not grow very large.

29278. From the Botanic Gardens, Tokyo, Japan; received under the name *Vigna sinensis* var. *bicontorta*. Grown under temporary No. 0511. A curious cowpea with curved or coiled pods and buff-colored seeds.

29279. From the Missouri Botanical Garden, St. Louis. Grown under temporary No. 0531. A cowpea with small buff seeds; quite prolific.

29280. From Livorno, Italy. Grown under temporary No. 0536A. An early cowpea with black-and-white seeds, similar to *Holstein*, No. 17327.

29281. From the same source as the preceding (No. 29280). Grown under temporary No. 0536B. Seeds white, splotched with red.

29282. From the same source as No. 29280. Originally grown from a single seed under temporary No. 0536J. The earliest cowpea yet grown at the Arlington Experimental Farm, maturing at least 10 days in advance of any other variety. The seeds are buff or pinkish buff. The variety is very prolific and will probably be of value for growing northward.

29283. From the same source as No. 29280. Grown under temporary No. 0536K. A prolific early variety, with buff-pink seeds, but too small to be of great value.

29271 to 29310—Continued.

29276 to 29302. VIGNA UNGUICULATA—Continued.

29284. From J. W. Trinkle, Madison, Ind. Grown under temporary No. 05541. This variety is very similar to *Brown Coffee*, No. 17404, but has much broader pods and is earlier. It is a derivative of a hybrid between *Black* and *Taylor*.

29285. From the same source as the preceding. Grown under temporary No. 0562. This is a prolific variety with very small, globose black seeds. It apparently originated as a natural hybrid between *Lady* and *Black*.

29286. *Red Yellow-Hull*. From the Arkansas Agricultural Experiment Station, 1903. Grown under temporary No. 0590. A prolific, vigorous variety. It is probably the best cowpea with maroon-colored seeds grown at Arlington Experimental Farm.

29287. *Self-Seeding Clay*. From the same source as the preceding. Grown from temporary No. 0593. A variety with buff seeds; of rather low habit.

29288. *Mountain Crowder*. From the same source as No. 29286. Grown under temporary No. 0594. This has buff-colored seeds and is very similar to *Michigan Favorite*, maturing in the same time.

29289. From Mr. W. S. O'Bier, Seaford, Del. Grown under temporary No. 0598. A maroon-colored cowpea of good habit and medium early.

29290. *Red Sport*. From the same source as No. 29286. Grown under temporary No. 0604. A very distinct variety with reddish seeds.

29291. *Cotton Patch*. From Mr. J. R. Register, Lamar, S. C. Grown under temporary No. 0814. This variety has pinkish-buff seeds and is very similar to *Clay*, No. 17340. It is, however, very prolific and quite early.

29292. From the Amzi Godden Seed Co., Birmingham, Ala. Grown for several years under temporary No. 0897. This is an excellent cowpea with black seeds.

29293. From the Arkansas Agricultural Experiment Station, through Prof. C. L. Newman. Grown under temporary No. 0905. This has white seeds with the *New Era* color about the eye. It is prolific and of fairly good habit.

29294. From Mr. P. L. Sigman, Alexis, N. C. Grown under temporary No. 0978. A very distinct cowpea with white seeds blotched with red.

29295. From Mr. A. D. McLeon, Red Springs, N. C. Grown under temporary No. 01014. This is undoubtedly a hybrid between *Whippoorwill* and *Taylor*, having the combined markings of both. The variety is very similar to *Taylor* in all respects except seed.

29296. From Mr. J. W. Markham, Guin, Ala. Grown under temporary No. 01017. This is a variety with seeds practically indistinguishable from *New Era*, but quite different in habit.

29297. From Mr. J. L. Forelines, Millard, Ark. Grown under temporary No. 01361. A variety with red-and-white blotched seed, of medium value.

29271 to 29310—Continued.

29276 to 29302. VIGNA UNGUICULATA—Continued.

29298. From Mr. J. D. McLouth, Muskegon, Mich. Grown under temporary No. 01363. A moderately early bushy variety with red-and-white blotched seeds.

29299. *White Giant.* From the Kansas Agricultural Experiment Station (Kansas No. 121). Grown under temporary No. 01375. A black-eyed cowpea very similar to No. 22050.

29300. From T. W. Wood & Sons, Richmond, Va., received under the name *Rice.* Grown under temporary No. 01380. This is a white-seeded cowpea very distinct from any other variety grown.

29301. *Miller.* From the N. L. Willet Seed Co., Augusta, Ga. Grown under temporary No. 01400. The seed of the Miller cowpea occurring on the market is a mixture of several varieties. This cowpea has buff seeds. It is very much like No. 17340 and not superior.

29302. From the same source as the preceding. Grown under temporary No. 01402. It is very vigorous and different from any other grown.

29303. VIGNA SESQUIPEDALIS (L.) W. F. Wight.

From Tehwa, China. Grown under temporary No. 01421. A very distinct cowpea with kidney-shaped seeds, pink excepting one end, which is white.

29304. VIGNA UNGUICULATA (L.) Walp. Cowpea.

From a single plant found at the Arlington Experimental Farm in 1909 and grown under temporary No. 01508. Seeds white, with the *Whippoorwill* color around the eye. In all probability this is a hybrid between *Whippoorwill* and *Blackeye.* It is a variety of moderate value.

29305. VIGNA CATJANG (Burm.) Walp.

From the Botanical Gardens, Madrid, Spain, received as *Dolichos tranquebaricus.* Grown three years under temporary No. 0409. Seeds cream buff. An interesting variety which makes but a small growth.

29306 to 29310. VIGNA UNGUICULATA (L.) Walp. Cowpea.

29306. From Mississippi, 1910. A buff-colored cowpea very similar to *Unknown,* but with very flat pale seeds. Grown under temporary No. 01331.

29307. From Mr. C. E. Fant, Chester, S. C., 1909. Grown under temporary No. 01281. A variety with maroon kidney-shaped seeds. It is much later than *Red Ripper,* bearing the same relation to it that *Unknown* does to *Clay.*

29308. From Mr. G. W. Duren, Booneville, Ark. Grown under temporary No. 01023. A white-seeded table cowpea having the same habits as *Clay,* No. 17359, but producing very large kidney-shaped white seeds.

29309. *Trinkle's Holstein.* A variety that originated with Mr. J. W. Trinkle, Madison, Ind. Grown for two years under temporary No. 0917. It is considerably superior to ordinary *Holstein,* No. 17327.

29310. From a single plant found at the Arlington Experimental Farm, 1909, and grown under temporary No. 01507. A cowpea with seeds like *New Era,* and like that variety growing erect, but producing slender viny branches having small leaflets.

29311 to 29314. CHAYOTA EDULIS Jacq. **Chayote.**

From San Salvador, Central America. Presented by Mr. Francisco G. du Cachon, Director General of Agriculture. Received December 21 and 27, 1910.

Seeds of the following:

29311. Small, white.

29312. Small, light green.

29313. Medium to large, smooth, light green.

29314. Medium to large, more or less spiny, dark green.

29315. NICOTIANA TABACUM L. **Tobacco.**

From the Compostela region, Territory of Tepic, Mexico. Presented by Mr. Alfred Lonergan, Ixtlan del Rio, Tepic, Mexico. Received December 28, 1910.

"This is generally conceded to be the best tobacco grown on this western coast of the Pacific slope in Mexico." (*Lonergan.*)

29316. ANONA CHERIMOLA Miller. **Cherimoya.**

From Oaxaca, Mexico. Presented by Prof. Felix Foex. Received December 27, 1910.

"These seeds came from a very interesting fruit of good size, good shape, pretty appearance, second quality, and having large seeds; the skin is as thick as the shell of a coconut, but not so hard. It resists well a pretty hard shock and pressure and would be very good for shipping." (*Foex.*)

29317. ZEA MAYS L. **Corn.**

From Quito, Ecuador. Presented by Mr. C. de San Juan, Barcelona, Spain, who procured them from Mr. Carlos Tobar, of Quito. Received December 28, 1910.

"Seed of a curious corn that in Ecuador gives great results. I gave some to my friends and everywhere it grew extraordinarily, from 3 to 4 meters high, but did not produce seed, I suppose for want of temperature. The stalks were so high and thick that they looked like bamboos." (*San Juan.*)

29318. BELOU MARMELOS (L.) W. F. Wight. **Bael.**

From Philippine Islands. Presented by Mr. William S. Lyon, Manila. Received December 29, 1910.

"Some of these fruits were from a tree producing fruits nearly spherical. This, however, I judge to be merely a variation from the type." (*Lyon.*)

29319. PASSIFLORA sp. **Passion flower.**

From Buitenzorg, Java. Presented by the director, Department of Agriculture. Received December 29, 1910.

Variety *Perbawati.*

29320. FURCRAEA sp.

From Nice, France. Presented by Dr. A. Robertson-Proschowsky. Received November 2, 1910.

"The plant from which these bulbs were obtained has formed no trunk and is evidently dying off after having produced its offspring. Leaves are, when mature, about 2 meters long by 15 to 20 centimeters broad. I do not know whether it is a species of industrial value. Here in my garden the leaves have proved very durable and strong for tying, for making mats to cover delicate plants, etc., just like the leaves of *Cordyline* (*australis* Hook.?) (*indivisa* Hort.)" (*Proschowsky.*)

29321. NICOTIANA TABACUM L. **Tobacco.**

From the Vuelta Abajò district immediately west of Pinar del Rio, Cuba. Presented by Mr. K. E. Reineman, Academia Raja Yoga, Pinar del Rio, at the request of Mr. H. S. Turner, Santiago de Cuba. Received December 31, 1910.

29322. MEDICAGO SATIVA L. **Alfalfa.**

From Quetta, British India. Presented by Mr. F. Booth Tucker, Salvation Army, Simla, India, who procured it from the Military Farm Department at Quetta. Received December 31, 1910.

29326 and 29327. COLOCASIA spp.

From Canton, China. Presented by Mr. G. W. Groff, Canton Christian College. Received December 20, 1910.

Tubers of the following:

29326. "*Kao tsao fu.*"

29327. "*Pat long fu.*"

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 228.

B. T. GALLOWAY, *Chief of Bureau.*

THE HISTORY AND CAUSE OF THE COCONUT BUD-ROT.

BY

JOHN R. JOHNSTON,

Assistant Pathologist, Laboratory of Plant Pathology.

Issued February 5, 1912.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1912.

DISEASED COCONUT TREE, SHOWING ONE SPIKE (AT "X") THAT HAS LOST ITS NUTS. ALL THE OTHER SPIKES ARE HEAVILY LOADED AND TOGETHER BEAR ABOUT 130 NUTS.

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BUREAU OF PLANT INDUSTRY.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., June 22, 1911.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 228 of the series of this Bureau the accompanying technical paper by Mr. John R. Johnston, entitled "The History and Cause of the Coconut Bud-Rot."

This paper deals with a very destructive and widespread disease of coconuts which has been known to occur in Cuba for more than 30 years, and undoubtedly the same disease occurs also in Jamaica, in the Cayman Islands, in British Guiana, and in British Honduras.

The results presented are based on investigations covering a period of four years, the extent and nature of the disease having been studied in Cuba, Jamaica, Trinidad, and British Guiana.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE HISTORY AND CAUSE OF THE COCONUT BUD-ROT.

INTRODUCTION.

For more than 30 years the people of Cuba have discussed the cause of the gradual dying off of their coconut trees and have tte mpted to overcome it, but without success. As a result of the unchecked progress of the disease the coconut groves have now almost disappeared from the western part of the island and are confined in a commercial way to a very small strip along the coast in the Baracoa district at the extreme eastern end. Ten to eighteen million nuts have been exported from this locality to the United States annually for the last few years. Dr. Erwin F. Smith, working on the disease in 1904, in the neighborhood of Baracoa, writes as follows: "If it continues to spread as it has done during the past 10 years it will inevitably destroy the coconut industry of the island, and that, too, within the next 10 or 15 years." [1]

This disease of the coconut is by no means confined to Cuba. It has caused great loss in Jamaica, British Honduras, Trinidad, and British Guiana, countries that are important sources of coconuts for the United States. The trouble occurs also in less important places in tropical America. A dying off of coconut trees in the Eastern Hemisphere is thought by some to be caused by a disease identical with that in the West Indies. It is probable that this is a widespread trouble, occurring wherever coconuts are grown. Desultory studies have been made of this disease at intervals ever since the early eighties, and it has been ascribed to various causes, such as insects, fungi, bacteria, atmospheric conditions, and soil. A malady so actively destructive in certain districts demands more attention from scientific investigators.

The present work has been carried on with the hope of establishing the cause and finding a remedy. The writer believes he has succeeded in showing that the disease is infectious and that it is due to

[1] Smith, Erwin F. The Bud Rot of the Coconut Palm in the West Indies. Science, n. s., vol. 21, Mar. 31, 1905, pp. 500–502.

certain specific bacteria, but methods by which it can be absolutely controlled remain yet to be found. A thorough knowledge of the conditions under which the disease occurs, including the difficulties involved in carrying on an investigation of it, is so important that it has been considered desirable to describe in some detail the work carried out by the writer. The salient points brought out by the observations of earlier investigators have also been included.

NATURE OF THE DISEASE.

General diagnosis.—The common name of the disease, bud-rot, well describes its nature, for in its acute or advanced stages the bud of the tree, i. e., the growing point in the center of the crown, is affected by a vile-smelling soft rot which destroys all the younger tissues. At this stage most of the nuts have fallen, the lower leaves are turning yellow, and the middle folded and undeveloped leaves are dead and hang down between the still green surrounding leaves. Signs of the disease in its incipiency are (1) the falling of the immature nuts (Pl. I); (2) a staining of the opening flower spikes, partly or wholly, to a rich chocolate brown (Pl. II, figs. 1 and 2; and Pl. III, fig. 1); and (3) the dying and bending over of the middle undeveloped leaves. When the nuts are being shed investigation reveals at the base of the affected spikes a dark-colored wet rot which spreads around the leaf sheaths, or strainers, as they are locally known. This rot appears as water-soaked areas which may reach a length of 15 or 20 centimeters on both the upper and lower surfaces of the bases of the leaves (Pl. II, fig. 3; and Pl. III, figs. 2 and 3). This condition often penetrates the leaf bases to a depth of 2 centimeters or more, and the tissues involved in it swarm with bacteria. As the white tissues at the base of the leaf become old and green the water-soaked spots harden, and they may often be found in this condition on otherwise perfectly healthy trees.

The rot gradually spreads from the base of one spike to another through the wet strainer. It is probable that insects carry the disease from one part to another, since there may be one or more points of infection. Gradually all the spikes become affected and shed their nuts, and the leafstalks become so rotted at their bases that they are not able to maintain their natural position, but are pendent (Pl. IV), often for a long time, or else fall off.

If the infection starts in the central leaves the disease is apt to progress rapidly downward into the younger tissues, which it is very active in disintegrating, the vascular bundles being so soft as to allow the tissues to go entirely to pieces. In the center it may progress into the trunk for a short distance and rot out the fundamental tissue,

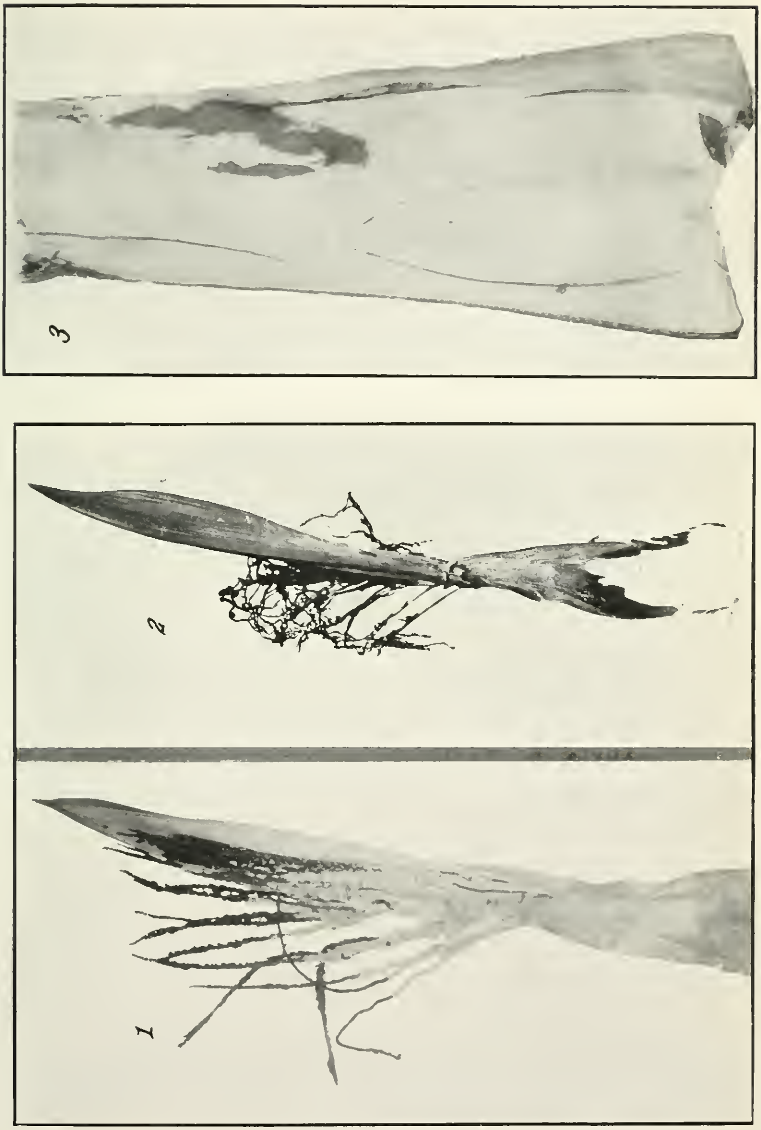

FIG. 1.—OPEN FLOWER SPIKE OF COCONUT PALM WITH DISEASED, BLACKENED TIPS. FIG. 2.—SAME, MORE ADVANCED. WILTED. FIG. 3.—WATER-SOAKED SPOTS ON INSIDE OF PETIOLE; HEALTHY SWORD AT BASE.

leaving only the fibers which are too hard to be disintegrated. This rot has been found, exceptionally, as far as 1.5 meters under the heart of the bud, a hard outer shell being left around the central rotted portion. Usually the decay extends in the trunk under the bud for a distance of only 0.2 to 0.5 meter and never throughout its length.

Spots which are merely fungous infections often occur on the middle leaves (Pl. V, figs. 1, 2, and 3). These spots spread and coalesce, leaving blackened, wet, and later, dry and dead tissues. Insects and small animals are often found in the decaying tissues, but the advancing margin of the soft rot appears to be occupied exclusively by bacteria.

Spread and loss.—The spread of this disease may be very rapid. It may occur year after year as only scattered cases in a grove, but frequently whole plantations may be affected in a short time. In such groves scores and scores of bare trunks may be seen (Pl. VI, fig. 1), the crowns of which have rotted and blown off. There may be trees with the whole crown bent over and hanging downward (Pl. VI, fig. 2), and others with three or four ragged leaves waving upright in the air and all the rest brown, broken, hanging down, and dead (Pl. VII). In the midst of this desolation there are often some green-crowned trees retaining a few nuts, or still in good bearing. From two months to more than a year may elapse from the time of the infection of a tree to its destruction. In Cuba a certain grove of 450 trees was totally destroyed in two years. Another grove was reduced from 1,200 to 300 bearing trees in the same time. A planter in Jamaica who formerly obtained a revenue of £5,000 per year from his coconuts now gets barely £500. Of an estate in Trinidad comprising some 5,000 trees only 15 per cent are standing at present (1907). Formerly many coconuts were grown on the Grand Cayman Island, but the industry has now been wiped out. In fact nearly every coconut-growing region of importance in the West Indies has been invaded by this menace to the industry.

GENERAL DISTRIBUTION OF THE DISEASE.

The coconut bud-rot has been studied most carefully in the West Indies. It has been reported from various parts of the Eastern Hemisphere and probably occurs in all tropical lands.

TROPICAL AMERICA.

Cuba.—While coconuts are grown in suitable places all over Cuba, coconut growing on a commercial scale is now mostly confined to a narrow strip of land on the north shore at the extreme eastern end of the island (fig. 1). This strip, which is about 80 kilometers long, is mostly within what is known as the Baracoa district. The bud-rot has been reported at La Gloria;[1] it occurs from Havana to Artemisa, at Cardenas, Cienfuegos, Manzanilla, Banes; on the coast between Santiago de Cuba and Cape Cruz;[2] and from Cape Maisi northwest to beyond Baracao. All the trees have been killed at the extreme eastern end of the latter strip of land and largely about Baracoa and in other more isolated places. The estimated monthly loss to the Cuban industry is $10,000.[3] The fact that coconuts are not now grown commercially over the greater part of the north shore of the island,

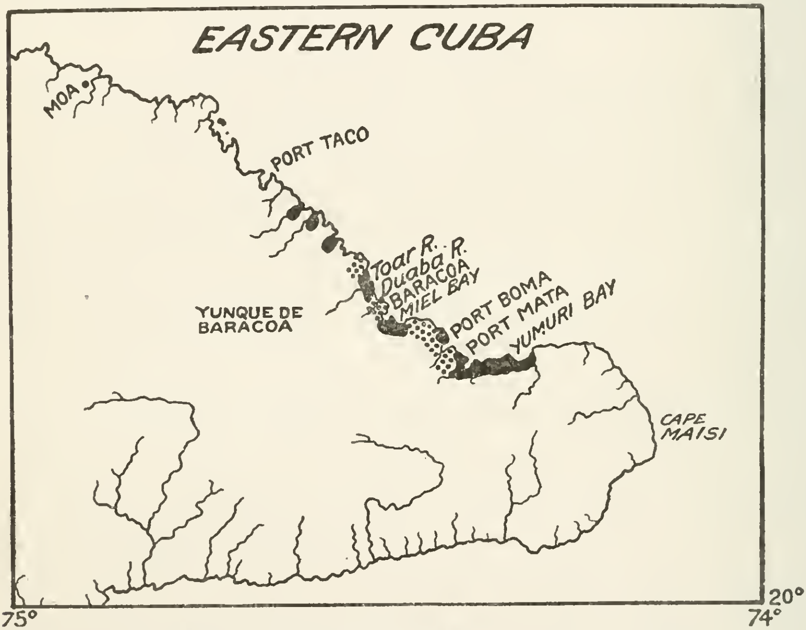

FIG. 1.—Map of the eastern end of Cuba, showing the location of coconut groves (dots). The diseased areas are indicated by heavy shading.

a distance of 900 to 1,100 kilometers, is attributed by some to the supposed prevalence of this disease in early times in those regions.

Diseases of the coconut palm have been reported from various parts of the West Indies for some years. In many cases the descriptions are so meager that it is impossible to identify them with the bud-rot, nevertheless the one characteristic, the rot in the heart tissues, is believed to apply only to this disease. In addition, the dying of the central undeveloped leaves is taken as a sign of the bud-rot, as it is usually the result of the rotting of the lower tissues.

[1] Merrick, F. Cocoanut Bud Rot. Cuba Review, vol. 6, April, 1908, p. 24.

[2] Horne, W. T. Bulletin No. 15, Estación Central Agronómica de Cuba, July, 1908, p. 4.

[3] Horne, Mary Tracy (Mrs. W. T. Horne). The Cocoanut Industry in Cuba. Cuba Review, vol. 5, no. 11, October, 1907, pp. 18–20.

With these considerations as a basis for their selection and as preliminary to the writer's own observations, the following extracts from earlier writers are made, and in order to avoid misinterpretation the exact statements are included.

Dr. Federico Galvez, in a letter[1] dated Havana, January 5, 1886, writes that when he returned to Cuba after an absence of more than 10 years, the place of his birth and childhood, Matanzas, presented a very different appearance in that all of the once beautiful coconut trees had been completely destroyed. Thousands of these dead trees were seen by him. The same conditions prevailed in Havana. Of the extensive coconut groves of Marianao and Jesus del Monte only a few isolated cases now remained standing. In his exact words:

Cuando volví á Cuba despues de una ausencia de más de diez años, fuí á visitar los campos donde había pasado mi niñez, y tambien á mi ciudad natal, Matanzas, y tanto en esta como en aquellos, me impresionó dolorosamente ver todos los cocoteros que tan frondosos había dejado, completamente destruidos. * * *

En los alrededores de la Habana sucedía lo mismo; de los extensos cocales de Marianao y Jesús del Monte solo quedaban en pié algunos árboles aislados. * * * Miles de cocoteros muertos durante este tiempo han sido examinados.

Sr. Antonio Bachiller, in a letter[2] dated Havana, January 26, 1886, stated that he had examined many trees dead and dying in several towns near Havana, and in none of the trees did he find the insect, or any sign of it, which was said to cause the trouble. He did find signs of putrefaction in the crown. To quote exactly:

He hecho abrir en Guanabacoa, en Marianao, en Cimarrones, en Camarioca, muchos árboles ya muertos ó en estado de morirse, y en ninguno se ha encontrado la larva del supuesto cucarachon, ni sus huellas ó galerías. * * * Solo en el penacho había señales de putrefacción con sus consequencias: allí he hecho recojer hidrófilos comunes, agua fétida y cucarachas.

One other letter from among the numerous ones published at this time is selected for reference. Raphael del Pino, in a letter[3] dated Hacienda Herradura, Pinar del Rio, January 25, 1886, says that he lost on his plantation more than 100 trees, all small ones from 1 to 1½ years old. To quote from him:

He perdido más de cien matas en esta hacienda. * * * Esas cien matas de coco eran todas pequeñas, de un año á año y medio las que más edad tenían.

From these letters, and many that have not been quoted, it is evident that a serious disease of coconuts has been present in Cuba for many years, according to Dr. Federico Galvez, at least some years prior to 1886. From Bachiller's mention of putrefaction it is more

[1] Balmaseda, F. J. Tesoro del Agricultor Cubano, vol. 2, 2d ed., 1893, p. 154.

[2] Balmaseda, F. J. Op. cit., p. 132.

[3] Pino, Raphael del. El Pais, Jan. 29, 1886. Reprinted by Balmaseda, F. J., in Tesoro del Agricultor Cubano, vol. 2, 2d ed., 1893, p. 135.

than likely that the disease was no other than the bud-rot, and from the fact that the notes of Galvez and of Pino apply to adjacent districts it may reasonably be supposed that they were speaking of the same disease. More recent investigations by Mr. August Busck and Dr. Erwin F. Smith, both of this Department, and a little later by the staff of the Estación Agronómica at Santiago de las Vegas, deal with the present occurrence of the disease. Mr. Busck,[1] in 1901, reported as follows on the disease in the Baracoa district:

> There were no diseased palms in the immediate neighborhood of Baracoa, but going out some 10 miles east and along the coast, yellow, drooping tops and naked trunks began to appear; and still farther out around Mata and neighboring towns, the disease reached its highest development. Here large areas were attacked, and already from 10 to nearly 100 per cent of the trees were lost.

Dr. Smith studied the disease in 1904 and reported as follows:

> The disease has made decided advances since it was studied by Mr. Busck in 1901, especially at Mata, and if it continues to spread as it has done during the past 10 years it will inevitably destroy the coconut industry of the island, and that, too, within the next 10 or 15 years. Already many of the planters are discouraged and are not setting any more trees, since it now attacks trees of all ages, including quite young ones, and those on the hills as well as those close to the sea.[2]

In their papers on the subject Mr. Busck and Dr. Smith describe the nature of the disease in such detail as to render it certain that it was the bud-rot which they were studying.

In the Primer Informe Anual de la Estación Central Agronómica de Cuba, 1905, on page 195, there appears the following:

> Esta enfermedad se presenta en la Provincia de la Habana, y se nos ha dado cuenta de que existe en otros varias localidades, probablemente afecta á toda la Isla.

In this quotation there is no direct mention of the bud-rot, but further on in the article the disease is described as the bud-rot identical with that in eastern Cuba. According to this evidence the disease is now present in the Province of Havana.

A former pathologist of the Estación Central Agonómica and the writer have carried on investigations more recently, and their work will be discussed more fully further on.

Jamaica.—In Jamaica the coconut region is proportionately more extensive than in Cuba, the only districts where there are no large groves being in the interior and on the south coast (fig. 2). Fortunately, the disease is serious only in the extreme western end of the island, in the district between Savanna la Mar and Montego Bay and a little beyond. It is not greatly feared by those planters who keep watch of their groves, although even with the utmost care many lose

[1] Busck, August. Report on the Investigations of Diseased Cocoanut Palms in Cuba. Bulletin 38, n. s., Bureau of Entomology, U. S. Dept. of Agriculture, 1902, pp. 20–23.

[2] Smith, Erwin F. The Bud Rot of the Coconut Palm in the West Indies. Science, n.s., vol. 21, 1905, pp. 500–502.

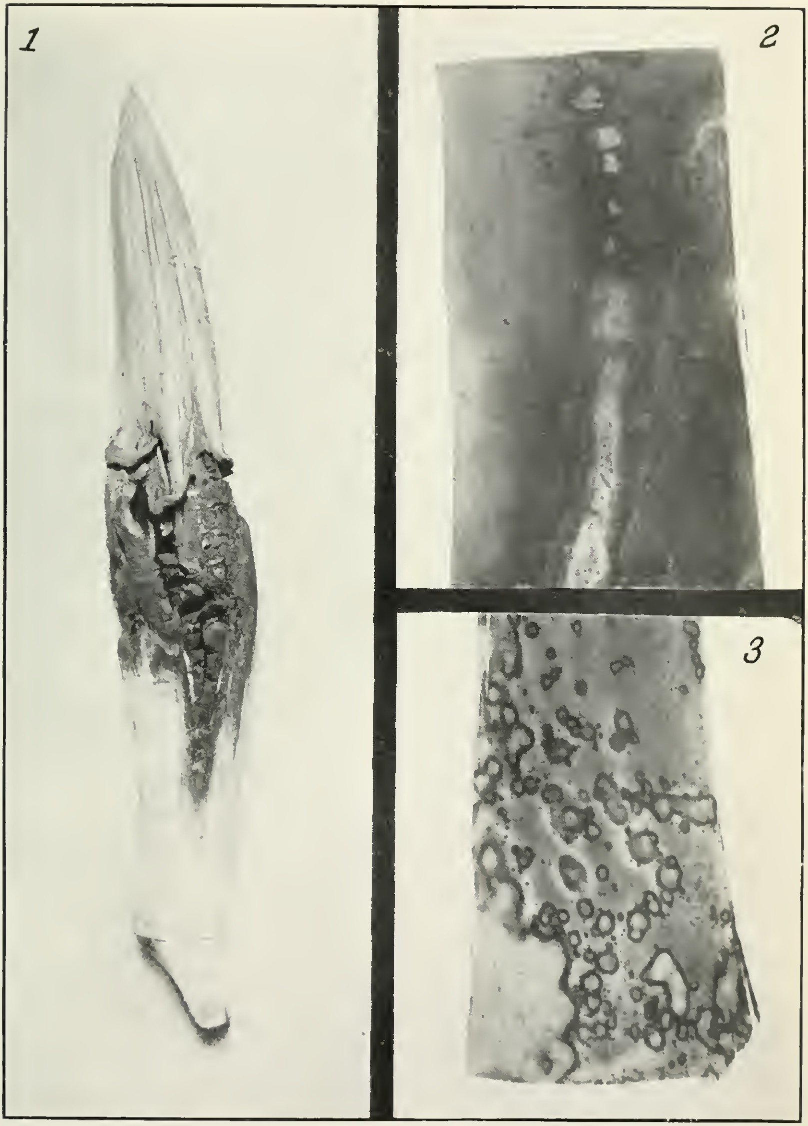

FIG. 1.—ROTTED SWORD OF COCONUT PALM. FIGS. 2 AND 3.—WATER-SOAKED SPOTS ON INSIDE AT BASE OF PETIOLE.

a dozen or so trees every year. The total loss for Jamaica per year at present is probably small, but the fact that the bud-rot occurs there and requires constant watching indicates a dangerous condition.

Mr. W. Fawcett, former director of the Botanical Gardens at Kingston, reports as follows:

I have visited Montego Bay to examine into the death on a large scale of coconut palms in that neighborhood. * * * Several trees were cut down and the roots, stem, leaves, and cabbage examined. There was no evidence whatever of attacks by a beetle. There were some small larvæ, some wood lice, earwigs, ants of several species, and other insects on the affected parts, but they were evidently only preying on the diseased juices, and were not the cause of the disease. * * *

The youngest parts were those affected. The leaves and flowers in the bud were sometimes able, though affected, to withstand the disease so far as to open out, and some leaves and nuts attained almost their full development before the tree succumbed. In the case of tall trees the first indication of the disease was the dropping of the young fruit. * * *

If the terminal bud in the cabbage is affected, the tree is doomed.

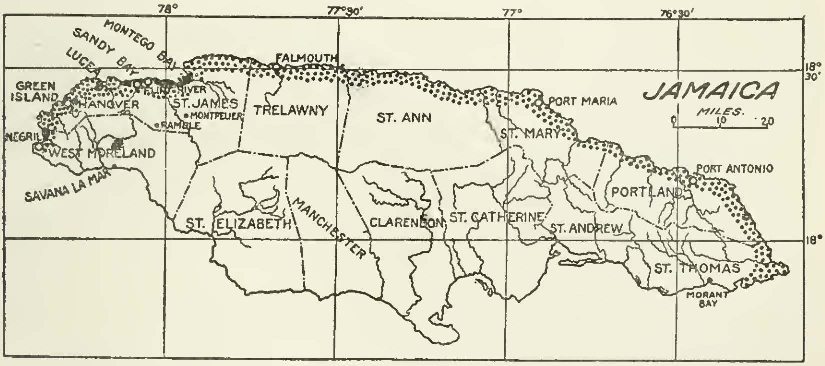

FIG. 2.—Map of Jamaica. The dots show the location of coconut groves, and the heavily shaded portions indicate diseased areas.

In almost all the trees examined the sour smell of a putrefactive fermentation was very noticeable, and I am of the opinion that the disease is due to an organized ferment which is able to attack the very tender tissues of the youngest parts, even outside the terminal bud. If this ferment can be destroyed by fire or other means before it reaches the terminal bud in the heart of the cabbage the tree may be saved.[1]

Cayman Islands.—In the Cayman Islands, midway between Jamaica and Cuba, the bud-rot has raged for some time. The industry has been practically destroyed on Grand Cayman. Mr. W. Fawcett reports:

Disease has for several years blighted the palms in Grand Cayman. * * * No accurate information could be obtained from the people as to the first appearance of the disease; some said it was 15 years ago, others, again, thought it might have been 40 years. In a dispatch from the Marquis of Sligo in 1834 he mentions that all the coconuts of the leeward side had been destroyed, but that the infection had not reached

[1] Fawcett. W. Report on the Coco-nut Disease at Montego Bay. Bulletin 23, Botanical Department of Jamaica, September, 1891, p. 2.

the windward side. It is probable that this was the same deadly disease. I saw a great number of these palms of different ages in various stages of the disease, and at several localities. * * * The inhabitants have been most persevering in their efforts to reestablish their coconut walks, but it is of no avail.[1]

Mr. Fawcett also describes the disease in full as like that of Jamaica, which, in turn, is similar to that of Cuba.

British Honduras.—A disease not due to insects has been noticed on the coconut trees of Honduras for some years. It has been reported as follows:

It is known as "fever," and at present no accurate account has been given of its symptoms or of its prevalence. * * * From the little known about it, it appears to be allied to one or other of the diseases (if, indeed, they are not the same) observed in Demerara in 1875–6, and in Montego Bay, Jamaica, in 1891. * * * According to Mr. Hunter, 50 to 80 per cent of the trees attacked by the weevil show signs of the disease at the top first. This may be merely a misinterpretation of the early signs of injury due to weevil grubs before they have been noticed in the trunk, but the statement is of importance and should be confirmed or refuted. In his evidence Mr. Baber says he "has a small spot on the seaside in Serango Bight (very swampy). He there noticed that the trees died off very rapidly, although of various ages from 7 to 10 years. Does not know the cause of death; some trees on better land close by were not affected." Mr. Schofield states that his plantation was apparently healthy on the 24th of December. * * * On the 7th of January he discovered some 15 trees more or less affected; some had actually fallen over, others had their fronds broken and trailing on the ground, while the rest from their yellow and drooping appearance showed plainly that they also were diseased.[2]

The following extract is from a letter to the United States Department of Agriculture from Belize, British Honduras, dated April 12, 1907:

We have in this colony thousands of trees killed every year either by insects, bacteria, or a combination of both.

These reports from British Honduras indicate that the disease referred to can scarcely be any other than the bud-rot.

Trinidad.—In Trinidad a disease occurs along the west coast (fig. 3) and in the interior, leaving the extensive groves of the east coast untouched.

Mr. J. H. Hart, formerly superintendent of the Botanical Gardens, says:

My observations lead me to conclude that the plantation itself affords distinct evidence that there has been for many years a succession of deaths among the trees on certain areas, which latter appear to have been replanted several times over. In my opinion this is strong evidence that the disease is not new but has been present in more or less severity for years.[3]

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[1] Fawcett, W. Report on the Cayman Islands. Bulletin 11, Botanical Department of Jamaica, February, 1889, pp. 3–4.

[2] Blandford, W. H. Palm Weevil in British Honduras. Kew Bulletin, Nos. 74 and 75, 1893, pp. 27–60.

[3] Hart, J. H. Bud-Rot Disease in Coconuts, Gulf Coast, 1905. Preliminary Report. Bulletin of Miscellaneous Information, Botanical Department of Trinidad, October, 1905, pp. 242–243.

Mr. F. A. Stockdale does not appear to consider the disease serious:

The few isolated cases in the Cedros district would indicate that this disease is not of a very infectious character, but large numbers have been killed out in the Siparia district, the spread being very rapid and apparently from the windward. I am inclined to the view that this disease is similar to the destructive disease of cocoanuts in Cuba.[1]

There has been a good deal published on the coconut-palm disease of Trinidad, and while the early local investigators admitted the presence of some bud-rot, they maintained that the worst of the injury was due to other diseases. The description and arguments of the various writers appear so unsatisfactory that they will be discussed more fully in a later paragraph. It is the belief of the writer from

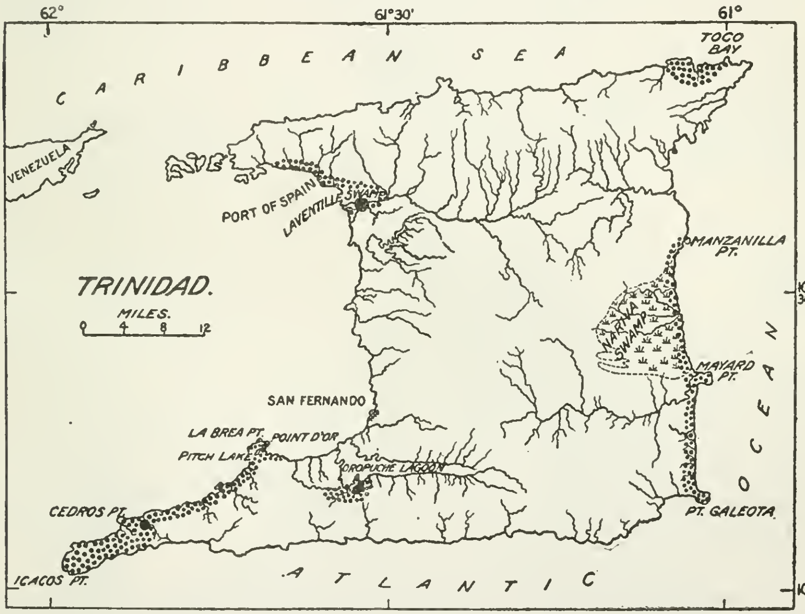

FIG. 3.—Map of Trinidad. The location of coconut groves is shown by dots. The heavily shaded portions indicate diseased areas.

personal examination in many places in the island that the bud-rot is the principal disease in Trinidad, and that the others are of less importance, or represent stages secondary to the bud-rot.

British Guiana.—In British Guiana the groves at the mouths of the Essequibo and Mahaicony Rivers are diseased (fig. 4). Hon. William Russell examined the trees and reported, in correspondence to the Kew Gardens in 1875, as follows:

On dissecting the top of the tree, all the fruit germs were found quite rotten (putrid fermentation), and gave a most offensive smell; and at the point where the last frond or central spike divides from the lower fronds the state of putrefaction was fearful.[2]

[1] Stockdale, F. A. Coconut Palm Disease (Society paper 247). Proceedings of the Agricultural Society of Trinidad and Tobago, vol. 7, December, 1906, p. 45.

[2] Anonymous. Bud-Rot Disease of Cocoanut Palm. West Indian Bulletin, vol. 6, 1905, pp. 307-321.

From this same colony comes the following report:

Travelers on the East Coast Railway can hardly have failed to notice the unhealthy appearance of many of the coconut trees which form so conspicuous a feature of the district from Mahaicony onwards to Belladrum. The drooping leaves, and yellow crowns, the "bare poles" of dead palms in too many cases point to disease of a widespread and malignant nature.[1]

So far as authentic reports or personal investigations are concerned there is no note of the further occurrence of the disease in the West Indies or tropical America. Three different travelers have, however, reported to the writer a disease of coconuts in both Haiti and the Dominican Republic similar in general aspect to the Cuban disease. Another traveler reports it from the Mexican coast south of Vera Cruz. A captain of a schooner engaged in collecting coconuts at Baracoa

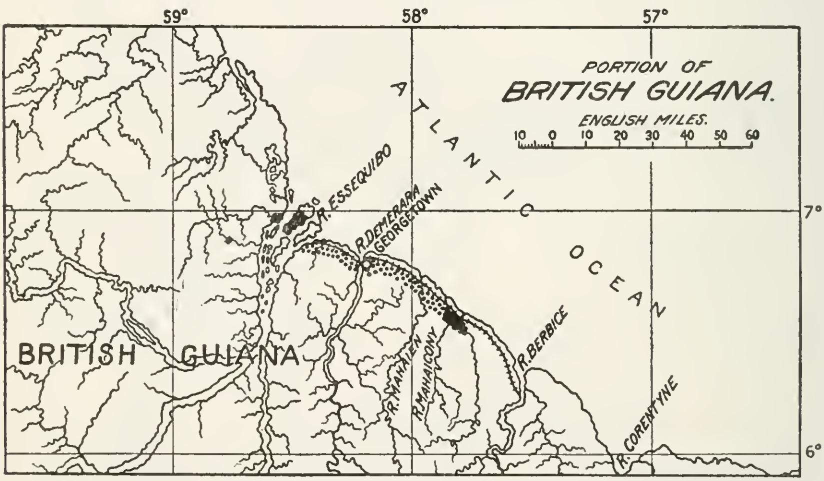

FIG. 4.—Map of a portion of British Guiana. The dots show the location of coconut groves and the heavily shaded parts indicate diseased areas.

claimed to the writer that he had seen what appeared to be the same disease on the San Blas coast of Panama, where the best nuts are obtained.

Although it does not appear to occur in Porto Rico, it is prevalent in all of the very important sources of coconuts in the West Indies and the adjacent coasts.

EASTERN TROPICS.

Diseases of coconuts in the Eastern Hemisphere have been known and investigated for some years, but it is only recently that one similar to the bud-rot of the West Indies has been reported. So far as known there have been no comparisons by photographs or by

[1] Leechman, Alleyne. The Radical Cure of Infectious Plant Diseases. Journal of the Board of Agriculture of British Guiana, vol. 2, no. 3, January, 1909, pp. 104–106.

DISEASED COCONUT TREE AT MONTEGO BAY, JAMAICA.

specimens of the bud-rot from both regions, nor has any investigator of the one region visited the other, a procedure eminently desirable to establish fully the probable fact that this destructive disease is present in all parts of the tropical world.

Philippine Islands.—In the Philippines the disease is present in several provinces and reported[1] to be very destructive.

The bud-rot is at present very prevalent in Lazaan, Sungi, and Ylaya. It is present, but does less damage, in two other of the upper barrios of Lilio. There are a few scattered cases in Balanacan and Sinipian, barrios of Nagcarlan, and probably in Pagsauitan and elsewhere. * * * Capt. Grove has heard that many years ago it practically wiped out the coconut industry of Lucban, and I have been told that it was very destructive about five years ago in Sariaya. * * *

In the badly infested districts there are patches where almost every tree is smitten and larger ones where fully half of the trees are dead or dying. * * *

The disease attacks the soft, undifferentiated tissue of growing points. * * * As soon as the youngest leaf is noticeably discolored it can easily be drawn out. * * * The decaying tissue has a powerful and vile odor. The stench is very characteristic.

Ceylon.—In Ceylon an infection apparently identical with the bud-rot of the West Indies destroyed the young trees on a small estate but spread no farther. An investigator reported that bud-rot, apparently identical with the West Indian disease, appeared in a small native estate early in the year. The place was visited and the diseased trees cut out.[2]

According to Copeland,[3] Petch of Ceylon found in a small isolated patch of 10 acres, including some 800 trees, 50 that were dead or dying. The diseased trees were 3 or 4 years old. Their condition is described as follows:

The first indication of the disease (in the case of young plants) is the withering of the youngest unfolding leaf. This turns brown and can be pulled out of its sheath; it is then found to end in a soft brown mass. * * * If the dying fronds are removed and the bud exposed there will be found instead of the white cabbage a pale brown semiliquid mass. * * * The organisms responsible for this decay are bacteria which are found in abundance in the rotting tissues; they are short, thick rods with rounded ends which form whitish colonies of slow growth on sugar agar.

India.—It is probable that the bud-rot occurs also in India proper, according to the following:

Some time ago the occurrence was reported of a coconut pest in the shape of a fungus which was eating into the vitals of the coconut palm in North Travancore.[4]

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[1] Copeland, E. B. Bud rot of the Coconut. Philippine Agricultural Review, vol. 1, no. 5, May, 1908, pp. 210–220.

[2] Hart, J. H. Diseases of Cacao, Coconut, Rubber, etc. Extract from the Report of the Botanical Department, Ceylon (Society paper 264). Proceedings of the Agricultural Society of Trinidad and Tobago, vol. 7, 1907, pp. 179–193.

[3] Copeland, E. B. Op. cit., pp. 210–220.

[4] See "Fungus Disease of Coconuts," in Tropical Agriculturist, vol. 24, February, 1905, p. 556.

A report of palm diseases in India mentions the coconut palm as follows:

The most serious aspect of the matter is the fact that coconut palms are undoubtedly subject to infection. In Ramachandrapuram taluka few cases only were seen, but in Amalpuram they are numerous, though fewer than in the palmyra. * * * In one locality some 200 dead coconut trees were seen; elsewhere only a dozen or two. The danger is that the disease may increase in virulence in regard to coconut palms if allowed to rage unchecked. * * * Very soon a rot follows, which extends with great rapidity in the delicate central tissues and converts the whole heart into a foul-smelling mass of putrefaction in which everything is involved, and the original agent is lost sight of.[1]

German East Africa.—In German East Africa a disease of coconuts is described as a rot of the heart tissues and is said to be contagious. The symptoms are merely that the leaves turn yellow and dry up, and the tree dies. Soon after the first appearance of the disease the heart leaves can be drawn out, as the bottom is rotted off. This meager description of it answers well for the typical bud-rot:

Die Fäulnis des Herzblattes is weit schlimmer, da sie ansteckend ist. Die Krankheit macht sich folgendermassen bemerkbar: Die unteren Wedel und die Spitze des Herzblattes werden gelblichrot und trocken, und der Baum stirbt ab. Man kann nach der ersten Erscheinung das Herzblatt mit leichter Mühe herausziehen, da das Ende vollkommen verfault ist. Ist das Herz verfault, so sind die Wurzeln und auch noch der untere Stamm vollkommen frisch und saftig, ein Zeichen, dass die Krankheit nicht von unten an den Wurzeln anfängt, wie leider hier noch vielfach behauptet wird.[2]

Portuguese East Africa.—In Portuguese East Africa a similar disease is reported, and there is great probability that it is the bud-rot:

In Quilimane the disease attacks the leaves, which become discolored and dried without there being any insect pest or any visible disease present. The disease quickly spreads from tree to tree until a whole plantation is destroyed. In Quilimane the only remedy known is the total destruction of the diseased tree in an early stage of the disease by cutting down and burning.[3]

Tahiti.—Since the manuscript of this bulletin was prepared report has been received by this Department through the Secretary of State of a serious disease of the coconut palm in Tahiti suspected to be identical with the West Indian disease.

From the foregoing it will be apparent that the bud-rot of the coconut is probably present in all parts of the tropical world (fig. 5). That it is such a cosmopolitan disease makes it doubly important to learn fully its nature and a method of control.

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[1] Butler, E. J. Some Diseases of Palms. The Agricultural Journal of India, vol. 1, pt. 4, 1906, pp. 299–310. Reprinted in Bulletin of the Department of Agriculture of Jamaica, vol. 5, pts. 2 and 3, 1907, pp. 48–58.

[2] Stein, Pflanzer. Die Kokosnuss und deren Bearbeitung in Deutsch-Ostafrika. Der Tropenpflanzer, vol. 9, 1905, pp. 195–201.

[3] See "Coconut Leaf Disease in Ceylon and Portuguese West Africa," in Tropical Agriculturist, vol. 23, no. 7, January, 1904, p. 477.

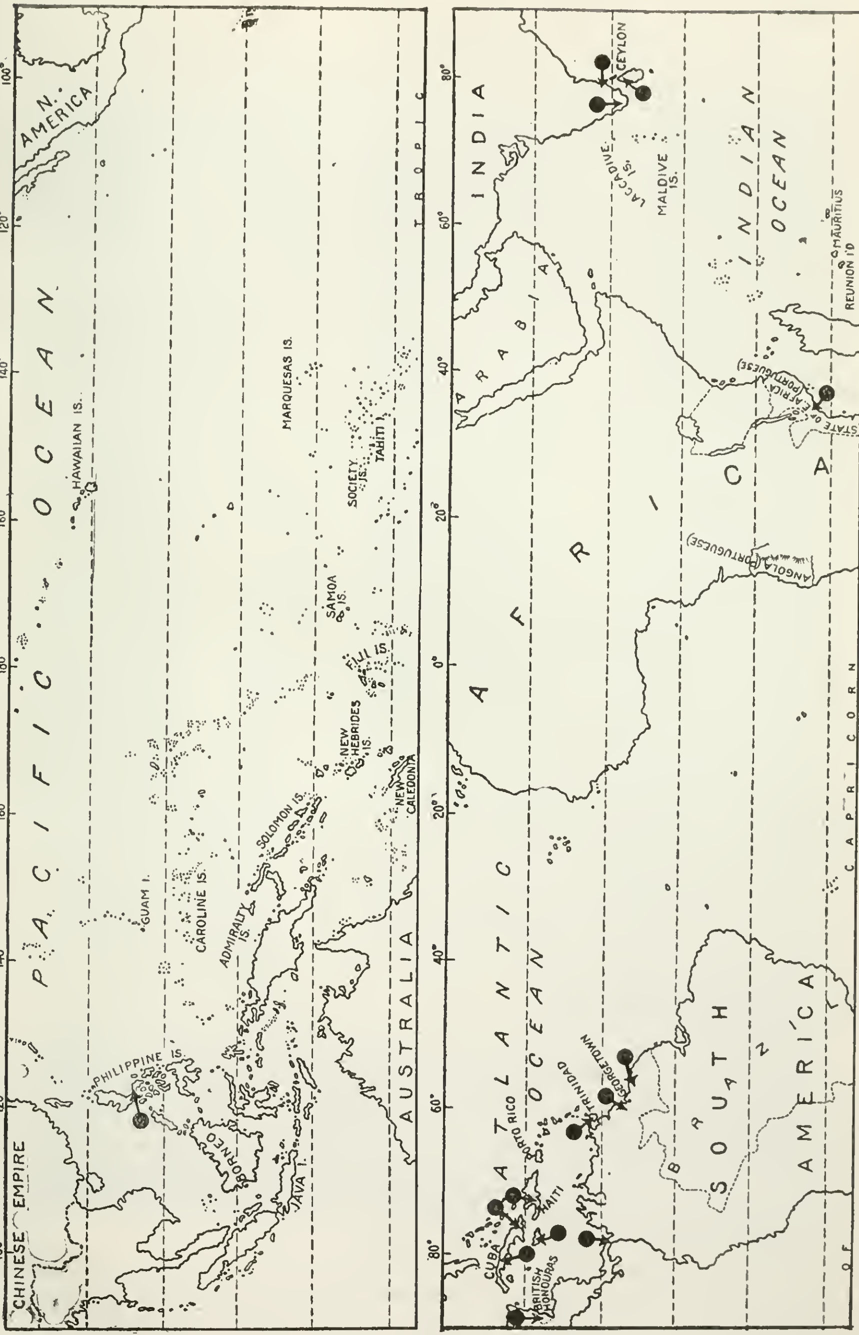

FIG. 5.—Map of the tropical countries of the world. The heavy arrows indicate the location of the bud-rot according to reports.

GENERAL INVESTIGATION OF THE DISEASE IN THE WEST INDIES.

Various investigators of the West Indies and of the United States have devoted some time to this disease of the coconut and have tried many different methods of controlling it, so that it is desirable to state here the results of their work.

In 1901 requests from the coconut planters of Baracoa, Cuba, to the United States Department of Agriculture resulted in the assignment of Mr. August Busck, of the Bureau of Entomology, to investigate the disease. Mr. Busck started in August and traveled for several months over various districts. He investigated the purely entomological aspects of the disease and reported that while numerous insects were present in the rotting tops of the trees none of them seemed to occur in sufficient numbers to be considered responsible for the trouble. He was unable to find the palm weevil at all. Considerable fungous growth which was thought to be the cause of the decay was noted in the crown. The fungus was identified as *Pestalozzia palmarum* Cke., the cause of a widespread coconut-leaf disease.

In 1904 Dr. Erwin F. Smith, plant pathologist of the United States Department of Agriculture, continued the investigations. Most of his examinations were made in April. Before visiting the island he assumed, from Mr. Busck's statement that the terminal bud of the tree was involved in a soft rot, that the trouble was probably due to bacteria. Dr. Smith's own investigations, covering a period of about six weeks in eastern Cuba, confirmed him in this idea. Microscopic studies and numerous poured plates were made from trees in various localities—Baracoa, Mata, and Yumuri. He found only bacteria in the advancing margin of the diseased parts in the crown of the tree. Plenty of fungi and insects were present in adjacent rotted tissues, but these were considered to be of secondary importance. No inoculation experiments were carried on to prove the bacterial origin of the disease. Dr. Smith, however, retained interest in the subject and induced the writer to undertake this research.

Dr. Carlos de la Torre, of the University of Havana, in an address [1] at the university, admitted that the putrid condition in the crown of the coconut tree was due to bacterial fermentation, but claimed it should be considered as a consequence of the dying of the tissues and not as a cause. To him it was clear that the scale insects were the primary cause of the diseased condition. Unfortunately, he made no experiments to support his theories.

The Cuban Central Agronomical Station has also carried on work in the past two or three years to ascertain the cause of and a remedy

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[1] Torre, Carlos de la. La Enfermadad de los Cocoteros. Revista de la Facultad de Letras y Ciencias, Universidad de la Habana, vol. 2, May, 1906, pp. 269-281.

FIGS. 1 AND 2.—BACTERIAL AND FUNGOUS SPOTS ON MIDDLE LEAVES OF COCONUT PALM. FIG. 3.—FUNGOUS SPOTS ON MIDDLE LEAVES.

for this disease. Mr. William T. Horne, until recently chief of the Department of Vegetable Pathology, has published a summary[1] of his investigations at the experiment station at Santiago de las Vegas and at Baracoa. His chief work has consisted of a search for a remedy for the disease, or means of controlling it. Search for a remedy has been prosecuted to some extent both in Cuba and in Jamaica, and the considerations of this aspect of the case will be discussed later.

As early as 1891 Mr. W. Fawcett reported a serious disease of the coconuts at Montego Bay, near the western end of the island of Jamaica. Since that time he and one of the agricultural instructors, Mr. W. Cradwick, have carried on investigations of this disease, giving more of their attention, however, to the study of methods of treatment than to ascertaining its cause. They have reported the disease from so many districts that it may be desirable to quote from their reports and correspondence.

Yesterday I inspected the coconuts at the railway station at Montego Bay. I find that the trees are dying there from rotting of the terminal bud in the same way that they are at Blue Hole and other places. * * * From my observations of yesterday I feel sure that the work is commenced by scale insects and the rot communicated by them. It does not start on the young flower sheaths, but on the old undeveloped ones; from these the rot spreads to the young flower sheaths, from these to the heart or terminal bud. (Dated Nov. 25, 1902. Unsigned, but kept in the files of the botanical department at Hope Garden.)

I cut down coconut trees at each place (Hopewell, Hanover, Sandy Bay, and Jericho) and fully succeeded in convincing the small settlers that my theory regarding the dying of the trees was the correct one. * * * I strongly advised them to cut down and burn any trees which were already in such a state as to render recovery impossible.

On Thursday, the 29th, I also visited Try-All estate, and with Mr. Brown cut down a coconut tree. This was a young tree apparently about 12 years old which had not long commenced to bear, growing on a hillside about 200 feet above sea level. It looked quite healthy, except that the nuts were dropping, but when we cut down the tree we found the rot had just reached the leaf bud and the youngest leaves were rotting.

The disease is evidently spreading. Trees are dying from Hopewell village to Green Island, but chiefly from Hopewell to Lucea. Some trees at Hopewell village were among the finest I have ever seen—about 7 or 8 years old, with the largest stems I have ever seen—just commencing to fruit, yet they were dying, one by one, from the rot of the heart leaf.

Trees are also dying at Barbican and Mosquito Cove, but I had not time to examine those closely.

At Sandy Bay and Jericho they are also dying.

There is quite a grove of young trees near Ramble, the property of Mr. Hudson. These are comparatively young ones, and are, I am afraid, doomed unless something can be done for them. (Dated Dec. 4, 1902. Unsigned, but in the files of the botanical department at Hope Garden.)

[1] Horne, W. T. The Bud Rot and Some Other Coconut Troubles in Cuba. Bulletin 15, Estación Central Agronómica de Cuba, July, 1908.

I entirely agree with Mr. Doull that the disease is spreading and no one, so far as I am able to ascertain, has tried the other remedies you suggested.

The disease is steadily thinning the coconut trees in and around the town, and its progress appears more rapid in the dry weather than in the rainy seasons. (J. W. Gruber. Dated May 4, 1892, addressed to W. Fawcett and on file at the botanical department at Hope Garden.)

In addition to the investigation of the disease by the staff of the botanical department of Jamaica, Prof. F. S. Earle, while on the staff of the New York Botanical Gardens, made studies of various maladies in Jamaica, in 1902, and among others investigated the coconut disease. His descriptions of it correspond exactly to the descriptions of the Cuban bud-rot. He came to the conclusion that it is a bacterial disease without, however, carrying on any infection experiments to prove this. He reports it as occurring not only in the extreme western part of the island, but also as far east as Port Antonio. He makes the noteworthy statement that at the time of his visit the disease was attracting little attention.

Mr. W. A. Murrill, also of the New York Botanical Gardens, visited Jamaica in 1908 and reported on the occurrence of the bud-rot in that island as follows:[1]

December 17 I left [Port Antonio] * * * and drove eastward along the north shore by Blue Hole and Priestmans River, and some distance beyond turned inland toward the John Crow Mountains until the road became impassable for vehicles, the trail continuing to Manchioneal. * * * Mr. Henslow pointed out trees 10 years of age that had been sprayed with Bordeaux mixture for the bacterial disease of the bud which has wrought such havoc with the cocoanut in Cuba, the Bahamas,[2] and elsewhere. The treatment has undoubtedly yielded good results, but the application of the mixture is sometimes a difficult problem.

The earliest published note of the occurrence of any serious coconut disease in Trinidad appears to be a letter from Mr. W. Greig to the imperial commissioner of agriculture for the West Indies, written June 30, 1905. Mr. Greig called the attention of the commissioner of agriculture to the fact that this disease was on the increase and that, according to the observations of Mr. August Busck, the disease in Trinidad was the same as the one studied by him in Cuba.

In September, 1905, Mr. J. H. Hart, formerly superintendent of the Botanical Gardens, made a personal investigation of La Retraite estate at Cedros. Here he found trees diseased from the ground upward, the stem showing a ring of red discoloration lying between the woody exterior and the softer interior. The discoloration became more prominent toward the growing point and appeared particularly at the base of the leafstalks and at the base of the embryonic spathes

[1] Murrill, W. A. Collecting Fungi in Jamaica. Journal, New York Botanical Garden, vol. 10, February, 1909, p. 25.

[2] Mr. Murrill's statement as to the occurrence of the bud-rot in the Bahamas can not be verified. It certainly is not present to any great extent on New Providence.

inclosing the floral organs. These all eventually became putrid, the leaves fell, and the tree finally died. Great quantities of bacteria, as well as fungi, were found in the affected tissues. Mr. Hart did not commit himself as to the cause of the trouble, but forwarded some of the material to the Imperial Department at Barbados, whence it was sent to the Department of Agriculture at Washington. Here the writer had the opportunity of examining it, and he is able to corroborate Mr. Hart's statement that the growing point was full of bacteria. From the particular specimens of Mr. Hart's material which are now preserved in the Laboratory of Plant Pathology at Washington microtome sections have been made and these demonstrate clearly numerous bacteria in the tissues and no signs whatever of a fungus.

During the latter part of July and the first of August, 1906, Mr. F. A. Stockdale, then mycologist of the Imperial Department of Agriculture, visited Trinidad and investigated the coconut diseases over the entire island. He reported on the same district that Mr. Hart investigated the preceding year, but contrary to Mr. Hart he found that the greatest number of diseased trees were injured primarily by a fungus rather than by bacteria. He investigated two maladies which completely destroyed the palms, one of which he called the "root disease" and the other the "bud-rot." He described the root disease as one in which the trunk shows a red discoloration toward the outside for a considerable portion of its length, while the decayed roots and the petioles are infected with a fungus which he considered as belonging to the genus Botryodiplodium. Eventually, when the vitality of the tree has been reduced, the terminal bud becomes involved in a soft rot, and the putrid mass then falls over and the tree dies. In describing the bud-rot, Stockdale says the roots appeared to be healthy and the stems showed no signs of discoloration, but the bud was involved in a vile sort of bacterial rot and eventually fell over. In the advancing margin of the rot usually there were only bacteria, but in a few cases there was some fungous mycelium. Mr. Stockdale concluded that the root disease was due to a fungus and the bud-rot to bacteria. In no case, however, did he make any infection experiments to prove the correctness of his theories. According to his descriptions, the tree suffering from the root disease differs from that affected by the bud-rot only in having a discolored trunk, diseased roots, and affected petioles, the rotted bud being common to both cases.

Mr. O. W. Barrett, in 1907, reported that of the diseased trees of the island about 95 per cent were affected with the root disease reported by Mr. Stockdale and only a very few cases were affected by bud-rot. Unfortunately no notes are given as to the appearance of the diseased trees, so that Mr. Barrett's conception of these maladies is uncertain.

Dr. A. Fredholm presented before the agricultural society an article published in March, 1909.[1] He described a serious disease in which the trunk was normal and the roots usually so, while the terminal bud became disintegrated into a sour-smelling, whitish, semifluid mass, which, when examined under the microscope, was seen to be swarming with bacteria. The adjacent tissues, out to the petiole bases, were traversed by fungous mycelium which Dr. Fredholm believed to be the forerunner of the bacterial rot. He states that he considers Stockdale's root disease and the foregoing disease distinct, chiefly for the reason that he has never found the decay of the roots and the discolored stems present in the affected trees which he examined. He further states that he found a few cases of what was supposedly bud-rot, i. e., a putrid terminal bud full of bacteria and entirely lacking fungi. To substantiate his statements Dr. Fredholm obtained successful fungous infections (small spots), but he made no bacterial inoculations.

Mr. J. B. Rorer, formerly of the Laboratory of Plant Pathology, United States Department of Agriculture, has been mycologist of the Trinidad department of agriculture since early in 1909. Along with his other work Mr. Rorer has devoted some time to the coconut diseases and has given much attention to clearing out and destroying all diseased trees without waiting to ascertain the cause of the trouble. He is, however, investigating the nature of the various coconut diseases on the island, and writes the author as follows in a letter of June 6, 1910:

> So far I have cut down nearly 10,000 trees all told. There is no question as to the fact that bud-rot is present here, and my main object is to keep it from spreading, as I think it much more contagious than the other diseases. It has killed many trees at Toco and Laventille and is scattered all about the southern part of the island, but there is no doubt that from Iron Forest to Cedros the root disease has done much more damage—whether bud-rot helps it out is another question. * * * From what I have seen at Cedros the root disease seems to be distinct, and the trees may die from it, even if the bud is not affected. The roots are well rotted before the tree shows much sign of disease. One of the main points to be determined, it seems to me, is whether or not the true bud-rot organism is present in the rotting buds of root-sick trees.

As early as 1875 and 1876 Hon. William Russell reported to the Kew Gardens, England, that considerable damage was being done to the coconut trees in British Guiana. Outside of a few notes in local newspapers there have been few other reports of this disease until recently. In 1906 material was sent from Georgetown to Barbados to be examined by the mycologist of the Imperial Department of Agri-

[1] Fredholm, A. Diplodia Disease of the Coconut Palm (Society paper 367). Proceedings of the Agricultural Society of Trinidad and Tobago, vol. 9, pt. 3, March, 1909, pp. 159-172.

FIG. 1.—DISEASED COCONUT TREES 3 MILES INLAND FROM BARACOA, CUBA. FIG. 2.—TOP OF COCONUT TREE BLOWN OVER ON ACCOUNT OF ROTTED BASE OF THE CROWN.

culture. He reported that the tree was probably diseased by the bud-rot, without, however, making any detailed experiments to prove the etiology of this disease.

Besides the work done by the above stations some investigations of the coconut troubles have been made by planters in various districts, but no descriptions of such observations have been published.

INVESTIGATIONS OF THE DISEASE BY THE WRITER.

In January, 1907, the writer made a trip to the West Indies to continue the investigation of the coconut bud-rot begun by Dr. Smith. In order to obtain a thorough knowledge of the conditions under which the disease occurs and to ascertain whether it is the same malady in all the coconut districts, most of the important regions were visited and studied with care. In 1908 the investigations were continued in Cuba throughout almost the entire year, and again in 1909 and 1910 visits were made to the same island.

In Cuba the coconut industry is limited almost entirely to the Baracoa district, at the eastern end of the island (fig. 1). Here the stretch of land from Moa, upon the coast west of Baracoa, to Yumuri, on the east, is devoted largely to this crop. Coconuts are raised, not only on the coast, but also 1 or 2 leagues inland, where they are often interspersed with other crops.

From Moa to the River La Lisa there is at present no sign of the disease. The trees here appear healthy, although it is reported that some 20 years previous considerable of this trouble was experienced. In fact, one of the estates from which only 8,000 nuts per month are now gathered is said to have produced 70,000 per month in former times. Between the River La Lisa and the River Duaba the bud-rot has caused considerable havoc; cases are common along the shore plain, and also on the hills at an altitude of 60 meters or more. On the west shore of the Duaba it is widespread, but on the east shore and eastward to the outskirts of Baracoa, a distance of 1½ leagues, cases are rare. Coconut groves to the west of Duaba, shoreward, are in a neglected condition, and farther inland trees are thickly interspersed with bananas, cacao, and taro. In contrast to this coconut groves to the east are under clean cultivation and are not interspersed with other crops. A few cases appear in this clean district, as would be expected when it is so close to an infected area. The manager of these estates says that in 1906 forty trees appeared diseased, but by treatment he cured them all, though three cases recently reappeared. In a large grove immediately on the west shore of the harbor of Baracoa, on an estate called Jaiticito, there were in 1908, according to the owner, some 60 or more incipient cases, i. e., merely the dropping of the nuts without the destruction of the crown, but these were cured. However, investigation of the grove in August, 1909, and again in 1910, revealed the presence of many more diseased trees.

The adjacent land to the south and southwest of the harbor of Baracoa is at the mouth of the River Macanagigua, and within a few years past this land was completely covered with groves in excellent condition. It is now a scene of the greatest desolation, many trunks standing without their crowns, and many with only a few leaves remaining upright. Following this valley inland the same scene of destruction is found. The slopes and the summits of the hills immediately between this valley and that of the River Duaba are covered with dead or dying coconut trees. In the Duaba Valley, at a point about 9 kilometers inland, there appeared during the year 1907 a number of cases of the disease which is now making great progress in the destruction of these excellent groves.

Turning back to the harbor of Baracoa one will see groves in devastation, not only on the south shore, but also on the eastern side of the valley. Here are several hundred cases where there were perhaps only two dozen two years ago. To the east of the town of Baracoa two large groves have been completely destroyed. A small grove of about 400 trees, having only a dozen cases two years ago, is now practically worthless, all of the trees being infected if not destroyed. Still farther east, along the River Miel, the same scene of destruction presents itself, there being a hundred or more of the bare trunks still standing and very few trees with green crowns.

The inland road from Baracoa east to Jamal runs 1 to 1½ leagues from the coast. It is well bordered by coconut groves which appear to be flourishing and show no signs of the bud-rot. From Jamal toward the coast the disease occurs in a few trees among many good ones. In a plantation on the hillside at Guirito many of the trees are dead or dying. From this town on toward the coast there are still many good trees, but at Mata Bay nearly all the trees are dead, and hundreds of headless tree trunks are standing. Many with the yellow tops yet remain, but only a few have green crowns and are bearing nuts. This description applies particularly to the south and east of Mata Bay. On the highlands just above Mata, at Guandao, a coconut grove, which formerly produced 12,000 nuts a month, now produces only 3,000. The trees that still remain are all bordering the shore, those that were inland having been destroyed. This estate has been replanted, and so far the young trees are doing well.

From Guandao to Yumuri, by the shore road, many dead or dying coconut trees appear, and the industry is at present of little importance. At the Yumuri River the land rises abruptly to a height of 200 to 250 meters to a broad table-land. About Yumuri, formerly a good coconut region, there is now little evidence of any coconuts ever having been grown. One league in toward Sabana and half a league to the east a few dead trees and a very few live ones appear. This region is a thriving district, bananas, coffee, and cacao being successfully grown. Formerly coconuts were grown here. The extreme eastern end of the high mesa is largely a waste land and extends down to the seashore, stretching out 1½ leagues to the extremity of the island at Maisi. No crops whatever are grown on this plain. The coconut growing of importance really stops at Mata.

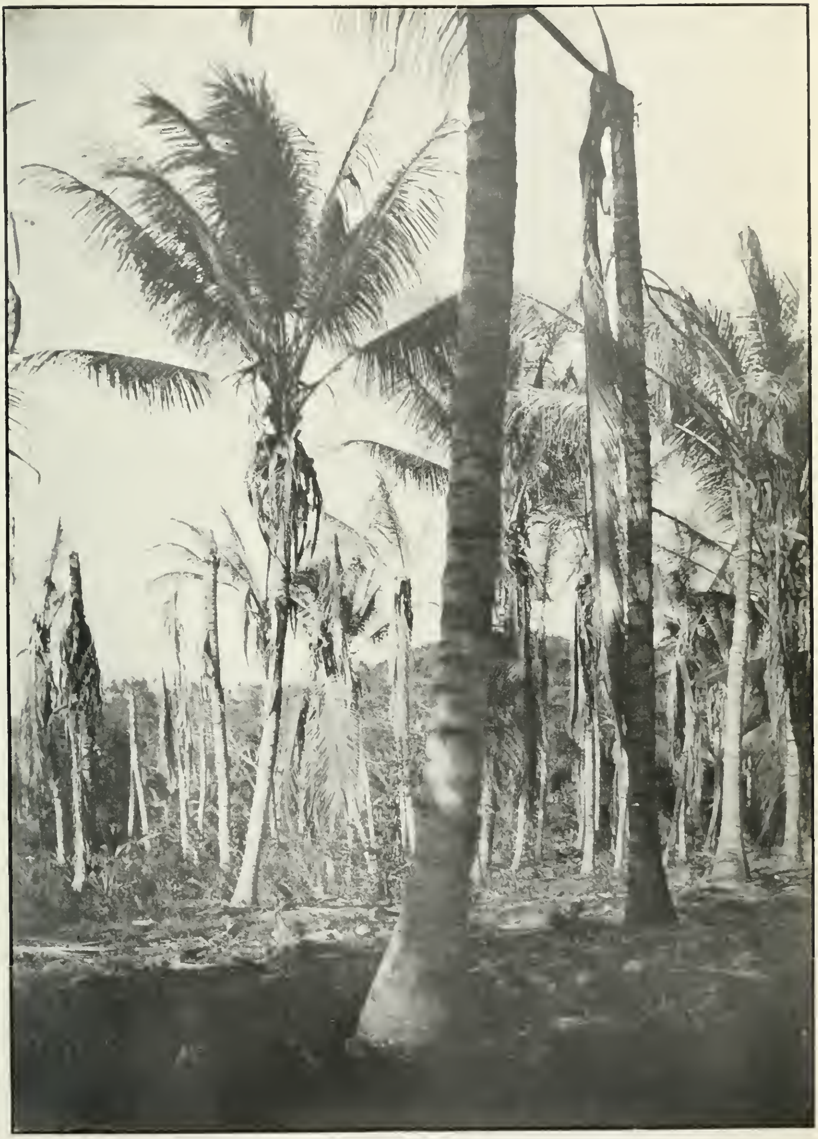
On the coast road between Mata and Boma the coconuts appear to be thriving. One continuous grove extends over the table-land at an altitude of 75 to 100 meters with almost no sign of the disease. Coconut groves here are notably well kept, the underbrush being cleared away and no other crops interspersed. The Bay of Boma, which is midway between Mata and Baracoa, is bordered by coconut trees free from the disease. The trees between Boma and the River Miel, just on the outskirts of Baracoa, were free from the disease until the present year, some cases of its occurrence there now being reported.

After making a preliminary survey of the disease in Cuba the writer crossed over to Jamaica, traveling all over the island to ascertain the extent of the injury done by the bud-rot and to compare its symptoms with those of the Cuban disease. From the eastern end of Jamaica along the north shore westward and down to the southwest corner is an almost continuous stretch of coconut groves. They are not by any means confined to the seacoast, but flourish inland 6 leagues from the sea at an altitude of 600 or more meters. From Kingston by rail to Anotto Bay coconut groves appeared at intervals, but in no case did there seem to be any serious disease. From Annotto Bay along the coast to Port Antonio many coconuts may be seen, some with bare trunks and stumps, but no appearance of bud-rot. These stumps are said to be the result of a destructive hurricane in 1903. Several specimens of diseased trees were examined at Port Antonio. Two of these trees had the center of the crown entirely missing, and merely a fringe consisting of the lower leaves remained; these leaves, however, were still in their horizontal fresh green condition. The manager of the estate stated that the cause of this trouble was lightning, but there was really no evidence that such was the case. The very center of the crown was in a dry-rotted condition, suggesting the work of insects. Many of the trees on one part of this plantation were seriously injured by the scale insects, and on another part, on a steep hillside, they appeared to be suffering from lack of water, judging from the extreme yellowing of the leaves. In none of these cases did there appear to be any suggestion of the bud-rot.

According to the report of the planters about Port Antonio, there was no indication of the presence of bud-rot at the extreme eastern end of Jamaica, so that no inspection of these groves was made at this time by the writer. A recent report (p. 24) indicates its presence in this district, although apparently in a mild form. No cases were apparent between Port Antonio and Annotto Bay. Between Annotto Bay and the Parish of St. James no disease has been reported, but in the Parishes of St. James, Hanover, and Westmoreland, the three extreme western parishes of the island, there is abundance of the bud-rot. On the road from Montpelier to Savanna la Mar, a few trees (at Petersfield and Amity Cross) have the typical appearance of this disease. Occasional cases appear at distant intervals from Savanna la Mar along the coast to Green Isle, and on to Lucea, also still farther to Montego Bay, and, according to report, a few kilometers to the northeast of Montego Bay. The disease was said to be very bad at Negril Point. In most of these places, however, the diseased trees had been cut out and destroyed. In one grove just to the south of Montego Bay there were a number of typical cases. Some of these trees were cut down for the writer and showed in every way the symptoms of the Cuban disease.

The conditions of culture in Jamaica are, as a rule, very good, in great contrast to the conditions in Cuba. The underbrush is kept out, the fallen leaves and other débris are burned up, and the planting of other crops between the trees is little practiced. Bananas are often kept running until the coconuts come into full bearing, when they are cut out. Thus, in every way the Jamaican planter has much better conditions under which to combat the disease. It is reported that in past years the bud-rot has done considerable damage. It is certain, however, that the disease is now well under control. It occurs chiefly along a stretch of about 20 leagues of the coast line and for the most part in isolated cases, probably not over 50 cases existing at the time of this investigation. In one grove at Negril Point, as the result of the neglect of the trees, the disease was allowed to progress. This was the only seriously affected grove in the district. *In Jamaica, then, the bud-rot has been put under control by keeping the diseased trees cut down.* Whether or not some conditions might arise favorable to the rapid spread of the infection from a single tree it is impossible to say. It is believed that the few planters in Jamaica who have the disease in their coconut groves do not cut down on an average more than one-tenth of 1 per cent of their trees annually. It is a question whether the value of these trees could begin to pay for any treatment of them.

In April, 1907, the writer visited all of the coconut-growing districts of Trinidad. The industry in this island is very extensive,



DISEASED COCONUT TREES AT BARACOA, CUBA.

almost the entire coast line on every side being given up to coconut trees. The important places are the great strip of land along the eastern coast from Manzanilla to Mayaro, and to Galeota, and the entire Cedros Point with the adjacent shores. Bud-rot appears to have caused great havoc in at least two places. At Laventille, a league or so east of Port of Spain and bordering on the Caroni River, great devastation appeared. The accompanying diagram (fig. 6)

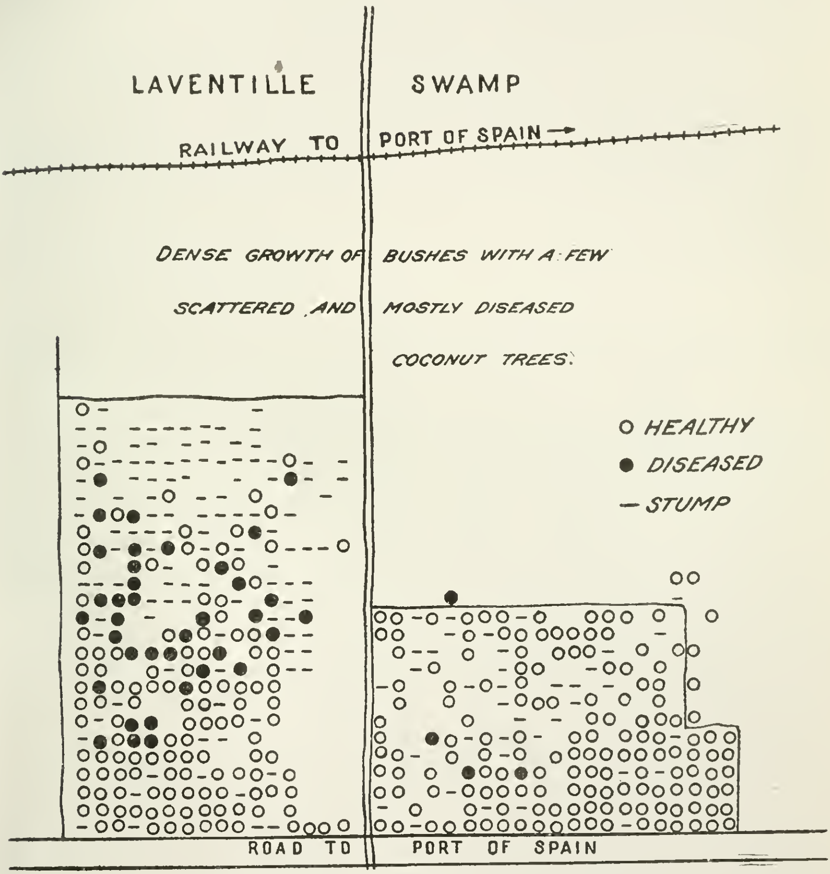


FIG. 6.—Diagram showing diseased coconut trees in Trinidad.

illustrates the condition of one estate at this time. As is here shown, a large area lying between the present growth of coconut trees and the railroad track was occupied by a dense growth of bushes with an occasional, and usually diseased, coconut tree. This was all a part of one estate, and formerly the entire area illustrated was covered with coconut trees in good condition. The place rivaled some of the worst in Cuba in the number of dead and dying trees. The attorney for the estate estimated that about 85 per cent of the trees had been destroyed. On a large part of the plantation the disease had reduced the trees to short stumps; on other parts to tall trunks with no tops, or with tops brown and hanging down, or consisting of two or three or half a dozen leaves. Healthy green trees were few in number. A public road separates this estate from one to the north on which there were many coconut trees, scarcely any of which were affected. The diseased area is a very low, swampy, and poorly drained place which was overgrown with underbrush and had been entirely left to itself as to the spread of the disease and general cultivation. Water is reached at a depth of 45 centimeters and often less in the wet season. The soil under the surface is a heavy, sticky clay. The diseased trees had all the appearance of bud-rot, the lower leaves having turned brown and for the most part fallen off, only a few leaves remaining more or less upright. Some trees were cut down and examined as to the exact nature of the affected parts of the crown. The rot in the tissues was found to correspond exactly to that present in diseased trees in Cuba and in Jamaica. All of the unhealthy trees of this estate, with the exception of one or two in which very clearly the cause was insects and in which the soft rot was absent, presented the typical appearance of the trees infected with bud-rot. The unfavorable conditions under which these palms were grown, i. e., in wet, clayey soil, together with the fact that the estate had been entirely neglected for many years, undoubtedly had some influence on the spread of the disease. Mr. Stockdale, in his report, considered the majority of the trees of this estate to be affected primarily with what he calls the root disease, and Mr. O. W. Barrett, in his investigations in 1907, confirmed Mr. Stockdale's opinion, but this is contrary to the observations of the writer. It is sufficient to say here that the disease called the "root disease" is very little understood and has no proved cause. According to Mr. Stockdale, who describes it, very frequently the crown of such a diseased tree becomes later involved in a soft rot, leading one to think, in many cases at least, that the root trouble is secondary and that the bud-rot or crown disease is the primary one. Careful observations leave no doubt that practically all of the diseased trees in this district are affected in their crown with a soft rot, the symptoms of which are typical of the well-known bud-rot. This statement does not at all oppose the idea that the trunks or roots of some of the trees so diseased may contain some fungus, or other organism quite different from that which occurs in the crown, but not the cause of the bud-rot.

Another district similar to Laventille is at Point d'Or, near La Brea and the Pitch Lake. This estate had not been in cultivation for a number of years. Consequently it was heavily overgrown and the malady had obtained considerable headway. During the year 1906 the manager had undertaken to clear up and eradicate the disease. After a year's work he was of the opinion that as fast as infested trees were cut down and their tops burned new cases appeared, and he seemed to have the prospect before him of the entire grove going to destruction. In contrast to the swampy condition of the Laventille estate, this place is hilly and well drained and apparently suitable for coconuts. Close examination of these trees, by cutting down and opening the crown, disclosed exactly the same condition as that of the trees affected by bud-rot in eastern Cuba.

From Point d'Or southwest coconut groves appeared to be in good condition. At Guapo there had been a few diseased trees that resembled those with the bud-rot. As a matter of fact, the trunks of these trees within 3 feet of the ground showed a red discoloration, and in all probability this is what Mr. Stockdale refers to as the root disease. Only three cases were observed here, so the prospect did not appear to be very serious.

From Guapo southward to the end of Cedros Point coconuts appeared to be in good condition, although it was reported (1905) that there were many diseased trees at Cedros Point. On Mr. Greig's estate of some 110,000 trees, there appeared to be only a very few affected ones, and on examination of the trunks these few showed the red discoloration characteristic of the root disease as described by Mr. Stockdale. Mr. Hart investigated the disease in 1905 on a part of Mr. Greig's estate, and reported the presence in the crown of the soft rot swarming with bacteria. The fact that Mr. Greig kept his estate in excellent condition, i. e., all of the diseased trees cut down and destroyed and the fallen leaves and other débris picked up, probably accounts for the presence of so few cases. The question as to whether the bud-rot or the root disease is the primary trouble on this estate needs further investigation.

It is reported [1] that in the Siparia district and along the swamp lands below Princestown there has been a great loss of coconut palms, and the description of the disease certainly answers very well for the bud-rot. On the east coast of the island, along which for almost the entire length is a narrow strip of coconuts, there appeared to be absolutely no sign of any serious trouble, the trees presenting a most healthy appearance and bearing well.

From these reports it will be seen that while the bud-rot has been extremely destructive in certain parts of Trinidad, it must be noted that these parts have in general been greatly neglected or else lie in low, swampy situations, such as are entirely unsuitable to coconut growing.

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[1] Stockdale, F. A. Coconut Palm Disease. Trinidad Royal Gazette, Feb. 14, 1907, pp. 361-362.

After investigating the diseased trees of Trinidad the writer went to Demerara, British Guiana, and there, with the help of the former superintendent of the Botanical Gardens, Mr. A. H. Bartlett, carried on studies of the disease in that region. Coconut palms occur scattered along the coast. They are found chiefly on the islands in the mouth of the Essequibo River and on the adjacent mainland, and in the southern part of Demerara, near Mahaica and Mahaicony. The islands of the Essequibo River are merely sand drifts which have been overgrown with vegetation. These have been partly cleared and on them coconut palms are grown. A disease has been reported from this locality, and from a personal examination of the trees externally the writer is inclined to think that it is the bud-rot; but the cases are comparatively few. At various intervals along the railway from the Essequibo to Georgetown and from Georgetown southeast to Mahaicony, which is largely a coconut district, there appeared isolated cases of what seemed to be the same disease. This entire coast line is at the level or below the level of the sea at high tide, so that sea defenses are built and canals are maintained with pumping stations for proper irrigation and drainage of the land. Under such circumstances the meadows are for the most part wet and partly under water. Much of the land is too wet for the coconut palm. A considerable number of diseased trees, some of which could be definitely said to have bud-rot, were found at Mahaicony. On one estate on which the soil was rather heavy and poorly drained certain trees were selected for examination. They were the only affected ones on the estate. All of them showed the typical conditions—the central leaf bud dead or dry, and low down in the crown a typical soft rot. Insects were present, to be sure, as is usually the case, but in no such numbers as to connect them directly with the disease.

The coconut industry of British Guiana is still on a rather small scale, owing chiefly to the fact that the land is more suitable and more valuable for sugar planting. In 1877 the exports amounted to 1,500,000 nuts, while now they are only 500,000 per year. The presence of this disease, though not very virulent in form, probably discourages more planting of coconuts under conditions which are also otherwise unfavorable for their growth, i. e., a heavy soil together with an excessive quantity of water present.

The island of Porto Rico as one of our possessions has been of great interest to us, especially as no disease of the coconuts appears to be present. The coconut industry of the island, although far below the value of that of sugar cane and tobacco, is of considerable importance and is by all means worthy of protection and extension. The fact that the bud-rot disease is so prevalent in nearly all the coconut-growing regions of tropical America, in regions not far removed from Porto Rico and in districts from which seed coconuts are sometimes brought into this island, made it eminently desirable to prove that this district was free from this disease, and when this was proved, to ask for legislative control of importation of seed coconuts into the island.[1] The fact that a former botanist of the agricultural station in Porto Rico and a former agent in charge of the station both expressed the belief that the disease was present, led the writer to examine carefully all of the groves on the island. In investigations which the writer made in 1907 around almost the entire coast and along the railroads no cases were found. The only part not visited at that time was between Ponce and Humacao. More recently, in December, 1910, an examination has been made of the groves between Ponce and Guayama and again between San Juan and Barceloneta, but no cases of bud-rot were found.

In 1910 the writer saw five or six trees on the coast between Anasco and Corsica which had very much the general appearance of bud-rot. Closer examination in the present year (1911) showed the diseased tissues to be somewhat similar to that of bud-rot but not typical. Further studies have been made by Mr. G. L. Fawcett, of the Mayaguez Experiment Station, but the presence of true bud-rot has not as yet been demonstrated.

A number of the trees in various places appeared to be in an unhealthy condition; leaves were yellowing or broken, or the lower ones had fallen, but in no case did it appear like bud-rot. In the groves along the north and west sides of the island at frequent intervals trees were found from which lower leaves had fallen, but the remaining fronds were green and to all appearances healthy, and in many cases nuts were still produced. A number of trees were also found whose crowns had rotted off entirely. These trees were always isolated cases and did not resemble those affected by bud-rot, but rather suggested insect work.

Coconut groves extend at intervals all along the coast (fig. 7). An almost continuous strip of them extends eastward from San Juan to Loisa and beyond to Luquillo. Thence beyond Cape San Juan down the coast to Naguabo the groves are very few. From Naguabo to Humacao another extensive grove extends along the beach. From Humacao westward to Ponce coconuts are reported to be infrequent. From Ponce westward small groves appear occasionally until the west coast is reached, where an extensive and almost continuous grove extends from the southwest and northward along the coast to Mayaguez, and on northward to Aguadilla. This west

[1] In 1907, Dr. Erwin F. Smith drew up a bill for the Porto Rico Island Legislature, looking to the prevention of the introduction of this disease, but in the form in which it finally passed the law is of no value for the protection of the island. Fortunately the legislature of 1910–11 passed a bill which covers the ground quite satisfactorily.

coast has by far the most coconut trees of any part of the island. From Aguadilla along the north shore to San Juan these palms appear at intervals in small groves, but never in large numbers. Trees of these groves as far as examined had no sign of bud-rot, nor any serious infectious disease.

The examination of the coconut industry in Porto Rico concluded the preliminary survey of the writer in regard to the distribution of bud-rot. Visits have also been made to the few groves on New Providence Island in the Bahamas, and to small groves scattered along the coast of Colombia and Venezuela; but in none of these districts was the coconut industry of any great importance, nor was any very serious disease found among them. The writer has not visited southern Florida, but understands from Prof. P. H. Rolfs and Dr. E. A. Bessey that none of the groves in that region have as yet shown any signs of this disease.

FIG. 7.—Map of Porto Rico. The location of coconut groves is indicated by dots.

STRUCTURE OF THE COCONUT TREE.

In order to understand the nature of the experimental work on the cause and methods of control of bud-rot it is necessary to know thoroughly the structure and arrangement of the parts of the coconut tree. The tree consists of a single unbranched trunk crowned by a huge rosette of leaves. Each of these leaves at maturity may be anywhere from 4 to 7 meters in length and from 1 to 1.5 meters in width. The leaf consists of a single heavy rachis bearing the simple pinnæ. This rachis, or leafstalk, broadens out at the base so as to form a complete sheath about the trunk. (See fig. 8, petiole *a* broadening out into a leaf sheath.) From its thin, fibrous character the sheath is commonly called the strainer. This forms a tough, tight binding about the inclosed portions. An average mature tree has from 25 to 30 leaves. The distance from the lower leaves of the under part of the crown to the center of the crown, the base of the highest and youngest leaf, is from 1 to 1.5 meters (fig. 9, the distance between points x and y). As leaves appear in the center of the crown they are upright and tightly folded, like a closed fan, gradually opening and assuming a more oblique and later a horizontal position as they mature. The great length of the leaves gives them the appearance of considerable flexibility as they wave in the breeze, but it is impossible to bend away the central leaves and get down anywhere near the center, this fact being due partly, of course, to the leaf sheath, and also partly to the rigidity of the stalk. At the inside base of every leaf is a flower bud which enlarges and splits open, allowing an elongate sword or spathe to develop to a length of 1 to 1.3 meters (fig. 9). Then the sword itself splits longitudinally and allows the flower spike to open out Each spike bears both pistillate and staminate flowers. An average tree will have perhaps 10 spikes of nuts and a dozen or so nuts on a spike. Usually 30 or 40 nuts are set from a flower spike, but seldom more than 10 to 20 mature. The arrangement of the crown of leaves in rosette fashion furnishes an excellent receptacle for rain, which runs down and soaks into the fibrous sheath and serves to keep the tender growing part in a constantly moist condition. The base of the leaves also serves as a catchall for fallen flowers, mature nuts, and the like—forms of débris which tend to rot close to the trunk. Under normal conditions there is no injury, but under certain conditions the débris and the constant moisture held in the strainer furnish a means by which the disease may pass from an innocuous condition among the hard tissues of the outer leaves to that of a most virulent pest in the inner delicate growing tissues.

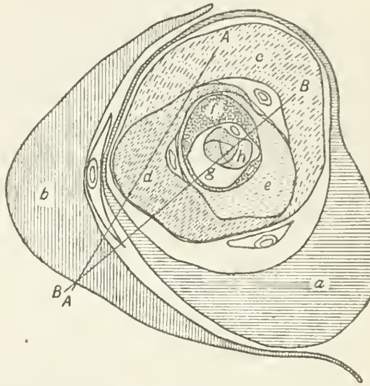


FIG. 8.—Diagrammatic cross section of bud of the coconut palm inclosed by some of the outer leaf sheaths: *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, Successive petioles, each extending laterally into a leaf sheath. Immediately adjacent to each leafstalk is a sword.

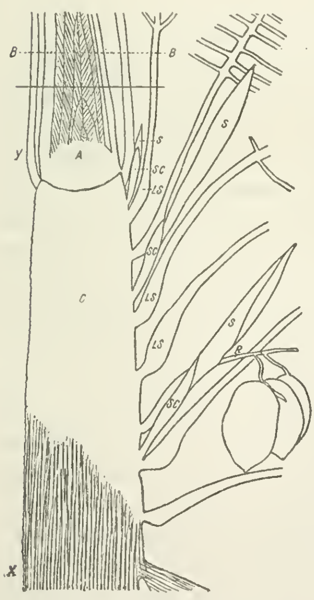


FIG. 9.—Diagrammatic longitudinal section of bud of the coconut palm, including the top of the crown: *C*, Trunk; *A*, heart; *S*, sword; *SC*, sword sheath; *LS*, leafstalk; *R*, rachis or fruitstalk.

The trunk of the coconut tree is an almost uniform mass of fibers and fundamental tissue from the roots to the crown, and is a hard, woody material. The roots are very numerous and radiate horizontally in all directions from the tree, extending practically as far as the leaves of the crown. The roots are almost uniform in size, about 1 centimeter in diameter.

The accompanying figures 8 and 9 are intended to show the relation of the different parts in cross section and in longitudinal section. It is difficult, or impossible, to show all parts in their proportionate sizes, but their relative position is more important, and it is believed that this may be clearly seen. The cross section is such as would appear if made through the line BB of the longitudinal section after the removal of the external leaves.

FIELD STUDIES OF THE DISEASE.

INFECTION STUDIES.

To determine the infectiousness of the disease was the first problem. That bud-rot was communicable from tree to tree was accepted by some, but ignored or disbelieved by others. By many it has been thought due to something in the soil or to the climatic conditions, and various applications have been made to the base of the tree in the hope of curing it. Insects eating the roots and working in the trunk or in the crown have also been considered as causes. It has likewise been claimed that a mechanical injury, such as a bullet piercing the tender heart tissues, would produce a rot of the crown. It is safe to say that most of the reasons given as to the causes were based on inaccurate or incomplete observations, together with a lack of any experiments to substantiate them. The rapid spread of the disease in itself seems good evidence of its infectious nature, for it does not stop in one valley or one grove, but frequently spreads over a hillside and into the next valley, always beginning in a small way and from that spreading sporadically over the entire grove. If the disease were due to soil or to climatic changes, many or all of the trees would show signs of the rot about the same time. It could hardly be supposed that this might be accounted for by variation in individual resistance, since in the end most or all of the trees contract the disease.

Assuming the trouble to be infectious, it has been a mooted question as to whether fungi or bacteria were the cause of it. Prior to 1887 Dr. Ramos, of Havana, maintained that a fungus (*Uredo coccivoro*) was the cause. This has been upheld by many, but by others—notably bacteriologists—it has been disputed a priori on the ground that fungi seldom cause a putrid fermentation such as is to be found in the crown of the diseased coconut tree, while bacteria frequently do, and from the observations of Dr. Smith it has been seen that only bacteria are in the advancing margin of the decaying tissues. Moreover, it has since been claimed that *Uredo coccivoro* is nothing else than the normal scales of the coconut leaf.[1]

Dr. Davalos, of the bacteriological laboratory of Havana, isolated in 1886 what he claimed to be *Bacillus amylobacter*, which he believed was the cause of the soft rot.[2]

Dr. Plaxton, of Jamaica, in 1891, before the Institute of Jamaica,[3] showed under the microscope some slides of a micrococcus which he thought was probably the cause of the coconut disease. In other parts of this paper the writer has quoted many investigators ascribing the cause of the disease either to bacteria or to fungi. The opinions as to the cause of the disease are so various, and hence, reasons for methods of treatment so unsatisfactory, that it has seemed eminently desirable to carry out a clear series of experiments to settle, first, the infectiousness of the disease; second, if infectious, whether due to fungi or to bacteria; and third, if possible, to isolate the organism causing the disease.

BACTERIAL INOCULATIONS.

Owing to the height of the trunk and the great size of the crown, inoculation of coconut trees is difficult. The rot is peculiarly one of soft tissues, so that in order to be effective the bacteria must be placed in the interior among these soft tissues. From the bottom of the crown to the growing point there is commonly a distance of 1 to 1.5 meters (fig. 9, from x to y), so that the exact location of a spot suitable for inoculation is hard to determine. Inoculations made below the heart into the trunk fail to produce the rot, since these tissues naturally soon harden as a part of the mature tree. If, on the other hand, the inoculation be made above the heart amid the growing leaves, their extremely rapid elongation takes the inoculation point out from the surrounding soft tissues. The inoculated tissues then become green and membranous and thus resist the advance of the rot. The point of easy inoculation is less than 0.5 meter above or below the growing point, and rather near the center of the tree. (See fig. 8. Inoculation on line *BB* is desirable; inoculation on line *AA* would seldom be successful.) This often requires an inoculating

[1] Tamayo, Dr. La Epifitia de los Cocoteros. Revista de Agricultura (Cuba), vol. 9, 1889, pp. 557–8, 570–1, 584–5.

Torre, Carlos de la. La Enfermadad de los Cocoteros. Revista de la Facultad de Letras y Ciencias, Universidad de la Habana, vol. 2, no. 3, May, 1906, p. 274.

[2] Davalos, Dr. Revista de Agricultura. Boletín Oficial del Círculo de Hacendados de la Isla de Cuba, vol. 9, no. 29, 1889.

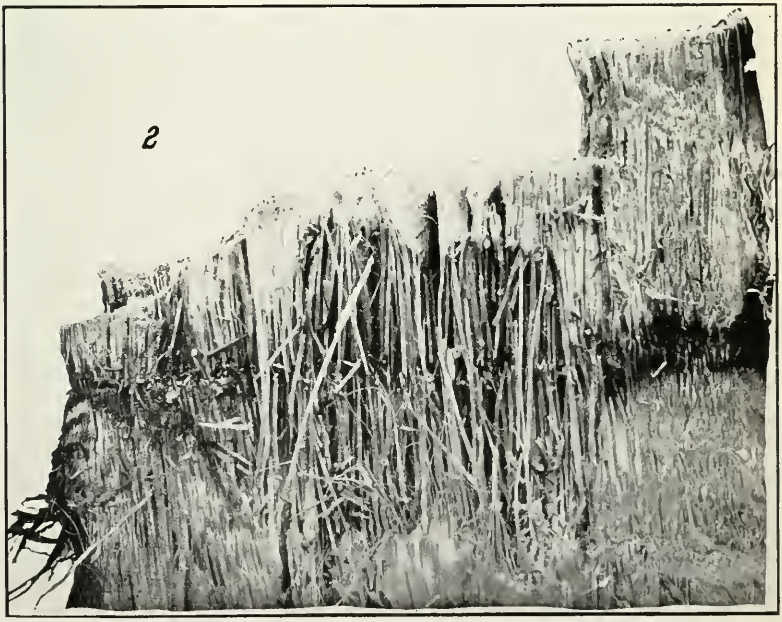
[3] Plaxtou, Dr. Journal of the Institute of Jamaica, vol. 1, 1891–1893, pp. 43–44.

instrument that will reach at least 30 centimeters from the surface of the trunk inward. These conditions probably account for the difficulty which different investigators have had in obtaining infections. Naturally, the right organism to cause the disease must first be obtained, although infection can probably be accomplished by using the juice of a seriously diseased tree. The matter of isolating specific bacteria is of course desirable, but presents greater difficulties. Ever since beginning the work the writer has occasionally obtained excellent rots at the point of infection with apparently different organisms. It has been said that any mechanical wound of the heart tissue will cause it to rot and die. This statement is proved to be untrue by the check inoculations and by some inoculations into the heart which failed to take and produced no rot whatever.

During the investigations of the writer in various parts of the West Indies, from January to June, 1907, diseased material was obtained from many different trees affected with the bud-rot, and bacterial organisms were isolated from these tissues. The cultures isolated consisted, in general, of two types: One which produced, usually, round, wet shining, white, and semiopaque colonies with raised surfaces; and one (the type most abundant) which produced colonies of very thin growth, spreading rapidly over the plate in an irregular fashion, often sending out long radiating branches. This most abundant type was also white, wet shining, and semitransparent. Comparisons were made of the cultures obtained from Cuba, Jamaica, Trinidad, and Demerara, but they were not found to be identical in their cultural characteristics. Notwithstanding this, several of the cultures were taken the following February, 1908, to Baracoa, Cuba, and there inoculated into apparently healthy trees. Together with these cultural inoculations wounds were made with a sterile instrument to serve as checks. Table I gives the data concerning all of these inoculation results.

TABLE I.—*Inoculations of coconut trees, February and March, 1908.*

Source of culture.	Character of colony or culture.	Inoculation. No.	Date of inoculation.	Date of examination.	Results.
Jamaica	Thin, irregular, white.	151	Mar. 10	Mar. 16	Decided rot; diseased part cut off and the tree left.
Demerara	....do	430	Feb. 21	Mar. 9	No result; inoculation too low.
Cuba	....do	392	Feb. 24	Mar. 10	Too low; still a small distinct rot.
Cuba	....do	417	Mar. 10	Mar. 16	No external symptoms.
Cuba	....do	189	...do	...do	Decided rot; tree left standing.
Cuba	....do	150	...do	...do	Do.
Cuba	Raised, round	421	...do	...do	No result; tree left standing.
Demerara	Thin, irregular, white.	385	...do	...do	Do.
Demerara	No notes	151	Feb. 24	Mar. 10	No infection; inoculation too low.
Demerara	....do	337	...do	...do	No result.
Demerara	....do	419	...do	Mar. 9	No result; too low.
Demerara	....do	417	...do	Mar. 10	No external symptoms.



BACTERIAL INOCULATION. SHOWING DESTRUCTION OF FUNDAMENTAL TISSUE ABOUT WOODY FIBERS OF COCONUT PALM. FIG. 1.—CROSS SECTION. FIG. 2.—LONGITUDINAL SECTION.

TABLE I.—*Inoculations of coconut trees, February and March, 1908*—Continued.

Source of culture.	Character of colony or culture.	Inoculation No.	Date of inoculation.	Date of examination.	Results.
Cuba:					
164......	Juice of diseased tissues.	78	Mar. 1	Mar. 16	No result; inoculation too low.
201......	.....do.............	408	Mar. 10	...do....	No external symptom of disease.
201......	Juice of diseased tissues poured on, not injected.	434	...do....	...do....	Do.
	Check tree inoculated with sterile agar.	156	Feb. 24	Mar. 10	Absolutely no effect toward rotting the tissues.
	Check; inoculation hole but nothing injected.	292	...do....	...do....	Do.

It will be seen from a study of the table that the inoculations were scarcely successful in proving the bud-rot to be due to bacteria. It will be remembered, however, that these were the first inoculations made by the writer, and apparently most of them were made in parts of the tree seldom affected by the bud-rot. This was owing to the difficulty of locating the precise area suitable for inoculation, a feature that has since been overcome by rather extended studies. All that can be said for this series of inoculations is that some of them, at least, showed a rot typical of the bud-rot. In view of the fact that the check inoculations did not affect the tissues in this way at all, it would seem to indicate that those few cases which had any rot or decay were actually caused by the organisms inoculated, notwithstanding the fact that in other cases certain organisms injected did not cause such a rot. No material was obtained from these artificially diseased tissues in order to reisolate the organisms injected.

In the summer following this series two more inoculations were made: On June 22 tree 173 was inoculated with a bacterial culture. Externally it showed no signs of infection until October 21. The tree was then cut down and carefully examined, when it was found that the entire heart of the tree was in a soft, putrid condition, typical of the bud-rot. Previous to inoculation this tree was bearing poorly, but not showing any distinctive signs of the disease.

Tree No. 380 was inoculated on July 22 as follows: All traces of the lower leaves were cleared away, so as to expose as much as possible of the white tissue about the bases of the remaining leaves; then small pyramidal pieces, 2 centimeters deep, were cut out, infected agar was put inside, and the pieces were replaced. Several of these inoculations were made, and bandages of wet cotton were tied about the wounds in order to maintain a constantly moist condition. On August 6 this tree was examined and none of the inoculations appeared to have taken effect. Either the right organism was not used or the tissue at the bases of the leaves was too hard to be easily infected.

The following November a new series of inoculations was made in the same grove, near Baracoa, Cuba. Cultures were obtained from four different trees, and inoculations were made into 13 others. Just as in previous isolations of organisms from diseased material, two types of colonies had predominated—the round and the irregular, both of them white—so in the isolations from this series these two types predominated and both of them were used for the inoculations. The results are shown in Table II.

TABLE II.—*Inoculations of coconut trees, November 2 and 3, 1908.*

Source of culture. Tree No.	Character of colony.	Inoculation into tree No.	Date of inoculation.	Date of examination.	Results.
96	Thin, round, white	337	Nov. 2	Nov. 10	Good rot about inoculation hole.
	Round, convex, white.	380	...do.....	Nov. 13	Good soft, white rot.
155	Thin, irregular, white.	417	...do.....	Nov. 10	Slight rot.
	Thin, round, white....	421	...do.....	Nov. 11	Water-soaked, discolored area about inoculation hole and soft rot in tissues below heart.
	Thin, irregular, white.	422	...do.....	...do.....	Good soft, white rot about inoculation hole.
	....do	423	...do.....	Nov. 13	Do.
296	Flat, round, white....	248	...do.....	Nov. 17	Extensive soft, white rot.
	Thin, irregular, white.	52	Nov. 3	Nov. 20	Fairly good, soft, white rot.
373	....do	78	...do.....	Nov. 17	Excellent soft, white rot, very conspicuous.
	....do	64	...do.....	Nov. 19	Inoculation high and one side of center; some rot in midrib of leaf.
	Round, convex, white.	153	...do.....	...do.....	No decided rot, but distortion of tissues just below heart.
	Thin, irregular, white.	189	...do.....	...do.....	Excellent soft, white rot.
	Convex, round, white.	150	...do.....	...do.....	Do.

Table II, in contrast to Table I, shows that many of these inoculations were successful. Full descriptions omitted from the table are here given:

No. 337 was examined 8 days after inoculation, when it showed rot just below the heart (Pl. VIII) and along the inoculation hole and adjacent tissues. The central leaves of this tree also had a wet rot considerably higher than the inoculation, but there was no visible connection between the two.

No. 380 was examined 11 days after inoculation and showed a soft, rotted area about 2.5 centimeters in diameter, running the entire length of the inoculation hole. This rot was the typical soft, white rot. The strainer was browned and rotted over a large area downward from the inoculation hole (Pl. IX, fig. 1).

No. 417 was examined after 8 days and showed only a slight rot, a water-soaked area about 3 centimeters in diameter, which extended from the inoculation hole; but it did not show the typical soft, white decay of the tissues. The middle leaves were also diseased higher up and apparently independent of the inoculation.

No. 421 was examined after 9 days, and showed an area about the hole very distinctly water soaked and discolored. There was clearly a soft rot in the tissues below the heart not definitely connected with the inoculation.

No. 422 was examined after 9 days and the inoculation hole was found to be directly through the heart and to have caused a good soft, white rot. The effect on the tissues was not limited to the softer ones in the interior, but was also evident on the harder tissues of the strainers and leaf bases.

No. 423 was examined after 11 days. The inoculation was found to pass immediately below the heart and to have caused an excellent soft, white rot, which affected a considerable area of the tissues. There were also on this tree numbers of the leaf-base spots.

No. 248 was examined after 15 days, and the inoculation was found to have passed 15 centimeters above the heart and a little to one side. The excellent soft, white rot was, however, spreading rapidly on all sides and above as high as 30 centimeters from the inoculation. The extreme upper parts of the leaves were perfectly healthy. In places where the inoculation passed through the strainers and leafstalks the rot extended in areas anywhere from 1 to 30 centimeters in length; all of the tissues within 20 centimeters of the heart were badly rotted (Pl. IX, fig. 2).

No. 64 was examined after 16 days, and the inoculation was found to be rather high and to one side of the center. A very little rot was present in the midrib of the outer leaf. All the other tissues were not affected.

No. 153 was examined after 16 days; very little sign of any rot was present. The inoculation had caused a distortion of the inner tissues, but no other noteworthy change.

No. 189 was examined after 16 days and showed a splendid typical soft rot just below the heart. The affected area extended for a distance of 10 centimeters above and below the inoculation.

No. 150 was examined after 16 days and showed an excellent inoculation which had passed but 5 centimeters below the heart; the rot from it had passed into the heart itself. Toward the outer side of the inoculation it passed through a young sword which, as a result, had become rotted and blackened at the tip on the inner tissues.

It thus appears that the successful infections were brought about apparently by a variety of organisms. Following the examination of these inoculations, material therefrom was carefully selected and sterilized on the outside surfaces so as to permit the transfer of uncontaminated portions into bouillon tubes, for the purpose of pouring plates and thus isolating the organisms which were present in the rotted tissues. Many plates were made and a variety of organisms were isolated. In general two types seemed to be predominant; one type, most conspicuous, was the round white colony with a raised surface, wet shining, and semiopaque. These colonies in the course of two or three days attained, on a +15 nutrient agar, a diameter of 4 to 8 millimeters, but seldom became much larger. The other abundant type was of thin growth whose colonies spread rapidly over the plate, i. e., where in one day's growth they might have a diameter of 2 centimeters; in two days the growth might be 5 or 6 centimeters.

Series of experiments were made in the Laboratory of Plant Pathology at Washington, D. C., for the purpose of comparing the cultures from the different trees. Plates of nutrient agar poured from the diseased material showed in general the same type of colony as was formed by the organism used in the inoculation. Comparison of the various cultures showed about half to be alike in their reaction in litmus milk. Several of the organisms were inoculated into various vegetables, and in a few cases good rots were obtained in cucumbers.

From this work it seemed most probable that the organism causing the bud-rot was the one which formed the thin, very much branched type of colony. Cultures of it were taken to Cuba in August, 1909, and inoculated into various trees. As will be seen in Table III, none of these cultures had any effect whatever in rotting the trees.

At this time other isolations were made from naturally diseased trees, and inoculations were made with these as indicated in Table III.

TABLE III.—*Inoculations of coconut trees, August 9 to 14, 1909.*

Source of culture.		Character of colony.	Inoculation into tree No.	Date of inoculation.	Date of examination.	Results.
Tree No.	Date.					
339	Nov., 1908	Good, irregular, white growth.	442	Aug. 9	Aug. 25	No rot.
			444	...do.....	Aug. 23	Do.
			406	Aug. 10	...do.....	Do.
			447	...do.....	...do.....	Do.
			331	...do.....	Aug. 25	Do.
209	Aug. 7, 1909	Irregular, thin	505	Aug. 12	...do.....	Extensive soft, white rot.
		Irregular, thin, white	502	...do.....	...do.....	Decided soft, white rot, but not extending much beyond inoculation hole.
		....do	508	...do.....	Aug. 24	Splendid rot, soft and white, along inoculation hole.
		....do	507	...do.....	...do.....	Fair rot in inner sword.
		Round, convex, white.	501	...do.....	Aug. 25	Extensive typical soft, white rot.
252	.....do	Irregular, thin, white.	504	...do.....	Aug. 26	Good soft, white rot.
		....do	506	Aug. 4	Aug. 24	Splendid rot along inoculation hole.
		....do	503	[1]	....	

[1] Not inoculated.

Table III shows that various successful infections were again made, and also that at this time, as in the spring of 1908, the inoculations were made with a variety of organisms. In more detail than is given in the table the results of these inoculations are as follows:

No. 505 was examined 13 days after the inoculation and showed an excellent soft, white rot extending a distance of 60 centimeters above the inoculation hole.

No. 502 was examined after 13 days, when it showed a very soft, white rot about the inoculation hole, but it was not very extensive.

No. 508 was examined after 12 days, when it showed a splendid soft, white rot. The lower part of the inoculation hole was entirely reduced to a thick white liquid. One of the inner swords was blackened at the tip in the interior. The inoculation passed 3 to 4 centimeters above the heart tissues, in the best possible place, and took effect. The resulting rot extended about 45 centimeters above the hole and also down into the heart tissues. The middle leaves of this tree some distance above the inoculation were in a perfectly healthy condition.

No. 507 was examined after 12 days, when it showed a fair rot in one of the inner swords.

FIG. 1.—BACTERIAL INOCULATION OF COCONUT PALM NO. 380, SHOWING DISCOLORATION OF THE SHEATH.

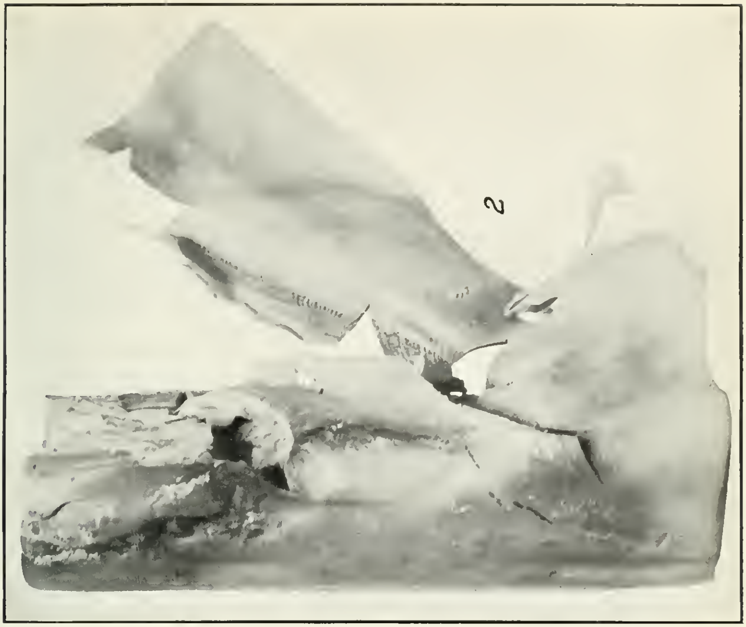


FIG. 2.—BACTERIAL INOCULATION OF COCONUT PALM NO. 248, SHOWING DECAY OF INNER TISSUES.

No. 501 was examined after 13 days; it showed an excellent decay for a distance of 60 centimeters above the inoculation and a considerable distance below it.

No. 504 was examined after 14 days, when it showed a good soft rot extending 4 centimeters about the inoculation hole.

Three other inoculated trees, Nos. 601, 602, and 603, were not examined.

Following the examination of these inoculated trees, plates were poured from the diseased tissue, and an attempt was made to isolate the organism present in the diseased parts. By comparing the predominant organism isolated in each case from these trees with the organism inoculated into the trees, it was found in a good many cases that several of these organisms seemed to be identical. This fact lent encouragement to the use of some of these isolated organisms for reinoculation into another series of trees. Unfortunately, it was not possible at this time to carry on the work in Cuba, so that inoculations were made into seedling coconuts in the greenhouse at Washington. These coconuts were not by any means desirable for this purpose, being decidedly stunted in their growth, and in consequence their tissues appeared to be drier and more woody than is natural to the tree. It was rather to be expected that greater difficulty would be encountered in producing the rot in these seedling coconuts than if the inoculations were made in good healthy trees. Table IV gives the results of these inoculations.

TABLE IV.—*Greenhouse inoculations of coconut trees, September 24 to 29, 1909.*

Source of culture. Tree No.	Character of colony.	Inoculated into tree No.	Date of inoculation.	Date of of examination.	Results.
503 (N series only)	Thin, white, irregular.	503 *a*	Sept 24	Oct. 27	A small, rotted area and a large water-soaked area.
506	do	506 *a*	Sept 29	do	Water-soaked area for a distance of 1 centimeter from inoculation hole.
505	do	505 *a*	do	do	Excellent brown, water-soaked condition.
508	do	508 *a*	Sept. 24	Oct. 16	Rot extended about 7.5 centimeters above hole and 2.5 centimeters below it in inner tissues; typical soft, white rot in inner tissues.

The results of the inoculations, shown in Table IV, are not nearly so striking as in the case of those made into the trees in Cuba. As has been brought out in the previous discussions, the inoculations can be made to take only where the disease is found to occur naturally—in the heart tissues—and the heart tissues of all of these sprouted coconuts were very limited. In each of these inoculations the tissues were well water-soaked, which certainly was due to the presence of the bacteria, as the check inoculation failed to show any effect whatever. One inoculation especially—that of 508—seemed a good one, extending for 7.5 centimeters above the inoculation hole and 3 centimeters below it. As these inoculations were made with a small injecting needle, the wound caused by the instrument itself was very slight.

So many successful inoculations with bacterial cultures inevitably lead one to the conclusion that a rot in the heart tissues of the coconut palm identical in every respect with the bud-rot is caused by these bacterial organisms. That such a condition is caused by mechanical injuries such as those of the inoculating instrument is disproved by the check inoculations which produced absolutely no rot at all. It has been suggested that the disease was carried by means of the inoculating instrument to the inner tissues from affected outer tissues. The possibility of this can not be denied. It is impossible to obtain evidence of the fact that the bases of the leaves and swords toward the interior are certainly free from disease. From the general appearance of the tree one may judge all its parts to be free or infected, but this is the best that can be done. However, this objection does not lie against the hothouse experiments in Washington, because the nuts were obtained from a disease-free district.

While this uncertainty may affect the probability of these inoculations causing the rot in individual trees, yet in view of the fact that the same organism as that injected into the tree has been isolated from the artificially diseased tissues, the probability seems greatly in favor of this particular organism, or else it suggests strongly that if any bacteria were already present in the tissues and caused the infection, they were of the same kind as those injected. Now that these reisolated organisms have been inoculated into other trees and have induced typical soft rots, from which the same organisms have been reisolated, proof seems complete that at least a certain kind of bacteria, namely the kind used in the successful inoculations just described, does cause the diseased condition of the coconut palm known as bud-rot.

No experiments have been carried on to prove that this is the only organism causing the bud-rot. The fact that cultures of apparently different organisms did produce decayed tissues certainly suggests that other organisms than the one isolated may produce the same effect. At the same time slight differences in the appearance of colonies on agar can not be regarded as specific. The question of the power of other organisms to produce the same appearance is an interesting one and undoubtedly will arise again with further work. It seems sufficient for the present (1) to have proved that this condition is due to a bacterial infection and (2) to have isolated a particular organism which is capable of producing the disease.

FUNGOUS INOCULATIONS.

It has been supposed by some people that Pestalozzia and Diplodia or Botryodiplodium play an important part in producing the disease, since one or more forms of these organisms are found in abundance on the central rotted leaves. Very frequently brown spots occur on the middle of young leaves of trees which are apparently free from bud-rot, i. e., which show an entire absence of a putrid condition of the heart. These brown spots range from minute ones to those 5 centimeters in diameter, and they seldom become larger, but remain in a dry condition, presenting the same appearance in the older and mature leaves. Such spots are, without much doubt, caused by both Pestalozzia and Diplodia, both of which form tiny black pustules in the center of a diseased area. If, as has been said, the spots remain dry, they seldom cause any serious damage to the leaves. On the contrary, if bacteria also are present, causing a wet, slimy condition, it is a beginning of the bud-rot. The bacteria destroy the leaf tissues immediately under the epidermis, leaving an extremely thin, paperlike covering over the destroyed parenchyma cells and the firm woody cells of the leaf veins. This condition occurs frequently in an infected region. There may be but a half-meter of diseased tissue, consisting of both a luxuriant, black, sooty covering of the fungus and the slimy bacterial growth. This tissue may be 1 to 1½ meters below the top of the central leaves and as far above the heart tissues. The slimy condition progresses downward into the more fleshy tissues, where it becomes a typical soft rot. The advancing margin of this rot almost never contains fungous filaments but swarms with bacteria and forms the typical bud-rot. The slimy condition extends upward only so far as it may have fairly soft tissue for food material, and is protected by surrounding leaves which keep it constantly moist. Higher up in the crown where the leaves begin to unfold the tissues are harder and more membranous and are exposed to the wind and sunlight which furnish conditions unfavorable to the growth of the bacteria. The fungous infection seldom extends to the top of the diseased leaves, which turn brown and dry and supply a poor substratum for the fungous growth. Under the foregoing conditions, when both fungi and bacteria were present in incipient cases, it was a puzzling question as to which was the cause of the diseased condition. In a number of trees, however, the middle leaves were affected with the fungous spots alone, and, as previously mentioned, it may be seen that either fungi or bacteria may be the first present. It is probable that germination and growth take place best in the presence of unusually moist conditions among the tightly packed middle leaves or on some of the frequent droppings of the tree frogs, lizards, and various insects which are found present in such places.

The scale insects, as well as cockroaches, earwigs, ants, and other insects, may cause small mechanical injuries that give the fungus foothold. In order to determine whether the fungus was infectious small pieces of seriously diseased tissue were loosely bound with wet cotton over the slightly scratched surface of some leaves, quite low down, where the tissues were just turning green. After six days the trees were examined and the two leaves which had been so thoroughly wrapped as to remain moist were infected, while those which had dried out were not. On one of them a typical fungous infection extended 3 centimeters beyond the inoculation and on another for the distance of 8 centimeters beyond the wounds. The four other inoculations showed no growth, the inoculation material itself having dried out, which rendered infection impossible. While this was but an incomplete experiment, carried on in a small way, the flourishing condition of the fungus on the tissues of the two infected leaves would indicate that, given proper conditions of moisture on slightly diseased or wounded tissues, the fungus would make good growth. The fact, however, that these two successful cases did not advance further and did not develop into the slimy condition and progress downward into a soft rot tends to prove, if any proof is necessary, that the soft-rotted condition in bud-rot is not caused by the fungus.

SPREAD OF INFECTION.

For the spread of disease caused by a parasitic organism some carriers of the infection are essential. The bud-rot has been shown on foregoing pages to be due to a bacterial organism and in some of the pages that follow it is demonstrated to be due to a particular organism. The means of spreading the infection from tree to tree has, however, not been ascertained. It has been claimed by some that wind is the chief means and by others that insects play an important part.

The arguments in favor of wind are based largely upon the observations that the distribution of the infection is sometimes in the direction of the prevailing wind. This condition appears to be true in some cases, but unfortunately for the argument the cases are quite as common in which the spread is against the wind. Not only this, but the new infections are more sporadic than would be expected. The disease occurred in Baracoa Harbor, serious first on the south side, and from there spread to the east side, skipping over a group of several hundred trees. This spread was off to one side of the usual course of the wind. On the west side of Baracoa Harbor there is a large estate which covers both sides of a small hill, on the one hand facing the sea and the breezes and on the other hand away from the sea and in the direction of the wind. The disease has been on the windward side for at least the last three years, but is only at present beginning to be serious on the leeward side.

Considering the examples as a whole, it seems difficult to find a definite case of the spread of the infection in any one direction. The most favorable example for this theory is that of the condition of the groves in the Macanagigua Valley and toward El Yunque—that is, to the south, nearly in the direction of the prevailing wind. The disease spread from the valley to the hilltop inland and then crossed the hilltop and has since gone a few miles farther south into the valleys. Even this is not a clear-cut example, as a closer study of it reveals. As already stated, a careful study was made of one grove in this region during the year 1908–9. Figure 10 shows the condition of the grove on March 10, May 28, August 5, and October 21, 1908. The lower right-hand side of each section of the diagram represents the windward side of the grove. Section *a* shows, however, that there are more healthy trees standing on that side than on the leeward side, represented on the diagram by the upper left-hand corner. The straight horizontal dash indicates diseased trees that have been cut down or destroyed. In sections *c* and *d* it will be seen that the leeward side is almost destitute of standing trees, either diseased or healthy. It will further be found that there are many trees represented in the lower left-hand corner that have become diseased and that are somewhat to the windward of the first lot. Perhaps the most striking thing shown by the diagram is the sporadic nature of the spread of the infection. It seems difficult to attribute this to wind.

An entirely different argument and one opposed to the idea of wind as the distributor of the germ is the nature of the infection. The diseased tissues consist of a soft, wet rot in the heart of the crown and surrounded by the hard tissues of the leaf bases and sheaths. It is difficult to conceive of the wind getting at such a location and blowing about moist bits of tissue. It is true that many forms of bacteria are carried about in the air, but they are forms that are able to withstand considerable desiccation and are usually, if not always, sporulating forms. The organism causing bud-rot is not, so far as known, a spore former and can not withstand sufficient drying to permit of its being blown about like so much dust.

In contrast to the idea of wind as a disseminator of the germs is the belief of many that insects, or birds, or some form of animal life is responsible for this trouble. If this were the case, the spread of the infection would occur in just such a sporadic manner as shown in figure 10, sections *a* to *d*. As seen in the field the evidence all tends to point in this direction. If the insects that may carry the disease are flying forms, it would explain the occasional apparent spread of the disease in the direction of the wind. The kind of insect or animal life responsible, however, is not yet determined. A great variety of forms, as described on other pages, has been found in the tops of both diseased and healthy trees. In the infected

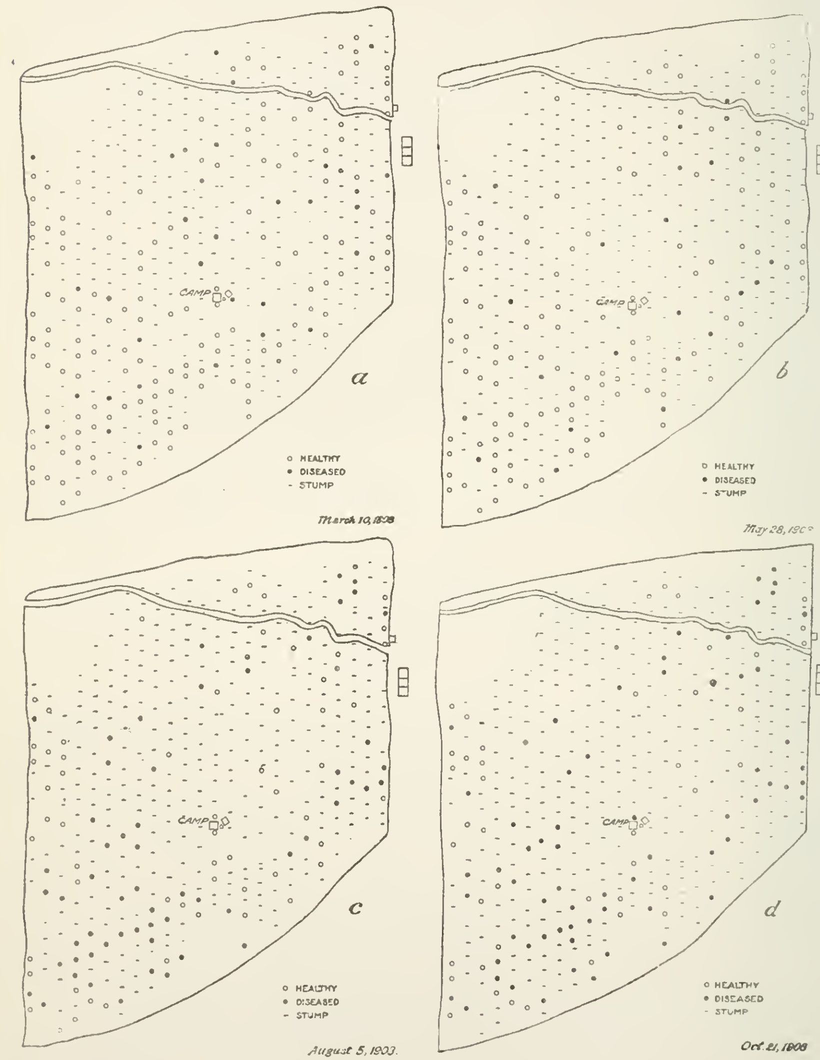


Fig. 10.—Diagrams showing the progress of the bud-rot in a coconut grove at Baracoa, Cuba, from March 10 to October 21, 1908. The four sections of the diagram indicate the condition of the grove on the dates specified.

tissues themselves are usually found in abundance larvæ of flies and earwigs. In some very deep portions, even where it was difficult to imagine the possibility of access to flies or other insects, numerous larvæ occur.

It seems most likely, in the face of all this, that insects are the carriers. In view of the fact that they are found so commonly on diseased tissue it seems very possible that they might carry off some organism either attached externally to their bodies or legs, or taken internally in the course of feeding and subsequently excreted upon healthy tissues. With the exception of fly larvæ, earwigs are the most common insects. Some of these were collected from diseased tissues, carefully washed for 20 seconds in mercuric chlorid (1:500), then rinsed in water and placed in tubes containing Dolt's medium (p. 79). The insects were well crushed in the tubes so that any bacteria from the digestive tract would come in contact with the medium.

Transfers were made in Washington from these tubes (eight in number) to beef bouillon, and an attempt was made to isolate the coconut organism. Plates poured from four out of the eight tubes showed among many a few colonies resembling the coconut organism. Transfers from each of the four plates to litmus milk gave the typical reaction. Transfers from the litmus milk to nitrate bouillon, to fermentation tubes with neutral red, to gelatin, and to Dunham's solution, likewise gave the reaction of the coconut organism. Thus, this investigation of the insects, while much too incomplete for proof, indicates that the disease-producing organism may be found in the intestines of earwigs; and such being the case, these insects may be at least partly responsible for the distribution of the disease.[1]

It seems possible also that turkey buzzards may be responsible for carrying the disease germ from tree to tree. These birds are found in all the tropical localities where the bud-rot occurs, and they may commonly be seen in diseased trees. That they feed on the infected tissues is uncertain, but it seems probable that they do. Such tissues have a very bad odor—at times it reminds the writer strongly of an abattoir—and it is likely that they are attracted by it.[2] It does not seem improbable that such birds may feed on the material or at least get some of the organisms on their feet, after which it is an easy matter to spread the infection. In the hope of ascertaining the probability of the coconut organism occurring in the digestive tract of these buzzards some of the fresh dropping was placed in tubes of Dolt's medium. Several plates were made, twice for each of the several bouillon tubes. In every case a small proportion of the resulting colonies appeared to be the coconut organ-

[1] In one of the last trees cut down at Yumuri, Dr. Smith found two larvæ in the rotting bud not far from the sound tissues. These larvæ were of a gray color and probably similar ones had been overlooked. They were put into a clean petri dish and brought to Washington. On the way they pupated and later one of them passed into the imago state and was identified by Mr. Coquillett as *Hermetia illudens* L., a common scavenger fly of the Tropics.

[2] Dr. Smith states that twice, at Baracoa, buzzards swooped down on the rotted hearts of palms he had laid aside for study and would have carried the material off if he had not made a frantic rush to protect it.

ism. From these colonies transfers were made to litmus milk, which in every case reddened the litmus and coagulated the milk and subsequently became partially bleached as in the true coconut organism. Transfers were made from these litmus-milk tubes to fermentation tubes containing peptone, dextrose, and neutral red, and in every case the typical greenish-yellow reaction took place in the closed arm of the tubes and gas was produced, usually the ordinary amount, though in one series of tubes it ran as high as 70 to 90 per cent. Transfers were also made from the litmus milk to nitrate bouillon, and tests after 48 hours' growth at 32° C. showed a reduction of the nitrate in every case. Similarly, transfers from the nitrate bouillon to beef gelatin +15 kept in the thermostat at 37° C. for 48 hours and afterwards placed in an ice box to harden, failed to show any liquefaction of the gelatin. Cultures of these organisms in Dunham's solution when tested for indol showed a good pink reaction.

Thus, in all these tests certain bacteria responded to the usual tests for the coconut organism. The proportion of this organism to the total amount found in the dejecta of the buzzard was, however, small.

In the tops of palms rats have frequently been found as well as other animal life, but it does not appear likely that these serve as carriers of the disease. An attempt was made to isolate the coconut organism from excreta of rats, but without success.

It will be seen in the following pages that the organism causing bud-rot is *Bacillus coli*, or at least an organism indistinguishable from it. This organism is one that has been known for a long time as being of almost universal distribution and one that is commonly found in the intestines of man and some of the lower animals. The widespread distribution of *Bacillus coli* would seem to coincide with the widespread occurrence of the bud-rot, for, as described on other pages, a disease identical with this appears to occur in almost all parts of the tropical world. If *Bacillus coli* is to be found in so many countries and is the cause of bud-rot, how is it that there are any regions free or apparently free from this disease? This is a question that naturally arises, and one that does not lend itself to an easy solution. To illustrate this: *Bacillus coli* is shown to be the cause of the coconut bud-rot in Cuba, but this disease does not appear to occur in Porto Rico. *Bacillus coli* undoubtedly occurs in Porto Rico but does not cause the coconut disease. Why is it that the organism that causes the disease in one locality does not cause it in another when it is present? A plausible explanation is in the supposed absence of the particular carrier of the infection in these regions where the disease does not occur.[1] As there is no complete evidence for or against this, the question must for the present remain unsettled. An explanation might, however, be sought in considering what passes for *Bacillus coli* as a group of organisms, the members of which, while alike in the usual cultural characters, possess varying pathogenic properties.[2] The only other possible explanation is a difference in the soil or climate. The necessary evidence to support such a theory is, however, entirely lacking.

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[1] An earwig similar to or identical with the Cuban species has been found by the writer in Porto Rico, but the turkey buzzard is either entirely absent or at least rare on that Island.

[2] Since this statement was written Daniel D. Jackson has published a very instructive paper (Journal of Infectious Diseases, March, 1911, pp. 241-249) in which he maintains *Bacillus coli* to be a group of related species, divided by him as follows: *B. cummunior* (Durham), *B. communis* (Escherich), *B. aerogenes* (Escherich), *B. acidi-lactici* (Hueppe). The first two species are separated from the second two by their gas production with dulcit and the first of each of these two groups may be separated from the second by its gas production with saccharose.

Each of these species may be separated into four possible varieties in accordance with their gas production with mannit and raffinose. Three varieties each of the first and fourth species are now known, two varieties of the third, and all four possible varieties of the second group have been found.

In a diagram 21 varieties of *Bacillus coli* are given, four of which are as yet unknown.

Bacillus communior (Durham).—Variety A_1: Fermentation with gas production with dextrose, lactose, dulcit, saccharose, mannit, and raffinose; milk coagulated, nitrate reduced, motile, and indol positive. Variety A_2: Fermentation the same as A_1; motile, reduces nitrate; differs from A_1 in not producing indol. Variety B: Ferments with gas production with dextrose, lactose, dulcit, saccharose, and mannit, but forms no gas with raffinose. Also distinguished by no coagulation in milk even after heating and by slow formation of gas in dulcit. This latter test usually takes three days for the gas formation to become active. Motile, indol positive, nitrate reduced. Variety C: Fermentation with gas production with dextrose, lactose, dulcit, saccharose, and raffinose; forms no gas with mannit; milk coagulated, nitrate reduced, motile, and indol positive.

Bacillus communis (Escherich).—Variety A: Fermentation with gas production with dextrose, lactose, dulcit, mannit, and raffinose; no gas formation with saccharose; motile, indol slight, nitrate reduced. Variety B: Fermentation with gas production with dextrose, lactose, dulcit, and mannit; no gas production with saccharose and raffinose; milk coagulated, nitrate reduced, motile, and indol positive. This appears to be the most common variety of *B. communis*. Variety C: Fermentation with gas production with dextrose, lactose, dulcit, and raffinose; no gas production with saccharose or mannit; nitrate reduced, indol positive, motile. Variety D: Fermentation with gas production with dextrose, lactose, and dulcit; no gas production with saccharose, mannit, or raffinose; nitrate reduced, indol positive.

Bacillus aerogenes (Escherich).—Variety A_1: Fermentation with production of gas with dextrose, lactose saccharose, mannit, and raffinose; no gas production with dulcit; indol positive, nitrate reduced, motility negative; viscous growth on agar and in lactose bile; in the latter it can be drawn out into a long, thin string. Variety A_2: Fermentations the same as A_1; motile, indol negative, nitrate reduction positive; differs from A_1 in being less viscid or stringy when touched with the needle; in being motile, and indol negative. Variety A_3: Fermentations and all tests with one exception same as A_2; liquefies after 26 days; differs from A_2 in being slightly liquefying in gelatin stab after about 26 days. The total gas and percentage of CO_2 is high when grown in dextrose broth and particularly in liver broth. This species has been at times grouped with *B. cloacae* (Jordan), but the former never fails to produce gas with lactose, while typical *B. cloacae* apparently always gives negative results, when dextrose-free lactose solutions are used. Another marked distinction is that true *B. cloacae* after rejuvenating is always strongly liquefying, while *B. aerogenes* A_3 never liquefies before 20 days, even after careful rejuvenation over long periods. Variety B_1: Forms gas with dextrose, lactose, saccharose, and mannit, but no gas with dulcit and raffinose; nonmotile, indol negative, nitrate reduced; viscous growth on agar and in lactose bile. May be drawn out into a thin string by using a platinum needle. Variety B_2: Differs from B_1 in being motile, indol positive, and nonviscous in lactose bile.

Bacillus acidi-lactici (Hueppe).—Variety A_1: Fermentation with gas production with dextrose, lactose, mannit, and raffinose; no gas production with dulcit and saccharose; nonmotile, indol positive, nitrate reduction positive. Variety A_2: Fermentation same as A_1; indol positive, nitrate reduction positive; differs from A_1 in being motile. Variety B: Fermentation with gas production with dextrose, lactose, and mannit; no gas production with dulcit, saccharose, or raffinose; milk coagulated, nitrate reduced, motile, and indol positive. Isolated by Melia in nine strains from human feces. Often exceeding in numbers all other varieties of bacteria in feces. Variety D: Gas production with dextrose and lactose; no gas production with dulcit, saccharose, mannit, or raffinose; indol positive, nitrate reduced.

While it appears probable from the studies of the writer that insects are the carriers of infection, it is still of the utmost importance that this matter be ascertained definitely.

REMEDIAL AND PREVENTIVE EXPERIMENTS.

In the early part of this work the writer had before him as the picture of bud-rot the conception most general among planters and investigators, that of a soft-rotted condition of the bud. Almost at a single glance one could state definitely that a tree in such a diseased condition had no hope of being cured either by indirect or direct methods. The single growing point of the tree being rotted, there was no power within the tree to produce another growing point.

In order to ascertain if the disease did not attack other tissues before getting into the heart or growing point, the writer repeatedly ascended many trees to the summit, and there made careful observations on the condition of the central leaves during the course of a year, as has been noted on other pages.

A month or so after the first examination it was observed in some cases that trees which had been free from rot in the center became badly diseased. It commonly happened in such trees that one or more flower spikes just opening revealed dark-brown wilted tips. Trees were also found with these discolored flower spikes and with healthy central leaves. This condition suggested the idea of removing the one diseased spike and watching further development. This was done, as shown in the following record:

Tree No. 96.

March 7, 1908: The tree had 5 spikes of nuts and 1 good sword visible from the ground.

May 28: Nine fairly good spikes and two good swords were found.

June 8: Same condition.

June 25: There were 9 spikes, bearing about 100 nuts, and 4 good swords. One spike with nuts just set showed dark-brown water-soaked tissue at its base—the only sign of disease in the tree. The middle leaves were healthy. The diseased spike and the adjacent tissues were cut out. Owing to the compactness of the leaf bases and their strainers at the base of the crown it was impossible to say that the infection may not have been carried to other parts. No satisfactory means of disinfecting the whole crown was at hand.

July 21: One of the green swords had become brown and dead. Six of the nut spikes were empty.

July 24: Of the 100 nuts on June 25 there remained about 40. Removed by pruning the dead sword and all of the spikes having no nuts, together with their subtending leaves. In all, cut off 19 leaves and 10 spikes. There were left 7 good leaves and 2 green swords. The central leaves were still healthy.

August 5: No change.

October 21: The two swords as well as the middle leaves were brown and dead. There was a soft rot in the heart tissues.

Similar conditions were noted and followed through their course of development in numerous other cases. Each time it was made reasonably certain by careful examination that there was no disease of the middle leaves, and then all of the lower infected leaves and spikes were removed, one by one, and the trees left standing. In the course of a few weeks the outermost flower spikes and swords which had been left in an apparently healthy green condition now became discolored and wilted. These were removed and only green ones left. This was repeated until finally in every case a typical rot appeared in the central leaves and quickly penetrated to the heart, thus killing the tree. In all, 21 trees were pruned through a series of months, as described above, and in each case the disease finally lodged in the central leaves. These experiments seem to furnish good evidence as to the origin and course of the infection. Although no inoculations have been made to prove it, yet in no other way can the condition be interpreted than that the water-soaked spots at the base of the leaves and the black wet-rot of the strainer is the precursor of the central bud-rot (Pl. X, figs. 1 and 2). Microscopic studies of the water-soaked spots, showing numerous bacteria, confirm this idea.

With this evidence, then, as to the course of the disease, the question as to remedies or preventives can be studied with a more thorough understanding of the conditions.

REMEDIES.

When it was found that the disease often first occurred at the inner leaf bases and gradually passed to the central leaves it was hoped that some application might be made to the crown that would destroy the incipient infections.

If the leaf-base spots and external strainer rot could be removed before the rot had penetrated to the deeper tissues there seemed some hope of success. The methods of accomplishing this have been varied. To remove the diseased tissues at the base of the leaves the writer resorted to pruning. As mentioned in previous paragraphs, 21 trees were treated in this way. It appeared impossible, however, to remove all of the infection. The germs could pass through the strainer, and they might have been present in the tissues without showing any sign of rot. For that reason it was difficult to tell how much to prune. Cutting off merely the diseased area did not seem efficient. As many as 15 to 20 leaves could be removed—leaving 5 or 6—without seriously injuring the tree. To carry this further would so weaken the crown that the first strong wind would blow it over entirely. In this work, as carried out by the writer, the trees remained undiseased at the heart from one to three months, but eventually they all succumbed.

In contrast to the plan of removing infected parts, other experiments were carried out to counteract the progress of the disease. It was hoped that by applying certain chemicals the affected tissues would be poisoned, or perhaps cauterized. Planters in various regions have applied salt, iron sulphate, Bordeaux mixture, etc., to the crown, presumably with this idea in mind. The writer tried salt, copper sulphate, and Paris green, but here, as in spraying to destroy the insects, it was found impossible to reach all of the infected portion. The experiment with these chemicals progressed as follows:

Tree No. 240.

February 26: It bore 9 spikes of nuts and 2 good swords. Appearance healthy.

March 11: Same.

May 28: Same.

June 22: There were a dozen fallen rotted nuts.

July 6: From the ground 1 flower spike appeared just opened and much discolored; also 1 dead unopened sword. There were 5 spikes bearing several 20-centimeter nuts, 7 or 8 spikes higher up having no nuts, a discolored opened spike, a dead sword, and 5 or 6 healthy swords. The middle leaves at the top were slightly discolored and a trifle soft rotted. These tips were cut off and 3 of the green swords and central leaves also, for the purpose of opening up the center. About 30 immature nuts were on the ground. The tree was badly diseased, atlhough the rot had not yet reached the heart. One kilogram of salt was placed about the base of the diseased leaves and upper spikes.

July 21: A few more nuts had dropped; otherwise no change.

August 6: Tree was cut down for examination. The salt had no visible effect upon the tissues, and certainly had none in stopping the progress of the disease. The rot had not reached the heart tissues, and all of the young leaves were turning green.

Tree No. 390.

March 11: Eight spikes of nuts and one good sword.

May 28: Same.

June 16: Same.

July 6: Showed one flower spike just opened, the tips chocolate brown in color, and drooping; showed another just opening and the tip chocolate brown; 2 swords. There were 3 spikes of large nuts and 5 or 6 spikes above just dropping their smaller nuts. The middle leaves appeared healthy. One kilogram of salt was placed about the base of the upper leaves.

July 21: Had dropped all of its large nuts; otherwise no change.

August 6: All spikes were empty and leaves were much yellowed.

October 21: Three dead opened flower spikes; middle leaves turning yellow; hopelessly diseased.

Thus, in this case also, the salt had absolutely no effect in retarding the progress of the disease.

A similar experiment was carried on with the use of copper sulphate crystals, the idea being to poison the diseased areas. It was not

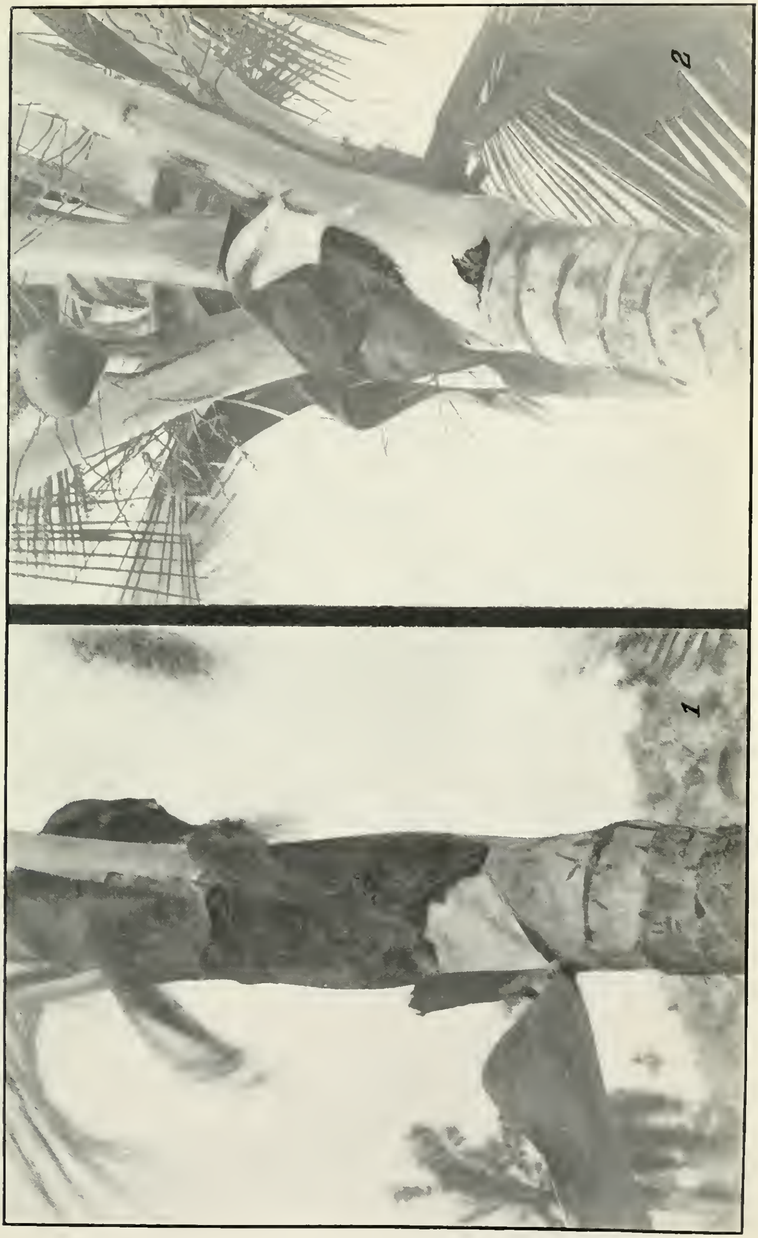

FIG. 1.—DISEASED COCONUT TREE, SHOWING BLACKENED PART OF SHEATH ABOVE THE WHITE, HEALTHY PORTION. FIG. 2.—DISEASED COCONUT TREE, SHOWING DARK WATER-SOAKED SPOTS AT BASE AND SIDE OF PETIOLE.

believed that the copper sulphate would affect seriously the woody tissues with which it would come in contact. Two trees showed the following conditions:

Tree No. 286.

March 11: Nine spikes of nuts and good open flower spike.

May 28: Same.

June 6: Practically the same.

June 29: Appeared unhealthy.

July 6: Had dropped 15 immature nuts; 5 spikes of few nuts; and above were 5 or 6 spikes of no nuts; 3 good swords and good middle leaves. Placed 1 kilogram of copper-sulphate crystals at the bases of the leaves. Rains were so frequent that the crystals were soon dissolved.

July 21: Showed 1 open discolored flower spike.

August 6: Only 2 nuts and many empty spikes on tree; a dead flower spike, opened some time ago, and 1 just opening.

October 21: Central leaves bent over dry and dead; swords dead; many empty spikes; all leaves yellow.

Tree No. 288.

March 11: Sixteen spikes of nuts in good condition.

May 28: Eleven spikes of nuts and 3 good swords.

June 10: General appearance unhealthy.

July 6: Middle leaves healthy and numerous; the second, third, and fourth swords from center were good; fifth and sixth diseased. The seventh and outermost sword was good; the next outward and the adjacent spikes were also good. The 10 or 15 other spikes had no nuts. The lower leaves were yellow.

July 21: Showed from the ground a dead sword and also 2 dead leaves. Applied 1 kilogram of copper sulphate directly to the base of the leaves.

August 8: Very yellow; only 1 green sword left; the tree apparently very far gone.

October 21: Middle leaves bent over, dry, and dead; all the remaining leaves yellow.

Thus from the application of copper sulphate no good result was obtained.

Two trees treated with Paris green, another poison, progressed as follows:

Tree No. 102.

March 7: Seven spikes of nuts and 1 good open flower spike, also 1 good sword; an excellent tree.

May 28: Thirty-six fallen green nuts, 9 spikes of nuts, and 2 good swords.

June 8: Practically the same.

July 8: About 40 fallen immature nuts; 8 good spikes of nuts; 3 spikes with no nuts above the others; 1 good open flower spike on one side and 1 bad open flower spike on the diseased side; 2 good swords and the middle leaves were healthy. About 250 grams of dry Paris green were applied.

July 21: Only 8 nuts left on 4 spikes; a dead sword just breaking open; 1 green sword visible; all leaves green and healthy. Removed 1 spike with 13 3-centimeter nuts, 1 spike with 6 8-centimeter nuts, 1 spike with 1 15-centimeter nut, 1 spike with 1 20-centimeter nut, 1 spike with 1 5-centimeter nut, and 7 spikes with no nuts. The bases of the spikes and of the leaves were well covered with water-soaked areas both on the upper side and on the lower side of the leaf base and spike base. This tree was treated with Paris green, but the spots on the under side could not be caused by arsenic poisoning, as they were out of reach of the Paris green. Spotting was very abundant. What could cause such a wholesale spotting at such places is a puzzling question. One sword and five leaves were left, and the middle ones besides. The outermost leaves had perfectly clear, undiseased, outside bases; but up toward the strainer were a few water-soaked spots. On the last leaf cut off a water-soaked area appeared as though following the distribution of the Paris green.

August 5: The tree remained about the same; 1 green sword was visible.

October 21: The outer sword was dead, and the middle leaves were also dead. The upper part of the crown was broken and blown over.

Tree No. 105.

March 7: Eleven good spikes of nuts; an excellent tree.

May 28: Same.

June 9: Had 14 fallen immature nuts.

July 8: About 35 fallen immature nuts; 7 spikes holding a few large nuts; above were about 12 spikes bearing no nuts. All the small ones had fallen. The outermost sword was dead, brown, and unopened. There were 4 green, healthy swords. The middle leaves were healthy. The tree had a crown of over 20 leaves, the lowermost circle of which was turning yellow. Applied about 250 grams of dry Paris green at the base of the leaves and below the good spikes.

July 21: There were 4 spikes, 1 brown sword, 2 green swords, and 3 pendent brown leaves. The lower leaves were yellow.

August 5: The central leaves were dry, bent over, and dead. The tree hopelessly diseased.

The treatment with Paris green offers no results different from the others. All applications failed to check the disease. Undoubtedly the criticism will be made that there is great possibility of the poison having hastened the progress of the disease, but no direct evidence appears to support such a supposition. The poison had no definite effect on the tissues with which it came in immediate contact. It is probable that the cutinous covering of the epidermis prevented to a large extent the corrosion, which might be expected. Moreover, the disease on those trees on which the experiments were made did not progress any faster than on adjacent untreated trees of which full records have been kept. It must be borne in mind that the application of these poisons was made rather to note the effect than with any hope of curing the disease. Such treatments have been made by planters in various districts, and the experiment was made to ascertain what possible effect was to be expected. In the light of the knowledge of the arrangement of the leaves at the base of the crown, it is believed to be a physical impossibility for external applications to reach the parts affected by the disease without at the same time seriously injuring the healthy tissues. It is thought that these applications might serve partly to arrest the progress of the infection—to render the condition of development less suitable—but it is certain that they could not absolutely check it.

High hopes have been entertained of another treatmert, that of the so-called flaming. So far as public records go this treatment was first used in Jamaica and subsequently adopted in Cuba. The method consists in setting fire to the crown, either by lighting the dry pendent leaves or by the addition of coal oil. It is desired to create considerable heat in and about the base of the crown and not in the central leaves nor among the upper green leaves. The writer made no experiments with this method as, after the studies on the arrangement of the crown leaves and experiments with the external treatment of other kinds, it was considered to have no practical value. Moreover, an examination of the results of such treatment carried out by several investigators and by planters led to the same conclusion.

The conclusions reached, after carefully examining different trees treated by various workers and watching the progress of many trees so treated during a period of a year, are as follows:

From the arrangement of the crown it is impossible for the heat to penetrate into the inner tissues in sufficient degree to dry out the diseased portion without seriously affecting the growing part of the crown. Any flaming whatever will destroy the lower leaves and all the nuts, so that even if the tree is not killed, at least a year's crop is destroyed. The scorching of the leaves and the charring of the trunk so kills the superficial tissues as to permit the rain to soak in and a subsequent rot to take place. It has been contended by some people applying this treatment to their trees that there was subsequent recovery from the disease, at least to the extent of flower spikes opening out and setting nuts. It should be noted, however, that the tree, while retaining the disease, may send forth new flower spikes and nuts for a period of at least a year after infection has taken place without any treatment having been applied. The writer possesses records of individual trees which show this. In many trees flamed the disease progressed subsequently so that it presented to the writer no evidence of the value of this treatment. As a diseased tree is certain to die if not treated, there can be no error in flaming it; but to try this method with healthy trees in the expectation of warding off infection is not advisable, because (1) there is no evidence that the treatment would succeed, and (2) there is the certainty that the tree would be seriously injured in a way that would make it more susceptible to infection.

PREVENTIVES.

In order to prevent the spread of the disease, it is necessary to destroy its source, or its means of transmission, or the conditions favorable to its development. The absolute destruction of diseased trees, a careful watch for the newly infected cases, and their immediate removal has done much to prevent greater loss in various regions. In Jamaica it is chiefly owing to this care that the bud-rot is not widespread. In some districts in Cuba care has enabled the planters to maintain successful plantations, while in other districts neglect of the trees has led to their entire destruction.

In 1908 the Government of Cuba appropriated $14,000 to assist in eradicating the disease. Owing partly to the failure to come to an agreement as to the method of work and partly to the lack of some one well enough acquainted with the disease to oversee the project, nothing has as yet been accomplished. Investigators themselves are by no means agreed as to the best method of eradication. The common practice at present is to cut down the diseased tree and, after heaping dry leaves about the crown, to set fire to it. This is fairly satisfactory except that the fallen trunk forms an objectionable obstacle and serves as a breeding place for many insects. Another method recommended is to bury the diseased top with quicklime. Burial presents a task too difficult, if one takes as much of the crown as is necessary to destroy all of the infected parts. Other disinfectants have been recommended for application to the crown as it lies on the ground, but none of these have much value, owing to the difficulty of penetrating to the center of the decayed parts. Personally, the writer is of the opinion that the crown should be cut off as the tree stands and then destroyed. This plan presents no such obstacles as may on the face of it appear, and it has the added advantage that the crown can be entirely burned, leaving no débris to litter the ground or furnish breeding places for insects. The bare trunk left standing would serve as a breeding place for insects to only a very limited extent, since it would remain fairly dry and exposed to all the sunlight and wind—conditions very different from those existing when the trunk lies on the damp ground in the grass and rotting leaves. To be sure, to fell the tree is much the easier method of procedure, but the other way takes only 30 minutes or less with the proper tools. A native can ascend the tree in his bare feet, and with his machete or cutlass quickly lop off all the leaves close down to the heart. If the rot extends below the heart, it would be advisable to pour over its surface a pint or so of coal oil and then set fire to it. The writer has himself ascended trees 15 or 20 meters high by the aid of an electrician's climbers and then removed the leaves with a small, sharp, hand ax. When a planter has only a half-dozen or two dozen trees to destroy, this method seems to be far the best, because it leaves the ground free from any large obstacles. If, on the other hand, several hundred or a thousand diseased trees are to be destroyed as soon as possible, it may be desirable to fell the trees and then burn the tops, afterwards obtaining a two-wheeled rig to draw the logs to one side of the grove where they may be placed in a heap and made the center of a fire, or covered with lime or heaped over with earth. The expense of this work would be excessive for a few trees, but in the case of many it most certainly would be advisable to carry it out. As a matter of fact it would pay a planter, planning to cut down any great number of trees, to girdle each tree at 1 to 1½ meters from the ground so as to allow the trunk to dry out. Then when it is felled it can be made into very serviceable timber for use on the plantation. It is worthless for use in any constantly moist situation, but is very valuable for siding or beams in sheds and makes especially beautiful pillars.

Besides destroying all sources of infection, it is desirable to reduce to a minimum the number of insects visiting the tree. It has not yet been proved that insects are a means of infection, yet their great abundance in diseased trees leads one to think that they may play an important part in distributing the germs. It is very rare not to find some insects present in an affected crown. The ones most commonly found are the earwigs [1] (*Pyragra buscki* Caud. and *Anisolabis janeirensis* Dohrn), occurring in the damp, rotted, and fungus-infected part of the central leaves some distance above the heart. These same species or closely allied ones have been found by the writer in the diseased trees in Cuba, Jamaica, Trinidad, and British Guiana. There have been a few cases, however, when these forms could not be found, so that they can not be given the entire blame. A few cockroaches [1] (*Leucophaea surinamensis* L., *Blabera fusca* Brunn., and *Periplaneta australasiae* Fab.), are very commonly present in and about damp, decaying portions. Ants may often be found in great numbers, even forming a nest in the crown. A few beetles,[2] such as *Lioderma quadridentatum* Fab., *Cyclonotum flavicorne* Muls., *Ischyrus flavitarsis* Lac., and *Lioderma devium* Muls.; and weevils [2] (*Rhynchophorus palmarum* L.) occur, but seldom in abundance. In the midst of the moist, rotten parts of the tissues centipedes, tree frogs, lizards, small snakes, and rats may very frequently be found. Although it has not been proved that insects carry the disease, it would seem advisable in a seriously infected district to place about the trees, a meter from the ground, bands of cloth 10 centimeters wide, soaked in coal tar, which will prevent the ascent of the tree by any forms of crawling insects. When it is known that rats or any of the larger animals frequent the tops of the trees of any grove it would pay to put a band of galvanized iron about the tree, some 15 centimeters wide and about 1½ meters from the ground. The manner of destroying insects already in the crown of the tree and any flying insects that may come to it is more difficult. In the hope of reducing the number to a minimum the writer undertook to spray a small grove during the course of a year. The experimental work was carried on at a grove about 3 kilometers from Baracoa, which could be reached only by traveling over an extremely rough

[1] Identified by Mr. A. N. Caudell, of the Bureau of Entomology.

[2] Identified by Mr E. A. Schwarz, of the Bureau of Entomology.

road and fording a river. The grove itself was full of underbrush, fallen leaves and logs, and contained some low, marshy places as well as high, dry ground.

Under such conditions it was deemed inadvisable to use an ordinary orchard spraying outfit, as it would be much too cumbersome to move about. A 2½-horsepower gasoline engine and a pump with a 2½-inch cylinder were mounted on a four-wheeled truck only large enough to hold the apparatus. The supply tank was a 200-liter barrel, mounted on two wheels and drawn by hand. Fifty meters of 9.5 millimeter 5-ply hose was taken along and in addition a two-cylinder hand pump. The proposed plan was to apply a mixed germicide and insecticide to the crown. In lieu of some apparatus to raise the spray to the required height—anywhere up to an average of 20 meters and an occasional height of 30 or 40 meters—it was decided to ascend the tree in person, carrying the hose, and then apply the spray to the crown. With the use of iron climbers and leather belt the writer found it possible to do this easily up to 18 meters, and with difficulty up to 20 or 25 meters. Above that height it was, for all practical purposes, impossible, owing to the weight of the hose.

In starting this work it was first necessary to clear out the underbrush and much of the débris littering the ground in order to get about with the spraying apparatus. The entire grove of 145 trees was then sprayed. It was possible to ascend a tree, spray it, and descend in about 15 minutes. An average of about 20 trees per day was the usual result. The grove was sprayed once in February and March, again in June, and a third time in August, 1908. A visit to the grove was made in November, but it was too badly diseased to make another spraying of any value. The following data will give an idea of the results of the spraying; or, perhaps more accurately, shows the progress of the disease in the grove during and after the application of the spraying solution, which consisted of 4–6–50 Bordeaux mixture containing Paris green, 1 part in 3,000:

TABLE V.—*Record of conditions of coconut trees sprayed in 1908.*

Date of inspection.	Number of trees.		Date of inspection.	Number of trees.	
	Newly diseased.	Healthy.		Newly diseased.	Healthy.
Feb. 18	35	145	Aug. 5	64	58
Mar. 11	35	145	Oct. 21	68	45
May 28	23	122	Nov. 20	25	6

This record of the steady spread of the infection during the progress of the spraying is distinctly against any practical value for such work. It may be said, however, that there were conditions which render the inference to be derived from these experiments not at all so conclusive as it would appear. It is important to inquire whether many, if not all, of the trees which eventually became diseased, may not have been infected before the spraying began. As has already been shown (p. 54), the infection may be present in the crown of a tree and not visible externally. And, further, the solution applied did not adhere evenly, but tended to run together and cohere in patches. When the spray was applied to the coconuts the solution would invariably run down to the under side, where it would dry on in drops. These facts were not particularly prejudicial to the use of the spray, for it was intended and desired to soak thoroughly only the strainer and the tissues at the base of the leaves. The foregoing data show that the spraying did no good in preventing the spread or development of the disease, but there is no definite means of determining the number of insects destroyed. From examining many of the trees in the crown during the course of the year it seemed evident to the writer that the insects were materially reduced, as there were practically none in the crown during the fall, with the exception of ants, of which there were as many as ever.

LABORATORY AND GREENHOUSE STUDIES OF THE DISEASE.

It has been shown in earlier paragraphs that bacterial organisms are able to produce a rotted condition in the heart of the crown of the coconut tree identical with the condition in the typical bud-rot disease as found in the field. It has been shown, also, that certain organisms apparently alike were originally isolated from a typically diseased tree; several cultures of these were inoculated into other coconut trees, and from the successful infections apparently the same organism was reisolated; that a number of these latter cultures were inoculated into other coconut plants, and after producing successful infections the same organisms apparently were again reisolated. In the process of isolation from the diseased tissues many plates were poured, and from these numerous agar-tube transfers were made. Not all of the tubes from any one inoculation proved to be identical, but the greater number turned out to be so. Of all the cultures in the successful inoculations there were two which originally came from the same naturally diseased tree and went through the same process of inoculation, isolation, reinoculation, and reisolation in different trees, and appeared in preliminary tests to be identical in almost every case. Other cultures appeared similar in their reaction in several tests, but these were not compared at any great length. The two original cultures were compared with two cultures from the inoculated trees and two cultures of those isolated from the reinoculated trees. These six cultures were used to make rather extensive studies of the identity of the organism inoculated, isolated, reinoculated, and reisolated, and for convenience are designated in the culture work as coconut Nos. 1, 2, 3, 4, 5, and 6. By the work described in the following paragraphs the identity of the organisms in these six cultures has been determined and consequently the particular organism which causes the disease is ascertained. In the course of the work such a close similarity of the coconut organism with *Bacillus coli* was observed that comparison of the two organisms was made in most of the cultures.

CULTURAL EXPERIMENTS.

Studies of the Group Characteristics of the Organism.

MORPHOLOGY OF ORGANISM AND COLONY.

The organism causing the coconut bud-rot is a short rod with rounded ends, averaging 1.5 to 1.8 μ in length, and 0.5 μ in width, although in length they may vary from 0.63 to 4.03 μ, and in width from 0.48 to 0.6 μ. They occur singly, or more commonly in groups of two or three; not infrequently they may be found in chains up to 20 μ in length. The rods are actively motile with several peritrichiate flagella (demonstrated with Löwit's flagella stain) three to four times the length of the organism. Single rods dart about often with a rapid, vibratory motion and sometimes a whirling motion. They also glide from place to place without any apparent vibration. Couples, when in progression, usually move with a bending, waving sort of motion. Occasionally, when in twos or threes, the rods appear almost rigid, but seem to vibrate rapidly at both ends as they glide along. The rods are nonsporulating. Thin-walled capsules are readily apparent when the organism is stained with Löwit's flagella stain. With this stain, also, dense bodies appear within the rods, located either centrally or more or less laterally. The organism does not stain by Gram's method.

On agar plates the organism is variable. The typical surface colonies are slightly raised, white, and semiopaque. Frequently they eventually become lobed or radiate branched, or from the beginning they may be thin and deeply lobed or radiate branched, with a dense nucleus in the center. They are always wet shining; white by direct light and bluish in transmitted light. The surface is always smooth. By transmitted light the thin colony appears homogeneous, but the raised colony or raised margin of the thin colony appears to have streaks more in some parts than in others. In 24 hours the thin colonies may extend 5 or more centimeters on the petri dish, and in 48 hours they frequently cover the dish. The moisture conditions affect the form and density of the colony.

In agar stabs the surface growth is thin and extends across the tube and slightly up the glass. The stab growth is slender and slightly beaded.

On agar streaks the growth is good, irregular, and bordered by numerous tiny white colonies.

On gelatin stabs the surface growth is thin and white. The stab growth is slender and bordered by, or consisting of, many tiny, separate, white colonies.

On gelatin plates the colonies are small, with irregular margins and uneven surface. After several days' growth the colony is usually zonate with alternating ridges and depressions. Savage [1] studied the appearance of *Bacillus coli* on gelatin plates and came to the conclusion that while there was a typical form of colony for this organism, yet there was enough variation in the forms to prevent using this character alone in diagnosing the species. Comparison by the writer of *B. coli* on gelatin plates with the coconut organism shows them to be, for all practical purposes, identical. Usually *B. coli* assumed the zonate form 24 hours later than the coconut organism under the same conditions, but ultimately they appeared indistinguishable.

GROWTH WITH AND WITHOUT AIR.

The fact that the organism grows in the stab inoculations of agar and gelatin and luxuriantly in the closed ends of fermentation tubes is indicative of its ability to grow either in the entire absence of free oxygen or at least when only very little is present.

Experiments were made with large U tubes in which pyrogallic acid and caustic soda were placed in a test tube and inserted in one end of the U and a beef-bouillon culture of the organism was placed in the other end. The ends of the U were sealed by standing them in beakers containing glycerin, and in some of the experiments with glycerin in one beaker and mercury in the other. The fluid used in each case, either glycerin or mercury, rose in the tube as the air was exhausted by the union of the pyrogallic acid and the caustic soda, but it was not possible to say that an absolute vacuum, or rather an entire absence of oxygen, was obtained. In 24 hours the cultures were always well clouded. Similar experiments were made in which it was contrived to insert also in a U tube a test tube containing bouillon, grape sugar, and methylene blue. In no case did this methylene blue lose its color, as would be expected if there were entire absence of oxygen. Similar experiments were made with large straight test tubes. The seal consisted of a rubber stopper smeared with vaseline. Heavy clouding also took place in these tubes, but the methylene

[1] Savage, W. G. Gelatin Surface Colonies of Bacillus Coli Communis. Journal of Pathology and Bacteriology, vol. 9, 1903-4, p. 358.

blue did not fade out. Other experiments were made by cutting off the top of the cotton plug of the inoculated tube, pushing it down below the top of the tube so as to form a cavity, and then putting pyrogallic acid and caustic soda into this space and sealing with rubber stoppers smeared with vaseline. In 24 hours these cultures also clouded.

Ordinary stab cultures were made in fresh nutrient agar, and melted vaseline was inserted with a sterile pipette to cover the agar to a depth of 1 c. c. The agar eventually shrunk and left a space about 3 mm. high between it and the solidified vaseline. A very thin film of growth appeared on the surface of the agar and a fairly good reticulate stab growth was produced, but no more than in agar stab cultures which were not sealed with vaseline.

Another experiment was made with the use of cover glasses. In this experiment 10 c. c. of sterile agar were poured into ordinary petri dishes and the solidified agar inoculated at one point. Sterile cover glasses were then placed over the point of inoculation and pressed down firmly to exclude the air. In 24 hours the growth under the cover glass was distinct and in 48 hours it had reached the edge of the cover glass and eventually spread over the plate.

No more exhaustive experiments have been carried out. It is believed that sufficient has been done to show that the organism will grow well in a reduced amount of oxygen and will grow moderately well in a very small amount of it. It has not been proved that the organism will grow when there is absolutely no oxygen present.

LIQUEFACTION OF GELATIN.

The six coconut cultures were inoculated into beef gelatin and placed in the gelatin box at about 19° C. All remained perfectly firm, until after 11 weeks when No. 1 was somewhat softened. A few days afterwards No. 1 appeared entirely liquefied. Six months after inoculation all remained firm with the exception of No. 1, which was liquefied. The growth on the surface of these tubes first became thin and white, with an irregular margin. The growth along the stab was at first slender and bordered by and consisting of numerous tiny spherical masses. Eventually the growth spread through the medium and over the entire surface.

The foregoing experiment was repeated with the same results. The experiment was again tried and No. 1 liquefied after 16 days, while the others remained solid.

In the work of Longley and Baton [1] for the identification of *Bacillus coli* the cultures containing the suspected organism are incubated in

[1] Longley, F. F., and Baton, W. U. C. Notes on the Determination of B. Coli in Water. Journal of Infectious Diseases, vol. 4, 1907, pp. 397-416.

gelatin at 37° C. for 48 hours, after which they are placed in an ice box to permit hardening. The solidifying of the gelatin is taken as a positive indication of the presence of *Bacillus coli*, and those tubes in which the gelatin did not harden are considered as positively free from *Bacillus coli*.

Cultures of the coconut organism and *Bacillus coli* (from animals) were incubated in gelatin at 37° C. for 48 hours and then placed in an ice box to harden. In six hours all of the tubes, including coconut No. 1, were perfectly firm.

The culture designated as coconut No. 1 was descended from one of many cultures made from the same isolation (505 R). In order to see if they all behaved alike, transfers were made into gelatin from all that were still alive nine months after isolation. There were in all 11 of these cultures from as many colonies. These tubes were incubated at 37° C. and tested daily for liquefaction by removing to an ice box, where they might harden. Seven days after inoculation all showed good growth and were perfectly firm when placed at a low temperature. Ten days after inoculation the check tubes (two) were perfectly firm; four of the cultures were slightly soft; and the remaining seven were in the nature of a thick liquid. Coconut No. 1 was the thinnest of these, but even that was not entirely liquefied.

Attempts were made to plate out coconut No. 1 to ascertain if by any chance it had become contaminated. A variety of colonies was obtained on the plates of plain agar, but transfers from various forms of these colonies to litmus milk, nitrate bouillon, Dunham's solution, neutral red in fermentation tubes, and gelatin all gave the reactions typical of the coconut organism. Platings were also made from the other coconut organisms and from *Bacillus coli* (Theobald Smith, XIV) with exactly the same results. On plain agar the variety of forms was great, ranging from the small, round, iridescent colonies to large, thin, homogeneous, much-branched colonies. Transfers from specific colonies to litmus milk gave the typical reaction for the coconut organism, and platings from these tubes gave in every case on plain beef agar the same variety of forms. In view of this work it does not seem possible that the culture coconut No. 1 was contaminated, but rather, as has been suggested, that it was a modified form of the original organism.

According to the recommendations of the Society of American Bacteriologists six weeks is the time fixed to ascertain the liquefying power of any organism when the cultures are grown in an ordinary gelatin box. *Bacillus coli* and all six of the coconut cultures answer to this test. According to the methods used by some workers and mentioned in the foregoing paragraphs, 48 hours at 37° C. (before placing in an ice box) is sufficient time in which to ascertain the liquefying power of an organism. *Bacillus coli* and all six of the coconut organisms answer to this test also. It has been seen, however, that coconut No. 1 if left longer than prescribed in the tests will cause liquefaction. This organism answers to all of the other routine tests for *Bacillus coli*, as do the other coconut cultures. On the other hand, coconut No. 1 differs somewhat in some minor tests. Can, then, *Bacillus coli* and coconut No. 1 be considered identical organisms? Apparently not. It would seem very probable, however, in view of the close similarity of the two organisms that coconut No. 1 was derived from coconut No. 2 (505 S, the organism inoculated into the coconut seedling from which No. 1 was isolated), but had changed its character to some extent. The similarity of coconut No. 1 to the other coconut cultures and to *Bacillus coli* will be brought out more clearly in subsequent pages.

PRODUCTION OF ACID AND GAS IN DEXTROSE.

In one series of experiments the average gas production in 10 days in the closed end of fermentation tubes was 24 millimeters and the average titration was +25 on Fuller's scale. As will be seen, however, in the citation of various titrations and gas production, there is considerable variation. Table VI gives the acidity ascertained on various cultures. The amounts are typical of many other titrations.

TABLE VI.—*Acid production by coconut cultures Nos. 1 to 6 and Bacillus coli in various media at 22° C.*[1]

Culture.	Medium 4193: 1 per cent peptone +2 per cent dextrose.	Medium 4192: Dunham's solution+2 per cent dextrose.				Medium 4268: Dunham's solution+1 per cent dextrose.			
	12 days.	6 days.	23 days.	31 days.	55 days.	20 hours.	5 days.	19 days.	47 days.
Coconut 1	....	+26	+14	+14	+20	....	....	....	....
Coconut 2	....	+27	+14	+14	+16	....	....	....	....
Coconut 3	....	+28	+14	+14	+16	....	....	....	....
Coconut 4	....	....	+14	+14	{+16 +16}	....	....	....	....
Coconut 5	+18	+26	+14	+14	+16.5	+9	+11	+13	{+32 +32}
Coconut 6	....	+27	+14	+14	+16	....	....	....	....
Bacillus coli	....	+24	+15	+15	+16	....	+11	+14	{+36 +36}
Check	....	+ 6	+ 4	+ 4	+ 3	+3	....	....	....

[1] Distilled water used in these 3 media.

In a dextrose solution in distilled water, originally +5, the culture became +11.5, showing an acid production but not so great (nor so good a growth) as in the presence of peptone also.

In dextrose plus KNO_3, originally +5, the culture became +8, this also showing less growth (and less acid) in the absence of peptone.

Cultures in peptone plus rosolic acid made good growth but did not affect the color. Cultures in peptone plus rosolic acid plus dextrose clouded well and changed from the pink color of the check to a sort of orange yellow, thus indicating the production of an acid.

Cultures in peptone plus neutral red grew well and changed the color of the medium to an orange yellow, in this case showing a slight production of alkali. In cultures containing peptone plus neutral red plus dextrose the growth was good and the color changed to a magenta, thus indicating the production of an acid.

A series of cultures was made in Dunham's solution colored with litmus, some of the tubes containing grape sugar and others without any sugar. Those containing the sugar in three days became well reddened and partially bleached. Those without the grape sugar became well clouded and showed good growth, but did not change in color from the check.

The amount of gas produced in media containing dextrose is shown in Table VII.

TABLE VII.—*Amount of gas (in millimeters) produced by various cultures in different media, experiments 1, 2, 3, and 4.*

Culture.	Peptone plus dextrose at 22° C.										Beef bouillon plus dextrose at 37° C.		
	Experiment 1, Dec. 8–14, 1909.		Experiment 2, Dec. 13, 1909, to Jan. 3, 1910.			Experiment 3, Jan. 17–27, 1910.					Experiment 4, Mar. 16–19, 1910.		
	2 days.	6 days.	1 day.	5 days.	21 days.	2 days.	4 days.	5 days.	7 days.	10 days.	1 day.	2 days.	3 days.
Coconut 1	5	27	0	0	......	1	......	32	45	56	......	......	......
Coconut 1 a	5	46	......	......	......	7	......	36	49	......	......	......	......
Coconut 2	5	13	0	8	2	11	21	......	......	......	45	51	55
Coconut 2 a	5	14	......	......	......	11	......	......	......	......	......	......	......
Coconut 3	0	0	......	......	......	11	......	26	28	26	39	44	46
Coconut 3 a	0	0	0	0	0	11	......	29	30	30	51	56	57
Coconut 4	0	0	......	......	......	0	......	29	30	......	46	52	53
Coconut 4 a	0	0	0	0	0	0	......	0	0	0	44	47	47
Coconut 5	5	15	0	10	4	9	......	20	23	27	41	46	46
Coconut 5 a	5	17	......	......	......	0	......	17	19	14	41	49	53
Coconut 6	0	0	0	0	0	9	......	24	24	24	46	49	50
Coconut 6 a	0	0	......	......	......	15	......	29	29	28	......	......	......
Bacillus coli	......	......	......	......	......	......	......	......	......	......	50	52	48
B. coli a	......	......	......	......	......	......	......	......	......	......	......	47	50

The failure of some of the cultures to produce gas in experiments 1 and 2 while they readily produced it in experiments 3 and 4 is rather striking and not readily explainable. Occasionally, in subsequent experiments not noted here, a similar failure of a certain culture to produce gas in dextrose has occurred. From further cultures of descendants of such a culture, however, it is evident that the same organism has been retained throughout, and that there has been no discernible contamination of the tubes.

PRODUCTION OF ACID AND GAS IN LACTOSE.

Titration of cultures in lactose fermentation tubes showed coconut No. 4 to be +15 and No. 6 +15 on Fuller's scale after growth for 15 days. No checks were titrated at this time, but they usually ran about +5.

In fermentation tubes containing 1 per cent peptone plus 1 per cent lactose in 24 hours no gas was shown. After five days at 22° C. the showing was as follows: Tube 1 a, 34 mm.; tube 2 a, 20; tube 3, 26; tube 4, 20; tube 5 a, 27; tube 6 a, 24.

After 15 days No. 5 a had produced 28 mm. of gas. In 21 days No. 6 a showed only 22 mm. of gas. Evidently the gas production had ceased and that already formed was being partly absorbed.

Table VIII shows the results of a similar experiment in peptone plus lactose at 22° C.:

TABLE VIII.—*Amount of gas (in mm.) produced by various cultures in experiment with 1 per cent peptone plus 1 per cent lactose, at 22° C., February 4 to 18, 1910.*

Culture.	1 day.	3 days.	7 days.	10 days.	14 days.
Coconut 1	0	0	6	12	21
Coconut 2	Tiny bubbles.	9	2	Tiny bubbles.	Tiny bubbles.
Coconut 3	0	0	0	0	0
Coconut 4	0	0	0	0	0
Coconut 5	0	11	8	4	1 large bubble.
Coconut 6	0	0	0	0	0

In the lactose as in the dextrose the ability of the organism to produce gas appears to vary. In the first experiment all of the cultures formed gas; and in the later experiment only three of them, and they apparently with difficulty. The fact that the organism can effect this change, even though it does not always do so, is of value in determining its characteristics. No experiments were carried out using beef bouillon with lactose. In general, the acid production in lactose seems to be less than in dextrose; and the gas formation also, at least in a peptone medium, seems to be effected with greater difficulty than in dextrose.

PRODUCTION OF ACID AND GAS IN SACCHAROSE.

Cultures in peptone plus cane sugar titrated after five days at 22° C., coconut No. 1, +14; No. 5, +13. No check was titrated at this time, but they usually were about +5. The following table shows the gas production:

TABLE IX.—*Amount of gas (in mm.) produced by various cultures in 1 per cent peptone plus 1 per cent cane sugar at 22° C., experiments 1 and 2.*

Culture.	Exp. 1: Dec. 8-28, 1909.				Exp. 2: Feb. 4-20, 1910.				
	1 day.	2 days.	10 days.	20 days.	1 day.	3 days.	7 days.	10 days.	14 days.
Coconut 1	0	5	40	50	0	13	40	50	59
Coconut 1 a	0	5	70	55	....	....	....	....	....
Coconut 2	(1)	5	13	12	5	11	10	5	(2)
Coconut 2 a	(1)	5	13	15	....	....	....	....	....
Coconut 3	0	0	0	[3] 0	0	0	0	0	0
Cocouut 3 a	0	0	0	[3] 0	....	....	....	....	....
Coconut 4	(1)	0	0	0	0	0	0	0	0
Coconut 4 a	0	0	0	0	....	....	....	....	....
Coconut 5	(4)	5	15	20	5	14	10	13	15
Coconut 5 a	(4)	5	17	15	....	....	....	....	....
Coconut 6	0	0	0	(2)	0	0	0	0	0
Coconut 6 a	0	0	0	(2)	....	....	....	....	....

[1] Tiny bubbles.
[2] One large bubble.
[3] Various tubes of this culture previously produced gas in cane sugar.
[4] Small amount.

Here, as in the case of dextrose and lactose, is a failure on the part of certain cultures to produce gas. Coconut Nos. 3, 4, and 6 seem to have less power in this direction than the other cultures. In dextrose and lactose media these cultures sometimes failed and sometimes did not. In the only experiments carried out with cane sugar they failed.

GROWTH IN NITRATE BOUILLON.

Cultures were made in nitrate bouillon, and within two days, tests for nitrites with starch, potassium iodid, and sulphuric acid showed the presence of nitrites, thus indicating the ability of the organism to reduce the nitrates. This test has been repeated many times and in no case did any of the cultures fail to give a good reaction.

COLOR PRODUCTION.

The coconut organism does not produce any pigment. On plain agar the growth is white in direct light. Where the growth is thin on agar plates the colonies in transmitted light are bluish. On potato cylinders there may be a slight yellow color to the growth. On media containing neutral red the growth is pink, eventually fading to orange yellow, but that is undoubtedly due to the presence of the neutral red. On Kashida's litmus-lactose agar (p. 119) the colonies are first slate blue, then red. On Endo's fuchsin agar (p. 88) the growth is bright red, or, at a certain stage, white in direct light and iridescent in transmitted light. All of these colors, however, are doubtless due to reactions in the medium and are not direct products of the bacterial growth.

GROWTH ON STARCH MEDIA.

Experiment 1.—Both the coconut organism and *Bacillus coli* were grown on potato cylinders and after 18 days were tested with an iodin potassium iodid solution for amylodextrin as follows:

Coconut No. 1 showed distinctly the red purple on the addition of Lugol's iodin. Some blue fragments indicated that not all the starch had been converted.

No. 5 showed a good red-purple reaction and also abundance of blue.

Bacillus coli showed red purple almost throughout the cylinder, there being only a few fragments of blue.

Check-potato cylinders showed only a bright Prussian blue on the addition of Lugol's iodin.

Experiment 2.—A nutrient solution consisting of 1 per cent peptone, 2 per cent dextrose, and 0.1 per cent cornstarch was made up, and a number of tubes were inoculated with the coconut and *Bacillus coli* cultures. After incubation for 17 days at 22° C. the tubes were tested for the presence of starch. As it was found in preliminary tests that a small amount of Lugol's iodin gave only a transitory blue, the exact amount used for the test was determined. It was also found that a tube showing a good test for one minute or five minutes might be entirely colorless after a longer time. One minute was selected arbitrarily as the limit of time for the color reaction to persist. It was found that from four to five drops of the iodin solution were necessary to give the Prussian blue starch reaction in a check tube and have it persist for one minute. Among the culture tubes it was found that, on the average, about 80 drops of the iodin solution were necessary to make the dark color persist one minute. While the test gave the bright blue in the check tubes, in all the culture tubes the color reaction was a red purple, or on long standing and adding more iodin a red or rich brown color. There was no evidence of the blue starch reaction in the culture tubes except on examination with the microscope. By this means blue particles could be found, but only in small quantities. This experiment demonstrated clearly that the starch is affected by the organism and in this particular case using a dextrose-peptone medium nearly all of the 0.1 per cent starch was converted.

Experiment 3.—Cultures of the coconut organism and *Bacillus coli* were made in three different media as follows: (1) Two per cent peptone plus 0.05 per cent NaCl plus 0.1 per cent potato starch; (2) the same with the addition of litmus; (3) a third medium similar to the first with the addition of dextrose. The purpose of this experiment was to ascertain if the action of the starch was independent of any sugar present. Litmus was added to the first medium to serve as a check to indicate the presence or absence of acid formation. If any acid were formed it would be from the starch. No titration was made of these cultures. It was assumed from other experiments that an acid would be formed in the presence of the sugar. The results in growth are as follows:

After one day at 37° C: Series 1 has all tubes moderately clouded but no gas; series 2, same with no change in color of litmus; series 3, has all tubes well clouded and abundant gas production.

After two days at 37° C: Conditions same in each tube.

After four days at 37° C: Series 1, all moderately clouded and thin films on surface; no gas formed. Series 2, all moderately clouded with thin film on surface; litmus, shows no signs of reddening nor of bleaching. Series 3, all well clouded with small amount of gas.

Test for starch in series 1: Checks with 26, 30, and 41 drops of iodin solution all showed blue-starch reaction. Culture No. 1 showed very transitory blue with 5 and up to 40 drops of iodin; not tested higher. Culture No. 2 with 61 drops produced a dark purple blue, persistent for at least 1 minute. Culture No. 3, up to 20 drops showed no color; 30 and 40 drops caused a slight tinge of purple. Culture No. 4, from 5 to 30 drops caused a very transient blue; 40 drops produced a blue lasting 5 seconds. Culture No. 5, 15 drops produced no color whatever; not tested higher. Culture No. 6, from 5 to 30 drops caused a very transient blue; 40 drops produced a blue lasting 5 seconds. *Bacillus coli*, as high as 40 drops were added without producing any starch reaction or other color.

Series 2 was not tested owing to the presence of the litmus.

Test for starch in series 3: Checks—(a) transient blue with 10, 15, and more drops; (b) same; (c) transient purple with 10 drops; (d) transient blue with 10 and 15 drops; with 20 drops lasts 5 seconds. Culture No. 1 showed transient red purple with 10 drops; with 15 drops color lasts 1 minute. Culture No. 2 showed dark purple blue with 24 drops. Culture No. 3 showed transient red purple, same as No. 1. Culture No. 4 showed blue at least 30 seconds with 10 drops; blue black and not purple with 15 drops. Culture No. 5 showed bright blue with 10 drops; dense blue black with 15 drops. Culture No. 6 showed purple with 15 drops of iodin. *Bacillus coli* showed purple with 10 drops, lasting slightly longer than with No. 3.

In series 1 no distinct amylodextrin test was obtained, the occasional purple blue being only what may occur in ordinary starch tests. If the iodin solution is added to starch the first reaction is a bright Prussian blue, but this on standing ultimately often becomes purple. The distinct red-purple reaction formed in some of the tests of series 3 is the typical reaction and one quite distinctive. This experiment tends to show that the diastase, if it is a diastase that produces the change from starch to amylodextrin, is produced in the presence of a sugar and not in its absence.

Experiment 4 a.—Cultures were made on slant potato-starch jelly tubes and incubated at 37° C. In 24 hours coconut cultures Nos. 3 and 4 showed good narrow, dry streaks. The other cultures showed no growth. In three days all the tubes but coconut No. 5 showed good growth on the surface of the slant. No 3 was tested with Lugol's iodin solution, but showed no signs of amylodextrin. No. 1 showed a slight red-purple coloration. None of the other cultures showed any signs of the amylodextrin reaction; all were bright blue.

Experiment 4 b.—This experiment was repeated and the tubes were tested, after growth, for five days at 37° C. In the *Bacillus coli* tube the application of the iodin solution indicated the change of amylodextrin over the surface of the slant and around the outside of the cylinder next to the glass halfway down the tube. This change did not extend to any appreciable depth. In the coconut-culture tubes the slightest indication of the amylodextrin was seen on applying the iodin solution. Practically all the color in these tubes was the bright Prussian blue characteristic of the pure starch.

Experiment 4 c.—Other cultures were made of coconut No. 5 and *Bacillus coli* upon slant jelly. Two tubes of each culture were inoculated for 23 days at 37° C. At the end of that time each tube had about 1 c. c. of a watery fluid, apparently from the disintegration of the starch; there was good growth, and in the case of *Bacillus coli* the jelly was somewhat browned. Examination of the cultures showed results as follows:

Coconut No. 5: The jelly is soft on the surface and sides, firm beneath. The test shows abundant red-purple coloration. About three-fourths of the cylinder was unaffected by the organism and showed a good blue starch reaction.

Coconut No. 5 a : Same as No. 5.

Bacillus coli: The jelly is very soft. The test shows nearly all red purple with only a small amount of blue reaction.

Bacillus coli a: Like Nos. 5 and 5 a in every respect.

Experiment 4 d.—Another series of cultures was made in which the six coconut organisms and four strains of *Bacillus coli* were used. After incubation for two weeks at 37° C. the tubes showed the following conditions:

Coconut No. 1: No sign of growth on slant; no amylodextrin shown by test. Nos. 2, 3, 4, and 5: Good slightly yellow streak; no amylodextrin. No. 6: Good distinctly yellow streak; no amylodextrin.

Bacillus coli (Hitchings) No. 1: Good yellowish growth over entire surface; liquefaction along sides; large amount of amylodextrin shown by test. *Bacillus coli* (Hitchings) No. 2: Narrow slightly yellow streak; some water; small amount of amylodextrin. *Bacillus coli* (VI–11–V–09) No. 1: Good yellowish growth over entire surface; abundant water along sides; definite but small amount of amylodextrin. *Bacillus coli* (VI–11–V–09) No. 2: Same growth and amount of amylodextrin. *Bacillus coli* (B. A. I.) No. 1: Same growth; small amount of amylodextrin. *Bacillus coli* (B. A. I.) No. 2: Good growth on surface and some water; no amylodextrin. *Bacillus coli* (Theobald Smith, XIV) No. 1: Narrow streak; very small amount of amylodextrin. *Bacillus coli* (Theobald Smith, XIV) No. 2: Narrow brown streak; small amount of amylodextrin.

Summary of starch-media experiments.—The results of these experiments may be briefly summarized as follows:

Experiment 1. Potato cylinders, amylodextrin formed.
2. Peptone-dextrose cornstarch solution, amylodextrin formed.
3. Peptone-potato starch solution, amylodextrin formed.
Peptone-dextrose potato-starch solution, no amylodextrin formed.
Peptone-potato starch with litmus, no acid formed; not tested for amylodextrin.
4 a. Starch jelly, no amylodextrin.
4 b. Starch jelly, amylodextrin formed.
4 c. Starch jelly, amylodextrin formed.
4 d. Starch jelly, no amylodextrin formed.

These experiments demonstrate the ability of the coconut organism as well as *Bacillus coli* to change starch into amylodextrin, although this power appears to be variable. *Bacillus coli* is, in general, more constant in this power and usually more effective. Contrary to the foregoing results of the author in regard to *Bacillus coli*, Savage[1] states that true *Bacillus coli* does not ferment starch.

PRODUCTION OF ACID AND GAS IN GLYCERIN.[2]

Cultures in peptone plus glycerin after growth for 5 days titrated +10 for cultures of coconut No. 3 and +11 for coconut No. 4. The gas production in this medium is shown in the following table:

TABLE X.—*Amount of gas (in mm.) produced in 1 per cent peptone plus 1 per cent glycerin at 22° C., February 4 to 20, 1910.*

Culture.	1 day.	3 days.	7 days.	10 days.	14 days.
Coconut 1	0	0	0	0	0
Coconut 2	One bubble.	11	13	10	10
Coconut 3	0	0	0	0	0
Coconut 4	0	0	0	0	0
Coconut 5	Few bubbles.	10	11	11	10
Coconut 6	0	0	0	0	0

In Table X it is seen that cultures Nos. 2 and 5 have produced gas in the glycerin medium while the others have failed. This experiment was repeated to determine if the same result would again be obtained at a higher temperature. The results appear in Table XI.

[1] Savage, W. G. The Characters of the Bacillus Coli as an Indicator of Excretal Contamination. Lancet, London, vol. 168, Feb. 4, 1905, p. 287.

[2] Giddings, N. J. A Bacterial Soft Rot of Muskmelon, Caused by Bacillus Melonis, n. sp. Bulletin 148, Vermont Agricultural Experiment Station, January, 1910, p. 400. The author reports 6 per cent of gas formed in nutrient broth cultures of *Bacillus coli* containing 2 per cent glycerin.

TABLE XI.—*Amount of gas (in mm.) produced by various cultures in 1 per cent peptone plus 1 per cent glycerin at 37° C., June 18–27, 1910.*

Culture.	2 days.	3 days.	4 days.	7 days.	9 days.
Coconut 1	([1])	([1])	([1])	([1])	([2])
Coconut 2	[3] 36	([4])	40	41	40
Coconut 3	([1])	([1])	([1])	([1])	([2])
Coconut 4	([1])	([1])	([1])	([1])	([2])
Coconut 5	[3] 32	([4])	32	32	30
Coconut 6	([1])	([1])	([1])	([1])	([2])
Bacillus coli (Hitchings)	([1])	([1])	([1])	18	21
Bacillus coli (B. A. I.)	([1])	± 5	11	27	32
Bacillus coli (XIV)	([1])	([1])	([5])	29	32
Bacillus coli (VI–11–V–09)	([1])	± 5	17	27	27
Check	([6])	([6])	([6])	([6])	([6])

[1] No gas; barely clouded in closed end.
[2] No gas; thinly clouded in closed end.
[3] Moderately clouded in closed end.
[4] About as before.
[5] Two large bubbles of gas.
[6] Clear in both ends.

GROUP NUMBER OF THE COCONUT ORGANISM.

It has been found in some of the preceding experiments that the six coconut cultures were neither constant nor identical in their reaction in every medium. In the case of liquefaction of gelatin, No. 1 liquefied the gelatin after several weeks, the others not even after six months. In dextrose medium all produced gas; No. 1 more than the others. In lactose medium all produced gas sometimes, but not always. In media containing saccharose as the only carbohydrate all the cultures produced gas at one time or another. In nitrate bouillon all the cultures reduced the nitrates to nitrites. As to color of the colonies, all may be considered nonchromogenic. As to growth on starch media, the coconut organisms have been definitely proved to have a variable effect on the starch, sometimes converting it rapidly into amylodextrin but more frequently feebly or not at all. In glycerin media the production of gas occurred only in Nos. 2 and 5. Doubtless the other strains might also produce gas if grown under the right conditions. It seems more reasonable to believe this than not for this reason: Nos. 2 and 5 are cultures isolated from two different coconut seedlings which were inoculated with Nos. 1 and 4, respectively, and 1 and 4 have here behaved alike. Moreover, Nos. 2 and 5, after being isolated, were reinoculated into two different coconut seedlings and from them were derived cultures Nos. 3 and 6, respectively, these being identical in this case with Nos. 1 and 4. That in such a set of experiments Nos. 3 and 5 are different species or varieties is an idea scarcely conceivable. Granted that this organism, represented by the six strains is capable of producing gas in glycerin media, it then appears that for this organism the following formula according to the chart of the Society of American Bacteriologists must be used: 222.1111021. The identity of this formula with that of *Bacillus coli* is at once apparent. Under these circumstances many more biological features of the coconut organism must be ascertained in order to distinguish it from or to identify it with the colon organism. As much work has been done by various investigators toward ascertaining a ready means of identifying *Bacillus coli*, it has been deemed advisable to consider these special means of identification before taking up the many miscellaneous biological features commonly discussed in this sort of work.

Special Test Reactions for the Identification of the Organism.

Various bacteriologists, working in connection with public boards of health or independently, have adopted routine methods for determining the presence of *Bacillus coli* in drinking water or elsewhere. In some cases these methods are considered by their users as sufficient to ascertain definitely the presence or absence of this organism. In other cases the probabilities are that the organism in question is *Bacillus coli* or some closely allied form. The tests made consist of only one or two or of several reactions. The adoption of the special methods here will be of service, not only in characterizing the coconut organism, but also in ascertaining any differences that there may be between it and *Bacillus coli*.

Of those reactions described in the following pages Dr. Theobald Smith [1] claimed that the production of gas to the amount of 40 to 70 per cent in dextrose media demonstrated the presence of the colon group of bacteria, the hog cholera group, *Bacillus lactis aerogenes*, and Friedlander's bacillus. In order to determine from among these various bacteria the true *Bacillus coli*, Dr. Smith suggested [2] that the following reactions were sufficient: Growth on gelatin in the form of delicate bluish or more opaque whitish expansions with irregular margins; actively motile when examined in a hanging drop from young surface colonies taken from the gelatin plates; coagulation of milk within a few days; growth upon potato either a rich, pale or brownish yellow deposit, or merely glistening, barely recognizable; also gives a distinct indol reaction.

Behavior of the organism in the fermentation tube must conform to the following scheme:

Variety A: One per cent dextrose bouillon at 37° C. Total gas about one-half the volume of the closed arm. Proportion of hydrogen to carbon dioxide about 2:1. Reaction strongly acid.

One per cent lactose bouillon. As in dextrose bouillon with slight variations.

One per cent saccharose bouillon. Gas production slower than in the preceding. Total gas finally about two-thirds. Proportion of H to CO_2 nearly 3 to 2. The final reaction in the bulb may be slightly acid or alkaline according to the rate of gas produced.

Variety B: The same as variety A, except that in saccharose bouillon neither gas nor acid is formed.

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[1] Smith, Theobald. The Fermentation Tube. The Wilder Quarter-Century Book, 1893, p. 229.

[2] Smith, Theobald. Notes on Bacillus Coli Communis and Related Forms. American Journal of Medical Science, vol. 110, 1895, pp. 283-302.

Dr. B. H. Stone [1] describes a rapid method of identifying *Bacillus coli* in water. A fermentation tube is filled with 2 per cent glucose bouillon and this is inoculated with 1 cubic centimeter of the water to be examined and grown 24 hours at 38° C. If from 25 to 70 per cent of gas is formed in the closed arm *Bacillus coli* is probably present. From those tubes which produce this amount of gas transfers of 0.5 c. c. are made to tubes containing 10 c. c. of neutral broth to which has been added 0.3 c. c. of Parietti's solution, and the tubes are grown 24 hours at 38° C. From those tubes containing Parietti's solution transfers of 0.5 c. c. are made to fresh fermentation tubes, and if gas is produced as before there is reasonable certainty that the organism is *Bacillus coli*. Further confirmation is obtained by ascertaining the gas formula, that of the colon group being $H:CO_2::2:1$.

Further transfers from the supposed *Bacillus coli* may be made into gelatin stab cultures, into litmus milk, and into Dunham's solution for indol. Also the morphology may be ascertained. These reactions are considered by Dr. Stone sufficient to verify the identification of *Bacillus coli*.

Drs. F. F. Longley and W. U. C. Baton [2] have published their routine method for identifying *Bacillus coli* in water, as follows:

1. Incubation in ordinary dextrose broth and fermentation tubes at 40° C. for 24 hours. From those tubes showing gas within 24 hours transfers are made to litmus-lactose-agar plates.

2. The litmus-agar plates are incubated at 40° C. for 18 to 26 hours. From those colonies which appeared red on these plates transfers are made to agar slants.

3. Agar slants are incubated for 24 hours at 40° C. Those slants which have the typical cultures characteristic of *Bacillus coli* are not examined microscopically. Atypical colonies are examined before discarding.

4. A. Those agar slants which show typical cultures are transferred to dextrose broth fermentation tubes and incubated at 40° C. for 24 hours. The absence of gas is considered negative. The quantity of gas present and the proportion of CO_2 are not determined.

4. B. Milk. Transfers to milk cultures are incubated at 40° C. for two days and examined daily for coagulation and digestion of the casein. Coagulation indicates *Bacillus coli*.

4. C. Nitrate broth cultures. Incubated at 40° C. for two days and then tested for nitrites. The presence of nitrites indicates *Bacillus coli*.

4. D. Peptone broth. Cultures incubated for three days at 40° C. and tested for indol. Presence of indol indicates *Bacillus coli*.

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[1] Stone, B. H. A Rapid Method of Detecting Bacillus Coli Communis in Water. American Medicine, vol. 3, Jan. 25, 1902, p. 154.

[2] Longley, F. F., and Baton, W. U. C. Notes on the Determination of Bacillus Coli in Water. Journal of Infectious Diseases, vol. 4, 1907, pp. 397–416.

Dr. W. G. Savage [1] studied the following points in identifying *Bacillus coli:* Motility, liquefaction of gelatin, type of colony on gelatin, indol production, acid production, milk coagulation, and fermentation of dextrose and lactose.

Dr. D. Rivas [2] states that the usual method for identifying *Bacillus coli* is as follows:

Plating out in Wurtz's litmus-agar plates with 1.5 to 2 per cent Parietti's solution. Examined after 24 hours' incubation at 37° C. All the pink colonies are isolated and transferred to sugar media for fermentation.

Transfers are made to Dunham's solution to test for indol. Also to nitrate bouillon to test for reduction of nitrates to nitrites.

Further transfers are made to gelatin tubes for liquefaction or nonliquefaction.

Dr. J. J. Kinyoun uses Endo's fuchsin agar for the determination of *Bacillus coli.* His method of making up the medium is one that he considers as furnishing a very distinctive test, as follows:

Take 2 liters tap water, 40 grams Liebig's meat extract, 40 grams Witte's peptone, 20 grams sodium chlorid, 160 grams agar flour. Put into a tall beaker and steam for three hours. Let settle over night. Cut off dirty part and throw away. Melt the remainder and neutralize to phenolphthalein. Add 4 c. c. of $\frac{N}{1}$ hydrochloric acid. Steam one hour. This forms the stock, which should be clear. The crux of the whole formula lies in the following: Take 200 c. c. of this hot stock and add to it 2 grams of lactose. Then add 2 c. c. of a solution of basic fuchsin (half-saturated solution) and 10 c. c. of fresh sodium-sulphite solution (5 grams to 100 c. c. of water). Divide into eight lots of 25 c. c. each to form the trial lots. Make up a 10 per cent solution of sodium carbonate, and add of this to the trial lots, in varying amounts, as follows: 0.01 c. c., 0.02 c. c., 0.03 c. c., 0.04 c. c., etc. Pour into large plates, cool, and streak for colon, typhoid, etc. Incubate 24 hours at 37° C. The standard of alkalinity to be used on the remainder of the stock is that of the plate which has given the most characteristic results. Fill and set away the stock in 100 c. c. portions in bottles plugged with cotton. As there is much water of condensation, the agar is hardened in the plates uncovered in a clean place. Air germs (exclusive of molds) seldom grow on it.

These points are stated to be the most essential in the identification of *Bacillus coli.*

The growth of the coconut organisms in various other media is described on the following pages.

DOLT'S SYNTHETIC MEDIUM NO. 1.

On slant cultures in Dolt's medium a good pink growth appeared within 24 hours, and the agar became partly reddened. Evidence of gas appeared in tubes of coconut No. 2 and *Bacillus coli.* Repetition of this experiment gave exactly the same result with the exception of no gas production. The growth along the streak was for the most

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[1] Savage, W. G. The Characters of the Bacillus Coli as an Indicator of Excretal Contamination. Lancet, London, vol. 168, Feb. 4, 1905, p. 284.

[2] Rivas, D. B. Coli Communis, "The Presumptive Test," and the Sewage Streptococci in Drinking Water. Journal of Medical Research, vol. 16, 1907, pp. 85–98.

part wet shining, smooth, and with raised margins. Near the top the growth consisted of more or less isolated colonies. In tube No. 1 a subsequent tendency to bleaching of the litmus appeared. In all the tubes the litmus was first reddened.

This medium is made up as follows:[1]

	Cubic centimeters.
Purified agar (3 per cent solution)	500
Glycerin ..... 5 grams; Ammonium phosphate .. 1 gram; Distilled water	500

NaOH was used to neutralize, and 1 per cent lactose added just before sterilization. Litmus was added in sufficient quantity to make a good blue color.

NEUTRAL RED USED IN VARIOUS MEDIA.

The use of neutral red in differentiating *Bacillus coli* from other species has been widely recommended. A few other organisms behave in a similar way, but the reaction at least differentiates a group of organisms if not a single one. A useful way to use neutral red in determining *Bacillus coli* is in fermentation tubes. This method and others are here described.

TABLE XII.—*Growth of coconut and Bacillus coli cultures of March 15, 1910, in fermentation tubes, using neutral red with 1 per cent dextrose and 1 per cent peptone solution in river water, incubated at 37° C.*

Culture.	3 days.	6 days.	8 days.	15 days.
Coconut 5	Greenish in closed end; 30 mm. gas.	Pink in open end; greenish-yellow in closed end.	Pale pink in closed end; bright pink in open end; 33 mm. gas.	No change.
Coconut 5 a	Pink in both ends; 25 mm. gas.	....do	Greenish yellow in closed end; pink in open end; 28 mm. gas.	Do.
Bacillus coli	Pink in both ends; 26 mm. gas.	Pink in both ends	Pink in both ends; 32 mm. gas.	Do.
Bacillus coli a	Greenish in closed end; 24 mm. gas.	Pink in open end; bleached in closed end.	Pale pink in closed end; bright pink in open end; 27 mm. gas.	Do.

The greenish-yellow color seen in tubes 5 and *Bacillus coli* a of this experiment is typical of the neutral-red reaction. Tubes 5 and 5 a, *Bacillus coli* and *Bacillus coli* a, derived, respectively, from 5 and *Bacillus coli*, did not show the same reaction. As the two tubes each from different cultures were made under the same conditions from the same tubes, this difference in results suggests an unreliability in the reaction. Further work, however, tends to show that the greenish-yellow or canary-yellow color is generally present. In other media it is demonstrated more clearly.

[1] Dolt, Maurice L. Simple Synthetic Media for the Growth of Bacillus Coli and for Its Isolation from Water. Journal of Infectious Diseases, vol. 5, 1908, p. 625.

Cultures with peptone and dextrose plus neutral red were made in ordinary test tubes. The check was an orange-red color. The culture tubes became in four days a magenta. In nine days they were a deep magenta with the exception of tube No. 1, which had paled to an orange red.

The change to an orange-red color may be accounted for by the production of ammonia, a small amount of which is found in peptone cultures of this organism. (See p. 93.)

This experiment was repeated with the same results. The color of the culture solutions (except No. 1, almost bleached) in transmitted light corresponds to Tyrian rose, tint No. 3, Répertoire de Couleurs, Publié par la Société Française des Chrysanthémistes.

Cultures without dextrose were made. In four days these still remained a pink color, though a trifle paler than the check. In nine days all were orange red.

This experiment was repeated with the same result. The color of the culture corresponded to reddish terra cotta, tint No. 2, Répertoire de Couleurs. The check tube very closely corresponded to the reddish old rose, tint No. 4.

In none of these cultures in peptone solutions with neutral red in straight test tubes was there any of the canary-yellow color produced. This is undoubtedly due to the strictly aërobic condition of the straight tube containing a liquid, while in the straight tube with the solid agar or in the fermentation tube anaërobic conditions existed which apparently are necessary for this canary-yellow reaction. The change of color under aërobic conditions with and without dextrose was caused by the acid production. In the presence of sugar acids are produced which change neutral red to a magenta color. The production of acid was not tested except in the presence of dextrose, saccharose, lactose, and glycerin; but gas, which is an indication of acid production, was observed to form in the presence of levulose, galactose, and mannit.

TABLE XIII.—*Growth of various cultures of March 18, 1910, on agar, containing neutral red and dextrose, at 37° C.*

Culture.	1 day.	3 days.	5 days.
Check	Red	Red	Red.
Coconut 1	Red; gas; pink surface growth.	Lower three-fourths canary yellow; upper part pink; pink growth on surface; color somewhat bleached at top.	Practically all bleached to a canary yellow.
Coconut 2	Yellowish-green spots in agar; gas; pink growth.	Lower three-fourths canary yellow; pink growth on surface.	Same as before.
Coconut 3	do	do	Do.
Coconut 4	do	do	Do.
Coconut 5	do	do	Do.
Coconut 6	do	do	Do.
Bacillus coli	do	do	Do.

This experiment was repeated with another lot of neutral-red agar, believed to be the same as the first lot, with the exception of titrating three degrees higher on the Fuller scale. Whatever the cause may have been there was no change in the color of the medium from pink to canary yellow. A moderate amount of pinkish growth appeared on the surface, but otherwise there was no characteristic reaction. This medium was made up in each case with 1 per cent agar flour, beef bouillon made with distilled water, 2 per cent dextrose, and enough neutral red to make a bright pink.

In MacConkey's bile-salt agar (for full description see p. 83) consisting of peptone, sodium taurocholate, lactose, and neutral red, the canary-yellow color in the lower part of the medium was very striking.

According to Hunter,[1] Rosenberger,[2] and Moore and Revis,[3] the neutral-red reaction is characteristic of *Bacillus coli* and a few other organisms. This reaction is thus useful in separating this group of organisms from others. Moore and Revis have found that under certain conditions the canary-yellow reaction does not always result. In particular they found that in the presence of glucose the reaction seldom occurred. Lactose was considered to be the best sugar to use, and the result in MacConkey's bile-salt agar containing lactose seems to verify this. It is stated by these authors that the canary-yellow color is only transitory when resulting in glucose media.

For a further test of the constancy of this canary-yellow reaction experiments were made with agar media without sugar, with lactose, with dextrose, with saccharose, and with glycerin. The six coconut organisms and *Bacillus coli* were grown in these media in two different experiments. Table XIV shows the results of these experiments with *B. coli* and coconut No. 5.

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1 Hunter, William. The Diagnosis of the Presence of Bacillus Coli Communis by Means of Neutral Red. British Medical Journal, Sept. 21, 1901, pp. 791–792.

2 Rosenberger, R. C. The Identification of the Colon Bacillus by Reactions Produced in Culture Media Containing Neutral Red. Philadelphia Medical Journal, vol. 9, Mar. 8, 1902, pp. 446–449.

3 Moore, Ernest W., and Revis, Cecil. The Neutral-Red Reaction for Bacillus Coli Communis. Journal of Pathology and Bacteriology, vol. 10, 1904–5, pp. 97–104.

TABLE XIV.—*Growth of Bacillus coli and coconut No. 5 on agar containing neutral red and various sugars, May 9–21, 1910, at 37° C.*

Culture and medium.	1 day.	2 days.	7 days.	12 days.
Bacillus coli:				
Without sugar.	Pink growth; liquid in V greenish fluorescent.	Excellent growth in each tube.	Both growth and agar entirely changed to a greenish-orange yellow.	Orange color throughout.
With lactose...	Pink growth; slight greenish color in V	.....do...........	Growth on surface bright pink.	No sign of change of color to greenish; all red.
With dextrose.	Same as without sugar.	.....do...........	.....do...........	All red.
With saccharose.	.....do...........	.....do...........	Almost entirely greenish yellow.	Greenish-orange yellow throughout.
With glycerin..	.....do...........	.....do...........	Growth on surface, pink; one-third of agar greenish yellow.	Pink growth; agar greenish yellow, fluorescent.
Coconut 5:				
Without sugar.	Pink growth; bright green fluorescence in V.	Same as before, only in each case the green extends to bottom of tubes.	Changed from pink to orange yellow with a green tinge.	Orange color throughout.
With lactose...	.....do...........	.....do...........	Bright red; shows no sign of greenish yellow.	Bright red.
With dextrose.	.....do...........	.....do...........	.....do...........	Do.
With saccharose.	.....do...........	.....do...........	Greenish yellow in lower part of front.	Most of growth is pink; firm part of agar greenish yellow.
With glycerin.	.....do...........	.....do...........	Bright red; shows no sign of greenish yellow.	No change in color.

In these experiments coconut No. 1 reduced the color in nearly every instance. The remainder were for the most part like *Bacillus coli* and coconut No. 5. In nearly every case the culture in medium without sugar changed to the greenish-fluorescent and then to an orange-yellow color. In the media with lactose, dextrose, and glycerin the same greenish-fluorescent reaction took place over a part of the medium and growth, and then a darker purplish-red color appeared. In the medium with saccharose there is the same apparently permanent change to orange yellow from the pink to greenish fluorescence as in the tubes with no sugar.

MACCONKEY'S BILE-SALT AGAR WITH NEUTRAL RED.

The sodium taurocholate and the lactose in this medium are said to have an inhibitive effect on nearly all but the intestinal bacteria. The addition of neutral red further aids in separating the species. The medium here used was made up according to the method in Eyre's Bacteriological Technique, page 169.[1]

[1] See also Grunbaum, A. S., and Hume, E. H., "Note on Media for Distinguishing Bacillus Coli, Bacillus Typhosus, and Related Species," in British Medical Journal, June 14, 1902, pp. 1473–1474.

TABLE XV.—*Growth of coconut cultures Nos. 1 to 6 and Bacillus coli on MacConkey's bile-salt agar with neutral red in slant tubes, April 22 to May 2, 1910, at 37° C.*

Culture.	1 day.	3 days.	6 days.	10 days.	18 days.
1	Greenish fluorescent liquid in lower part of V; in upper part, pink suspension; no gas; good pink growth like that on ordinary agar.	No gas; upper part of agar dull pink; lower part greenish yellow; pale pink growth on slant.	Somewhat bleached.	Somewhat bleached throughout.	Same as on tenth day.
2	Gas; otherwise like culture 1.	Gas; color like culture 1, except for bright pink growth on slant.	Same as on third day.	Bright pink growth on surface; portion of agar is greenish yellow.	Bright pink throughout.
3	No gas; otherwise like culture 2.	do	do	Same as culture 2, only more greenish yellow.	Only a tinge of greenish yellow.
4	do	No gas; growth and color like culture 2.	do	Bright pink throughout.	Bright pink throughout.
5	Same as culture 2	Gas; like culture 2.	do	do	Do.
6	Same as culture 3	do	do	do	Do.
Bacillus coli.	do	do	do	do	Do.

TABLE XVI.—*Growth of coconut cultures Nos. 1 to 6 and Bacillus coli on MacConkey's bile-salt agar with neutral red on plates, April 26 to May 2, 1910, at 37° C.*

Culture.	2 days.	4 days.	6 days.	14 days.
1	Numerous fairly large white colonies.	Round, wet-shining, semitransparent, slightly pinkish colonies; agar translucent.	Same as on fourth day.	Same as on sixth day.
2	Many tiny submerged bright pink colonies; surface colonies small, round, white or with pinkish tinge.	Numerous tiny submerged pink colonies; moderate number of surface white or pinkish colonies; agar dull pink, opaque.	do	Pink surface colonies; bright pink submerged colonies; agar semiopaque.
3	Few colonies with peculiar tiny projections.	Numerous tiny submerged pink colonies; moderate number of surface white or pinkish colonies; agar translucent.	do	Same as culture 2, only agar is translucent.
4	Few colonies; not at all characteristic.	Same as culture 3	do	Do.
5	Same as culture 2	Same as culture 2	do	Like culture 2.
6	Few colonies; not at all characteristic.	Like culture 5, only agar is translucent.	do	Pink surface colonies bright pink submerged colonies; agar translucent.
Bacillus coli.	Like culture 2	Like culture 5	do	Like culture 2.

From these experiments it will be seen that the organism in question grew very well on this medium, equally well with the *Bacillus coli* used. There was a little variation in the plates, but all the tubes were practically alike with the exception of No. 1. It will be noted that the greenish-yellow fluorescence was only a transitory character, and that subsequent to it a bright pink or slightly purplish-pink semiopaque color was produced quite in contrast to the semitransparent orange-red of the check tubes. This reaction appears to be similar to that already discussed in the foregoing pages.

TEST 1 OF D. RIVAS.[1]

One-fourth c. c. of a 48-hour culture in neutral dextrose bouillon was rapidly boiled in about 5 c. c. of a 10 per cent solution of NaOH. Tests made with both the coconut organism and *Bacillus coli* gave the typical clear lemon-yellow color reaction of this test.

The color in this reaction is discharged by acid and restored by alkali. This reaction depends upon the biological action of the bacteria upon the sugar.

This experiment was also tried using beef bouillon +14 instead of neutral, with the same results. Cultures in 1 per cent peptone with 2 per cent dextrose, titrating +3 likewise gave the same lemon-yellow reaction.

TEST 3 OF D. RIVAS.

According to Dr. Rivas,[1] *Bacillus coli* does not exhaust all the sugar from a medium, at least if there is any large amount. On this ground he would separate this organism from closely allied ones which he would place in a so-called saccharolytic group, i. e., those capable of exhausting all the sugar. So incomplete is the exhaustion of sugar by *Bacillus coli* that it is inadvisable to use it for the purpose of freeing beef bouillon from the small amount of muscle sugar it may contain. *Bacillus cloacæ* is said to be much preferable. At least a partial explanation of this condition is that *Bacillus coli* produces so much acid in the presence of sugar that it prevents the extensive growth that would otherwise take place.

For the purpose of identifying the coconut organism with *Bacillus coli* tests were made of cultures in sugar solutions to ascertain the relative amount of sugar used in the growth of the organisms.

Two methods were used for determining the amount of sugar remaining in the cultures after a certain amount of growth. Fehling's solution was diluted with an equal amount of water and divided among a number of small test tubes, 1 cubic centimeter being placed in each. To these the cultures were added in increasing amounts, beginning with one, two, three, etc., drops up to 1 cubic centimeter, and the mixture was then boiled. In the other experiments a less accurate method was used. Fehling's solution was added directly to each 10 c. c. of the culture tubes. Amounts from 2 to 3 c. c. were added at a time and then boiled to bring about the reduction. Fehling's was added only until the light orange-red color of the heated solution began to change to a greenish tinge.

(1) Cultures of February 26 in medium 4192, tested after 55 days in Dunham's solution with 2 per cent dextrose. The average of six

[1] Rivas, D. Contribution to the Differentiation of Bacillus Coli Communis from Allied Species in Drinking Water. Journal of Medical Research, vol. 18, 1908, pp. 81-91.

tests with check solutions resulted in four drops of the sugar solution being sufficient to reduce completely 1 c. c. of Fehling's solution.

The cultures gave results as follows:

No. 2: 2 drops reduced 1 c. c. of Fehling's; that is, twice the amount of sugar. (This must be incorrect.)

No. 5: 4 drops reduced 1 c. c. of Fehling's; that is, no measurable amount of sugar was consumed.

No. 6: 5 drops reduced 1 c. c. of Fehling's; that is, one-fifth the amount of sugar.

Bacillus coli: 6 drops reduced 1 c. c. of Fehling's; that is, one-third the amount of sugar.

No. 3: 5 drops reduced 1 c. c. of Fehling's; that is, one-fifth the amount of sugar.

No. 4: 5 drops reduced 1 c. c. of Fehling's; that is, one-fifth the amount of sugar.

(2) Cultures in medium 4268 tested after five days in Dunham's solution with 1 per cent dextrose, incubated at 37° C.

Bacillus coli: 10 c. c. reduced 16.5 c.c. Fehling's = one-fifth of the total amount.

Bacillus coli a: 10 c. c. reduced 18 c. c. Fehling's = one-tenth of the total amount.

No. 5: 10 c. c. reduced 17 c. c. Fehling's = three-twentieths of the total amount.

No. 5 a: 10 c. c. reduced 18 c. c. Fehling's = one-tenth of the total amount.

According to calculation the check tube of 10 c. c. with 1 per cent dextrose requires 20 c. c. of Fehling's to reduce it.

(3) Cultures similar to those in experiment 2 tested after 47 days. These cultures were dried down to less than one-half their original amount. As only a portion of each tube was tested the cultures were diluted to their original amount and well shaken up before using. It was found by repeated experiments with tubes of *Bacillus coli* and coconut No. 5 that 1 c. c. of the culture solution just completely reduced 1 c. c. of Fehling's solution. As 10 c. c. of Fehling's is supposed to reduce 0.05 grams of dextrose, 1 c. c. must reduce 0.005 grams, and as the amount of dextrose used was 0.01 grams to the cubic centimeter, one-half the original amount had been consumed by the bacteria.

(4) Cultures in medium 4193, 1 per cent peptone and 2 per cent dextrose, tested after 12 days.

Ten c. c. of culture No. 5 in this solution were able to reduce only 30 c. c. Fehling's, thus showing that about one-fourth of the sugar had been used.

It required 40 c. c. of Fehling's solution to be completely reduced by the 10 c. c. of the check culture solution.

(5) Cultures of February 26 in medium 4192, tested after 23 days. (See experiment 1.) The number of cubic centimeters of Fehling's solution reduced by 10 centimeters of culture was as follows:

No. 5, 38; *Bacillus coli*, 20; No. 1, 15; No. 3, 30; No. 6, 32; No. 4, 38; check, 43; check, 43.

(6) Cultures in medium 4229, neutral beef bouillon plus 1 per cent dextrose, after 48 hours at 37° C. The number of cubic centimeters of Fehling's solution reduced by 10 centimeters of culture was as follows:

No. 6, 10; No. 1 a, 10; No. 5, 10; No. 1, 10; No. 4 a, 11; No. 4, 5; No. 3, 10; *Bacillus coli*, 10; check 2, 20; check 5, 10.

The results in this experiment indicate that on an average one-half of the sugar was exhausted in 48 hours.

The experiments may be summarized as follows:

Experiment 1: In 2 per cent dextrose after 55 days.
Bacillus coli used one-third of the amount of sugar.
Coconut used one-fifth of the amount of sugar.

Experiment 2: In 1 per cent dextrose after 5 days.
Bacillus coli used two-twentieths to four-twentieths of the amount of sugar.
Coconut used two-twentieths to three-twentieths of the amount of sugar.

Experiment 3: In 1 per cent dextrose after 47 days at 37° C.
Bacillus coli used one-half of the amount of sugar.
Coconut used one-half of the amount of sugar.

Experiment 4: In 2 per cent dextrose after 12 days.
Bacillus coli not tested.
Coconut (No. 5) used one-fourth of the amount of sugar.

Experiment 5: In 2 per cent dextrose after 23 days.
Bacillus coli used one-half of the amount of sugar.
Coconut used one-twentieth to one-third of the amount of sugar.

Experiment 6: In 1 per cent dextrose after 48 hours at 37° C.
Bacillus coli used one-half of the amount of sugar.
Coconut used one-half to three-fourths of the amount of sugar.

In these experiments the amounts given for coconut are the average of the coconut organism series 1 to 6. The results indicate that from small quantities up to one-half [1] the amount of sugar in a 1 per cent or 2 per cent solution of dextrose is broken up by the organism. In experiment 6 the limit of coconut is given as three-fourths. This unusual amount may be due to error in the test, for it is difficult, even with the utmost care, to ascertain the exact end of the reduction in each case. In general, it seems safe to assume that any error lies on the side of reckoning too much sugar used rather than too little. It is a very easy matter to allow a little of the blue Fehling to stand unnoticed in the intense orange-red of the reduced solution. In these experiments, however, it is shown that *Bacillus coli* and the coconut organisms behave much alike in their relation to the sugar content of the medium.

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[1] Scruel, M. Contribution à l'Étude de la Fermentation du Bacille Commun de l'Intestin." Archives Médicales Belges, ser. 4, vol. 1, 1893, pp. 9–33, 83–107.

M. Scruel records, for the amount of sugar consumed, the following: 1 day, 0.92 out of 3; 2 days, 1.22 out of 3; 3 days, 1.25 out of 3; 6 days, 1.28 out of 3. And another time: 1 day, 0.50 out of 2; 2 days, 0.78 out of 2; 3 days, 0.81 out of 2; 4 days, 0.88 out of 2.

GROWTH ON ENDO'S FUCHSIN AGAR.

Endo's method has been particularly discussed by Herford [1] and Ruata.[2] By the latter it has been stated that one difficulty with the method is the instability of the medium, due to the looseness of the combination of fuchsin with the sodium sulphite and the inconstancy of the color reaction. Notwithstanding this objection, the writer believes that the variation of the medium will be the same for *Bacillus coli* as for the coconut organism, so that the behavior of the organisms on this medium can be compared regardless of any such difficulty.

The method of making Endo's fuchsin agar as given by Ruata, is as follows:

Half a kilogram of powdered meat, 1 liter of water, 10 grams of peptone, 5 grams of sodium chlorid, and 30 grams of agar are boiled together; the mixture filtered and neutralized. Then 10 c. c. of a 10 per cent solution of sodium carbonate are added in order to render the fluid alkaline. Finally, 10 grams of lactose and 5 c. c. of an alcoholic solution of fuchsin are added. The medium assumes a deep-red color which disappears on the addition of 25 c. c. of a 10 per cent solution of sodium sulphite. The medium is then poured into tubes, each containing 15 c. c., and is sterilized by steam. In order to obtain good results all the constituents of this formula must be obtained pure, the solution of sodium sulphite must be kept well stoppered, and the solution of fuchsin must be filtered before using and must be kept in a dark place. When using this medium the agar, melted and cooled to 40° C., after inoculation is poured into sterilized petri dishes where it is allowed to solidify. These dishes are kept at 37° C., and after 15 hours colonies of the colon bacillus may be seen. After 24 hours these colonies become completely red and assume the greenish iridescence characteristic of fuchsin. In contrast to this reaction on the part of the colon bacillus, the typhoid bacillus remains colorless.

Ruata states that in his experiments both the bacillus of typhoid fever and *Bacillus coli* either turn the medium red or do not color it, according to the variety of the germ and the particular source in each case, as well as according to the nutrient medium in which they have been cultivated, the age of the cultures, the quantity of the material used for infection, etc.

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[1] Herford, Max. Das Wachstum der zwischen Bacterium coli und Bacillus typhi stehenden Spaltpilze auf dem Endoschen Fuchsinagar. Arbeiten aus dem Kaiserlichen Gesundheitsamte, vol. 24, 1906, pp. 62–67.

[2] Ruata, Guido. Il Metodo di Endo per la Differenziezione del Bacillo di Eberth del Bacillo del Colon. Reforma Medica, vol. 20, Apr. 27, 1904, pp. 449–453. Reviewed in the New York and the Philadelphia Medical Journal, July 16, 1904, p. 126.

TABLE XVII.—*Growth of coconut cultures Nos. 1 to 6 and Bacillus coli on plates of Endo's medium (made by Ruata's method), April 21 to May 4, 1910, at 37° C.*

Culture.	1 day.	2 days.	4 days.	5 days.	7 days.	9 days.	13 days.
1	Fairly thickly sown with colonies; white to iridescent.	White colonies; no color, or sign of iridescence.	No sign of pink.	Still uncolored.	Still uncolored.	No color..	....
2	Same as culture 1.	Small area still white; rest bright pink.	Half of plate with white colonies; other half with pink.	Two-thirds of plate brightly colored.	Less than one-sixth pink.	...do.......	....
3	White colonies without iridescence.	Almost all of many colonies are bright pink. The light-colored ones are iridescent; colonies are smooth, wet shining.	Bright red colonies throughout; same as B. coli.	Same as before.	Same as before.	Bright red all over.	At 45° C. remains same.
4	.....do.........	Part of plate bright pink.	Small area on one side bright red.	.....do.......	No signs of pink.	No color..	....
5	Same as culture 1, with a slight pink tinge to surface of agar on one side.	Bright pink over two-thirds of plate.	About one-half bright red.	Bright red color over one-fourth of plate.	One-sixth of plate still pink.	...do.......	....
6	White colonies without iridescence.	Portion of colonies are bright pink, some with denser centers than margins.	Small area on one side bright red.	No pink colonies whatever; only a pinkish caste remaining in a few.	No sign of pink.	...do.......	....
Bacillus coli.	Well sown. A decided pink color throughout plate. Colonies pink in direct light; iridescent in reflected light.	All colonies and all of agar bright red; some colonies zonate.	Red throughout.	Bright red..	Remains bright red all over.	Bright red all over.	At 45° C. remains same.

From this first experiment it is seen that the reaction is not complete in all cases, and, moreover, it is not permanent in all cases In *Bacillus coli* and one of the coconut cultures (No. 3), which were placed in the thermostat at 45° C. after 9 days, the color reaction 13 days after inoculation was complete and apparently permanent. In other tubes portions of the plates became red and then bleached out. One culture (No. 1) failed to show the reaction.

TABLE XVIII.—*Growth of cultures Nos. 1 to 6 and Bacillus coli on plates of Endo's medium (Ruata's formula), April 26 to May 6, 1910, at 37° C.*

Culture.	2 days.	4 days.	6 days.	10 days.
Coconut 1..	Numerous white colonies.	Numerous white colonies.	Numerous white colonies.	No color.
Coconut 2..	Numerous round white colonies.	About one-fifth of colonies are pink.	Same as before........	Only a trace of pink.
Coconut 3..	.....do.................	Numerous round white colonies.	Many pink colonies about circumference; center white.	Do.
Coconut 4..	.....do.................	Some of colonies are iridescent.	Same as before........	Do.
Coconut 5..	.....do.................	Colonies same form; all bright pink in color.	.....do.................	Do.
Coconut 6..	.....do.................	Some of colonies are iridescent and some pink.	About one-eighth of the plate is pink.	Do.
B. coli.....	Numerous round white and some pink colonies.	Colonies all same form; all bright pink in color.	About one-fifth of the colonies are bright pink.	Bright red all over.

Slant-tube cultures on Endo's medium, May 4 to 11, 1910, at 37° C.

Two days: *Bacillus coli* and *Bacillus coli*a were bright pink. Some of the others showed a tinge of color but nothing more, although the growth was good.

Three days: Nos. 1 and 1 a are slightly pink. *Bacillus coli* and *Bacillus coli*a are bright red throughout the medium. All others show a bright pink surface growth, but the bottom of these tubes is colorless.

Five days: Nos. 1 and 1 a are slightly pink. All the others are bright red throughout. *Bacillus coli* and *Bacillus coli*a are a trifle brighter than the others. The growth is good in all cases; pink, smooth, and wet shining.

Seven days: No change. All but 1 and 1 a still retain their bright color.

From these experiments it may be seen that the reaction of the medium seems to be the same for the coconut cultures as for *Bacillus coli.* Luxuriant white colonies which appear in transmitted light like drops of water first develop on the medium. Then appears a slight pink color, as seen in direct light, or an iridescence passing from pink to green and blue, as seen in reflected light. Later the pink darkens to a deep red and the colonies appear opaque. There is no sign of the greenish metallic fluorescence characteristic of fuchsin and mentioned by Ruata as a part of the typical reaction with *Bacillus coli.* In an attempt to obtain this reaction on old cultures two plates were placed at 47° C. until they were completely dried down. The bright red deepened to a dark magenta, but in no case were there any signs of the fuchsin metallic luster.

In the original make-up of the medium the fuchsin is decolorized by the sodium sulphite. This action probably results in the formation of sodium sulphate and some colorless derivative of fuchsin. As a result of the growth of the organism some reducing agent is formed which removes the atom of oxygen from the sulphate and restores it to the fuchsin, thus yielding sodium sulphite and fuchsin if good growth takes place.

STODDART'S PLATE MEDIUM.

Stoddart's plate medium is used to distinguish *Bacillus coli* from *Bacillus typhosus*. Its value depends upon the fact that a nonmotile or slowly motile organism forms a thick nonspreading or slightly spreading growth on the surface, while a moderately or rapidly motile organism will quickly diffuse throughout the medium and over the surface. The efficiency of this medium seems to the writer to be impaired by the fact that not only *Bacillus typhosus* is rapidly motile but many forms of *Bacillus coli* are also. For the purpose of comparing the coconut cultures with those of *Bacillus coli*, however, the medium may well be of service.

The composition of the medium was that described in Novy's Bacteriology, page 492. It consisted of gelatin 5 per cent, peptone 1 per cent, agar 0.5 per cent, and NaCl 0.5 per cent. The method of using it was to pour into petri dishes and allow it to solidify. The organism to be tested was touched by means of an inoculating needle to the center of the surface of the medium. The Eberth bacilli are said to spread over the entire surface of the plate exposed at 35° C. for 18 hours and to form a transparent, scarcely visible growth. The nonmotile colon bacilli will form a small white colony on the surface without any diffusion. The motile colon bacilli will diffuse, but unlike the Eberth bacilli the growth will be opaque and easily visible.

Stoddart's plates, March 18, 1910, at 22° C.

After 18 hours:

Bacillus coli, and *Bacillus coli* a: Semiopaque growth over four-fifths of the plate.

Coconut 5, 5 a, 3, 3 a: Entirely overgrown with semiopaque growth.

Coconut 2, 2 a, 6, and 6 a: Same as *B. coli*.

Coconut 1, 1 a, 4, and 4 a: Nine-tenths overgrown; semiopaque growth.

The growth in all of these plates was very rapid, semiopaque, and wet shining. There was practically no difference between *Bacillus coli* and the coconut cultures. Evidently the strain of *Bacillus coli* here used and the coconut organism are rapidly motile.

HISS'S TUBE MEDIUM.

Dr. P. H. Hiss has used for differentiating the typhoid bacillus and the colon bacillus a certain "tube medium" and another "plate medium." Only the tube medium[1] has been tried by the writer. It consists of dextrose 1 per cent, beef extract 0.5 per cent, gelatin 8 per cent, agar 0.5 per cent, NaCl 0.5 per cent. Ordinary stab cultures are made. The colon bacilli give rise to gas bubbles, whereas the Eberth bacillus does not.

[1] Hiss's tube medium. Novy, Frederick G. Laboratory Work in Bacteriology, p. 494. Also Studies from the Department of Pathology of the College of Physicians and Surgeons, Columbia University, New York, vol. 5, 1897-98, pt. 2; and Journal of Medical Research, vol. 8, 1902, pp. 148-167.

Hiss's tubes.

April 14, 1910, at 22° C. One day: All the tubes, both *Bacillus coli* and the coconut, show abundant gas bubbles which are well distributed throughout the medium. Two days: Same.

March 18, 1910, at 37° C. One day: In all the tubes the medium is clouded throughout, and many gas bubbles are scattered throughout.

In these tubes, as on the Stoddart plates, *Bacillus coli* and the coconut organism behaved alike and showed active motility.

GROWTH IN STERILE MILK.

Cultures of the coconut organism grown in sterile milk at room temperature coagulated the milk in from three to four days. It became a solid homogeneous mass and little or no whey was extruded. No subsequent digestion of the curd took place. Incubated at 37° C., the organism usually caused coagulation in two or three days; but some variability was shown.

GROWTH IN LITMUS MILK.

Cultures grown in litmus milk (lavender blue) usually changed the color of the medium within 24 hours to a dark lavender red, and within 48 hours it became lighter. At the end of two or three weeks the lower part of the culture became bleached. The milk itself gradually coagulated, as in the case of the sterile milk cultures, and usually no whey was extruded. (For further discussion of growth in plain and litmus milk see pp. 94–96.)

Products of Growth of the Organism.

PRODUCTION OF INDOL AND PHENOL.

Cultures of the coconut organism were made in Dunham's solution, which quickly clouded. After six days sulphuric acid was added, which, even after standing, failed to show any reaction. The addition of sodium nitrite to this, however, turned all of the tubes strongly pink in color, showing the presence of indol. This experiment was repeated with cultures of eight days' growth and a light pink resulted from the test. A repetition of this experiment, using a five days' growth and comparing with *Bacillus coli*, gave a light pink identical in each case. It is evident that this organism develops indol much the same as *Bacillus coli*, but whether in the end it develops as much is uncertain.

Cultures of the coconut organism, together with four strains of *Bacillus coli*, were grown in Dunham's solution. The tubes were incubated at 37° C. and tested at the end of 10 days. The results showed that all four of the *Bacillus coli* strains produced an equal amount of indol, and that each of the coconut organisms produced nearly the same amount, respectively, except coconut No. 3, which showed as much as *Bacillus coli.*

Other cultures of the organism were made in ordinary bouillon, and an attempt was made to separate indol and phenol, if present, by distillation. No results were obtained, either by the sulphuric-acid and sodium-nitrite test for indol or by the Millon's reagent and the ferric-chlorid test for phenol. These experiments were repeated several times, and the same results were obtained. It would seem, therefore, that a small amount of indol may be produced, but no phenol.

PRODUCTION OF HYDROGEN SULPHID.

Cultures of the coconut organism made in an iron-peptone solution had in a week's time a slightly or wholly blackened precipitate, and the solution was either inclined to be a greenish black or was intensely green and black, thus indicating the production of hydrogen sulphid. Lead acetate paper used for testing the solution became discolored, also indicating the presence of hydrogen sulphid.

Cultures were also made directly in a lead acetate solution with peptone and showed a good growth. The precipitate in all of the culture tubes was black, indicating the production of H_2S, while in the check tube the precipitate was white. These cultures were also tested with lead acetate paper, which showed the brown-black discoloration typical of H_2S.

PRODUCTION OF AMMONIA.

A 250-c. c. flask containing 100 c. c. of beef bouillon + 15, was inoculated with the organism and incubated for 18 days. The culture was then distilled with the addition of 2 grams of calcined magnesia, and to 50 c. c. of the distillate was added 1 c. c. Nessler's solution. A bright orange-yellow color was produced. Checks were made by distilling over uninoculated bouillon which gave a gray-black color with Nessler's solution and by the use of solutions of ammonium hydrate, 1 to 1,000, 1 to 5,000, 1 to 4,000, and 1 to 3,333⅓. All of the solutions containing ammonia gave an orange color on the addition of Nessler's solution. The color of the reaction of the culture most nearly corresponded to the check solution containing 1 to 4,000 of ammonia.

Cultures were made in Fischer's solution, plus 1 per cent dextrose, plus 1 per cent KNO_3. The solution contained dipotassium phosphate, magnesium sulphite, and calcium chlorid. The growth of the organism after three weeks was fair. The culture was distilled over and tested for ammonia. The distillate showed the presence of a very small quantity of ammonia, about 1 to 80,000. Unfortunately, however, a check flask on being distilled over also showed about the same amount present. The only conclusion is that there was some impurity in the chemical used. It is probable that ammonia would be produced only in the presence of some product as peptone or such as might be in beef bouillon. In a solution containing merely peptone plus NaCl (Dunham's solution) check tube titrated +9, and cultures grown 11 days were only +5, indicating a slight alkali production.

ENZYMES IN MILK.

In the coagulation of milk by the coconut organism the question arises whether the reaction was due to the acid formed or to an enzyme produced. This question has been discussed by O'Hehir [1] and by Savage,[2] both of whom claim that there may be a small degree of enzymatic action as well as acid coagulation.

Cultures of both the coconut organism and *Bacillus coli* were made in sterile litmus milk tubes. After incubation for nine days, when a good coagulation had taken place in all the tubes, ammonia was added to the tubes in quantity more than sufficient to neutralize the acid in the cultures. Practically complete dissolution of the curd quickly took place. The only residue left might be attributed to the small amount of fat in the tubes, as it had not been completely removed in the preparation of the medium. This experiment would indicate the coagulation to be entirely an acid one.

Attempts were made to free milk completely from its fat by repeated boiling and subsequent skimming off of the film formed on the surface, but without success.

Dr. Erwin F. Smith suggested the addition of calcium carbonate to the milk to take up the acid formed by the growth of the organism. Accordingly, cultures were made in litmus milk and in plain sterile milk, both containing 10 per cent $CaCO_3$. Coagulation took place, and the tubes were subsequently treated with ammonia. Their behavior and appearance are shown in Tables XIX and XX.

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[1] O'Hehir, C. Jocelyn. A Note on the Coagulation of Milk by Bacillus Coli Communis. Journal of Pathology and Bacteriology, vol. 11, 1906–7, pp. 405–407.

[2] Savage, W. G. The Coagulation of Milk by Bacillus Coli Communis. Journal of Pathology and Bacteriology, vol. 10, 1904–5, pp. 90–97.

TABLE XIX.—*Coconut cultures Nos. 1 to 6 and Bacillus coli in litmus milk with calcium carbonate, at 37° C, May 27 to June 6, 1910.*

Culture.	Untreated.		Ammonia added in excess.	
	4 days.	5 and 6 days.	Immediate effect.	After standing 3 days.
1 and 1 a...	Soft curd with one-fifth whey; lavender color.	Pale lavender and semisolid.	Does not appear to dissolve the curd.	
2 and 2 a...	Bleached except for thin pink layer at top; firm curd.	Same as on fourth day.	Apparently all dissolved.	
3 and 3 a...	Lavender; semisolid..	.....do................	Apparently no dissolving.	No residue remaining.
4 and 4 a...	.....do................	....	....	
5 and 5 a...	Pink; firm curd.......	Lavender; firm curd..	No dissolving discernible.	Do.
6 and 6 a...	Same as cultures 3 and 3 a.	Pale lavender; semisolid.	No dissolving action...	Do.
Bacillus coli and Bacillus coli a.	Half bleached, rest pink; curd firm; some whey.	Same as on fourth day.	.....do................	Do.

TABLE XX.—*Coconut cultures Nos. 1 to 6 and Bacillus coli in plain sterile milk with calcium carbonate, at 37° C., May 27 to June 6, 1910.*

Culture.	Untreated.		Ammonia added in excess.	
	4 days.	5 and 6 days.	Immediate effect.	After standing 3 days.
1 b and 1 c.....	A soft curd; about one-fifth whey.	Part firm curd and rest whey; less whey in 1 c than in 1 b.	Apparently no effect in dissolving.	Curd appears completely dissolved.
2 b and 2 c.....	.....do........	2 b, fairly firm curd; 2 c, almost solid; moderate amount of whey in both.	.....do................	2 b, appears completely dissolved; 2 c, shows a translucent gelatinous portion.
3 b and 3 c.....	.....do........	3 b, almost solid; 3 c, semisolid. Moderate amount of whey in both.	.....do................	Both show a translucent gelatinous portion.
4 b and 4 c.....	.....do........	Fairly firm curd; moderate amount of whey.	.....do................	Appear completely dissolved.
5 b and 5 c.....	.....do........	Solid curd with small amount of whey.	.....do................	Thick gelatinous, translucent mass.
6 b and 6 c.....	.....do........	Soft; slightly acid to neutral litmus paper.	.....do................	6 b, shows a thin gelatinous, translucent layer at bottom.
Bacillus coli b and c.	.....do........	Solid curds with small amount of whey.	.....do................	Both have a translucent gelatinous portion.

From these experiments it will be seen in the first place that the $CaCO_3$ did not entirely prevent the acid from producing an effect on the litmus, i. e., reddening it. Consequently, the curd produced may have been the result of this acid. When the ammonia was added it appeared to have no determinate immediate effect. The curd was finally broken up by means of a glass rod and thoroughly mixed with the ammonia. The broken fragments of curd showed no sign of immediate disappearance; but after the tubes were allowed to stand for three days there were no signs whatever of the curd in certain tubes. These cultures were diluted and strained through a filter paper without leaving the slightest trace of residue other than what was apparently the $CaCO_3$. In other tubes, on the contrary, there still persisted, not a distinct curd, but a residue, gelatinous in appearance—a small amount in several tubes, but a large amount in others. The nature of this mass was not ascertained. It was by no means similar to the cheesy curd of acid formation; yet it appeared to represent a coagulation of some sort. These experiments seem to justify the conclusion that the major part of coagulation is caused by the acid formation, but that a small amount of coagulation may also be due to an enzymatic action.

PRODUCTION OF ALCOHOLS, ALDEHYDES, AND ACETONE.

In testing for alcohols, aldehydes, and acetone 500 c. c. of a medium consisting of peptone and dextrose, to which 10 c. c. of calcium carbonate was added, was inoculated in a liter flask and incubated at 37° C. In two days the organisms had produced a large amount of gas which, however, had completely disappeared in seven days. Then a cubic centimeter of paraffin was thrown into the cultivation and the flask was connected with a condenser for distillation. The paraffin was for the purpose of forming a thin layer over the surface of the fluid to prevent frothing up and running over into the condenser. The distillate obtained was about 300 c. c., which was then tested for alcohols, aldehydes, and acetones. It was divided into four portions and tested. To one portion was added Lugol's iodin (iodin, 1 gram; iodid of potassium, 3 grams; distilled water, 300 c. c.), then a little NaOH solution to the liquid, which was stirred with a glass rod. Abundant pale-yellow crystalline precipitate was formed, which indicated the presence of iodoform, which was very evident also from the odor. This reaction indicated that either alcohol, aldehyde, or acetone was present, and further tests were made for their identification.

To a portion of the solution enough ammonia was added to make the solution strongly alkaline and then gradually a solution of iodin in ammonium iodid was added. A black precipitate formed,[1] but no other change took place, thus indicating the absence of acetone.

In order to determine the presence of alcohol, 1 cubic centimeter of molybdic acid was gently warmed in 10 c. c. of strong H_2SO_4, and then a few drops of the distillate were added and warmed in a porcelain dish for a few moments. A bright Prussian-blue color resulted, indicating the presence of an alcohol.

In order to test for the presence of an aldehyde, a solution of phenol in excess of sulphuric acid was made up and to it was added a small amount of the distillate. The absence of any resulting dark-red color

[1] M. Scruel says (Archives Médicales Belges, ser. 4, vol. 1, 1893, pp. 9-33) that acetone is reported as occurring in *Bacillus coli* cultures.

on warming the mixture indicated the absence of any aldehydes. From this distillate the presence of alcohol only was thus demonstrated.

PRODUCTION OF VOLATILE AND FIXED ACIDS.

The residue from the distillate for alcohol was used for detection of acid production. The flask was disconnected from the condenser and the calcium carbonate filtered from the residue. Ten cubic centimeters of concentrated hydrochloric acid were then added to this filtrate and mixed well. The calcium remaining in the filtrate was precipitated by adding sodium carbonate solution to alkalinity. The mixture was thoroughly boiled to insure complete precipitation. It was then filtered and 20 c. c. of 25 per cent sulphuric acid were added to the filtrate for the purpose of liberating the volatile acids; finally the filtrate was distilled as completely as possible. (This distillate will contain the volatile acid, if one be present.) The solution was first saturated with baryta water to alkalinity and then evaporated to dryness. To this 20 c. c. of absolute alcohol were added, and it was allowed to stand with frequent stirring for about three hours, when it was filtered and washed with alcohol. This last filtrate should contain barium propionate and barium butyrate, if present. The filtrate was evaporated to dryness; the residue was dissolved in 150 c. c. of water and saturated with calcium chlorid. It was then distilled and the distillate tested for butyric acid. Three cubic centimeters of alcohol and four drops of concentrated sulphuric acid were added to a part of the solution, but there was no resultant pineapple odor to indicate the presence of butyric acid. The propionic acid was not given a special test.

The residue from the alcohol washing described in the previous paragraph was treated for barium acetate and barium formate. It was first dried, and the residue dissolved in the filter in hot water, and the resultant solution was divided into four portions. To one portion was added ferric-chlorid solution, and the absence of any brown color gave negative results for the presence of acetic or formic acid. To another portion silver-nitrate solution was added and then one drop of ammonium water, and the solution was boiled. A black precipitate resulted from this, which indicated the presence of formic acid. To another portion a few drops of mercuric-chlorid solution were added and heated to 70° C. There was, however, no distinct precipitate of mercurous chlorid nor a formation of a metallic mirror. Thus, the tests suggested the presence of formic acid without absolutely proving it, while they indicated the absence of acetic acid.

The residue remaining from the distillation of the mixture after the addition of sulphuric acid was tested for the fixed acids. It was evaporated to a syrup and then extracted with ether by agitation in the separatory funnel. The ethereal extract was evaporated to a syrup and a small residue was left, thus suggesting the presence of either lactic, oxalic, or succinic acid. To the extract was added and thoroughly mixed 100 c. c. of water. Then an excess of zinc oxid was added, and the mixture was heated nearly to boiling and filtered. To 6 c. c. of the filtrate were added 4 c. c. of concentrated sulphuric acid, and the whole was warmed to 75° C. The absence of any crimson color indicated the absence of glycocholic, taurocholic, or cholic acid.

To another portion of the filtrate was added Lugol's iodin, and the absence of any blue color here also indicated the absence of any chloric acid. Another portion of the filtrate was acidified with hydrochloric acid. Ammonia was added in slight excess, and the excess then boiled off. A solution of cobalt nitrate was added, and absence of any lactic acid was indicated by the lack of a violet color.

Another portion of the filtrate was evaporated to dryness and then dissolved in 10 c. c. of hot water and allowed to crystallize, but there resulted only a yellowish amorphous mass which indicated the absence of any crystals of zinc lactate.

The residue left from the filtering after the addition of zinc oxid was dissolved in hydrochloric acid on the filter, and then a portion tested for oxalic acid as follows:

It was neutralized with ammonia until faintly alkaline, and then a solution of calcium chlorid was added. There was no resultant white precipitate of calcium oxalate, which indicated the absence of oxalic acid.

Another portion of this filtered residue was neutralized with ammonia, and the excess boiled off. To a portion of this was added ferric-chlorid solution on a glass rod. A distinct red-brown coloration showed the presence of succinic acid. The absence of buff coloration indicated the lack of any benzoic or hippuric acid in the solution; the absence of a violet coloration indicated the lack of any salicylic acid; and the absence of an inky coloration indicated the lack of tannic or gallic acid in the solution.

This last series of tests for oxalic, succinic, benzoic, hippuric, salicylic, tannic, and lactic acids was repeated, and the same results obtained.

So far as this analysis shows, only succinic acid was certainly demonstrated to be present, and possibly formic. It has been shown by other investigators [1] that in the case of *Bacillus coli*, acetic, formic,

[1] M. Seruel reported (Archives Médicales Belges, ser. 4, vol. 1, 1893, pp. 9–33) finding lactic, acetic, and formic acids.

Leo. F. Rettger (Studies from the Rockefeller Institute for Medical Research, vol. 1, 1904, pp. 284–293) reports finding in egg-meat cultures of *Bacillus coli*, indol, skatol, phenols, aromatic oxyacids, skatolcarbonic acid, leucin, tyrosin, trytophan, hydrogen disulphid, mercaptan, albumoses, and peptones.

Arthur Harden (Journal of Hygiene, vol. 5, 1905, pp. 488–493) states that he found lactic acid, acetic acid, and a small amount of succinic acid present in glucose cultures of *Bacillus coli*.

and lactic acids were present, and succinic in small amount. The coconut organism is so similar to *Bacillus coli* in its cultural characteristics that it would be very surprising if it were not likewise similar in its chemical products. The foregoing single analysis is not sufficient to show that they are not the same in this respect, and it should be repeated.

Dr. Smith gave flasks of this organism (grown in river water containing Witte's peptone, Merck's dextrose, and calcium carbonate) to Dr. Carl L. Alsberg for quantitative chemical analysis, who reported as follows:

Received from Dr. Erwin F. Smith, February 23, 1910, one flask labeled "4101 February 4, 1910, Coconut from Agar, February 2, 5083, fr. 5 January 26."

The culture flask contained a white deposit, which on close inspection was seen not to be homogeneous, for in addition to the calcium carbonate put into the flasks before inoculation there were a few crystalline crusts, the total bulk of which was small. The precipitate was removed by filtration. The filtrate was acid and on warming some carbonic acid gas was liberated.

A part of the culture liquid filtered free from the calcium carbonate was acidified with sulphuric acid and exhausted with ether. The ether on evaporation left a mass of white crystals which after repeated recrystallization from hot water had a melting point of 183–4° C. uncorr. These crystals gave a very powerful pyrrol reaction (Neuberg). The aqueous solution was neutralized with ammonia and an excess of silver nitrate added. The resulting white silver salt was filtered off with suction and washed successively with water, alcohol, and ether. After drying in a desiccator 0.6655 gram was weighed into a crucible and ignited to constant weight. 0.4305 gram silver remained, or 65.12 per cent. The amount calculated for silver succinate is 64.70 per cent. On the basis of the silver content of the silver salt, the melting point of the free acid, and the pyrrol reaction, it is safe to say that this substance is undoubtedly succinic acid.

The mother liquor from which the succinic acid had been removed was subjected to distillation with steam. The distillate was quite acid. It was neutralized with ammonia, and silver nitrate added. The latter was immediately reduced to metallic silver, so that formic acid was probably present. The black silver precipitate was removed, and the clear filtrate concentrated in a desiccator. A crystalline crust, gray in color, formed in the course of a few days. This was removed, washed and dried, and, though obviously impure, its silver content was determined. 0.2305 gram yielded 0.1365 gram silver, or 59.23 per cent. As this corresponds neither to silver acetate (64.67 per cent Ag) nor to silver propionate (59.67 per cent Ag), and as the preparation was obviously impure, the determination was repeated.

Another culture was taken and after removal of the calcium carbonate distilled with the addition of a little sirupy phosphoric acid. The acids in the distillate were converted into the barium salts by evaporating on the water bath with an excess of barium carbonate. To the solution of the barium salts an amount of silver nitrate was added sufficient to combine with only a portion of the acid. On standing over night beautiful long white needles were formed. These were removed, washed and dried, and the silver content determined. 0.3925 gram yielded 0.2530 gram silver, or 64.46 per cent. Silver acetate contains 64.67 per cent. It is therefore evident that beside formic acid there can be present no other volatile acid but acetic.

The presence of formic acid was further verified by distilling a fresh portion of the culture liquid after it had been rendered faintly alkaline with sodium carbonate. Under these conditions any aldehyde which may have reduced the silver in the preceding experiments, would distill over, while all the volatile acids would remain behind. The distillate failed to reduce ammoniacal silver solution, thus demonstrating the absence of volatile aldehydes. The distillate did, however, give a powerful iodoform test, showing the presence of alcohol.

The residue from the distillation was made acid with syrupy phosphoric acid and distilled again to drive over volatile acids. The presence of formic acid was verified in an aliquot part of the distillate by the reduction of mercuric chloride in the presence of sodium acetate. The calomel formed was weighed, so that the formic acid contained in one culture flask was estimated quantitatively with some degree of accuracy. The 700 c. c of the culture liquid contained 0.197 gram formic acid.

With ferric chloride the distillate gave a deep blood-red color characteristic of ferric acetate, a verification of the finding of acetic acid.

The crystalline crusts mentioned in the beginning of this paper seemed to consist mainly of calcium succinate. Oxalic acid could not be found. Lactic acid could not be found.

The culture liquid still reduced Fehling's solution powerfully. This was at first supposed to be due to the presence of unfermented glucose. However, the presence of formic acid was certainly responsible for a part if not all of this reduction. The culture liquid was not tested for glucose, so that the presence of glucose was not decided.

Summary: The organism forms much succinic acid and alcohol, as well as appreciable quantities of acetic and formic acid.

REDUCTION OF COLORS.

Cultures in litmus milk soon turned red and eventually usually bleached, at least in the lower part. The entire culture never lost its color, but frequently the lower one-half to two-thirds became reduced.

Cultures in litmus bouillon also reddened and either became almost entirely bleached or partially so.

Cultures in fermentation tubes containing beef bouillon and 1 per cent cane sugar and litmus became entirely bleached in the closed end, but unchanged in the open end of the tubes, both in the case of *Bacillus coli* and of the coconut organism. When the tubes are made up with a higher per cent of sugar, for instance, 3 or 5 per cent, the closed end of the tube becomes bleached on steaming and expulsion of the air from that end. According to Dr. Theobald Smith,[1] cultures of *Bacillus coli* grown in these tubes of litmus-sugar bouillon with the bleached closed ends cause the return of the litmus color. This reaction has not been tried by the writer.

A series of cultures was made in Dunham's solution (1 per cent peptone plus 0.5 per cent NaCl) and litmus; in Dunham's solution plus indigo carmine, and in Dunham's solution plus methylene blue, both with and without grape sugar. In the cultures with litmus, in one experiment, the color was reduced only in the tubes containing grape sugar. When cultures were grown in another lot of the

[1] Smith, Theobald. The Fermentation Tube. The Wilder Quarter-Century Book, 1893, p. 190.

Dunham's solution plus litmus with and without grape sugar, reduction either entire or partial took place.

In the Dunham's solution cultures containing indigo carmine there was no reduction either in the tubes with sugar or in those without.

In the Dunham's solution cultures containing methylene blue there was no reduction in color except in one tube containing the grape sugar.

From these experiments it would seem that a reducing agent is not always produced and does not affect all colors. As seen on other pages (pp. 69, 80, 115) cultures were made in neutral red and in rosolic acid. In these cases, however, the action was a complex one caused by the presence of an acid or an alkali, so that a clear reducing action could not be determined; there would seem to be one in neutral red but not in rosolic acid.

Growth on Miscellaneous Culture Media.

The media used in the following experiments are for the most part such as are commonly used in general cultural studies of a bacterial organism. In some cases they have little or no value in diagnostic work, but they serve as means to increase our knowledge of the life processes of the organism under investigation. In a few cases the media used were originally recommended by their authors as means of diagnosing or differentiating *Bacillus coli* from other organisms. For various reasons, under the writer's manipulations some of these tests have failed of their original purpose, but will here serve well as a means of comparison between the coconut organism and *Bacillus coli.*

NITROGEN-FREE MEDIA.

Cultures were made in a nitrogen-free nutrient medium plus various chemicals containing nitrogen to ascertain from which the organism could obtain its supply. Three salts of ammonium (tartrate, citrate, and lactate), asparagin, and sodium asparaginate were used. The nutrient medium was made up in the proportion of 1,000 c.c. triple distilled water, 5 grams of cane sugar, 2 grams of monopotassium phosphate, 0.1 gram of magnesium sulphate, and 0.5 gram of sodium chlorid.

TABLE XXI.—*Growth of various cultures in nitrogen-free media with various additions, at 22° C.*

EXPERIMENT 1, FEBRUARY 9 TO 25, 1910.

Medium and days of incubation.	Culture.						
	Coconut 1.	Coconut 2.	Coconut 3.	Coconut 4.	Coconut 5.	Coconut 6.	B. Coli.
Ammonium tartrate:							
1 day	Well clouded	Well clouded	Barely clouded	Barely clouded	Well clouded	Barely clouded	Barely clouded.
5 days	do	do	do	do	do	do	Do.
9 days	do	do	Practically clear	Practically clear	do	Practically clear	Practically clear.
15 days	do.[1]	do.[1]	do.[2]	do.[2]	do.[1]	do.[2]	Do.[2]
Ammonium citrate:							
1 day	do	do	Barely clouded	Barely clouded	do	Barely clouded	Barely clouded.
5 days	do	do	Well clouded [3]	Well clouded [3]	do	Well clouded [3]	Do.
9 days	do	do	do	do	do	do.[3]	Clear.
15 days	(4)	(5)	Partial film	Thick film [4]	(5)	(5)	Do.[6]
Ammonium lactate:							
1 day	Moderately clouded.	Moderately clouded.	Thinly clouded	Thinly clouded	Moderately clouded.	Thinly clouded	Thinly clouded.
5 days	Well clouded	Well clouded	Well clouded [7]	Well clouded [7]	Well clouded	Well clouded [7]	Well clouded.
9 days	do	do	Heavy film [8]	Heavy film [8]	do	Heavy film [8]	Do.
15 days	do	do	Slightly brown solution.	do.[8]	do	do.[8]	Do.
Asparagin:							
1 day	Moderately clouded.	Moderately clouded.	Thinly clouded	Thinly clouded	Moderately clouded.	Thinly clouded	Thinly clouded.
5 days	Well clouded	Well clouded	Well clouded [9]	Well clouded [9]	Well clouded	Well clouded [9]	Well clouded.
9 days	do.[10]	do.[10]	do.[11]	do.[11]	do.[10]	do.[11]	Do.[10]
15 days	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Sodium asparaginate:							
1 day	Well clouded	Well clouded	Barely clouded	Barely clouded	Well clouded	Barely clouded	Barely clouded.
5 days	Moderately clouded.[11]	Moderately clouded.[11]	Moderately clouded.[9]	Thinly clouded [9]	Moderately clouded.[11]	Moderately clouded.[9]	Thinly clouded.[11]
9 days	do	do	Thinly clouded [9]	do.[9]	do	Thinly clouded [9]	Moderately clouded.
15 days	Well clouded [4]	Thinly clouded [12]	Well clouded [10]	do.[13]	Thinly clouded [12]	do.[12]	Well clouded.[10]

EXPERIMENT 2, FEBRUARY 21 TO MARCH 14, 1910.

Medium and days of incubation.	Culture.						
	Coconut 1.	Coconut 2.	Coconut 3.	Coconut 4.	Coconut 5.	Coconut 6.	B. Coli.
Ammonium tartrate:							
4 days	Moderately clouded.	Moderately clouded.	Barely clouded	Barely clouded	Moderately clouded.	Barely clouded	Barely clouded.
21 days	do	do	Clear [2]	Clear [2]	do	Clear [2]	(11)
Ammonium citrate:							
4 days	do	do	Moderately clouded.[11]	Moderately clouded.[11]	do	Moderately clouded.[11]	Barely clouded.
21 days	(14)	(14)	(16)	(15)	(14)	(15)	Clear.
Ammonium lactate:							
4 days	Moderately clouded.	Moderately clouded.	Moderately clouded.[11]	Moderately clouded.[11]	Moderately clouded.	Moderately clouded.[11]	Moderately clouded.
21 days	(14)	(14)	(16)	(16)	(14)	(16)	(17)
Asparagin:							
4 days	Well clouded [2]	Well clouded [2]	Well clouded [2]	Well clouded [2]	Well clouded [2]	Well clouded [2]	Well clouded.[2]
21 days	Moderately clouded.	Moderately clouded.	Moderately clouded.[11]	Moderately clouded.[18]	Moderately clouded.	Moderately clouded.[11]	Moderately clouded.
Sodium asparaginate:							
4 days	Well clouded [19]	Well clouded [19]	Well clouded [19]	Well clouded [19]	Well clouded [19]	Well clouded [19]	Well clouded.[19]
21 days	Moderately clouded.[20]	Moderately clouded.[20]	Moderately clouded.[21]	Moderately clouded.[21]	Moderately clouded.[22]	Moderately clouded.[21]	Moderately clouded.[21]

1 Good white precipitate.
2 Small precipitate.
3 With better film.
4 Heavy white precipitate.
5 Good brown precipitate.
6 Minute precipitate.
7 Thicker film.
8 Clearer than others.
9 Good film.
10 No film.
11 Thin film.
12 Heavy, slightly brown precipitate.
13 Good film; slightly brown precipitate.
14 White precipitate and solution.
15 Brown precipitate and solution; thin film; few crystals.
16 Brown precipitate and solution; thin film; many crystals.
17 Brown precipitate and solution.
18 Thin film; many crystals.
19 Moderate amount of white precipitate.
20 White precipitate; solution colorless.
21 Brown precipitate and solution; thin film; crystals.
22 Slightly brown precipitate and solution; thin film; crystals.

The two experiments show very much the same results, the only difference being a browning of the solution and precipitate of the scantily growing cultures in the second experiment. In these experiments cultures Nos. 1, 2, and 5 seem to be identical; and 3, 4, 6, and *Bacillus coli* identical with each other and different from 1, 2, and 5. This variation may not, however, be constant, and is certainly not of specific value. Considering these groups different, it would show the following improbable results: No. 3 (505 N) was inoculated into a tree producing a disease from which was isolated No. 2 (505 S) identical with it. No. 2 was inoculated into a tree and produced the disease and from it was isolated No. 1 (505 R), an organism differing slightly in the growth in the nitrogen compound. No. 1 was not tried to see if it has the same pathogenic properties as No. 2. Again, No. 6 (508 N), identical with No. 3, was inoculated into a tree and produced a disease from which was isolated No. 5 (508 S), identical with Nos. 1 and 2, but different from No. 4. Then No. 5 was inoculated into another tree, and from the resulting diseased tissue was isolated No. 4 (508 R), different from No. 5, but identical with No. 6. The assumption must be either that the organism is variable or that there are numerous organisms to be found in such places which are so nearly alike that they may be considered identical for practical purposes—that is, all have an identical disintegrating action on the plant tissues. Moreover, the chance in favor of there being separate forms is reduced to a minimum by the method of inoculation and isolation, every precaution being taken to avoid contamination.

FISCHER'S MINERAL SOLUTION WITH VARIOUS NUTRIENT SUBSTANCES.

For determining the source of nitrogen and carbon for the organism various compounds containing these substances were added to Fischer's mineral solution, which contained neither nitrogen nor carbon. The mineral solution consisted of dipotassium phosphate 1 gram, magnesium sulphate 0.2 gram, and calcium chlorid 0.1 gram, all dissolved in 1,000 c. c. of distilled water.

TABLE XXII.—*Experiment 1. Fischer's mineral solution with various additions. Inoculations made from fluid coconut cultures Nos. 1 to 6, February 3 to 18, 1910, at 22° C.*

Medium.	1 day.	3 days.	6 days.	11 days.	14 days.
Fischer's mineral solution (4110).	All equally and slightly clouded.	Same as 1 day.	Barely clouded; no precipitate.	Practically clear; no appreciable precipitate.	Same as 11 days.
Fischer's + dextrose (4113).	All equally and thinly clouded; not so good as in dextrose + KNO_3.	Thinly clouded.	Slightly clouded; minute precipitate.	1 thin; others clear; minute precipitate.	Do.
Fischer's + KNO_3 (4112).	All equally and slightly clouded.	Slightly clouded.	Barely clouded; no precipitate.	Clear; minute precipitate.	Do.

TABLE XXII.—*Experiment 1. Fischer's mineral solution with various additions. Inoculations made from fluid coconut cultures Nos. 1 to 6, February 3 to 18, 1910, at 22° C.*—Continued.

Medium.	1 day.	3 days.	6 days.	11 days.	14 days.
Fischer's + cane sugar (4115).	All equally and slightly clouded; not so good as in dextrose.	Slightly clouded.	Barely clouded; no precipitate.	Practically clear.	Same as 11 days.
Fischer's + peptone (4116).	All equally and thinly clouded.	Moderately clouded.	Moderately clouded; small precipitate.	Moderately clouded; moderate precipitate.	Do.
Fischer's + peptone + dextrose (4118).	Moderately clouded; some gas; best growth.	Same as 1 day.	Nos. 2 and 5 moderately clouded; others nearly clear; all good precipitate.	No. 5 moderately clouded; large precipitate.	Thin; large precipitate.
Fischer's + peptone + glycerin (4119).	Moderately clouded; no gas.	.....do........	Moderately clouded; good precipitate.	No. 5 moderately clouded; others thin.	Same as 11 days.
Fischer's+glycerin (4117).	All slightly clouded; a trifle better than plain Fischer's.	Thinly clouded.	Barely clouded; minute precipitate.	All barely clouded.	Do.
Fischer's + cane sugar + KNO_3 (4114).	Nos. 1 and 5 moderately clouded; others slightly.	Same as 1 day.	Same as 1 day...	No. 5 moderately clouded; No. 1 thin; Nos. 3, 4, and 6 barely; No. 2 clear.	Do.
Fischer's + dextrose + KNO_3 (4111).	Slightly but distinctly clouded.	All thinly and equally well clouded.	Same as 3 days..	Barely clouded; small precipitate.	Do.

TABLE XXIII.—*Experiment 2. Fischer's mineral solution with various additions. Inoculations from fluid coconut cultures Nos. 1 to 6 and Bacillus coli, February 15 to 28, 1910, at 22° C.*

Medium.	1 day.	3 days.	10 days.	13 days.
Fischer's solution (4110).	All but the checks are barely clouded.	Same as 1 day.....	All clear and no appreciable precipitate.	
Fischer's + dextrose + KNO_3 (4111).	All thinly clouded; B. coli is a trifle better than others.	All thinly clouded.	Thinly clouded and small precipitate.	Checks titrated+5; cultures +8.
Fischer's + KNO_3 (4112).	All barely clouded...	.....do............	Thinly clouded and very small precipitate.	
Fischer's + dextrose (4113).	All very thinly clouded.	All just barely clouded.	Thinly clouded and small precipitate.	Check titrated + 5; cultures+11.5.
Fischer's + cane sugar + KNO_3 (4114).	Nos. 1 and 5 moderately; others thin.	Nos. 1 and 5 thin; others barely clouded.	Nos. 1 and 5 moderately clouded; others clear; all small precipitate.	
Fischer's + cane sugar (4115).	All very thin........	All just barely clouded.	No. 1 thin; others clear.	
Fischer's+peptone (4116).	All thin; B. coli a trifle thinner than the others.	All moderate; B. coli a trifle thinner than others.	Well clouded with small white precipitate; no film.	Check titrated + 9; cultures+5.
Fischer's+glycerin (4117).	All barely clouded...	All barely clouded; No. 1 a little more than others.	Slightly clouded; minute precipitate.	
Fischer's+peptone +dextrose (4118).	All well clouded except No. 3.	Nos. 3, 4, and 6 almost clear and heavy white precipitate; others still clouded and good precipitate.	Nos. 1, 2, 5, and B. coli moderately clouded; abundant precipitate; others thin; and abundant precipitate.	Check titrated + 9; cultures+24.
Fischer's+peptone + glycerin (4119).	All are moderately clouded; B. coli a little thinner than others.	Well clouded and large white precipitate.	All are moderately clouded; abundant white precipitate.	Check titrated +8; cultures+21

Bacillus coli was used for comparison in the second experiment, but not in the first. There appear to be no great differences between these organisms and *B. coli.* The experiments show in general that in Fischer's mineral solution alone or when KNO_3 is added the organism barely clouds; when peptone is added moderate growth results; adding glycerin either with or without KNO_3 gives slight growth; when either dextrose or cane sugar, either with or without KNO_3 is added poor growth results; when peptone with either dextrose or glycerin is added moderate growth results.

From this table it will be observed that the organism can obtain its nitrogen and carbon easily from peptone alone, but somewhat better when dextrose is present. It can not obtain any nitrogen from KNO_3, and carbon from glycerin only with difficulty (p. 75). The organism can obtain carbon only with difficulty from either cane sugar or dextrose alone; undoubtedly some nitrogenous substance, such as peptone with either cane sugar or dextrose is necessary for good growth.

MEDIA WITH MALACHITE GREEN.

The use of malachite green as a differentiating medium between *Bacillus coli* and *Bacillus typhosus* has been recommended by Loeffler, according to Kiralyfi,[1] who has also tried it but without success. In view of the variable results obtained by Kiralyfi the effect of malachite green as inhibitory to *Bacillus coli* is not taken here as a diagnostic character. As a matter of fact, notwithstanding that Kiralyfi in some experiments found that a 0.02 per cent solution of malachite green prevented good development of *Bacillus coli* colonies, in the following experiments with the same amount *Bacillus coli* grew well. The only points to be ascertained here were whether *Bacillus coli* and the coconut organism grew equally well, producing colonies of the same form and causing a reduction of the color. The experiments were carried out as follows:

(1) Agar slant cultures with malachite green. In 24 hours the growth was wet shining and irregular, the same as in ordinary agar tubes. The growth appeared slightly greenish, but this may have been due to the medium. After three days all the tubes showed good growth and all were entirely or nearly bleached. Culture No. 5 had entirely reduced the malachite green, but in *Bacillus coli* a very distinct green was still at the bottom. After four days none of the cultures showed even a trace of the green color.

(2) Agar plate cultures with malachite green. The malachite green became entirely reduced on all the plates within three days, *Bacillus coli* accomplishing the reduction more slowly than the others. Plates from cultures No. 5 and *Bacillus coli* showed only round or nearly round colonies. All the other plates showed a mixture of the round colonies and deeply lobed or radiate-branched ones. As some of the smallest colonies

[1] Kiralyfi, G. Ueber den Wert der Malachitgrünnährböden zur Differenzierung der Typhus- und Colibacillen. Centralblatt für Bakteriologie, pt. 1, Originale vol. 42, 1906, pp. 276–279, 371–375.

showed a tendency toward branching, this condition probably is due to the medium rather than to varieties of bacteria.

In all of the cultures *Bacillus coli* and the coconut organism behaved alike in that they grew well and reduced the color of the malachite green.

BEEF AGAR CONTAINING CAFFEIN.

The use of caffein in media as a means of differentiating *Bacillus coli* from *Bacillus typhosus* has been discussed, among others, by Roth,[1] by Birt,[2] and by Courmont and Lacomme,[3] who have not, however, presented evidence of the reliability of this means. The one point in agreement among the workers is that 1 per cent, or sometimes less, caffein in the culture media will completely inhibit the growth of *Bacillus coli*. Under certain conditions it is said also to inhibit *Bacillus typhosus*, but that is of little importance here.

Cultures were made in slant agar tubes containing 1 per cent caffein with all the organisms used in this comparative work. After eight days no sign of growth appeared on any of the slants.

Other cultures on the same medium were made in petri dishes. These were kept for several days, but gave no sign of colonies either in the coconut plates or the *Bacillus coli* plates.

THE MEDIA OF CAPALDI AND PROSKAUER.

Two media,[4] designated Capaldi and Proskauer No. 1 and Capaldi and Proskauer No. 2, are used in these experiments.

No. 1 is made as follows:

Asparagin	grams..	0. 2
Mannit	do....	. 2
Sodium chlorid	do....	. 02
Magnesium sulphate	do....	. 01
Calcium chlorid	do....	. 02
Potassium monophosphate [5]	do....	. 20
Water (distilled)	c. c..	100

No. 2 is made as follows:

Witte's peptone	grams..	2. 0
Mannit	do....	. 1
Water (distilled)	c. c..	100

In the first of these media, which is free from albumin, *Bacillus coli* is said to grow well and produce acid freely. The second medium

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[1] Roth, Emil. Versuche über die Einwirkung von Kaffeïn auf das Bacterium typhi und coli. Zentralblatt für Stoffwechsel- und Verdauungs Krankheiten, vol. 5, 1904, p. 125; Versuche über die Einwirkung des Trimethylxanthins auf das Bacterium typhi und coli. Zentralblatt für Stoffwechsel- und Verdauungs Krankheiten, vol. 6, January to December, 1905, p. 557.

[2] Birt, C. Caffeine Enrichment Method. British Medical Journal, October 28, 1905, pp. 1110–1111.

[3] Courmont, J., and Lacomme, L. La Caféine en Bactériologie. [Discusses certain distinct uses of caffein as an aid in bacterial diagonsis.] Journal de Physiologie et de Pathologie Générale, vol. 6, March 15, 1904, p p. 286–294.

[4] Muir, Robert, and Ritchie, James. Manual of Bacteriology, p. 329.

[5] Potassium biphosphate, monobasic, Merck, was used by the writer in making up this medium.

contains albumin, and is such that *Bacillus coli* is said to grow well but to produce no acid.

After its constituents are mixed and dissolved each medium is steamed for 1½ hours and litmus solution added; the medium is then made neutral, filtered, tubed, and sterilized.

Tubes were made up according to these formulas and inoculated with the coconut organism and *Bacillus coli.*

TABLE XXIV.—*Growth of coconut cultures Nos. 1 to 6 and Bacillus coli in Capaldi and Proskauer medium No. 1, at 22° C.*

Culture.	Experiment 1, Apr. 7 to 11, 1910.		Experiment 2, Apr. 13 to 30, 1910.		
	1 day.	4 days.	1 day.	3 days.	17 days.
Check	Light reddish purple.	Light reddish purple.	Light reddish purple.	Light reddish purple.	Light reddish purple.
1	Bright pink gas.	do	Bright pink with tinge of purple.	Purple.	
2	do	do	do	Reddish purple above; light pink below.	
3	do	Somewhat purple in upper third; light red below; precipitate bright red.	do	do	
4	Slight change; no gas.	do	do	Light purple nearly throughout.	
5	No change	do	do	Reddish purple above; light pink below.	
6	Bright pink; no gas.	do	Changed only a trifle.	do	
Bacillus coli	Bright pink; gas.	do	Bright pink with tinge of purple.	do	

TABLE XXV.—*Growth of coconut cultures Nos. 1 to 6 and Bacillus coli in Capaldi and Proskauer medium No. 2, at 22° C.*

Culture.	Experiment 1, Apr. 7 to 11, 1910.		Experiment 2, Apr. 13 to 30, 1910.	
	1 day.	4 days.	1 day.	3 days.
Check	Light purple blue	Almost clear solution with blue-purple precipitate.	Solution light blue: precipitate deep blue.	
1	Gas; purple-red precipitate; very light color in solution.	Practically colorless solution; purple precipitate.	Abundant gas; solution almost colorless; precipitate reddish purple.	Same as on first day.
2	do	Practically colorless solution; white precipitate.	do	Precipitate partially bleached.
3	do	Practically colorless solution; purple precipitate.	do	Do.
4	do	do	do	Do.
5	do	Practically colorless solution; white precipitate.	do	Do.
6	do	Practically colorless solution; purple precipitate.	do	Do.
Bacillus coli	do	do	do	Do.

Check tubes of these media were treated as follows:

No. 1+acid =bright salmon pink.
No. 1+alkali=deep blue.
No. 2+acid =bright salmon pink.
No. 2+alkali=no change.

In the first medium the culture grew well and produced acid, as shown from the change in the color of the light reddish-purple check to the bright pink cultures, *Bacillus coli* acting in the same way as the coconut cultures. In most cases the color subsequently became bleached and in the upper part a distinct blue (after 17 days). These tubes tested with neutral litmus paper indicated an alkali formation, as the change in color of the culture from bright pink to blue also indicates.

The reaction in medium No. 2 was unsatisfactory. In the check tubes as in the cultures the blue color precipitated in the form of fine particles. This precipitate remained blue in the check, but became a distinct purple in the cultures, and in 17 days was bleached almost white. A distinct, though not striking, change from deep blue to purple took place in the color of the precipitate. This change would suggest some acid formation, although the medium is not supposed to permit of acid formation. The reduction of the litmus is the only striking part of the reaction in medium No. 2.

BEEF BOUILLON OF VARIOUS DEGREES OF ACIDITY.

Table XXVI gives the results of four experiments, showing very little constant difference in the growth of cultures in beef-bouillon media of various degrees of acidity or alkalinity. Any sort of bouillon from −12 to +30 on Fuller's scale seemed to furnish the means for luxuriant growth of the organism. The cultures show a tendency to clear sooner at +23, +25, and +30 than at the lower degrees of acidity.

TABLE XXVI.—*Growth of coconut cultures Nos. 1 to 6 and Bacillus coli in beef bouillon of varying degrees of acidity or alkalinity, at 22° C., as shown in experiments 1, 2, 3, and 4, February 5 to March 14, 1910.*[1]

Titration (grade of acidity or alkalinity).	1 day, experiments 1 and 2.	3 days, experiments 1 and 2.	4 days, experiment 3.	7 days, experiment 1.
−4	All well clouded; Nos. 3 and 6 have thin films (experiment 1).	Nos. 2, 3, 4, and 6 have good films; all well clouded (experiment 1).	All heavily clouded; B. coli has no film; Nos. 2 and 6 good.	All heavily clouded; Nos. 1 and 5 and B. coli have no films.
−6	All well clouded with thin films (experiment 2).	Nos. 3, 4, and 6 have good films; all heavily clouded (experiment 2).	All heavily clouded; B. coli and No. 2 have partial films; others none.	
−12	All well clouded with very thin films (experiment 2).	All heavily clouded with films (experiment 2).	All well clouded; abundant white precipitate; Nos. 1 and 5 have no films.	
+2	All well clouded; No. 1 has good film; others heavy precipitate (experiment 2).	All well clouded; good precipitate (experiment 2).	All heavily clouded; B. coli has no film; Nos. 2 and 6 good films.	
+7	All well clouded; Nos. 3 and 1 have thin films (experiment 1).	Nos. 2, 3, 4, and 6 have good films; others have thin films, except B. coli (experiment 1).	....	All heavily clouded; Nos. 1 and 5 and B. coli have no films.
+23	All well clouded; thin films (experiment 1).	All good films; well clouded (experiment 1).	All heavily clouded; good films.	All heavily clouded; good films; large white precipitate.
+25	All well clouded; No. 1 has good film; others barely perceptible films (experiment 2).	All well clouded; good precipitate; good films (experiment 2).	.....do................	
+30	Same as +23, only more heavily clouded (experiment 1).	All but Nos. 4 and 6 have good films; all well clouded (experiment 1).	....	All heavily clouded; good films; large white precipitate.

[1] Experiment 1, Feb. 11 to Feb. 25; 2, Feb. 5 to Feb. 25; 3, Feb. 21 to Mar. 14; 4, Feb. 25 to Mar. 14.

Table XXVI.—*Growth of coconut cultures Nos. 1 to 6 and Bacillus coli in beef bouillon of varying degrees of acidity or alkalinity, at 22° C., as shown in experiments 1, 2, 3, and 4, February 5 to March 14, 1910*—Continued.

Titration (grade of acidity or alkalinity).	10 days, experiment 2.	14 days, experiment 4.	14 days, experiment 1.	17 days, experiment 4.	21 days, experiment 3.
−4	....	....	All have good films but No. 1 and B. coli.	....	All well clouded; B. coli has no film and no crystals; all others have crystals.
−6	All well clouded; abundant white precipitate; B. coli has no film; No. 1 thin film; all others have good films.	....	....	....	All heavily clouded; B. coli has no film but many crystals.
−12	All well clouded; abundant white precipitate and with films.	....	....	....	All heavily clouded; Nos. 2 and 6 have heavy films.
+2	All heavily clouded; films and abundant white precipitate.	....	....	....	All well clouded; B. coli has no crystals; all have films.
+7	....	All heavily clouded; all but B. coli have films and crystals.	All heavily clouded.	All well clouded but No. 5, which is partly cleared; all have heavy precipitates; all but B. coli have films and crystals.	
+23	....	....	All but Nos. 2 and 4 heavily clouded.	....	All well clouded; No. 2 has pretty well cleared; all the rest have moderate films; all but B. coli and No. 2 have numerous crystals.
+25	All well clouded; abundant white precipitate and good films.	....	....	....	All well clouded.
+30	....	All heavily clouded; heavy films; No. 1 has crystals.	All heavily clouded but No. 2.	All well clouded; good films and abundant precipitate; Nos. 1, 3, and 4 have crystals.	

DUNHAM'S SOLUTION WITH VARIOUS PROPORTIONS OF SODIUM CHLORID.

Table XXVII, gives the results of three experiments, showing that the growth of cultures 1 to 6 and *Bacillus coli* is good only in those solutions containing 3 per cent or less of sodium chlorid. There was growth in the 7 per cent solution, but it was very slight. The amount of indol produced by the organism as shown in the column for 25 days indicates to some extent the amount of growth in each of the culture solutions. In solutions containing as high as 3 per cent NaCl a good indol reaction was obtained, the color corresponding to rose-violet tint No. 1, Répertoire de Couleurs, in the light tubes and darker in others.

TABLE XXVII.—*Growth of coconut cultures Nos. 1 to 6 and Bacillus coli in Dunham's solution with varying amounts of sodium chlorid, at 22° C., as shown in experiments 1, 2, and 3, February 8 to March 14, 1910.*[1]

Medium.	1 day, experiments 1 and 3.	3 days, experiment 2.	5 days, experiment 1.	7 days, experiments 1 and 2.	8 days, experiment 3.
Dunham's solution—					
With 1 per cent NaCl (4137).	All moderately clouded except No. 4, which is thin with flocculence.	....	Moderate growth; small precipitate; thin films.	No. 5 titrated+2; check titrated+4.	All moderately clouded; moderate precipitate; no films; Nos. 1 and 2 begin to clear.
With 1.5 per cent NaCl (4138).	All moderately clouded except No. 4, which has a flocculent suspension.	....	Moderately clouded; No. 1 has flocculent suspension; all have thin films.	....	All moderately clouded and moderate precipitate; Nos. 2 and 3 have thin films.
With 2 per cent NaCl (4139).	In experiment 1 same as with 1 per cent; in experiment 3 all are thinly clouded.	....	All but B. coli have thin films; all moderately clouded.	....	All well clouded with moderate precipitate; Nos. 2 and 4 have thin films.
With 2.5 per cent NaCl (4140).	A trifle less clouded than with 1 per cent.	....	.....do.........	No. 5 titrated + 3; check titrated+4.5.	
With 3 per cent NaCl (4141).	All are thinly clouded.	....	All moderately clouded; thin films.	No. 5 titrated + 4; check titrated+5.	All well clouded; small precipitate; No. 2 is beginning to clear; no films.
With 4 per cent NaCl (4159).	All are thinly clouded. B. coli is a trifle thinner than the rest.	All thinly clouded; very thin films.	....	All thinly clouded; small precipitate.	All thinly clouded; small precipitate.
With 5 per cent NaCl (4160).	Nos. 1 and 5 are thin; others are practically clear.	.....do........	....	....	All thinly clouded; small precipitate; no films.
With 6 per cent NaCl (4161).	All clear except No. 1, which is very thin.	All thinly clouded; barely perceptible films.	....	All thinly clouded; small precipitate.	Nos. 1, 3, and 4 are thinly clouded; small precipitate.
With 7 per cent NaCl (4162).	All are clear.....	All thinly clouded.	....	Nos. 1, 3, 4, and 6 thinly clouded and small amount of precipitate; Nos. 2 and 5 barely clouded; B. coli appears clear.	Nos. 1, 3, and 4 thinly clouded small precipitate; others barely clouded, with very small precipitates.

[1] Experiment 1, Feb. 8 to Feb. 25; 2 and 3, Feb. 17 to Mar. 14.

TABLE XXVII.—*Growth of coconut cultures Nos. 1 to 6 and Bacillus coli in Dunham's solution with varying amounts of sodium chlorid, at 22° C., as shown in experiments 1, 2, and 3, February 8 to March 14, 1910*—Continued.

Medium.	10 days, experiment 1.	14 days, experiment 2.	17 days, experiment 1.	25 days, experiment 3.
Dunham's solution—				
With 1 per cent NaCl (4137).	Moderate growth; small precipitate; thin films.	....	Moderately clouded; abundant white precipitate; No. 6 has brownish precipitate.	Same as 17 days; addition of H_2SO_4 gave no result; $H_2SO_4+NaNO_3$ gave in 1, 2, and 5 bright red, which after shaking became pink; other tubes were copper red.
With 1.5 per cent NaCl (4138).	Moderately clouded; No. 1 has flocculent suspension; all have thin films.	....	Same as with 1 per cent except that No. 3 has brownish precipitate.	Same as 17 days; in indol test, Nos. 1, 2, and 5 rose-violet; the others darker.
With 2 per cent NaCl (4139).	All thinly clouded; small precipitate.	....	Same as with 1.5 per cent except that B. coli has brownish precipitate.	B. coli is thin; others moderate; in indol test No. 1 barely pink; Nos. 2 and 5 bright pink; others dark rose as with 1.5 per cent.
With 2.5 per cent NaCl (4140).	....	....	All except No. 1 thinly clouded; No. 1 moderate; all have abundant white precipitate.	
With 3 per cent NaCl (4141).	All thinly clouded; moderate precipitate.	....	Same as with 2.5 per cent except that B. coli and No. 4 have brownish precipitate.	Same as with 2 per cent.
With 4 per cent NaCl (4159).	....	Nos. 1, 3, and 6 thinly clouded; Nos. 2, 4, and B. coli only slightly clouded.	....	Same as before; in indol test B. coli barely pink; others same.
With 5 per cent NaCl (4160).	....	B. coli and No. 2 are barely clouded; others are thin.	....	B. coli is clear; others as before; in indol test all show a trace of pink.
With 6 per cent NaCl (4161).	....	No. 2 and B. coli are practically clear with very small precipitate; others are thin with small brownish precipitate.	....	B. coli is clear; No. 5 is clear; others thinly clouded; in indol test Nos. 1, 2, and 5 show a distinct pink, others a mere trace of pink.
With 7 per cent NaCl (4162).	....	No. 2 and B. coli are clear with small brownish precipitate; others are slightly clouded with small brownish precipitate.	....	B. coli is clear; in indol test all tubes show a mere trace of color reaction.

USCHINSKY'S SOLUTION.

Growth in Uschinsky's solution becomes moderate in 48 hours, but never heavy.

COHN'S SOLUTION.

Cultures 1 to 6 and *Bacillus coli* show only a very slight indication of growth, with the exception of No. 5, which in one experiment became well clouded. In a repetition by Miss Lucia McCulloch, an associate worker, the same results were obtained. The six coconut strains and four *Bacillus coli* strains were inoculated from agar slant cultures three days old, using one 1-mm. loop. The tubes were incubated at 33° C. No growth occurred in any except coconut No. 5, which formed a heavy pellicle and numerous crystals.

POTATO AGAR.

Excellent widespread, wet-shining, white growth with raised irregular margins in all the tubes within 48 hours.

CARROT AGAR.

Growth on tubes of carrot agar is thin, wet shining, white, but very restricted, never extending over the surface of the medium.

LITMUS-LACTOSE AGAR.[1]

Growth on litmus-agar slant tubes is barely perceptible, thin, transparent, and spreads along the streak. Occasionally it develops into small colonies, in which case it reddens the litmus.

On plates both *Bacillus coli* and the coconut organism form small colonies which redden the litmus and are semitransparent and zooglœa-like.

OXALIC-ACID AGAR.

Growth on agar containing 0.2 per cent oxalic acid is similar to that on litmus-lactose agar, being very slight.

MERCURIC CHLORID.

Solutions of beef bouillon containing different percentages of mercuric chlorid were made up for the purpose of ascertaining how strong a solution this organism was able to withstand. In one experiment none of the cultures were able to survive in a solution containing mercuric chlorid as strong as 1 to 3,000. In another experiment the cultures became heavily clouded when the tubes contained mercuric chlorid in the proportion of 1 to 1,000, as well as in weaker proportions up to 1 to 7,000.

Miss Lucia McCulloch made additional tests as follows: A flask containing 250 c. c. of mercuric chlorid water (1 to 1,000) was inoculated with one 1-mm. loop of the cloudy water in the V of an agar slant culture (48 hours old) of coconut No. 5. After 1 minute of vigorous shaking two plates were poured. At the end of 3, 5, and 10

[1] For description of the use of litmus-lactose agar or gelatin, see Wurtz's "Method for the Differentiation of Bacillus Typhi from Bacillus Coli," Technology Quarterly, vol. 6, 1893, pp. 241–251.

minutes, respectively, other plates were poured. For inoculation one 3-mm. loop from the flask was used.

A similar set of plates was made from 250 c. c. mercuric chlorid (1 to 5,000) and from 250 c. c. sterile water. In all three cases inoculations were of the same amount and from the same culture, and the plates were poured at the same intervals of time. The plates were incubated at 33° C.

After 24 hours the plates poured from sterile water had numerous colonies (about 1,500 in each plate). The plates from $HgCl_2$ 1 to 1,000 had a total of two colonies; the plates from $HgCl_2$ 1 to 5,000, a total of three colonies.

After 9 days no more colonies had developed in the plates from the $HgCl_2$ solutions.

Another experiment with similar strengths of $HgCl_2$ was made with plates poured at end of 20, 30, and 40 seconds.

No colonies appeared even after six days at 33° C. The check plates from sterile water gave 450 to 500 colonies in 24 hours.

MONOCALCIUM PHOSPHATE.

Two solutions, A and B, were made up, each containing 1 per cent peptone, 1 per cent dextrose, 0.5 per cent sodium chlorid and neutral red, and into A was put 1 per cent monocalcium phosphate and into B, 0.1 per cent. The amount of calcium phosphate in normal coconut tissues is 0.05 per cent.

After 1 day: A tubes were clear.
B tubes were well clouded, but had produced no change in color.
After 16 days: A tubes were perfectly clear.
B tubes all moderately clouded with moderate amount of precipitate. No change in color.

PEPTONE SOLUTION CONTAINING ROSOLIC ACID.

Two solutions, A and B, were made up, each containing 1 per cent Witte's peptone and sufficient rosolic acid to make a bright red, and into A was put 1 per cent dextrose.

After 1 day: A tubes were yellow; good growth.
B tubes remain red; good growth.
After 4 days: A tubes were orange yellow; well clouded.
B tubes unchanged in color; well clouded.
After 11 days: A tubes, same as before.
B tubes, same as before.

This experiment was repeated, and the colors in the tubes were compared with the color chart of the Répertoire de Couleurs:

A check tubes were pink.
A culture, tested after 17 days, resembled honey yellow, tint No. 3.
B check, a trifle darker than the culture tubes.
B culture, tested after 17 days, resembled cardinal red, tint No. 1.

Thus in solution A an acid was produced in the presence of the dextrose and in consequence the rosolic acid changed from pink to yellow.

In solution B, on the other hand, where no sugar was present, no acid was produced, and hence practically no change in color of the medium.

ALBUMIN.

Tubes were made up containing the white of eggs. In order to prepare them the surfaces of the eggs were sterilized in mercuric chlorid and some of the albumin drawn out through the broken surface by means of a sterile pipette and put into sterile test tubes. To several tubes was added a small amount of sterile dextrose. The tubes were then allowed to stand a week to ascertain if they remained sterile, and then inoculated.

The cultures were examined after 20 days incubation and appeared as follows:

No. 6: With sugar; moderately clouded; no odor.

Bacillus coli: Without sugar; clouded; no odor.

No. 3: With sugar; thinly clouded and small precipitate; no odor.

No. 1: And all others with sugar; a little clouded, but the albumin did not appear in any way to be affected.

Transfers were made into beef bouillon from these tubes to ascertain if the organism was still living. After 30 days all the transfer tubes were well clouded. There was a slight clouding in the check tubes themselves, due to the fact that the albumin from the egg is not perfectly homogeneous, and in consequence it was difficult to tell whether growth actually took place or not. In some cases there appeared to be distinct clouding, but in no case was there any evidence of disintegration of the albumin as evidenced by an odor. At no time was there any odor other than that of a fresh egg. It appears probable that the coconut and *Bacillus coli* organisms do not have the power of disintegrating albumin to any appreciable extent.

SUCCINIC ACID.

In a chemical analysis of a peptone-dextrose medium in which the coconut organism had been grown for some days it was found that an abundance of succinic acid was formed. In order to ascertain if it was the production of this acid that inhibited long growth of this organism, a culture solution was made containing 1 per cent peptone and 1 per cent dextrose plus 0.5 per cent succinic acid in one case and plus 1 per cent acid in another case. It was found that even after incubation for 21 days no growth resulted in either medium. Weaker acidities were then tried, as it was thought the organism could not grow when so large an amount of acid was present.

November, 1910, Miss Lucia McCulloch made the following additional tests: A medium containing 1 per cent peptone, 1 per cent dextrose, and 0.1 per cent succinic acid was inoculated from slant-agar cultures 3 days old of the six coconut strains and four *Bacillus coli* strains. Another medium containing 1 per cent peptone, 1 per cent dextrose, and 0.05 per cent succinic acid was inoculated from the same agar cultures. One 1-millimeter loop was used for inoculation and the tubes were incubated at 33° C. At the end of 48 hours a very moderate growth appeared in all the cultures, represented by thin clouding, flocculent particles, and precipitate; no pellicles. Seemingly there is no particular difference in growth in the two media. After 10 days the medium containing 0.05 per cent succinic acid was moderately cloudy, while that containing 0.1 per cent succinic acid was much clearer. The amount and character of the precipitate in the two media are very similar.

After 18 days the 0.05 per cent succinic acid was still cloudy while the 0.1 per cent succinic acid was practically clear. There seemed to be slightly more precipitate in the weaker acid medium.

COCONUT CYLINDERS.

Small pieces of firm coconut tissue from the petioles of leaves were placed in test tubes and a solution of 1 per cent dextrose was added in amounts to cover the lower half of the cylinder. The sugar was for the purpose of facilitating the growth of the organism, the tissues used being too hard to furnish much nutriment.

After 1 day at 37° C.: Growth in each tube indicated by clouding of the liquid.

After 2 days: The liquid and pieces of coconut much discolored. Slow growth on some pieces, blackening and reddening of others.

After 10 days: Check, liquid clear; cylinder hard.

Bacillus coli a, cylinders blackened—not softened, nor slimy.

B. coli, one cylinder soft, but not disintegrated; microscopic examination of section shows no change.

No. 4, brown, slimy growth on a portion of the cut surface of the cylinder which is reddish black; portion of the side blackened; by squeezing the cylinder drops of reddish thick liquid are forced out; no soft rot; the cylinder remains firm.

No. 6, blackening of the tissues as in others; also a rotting of the soft tissues.

No. 2, abundant orange-yellow precipitate and same brown slime as in No. 4; tissue woody, not soft rotted.

No. 3, same abundant orange-yellow precipitate as in Nos. 2 and 4; cylinder blackened but not soft rotted.

No. 5, same as Nos. 2, 3, and 4.

No. 5 a, same orange-yellow precipitate and same brown slime on cut surface of blackened cylinder.

No. 1, same abundant orange-yellow precipitate as in others.

This experiment was repeated under the same conditions, but there was only a flocculent clouding which quickly cleared away.

No change appeared in any of the cylinders but No. 1, and that was one of the *Bacillus coli* tubes which blackened the cylinder without showing any growth on the surface. It is evident in any case that such woody tissues of the coconut tree furnish a poor medium for the growth of the organism.

TEST 2 OF D. RIVAS.[1]

One c. c. of a 10 per cent solution of NaOH and 1 c. c. of a 50 per cent solution of H_2SO_4 are added to 5-hour cultures incubated at 37° C. in neutral sugar-free bouillon. A purple color resulting from the addition of the NaOH and H_2SO_4 is the test. The color is said to appear upon the addition of acid and to be discharged upon the addition of an alkali in excess, and is not produced in the presence of sugar. The reaction is thought to be closely allied to indol production and is dependent upon the action of the bacteria upon some proteid substance. Experiments were conducted as follows:

1. Neutral bouillon cultures grown at 37° C. Tubes inoculated at 10 a. m. on March 17 and tested at 4.30 p. m. of the same day. No purple coloration appeared either then or after allowing the tubes to stand 16 hours.
2. Sugar-free neutral bouillon tubes were inoculated at 11 a. m. on April 12 and tested at 4 p. m. The tubes were moderately clouded, but no purple color appeared on the addition of the reagents. This bouillon was made sugar-free by growing *Bacillus coli* in it and then filtering, titrating, retubing, and sterilizing. The tubes after sterilization titrated zero on Fuller's scale.
3. Sugar-free bouillon as before. Tested after three days, but no purple reaction appeared, although the tubes containing the reagents were allowed to stand 48 hours.

The failure of the cultures, both *Bacillus coli* and those of the coconut, to respond to this test is not clear. Possibly bouillon only normally free from muscle sugar should have been used.

PEPTONE WITH LEVULOSE, GALACTOSE, AND MANNIT IN FERMENTATION TUBES.

Table XXVIII shows that all the coconut cultures grow well in levulose, galactose, and mannit, and at the same rate as *Bacillus coli*. The gas production in levulose averaged in 15 days 15 mm.; in galactose 35 mm.; and in mannit 25 mm.

[1] Rivas, D. Contribution to the Differentiation of Bacillus Coli Communis from Allied Species in Drinking Water. Journal of Medical Research, vol. 18, 1908, pp. 81-91.

TABLE XXVIII.—*Growth and production of gas (in mm.) in peptone with levulose, galactose, and mannit in fermentation tubes, February 21 to March 8, 1910, at 22° C.*

Culture.	1 per cent peptone+1 per cent levulose.				1 per cent peptone+1 per cent galactose.				1 per cent peptone+1 per cent mannit.			
	2 days.	3 days.	4 days.	15 days.	2 days.	3 days.	4 days.	15 days.	2 days.	3 days.	4 days.	15 days.
Coconut 1	(1)	11	20	51	[2] 16	26	35	69	[3] 0	11	20	32
Coconut 3	[3] 8	18	20	20	[4] 0	21	30	37	(5)	16	22	28
Coconut 4	(6)	14	16	14	[4] 0	22	30	33	(5)	15	20	26
Coconut 5	[3] 10	15	17	14	[3] 15	27	35	32	[3] 17	20	22	22
Coconut 6	(7)	11	15	15	(8)	24	33	37	[4] 8	16	22	23
Bacillus coli	(9)	16	19	15	[3] 11	18	22	43	(9)	16	19	22

1 Well clouded in both ends; a few bubbles of gas.
2 Well clouded in open end; thin in closed end.
3 Well clouded in both ends.
4 Moderately clouded in both ends.
5 Moderately clouded in both ends; three small bubbles of gas.
6 Well clouded in both ends; one large bubble of gas.
7 Well clouded in open end; moderate in closed end; many small bubbles of gas.
8 Well clouded in both ends; a few large bubbles of gas.
9 Well clouded in both ends; many small bubbles of gas.

KASHIDA'S LITMUS-LACTOSE AGAR.

Kashida's medium [1] consists of bouillon containing 1.5 per cent of agar, 2 per cent of milk sugar, 1 per cent urea, and 3 per cent of tincture of litmus. The culture medium should be blue. When liquefied, inoculated with the colon bacillus, poured into petri dishes, and allowed to stand 16 to 18 hours in the incubator, the blue color passes off and the culture medium becomes red. If a glass rod dipped in HCl be held over the dish, vapor of ammonium chlorid is said to be given off. The typhoid bacillus produces no acid in this medium, and there is consequently no change in color.

TABLE XXIX.—*Growth of coconut cultures Nos. 1 to 6 and Bacillus coli on plates of Kashida's medium, April 14 to 18, 1910, at 22° C.*

Culture.	2 days.	4 days.
Coconut 1	Numerous round, wet-shining colonies; plate blue.	Densely sown with minute colonies; plate blue.
Coconut 2	Numerous roundish, wet-shining colonies; plate somewhat reddened.	Numerous large bluish, wet-shining colonies; agar blue.
Coconut 3	do	Numerous large slightly pinkish colonies; agar reddened all over.
Coconut 4	Like culture 2 only with larger colonies	Almost entirely reddened.
Coconut 5	Like culture 2	Medium entirely reddened.
Coconut 6	Like culture 2 only with larger colonies	Portion of medium reddened; portion still blue.
Bacillus coli	Only two colonies of distinct size; many minute ones; agar partly reddened.	Few colonies have reddened the medium.

A glass rod dipped into hydrochloric acid which was not fuming was held over each of the plates, and in the cases of cultures 1 and 2, which were still blue, white fumes arose from the hanging drop. In none of the other plates, all of which were entirely red or partly

1 MacFarland, Joseph. Textbook upon the Pathogenic Bacteria, p. 487.

so, did any fuming take place. As a check a small drop of HCl was held over a solution of ammonia which was not fuming, and from the hanging drop fumes arose.

TABLE XXX.—*Growth of coconut cultures Nos. 1 to 6 and Bacillus coli on plates of Kashida's medium, April 21 to 25, 1910, at 37° C.*

Culture.	1 day.	2 days.	4 days.
Coconut 1	Shows a reddening; several colonies on one side.	A number of colonies; some on the blue side; some on the red.	Same as on 2d day.
Coconut 2	Slight reddening on one side; no distinct colonies.	Number of colonies; plate all red and partly bleached.	Do.
Coconut 3	Reddened on one side; about 20 pink colonies surrounded by a pink halo.	Number of colonies; part reddened and bleached, part still blue.	Do.
Coconut 4	Slight reddening on one side; no colonies visible.	Several red colonies on red side; a few light brown ones on blue side.	Do.
Coconut 5	do	A few small red colonies	Do.
Coconut 6	Reddening on one side; several pink colonies.	Several red colonies on red side; several pink colonies on blue side.	Do.
Bacillus coli	Reddened on one side; a number of pink colonies surrounded by a pink halo; in direct light all the plates of this date are a dense blue black.	Number of red colonies; agar all red; some small colonies with reddish-black centers, then a pink zone, and outermost a yellowish zone.	Do.

The reaction, although apparently sometimes not complete, is characterized by the appearance of the red colonies on the medium which changes from blue black to red under the influence of the bacterial secretions. The color of the colonies themselves may first be blue black or a slate color, eventually becoming red if the reaction takes place. There is probably an incomplete union of the litmus with the other constituents of the medium, hence, the unevenness of the reaction, remaining blue on part of certain colonies and becoming red on the other part.

The statement of Kashida as to the reaction of the drop of hydrochloric acid to the gas arising from the colonies is not clear. If the drop of HCl held over the colonies fumes it is due to the formation of ammonium chlorid. Why this result would not take place with *Bacillus typhosus*, which blues litmus and presumably forms ammonia, is not clear. It seems to the writer that *Bacillus typhosus* would cause HCl to fume as well as *Bacillus coli* and more so. The latter organism, it is true, forms ammonia, but only in small amounts. It reddens litmus, and thus the bulk of the product is an acid. In fact, the foregoing experiments showed no response to this test of Kashida's when the colonies became red. When they remained blue it was probably the result of a failure to produce an acid, and of the positive production of an alkali.

REMY'S SYNTHETIC MEDIUM.[1]

Remy uses an artificial medium approximating a potato in composition, but without dextrin or glucose. The composition is as follows:

Composition of Remy's synthetic medium.

	Grams.
Distilled water	1,000.0
Asparagin	6.0
Oxalic acid	.5
Lactic acid	.15
Citric acid	.15
Disodic phosphate	5.0
Magnesium sulphate	2.5
Potassium sulphate	1.25
Sodium chlorid	2.00

All the salts excepting the magnesium sulphate are powdered in a mortar and introduced into a flask with the distilled water. Thirty grams of Witte's peptone are then added and the mixture heated in the autoclave under pressure for 15 minutes. As soon as removed the contents are poured into another flask into which 120 to 150 grams of gelatin have previously been placed. The flask is shaken to dissolve the gelatin, and the contents are then made slightly alkaline with soda solution. The mixture is again heated in the autoclave at 110° C. for 15 minutes, then acidified with a one-half normal solution of sulphuric acid, so that 10 c. c. have an acidity neutralized by 0.2 c. c. of one-half normal soda solution. This acidity is equal to 0.5 c. c. sulphuric acid per liter. After shaking the flask is placed in a steam sterilizer for 10 minutes, then the solution is filtered, and the acidity of the medium verified and corrected if necessary. Finally the magnesium sulphate is added, dissolved, after which the medium is tubed and sterilized by the intermittent method.

At the moment of using, 1 c. c. of a 35 per cent solution of lactose and 0.1 c. c. of a 2.5 per cent solution of carbolic acid are put into each tube.

Upon this medium the *Bacillus coli* colonies are said to be yellowish brown, the typhoid colonies bluish white and small. Fine bubbles of gas from the fermentation of the lactose often occur about the *Bacillus coli.*

Plates with Remy's medium, April 14 to 18.

Two days: No. 4, densely occupied by tiny white colonies. The other coconut plates and *Bacillus coli* just the same.

Three days: Plates just the same as two days.

Four days: Coconut and *Bacillus coli.* The colonies are very numerous on each plate. Where the medium is fairly thick they appear white, and where it is

[1] Remy, L. Contribution à l'Étude de la Fièvre Typhoide et de Son Bacille. Annales de l'Institut Pasteur, Paris, vol. 14, August, 1900, pp. 555–570.

thin they are colorless or transparent. They do not have a perfectly smooth surface, the tiny colonies, especially, appearing more or less conical. All of these plates are identical with one another.

Doubtless these plates were too thickly sown for a characteristic reaction. At any rate, the yellowish-brown color said to be produced by *Bacillus coli* was entirely lacking, while on the other hand the slightly bluish color considered characteristic of *Bacillus typhosus* on this medium was seen in the colonies where the medium was extremely thin.

ELSNER'S POTATO MEDIUM.

Cultures were made on Elsner's potato medium several times, but in each instance the medium became liquefied owing to the high temperature, so that no satisfactory results were obtained. Finally the poured plates were put in a temperature of about 15° C. Within two days tiny white colonies appeared. They were rather numerous, so that even after several days they did not become large. The smallest colonies appeared colorless or white, the larger ones a very light brown. The distinct brown color in the colonies, said to be characteristic of growth on this medium, failed to appear. The medium was made up according to the method given in Novy's Laboratory Work in Bacteriology, page 490.

COCONUT ABSORBENT-ORGAN CYLINDERS.

The absorbent organ of the coconut consists entirely of a spongy tissue which by the time the coconut is well sprouted, completely or almost fills the entire nut. In it are enzymes which convert the insoluble food material in the coconut meat into soluble material for the use of the growing plant. This organ is in actual contact with the meat, at least in the upper end, and thus is able to conduct the converted material directly into the young shoots. The arrangement of these parts is seen in Plate XI. In order to see if there was food material in the absorbent organ sufficient for the growth of the coconut organism, cylinders were steamed in the usual way and the tubes were inoculated with cultures of the coconut organism and with *Bacillus coli*. The tubes were then incubated at 37° C. The results were as follows:

After 1 day: All the tubes were moderately clouded and all but coconut No. 1 b and *Bacillus coli* (Hitchings) a and b had produced some gas.

After 2 days: Only a tiny bubble or so of gas in some of the tubes; no signs of rotting of the cylinders.

After 6 days: No gas; moderately clouded; no signs of rotting of the cylinders.

After 27 days: Same appearance; the organisms seem to have been able to grow well in the water but not to affect the tissues of the cylinders.

SEEDLING COCONUT SPLIT OPEN TO SHOW PARTS. *a*, ABSORBENT ORGAN; *b*, COCONUT MEAT.

COCONUT ABSORBENT-ORGAN PLATES.

Pieces of the absorbent organ were sterilized by means of alcohol, mercuric chlorid, and distilled water, and then placed in petri dishes. The plates were then inoculated, but even after eight days there appeared to be no growth on the tissues.

COCONUT-MEAT CYLINDERS.

Cylinders were made in the usual way from coconut meat and placed in test tubes with enough water to cover the lower half of each cylinder. The tubes were sterilized on three successive days by steaming and were then inoculated. The growth resulted as follows:

After 6 days: The submerged parts of the cylinders were pink in the culture tubes and white in the check tubes. The top of the cylinder was dark and translucent. The liquid was moderately clouded.

After 27 days: All the checks were pink under water; coconut Nos. 2 and 5, and *Bacillus coli* (Hitchings, XIV, and VI–11–V–09) were greenish white under water, and the water was of the same color; the others, including *Bccillus coli* (B. A. I.) were dark pink under water; no definite film in any case; the growth appears to have been only moderate.

COCONUT LEAFSTALK-TISSUE PLATES.

Large pieces of leafstalk of both old and very young leaves were sterilized in alcohol, mercuric chlorid, and distilled water and then placed in plates and inoculated.

After 12 days: *Bacillus coli* (Hitchings) on a large hard piece of leafstalk, surface mottled, but no rot.

Bacillus coli (VI–11–V–09) on a very fibrous piece of leafstalk, covered with a brownish slimy mass; not soft rotted to any extent.

Bacillus coli (XIV) on rather young leaf tissues, black, soft rotted as in similar portions of a naturally infected tree; exactly the appearance of the leaf-base rot in the mature tree.

Bacillus coli (B. A. I.) on two slender leaflets became completely dried up.

Coconut 5, one of the pieces of young tissue was black, soft rotted as in typical cases.

No other coconut organism was tried.

COCONUT-WATER CULTURES.

The ordinary water from the ripe coconut was sterilized in tubes and inoculated. All of the tubes became moderately clouded in two days at 37° C., but they produced no gas and did not remain clouded long. In 15 days all were practically clean except coconut No. 1, which was well clouded.

COCONUT-OIL MEDIA.

Coconut oil was pressed out of finely cut coconut meat both before and after cooking, and this was purified by mixing with alcohol and then drying out completely. After purification it was a perfectly clear oily liquid. Cultures were made into tubes of this material, but in none of them was there the slightest sign of clouding.

DETERMINATION OF CHARACTERISTICS OF THE ORGANISM BY PHYSICAL METHODS.

Optimum temperature.—Cultures in beef bouillon (+15) were placed in different temperatures and it was found that good clouding resulted in 24 hours and heavy clouding in 48 hours at any temperature from 25° to 45° C. Surface films formed more quickly at the higher temperatures, and the bouillon showed an inclination toward clearing sooner than at the lower temperatures. Cultures have remained heavily clouded at 30° C. for one month; at 22° C. (room temperature) for two months and more; at 39° C. for one month and more. The point of most luxuriant growth appears to lie between 30° and 35° C.

Maximum temperature.—The maximum temperature is not known Cultures kept at 46° C. for two weeks became heavily clouded with a good surface film and afterwards gradually thinned, as though having passed their best growth.

Minimum temperature.—Cultures in beef bouillon (+15) were kept at various temperatures ranging from 3° C. up to room temperature. After one month cultures at 4° C. and below showed no clouding. Cultures at 8.5° C. failed to cloud until after one month, when one-third of the tubes became thinly clouded. Cultures at 10° C. clouded slowly and within a week were moderately well clouded.

Thermal death point.—Cultures in beef bouillon (+15) were exposed for 10 minutes in water heated to various temperatures. Cultures exposed to an average temperature of 54.9° C. (variation from 54.4° to 55° C.) for 10 minutes failed to grow. Cultures exposed to an average temperature of 51.6° C. (variation from 51.4° to 51.8° C.) failed to cloud in 24 hours, but in 48 hours showed a retarding of growth, though not inhibition. Cultures exposed to an average of 51.° C. (the variation from 50.8° to 51.2° C.) were moderately clouded in 24 hours.

Another set of experiments was made and the culture in bouillon clouded in 24 hours after an exposure of 10 minutes to an average of 54° C. (varying from 53.85° to 54.05° C.). Cultures exposed to 53.35° C. (varying from 53.20° to 53.40° C.) clouded well in 24 hours as did cultures exposed to 52.80° and 52° C.

The experiment was repeated, and cultures exposed for 10 minutes to an average of 54° C. (53.95° to 54° C.) clouded in 18 hours. Cultures exposed to a temperature of 55° C. (54.85° to 55.15° C.) became lightly clouded in 18 hours and well clouded in 24 hours. Three of the six culture tubes exposed to a temperature of 56° C. (56° to 56.10° C.) clouded in 24 hours, the three remaining tubes failed to cloud. Higher temperatures were not tried. The thermal death point is at least above 56° C.

A repetition of this experiment gave the following results: The six coconut cultures and four strains of *Bacillus coli* exposed 10 minutes to a temperature ranging from 59.2° to 59.6° C. failed to cloud in 48 hours at 37° C.; the same series exposed for 10 minutes to a temperature ranging from 57.4° to 57.8° C. failed to cloud in 48 hours at 37° C.; the same series exposed for 10 minutes to a temperature ranging from 56.4° to 56.6° C. failed to cloud in 48 hours at 37° C. with the exception of *Bacillus coli* (Hitchings). None of the coconut cultures and only this one strain of the four *Bacillus coli* strains survived this experiment. It is reported in some textbook of bacteriology that 59° C. is the thermal death point of *Bacillus coli*. However that is, it is certain that none of the organisms used survived 57° C. in this experiment. It was seen in the preceding experiment that all the coconut cultures exposed to a temperature of 54.85° to 55.15° C. grew well, and that after an exposure to a temperature from 56° to 56.10° C. three of the six tubes grew well. From these experiments it would seem that the thermal death point of the coconut organisms and of *Bacillus coli* is between 56° and 57° C.

Miss McCulloch carried out the following additional tests in November, 1910: Six coconut and the four *Bacillus coli* strains in newly inoculated beef bouillon were subjected for 10 minutes to temperatures of 56°, 57°, and 58° C., then incubated at 33° C. In 24 hours two of the *Bacillus coli* (B. A. I. and Hitchings) in the 56° C. set were clouded; no growth in the 57° C. set; coconut No. 1 was clouded in the 58° C. set. In 48 hours three of the *Bacillus coli* (B. A. I., Hitchings, and VI–11–V–09) were clouded in the 56° C. set; no changes in the others. In 10 days no further change.

Other experiments were made, trying 55°, 56°, and 57° C. In 48 hours at 34° C. all of the 55° C. set, with the exception of coconut Nos. 4 and 5, were clouded. Three strains of *Bacillus coli* (Hitchings, VI–11–V–09, and XIV) and coconut No. 2 were clouded in the 56° C. set. Coconut No. 1 and two strains of *Bacillus coli* (Hitchings and B. A. I.) were clouded in the 57° C. set. In six days coconut Nos. 4 and 5 were still clear in the 55° C. set. Coconut Nos. 1, 2, and 3, and three *Bacillus coli*, in the 56° C. set clouded. No further change in the 57° C. set.

Desiccation.—Clean cover glasses were sterilized and drops of the cultures were placed upon them, after which they were set away in sterile petri dishes to dry out at room temperature. Cultures dried two days clouded well in 24 hours. Those dried six days clouded but little in the same time. Cultures dried 15 days were still able to cloud the bouillon.

Sunlight.—Agar plates were made and half of each of them covered with black paper; they were then set on ice in direct sunlight, the ice serving to counteract the heat effect of the sun's rays. This experiment was carried on in the middle of January, about 1 p. m., with a somewhat hazy sun. The plates were thickly sown. Those exposed for one hour failed to show any effect whatever from the sunlight, and developed in an apparently normal manner.

This experiment was repeated on February 2, at noon, in bright sunlight, and salt was added to the ice to reduce to a minimum the liability of the sun's heat affecting the organism. Exposures to the direct sunlight were made for 30, 45, 75, 90, and 120 minutes. In 24 hours all the plates showed good growth on the unexposed half of the dish. On the plate exposed for 30 minutes only about half as many colonies appeared on the exposed side as on the unexposed. On the plate exposed 45 minutes the reduction was still greater, but the colonies could not be definitely counted on account of their tendency to coalesce. On the plate exposed for 60 minutes about one-eighth as many colonies appeared on the exposed as on the unexposed side. On the plate exposed 75 minutes no colony appeared on the exposed side. The same condition was true for the plates of 90 and 120 minutes exposure. In 36 hours six submerged colonies were visible on the 120-minute plate, and some were visible on all the others, in addition to the spread of the colonies from the unexposed side of the plate.

INOCULATIONS FOR THE COMPARISON OF THE COCONUT ORGANISM AND BACILLUS COLI.

In earlier pages of this paper it has been shown that a certain organism could produce diseased conditions by artificial inoculations into healthy coconut trees, identical with typical bud-rot. On subsequent pages it has been shown that this coconut organism is practically identical in its cultural features with the common *Bacillus coli.* The next step was to produce conditions similiar to bud-rot by means of inoculations with *Bacillus coli* derived from animals. For this purpose several experiments have been carried out in the greenhouse with coconut seedlings. The coconut organism was inoculated into some seedlings for comparison with the *Bacillus coli* inoculations.

Experiment No. 1.

Inoculations with the coconut organism and with *Bacillus coli* (from animals) were made into coconut seedlings on February 17 from cultures of February 16. At the same time a solution of ammonium oxalate was injected into a seedling. No check inoculations other than this were made at this time.

The inoculations were examined from time to time, and finally on March 7, 18 days after the injection, the material was collected and attempts were made to isolate the organisms inoculated. The methods of procedure for identifying the coconut organism and *Bacillus coli* were the same and were based on some of the characteristic reactions of these organisms. Dolt's synthetic medium No. 1 (a litmus-lactose-glycerin agar, p. 79), litmus milk (p. 94), nitrate bouillon (p. 71), fermentation tubes containing peptone and dextrose with neutral red (p. 80), and, in some instances, gelatin, were used. These media have been recommended by various investigators who have carried out extensive work with *Bacillus coli* in connection with their "board of health" investigations and full discussions of them are given on the pages cited. Following are the results of this experiment:

Inoculation No. 1, with ammonium oxalate: The inoculation point was about the same as with *Bacillus coli*, only drier.

Inoculation No. 2, with *Bacillus coli:* Discoloration for only a short distance from the inoculation hole; a water-soaked discoloration but not appearing like a soft rot.

Inoculation No. 3, with coconut No. 5: Discoloration extended a distance of 4 centimeters from the hole and the tissues appeared under the microscope to be full of bacteria.

Inoculation No. 4, with coconut No. 5: Discoloration appeared for only a short distance about the inoculation hole; discolored tissues appeared under the microscope to be full of bacteria.

On the agar plates poured in the usual way from these diseased tissues there appeared round, white colonies, typical of the coconut organism in the case of the coconut plates; but round, thin, white colonies, some with dentate margins, both typical and atypical forms of *Bacillus coli,* in the case of the *Bacillus coli* plates.

Transfers were made of selected colonies from these plates to litmus milk, and after five days all of the tubes had produced red surface rings, but in only one case (from coconut inoculation No. 3) had the medium turned entirely red.

These cultures were also transferred to agar containing neutral red, to Dolt's synthetic medium, and again to litmus milk. In each case negative results were obtained for both the coconut organism and *Bacillus coli.*

Plates were again poured from dilutions of the original bouillon tubes containing the diseased material, and this time Dolt's litmus-lactose-glycerin agar was used. In five days pink colonies typical of both the coconut organism and of *Bacillus coli* were formed on their respective plates. Twelve out of the fourteen plates poured showed these colonies.

Transfers were made from these pink colonies to nitrate bouillon, and two days afterwards test for the reduction of nitrate to nitrite showed in tubes from two of the *Bacillus coli* plates, in tubes from three of the plates of coconut inoculation No. 3, and in one of the plates from coconut inoculation No. 4.

Before the nitrate tubes were used for the test transfers were made to beef bouillon and subsequently transfers from these were made to litmus milk. In two days each of the litmus-milk tubes, from nitrate tubes that had responded to the reduction test, showed the typical reddening of the litmus and coagulation of the milk that is found in the coconut organism and in *Bacillus coli.*

The tests for these organisms were not carried out further, it being considered that the typical reaction found in the litmus-lactose-glycerin agar, in the nitrate bouillon, and in litmus milk were sufficient for identification.

The only further means of identification was to make transfers from the original bouillon which contained the diseased matter directly to various media without the preliminary plating out of individual colonies. In this way transfers were made to litmus milk, in which case all but one of the tubes reddened and coagulated the milk; to beef agar containing neutral red, in which case all the tubes produced gas and turned the color of the medium to a canary yellow at the base; and to litmus-lactose-glycerin agar, in which good pink colonies were formed, as in *Bacillus coli* and the coconut organism, and the agar was entirely reddened. These tests were considered sufficient to indicate that the same organisms were to be found in the diseased material as were originally injected into the healthy tissues. It appears from this that not only the coconut organism but also *Bacillus coli* (from animals) is capable of producing a destruction of the heart tissues of the coconut plant. Although this was not altogether a surprise after making the extensive comparison of the two organisms that has been described on previous pages and the close similarity of the organisms that has been shown, yet the fact that *Bacillus coli* or any bacterial organism that is commonly associated with animal life is capable of producing a plant disease was so unexpected that further confirmation was thought desirable. The one inoculation of *Bacillus coli* described in this experiment, while on the face of it appearing to have all the points necessary for verification, yet demands several repetitions before it can be accepted as an incontrovertible fact. To this end further inoculations were carried out.

Experiment No. 2.

Along with the other inoculations just described as being made on February 17 a second injection of *Bacillus coli* (derived from animals) was made into a coconut seedling and likewise another solution of ammonium oxalate. This work was done in the usual way and left until April 5, at which time (after 47 days) the material was collected and platings from the diseased tissue were made both by the writer and by Miss Lucia McCulloch. The appearance of the inoculations was as follows:

Bacillus coli.—The outermost point of the inoculation was merely a trifle browned and water soaked and not at all extensive. The next inner leaf and the one inclosing the central leaf had uppermost an inoculation hole which was browned and water soaked, but only 8 millimeters in extent. On the other side of this same leafstalk was a soft-rotted white area about 5 centimeters long. The innermost leaf, which was still folded, showed the result of the inoculation extending over a distance of 9 centimeters. The diseased part at the lower end was only slightly browned and dry, the middle was soft rotted and water soaked, and the upper part was considerably blackened. The rot was a typical soft rot, although it had not reduced the tissues to a watery fluid.

Ammonium oxalate.—In the outer tissues this inoculation had no characteristic effect. In the inner tissues the leaf was somewhat blackened and dry. No soft rot was in evidence. The action seems to have been a poisonous one rather than one having any effect in dissolving the tissues.

The isolation of the organism from the diseased material as carried out by Miss McCulloch is described in the following paragraphs:

Young coconut leaf, brown to black with rot at base. Bacteria only moderately abundant as seen by the microscope. Some mycelium found.

Plates poured with ordinary beef agar showed in 20 hours numerous round, white colonies up to 2 millimeters in diameter. Transfers were made to agar and to litmus milk.

In 48 hours the agar colonies which had been white were cream color, opaque, and not quite round. Transfers were made from the agar tubes to fermentation tubes containing 1 per cent peptone water plus 1 per cent dextrose plus neutral red and to tubes containing nitrate bouillon.

In three days the fermentation tubes contained gas to the amount of 2.5 to 3 centimeters and the closed arms were canary yellow. Five out of the six tubes showed this reaction. The nitrate-bouillon cultures were then tested for the reduction of nitrates to nitrites and the same five out of the six tubes responded to the test.

Transfers were made from the five fermentation tubes which produced gas to slant tubes of Dolt's synthetic medium. In two days the medium became reddened and the cultures showed a good pink, wet-shining growth.

Transfers were made from these slant agar tubes to litmus milk and to agar containing dextrose and neutral red.

The litmus-milk cultures made directly from the plates, for the most part, reddened and coagulated. The litmus-milk cultures, from the slant-agar Dolt's medium, likewise reddened and coagulated.

The agar tubes containing dextrose and neutral red after inoculation showed good growth and a subsequent bleaching of the color, but no change to canary yellow. As the reaction is an inconstant one, however, it can not be considered evidence against the identification of *Bacillus coli*.

Thus, in Miss McCulloch's isolations of the organisms she obtained bacteria which coagulated milk, reddened litmus, grew well on Dolt's litmus-lactose-glycerin agar, produced gas, and caused a change to canary yellow of fermentation tubes with peptone and neutral red, and reduced nitrates to nitrites.

The writer of this paper likewise made attempts to isolate *Bacillus coli* from the same diseased seedling used by Miss McCulloch. The process was similar to that in experiment 1 and showed results as follows:

The agar plates which were poured from the diseased material showed in 24 hours numerous round, white, raised, wet-shining colonies typical of *Bacillus coli*. Some of the colonies were irregular in shape, even to radiate branching, and some were bluish and iridescent in transmitted light, but these are variations often met with in what passes for *Bacillus coli*.

Transfers were made from the various colonies to plain beef-bouillon tubes and thence to nitrate-bouillon tubes. After three days in the nitrate bouillon, tests were made for the reduction of nitrates, and it was found that 6 out of the 13 tubes responded to the test. Of these six, two were from round, white colonies; one from round, white, iridescent; one from blue iridescent; one from radiate branched; and one from an irregular blue iridescent colony. Those cultures which failed to show the reduction were largely from round colonies.

Fermentation tubes containing dextrose, peptone, and neutral red were inoculated, and after two days at 37° C. showed the typical canary-yellow color in the closed arm, together with an average of 35 millimeters of gas. Four out of seven of the tubes tried responded to this test. From these four tubes transfers were made to Dolt's litmus-lactose-glycerin agar slant tubes where all grew well, reddened the agar, and produced good pink growths.

Transfers were made from these same tubes in gelatin and placed in the thermostat at 37° C., where an excellent growth took place. After 48 hours the tubes were placed in an ice box and the medium soon became entirely solidified, showing that no liquefaction had taken place.

From these results it will be observed that the same conclusion may be derived as from Miss McCulloch's platings, that is, that *Bacillus coli* was isolated from the diseased material obtained from an inoculation of *Bacillus coli*.

Experiment No. 3.

On April 14, 1910, two inoculations were made into coconut seedlings with cultures of *Bacillus coli*.

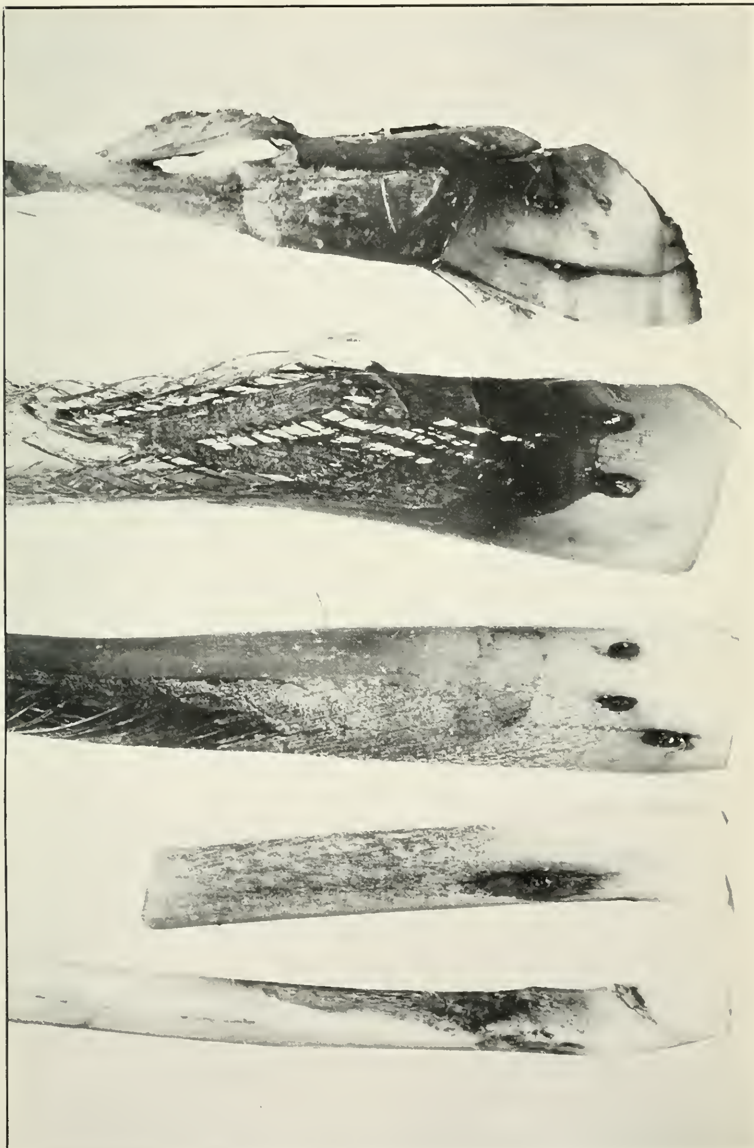
The point of inoculation on the seedling was washed with a solution of mercuric chloride before inoculation.

On May 16, just 32 days afterwards, these two inoculations were cut out and examined. They appeared as follows:

(*a*) Dry, brown discoloration about upper part of hole. At extreme lower end were water-soaked discolorations and slight signs of rot. At the lower part the tissues were considerably split up. The edges of the cracks were yellowed, and in the cracks were masses of what appeared to be bacteria, but little active motility was discernible.

(*b*) Good water-soaked, brown, soft rot extending about 5 centimeters (Pl. XII).

Diseased material from these inoculations was carefully rinsed in alcohol, soaked in mercuric chlorid, and rinsed in distilled water; then, by means of sterile knives and forceps, small pieces were put into test tubes containing beef bouillon and there thoroughly cut up.



RESULT OF INOCULATING BACILLUS COLI INTO COCONUT SEEDLINGS. TIME, 32 DAYS.

These tubes were allowed to stand over night, and on the following day dilutions of the tubes were made in the customary manner and plates were poured, using Dolt's synthetic medium.

In two days every one of the 10 plates showed pink colonies, and where there were more than two or three colonies the agar was entirely reddened. In some plates the colonies were few, while in others they were numerous. For the most part they were round and to all appearances like *Bacillus coli*. The fact that they reddened the litmus and grew well in this lactose medium is good evidence of their identity.

Transfers were made on May 21 from the pink colonies to litmus milk and incubated at 37° C. In 24 hours the four tubes were red, coagulated, and showed abundant whey. Transfers from these litmus-milk tubes were made to nitrate bouillon on May 28 and three days afterwards were tested for the reduction of nitrates to nitrites. Each one of the tubes showed the reduction well.

On June 2 transfers were made from the litmus-milk tubes to fermentation tubes containing peptone and neutral red to test for the canary-yellow color. The tubes were incubated at 37° C. After two days light clouding took place, but no gas formation nor reduction of color. This behavior being entirely contrary to that of *Bacillus coli*, the medium was tested for dextrose, which it should have for the complete reaction. It was found by the use of Fehling's solution that not a particle of reducing sugar was in the fermentation tubes, so a fresh medium containing the peptone, dextrose, and neutral red was made up. These tubes were incubated at 37° C. After 18 hours a small amount of gas appeared, but little change in color. In 24 hours the tubes showed 31 to 34 millimeters of gas, and each one was changed to the canary yellow in the closed end and to a bright red in the open end.

Transfers from each of these four fermentation tubes were made to beef gelatin and incubated for 48 hours at 37° C. At the end of that time all the tubes showed heavy precipitate, several large clots in suspension, and moderate films. The tubes were placed in an ice box and allowed to harden. Eventually each one of these became solidified and showed absolutely no sign of liquefaction of the gelatin.

Thus, in this third experiment the same organism that was inoculated, viz, *Bacillus coli*, was isolated from the decayed tissues.

Experiment No. 4.

On May 7 Miss McCulloch inoculated several coconuts under the supervision of the writer. Strains of *Bacillus coli* (Hitchings and VI–11–V–09) which had not been in the hands of the writer at all were used. The coconuts for this experiment had but recently been set out after their arrival from a locality in Florida where the bud-rot does not occur. They were just beginning to make good growth. The following notes are from Miss McCulloch:

Seedlings 6 to 12 inches out of nut: At base of stalk a spot was washed with 1:1000 $HgCl_2$, rinsed in sterile water, then with sterile needle a puncture made to heart or center of stalk. The bacterial growth from agar slant was washed off in sterile water and this water (cloudy with bacteria) was injected with a hypodermic needle into the center of the plant. Inoculations Nos. 1 to 4 from agar slants 1 to 4 Hitchings strain of *Bacillus coli;* inoculations Nos. 5, 6, and 7 from agar slants 1, 2, and 3 of VI–11–V–09 strain of *Bacillus coli*. After inoculation the agar from the tubes was taken out on the cotton plug and bound over the point of inoculation. Checks Nos. 8 and 9 were punctured with sterile needle and the binding of agar and cotton put on as with inoculated plants.

Inoculation No. 4, collected June 8: The path of the inoculating needle is brown. In the youngest inner leaf there is a brown, water-soaked area about the inoculation point; extends 1.5 centimeters above and 1 centimeter below the inoculation point. Brownish tissue 1.5 centimeters above used for plating. Tissue was washed in alcohol, mercuric chlorid, and water, and then crushed in the test tubes.

June 10: No colonies on these plates. They have been at 37° C. for 24 hours, and at room temperature for 24 hours. A new set of plates was poured from same tubes.

June 13: A few white colonies only, on original plate; discarded. Same with second set.

Inoculation No. 5: Inoculating needle missed the center of the growth. There is no discoloration about the path of the needle except in the leaf base last punctured, where there is considerable water-soaked, reddish tissue, some of it 3 centimeters from inoculation point. Some of this diseased tissue farthest from inoculation was washed in alcohol, mercuric chlorid, and water, and crushed in test tubes. No organisms responding to *Bacillus coli* tests were isolated.

Inoculation No. 7: The central leafstalk seems unaffected by the inoculation. The base of the leaf just outside this shows discoloration and is slightly water-soaked around the opening made by the needle. All the dark part was cut off from the remainder of the leaf. The hole was laid open—the loose soft part in the opening removed—then the whole discolored part was immersed in 95 per cent alcohol 15 seconds, then in $HgCl_2$ for 2 minutes, and washed in several changes of distilled water for half an hour. The material was then crushed finely in beef bouillon and allowed to stand with frequent shaking for 3.5 hours before plates were poured. After 2 days at 37° C. only a few white colonies appeared on the plate. Plates were again poured on the Dolt's synthetic medium, but as before only white colonies appeared. Plates discarded.

The remaining inoculations of May 7 were examined by the writer, using the customary precautions of rinsing in alcohol and soaking in mercuric chlorid. The results were as follows:

Inoculation No. 1, collected on June 8: The tissues about 2.5 centimeters above inoculation point showed a browning; a rather dry rot. Plates were made in the usual way on June 9 in Dolt's synthetic medium and incubated at 37° C.

June 10: Plate 1b thickly sown with irregular, luxuriant pink colonies.
Plate $1c^2$, no colonies.
Plate 1c, numerous pink colonies.
Plate 1b, Five round pink colonies; one irregular mass.

Plate 1 a, numerous pink colonies.
Plate 1, numerous pink colonies.
Plate 1^2, Four tiny pink colonies.
Plate 1 a^2, Four tiny pink colonies.

Thus, some of these plates suggest the presence of *Bacillus coli.* Four tubes were made from the diseased material, marked thus: No. 1, No. 1 a, No. 1 b, and No. 1 c. From these dilutions were made, marked the same, and from them second dilutions were made, marked No. 1^2, No. 1 a^2, No. 1 b^2, and No. 1 c^2. Plates from these tubes have already been described for one day's growth. In two days they appeared as follows, in the order of their dilution:

No. 1: Well sown with round pink colonies, mostly typical of *Bacillus coli.*
No. 1^2: Five round pink colonies, unlike *Bacillus coli.*
No. 1 a: Many luxuriant pink, irregular, smooth colonies, unlike *Bacillus coli.*
No. 1 a^2: Six colonies, unlike *Bacillus coli.*
No. 1 b: Well sown with round, pink colonies, typical of *Bacillus coli.*
No. 1 b^2: Several colonies; none like *Bacillus coli.*
No. 1 c: Well sown with small, round pink *Bacillus coli* colonies.
No. 1 c^2: Four colonies, unlike *Bacillus coli.*

These notes were made on the plates after transfers, so that some colonies which might have been *Bacillus coli* were destroyed by the needle. Transfers from these plates to litmus milk were incubated at 37° C. All the tubes became reddened and coagulated in 48 hours. Transfers were made from the litmus-milk cultures into nitrate bouillon and incubated at 37° C. for 48 hours. At the end of that time they were tested and all showed reduction of nitrates to nitrites. Transfers were then made from the litmus milk to fermentation tubes containing neutral red and dextrose, and these were incubated at 37° C. After 48 hours every one of the 10 tubes showed the typical greenish-yellow color reaction in the closed arm of the fermentation tube characteristic of *Bacillus coli.* Transfers were made to gelatin and incubated at 37° C. for 48 hours. They were then placed in an ice box to permit hardening. After 10 hours all of these tubes were found to be perfectly firm, thus showing that no liquefaction of the gelatin had taken place. No further tests were made, as it was believed that sufficient had been shown to indicate that *Bacillus coli* was in the tissues into which it had been injected in inoculation No. 1.

Inoculation No. 2, of May 7: The outer sheath was very slightly water soaked about the inoculation hole. The under leaves were rotted only a slight distance; more than in the checks, but scarcely enough to plate out.

Inoculation No. 3, of May 7: The outer sheath was brown rotted 2 millimeters about the inoculation hole on the inner side. Above the hole were numerous brown spots, apparently stomatal infections from the excess of bacterial liquid inoculated. These tiny brown spots were surrounded by water-soaked areas. The inner part of the tissue was browned and rotted for a distance of 2.5 centimeters. The tissues were not soft rotted. The middle leaves were densely covered with brown water-soaked spots up to 2.5 centimeters from the brown-rotted area. From this inoculation 6 plates were made on June 7 using Dolt's synthetic medium. On June 9 all of the plates showed one or more pink colonies. Transfers were made from the pink colonies to litmus milk and incubated at 37° C. After four days two of the tubes had reddened and coagulated; five had reddened but remained uncoagulated; and one had turned the litmus blue. Transfers to nitrate bouillon showed after 48 hours that all of these cultures except the one which had blued litmus were capable of reducing nitrates to nitrites. Transfers were then made to fermentation tubes containing neutral red and dextrose. These tubes after incubation for 48 hours at 37° C. showed the greenish-yellow reaction in the closed arm as in the case of the same cultures that had both reddened the litmus and coagulated the milk. Those which had only reddened the litmus without coagulating the milk produced a deep-red color in both ends of the fermentation tubes. Thus two, at least, of these cultures appeared to be *Bacillus coli*.

Inoculation No. 6, of May 7, collected on June 8: The outer sheath was brown and water soaked for 8 millimeters about the hole. The inner leaves were brown rotted 25 millimeters from the hole, but there was no soft white rot. No platings were made.

Inoculation No. 8, check: Browning of the tissue was only immediately about the inoculation hole. This discoloration did not extend any appreciable distance. Absolutely no sign of rot or of destruction of tissue.

The results of these inoculations show that all of the cultures produced much more effect on the coconut tissue than did the bare check inoculation; that in some cases there was a distinct rot and that in two inoculations apparently *Bacillus coli* was reisolated. These inoculations were all made with *Bacillus coli*, a strain designated as Hitchings, and made by one unaccustomed to work with the coconut plant—a very important matter. Moreover, the plants were in poor condition for the purpose, as they were just starting a rapid growth which in several cases caused the central leaves to develop into firm, resistant tissue before the rotting effect could take place. The work would probably be more successful if the husk were partly removed about the young shoot and the inoculations made in the thickest part of the stem. As it was, all the inoculations were made outside of the husk in the more or less unsatisfactory green hardened tissues (Pl. XI) and in plants not making one-quarter as rapid growth as they would have made in the Tropics.

EXPERIMENT NO. 5.

On August 15, 1910, three inoculations were made into coconut trees in Baracoa with a strain of *Bacillus coli* obtained from Dr. Theobald Smith. The three trees were each about 6 years old and were apparently in a perfectly healthy condition, although they were bordering a grove of some 1,200 trees that had just been entirely destroyed by the bud-rot.

On September 28 these inoculations were examined.

Inoculation No. 1 proved to have been made too low. It was below the heart and in the woody tissue. The tissue was entirely rotted about 1 centimeter around the hole from the outside to the interior. On the outer sheaths the brown discoloration extended several centimeters.

Inoculation No. 2 was the same as No. 1. Here also the inoculation was in the wood below the heart.

Inoculation No. 3 was in the soft tissues above the heart. The hole itself was perfectly dry and uninfected in the interior. Extending from the hole upward for 1 meter and only on the inoculated side was the typical soft white rot of the bud-rot disease. The infection was visible on the upper part of the central leaves. There were no insects or other signs of carriers of the disease. It could not be determined if the rot was caused by the inoculation, because, (1) it became more conspicuous from a point 8 centimeters above the hole, but this may have been because of tissues better suited to infection at that point and upward, infectious fluid being injected into all this area; or because (2) by rapid growth the soft injected tissues were carried up beyond the level of that part of the puncture passing through the older tissues. The method of inoculation consisted first in boring a hole to the center of the trunk by means of a 9-millimeter steel bit and then injecting the fluid containing the germs by means of a large syringe. As the terminus of the hole in this case was made into the soft tissues it is very possible that the syringe did not follow the hole throughout, but was pushed to one side in the soft inner tissues. Such a condition could not be determined for the reason that the end of the syringe was small and would make only a very small hole, and the tissues were rotted at this point so that any hole, unless very large, would be indistinguishable. The writer considered the rot due to the *Bacillus coli* introduced by him. On the other hand, it might be claimed that the inoculation failed and that the infection was entirely an outside one. However, if the same kind of organism that was injected could be isolated from the diseased tissues it would go a long way toward proving the relation of *Bacillus coli* to the disease.

Material from each of these three inoculations was secured, rinsed in mercuric chlorid, then in water, and finally pieces of it transferred by means of sterile knives and forceps to tubes containing Dolt's synthetic medium. These tubes were taken to Washington and there plated out. It was found, by the usual method of isolation described on other pages, that in the case of each of the inoculations, *Bacillus coli,* the same organism that was injected was present in great numbers, although in no case were pure cultures obtained. The results of these inoculations by themselves are rather unsatisfactory, but taken together with the earlier results they afford good evidence as to the relation of *Bacillus coli* to the disease.

Experiment No. 6.

Ten inoculations into coconut seedlings were made with *Bacillus coli* (Theobald Smith XIV) on October 14 in the greenhouse at Washington. Examined on November 10 they showed the following conditions:

Six of the inoculations showed only a slight browning of the tissues about the hole and some water-soaked areas, but no rot nor discoloration of the sheaths.

Two inoculations showed a good brown rot for a short distance about the hole and brown staining for a distance of about 3 centimeters above the hole.

One showed a typical soft wet rot 3 centimeters long and a brown stain 5 centimeters above the hole.

One showed splendid brown soft rot for a distance of 12 centimeters in middle leaves. Outer leaves were well water-soaked and rotted for a distance of 2 centimeters all around inoculation hole, even on the outside sheaths.

No isolations were attempted from any of this series of inoculations.

BACILLUS COLI, THE CAUSE OF BUD-ROT.

Cultures of true *Bacillus coli* have produced infections in the heart tissue of the coconut crown similar to those infections caused by the coconut organisms. Isolations from the *Bacillus coli* inoculations and from the coconut organism inoculations have shown cultures identical in nearly every particular. From the early coconut inoculations, isolations, reinoculations, and reisolations (described on pp. 43–46) the cultures which were obtained have appeared identical in most cases. When difference has existed, it has usually been a matter of degree rather than of kind.

The proof of the cause of the bud-rot will depend for its verity upon the similarity of the various cultures isolated from diseased tissues and upon the constancy of the reactions. Dissimilarity or variation will require satisfactory explanation, or it will count against the statement to be proved. For the proof, so far as inoculations are concerned, the results cited seem sufficient. There can be no question that good infections were obtained. If now the similarity of the organism injected into the tissues and of the organism isolated from the tissues in various experiments be shown, the cause of bud-rot, and, moreover, *Bacillus coli* as the cause, will be demonstrated. In order to show briefly and in a concise form the similarities and differences among these organisms as ascertained in the cultural work, Table XXXI has been prepared.

TABLE XXXI.—*Summary of characters*[1] *of the coconut organisms and of Bacillus coli.*

Detailed features.	Coconut culture.						Bacillus coli.
	1.	2.	3.	4.	5.	6.	
Morphology of organism	+	+	+	+	+	+	+
Morphology of colony on agar plate, agar stab, streak, gelatin stab, plate	+	+	+	+	+	+	+
Facultative anaerobism	+	+	+	+	+	+	+
Gelatin liquefaction [2]	±	—	—	—	—	—	—
Acid in dextrose	+	+	+	+	+	+	+
Gas in dextrose	±	±	±	±	±	±	±
Acid in lactose	+	+	+	+	+	+	+
Gas in lactose	+	+	±	±	+	±	+
Acid in saccharose	+	+	+	+	+	+	+
Gas in saccharose	+	+	±	±	+	±	+
Reduction of nitrates	+	+	+	+	+	+	+
Pigment production	—	—	—	—	—	—	—
Growth on starch media	±	±	±	±	±	±	+
Acid in glycerin	+	+	+	+	+	+	+
Gas in glycerin	—	+	—	—	+	—	+
Dolt's litmus-lactose-glycerin agar [3]	+	+	+	+	+	+	+
Neutral red:							
With peptone water + dextrose in fermentation tubes	+	+	+	+	+	+	+
With dextrose in agar [3]	+	+	+	+	+	+	+
With lactose in agar	......	......	......	......	+	......	+
With saccharose in agar	......	......	......	......	+	......	+
With glycerin in agar	......	......	......	......	+	......	+
Without sugar in agar	......	......	......	......	+	......	+
MacConkey's bile-salt agar with neutral red: [3]							
In tubes	+	+	+	+	+	+	+
In plates [4]	+	+	+	+	+	+	+
Test 1 of D. Rivas	+	+	+	+	+	+	+
Test 3 of D. Rivas	+	+	+	+	+	+	+
Endo's fuchsin agar [5]	+|	+	+	+	+	+	+
Stoddart's plate medium	+	+	+	+	+	+	+
Hiss's tube medium	+	+	+	+	+	+	+
Sterile milk	+	+	+	+	+	+	+
Litmus milk	+	+	+	+	+	+	+
Production of—							
Indol [6]	+	+	+	+	+	+	+
Phenol [7]	......	......	......	......	—	......	......
H_2S	+	+	+	+	+	+	+
Ammonia	+	+	+	+	+	+	+

[1] Explanation of arbitrary signs used in the table: + indicates that the reaction is positive, or merely that the characters are all the same; — indicates that the reaction is negative; ± indicates that the reaction sometimes occurs and sometimes does not; +| indicates that the reaction is a variation in the positive reaction, which is the same in all cultures so marked; ±| indicates that there is a variation in the positive reactions which sometimes occurs and sometimes does not.

[2] For variations in No. 1, see p. 66.

[3] No. 1 tends to bleach.

[4] Nos. 2 and 5 and *Bacillus coli* are slightly different from others.

[5] No. 3 and *Bacillus coli* are slightly different from others.

[6] *Bacillus coli* a trifle more than others.

[7] This result is questioned.

TABLE XXXI.—*Summary of characters of the coconut organisms and of Bacillus coli*—Continued.

Detailed features.	Coconut culture.						Bacillus coli.
	1.	2.	3.	4.	5.	6.	
Enzymes in milk [1]	–	–	–	–	–	–	–
Growth in nitrogen-free media:							
With ammonium tartrate [2]	+	+	+|	+|	+	+|	+|
With ammonium citrate [3]	+	+	+|	+|	+	+|	+|
With ammonium lactate	+	+	+|	+|	+	+|	+|
With asparagin	+	+	+|	+|	+	+|	+
With sodium asparaginate	+	±|	±|	±|	±|	±|	+
Fischer's mineral solution:							
Alone [4]	–	–	–	–	–	–	....
With dextrose	+	+	+	+	+	+	....
With KNO_3 [5]	–	–	–	–	–	–	....
With cane sugar	+	+	+	+	+	+	....
With peptone	+	+	+	+	+	+	....
With peptone + dextrose	+	+|	+	+	+|	+	....
With peptone + glycerin	+	+	+	+	+|	+	....
With glycerin	+	+	+	+	+	+	....
With cane sugar + KNO_3	+|	+	+	+	+|	+	....
With dextrose + KNO_3	+	+	+	+	+	+	....
Malachite green in sugar	+	+	+	+	+	+	+
Caffein in agar	–	–	–	–	–	–	–
Capaldi and Proskauer:							
No. 1	+	+	+	+	+	+	+
No. 2	+	+	+	+	+	+	+
Dunham's solution:							
With 7 per cent NaCl	+|	+	+|	+|	+	+	–
With 6 per cent NaCl	+|	+	+|	+|	+	+	+
Uschinsky's solution	+	+	+	+	+	+	+
Cohn's solution [6]	–	–	–	–	±	–	–
Potato agar	+	+	+	+	+	+	+
Carrot agar	+	+	+	+	+	+	+
Litmus-lactose agar	+	+	+	+	+	+	+
Oxalic-acid agar (0.2 per cent acid)	+	+	+	+	+	+	+
Coconut cylinders	+	+	+	+	+	+	+
In fermentation tubes:							
Acid from galactose	+	+	+	+	+	+	+
Gas from galactose [7]	+|	+	+	+	+	+	+
Acid from levulose	+	+	+	+	+	+	+
Gas from levulose [8]	+|	+	+	+	+	+	+
Acid from mannit	+	+	+	+	+	+	+
Gas from mannit	+	+	+	+	+	+	+
Kashida's medium	+|	±|	±|	±|	±|	±|	+
Temperatures (degrees Centigrade):							
Optimum	35	35	35	35	35	35	35
Maximum	47	47	47	47	47	47	47
Minimum	8.5	8.5	8.5	8.5	8.5	8.5	8.5
Thermal death-point	57	57	57	57	57	57	57

[1] If present, in only very small quantities.
[2] Nos. 3, 4, and 6 and *Bacillus coli* have much poorer growth than others.
[3] Growth in these tubes varies considerably in amount and color of precipitate.
[4] There appears to be a very slight clouding.
[5] Very slight clouding, if any.
[6] Very slight growth, if any, in all but 5.
[7] No. 1 produced 69 mm. of gas; others ranged from 32 to 43.
[8] No. 1 produced 51 mm. of gas; others averaged 14 to 20 mm.

The importance of the variations shown in the foregoing tables has been discussed under the various experiments. It will suffice to summarize them briefly at this point.

In comparing coconut cultures Nos. 4, 5, and 6 (which are inoculation (6), isolation (5), reinoculation, and reisolation (4) cultures of the same origin) with *Bacillus coli* it is seen that they are all identical until it comes to acid and gas in lactose. In that medium No. 5 and *Bacillus coli* have always behaved alike; Nos. 4 and 6 have always acted similarly to each other and frequently in this medium similarly to No. 5 and *Bacillus coli.* This variation is the same in saccharose. The growth on starch media shows that all the coconut cultures find difficulty in obtaining sufficient nutriment in such media; but, as before, No. 5 is more nearly like *Bacillus coli.* In glycerin media No. 5 always has reacted like *Bacillus coli* and Nos. 4 and 6 like each other. In all the media, following down to the nitrogen-free media, the reactions of Nos. 4, 5, and 6, and of *Bacillus coli* are identical. In media with ammonium tartrate these cultures are sometimes all alike, but then again Nos. 4, 6, and *Bacillus coli* may differ from 5. It is the same with ammonium citrate and ammonium lactate. In asparagin No. 5 is like *Bacillus coli,* while Nos. 4 and 6 are sometimes similar and sometimes slightly different. In the sodium asparaginate, Nos. 4, 5, and 6 are identical and *Bacillus coli* slightly different. In Fisher's mineral solution with peptone and dextrose, with peptone and glycerin, and with cane sugar and KNO_3, No. 5 is sometimes slightly different from Nos. 4 and 6. In Dunham's solution containing large amounts of NaCl No. 4 shows slightly stronger growth than Nos. 5 and 6 and *Bacillus coli.* In all the other reactions down to Kashida's medium, which gives variable results, the reactions of Nos. 4, 5, and 6 and of *Bacillus coli* are identical.

These experiments have carried these cultures through all the ordinary tests for *Bacillus coli* and many special ones. The few slight variations that have occurred are in no case either sufficient or constant enough to warrant considering any one of the four cultures distinct from the others. As for coconut Nos. 1, 2, and 3, they show almost the same results as Nos. 4, 5, and 6. The origin of these cultures is as follows: No. 6 was isolated from a naturally diseased tree in Cuba on August 7, 1909; transfers from this culture were inoculated into coconut in Cuba on August 12, 1909, and produced a typical soft rot; from this artificially diseased tree coconut No. 5 was isolated on August 24, transfers from No. 5 were then inoculated into a coconut seedling in Washington on September 24, 1909, and a successful infection resulted, from which coconut No. 4 was isolated. Coconut Nos. 1, 2, and 3 represent an isolation in Cuba, an inoculation, reisolation, and reinoculation into a coconut seedling in Washington, and reisolation. Nos. 2, 3, 4, 5, and 6 have been shown to be similar to each other and to *Bacillus coli.* No. 1 has also responded to all the usual tests for *Bacillus coli,* but has in some minor ways shown slight differences. These are probably indications of acquired or lost characteristics and not indicative of a distinct species. The fact that No. 2 was isolated from an infection produced by No. 3 and is identical with it, together with the fact that No. 1 was isolated from an infection produced by No. 2 and is so nearly like it is fair evidence of the identity of these organisms.

From the foregoing remarks on the origin of these cultures it will be seen that Koch's rules for proof of an organism causing a disease have been followed out. The many additional inoculations tend only to corroborate these results.

Thus, having shown, as above stated, that these six cultures are similar to each other and to *Bacillus coli*, the following conclusion seems inevitable: The organism (No. 6) isolated from a naturally diseased tree in Cuba on August 7, 1909, was *Bacillus coli.*

There have been some slight differences as already noted between *Bacillus coli* and the six coconut organisms. They consist in the variable differences found in the nitrogen-free media, with the ammonium compounds, in strength of reaction on starch media, in constancy of reaction in lactose-peptone solution, and in amount of indol produced. In no case is there any definite or constant difference other than in strength of reaction. Taking the reactions as a whole, *Bacillus coli* has at times appeared to differ from the coconut organisms to the slight extent already indicated, differing from them more than they have differed from each other with the exception of No. 1, but not more than the various strains of *Bacillus coli* differ among themselves. This condition indicates that the organisms isolated from the coconut tree are forms of *Bacillus coli,* or at least belong in the colon group, and can not be distinguished from *Bacillus coli* by any of the current methods of bacterial separation.

Moreover, and this appears to the writer to be a decisive point, typical *Bacillus coli* has been shown to be capable of producing typical bud-rot. The conclusion, therefore, seems inevitable that the organism or organisms of the colon group, commonly called *Bacillus coli,* must be considered as the cause of the coconut bud-rot.

In the course of such an extended study on a disease as this has been there naturally occur certain results some of which tend to weaken the case and others to strengthen it. The many successful inoculations and the similarity of the cultures injected and isolated, together with the similarity of many other cultures isolated from diseased coconut material by the writer and earlier by Dr. Smith (p. 142) all tend to strengthen the case. On the other hand, successful inoculations by the writer with cultures of variable appearance rather tend to weaken the argument. These results may be explained by the supposition that other organisms than *Bacillus coli* also produce the bud-rot, or that what passes for *Bacillus coli* includes a group of closely related but not identical organisms. As there is no conclusive evidence for or against such a proposition, this question must remain open. It may be said, however, that the writer does not consider this a probable case. The only alternative in explaining the successful infections with apparently different cultures is the admission that possibly mixed cultures were used. This alternative is one that no bacteriologist would like to admit, and yet to be perfectly honest it must be considered.

It will be noted that all of the isolations of organisms for inoculation in the case of these successful infections (those with organisms apparently not *Bacillus coli*) were made in Cuba at a relatively high temperature and without the best facilities for work. Bacterial colonies grew luxuriantly in 18 hours, and when the plates had some of the widespreading colonies, they became entirely overgrown in 24 hours, even when sown in the thinnest possible manner. One-half or more of a plate would contain these radiate and rapidly spreading colonies. In the case of the plates which in 24 hours showed apparently only round colonies, after 48 hours some of them showed a tendency to branch. While it does not seem probable to the writer, yet it would seem necessary to admit the possibility in these particular cases of making a transfer from a colony which was apparently a single one, but which in reality consisted of more than one species of organism. The different forms of colonies produced by different organisms and the secretions produced by some species inimical to the growth of others appear to reduce this possibility to a minimum. However, in the case of numerous rapidly growing organisms, all of which are white, wet-shining growths on agar, and varying in their form of colonies, this possibility can not be entirely ignored. The facts of the case, though, do not seem at all to warrant the supposition that the successful infections with organisms apparently different from *Bacillus coli* weaken the claim that *Bacillus coli* itself causes the bud-rot.

It has been shown in foregoing pages that certain organisms were isolated from bud-rot tissues, were inoculated into healthy trees, and carried through a series of isolations and reinoculations, and that certain of the organisms used in these experiments were identical with each other and with *Bacillus coli*. In the very first isolations *Bacillus coli* was unthought of, those colonies being taken which were in the majority and which were thought to be the cause of the disease. Only subsequent work revealed to the writer that the organism was *Bacillus coli*, or at least indistinguishable from it. Later, with inoculations of *Bacillus coli* isolated from animals, a disease similar to bud-rot was produced.

Finally it was decided to search directly in the diseased tissues for *Bacillus coli*. Material was secured on two different occasions. On August 16, 1910, material from two trees was obtained in Baracoa, and transfers of the infected material were made under clean conditions to tubes of Dolt's synthetic medium. Then, in Washington, platings were made and the routine examination for *Bacillus coli* was made as described on pages 127 to 136. It was found that in the majority of the plates and subsequent cultures made from them true *Bacillus coli* was present as indicated by these tests.

Subsequently, on September 26, 1910, more diseased material was secured near Baracoa, but it was impossible to make cultures at that time. The material was brought to Washington, and after 16 days from the time the material was collected platings were made and *Bacillus coli* isolated. A majority of the colonies on the plates gave the typical reaction, and likewise by the subsequent transfer to litmus milk, nitrate bouillon, neutral red in fermentation tubes, and gelatin the presence of *Bacillus coli* was indicated.

COMPARISON OF BACILLUS COLI WITH VARIOUS ORGANISMS ISOLATED FROM THE COCONUT.

In the early work of the writer many cultures were made from the diseased coconut palms, as has been stated on previous pages. None of these were studied sufficiently in a cultural way to identify them. Dr. Smith also obtained numerous bacterial cultures during his work in Baracoa, but none of them were studied sufficiently to prove them the cause of the bud-rot or to identify them in any way. Studies were made, however, with many of these cultures in such media as litmus milk, nitrate bouillon, sugar peptone, or sugar broth. As these media give characteristic reactions for *Bacillus coli*, the reaction of these various organisms in them will give some indication of whether they are similar to *Bacillus coli* or are decidedly different. A great difference in the cultures would make it difficult to explain so many isolations totally dissimilar. On the other hand some similarity, that is to say similarity so far as tested, would indicate that probably *Bacillus coli* had been isolated in early cultures, but was not identified as such. If some of Dr. Smith's cultures can be shown to be similar to *Bacillus coli*, so far as tested, it will tend to corroborate this paper, which shows that the colon organism is found in the advancing margin of the diseased tissue and is the cause of the diseased condition.

The following are brief notes on some of the early cultures made by the writer:

Culture Cuba B No. 2 of January 2, 1908, produced gas in fermentation tubes with maltose.

Culture Cuba B No. 3 produced gas in fermentation tubes containing dextrose.

Culture Demerara B No. 5 of January 2, 1908, produced gas in fermentation tubes with maltose.

Culture Demerara B No. 6 produced gas in fermentation tubes with dextrose.

Culture Cuba Nos. 1, 2, and 3 of April 9, 1908, reduced the litmus entirely with the exception of a slight reddening at the surface. At room temperature coagulation took place in four days.

Of fermentation tubes of April 16, 1908, with various coconut cultures, 16 out of 24 produced gas in amounts from 5 to 9 centimeters in seven days.

Six bouillon tubes containing cultures from Trinidad on July 23, 1907, showed some gas formation.

Two bouillon tubes of July 12, 1907, from Demerara showed some gas formation.

Five bouillon tubes of July 13, 1907, from Demerara showed some gas formation.

Three tubes of July 29, 1907, from Demerara in litmus milk became bleached and coagulated.

Four tubes on August 7, 1907, from Demerara in litmus milk become reddened and coagulated.

Two litmus-milk tubes of Cuba became bleached.

One litmus-milk tube of Jamaica became partially bleached and another of Jamaica became bleached and coagulated.

Of the cultures of 1909 isolated in 1908, two tubes of 248 Cuba bleached litmus milk and coagulated it. Of all the coconut cultures in use by the writer early in 1909, seven different ones blued litmus milk, seven turned the litmus pink but did not coagulate the milk, and 23 both turned the litmus pink and coagulated the milk. This change from blue to pink in some cases progressed even to bleaching. Some cultures from each of the trees 380, 78, 422, 248, and 153, reddened or both reddened and coagulated the litmus milk as with typical *Bacillus coli.*

Many cultures were isolated in the fall of 1909, among which were the two, 508 N (coconut No. 6) and 505 N (coconut No. 3), carried through the experiments described on previous pages.

Of this lot isolated September 23, 1909, which was designated series N (Table IV, p. 45), many show the *Bacillus coli* reactions.

No. 502 failed to show any reduction of nitrates.

No. 503, two tubes, both showed good reduction of nitrates.

No. 504 failed to show any reduction of nitrates.

No. 505, two tubes, both showed reduction of nitrates.

No. 506, three tubes, all showed reduction of nitrates.

Nos. 502 and 504 failed to show the reaction in nitrate bouillon that is characteristic of *Bacillus coli.* Several cultures, however, were taken from each of the trees and designated by the same tree number, but with some different tube number, and possibly representing different organisms. For this reason other tubes were selected to repeat the nitrate test, with the following results:

Nos. 502, 504, 505, 506, and 508 showed good reduction of nitrates.

Transfers from these cultures were inoculated into trees, produced a disease, and have been studied subsequently, as shown in the foregoing pages. Other cultures were isolated from trees and, in some cases, inoculated, but have not been further studied. The original cultures, however, were grown in nitrate bouillon and show the following results:

Nos. 503, 507, 601, 602, 603, and 604 show good reduction of nitrates.

Thus, it is shown that some tubes of all these original cultures responded to this test as does the colon organism.

Cultures of these organisms were made in litmus milk and showed the following results:

Series N: Nos. 501 and 501a turned litmus milk blue. Nos. 502, 504, 506, and 508 (six tubes) reddened litmus milk.

Series S: This series was isolated from inoculations made with Series N. No. 502 blued litmus milk. Nos. 504, 505, 506, and 508 reddened litmus milk. A large number of tubes of 508 S were all reddened and coagulated.

Of the series R, the isolations from inoculations with series S, cultures were made on litmus-lactose agar with 505 R (coconut No. 1) and 508 R (coconut No. 4). Ten tubes of 505 R all showed reddening of the agar as with *Bacillus coli*. Fifteen tubes of 508 R showed a similar reddening, while the remaining 18 tubes did not. No other of the early coconut cultures were tried on this medium.

In fermentation tubes with dextrose and peptone many of the cultures produced gas.

The production of gas (in millimeters) by cultures of series N at room temperature for nine days was as follows: No. 502, 24; No. 504, 25; No. 505, 21; No. 506, 30; No. 507, none; No. 508, 26; No. 601, 81; No. 602, 29; No. 603, 28; No. 603a, 31; No. 604, 26.

The production of gas by cultures of series S at room temperature for nine days was as follows: No. 503, 21 mm.; No. 504, none; No. 505, 24; No. 506, 64; No. 508, none; No. 508a, 24.

It must be borne in mind that each number represents several tubes derived from as many colonies, and in each one of these tests given only one of the tubes is represented. For example, in the preceding paragraph one tube of 504 failed to produce gas, while 503 and 505, etc., did produce gas. Other tubes of 504 might also have done so if they had been tried.

The foregoing paragraphs show that the writer had early cultures isolated from diseased coconut trees and that some of these cultures resembled *Bacillus coli* so far as tested. It must also be admitted that there were many cultures which gave positive evidence of not being *Bacillus coli*. It will now be of interest to turn to Dr. Smith's cultures obtained by him in 1904.

Of this series the so-called coconut B responds to many of the tests for *Bacillus coli*. In every medium in which it was tested it gave a positive reaction for that organism. The results for coconut B are as follows:

Reduces nitrates.

Produces indol in Dunham's solution.

Produces no nitrous acid in Dunham's solution.

Produces gas in glucose, in cane sugar, in lactose, in maltose, in glycerin, and in mannit.

Coagulates litmus milk.

Besides coconut B, the organisms called coconut D and F responded to the same tests. Moreover, coconut V, AA, BB, and CC, were the same, excepting that there are no records for glycerin and mannit. In addition to these tests, the various organisms were grown in gelatin tubes, and all of the above, with the addition of 15 others, failed to liquefy the gelatin. All of these cultures were grown in litmus milk, and these same strains with some others reddened the litmus and coagulated the milk.

All of the cultures were grown in Dunham's solution and tested for indol after five days. All of the strains indicated above produced indol, B best of all.

The similarity of these organisms in the media used with the coconut organism and *Bacillus coli* is very suggestive of the identity of all.

Of further interest in the comparison of various cultures is the fact that Mr. James B. Rorer has sent to the writer some cultures of organisms isolated by him from diseased coconut palms in Trinidad. These five cultures in litmus milk and in nitrate bouillon are all alike and give the same reaction as the coconut organism, isolated from Cuba, or *Bacillus coli.* They differ, however, in gelatin. This variation seems at once sufficient to consider the organism a different species, but whether the Trinidad form is not a variety of the Cuban organism may well be questioned. It has been noted on a previous page that many of the cultures of 505 R (e. g., coconut No. 1) differed from the others mainly in liquefying gelatin, while *Bacillus coli* does not. It will be noted that the failure to liquefy gelatin is the main difference (at least so far as the arbitrary relationship shown in the chart of the Society of American Bacteriologists goes) between *Bacillus coli* and the soft-rot organism, as shown in the work of Jones, Harding, and Morse.[1] Other differences depend largely upon the ability of the varieties of soft-rot organisms to form acid and gas in media containing carbohydrates. But this is a variation found also in so-called varieties of *Bacillus coli.* The organism isolated by Mr. Rorer appears then to belong rather to the well-known soft-rot types. May it not well be that as there is a variation in production of acid and gas in media containing dextrose, lactose, saccharose, glycerin, and other carbon compounds, both in the case of varieties of the soft rot and in varieties of *Bacillus coli,* there may also be a variation in the production of a proteolytic enzyme as demonstrated in the liquefaction or nonliquefaction of gelatin? It has not yet been shown how this can be other than an arbitrary separation of the two groups. *Bacillus coli,* so far as known, is not able

[1] Jones, L. R., Harding, H. A., and Morse, W. J. The Bacterial Soft Rots of Certain Vegetables, Technical Bulletin 11, N. Y. Agricultural Experiment Station, November, 1909, p. 264.

to produce soft rot in the ordinary vegetables which are affected by various kinds of the so-called soft-rot organisms. It seems to the writer, however, that it has been clearly shown that the colon organism can produce a soft rot in a certain vegetable tissue, namely the coconut bud tissue. Not even the recognized soft-rot organisms can produce this sort of decay in all of the ordinary vegetables; so the mere fact that the colon organism and the so-called soft-rot organism do not affect the same tissues is not sufficient argument for placing them in widely separated groups. The writer does not contend that all these organisms are by any means the same, but that there is at least a very close relationship between all of them. It is probable that the whole group of these organisms represents a class extremely variable, and able in some of its many forms to adapt itself to a great variety of conditions. In this question, of course, hybridization plays no part. It is purely a matter of vegetative changes. Surely there has been enough shown in variation of vegetative parts of flowering plants to warrant the conclusion that the vegetable units resulting from the bacterial division may differ sometimes in their biochemical reactions from the original units. From cultural studies it would seem as though the life processes of the bacteria were even more delicately balanced, and that this balance is more easily overthrown than in the higher plants.

BUD-ROT ATTRIBUTED TO CAUSES OTHER THAN BACILLUS COLI.

With a knowledge of the cause of bud-rot and with a thorough understanding of the effects of the bacterial organism, the source of all the trouble, one may compare more intelligently the various diseases of the coconut palm as reported by different workers. That disease of the tree which is characterized by a rot of the heart of the crown has been attributed to numerous causes. The most important of these which have been seriously proposed by practical coconut growers and by scientific investigators are worthy of some consideration. Of late the general trend of opinion has been to admit the possibility of bacteria producing the rot, but to claim that some other cause was responsible for the presence of the bacteria. Such reasons as soil with too much lime, with too much clay, with too little salt; soil too dry, too wet; insects; and fungi; all of these and other minor reasons for the presence of this disease have been given.

The preceding pages have shown distinctly that the bud-rot may be actually induced by means of a wound inoculation into an apparently healthy coconut tree; in other words that the bacterial organism already described is an active parasite. It is only reasonable to assume that some condition unfavorable to the proper growth of the tree will do much to facilitate the work of the bacterial parasite.

For this reason many of the theories as to the cause of the disease may have a grain of truth in them in that the causes assigned may be auxiliary, though not primary, factors in producing the diseased condition. Such being the case, it is desirable to discuss briefly these factors and the probable relative amount of their influence.

In soils containing too much lime, lack of good drainage is probably the immediate cause of the trouble. Trees growing in such soils are rather slender, and have yellowish leaves, and either fail to bear fruit or produce an imperfect fruit. In addition to poor drainage an excess of lime in an insoluble form may have some direct effect upon the roots which will produce in the crown an appearance similar to drought.

Soils consisting too largely of clay are heavy, cold, and damp. Under such conditions stagnation follows, the roots are not able to absorb water with sufficient facility, and injury results.

The question of the amount of salt (NaCl) desirable in the soil has been much debated. It is claimed by some investigators that a very small proportion is necessary, no more than may be found in an average soil whether near the sea or remote from it. Others maintain that placing about the roots of the tree a small quantity of salt and mixing it with the soil benefits the tree greatly. Whether a reduced quantity of salt would so affect the tree as to render it easy to succumb to the bud-rot is not easy to determine. There has been no work done as yet to ascertain this.

In the case of soils either constantly or temporarily too dry there is certainly a weakening of the vitality of the tree. It is difficult to distinguish this condition from the one in which there is an excess of water. It would seem probable that the latter condition would be the most suitable for bacterial growth. Comparison of the spread of the bud-rot in rainy weather with that in dry weather inclines the writer to say that the rainy weather is more favorable, although the difference is not very striking. The effect may depend not so much upon a large amount of moisture as on an upsetting of the balance of chemical constituents of the tissues by any such untoward conditions as drought or excess of moisture.

In the matter of insects occasioning the trouble in the coconut trees Dr. Carlos de la Torre (p. 22) has maintained that the scale insects covering the stomata of the leaves tend to suffocate the plants, i. e., prevent transpiration, and in that way render the tree susceptible to the disease. It can scarcely be denied that a hindrance to the proper amount of transpiration would seriously affect the health of the trees and possibly in that way furnish an opportunity for the work of the bacteria. From the examination of numerous trees affected with bud-rot, where the scale insects were either absent or present in such small numbers as to have no serious effect on the transpiration, it is very clear that these insects can not be considered as a primary cause of the bud-rot. Reports [1] have been made on the serious injury and even death of coconut trees in Tahiti and other South Sea islands by these scale insects. It is much to be regretted that the investigator has failed to give a sufficient description of the tissues of the diseased tree to enable a comparison to be made with trees affected by bud-rot.

The claim that insects such as the palm weevil, the rhinoceros beetle, and others are the cause of the bud-rot is frequently made by coconut planters. The effect of such insects is purely local, and even if they are present in great numbers they can have no direct influence in bringing about a rotted condition of the bud. They may, however, possibly play an important part in carrying the bacteria from diseased tissues to healthy ones, the organism gaining entrance through the wound caused by the boring or feeding of the insect.

Not many scientific investigators have definitely ascribed the rot of the heart tissue of the coconut to any particular cause. For the most part they have stated what they have seen in the tissues and suggested what might be the cause. In several cases, however, the diseased condition of the coconut tree has been distinctly said to be due to fungi. The most striking are two late publications, those of Mr. Stockdale and of Dr. Fredholm, one of which has been published widely, in regard to diseases in Trinidad. The work of both of these investigators has already been discussed in detail in another publication,[2] but it seems desirable to repeat it in this connection.

Mr. Stockdale's investigations showed to him two distinct types of coconut disease in Trinidad. In one, which he called the "root disease," the trunk showed a red discoloration toward the outside for a considerable part of its length, and the decayed roots and the petioles were infested with a fungus. Eventually, when the vitality of the tree had been reduced, the terminal bud became involved in a soft rot, and the putrid mass then fell over and the tree died. Mr. Stockdale found, also, what he supposed was bud-rot. In this disease the roots appeared to be healthy, the stem showed no sign of the discoloration, but the bud was involved in a vile sort of bacterial rot, and eventually fell over. In the advancing margin of the rot usually were only bacteria, but in a few cases there was some fungous mycelium. This investigator concluded that the root

[1] Doane, R. W. Notes on Aspidiotus Destructor Sig. and Its Chalcid Parasite in Tahiti. Journal of Economic Entomology, vol. 1, 1908, pp. 341–342. Also Notes on Insects Affecting the Coconut Trees in the Society Islands. Journal of Economic Entomology, vol. 2, 1909, pp. 220–223.

[2] Johnston, J. R. The Serious Coconut Palm Diseases in Trinidad. Bulletin 64, Trinidad Department of Agriculture, 1910, pp. 25–29.

disease is due to fungi and the bud-rot to bacteria, claiming in the case of the root disease that the rotted crown was secondary to the diseased root, but admitted the possibility in the case of the bud-rot that bacteria were the primary cause of the trouble. No experiments were made to prove either the fungous or bacterial nature of either disease. In view of the investigations of the writer, it must be admitted that there have been in Trinidad some diseases answering to Stockdale's description of root disease. As noted on page 33, there were a few cases at Guapo which seemed to correspond to this malady. On the other hand, the trouble in Laventille and Point d'Or (pp. 31–33), so far as the writer could ascertain, was entirely due to bud-rot. That fungous infection might easily take place in the root when the crown is affected is admitted, but it must be denied that the cases of rot in the crown in these two districts were cases in which the rot was secondary and the root disease primary. Actual investigation of the tissues of several trees typically diseased revealed a bacterial rot in the crown and no signs of the root disease. What was true for those trees examined may well be assumed to be true for all the other trees showing exactly similar symptoms.

Mr. Stockdale states [1] that in a tree affected with root disease "it is only a question of time before the terminal bud falls over and becomes a putrid mass, and the palm eventually dies." However, he qualifies this statement in a footnote,[1] as follows:

> When a cocoanut palm is affected by any disease or pest, the terminal bud, in the advanced stages, becomes involved in a rot. This must not be confused with "bud-rot."

These remarks would indicate that their author was not very clear on his subject. In the first place, the statement that "when a cocoanut palm is affected by any disease or pest, the terminal bud, in the advanced stage, becomes involved in a rot" is a most sweeping one to make and is not confirmed by any explanatory notes or experiments. Moreover, the statement is misleading, causing one to think that the ultimate rot is due to the disease or pest, whereas it can only mean that when the tree is so affected or diseased that it dies, then the crown rots, quite as is the case with any dead vegetable tissues when sufficient moisture is present, and this is a truism. Furthermore, this note, taken in connection with the preceding statement in describing the root disease, to the effect that "it is only a question of time before the terminal bud falls over and becomes a putrid mass," is still more misleading.

That diseased coconut trees will rot when they die anyone will admit, but that the terminal bud falls over and becomes a putrid

[1] Stockdale, F. A. Coconut Palm Disease. Trinidad Royal Gazette, Feb. 14, 1907, p. 350.

mass as the result of any disease is untrue. The terminal bud will become a soft putrid mass only in the case of bud-rot. The writer of this discussion has studied closely, by actually ascending the trees and by pushing apart the central leaves, the condition of the bud tissues in many trees and has followed out the changes in individual trees during a period of two years. Some trees were naturally diseased with bud-rot, some by insects, and some were artifically inoculated by making holes 45 centimeters long into the heart tissues and then injecting the organisms. It is possible for the writer to state definitely that miscellaneous diseases or injuries to the tree will not cause a soft, putrid condition of the bud. It is moreover possible to state that, so far as the writer's experiments have gone, only a specific kind of bacteria will produce this soft rot. That Mr. Stockdale found such a condition as he describes in the trees he examined is not questioned. The correctness of his conclusion as to the cause of the condition is, however, much in question. Soft rots may occur in the crowns of trees affected with various maladies, but it is probable from the writer's experiments that the apparent cause of the diseased condition of the tree has been only an accompaniment of the real cause. It is the writer's belief that in those cases of root-rot which had rotting crowns the trouble in the crown was distinct from that in the roots and not to be considered a part of it, i. e., the root disease (whatever its cause) and the bud-rot were two independent diseases in the same tree.

Dr. Fredholm has also made investigations of the coconut-palm diseases of Trinidad (p. 26). He described a serious disease in which the trunk was normal and the roots usually so, while the terminal bud became disintegrated into a sour-smelling, whitish, semifluid mass, which when examined under the miscroscope was seen to be swarming with bacteria. The adjacent tissues out to the petiole bases were traversed by fungous mycelium which Dr. Fredholm believed to be the forerunner of the bacterial rot. He states that he considers Stockdale's root disease and the foregoing disease distinct, chiefly for the reason that he has never found the decay of the roots and the discolored stem present in the affected trees which he examined. To substantiate the claim of the fungous nature of the disease, Dr. Fredholm made fungous inoculations which resulted in small, diseased spots on the leaves (p. 26). These inoculations however, were by no means sufficient to prove the fungous nature of the disease. In order so to affect the tree as to produce a bacterial soft rot in the bud it would actually be necessary to destroy the greater part of the leaves. Dr. Fredholm admits that the soft rot is caused by bacteria, and his claim is that the fungus produces conditions in the tree suitable for bacterial infection. He has admitted, however, in other paragraphs that evidently the bacterial infection can take place independently of the fungi, for he has found what appeared to be that condition. Since he admits the possibility of bacterial infection without fungi, it is difficult to understand why he considers fungi when they do happen to be present as the forerunners of the bacteria. It would appear as though Dr. Fredholm had called the accompaniment of the disease (fungi in this case) the cause of the disease, assigning the real cause of the trouble, bacteria, to a secondary position. The fact that bacteria both alone and with fungi can cause the trouble, while fungi only in connection with bacteria can produce a similar effect, seems to the writer to demonstrate the primary importance of bacteria. That other organisms may subsequently infect trees diseased with bacteria is of comparatively little importance, while it is of the utmost importance to determine the sole and primary cause of the soft, putrid condition in the crown.

The factors rendering trees specially susceptible to this bacterial rot can not be described now. Only enough has been ascertained to indicate that the bacterial disease is induced by certain conditions; whether they be insect injuries or unhealthy conditions of the tree has not yet been determined.

From the nature of the disease itself, in that it is a soft rot, strong arguments may also be advanced against the probability of its being due to unsuitable soil, climate, insects, or fungi. In no case, so far as the writer knows, has a soft rot of tissues been demonstrated to be due to any condition whatever other than to a few fungi and to bacteria. In the case of fungi it seems to the writer that the only claims to their being the cause of this rot in question have been sufficiently disproved.

Others have maintained that certain bacteria are the cause. Only two of these investigators have indicated at all the organism thought to produce the rot. Dr. Davalos (p. 39) isolated in 1886 what he claimed to be *Bacillus amylobacter*, which he believed to be the cause of the soft rot. He, however, has published no series of experiments to prove this belief. Dr. Plaxton (p. 39) showed to the Institute of Jamaica in 1891, under the microscope, slides of a micrococcus. He believed this micrococcus to be the cause of the rot of the crown, without, however, publishing any experiments to demonstrate the truth of his idea.

It seems to the writer that the symptoms of bud-rot are sufficiently characteristic to distinguish it at once from any other known malady of the coconut palm. If such indications as a falling of the immature nuts, a blackening of the flower spikes, a wilting of the central unfolded leaves, and a soft, putrid condition in the heart are mentioned by a coconut planter or by an investigator, and the cause of such symptoms is asked, it seems reasonably safe to state that they represent a case of bud-rot and are caused by bacterial action. Such has been the basis in discussing on other pages of this paper many American reports of coconut-palm diseases that have not been personally investigated by the writer. Reports of the disease in the Eastern Hemisphere are discussed on the same basis. If there is a fair reasonableness in doing this with the coconut palm it does not seem at all beyond reason strongly to suspect similar symptoms of disease in other palms to be due to a similar cause. Such is the point of view in discussing the occurrence of the disease on other palms.

OCCURRENCE OF THE DISEASE ON OTHER PALMS.

It is not known positively at present whether or not this bud-rot occurs on other palms than the coconut. Information on the subject is extremely desirable. In Cuba a disease of the royal palm has been noted for some time. Mr. Horne,[1] in 1908, wrote in regard to it as follows:

> The royal palms on the high limestone ridge back of Baracoa were in bad condition and some of them were dying. A similar condition was observed at Banes and at various places, in some of which no bud-rot was known to exist. * * * If royal palms are attacked it is so rarely that probably there is no practical importance to be attached to the matter.

The writer has noted dead and dying royal palms near Baracoa during the past three years. There were not, however, more than 15 or 20, nor did the diseased trees have just the appearance of coconut trees affected with the bud-rot. In the royal palm the central leaves remained healthy longest, while the surrounding leaves gradually turned brown and fell off.

In the summer and fall of 1910 the writer had an opportunity to watch this disease more closely. On August 15 the central leaves and three adjacent ones of a certain tree were left standing, while the remaining leaves were either hanging or had dropped to the ground. Natives stated at that time that the trouble with the tree was due to lightning. On September 29 there was only one upright leaf. On the following morning the entire leaf had blown off, thus furnishing a good opportunity to examine its condition. The column, about 2.5 meters long, composed of the leafstalk sheaths, was intact, but most of the leaves had either bent over or had been broken off just above the sheaths. From this point down the entire column to the base, which represented the growing point, there were great areas of brown, water-soaked, and rotted tissue. These areas were more or less con-

[1] Horne, W. T. The Bud Rot and Some Other Coconut Troubles in Cuba. Bulletin 15, Estación Central Agronómica de Cuba, July, 1908.

tinuous on one side from top to bottom, and their extent at the base was undoubtedly the cause of the column blowing over and falling away from the tree trunk. The rotted areas seemed also to extend from one sheath inward to the next, gradually lessening in extent as the middle was approached. The central tissues themselves were not in the least discolored or rotted. In general, the rotted areas closely resembled bud-rot tissues of the coconut, and the same kind of insects that are found in diseased coconut trees, e. g., earwigs, were abundant. The odor from the rotting tissues, while bad, was not exactly that of bud-rot. The whole aspect of these wilting sheaths was that of fleshy tissue that had been completely cut off from the source of life and was undergoing a normal course of decay. In the coconut palm affected with bud-rot the undiseased tissues are white and the cells are turgid. In the royal palm the unaffected unrotted tissues were white, but the cells were rather flaccid. Because of the resemblance between this disease of the royal palm and the bud-rot some of the tissues were brought to Washington and attempts were made to plate out *Bacillus coli.* All but one of the 23 plates made showed some signs of this organism; the average was about 15 out of 100 colonies, in some plates the proportion of *Bacillus coli* being higher and in others lower. The other organisms were of a very great variety. That *Bacillus coli* was present was demonstrated by transferring the suspected colonies, which had reddened Dolt's medium, (1) to litmus milk, (2) to nitrate bouillon, (3) to fermentation tubes containing dextrose, peptone, and neutral red, and (4) to gelatin. The various cultures responded to the tests as follows:

In litmus milk 22 out of 31 gave typical reactions.
In nitrate bouillon 31 out of 31 gave typical reactions.
In neutral red fermentation tubes 26 out of 31 gave typical reactions.
In gelatin 31 out of 31 gave typical reactions.

Thus, over two-thirds of the tubes gave the customary reactions for *Bacillus coli.* There can be very little question of contamination, for the utmost care was taken to wash and soak large pieces of the diseased material in mercuric chlorid, and then by means of sterile knives portions from the interior of the pieces were removed to the test tubes for plating out. There can be very little question that *Bacillus coli* was in the diseased tissue. It may well be questioned, however, whether this organism was the cause of the disease. Certainly the mere fact of finding a small quantity of these germs in the well-rotted tissues is no proof. Thus, the evidence in regard to this royal-palm trouble being bud-rot is of doubtful value. It should be noted in passing that along the coast near Maravi, 7 miles west of Baracoa, scattered at intervals, about 50 dead or dying royal palms may be seen among many hundreds of healthy ones. It should further be noted, should this disease ultimately be shown to be the same as bud-rot, that some of the younger royal palms are also affected, and that examination showed on the inside of the leaf sheath honeycombings of the tissues caused apparently by a small brown weevil. Surrounding these injuries to the leaves are brown, water-soaked areas similar to those in the royal-palm tissues already described. Whether these rotted areas may be due either directly or indirectly to the insect injuries has not been demonstrated.

A serious disease of the betel-nut palm and of the palmyra palm has been reported as prevalent in India. The description of the disease of the betel-nut palm as given by Mr. E. J. Butler is as follows:

The first symptoms of the disease appear at the time of flowering. A number of the flowers fall without setting fruits, and their stalks blacken and putrefy. The rot gradually extends along the inflorescences and affects the stalks on which nuts are forming, causing the latter to drop while immature. Very often the damage does not stop here. The flower stalk arises from the axil of the lowest leaf and, therefore, leads directly to the base of the swollen green part of the top of the stem. This green portion consists of a number of leaf sheaths which clasp the young, growing end of the palm, forming thick, protective covering to the growing point. The lowest of these sheaths becomes affected near the point of origin of the flower stalk, and a patch of rot makes its appearance at this point. The sheaths next underlying the first are then attacked, and, since the internal parts are softer than those outside, the rot spreads with increasing rapidity as it approaches the apical bud. When the growing point in the center of the bud is reached it also is destroyed, and the whole head withers and falls off. Not alone, therefore, is the crop lost, but the whole tree is killed, the damage caused in the affected districts being very heavy.[1]

This description answers perfectly to the bud-rot of the coconut. Mr. Butler, however, attributes the disease to a species of Phytophthora. Mr. L. C. Coleman has also studied this disease, but he lays more stress on the infection of the nuts than on that of the bud. He writes:

The real cause is a parasitic fungus which lives in and on the areca nuts.[2] * * * Occasionally it succeeds in making its way into the tissues of the tree top, and in this case the tree is killed, death taking place within a comparatively few weeks.[3]

As the trees in this region extend up to 70 or 80 feet in height, the disease in the top is to be noticed only after it is quite advanced. It is, therefore, difficult to decide just where the preliminary infection takes place.[4]

The tree top pictured shows a decidedly different condition. Here also the nuts have become diseased and have dropped off, but the bunch stalk, especially at the base, appears to be perfectly healthy, nor could any trace of mycelium be found in sections taken from it. On the other hand, the growing point was badly decayed,

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[1] Butler, E. J. Some Diseases of Palms. Bulletin of the Department of Agriculture of Jamaica, vol. 5, pts. 2 and 3, 1907, pp. 48–58.

[2] Coleman, Leslie C. Diseases of the Areca Palm. I. Koleroga. Bulletin 2, Mycological Series, Department of Agriculture, Mysore State, 1910, p. 4.

[3] Coleman, Leslie C. Op. cit., p. 13.

[4] Coleman, Leslie C. Op. cit., p. 53.

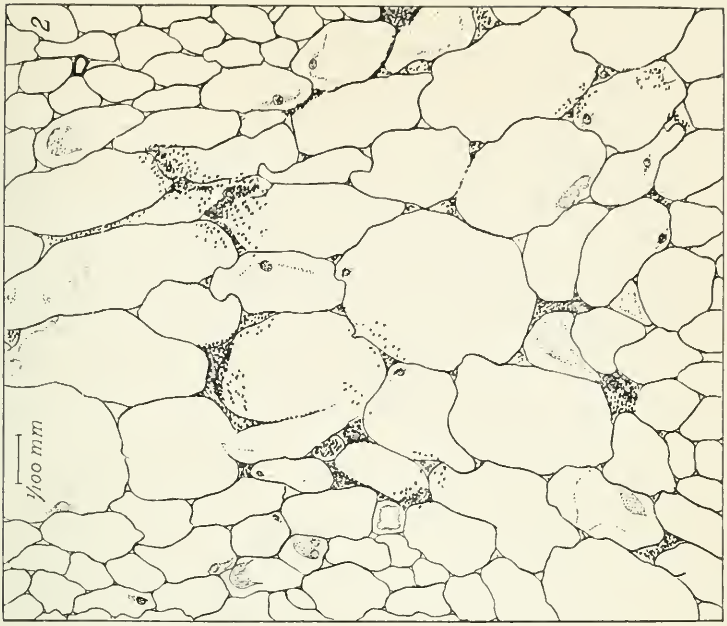

FIG. 2.—DRAWING FROM MICROTOME SECTION OF DISEASED TISSUES OF BUD-ROT, SHOWING BACTERIA BETWEEN THE WALLS OF NORMAL CELLS.

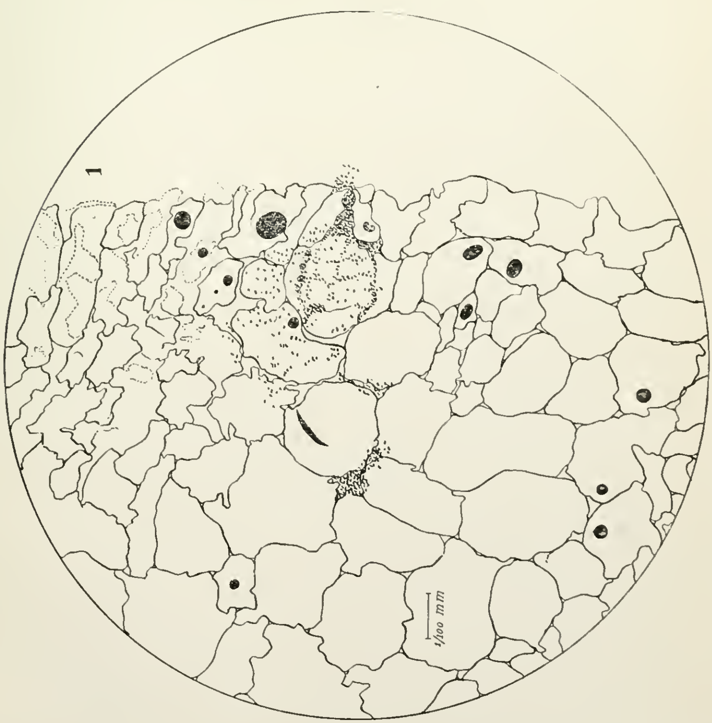

FIG. 1.—DRAWING FROM MICROTOME SECTION OF DISEASED TISSUES OF BUD-ROT, SHOWING BACTERIA IN STOMATAL CAVITY.

and the course of the decay seemed to have been along the line of the bases of the leaf sheaths which form the protective covering of the tender growing point of the stem.[1]

Coleman made infection experiments both in the nuts and at the growing point of the tree, using Phytophthora for that purpose. The inoculations of the nuts took very easily, as did that of the growing point. In regard to the latter he says:

An examination made two weeks after inoculation showed that the fungus had grown right through the several underlying leaf sheaths and had attacked the growing point.[2]

In view of these inoculations by Mr. Coleman there can be little doubt that he has found the cause of the disease. The resemblance between this betel-nut-palm disease and the coconut-palm disease is, however, most striking, infection occurring as blackening of the tissues either in the flower stalks or in the crown of leaves, or in both; subsequent infection of the growing point; soft rot and death of the tree; in the case of the betel-nut palm or areca palm, Phytophthora believed to cause the disease, although numerous bacteria are present in the diseased growing point; in the case of the coconut palm, *Bacillus coli* proved to be the cause of the disease, although Diplodia is usually abundant on diseased nuts and the upper part of the middle leaves.

In some ways the disease of the royal palm of Cuba resembles more closely the areca-palm disease than it does that of the coconut palm. It is not at all improbable that some fungus may be found to occasion this.

The palmyra palm of India has a disease similar in general aspect to that of the areca palm, but it is said to be due to a species of Pythium. The following is from Mr. Butler:[3]

The earliest sign is the alteration in color of one of the leaves, usually one of those recently expanded toward the center of the bud. This turns white and soon afterwards commences to wither. Other leaves are attacked in turn; the heart of the bud is reached, and the whole top withers and falls off, the last stage being reached only after a considerable time.

The leaf sheaths of all diseased trees are marked by irregular sunken spots in greater or less number. In the earlier stages, and particularly in the inner layers where young ones are often numerous, the spots are white; later on they become brown. They are always sunken and usually have somewhat raised edges. They begin on the outer sheaths and may be traced in through succeeding ones toward the heart of the bud. As the inner layers are softer, the inside patches are often larger than those outside, and may even give rise to new patches which extend out again to the outside sheath. In all cases, however, the first appearance is on the outer sheaths. The earlier patches are dry and either free from any appearance of a parasite on the surface or covered with a white mycelium felt. Very soon a wet rot follows, which extends with great rapidity in the delicate central tissues and converts the whole heart into a foul-smelling mass of putrefaction in which everything is involved, and the original agent

[1] Coleman, Leslie C. Op. cit., p. 54. [2] Coleman, Leslie C. Op. cit., p. 58. [3] Butler, E. J. Loc. cit.

is lost sight of. It is at this stage that the insect grubs referred to make their appearance, possibly attracted by the smell. * * *

It is only in the early stages, before the wet rot starts, that the true cause can be made out. This is a fungus of the genus Pythium, a near ally of the Phytophthora found in koleroga.

In no other palm than the coconut has there been shown to be a rot of the crown due to bacteria. In the royal palm, in the areca or betel-nut palm, and in the palmyra palm there occurs, however, a soft-rotted condition, and in all cases bacteria are present. In the areca and in the palmyra palm the disease is said to be due to fungi. It would be of great value to ascertain if bacteria would not bring about a similar condition. Palm trees are difficult subjects for experimentation, and yet it would seem as though the fleshy part of the crown, i. e., the growing point, furnishes unusually good opportunities for the work of bacteria, especially soft-rot bacteria.

In a recent publication [1] Mr. Butler describes in full the bud-rot of the palmyra and coconut palms as he has found it in India. He made several apparently successful inoculations with *Pythium palmivorum*, one of which was on the coconut palm and the others on the palmyra. It must be noted that the inoculations were not made with pure cultures, at least not pure from a bacteriological point of view. This would seem to lay the results open to question.

MICROSCOPIC STUDIES.

The effect of the bacteria on the tissues can readily be seen by studying infected material under the microscope. Microtome sections stained with carbol fuchsin are best adapted for this purpose.

From the section it is evident that the bacteria may gain entrance through stomata (Pl. XIII, fig. 1) and from the inoculation experiments described on other pages it is known that they also effect an entrance through wounds. The germs multiply at the point of entrance and cause a shrinking of the cells immediately surrounding. They rapidly pass into the interstices and between the walls of normal cells (Pl. XIII, fig. 2), far in advance of the collapsed tissues.

The cells of the fundamental tissues have bordered pits in their walls, or it is possible that they are actually pores. The sclerenchyma cells have greatly thickened walls and in consequence have much deeper pits, which appear in places to be actual canals. These canals pass to the middle lamellæ, but it is not certain that they pass through them. In some of the vessels the pits are so numerous as to give the form of papillæ to the thickened wall. Comparison of the pits of the vessels with those of the fundamental tissues is not to be taken to indicate that they are analogous, but merely to show

[1] Butler, E. J. The Bud-Rot of Palms in India. Memoirs of the Department of Agriculture in India, vol. 3, no. 5, 1910, pp. 221–280.

that there are depressions of some kind in the walls of these two classes of cells. In small, thin-walled cells of the wood parenchyma there appear to be no such depressions.

The bacterial action under these different conditions is according to the structure of the tissue; the thin-walled tissue of the woody parenchyma is completely disintegrated and the vessels which it surrounds are set free (Pl. XIV, figs. 1 and 2). Apparently, in this case the bacteria have a solvent action on the thin walls, which are little or not at all lignified. In the fundamental tissue when young, disintegration also results from the bacterial action. In such cases swarms of bacteria, adhering in groups which are of the shape of the cells, may commonly be seen with no distinct walls intervening. In older parts of the fundamental tissue when the walls have become somewhat lignified no disintegration takes place; nevertheless, the bacteria gain entrance and cause a disintegration of the contents of the cells. Whether this entrance is gained solely through the pits (or pores) or is effected by some solvent action of the bacteria on the walls is not certain. With the disintegration of the contents of these fundamental tissue cells the walls collapse, and a soft, watery mass results. As the infection becomes farther removed from the growing point where the tissues are harder the softening action is lessened. In the trunk below the heart an actual rot, i. e., a softening to the consistency of a thick liquid, takes place for a distance of half a meter or so below the growing point (in one case $1\frac{1}{2}$ meters). This rot does not affect the outer portion of the tree (cortex), but leaves it firmly bound together by its many wood bundles as a shell surrounding and containing the soft mass. Toward the lower part of the rot the bundles in the center of the trunk, as well as those at the periphery, remain unaffected, and at the lowest point there is a discolored area which contains no soft rot whatever. It is frequently possible to obtain a bundle of the fibers a foot or more in length which have been freed from the surrounding parenchyma by the rot. Proceeding from the soft tissues upward similar changes are noticed. As the leaves mature the pinnæ become very membranous and lose their fleshy condition. The epidermis becomes thicker and hardened to such an extent that it is unaffected by the bacterial rot. The middle tissues may be disintegrated, but the epidermis remains a transparent, papery membrane, covering the vascular bundles, or veins. Spots often appear high up in both the mature and young leaves, first as small yellow or brown dots which may gradually spread into long, brown, water-soaked streaks, or may be restricted to small dry areas. In the water-soaked streak, which eventually passes down the leaves to the heart, are swarms of bacteria which cause the slimy condition. Fungi also are frequently present. In the small restricted dried areas are found both bacteria and fungous filaments. It has not been possible always to prove that fungous filaments were present, but it has always been demonstrated that bacteria were present. This is not conclusive evidence one way or the other as to the cause of the spots. In case the spot remains restricted it is evident that the bacteria have gained no foothold to thrive; but when the spots have elongated and become slimy, then the bacteria are flourishing. Diseased areas may occur not only in the upper parts of the mature leaves but also near the base of the leafstalks and on the adjacent part of the trunk. These spots commonly develop as brown areas with a water-soaked appearance. They vary in size from minute ones to those a decimeter or more in length on the main part of the stalk, or they may extend indefinitely into the strainer when it is in a moist condition. These spots, as a rule, are slightly below the general level of the tissue. If a piece of the diseased leaf tissues, the surface of which has been washed clean, is pressed, a cloudy juice oozes out, consisting of the ordinary juice from the tissues made cloudy by the crushed cell tissues and myriads of bacteria. Hand sections of this tissue are difficult to make, but not impossible. These sections show a general brown staining of the tissues and slight, if any, collapse of the cell walls. The contents are granular in appearance. What appear to be bacteria occur in these cells scattered unevenly throughout the diseased parts; they swarm in some of the cells, but are apparently absent from others. No fungous filaments have been found in these water-soaked areas, although fungous infections frequently take place near the base of the leafstalks. Such places present dry, gray, hardened surfaces with tiny pustules here and there. It often happens that spots occur on the upper part of the middle leaves when the heart is perfectly sound and no bud-rot is apparent. These spots have been described above in that they were said to be brown, becoming dry, and to contain either bacteria or fungi, or both. The diseased spot seldom if ever spreads more than 5 to 8 centimeters unless the leaves are very young or have been injured. If the leaves are young or fleshy the rot will spread downward from the bacterial action, causing typical bud-rot at the heart. Until the leaf where the infection first occurred becomes old and membranous the fungous infection will spread either upward or downward, but it will not spread in a healthy uninjured leaf. The fungi that occur on these tissues are various, but the most common are *Pestalozzia palmarum* Cke. and what has been called *Botryodiplodium* sp. They appear at maturity as an irregular sooty mass on the surface of the leaves, or they break out from slender elongated pustules, or they may appear as tiny black dots in the centers of the dry spots. The Pestalozzia is common on diseased palms and

FIG. 1.—MICROTOME CROSS SECTION THROUGH SMALL LEAF BUD OF COCONUT PALM, SHOWING DISORGANIZATION OF THE TISSUES DUE TO THE ACTION OF THE BACTERIA. BACTERIAL CLUMPS AT BOTTOM AND TOP.

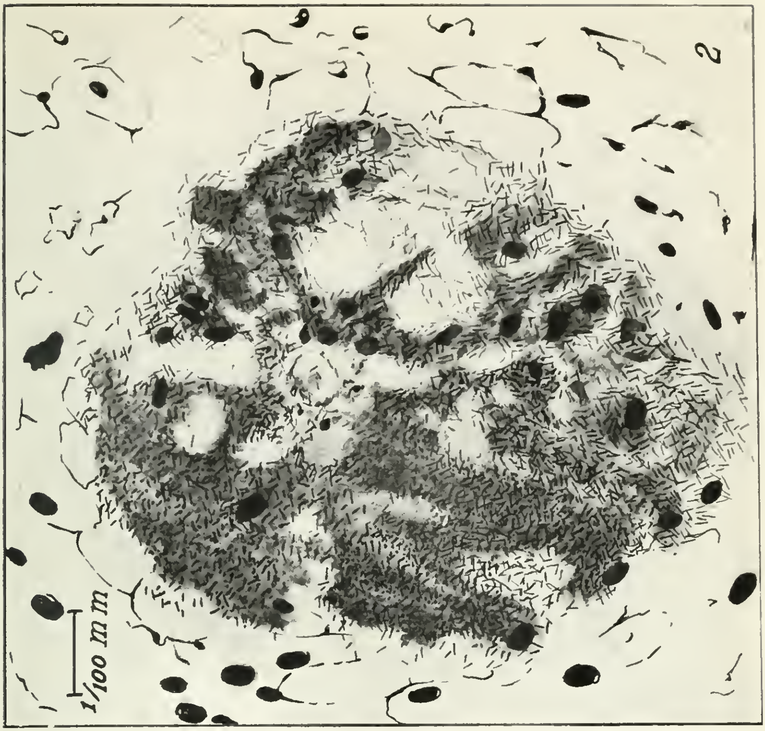

FIG. 2.—ENLARGEMENT OF A PORTION FROM MIDRIB OF LEAFLET.

is easily distinguished. The Botryodiplodium is less distinctive in that its spore form seems to be varied, i.e., there is often either an ovate, olive-black, one-celled spore or an olive, more or less cylindrical, two-celled spore with rounded ends. Either one or the other spore may be colorless or may range from olive to olive-black in color. It is possible that two different fungi are here confused. However that is, it is certain that the forms mentioned are almost invariably found on the diseased central leaves of the coconut.

In addition to the above considerations, tiny brown spots have been rarely found on the surface of the soft tissues near the heart. They appear as slight cracks from which a red, transparent gum oozes. Microscopic sections of these spots revealed no parasites whatever, either fungous or bacterial. The cell corners of the brown area stain deeply, but otherwise no change is apparent. The cause of this has not been discovered.

VALUE OF COCONUT PRODUCTS.

In order to suggest the importance of the coconut industry, statistics as to the exports, imports, acreage, etc., of various countries are here included. It is impossible to obtain full data from all districts, but it is believed that the figures here given are sufficient to indicate partially the great extent of this industry and the very ɔus nature of any disease so widely distributed and destructive as the bud-rot.

Table XXXII gives the value of the imports of coconuts and coconut products into the United States for the years 1903 and 1904. It will be noted that the items listed are coconuts, oil, copra, prepared copra, and coir fiber. Of these the nuts are obtained almost entirely from tropical America, while some of the other products come largely from the East Indies.

LE XXXII.—*Value of coconuts and coconut products imported into the United States.*

Item.	1903.	1904.
Coconuts	$908,242.00	$971,852.00
Coconut oil	2,494,442.20	2,186,161.77
Copra	354,122.00	273,143.00
Prepared copra	134,240.00	135,386.00
Coir fiber	7,098.00	3,462.00
	3,898,144.20	3,570,004.77

Table XXXIII gives the source of a part of the coconuts imported into the United States, as per official reports of exporting countries. The source of the products, oil and copra, are given in volumes entitled Trade and Navigation of the United States, published by the Department of Commerce and Labor, but the sources of coir are not so readily obtainable; these products come chiefly from the East Indies and the Philippines. Colombia is known to be a large exporter to the United States from the fact that the value of coconuts imported thence into the United States, as shown by the United States Department of Commerce and Labor, is in some years larger than the value of like imports from any other single country. Brazil is said to be a very large producer of nuts, but the exports to all countries in late years are of small importance; there is no record of importations thence into the United States. The places mentioned in Table XXXIII are the ones commonly heard of in the markets.

TABLE XXXIII.—*Source and number of coconuts imported into the United States, by years, 1903–1906.*

[Figures under Bahamas, Honduras, and Porto Rico not verified, as there are no statistics of same on record in the Bureau of Plant Industry.]

Country of origin.	1903.	1904.	1905.	1906.
Cuba [1]	14,579,000	16,733,000	15,501,000	15,968,000
Jamaica [2]	17,670,212	9,364,543	2,258,065	4,651,046
Bahamas				297,850
Honduras	7,868,456			
Trinidad [2]	3,951,801	4,245,530	8,508,226	9,054,355
British Guiana [3]	17,258	46,829	561,334	
Porto Rico			4,888,053	

[1] From Estadistica General Comercio Exterior, Republica de Cuba.
[2] Statistical Tables, Colonial and Other Possessions, Great Britain.
[3] From Handbook of British Guiana, 1908.

Coconut trees are found in greater or less numbers in all countries of tropical America bordering the ocean, but they are found by no means along all the coast line. In these countries there are many miles of coast where no such trees are visible. The few countries mentioned in Table XXXIII, together with Nicaragua, Colombia, and Venezuela, of tropical America are the chief sources of the coconuts which are sent to the United States. It is said that the coast of Brazil between the Rio San Francisco and the bar of Mamanguape, a distance of 450 kilometers, is one almost unbroken stretch of coconut trees. In addition, there are some coconuts on the western coast of tropical America, though excepting in Colombia not in great numbers. According to report, South America has 1,000,000 acres in coconut cultivation. Table XXXIV is here included to show the immense importance of the exportation from the East. The data are incomplete and not in all cases comparable, but they suffice to show that the industry is widespread and of very great importance.

TABLE XXXIV.—*Exports, products, or acreage of coconuts of various countries.*

Countries.	Amount.	Year.	Remarks.
Philippines.................... dollars..	3,819,793	1903	Value of copra exported.
Fiji Islands..............................	....	1903	Land is covered with coconut trees which, if counted, would number millions.
Samoa Islands......................tons..	5,400	1907	Amount of copra exported valued at £77,981.
Marshall Islands..........................	....	1907	Imported crop.
Tutuila...............................tons..	500	1907	Copra annually exported.
Solomon Islands..........................	....	....	Only product yet cultivated.
Federated Malay States............acres..	77,500	1904	Valued at $12,000,000 to $15,000,000.
Portuguese West Africa..................	....	1904	Production of copra increasing. Coir fiber has been made for years.
Portuguese East Africa..................	....	1901	
German East Africa......................	....	1903	German East African Association in Muoa has 200,000 trees; Kjeine, in Togo, 136,000 trees at end of 1901.
New South Wales......hundredweight..	145,510	1907	Valued at £180,787.
Ceylon...................................acres..	606,134	1886	These exports represent a total number of 565,527,757 nuts.
Oil.................hundredweight..	687,623	1903	
Copra.............................do....	732,015	....	
Desiccated..................pounds..	18,384,800	....	
Nuts...............................nuts..	13,615,589	....	
British India and its dependencies.acres..	480,000	1886	Valued at £8,680.
Mauritius ....hundredweight..	7,430	1907	
South America......................acres..	1,000,000	1886	

It is reasonable to assume that the use of such products is likely to increase in this country. The present situation in regard to the extent of the coconut industry makes it apparent that the progress of any such widespread disease as the bud-rot should be studied with great care.

Owing to the great distance of the East from the European countries the produce is carried in the form of copra, oil, or coir, rather than as whole nuts, the most common form in tropical America.

No data are available to prove the statement, but it may be gathered from various notes on the subject that European countries are away ahead of America in the consumption of coconut products, particularly that of coconut oil for cosmetics, cooking compounds, butter, medicinal compounds, etc., and coir for mats and ropes.

SUMMARY.

(1) A disease of coconuts has been known for more than 30 years in Cuba. A similar trouble has also caused widespread loss in Jamaica, British Honduras, Trinidad, and British Guiana.

(2) This disease is called the bud-rot, owing to a rot occurring in the bud of the tree. The early symptoms are the yellowing and falling of the leaves and the dropping of immature nuts. Eventually the middle folded leaves bend over and the entire heart of the crown is involved in a vile-smelling soft rot.

(3) The spread of the disease, with the consequent heavy loss, may be very rapid. A single tree may be killed in two months to a year or more after infection, and entire groves may be destroyed in two or three years.

(4) This disease (or a disease with similar symptoms) occurs in many parts of Cuba, both in the eastern and western ends; in western

Jamaica, and in a few cases in the extreme eastern end; in the Cayman Islands; in British Honduras; in Trinidad on the north and west sides; in British Guiana at the mouth of the Essequibo River and at Mahaicony. According to reports it occurs also in the Philippines and in Ceylon; probably in British India, in German East Africa, and in Portuguese East Africa.

(5) This disease was investigated in 1901, at the request of the planters of Baracoa, Cuba, by Mr. August Busck, entomologist of the United States Department of Agriculture. In 1904, Dr. Erwin F. Smith, plant pathologist of the same Department, made further investigations in the same district, and declared the disease to be a bacterial soft rot of the terminal bud. Mr. W. T. Horne, until recently plant pathologist of the Estación Central Agronómica of Santiago de las Vegas, studied the disease in 1906 to 1909, in both the eastern and western districts of Cuba. Mr. W. Fawcett, formerly director of the botanical department of Jamaica, reported the trouble in Jamaica in 1891, and since then has made frequent observations on it. Mr. W. Cradwick, traveling instructor of the same department, has also made studies on the same malady. Prof. F. S. Earle, while on the staff of the New York Botanical Gardens, reported on the disease in Jamaica in 1902. Mr. W. A. Murrill, of the same staff, reported on it in 1908. In Trinidad, Mr. W. Greig called attention to the disease in 1905. Mr. J. H. Hart, formerly director of the botanical station of Trinidad, investigated the trouble in the same year. Mr. F. A. Stockdale, until recently mycologist of the Imperial Department of Agriculture for the West Indies, studied the troubles of the coconut in 1906. Dr. A. Fredholm made a report on the fungous diseases of the coconut in Trinidad in 1909.

(6) The extent and nature of the disease of the coconut were investigated by the writer for the United States Department of Agriculture, in 1907, in Cuba, Jamaica, Trinidad, and British Guiana. Other investigations were carried on in eastern Cuba in 1908, 1909, and 1910, and some observations were made in Porto Rico in 1910 and 1911.

(7) The location of the malady in the tissues with reference to the general structure of the tree makes it a particularly difficult one with which to experiment by direct means.

(8) Infection experiments with bacteria were successful in producing typical bud-rot. Infection experiments with fungi produced only dry and brown spots of limited extent.

(9) Experimental application of various approved fungicidal mixtures as remedies gave negative results. In general, those planters attending to ordinary methods of sanitation in their groves had little trouble with this disease.

(10) The cause of the disease in eastern Cuba is shown by repeated inoculation experiments to be a bacterial organism.

(11) Cultural studies of the organism causing the bud-rot show it to be practically identical with *Bacillus coli* (Escherich) Migula.

(12) Inoculations into coconut seedlings with *Bacillus coli* of animal origin give infections similar to inoculations with the coconut organisms.

(13) Comparison of *Bacillus coli* with the organisms first isolated by the writer and those isolated by at least one other worker indicate that *Bacillus coli* has been isolated in other experiments but not identified.

(14) Comparison of the bud-rot caused by *Bacillus coli* with several diseases of the coconut palm ascribed in literature to other causes indicate that several of these diseases are identical with bud-rot.

(15) Comparison of the bud-rot of the coconut palm with diseases of several other palms suggests that they may be the same thing.

(16) Studies with the microscope show that the bacteria thrive only in the meristematic tissues which are little or not at all lignified. Stomatal infections are common on the young tissues.

(17) It is believed that birds and insects are carriers of this disease, but the subject requires further study.

(18) The value of the annual importation of coconuts and coconut products into the United States is about $4,000,000. In 1906 Baracoa, Cuba, was our largest source of coconuts, with Trinidad as second.

RECOMMENDATIONS.

Owing to the widespread distribution of the bud-rot no coconut district in the American Tropics is secure from danger of infection. This bud-rot is due to a bacterial organism which may be distributed from place to place on the green unhusked coconut, and may be carried to healthy trees by insects or other animal life infesting diseased trees.

It is recommended, therefore, to cut down all badly diseased trees, or at least trim the tops and set fire to them. All débris, fallen leaves, nuts, etc., should be removed so as to destroy any infected material and any breeding place for insects which might serve to transmit the disease.

These ordinary methods of sanitation, together with proper methods of cultivation, if carried out faithfully by the planters of a whole district will reduce the loss by this disease to a minimum.

It is further urged that attempts be made to extend the coconut industry in Porto Rico to take the place of the rapidly failing groves of eastern Cuba. Inasmuch as this island appears to be free from the disease, it is urged also that special efforts be made by the General Government of the United States to keep it so.

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