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INTRODUCTION

This circular reports the results and progress of experiments at the United States Field Station at Sacaton, Ariz., from 1931 to 1935, inclusive. It also includes statements of cotton conditions in Maricopa and Pinal Counties, and of agricultural developments on the Gila River Indian Reservation.

The station was established in 1907, and is conducted on the basis of cooperation between the Bureau of Plant Industry of the United States Department of Agriculture and the Bureau of Indian Affairs of the United States Department of the Interior. Investigations are carried on with many crop plants that show adaptation to the Southwestern States, special attention being given to those having possibilities of being valuable to the Pima Indians. A seed farm is maintained for the purpose of increasing the stock of pure seed of new or improved strains that are developed at the field station for distribution to the Indians, and in some cases to organized groups of white growers in the nearby farming areas.

The investigations are also conducted under a cooperative arrangement between several divisions of the Bureau of Plant Industry, especially the Divisions of Cotton and Other Fiber Crops and Diseases,

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Fruit and Vegetable Crops and Diseases, and Cereal Crops and Diseases. The investigations during the period of this report included the breeding and selection of cotton, cereals, sorghums, and beans; variety and strain tests; acclimatization tests; irrigation and fertilization experiments; cultural methods; rotation experiments; studies of dates, pecans, citrus, pistache, ornamentals, and truck crops. Special attention is given to the life history, distribution, habits of growth, and control of the cotton root rot fungus, and to the causes and control of the cotton crazy top disorder. Other cotton diseases are studied to some extent, especially black arm or angular leaf spot, root knot, and sore shin.

The following cooperative investigations are conducted with other bureaus of the Department of Agriculture: Investigations of the quality of cotton, methods of appraising quality in one-variety communities with the Division of Cotton Marketing of the Bureau of Agricultural Economics; the nature and extent of damage to cotton from hemipterous insects, and relations of soil fauna to cotton diseases, with the Division of Cotton Insects of the Bureau of Entomology and Plant Quarantine; cotton-ginning methods and attachments adapted to American-Egyptian cotton with the cotton-ginning project of the Bureau of Agricultural Engineering; and studies on root rot infection and resistance of plants grown for prevention of soil erosion, with the Soil Conservation Service.

The field station also has cooperated with the Arizona Agricultural Experiment Station, the Agricultural Extension Service, the Maricopa County Farm Bureau Pure Seed Association, and the Arizona Crop Improvement Association in maintaining stocks of pure seed of the Pima, S × P, and Acala varieties for planting in the Salt River and Gila River Valleys. Most of these activities have possibilities of being beneficial to the Indians as well as to the white farmers, since the prosperity of the Indian agriculture is closely dependent upon that of the general agriculture of the region.

Diagrams showing the location of buildings and the arrangement of crop experimental plantings at the field station and at the seed farm in 1935 are shown in figures 1 and 2.

CLIMATIC CONDITIONS

The climate at Sacaton is very pleasant during the autumn, winter, and spring, but the summer is not so comfortable. The temperature during the coldest weather seldom goes below 20° F., and then usually for only a few hours. However, the summer temperatures have been as high as 117° with the night minima above 80°. Fortunately, there is more rainfall during July and August than any other period of the year, which affords temporary relief from the oppressive high temperatures.

The long frost-free period, which is about 263 days, makes Sacaton and the surrounding communities especially favorable for the production of plants of a subtropical nature, such as dates, olives, and American-Egyptian cotton.

The mean daily range of about 35° F. between day and night temperature is another characteristic. The low atmospheric humidity is also worthy of mention, as it makes the high temperatures of the day endurable without great discomfort and allows rapid cooling at night.

The average annual rainfall for Sacaton, over a period of the past 26 years, is 10 inches. The driest period is during April, May, and June, and the period of most rainfall is during July and August.

The winter temperatures at the seed farm, which is located about a mile southwest and on higher land than the field station, are sufficiently mild to permit satisfactory culture of citrus fruits with only occasional light frost injury to the trees and fruit.

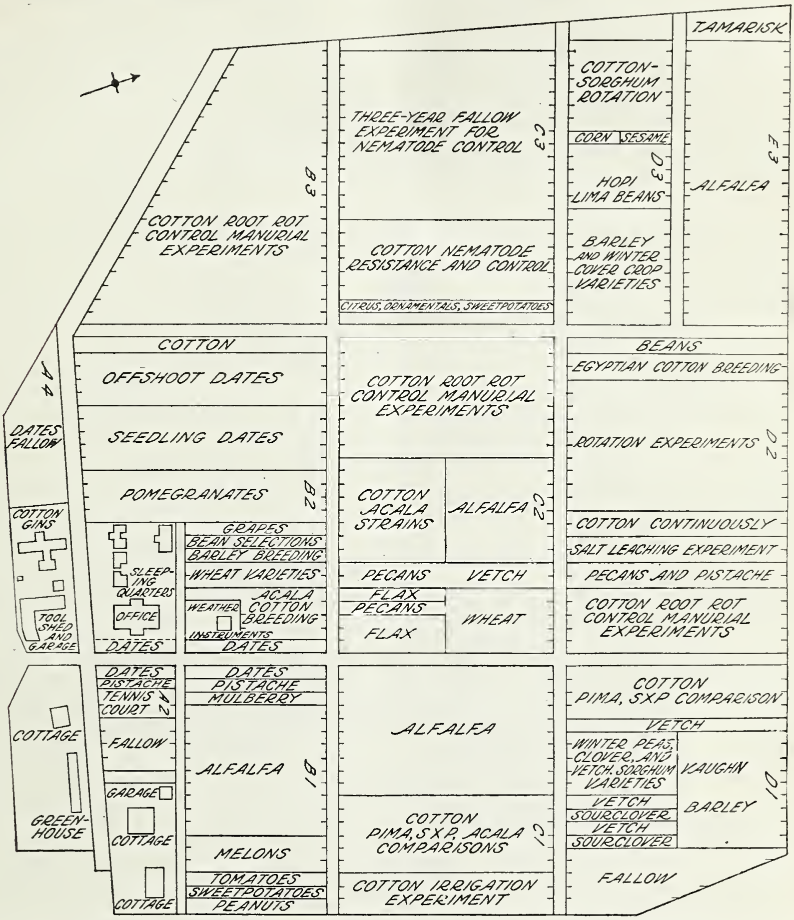

FIGURE 1.—Diagram of buildings and plantings at the United States Field Station, Sacaton, Ariz., 1935.

During 1931 the rainfall was far above average. The total precipitation was 15.7 inches, whereas the average for the 21 years preceding 1931 was only 9.9 inches. Heavy rainfall occurred in February, July, August, November, and December. August had a total rainfall of 4.9 inches, which is the second highest ever recorded for any 1 month at this station, where the records have been kept since 1908. July temperatures were above normal with unusually warm nights and hot, humid days.

An important feature of 1931 from the standpoint of irrigation agriculture was the amount of water accumulated behind the dams of the five principal reservoirs of the State. At the beginning of the year there was only 302,848 acre-feet of stored water in the reservoirs, whereas at the end of the year the stored water had increased to 760,206 acre-feet, an increase of 457,358 acre-feet during the year.

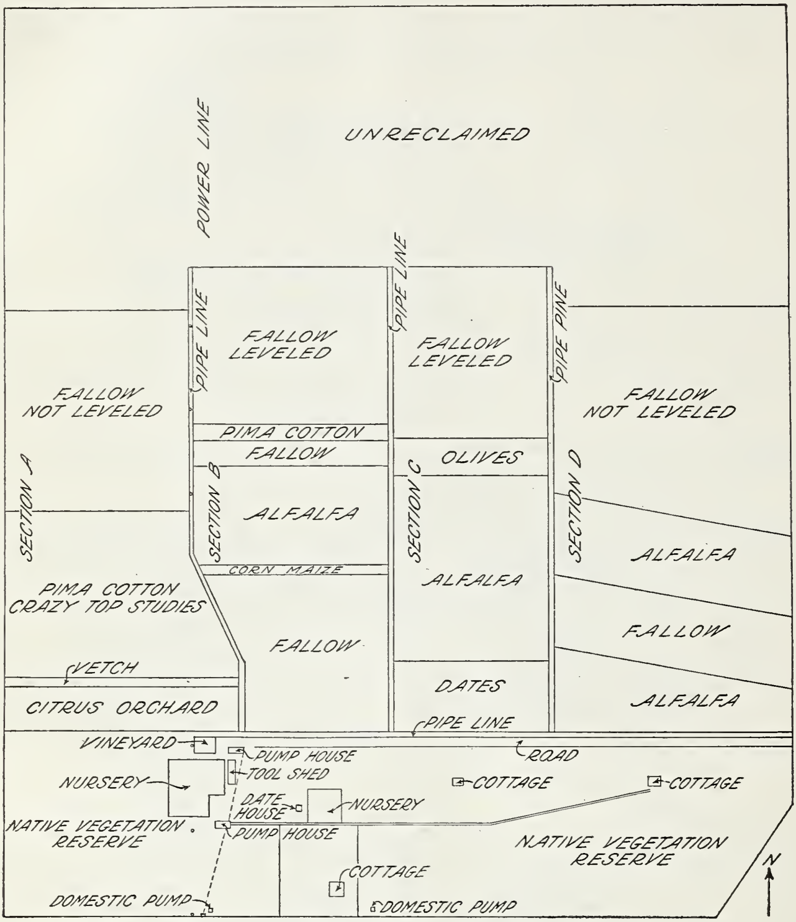

FIGURE 2.—Diagram of buildings and plantings at the seed farm, Sacaton, Ariz., 1935.

In 1932 the total rainfall was near normal and the evaporation of 70.6 inches was slightly above normal. The wind movement for the year was considerably above the average, and was climaxed by a windstorm, accompanied by hail and rain, in August that did considerable damage to cotton and other crops at the field station. The cotton yields for the year were below normal, but this was attributed to insect injury as well as to unfavorable weather conditions. The lowest temperature for the year was 19° F., recorded on January 26. The low temperature of this period caused some damage to citrus trees in the Salt River Valley. January of 1932 was the coldest month ever recorded at this station, with a mean temperature of 43.3°. The maximum temperature of the year was 114° recorded on June 27.

The year 1933 was characterized by exceedingly dry weather, the total precipitation being 7.19 inches, which was less than half the amount received in 1931. On January 20, Sacaton and vicinity received approximately 1 inch of snowfall, which is a very unusual occurrence for this locality. The last killing frost of the spring occurred on April 11, which was unusually late, and necessitated the replanting of some plots of cotton at the station, and caused poor stands on other plots. July 1933 was the hottest month ever recorded at Sacaton, the mean temperature being 91.3° F. Cotton made good growth during July and August after recovering from the poor start caused by the low temperatures of April and May, and the final yields were satisfactory.

The year 1934 was one of average rainfall at Sacaton, but for the State it was one of the driest and warmest years in Arizona history. The dryness of September and October made conditions exceptionally favorable for the production of dates, especially for the Deglet Noor variety. The last killing frost of the winter occurred on February 12. The absence of cold weather during the spring planting period was especially favorable for obtaining good stands of all crops. The extreme warm weather was injurious to the spring lettuce crop, but an excellent crop of fall lettuce was obtained. High yields of good quality were obtained on cotton, grain, and citrus crops. December was a very unusual month with more than twice the average precipitation, and with dense fogs occurring on the 29th, 30th, and 31st. An earthquake was felt in this section on December 31, which is a very rare occurrence for this locality.

In 1935 temperatures and rainfall were average with the exception of an early frost on October 24. Seven of the twelve months were cooler than average, but the mean annual temperature of 67.6° F. was only 0.7° below normal. A heavy sleet was recorded on March 10, with the last killing frost of the winter occurring March 11. The early fall frost occurring on October 24 was the earliest ever recorded at Sacaton. Considerable damage was done to the Egyptian cotton, and the final yields were reduced appreciably.

At the end of 1935 the principal water reservoirs of the State contained 576,220 acre-feet. This was an increase of 273,372 acre-feet over the contents at the beginning of 1931. These figures are exclusive of the water impounded behind the Boulder Dam in the Colorado River.

The meteorological records at the field station for the years 1931–35, and the average of the data obtained for the 26 years 1910–35, and the absolute maximum and minimum temperatures at the seed farm for 1918–35 are summarized in table 1.

TABLE 1.—*Meteorological records at the United States Field Station, Sacaton, Ariz., showing the 26-year mean from 1910 to 1935, compared with each year from 1931 to 1935, and including absolute maximum and minimum temperatures at the seed farm from 1918 to 1935*

MEAN TEMPERATURES (°F.)

Period	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean annual
26-year mean	49.7	54.2	59.3	66.0	73.7	83.0	88.1	86.6	81.3	69.3	57.9	50.1	68.3
1931	49.9	56.4	59.5	69.7	76.2	83.1	91.1	85.8	82.2	69.5	55.1	48.1	68.9
1932	43.3	54.8	58.9	65.8	73.6	81.3	88.4	88.2	83.8	69.2	59.8	46.9	67.8
1933	46.2	46.9	58.6	62.2	69.4	83.9	91.3	88.4	83.9	74.5	59.5	51.4	68.0
1934	51.0	58.0	67.0	72.1	80.0	80.3	90.5	87.0	80.1	71.7	57.9	52.6	70.7
1935	51.0	55.7	55.8	66.1	70.5	84.4	87.8	85.2	81.1	69.1	54.1	50.5	67.6

MEAN MAXIMUM TEMPERATURES (°F.)

Period	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean annual
26-year mean	65.8	70.3	76.5	83.6	92.5	101.9	102.6	100.6	97.5	87.2	75.8	66.0	85.0
1931	67.5	68.4	77.5	86.8	95.5	101.0	105.8	99.0	97.4	88.0	69.0	63.1	84.9
1932	59.3	68.6	75.7	85.2	93.6	100.8	102.4	103.7	101.6	85.1	80.6	60.0	84.7
1933	62.1	63.2	77.5	79.7	88.5	102.6	106.1	103.5	99.0	90.8	80.0	69.4	85.2
1934	69.5	74.7	85.5	90.8	99.1	99.1	105.0	99.1	96.6	90.7	75.5	68.0	87.8
1935	65.6	69.5	69.9	83.0	87.8	104.5	103.8	98.3	97.0	88.4	71.8	67.0	83.9

MEAN MINIMUM TEMPERATURES (°F.)

Period	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Mean annual
26-year mean	33.6	38.2	42.2	48.4	54.9	64.2	73.7	72.6	65.2	51.5	40.0	34.2	51.6
1931	32.3	44.4	41.6	52.6	56.9	65.3	76.5	72.7	67.0	51.0	41.3	33.1	52.9
1932	27.3	41.1	42.2	46.4	53.7	61.8	74.4	72.8	66.1	53.3	39.1	33.9	51.0
1933	30.4	30.7	39.7	44.7	50.4	65.3	76.6	73.3	68.8	58.2	39.0	33.4	50.9
1934	32.5	41.4	48.6	53.5	60.9	61.6	76.1	74.9	63.7	52.8	40.4	37.3	53.6
1935	36.4	41.9	41.8	49.3	53.3	64.3	71.8	72.2	65.2	49.8	36.4	34.1	51.4

ABSOLUTE MAXIMUM AND MINIMUM TEMPERATURES (°F.)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Absolute maximum:												
1910	81	84	98	106	117	114	115	110	111	107	92	82
1911	81	80	92	95	101	109	109	109	108	96	88	86
1912	84	84	84	92	107	112	110	113	104	96	90	73
1913	73	80	90	98	103	108	112	110	108	100	89	76
1914	79	88	96	100	109	114	113	114	108	96	95	75
1915	75	80	88	97	107	111	113	113	108	105	98	79
1916	75	86	98	101	105	114	113	110	108	92	94	88
1917	79	79	90	93	102	112	111	103	104	102	90	80
1918	82	80	84	92	96	111	106	111	104	99	91	78
1919	74	77	84	97	98	110	106	109	103	89	83	75
1920	81	75	82	92	101	108	111	105	103	99	82	78
1921	80	92.5	93	97.5	101	110	107	106	103	99	88	79
1922	72	82	86	93	107	114	111	109	107	100	81	74
1923	83	82	85	92	105	112	111	105	106	96	79	74
1924	72	80	85	91	102	109	108	109	107	98	94	80
1925	79	83	91	99	104	108	113	106	101	96	84	78
1926	74	93	87	96	102	112	109	105	103	94	82	81
1927	81	82	87	98	106	111	111	110	104	97	87	76
1928	77	81	90	97	103	110	112	107	106	99	86	82
1929	72	81	87	90	101	113	108	105	103	100	84	79
1930	77	86	84	98	101	109	109	108	105	94	88	75
1931	81	82	91	95	106	108	112	110	104	98	94	72
1932	74	86	87	95	105	114	110	110	110	97	85	78
1933	74	82	86	92	108	112	112	112	109	99	91	79
1934	77	84	96	100	110	109	114	108	105	104	94	83
1935	84	83	85	94	99	110	111	107	105	100	81	79
Absolute minimum:												
1910	17	17	32	39	44	56	62	65	55	40	33	24
1911	18	24	37	35	43	52	57	61	54	36	19	17
1912	17	25	35	36	42	54	56	65	49	33	31	20
1913	9	29	27	36	39	48	61	61	43	37	38	28
1914	25	27	33	42	44	56	68	67	60	47	35	21
1915	23	30	30	41	33	51	58	65	48	43	22	24
1916	27	24	33	35	44	54	62	63	55	37	21	15
1917	28	27	25	35	42	44	69	59	48	33	31	23
1918	20	27	34	38	46	52	66	58	53	30	25	26
1919	20	28	28	40	52	45	69	62	56	36	27	29

TABLE 1.—*Meteorological records at the United States Field Station, Sacaton, Ariz., showing the 26-year mean from 1910 to 1935, compared with each year from 1931 to 1935, and including absolute maximum and minimum temperatures at the seed farm from 1918 to 1935*—Continued

ABSOLUTE MAXIMUM AND MINIMUM TEMPERATURES (°F.)—Continued

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Absolute minimum—Con.												
1920	27	33	31	37	43	53	58	58	48	35	20	21
1921	20	24.5	30	31	42	48	58	68	55	30	21	22
1922	17	24	22	30	38	49	68	68	59	32	26	28
1923	20	24	26	35	43	48	67	65	44	36	30	25
1924	24	23	31	31	52	53	57	57	49	33	22	21
1925	15.5	29	29	35	47	49	62	66	52	47	27	24
1926	22	29	34	46	46	57	59	64	57	44	29	23
1927	26	32	32	38	42	51	60	65	52	42	30	25
1928	21	28	31	29	52	51	62	61	54	37	23	18
1929	20	20	26	31	42	50	69	67	59	32	23	21
1930	26	30	26	42	39	49	68	64	52	37	21	20
1931	21	34	27	41	47	55	64	67	53	40	23	22
1932	19	23	30	33	41	49	70	63	57	35	30	24
1933	24	19	30	31	41	51	66	64	58	47	28	21
1934	22	31	40	37	50	47	70	69	46	39	23	18
1935	21	27	30	35	45	50	57	66	55	29	27	22

ABSOLUTE MAXIMUM AND MINIMUM TEMPERATURES (° F.) AT SEED FARM

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Absolute maximum:												
1918	------	------	88	93	97	113	108	112.5	104	99	90	79
1919	72.5	75	86.5	98	99	112	107	106.5	104.5	90.5	83	74
1920	78	77	82	93	103	111	114	106	103	98	81	71.5
1921	76.5	91.5	93	98	101.5	111	108	103	103	99	89	77
1922	71.5	80	85	93	107	113	110	108	104	99	81.5	74
1923	84	83	84	93	104	112	111	104	102.5	94.5	79	73
1924	71.5	81	83.5	91	102	110.5	108	108	106	96	91	77
1925	76	81.5	89	97	103	105	106.5	104	100	94	82	75
1926	74	85	84.5	94	100	109	110	105	102	95	81	78
1927	78	82	86	99	103	104	112	112	103	95	84	79
1928	76	80	89	98	104.5	111.5	111	107	101	97	85	81.5
1929	73	81	87	91	101	113.5	109	104	101.5	98	82	78
1930	75	86	85	101	102	109	110	108	105	94	87	74
1931	80	82	90	94	103	107	110	109	104	96	93	73
1932	76	87	86	93	102	110	109	107	108	97	85	86
1933	73	81	86	92	105	110	114	109	106	97	93	78
1934	76	83	90	99	108	106	112	108	104	103	93	83
1935	83	85	87	95	99	112	112	109	110	107	82	81
Absolute minimum:												
1918	------	------	35	39	48	57	61	61	56	40	26	28
1919	21	29.5	30	40	53	51.5	68	67	57	37.5	27	32
1920	30.5	35.5	33	37	44	57	62.5	60	51	36.5	31	21
1921	22.5	26.5	35.5	36	42	51	64	66	56.5	38.5	22	30
1922	18	25	26	32	42	51	70	67	59	35	28.5	28.5
1923	23	26.5	30	39	47.5	51.5	66.5	68	46	36.5	33	27
1924	26.5	28	33	34	53	58	63	60	54	36	31.5	26
1925	21.5	36.5	36.5	37	53	54	64.5	67	54	47	32	28.5
1926	24	33	35	46	48	60	64	62	59	46.5	34	21
1927	29.5	34	34	39	43	52	61	67	55	46	37	26
1928	23	30	34	33	53	54	65	65	56	39	26	23
1929	22	27	30.5	36	47.5	53	68	65.5	60	34	24	25
1930	28	32	33.5	42.5	41	54	68.5	67	53.5	41	28	23
1931	23	35	28	46	48	58	73	67	61	44	26	24
1932	21	25	31	38	44	50	69	65	60	40	34	24
1933	25	21	31	34	42	53	71	66	57	50	31	23
1934	26	33	43	38	50	50	71	69	46	41	25	22
1935	22	29	30	35	45	51	58	68	58	31	27	26

TABLE 1.—*Meteorological records at the United States Field Station, Sacaton, Ariz., showing the 26-year mean from 1910 to 1935, compared with each year from 1931 to 1935, and including absolute maximum and minimum temperatures at the seed farm from 1918 to 1935*—Continued

RAINFALL (INCHES)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1910	0.75	------	0.50	------	------	------	0.65	1.45	------	------	2.36	0.31	6.02
1911	1.52	0.69	.47	T	------	------	4.11	.82	1.38	1.40	------	.25	10.64
1912	------	------	2.61	0.85	0.38	0.98	4.27	1.02	------	.96	------	1.05	12.12
1913	.72	1.72	------	.40	------	.07	.92	.73	.04	.18	2.63	.81	8.22
1914	.18	.39	1.02	.16	.10	.34	3.26	1.77	.30	2.28	1.79	5.16	16.75
1915	2.45	1.45	1.01	1.16	.69	.10	2.44	1.05	------	T	.44	3.85	14.64
1916	2.87	.26	.71	.45	------	------	1.19	.63	3.61	.02	------	.65	10.39
1917	1.47	.67	.40	.11	1.29	------	3.33	.05	.43	.16	------	------	7.91
1918	1.15	.77	1.17	.19	------	.20	1.09	1.63	.47	.29	.88	2.07	9.91
1919	.01	1.47	.55	.20	.04	T	3.76	1.63	1.80	.15	2.48	.89	12.98
1920	2.03	.98	1.41	.03	.17	.23	.48	.89	.21	1.21	------	------	7.64
1921	.44	.34	.09	.08	.09	T	2.41	3.26	.39	.23	.11	.80	8.24
1922	1.11	.41	1.23	.78	.22	.11	.53	3.32	.55	------	1.20	.26	9.72
1923	.67	.64	.81	.16	------	------	3.27	.97	.01	.24	2.36	3.25	12.38
1924	------	T	1.33	.25	.51	------	.39	.20	.40	.49	T	1.86	5.43
1925	.11	T	.18	.62	.08	.14	.54	3.09	1.78	.85	.19	.93	8.51
1926	.99	.35	3.40	1.16	.46	T	2.54	.94	3.36	.60	------	2.12	15.92
1927	.14	1.51	1.11	.54	------	.52	.05	.42	2.26	.15	.02	.64	7.36
1928	------	1.37	.13	.01	.04	------	.78	1.99	.23	.32	.11	.61	5.59
1929	.44	.37	.10	.26	T	------	1.22	1.66	1.44	------	T	------	5.49
1930	2.27	.12	2.19	.25	.66	T	1.79	3.12	.14	.10	1.92	.01	12.57
1931	.18	3.65	.02	.16	------	T	1.47	4.97	.69	.30	2.67	1.62	15.73
1932	.59	1.07	.87	.13	------	.19	1.67	2.69	.72	.87	------	1.71	10.51
1933	2.59	.27	------	.70	.02	.15	.46	.49	1.31	.09	1.11	T	7.19
1934	.26	.66	.04	.05	.08	.75	1.04	2.50	.07	------	.52	2.34	8.31
1935	.78	1.45	1.54	.39	.64	------	1.04	2.10	.60	.10	.88	.33	9.85
26-year mean	.91	.79	.88	.35	.21	.15	1.72	1.67	.85	.42	.83	1.21	10.00

EVAPORATION (INCHES)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Mean [1]	2.214	2.762	4.515	6.056	8.242	9.025	8.593	7.481	6.297	4.448	2.893	2.042	64.368
1931	2.305	2.516	4.994	6.461	8.989	9.628	9.953	7.915	6.166	5.101	2.585	1.725	68.338
1932	1.880	2.007	4.675	6.628	9.423	9.240	9.669	8.863	8.207	4.808	3.241	2.012	70.653
1933	2.109	2.232	4.748	6.525	8.502	9.173	9.941	8.727	6.843	4.786	3.479	1.870	68.935
1934	2.538	3.209	5.685	7.965	10.077	10.336	9.164	8.762	6.554	4.519	2.751	2.388	73.948
1935	1.735	2.868	4.030	6.471	7.591	10.229	9.785	7.602	6.379	5.112	2.525	1.777	66.104

MEAN DAILY WIND VELOCITY (MILES PER HOUR)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Maximum:												
1931	2.4	2.5	4.7	3.4	3.8	2.4	2.7	1.8	1.6	2.5	2.0	1.1
1932	4.5	3.8	5.3	8.2	3.9	2.8	2.2	2.2	3.2	5.4	1.2	3.3
1933	3.3	3.4	2.9	5.0	6.9	3.6	2.9	2.2	1.9	1.4	4.9	2.3
1934	2.2	3.2	4.1	5.3	5.4	4.7	2.5	2.4	3.9	2.4	1.7	1.5
1935	2.8	5.0	2.1	3.1	3.2	4.8	3.2	2.5	1.5	1.8	2.1	2.3
Minimum:												
1931	.8	1.0	1.1	1.2	1.0	.3	.8	.1	.1	.5	.6	.1
1932	.5	.5	1.0	.5	.7	.7	.4	.3	.5	.4	.5	.7
1933	.6	.8	.8	1.1	1.3	1.3	.6	.5	.5	.2	.6	.6
1934	.6	1.0	.8	1.1	.7	.9	.6	.3	.3	.2	.1	.1
1935	.1	.3	.7	.4	.5	.3	.8	.4	.5	.5	.3	.3
Mean:												
1931	1.4	1.6	2.1	1.8	1.7	1.4	1.4	.8	.8	1.1	1.0	.6
1932	1.1	1.5	1.9	1.7	1.7	1.2	1.2	.9	1.1	1.4	.9	1.4
1933	1.4	1.6	1.7	2.3	2.6	1.8	1.6	1.2	1.0	.7	1.1	.9
1934	1.2	1.8	2.0	1.9	1.9	1.9	1.4	1.1	.8	.6	.6	.6
1935	.9	1.8	1.3	1.5	1.6	1.6	1.5	1.1	.9	.9	.9	.9
18-year mean	1.6	1.9	2.0	2.2	2.0	1.7	1.5	1.3	1.2	1.1	1.2	1.3

[1] Means are from complete records for following numbers of years: August, September, October, November, and December, 19; January, March, June, and July, 18; February and April, 17; and May, 16.

AGRICULTURE ON THE GILA RIVER INDIAN RESERVATION

With the completion of the Coolidge Dam in 1929, and the assurance of an ample supply of irrigation water, the agricultural status of the Pima Indians changed decidedly. A census made in 1929 of the Indian farms and crops showed that, owing to lack of irrigation water, crops were harvested from only 7,774 acres of the 29,530 acres of available farm land (*9*).[1] Approximately one-half of the harvested area was planted to cotton, and the remainder largely to wheat and alfalfa.

During 1935 the harvested acreage amounted to approximately 35,000 acres, of which 24,000 were farmed by Indians, and the remainder was planted to alfalfa by officials of the Indian Service. Of the area farmed by the Indians, 1,443 acres were planted to cotton of the American-Egyptian and upland types, 4,188 to wheat, and 2,500 acres to alfalfa. The yields obtained were approximately 150 bales of the Pima variety of American-Egyptian; 650 bales of upland cotton; and 62,820 bushels of wheat. A large portion of the alfalfa acreage was pastured. Grain sorghums, Sudan grass, corn, and barley were also grown on a considerable acreage for feed and pasture.

Truck crops, consisting of beans, corn, tomatoes, onions, and melons, are grown by the Indians each year for home use and, to a small extent, for commercial purposes.

During the period 1931–35 the Indian farmers have shown an increased interest in planting of grapes and various trees, such as dates, figs, pomegranates, and citrus. This is clearly shown by the number of plants propagated by the station and distributed to them (table 2).

DEVELOPMENT OF NEW LAND ON THE RESERVATION[2]

During the period 1931–35, the subjugation or land-development program on the Gila River Indian Reservation was a major activity. With the completion of the Coolidge Dam in 1929, water was made available for 50,000 acres of Indian land, and soon thereafter, the development program, which included the clearing, leveling, and preparing this acreage for irrigation, was inaugurated.

Before this program had progressed very far it became obvious that a large portion of this land was unfit for agricultural purposes, because of the excessive salt content of the soil, the presence of a tight impervious subsoil or substratum or a combination of the two conditions. To determine what land should be classed as irrigable and which lands should be excluded from the project, a soil survey was made, and, as a result, almost one-half of the portion heretofore considered irrigable was condemned.

After this soil survey was made, only approved lands were developed, and it is felt that by adhering to this policy a project has been developed which will endure.

[1] Italic numbers in parentheses refer to Literature Cited, p. 64.
[2] Prepared by A. E. Robinson, Superintendent, Gila River Indian Reservation.

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TABLE 2.—*Nursery stock and propagation materials produced at the United States Field Station, Sacaton, Ariz., and distributed on the Gila and Salt River Reservations, 1931–35*

Item	1931		1932		1933		1934		1935		Total	Total estimated value [1]
	Quantity	Estimated value [1]	Quantity	Estimated value [1]	Quantity	Estimated value [1]	Quantity	Estimated value [1]	Quantity	Estimated value [1]		
Date trees ... number	118	$1,200	193	$965	381	$1,810	254	$1,270	268	$1,340	1,214	$6,585
Figs, rooted ... do	236	71	300	90	470	141	1,074	322	1,321	396	3,401	1,020
Grapes, rooted ... do	301	45	12	2	122	18	297	44	398	60	1,130	169
Pomegranate, rooted ... do			600	180	111	33	836	250	706	212	2,253	675
Citrus trees ... do			15	11	7	5	48	36	40	30	110	82
Ornamental trees ... do					216	108	16	8	212	106	244	222
Fruits and nuts ... pounds	5,500	791	2,757	193	2,859	274	2,740	181	2,377	102	16,233	1,541
Cottonseed ... tons	2.5	151	3.8	129	13.9	238	5.0	175	5.5	218	30.7	911
Corn (seed) ... pounds	700	14	400	8	1,200	18	4,900	98	1,600	32	8,800	170
Wheat and barley ... do			450	4			2,900	35	1,700	17	5,050	56
Onion seedlings ... thousands			220	55	28	28	6	9	75	112	329	204
Miscellaneous seeds ... pounds	2,800	56			2,200	44	3,320	92	1,406	56	9,726	248
Total		2,328		1,637		2,717		2,520		2,681		11,883

[1] Based on local prevailing prices at the time distribution was made.

To offset some 23,000 acres of condemned land, it was necessary to find other reservation lands that might receive water from the irrigation system and also bear the approval of soil specialists. A body of land, which met with these requirements and which contained 19,000 acres and is located south of the old project boundary, made up the balance in accreted lands along the upper bench of the Gila River which runs from east to west through the entire project.

In 1931 the land development was begun in the Casa Blanca district. A considerable acreage had already been developed, which the Indians had farmed prior to the construction of the present irrigation system. To this amount was added some 9,000 acres of newly developed land. The Santan district on the north bank of the Gila River was next developed, a portion of which had been previously irrigated by a series of pumping plants. Some 3,000 acres remained undeveloped, and this was prepared by the land-development force for irrigation. After the Santan district was completed, development of the south-side land was started and is still under way.

To date, some 10,000 acres of this land have been developed which are supplied with water by a canal carried on a high contour to the south of the old project. This land, not having been previously considered irrigable, was not allotted, and therefore remains as tribal lands. In order to build up the soil and prevent wind and water erosion on this land as it is developed, it is planted to alfalfa; and by the end of the current season (1935) there will be some 10,000 to 12,000 acres of tribal land seeded to this crop.

With the new land policy of the Bureau of Indian Affairs now effective, this acreage in the near future will be assigned to Indian families. By taking 40 acres as a basic assignment for an average family, and considering the size of families and their ability to operate as a determining factor in increasing or decreasing this amount, it is believed that the land program will not only develop the reservation, but will develop the Pima Indians as an outstanding agricultural people.

CROPPING OF THE INDIAN LAND[3]

In 1931 quite a large block of land was prepared in the Casa Blanca district before planting began in October. In preparing a program for this land an effort was made to create one that would substantiate a large acreage being added for the next 3 years. The farms ranged from 10 to 80 acres, with an average over the whole district of 30 acres to each Indian family. This new project when completed would consist of 9,000 acres of new desert land with 3,000 acres of very fertile old land along the Gila River, which had been leveled by allowing river silt to settle in low places.

In addition 3,000 acres in the Santan district, 2,000 of old area on the north side of the Gila River, 5,816 on the south side, and 900 acres in the extreme west end adjoining the 160-acre experimental tract were brought under cultivation in 1933.

The greater portion of the newly subjugated land was deficient in humus and nitrogen and, therefore, alfalfa was planted to 800 acres in the fall and winter of 1931–32 as a soil-building crop. At the completion of this project in 1933, 7,500 acres of this land was in

[3] Prepared by Omer O. Davis, farm agent, Bureau of Indian Affairs, U. S. Department of the Interior.

alfalfa with 4,500 being used for barley, wheat, Sudan grass, cotton, and subsistence truck crops.

As a result of the large acreage of alfalfa on the reservation it was necessary to bring in custom cattle as a means of harvest to avoid flooding the hay market. This was also approved by the Indians.

These two projects (hay and pasture) made possible a consistent harvest for the whole year with the addition of barley in the winter and Sudan grass on the old area in the summer.

The pasture and hay programs are the major agricultural activities on the reservation at the present time and will continue until the new land is sufficiently built up to produce other desirable crops.

The south-side district, consisting of 5,816 acres, the west-end district of 900, and the Santan extension district of 1,080 acres are all conducted as a Government project and designated as subjugation cropping operations. The Government operation of these projects resulted from complications of land-assignment code that would have made it necessary for the land to lie idle for 2 or 3 years. It has been the means of creating one of the best farming areas on the reservation.

The pasturing of custom cattle has steadily grown since November 1932, when 600 were obtained from the Tremaine alfalfa ranch. In 1935 there was a total of approximately 55,000 cattle pastured on the reservation. In addition to cattle, approximately 1,200 sheep were pastured during the winter months in 1935 (fig. 3).

During 1935, 345 families participated in the pasture project with an average income of $16.66 per month with total receipts for the year of $68,972.40. Under the hay project, 8,000 tons were harvested and sold at an average of $6.50 per ton in the field.

COTTON INVESTIGATIONS

CONDITIONS IN MARICOPA AND PINAL COUNTIES

The low prices received by cotton growers in Arizona in 1930 and 1931 for the upland and American-Egyptian types of cotton caused a reduction in acreage of both kinds in 1932. The yields in 1932 were exceptionally low and only about 67,000 bales were produced in the State, 8,000 of which were the Pima variety. In 1933, efforts to control production were begun by the Government and approximately 21,000 acres were plowed up. A crop of about 86,000 bales was harvested from 97,000 acres. The yields of Pima were again exceptionally low this season and only 9,700 bales were produced on approximately 27,000 acres. The prices, however, were much improved over the 3 previous years.

The year 1934 was especially favorable for cotton, and the State produced 116,363 bales from 137,000 acres. In Maricopa County about 58,700 bales of upland cotton were produced on 62,800 acres, and 10,500 bales of Pima cotton from 22,000 acres. In 1935 the returns per acre were higher than at any time since 1929. The average value of lint per acre in Maricopa County for both Pima and upland cotton was about $53.

The acreages, total production, acre yield, price, and acre value of Pima and upland cotton in 1931–35 in Maricopa County are given in table 3.

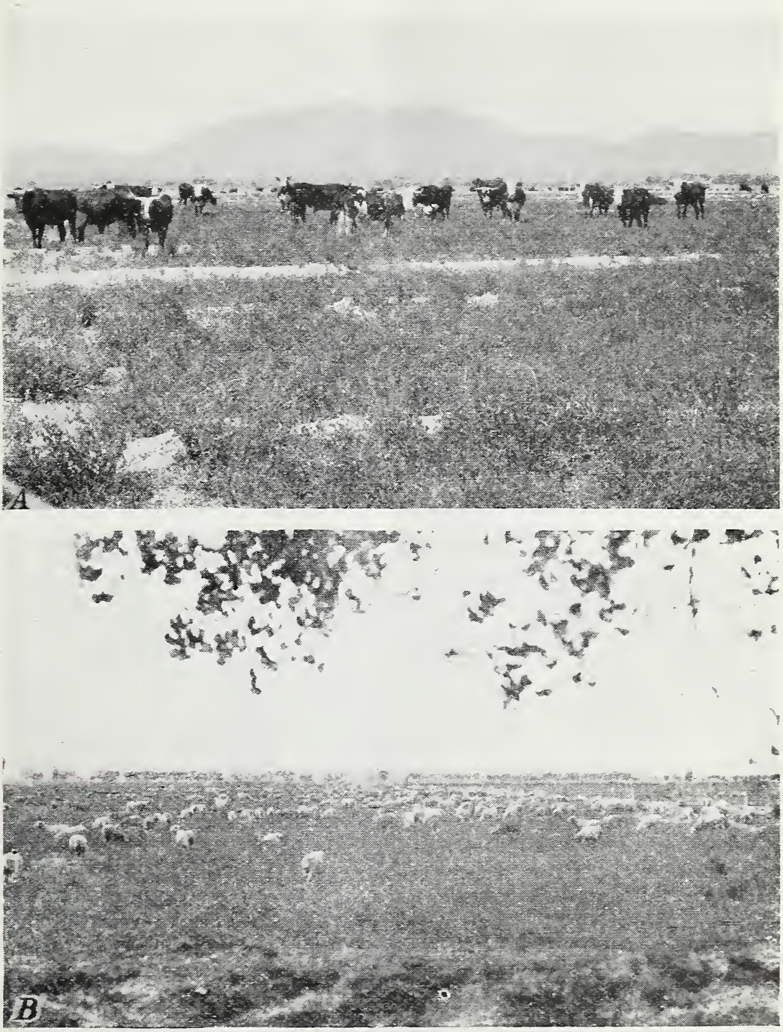

FIGURE 3.—Pasturing on alfalfa on the Gila River Indian Reservation: *A*, Beef cattle in early spring growth on alfalfa; *B*, sheep on winter growth of alfalfa.

TABLE 3.—*Acreage, total production, acre yield, price, and acre value of American-Egyptian (Pima) and upland cotton in Maricopa County, Ariz., 1931–35* [1]

Type and year	Acreage	Total production	Lint		
			Acre yield	Price f. o. b. Phoenix, Dec. 1	Crop value per acre
		Bales	*Pounds*	*Dollar*	*Dollars*
American-Egyptian (Pima):					
1931	29,000	13,000	224	0.16	35.84
1932	20,000	7,200	180	.14	25.20
1933	21,300	7,400	173	.21	36.33
1934	22,000	10,500	239	.205	48.99
1935	28,000	12,500	223	.24	53.52
Upland:					
1931	70,000	50,000	357	.078	27.84
1932	45,300	30,300	335	.062	20.77
1933	57,000	48,700	427	.103	43.93
1934	62,800	58,700	467	.130	60.71
1935	70,300	62,500	444	.120	53.28

[1] These data were obtained partly from reports prepared by the Division of Crops and Livestock Estimates of the Bureau of Agricultural Economics and partly from cotton ginners and brokers.

During the period 1921–28 very little Pima cotton was produced in Pinal County. In 1929 about 1,400 acres were planted near Coolidge, and by 1935 about 8,000 acres were grown, compared with about 21,000 planted to upland. The quality of the Pima cotton grown in recent years in Pinal County was exceptionally good.

Although some of the older cotton districts in Maricopa County have gradually gone into production of alfalfa, grains, and truck crops, other new cotton-growing areas adjacent to the Salt River Valley irrigation project have been added so that the average cotton acreage has been maintained. The Roosevelt irrigation district, located west of the Agua Fria River near Buckeye, Ariz., was established about 1925, and about 20,000 acres in this district are planted each year to upland cotton. Another extensive cotton development has been made within recent years on the Beardsley irrigation project, which is located about 25 miles northwest of Phoenix.

In 1933 a new variety of American-Egyptian cotton known as S × P, which was developed at the United States Field Station at Sacaton, was planted on 200 acres near Chandler, Ariz. In 1934 this planting was extended until it included about 600 acres; and in 1935 about 1,700 acres were grown in the county, mostly in the Chandler and South Tempe districts. The new cotton showed some advantages over Pima, especially from the standpoint of earliness and a higher lint percentage. The prices received in 1935 also were satisfactory in comparison with those of Pima, and the growers made use of all available seed in planting the crop of 1936. Approximately 9,000 acres of S × P were harvested in Maricopa County in 1936 and 1,600 acres in Pinal County.

The quarantine [4] affecting the cotton-growing areas of Maricopa and Pinal Counties because of pink bollworm infestations was lifted in 1932, when it appeared that the pest had been eradicated. Other types of insects that are not commonly regarded as major cotton pests have been the cause of considerable damage during the past 5 years to the cotton crop in Maricopa, Pinal, Pima, and Yuma Counties.

[4] The information on quarantine and insects was prepared by T. P. Cassidy, entomologist, Bureau of Entomology and Plant Quarantine.

Investigations conducted by the Division of Cotton Insect Investigations of the Bureau of Entomology and Plant Quarantine have shown

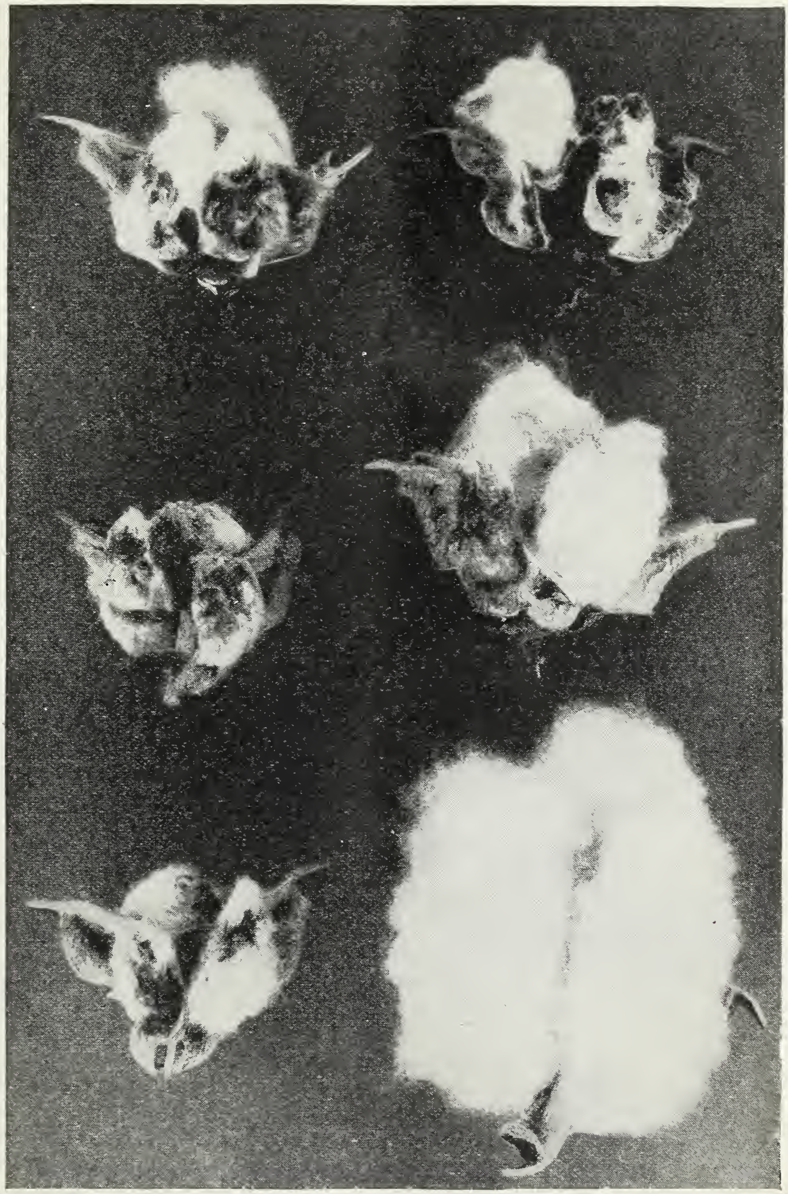

FIGURE 4.—Injury to Pima cotton bolls caused by hemipterous insects of the pentatomid or stinkbug family. Damage of this type affecting both upland and Pima cotton has been severe in parts of the irrigated region since 1932. The boll in the lower right-hand corner is uninjured.

that the damage to the bolls (fig. 4) is caused principally by three kinds of hemipterous insects, two of which are commonly called "stinkbugs" and belong to the family Pentatomidae. The most damaging of these is a brown species (*Euschistus impictiventris* Stål) and the other is a green species (*Chlorochroa sayi* Stål). A third type, rather prevalent in cotton fields but less damaging than the other two, is *Dysdercus mimulus* Hussey, which closely resembles the true cotton stainer (*D. suturellus* (H. S.)).

The investigations also showed that a number of other insects have a part in causing shedding of squares and young bolls in the irrigated valleys of Arizona and California. Among these are three species of the genus *Lygus* and the cotton hopper (*Psallus seriatus* (Reut)). For 2 or 3 years control experiments have been carried on involving the use of a large number of insecticide dusts. Some of these have given promising results, but further evidence should be obtained before recommendations are justified.

In 1934 a cotton wilt disease began to attract the attention of growers in the Roosevelt irrigation district near Buckeye, Ariz. In a survey made by one of the authors in 1934 and 1935 the information was obtained that the first spots of infection were observed about 1929. By 1936 a few infected plants could be found in most of the fields in the district, but in only a few of them was the disease severe enough to cause material damage. The same disease in recent years has affected several fields in the Marana district of Pima County. It was observed in this district as early as 1924 by R. S. Hawkins, agronomist of the University of Arizona, and also near Eloy about the same year by G. L. Peltier and C. J. King of the Bureau of Plant Industry. In 1936 the disease was found widely distributed in the upper Gila River Valley near Safford and also was common in the middle Gila River Valley near Coolidge.

It has been believed that this disease was caused by the so-called Waxahachie type of fusarium (*1*, *2*). However, observations in several widely separated regions indicated that the symptoms of the disease in the field were those produced by *Verticillium*. Subsequent isolations yielded no *Fusarium vasinfectum* Atk., but usually gave *Verticillium*. It, therefore, seems probable that most if not all of the wilt in Arizona is due to *Verticillium albo-atrum* Reinke and Berth.

VARIETAL TESTS

Cotton variety tests have been conducted for a number of years at the field station. These tests have included the most promising varieties of upland cotton and the Pima and S × P varieties of American-Egyptian cotton. During the past few years the Acala variety, which represents approximately 85 percent of the upland cotton grown in Arizona, has been used as a standard for comparison with other upland varieties, and has also been compared with Pima.

During the period 1931–33, plantings of two varieties were made in alternate three- and four-row blocks, and the yield of seed cotton for each 100-foot section of the row was recorded. In some of the tests made during 1934–35 the varieties were placed in the field at random.

As a continuation of records begun in 1925, data were obtained on the fruiting behavior of selected observation plants of Pima and Acala in alternate blocks grown under similar conditions. These data, which include flowering, boll shedding, and boll retention, are shown in figure 5.

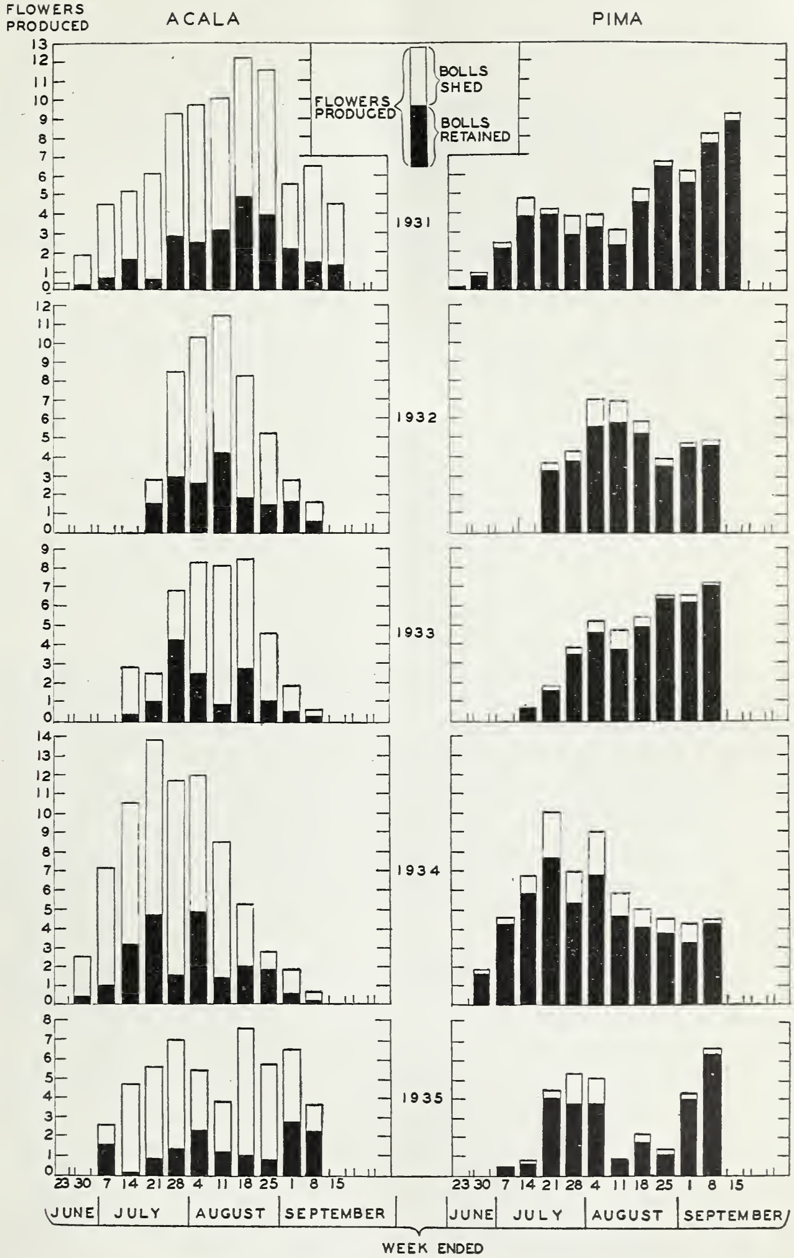

FIGURE 5.—Comparison of the rates of flowering, boll shedding, and boll retention per plant per week on Acala and Pima cotton grown under similar conditions at the United States Field Station, Sacaton, Ariz., 1931–35.

Tests comparing the seed-cotton yields of Pima and Acala varieties were conducted during 1932–35. The tests in 1932 and 1935 were planted on land infested with root knot nematodes, and the yields of Pima cotton were greatly reduced while those of Acala were considered normal. The Acala outyielded the Pima 14.2 pounds of seed cotton per 100-foot row section in 1932 and 8.8 pounds in 1935. The 1933 and 1934 comparisons were grown on disease-free plots, and the difference in yields of seed cotton in favor of Acala were not so great (table 4).

TABLE 4.—*Comparative seed-cotton yields of Acala and Pima varieties from plots infested with root knot nematodes and from disease-free plots at the United States Field Station, Sacaton, Ariz., 1932–35*

Condition and plot Nos.	Year	Variety	Row sections 100 feet long	Yield of seed cotton	Mean seed cotton increase of Acala over Pima
Infested with root knot nematodes:			*Number*	*Pounds*	*Pounds*
C1–11A to C1–14A	1932	Acala	28	21.7±0.34	
Do	1932	Pima	28	7.5± .26	14.2±0.43
C1–4 to C1–6	1935	Acala	48	17.2± .19	
Do	1935	Pima	48	8.4± .20	8.8± .28
Free from root knot nematodes:					
C3–17 to C3–20	1933	Acala	56	[1] 21.9± .30	
Do	1933	Pima	56	[1] 14.5± .28	7.4± .41
C1–2 and C1–3	1934	Acala	8	20.7± .78	
Do	1934	Pima	8	18.8± .52	1.9± .94

[1] Corrected for root rot.

Tests were made in 1931, 1932, and 1933, comparing Acala California with Mebane, Lone Star, Delfos, Durango, and Paris Big Boll, and the yields for these varieties are given in table 5. In these comparisons Acala produced significantly higher yields of seed cotton than Mebane, Lone Star, and Delfos, except for one comparison with Delfos in 1931. Acala outyielded Durango in 1931 and 1933, but the difference in the yield in 1933 was not considered significant and neither was the increase in yield of Durango over Acala in 1932. Acala yields were also greater than those of Paris Big Boll for the three comparisons, but the increase in 1932 and 1933 was not statistically significant.

The planting in 1934 consisted of eighteen 4-row blocks 400 feet long, which included Acala California, Acala Q–6,[5] Acala Rogers, and Stoneville No. 5, represented in three 4-row blocks, and Mebane, Kasch, and Delfos No. 6102, represented in two 4-row blocks.

The planting in 1935 consisted of Acala California, Acala N–28–5; Acala Q–6, Missdel No. 4, and Stoneville No. 5; and Mebane and Lone Star. This test was planted in seven sections each 100 feet long and each of the seven strains or varieties was represented by a four-row block in each section.

Yields of seed cotton in both years were recorded on each 100-foot row section. The yields shown in table 6 represent the mean yield per 100-foot section of rows for each variety.

[5] Acala Q–6 represents a progeny increased from the Queen Creek strain of Acala.

Table 5.—*Yields of seed cotton of Acala California compared with other varieties in 100-foot row sections at the United States Field Station, Sacaton, Ariz., 1931–33*

Year and plot Nos.	Strain or variety	Row sections 100 feet long	Yield of seed cotton	Difference
		Number	*Pounds*	*Number*
1931:				
C2–9 to 11	Acala	48	19. 2±0. 34	3. 3±0. 40
Do	Mebane	48	15. 9±0. 22	
1932:				
C2–9 to 11	Acala	48	11. 7± . 44	
Do	Mebane	48	9. 2± . 26	2. 5± . 51
1933:				
C1–10 to 12	Acala	24	21. 4± . 48	
Do	Mebane	24	16. 1± . 42	5. 3± . 64
1931:				
D3–1 and 2	Acala	14	[1] 22. 6± . 81	
Do	Lone Star	14	[1] 17. 8± . 40	4. 8± . 90
1932:				
D1–14 and 15	Acala	14	14. 1± . 50	
Do	Lone Star	14	10. 4± . 39	3. 7± . 63
D3–1 and 2	Acala	14	12. 8± . 45	
Do	Lone Star	14	9. 7± . 43	3. 1± . 62
1933:				
D3–3 and 4	Acala	14	[1] 23. 2± . 52	
Do	Lone Star	14	[1] 16. 5± . 48	6. 7± . 71
1931:				
C2–12 to 14	Acala	48	19. 8± . 37	
Do	Delfos	48	15. 1± . 37	4. 7± . 52
D1–6 and 7	Acala	14	22. 1± . 78	
Do	Delfos	14	21. 2± . 50	. 9± . 93
1932:				
C2–12 to 14	Acala	48	16. 8± . 34	
Do	Delfos	48	11. 3± . 30	5. 5± . 45
1933:				
C1–16 and 17	Acala	24	20. 8± . 41	
Do	Delfos	24	15. 9± . 33	4. 9± . 53
1931:				
D1–8 and 9	Acala	14	21. 7± . 80	
Do	Durango	14	14. 1± . 74	7. 6±1. 09
1932:				
D1–8 and 9	Acala	14	11. 8± . 59	
Do	Durango	14	13. 8± . 65	—2. 0± . 88
1933:				
D3–8	Acala [1]	6	20. 1±1. 19	
Do	Durango [1]	8	16. 2± . 56	3. 9±1. 32
1931:				
D3–3 and 4	Acala	14	[1] 21. 5± . 45	
Do	Paris Big Boll	14	[1] 18. 2± . 72	3. 3± . 85
1932:				
D1–16 and 17	Acala	14	11. 4± . 37	
Do	Paris Big Boll	14	9. 9± . 26	1. 5± . 45
1933:				
D3–5 and 6	Acala	14	19. 6± . 69	
Do	Paris Big Boll	14	18. 9± . 80	. 7±1. 06

[1] Corrected for root rot.

Table 6.—*Comparative yields of seed cotton, percentage and length of lint, and number of bolls per pound of seed cotton at the United States Field Station, Sacaton, Ariz., 1934–35*

Year and plot Nos.	Strain, variety, and place of origin	Row sections 100 feet long	Yield of seed cotton	Lint	Length of lint	Bolls per pound of seed cotton
		Number	*Pounds*	*Percent*	*Inches*	*Number*
1934:						
C1–10, 13, 17	Acala (Calif.)	48	19. 54±0. 243	37. 1	1⅛	67. 1
C1–10, 14, 18	Acala Q–6 (Ariz.)	48	21. 95± . 544	34. 8	1⅛	68. 5
C1–11, 14, 18	Acala Rogers (Tex.)	48	15. 05± . 333	36. 2	1⅛	73. 6
C1–11, 16	Mebane (Tex.)	32	11. 39± . 384	36. 9	1	63. 1
C1–12, 16	Kasch (Tex.)	32	10. 87± . 340	38. 5	1	63. 1
C1–12, 15, 17	Stoneville No. 5 (Miss.)	48	13. 72± . 305	34. 0	1	93. 5
C1–13, 15	Delfos No. 6102 (Miss.)	32	16. 49± . 285	31. 0	1³⁄₁₆	90. 8
1935:						
School garden	Acala (Calif.)	28	20. 03±1. 078	36. 3	1³⁄₁₆	74. 2
School garden	Acala N–28–5 (N. Mex.)	28	20. 20± . 631	36. 9	1⅛	78. 5
School garden	Acala Q–6 (Ariz.)	28	19. 60± . 692	33. 8	1³⁄₁₆	72. 7
School garden	Missdel No. 4 (Miss.)	28	20. 72± . 482	33. 0	1⅛	87. 9
School garden	Stoneville No. 5 (Miss.)	28	18. 10± . 809	32. 7	1¹⁄₁₆	95. 0
School garden	Mebane (Tex.)	28	16. 30± . 568	36. 9	1¹⁄₁₆	62. 7
School garden	Lone Star (Tex.)	28	15. 73± . 544	33. 8	1¹⁄₁₆	58. 7

In the 1934 test Acala Q-6 produced the highest yield of seed cotton, and Acala California the next highest. Delfos No. 6102 was third in production of seed cotton, but on the basis of lint Acala Rogers was slightly higher because of a higher lint percentage. Stoneville No. 5 was fifth in yield of seed cotton, but both Mebane and Kasch outyielded it in production of lint cotton.

In 1935 Missdel No. 4 produced the highest yield of seed cotton, followed by Acala N-28-5, Acala California, Acala Q-6, and Stoneville No. 5. However, the differences in yields of these five varieties were not statistically significant. The yield of Lone Star was significantly lower than all varieties in the 1935 test except Mebane, and the yield of Mebane was significantly lower than all varieties except Stoneville No. 5. Based on lint percentage, Acala N-28-5 produced the highest yield of lint followed by Acala California, Missdel No. 4, Acala Q-6, Mebane, Stoneville No. 5, and Lone Star.

STRAIN TESTS WITH ACALA COTTON

Tests comparing the California strain of Acala with a strain maintained in Arizona, known as Queen Creek, were begun in 1927 at the Sacaton field station and in the Salt River Valley. These comparisons showed that in five of the six tests made at Sacaton during 1927-30 the Queen Creek strain materially outyielded the California strain in production of seed cotton.

Comparisons between these two strains were continued in 1931 and 1932, and the Queen Creek strain outyielded the California strain in both of these years, but the difference in 1932 was not considered significant (table 7).

Progeny selections were made from the Queen Creek strain in 1928 and grown at the field station during 1929-30. During 1930 one of these selections (Q-6) produced a considerably higher yield than the others, and was therefore used for increase plantings in 1931 (fig. 6).

This increase progeny (Q-6) was planted in comparison with the California strain during 1931-35, and in five of the eight comparisons, as shown in table 7, it produced significantly higher yields of seed cotton than the California strain. However, since the California strain has a lint percentage averaging from 2 to 2.5 higher than the Q-6 strain the difference in yields on the basis of lint are not so great, and in many cases are not significant.

The California strain was also tested in comparison with Youngs and Rogers strains of Acala from Texas and the N-28-5 strain from New Mexico. In the comparison with Youngs strain in 1932, 1933, and 1935, the California strain produced higher yields during the 3 years, but differences in 1933 and 1935 were not significant. California Acala outyielded Rogers and the N-28-5 strains in 1934, but the differences in 1935 were not considered significant (table 7). Figure 7 shows plant types of these strains of the Acala variety and one of Stoneville No. 5.

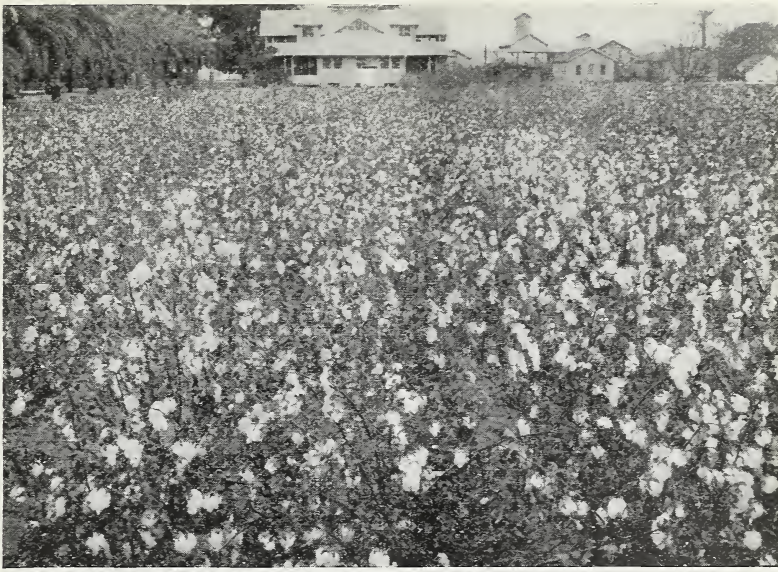

FIGURE 6.—Acala breeding block at the United States Field Station, Sacaton, Ariz., in 1935.

TABLE 7.—*Yields of seed cotton of Acala California compared with other Acala strains at the United States Field Station, Sacaton, Ariz., 1931–35*

Year and plot Nos.	Strain	Row sections 100 feet long	Yield of seed cotton	Difference
		Number	*Pounds*	
1931:				
C1–17 and 18	Queen Creek	28	22.7±0.38	
Do	California	28	19.6± .26	−3.1±0.46
1932:				
D3–5–7 and 8	Queen Creek	17	12.2± .51	
Do	California	18	10.7± .58	−1.5± .77
1931:				
C1–15 and 16	Q–6 (Queen Creek)	28	24.0± .35	
Do	California	28	20.5± .32	−3.5± .47
1932:				
C1–16 to 18	Q–6 (Queen Creek)	34	19.2± .43	
Do	California	36	16.8± .36	−2.4± .56
1933:				
C1–15 to 18	Q–6 (Queen Creek)	40	19.5± .31	
Do	California	40	19.0± .34	−.5± .46
C2–17, 19, 21, 23	Q–6 (Queen Creek) [1]	[2] 24	49.2± .70	
Do	California [1]	[2] 32	39.8± .70	−9.4± .99
1934:				
D3–19 and 20	Q–6 (Queen Creek) [1]	14	25.6±1.00	
D3–17, 18, 21, 22	California [1]	28	23.8± .32	−1.8±1.05
C1–10, 14, and 18	Q–6 (Queen Creek)	48	21.9± .54	
C1–10, 13, and 17	California	48	19.5± .24	−2.4± .59
1935:				
School garden	Q–6 (Queen Creek)	28	19.6± .69	
Do	California	28	20.0±1.08	+.4±1.28
B3–1, 4, 6, 10	Q–6 (Queen Creek)	41	18.6± .44	
Do	California	36	14.7± .36	−3.9± .57
1932:				
C1–8 to 10	Youngs	20	8.8± .38	
Do	California	22	10.8± .49	+2.0± .62
1933:				
B3–4	Youngs	12	14.1± .37	
Do	California	9	16.1± .95	+2.0±1.02
1935:				
C2–13 and 14	Youngs	12	15.8± .56	
C2–9, 12, and 15	California	22	17.2± .62	+1.4± .84
1934:				
D3–20, 21, and 22	N–28–5 [1]	22	20.4± .43	
D3–17, 18, 21, and 22	California [1]	28	23.8± .32	+3.4± .54
1935:				
School garden	N–28–5	28	20.2± .63	
Do	California	28	20.0±1.08	−.2±1.25
1934:				
C1–11, 14, and 18	Rogers	48	15.1± .33	
C1–10, 13, and 17	California	48	19.5± .24	+4.4± .41
1935:				
C2–14 and 15	Rogers	14	16.9± .32	
C2–9, 12, and 15	California	22	17.2± .62	+.3± .70

[1] Corrected for root rot. [2] 200-foot row sections.

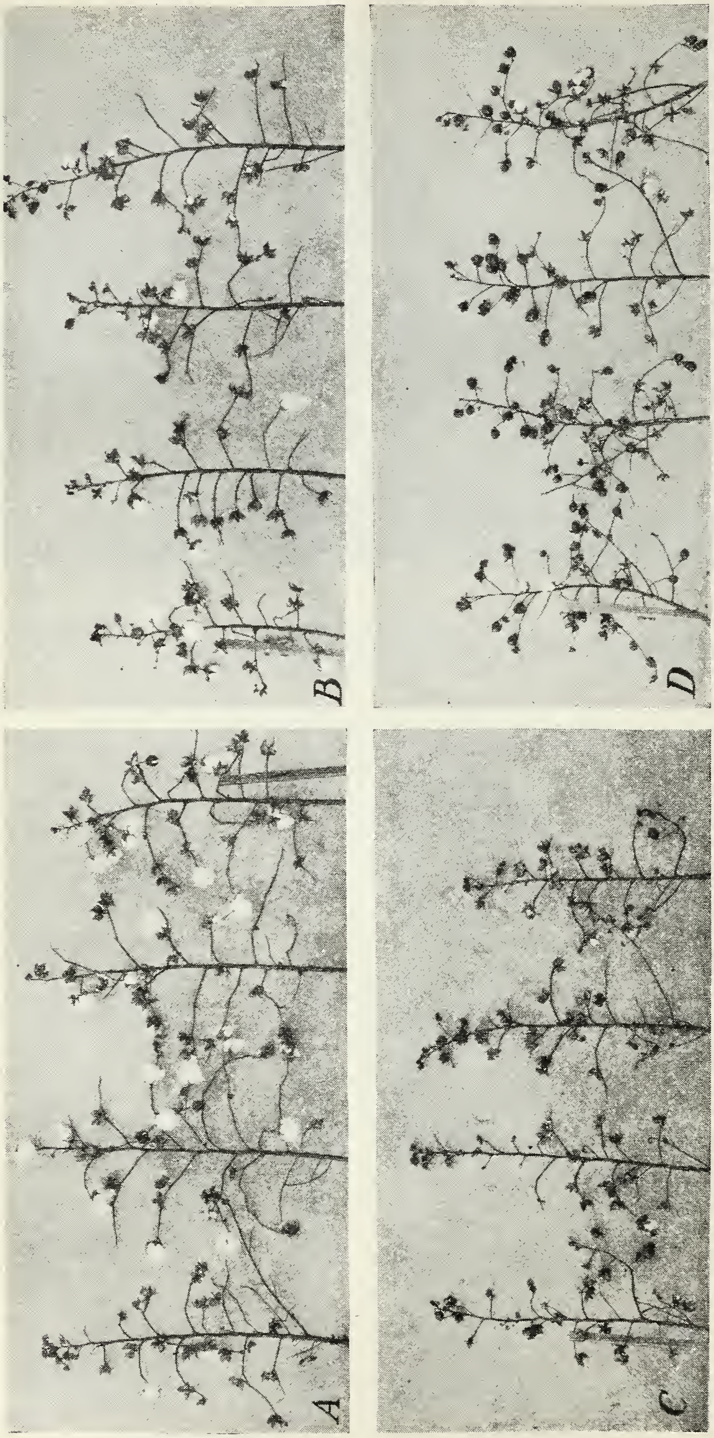

FIGURE 7.—Representative types of three strains of Acala and one of Stoneville No. 5 cotton in a variety test at the United States Field Station, Sacaton, Ariz., in 1934: *A*, Acala Q-6 (Queen Creek), (Sacaton, Ariz.); *B*, Acala California (Shafter, Calif.); *C*, Acala Rogers (Navasota, Tex.); *D*, Stoneville No. 5 (Stoneville, Miss.).

COMPARISONS OF PIMA AND S × P VARIETIES

Comparative tests were made in 1931 and 1933–35 with Pima and S × P varieties of American-Egyptian cotton. Six alternate-row comparisons were conducted; the yields are given in table 8.

In three of these tests Pima slightly outyielded S × P in production of seed cotton, and in the other three, S × P outyielded Pima. The difference in favor of S × P in the 1931 comparison was considered significant.

Yields of lint were determined for these comparisons on the lint percentage basis of 25.4 percent for Pima and 27.5 percent for S × P, which represents the mean percentage of lint for these varieties at Sacaton for the past 5 years.

Comparing the results of these tests on a basis of lint yields, S × P outyielded Pima in five of the six comparisons. The mean increase in yield of lint of S × P over that of Pima was approximately 9 percent.

Table 8.—*Comparative seed and lint cotton yields of Pima and S × P varieties at the United States Field Station, Sacaton, Ariz., 1931 and 1933–35*

Year and plot Nos.	Variety	Row sections 100 feet long	Yield of seed cotton	Yield of lint cotton	Mean lint increase of S×P over Pima
		Number	*Pounds*	*Pounds*	*Percent*
1931:					
E3–5 to 8	Pima	14	9.6±0.29	2.44	23.3
Do	S × P	14	11.3± .26	3.01	
1933:					
C1–7 to 9	Pima	44	9.4± .19	2.39	
Do	S × P	40	8.8± .26	2.42	1.23
C3–15 and 16	Pima	32	12.6± .35	3.20	
Do	S × P	24	11.8± .47	3.35	4.7
1934:					
C3–13 to 15	Pima [1]	44	10.3± .33	2.62	
Do	S × P	41	10.5± .28	2.89	10.3
1935:					
D1–15 to 18	Pima	48	7.1± .15	1.80	
Do	S × P	64	6.5± .18	1.79	−0.6
School garden	Pima	40	6.6± .22	1.68	
Do	S × P	40	7.5± .27	2.06	22.6

[1] Corrected for root rot.

YIELDS OF PIMA COTTON FROM DIFFERENT DATES OF PLANTING

In connection with the crazy top studies with Pima cotton at the seed farm in 1935, plantings were made on March 27, May 6, and June 6. Plots A–11 and A–12, consisting of eight rows each and averaging 800 feet long, were used. Each plot was planted in the following order: Three rows, March 27; two rows, May 6; and three rows, June 6. The same kind of seed was used in each planting and planted at the same rate.

The different dates of planting had no effect on the disease, but there was a marked difference in the yields of seed cotton. The first picking was made October 1, and the mean acre-yield of seed cotton for the March planting was 670 pounds. There were insufficient open bolls on the later plantings to justify a picking at that date. The second picking was made December 23, and the mean acre yields were 634, 619, and 94 pounds for the March, May, and June plantings, respectively. The last picking was made January 16, 1936, and the mean acre yield for the March planting was 274 pounds, 137 pounds for the May 6 planting, and 58 pounds for the June 6 planting.

These yields provide further evidence that early plantings of Pima cotton are likely to be much more productive and profitable than plantings made after May 1.

COTTON IRRIGATION EXPERIMENTS

The irrigation experiments, which for several years had been conducted to study the fruiting behavior of Pima and Acala under different frequencies and quantities of water, were continued during 1933–35.

In 1933 a series of plots planted to Pima cotton was irrigated at frequencies of 5, 10, 20, and 30 days. In 1934 and 1935 the irrigation consisted of a large number of small plots containing alternate four-row blocks of Pima and Acala. The irrigation intervals on the different series of plots were 7, 14, 21, and 28 days (table 9).

In 1933 the Pima cotton plants irrigated at intervals of 5 and 10 days became too rank in growth and were severely attacked by black arm which greatly reduced the yields. The plots irrigated at intervals of 20 and 30 days were only slightly diseased and good yields were obtained. In 1934 the yields and fruiting behavior showed that intervals of 7 and 14 days were more advantageous than intervals of 21 and 28 days. Many of the bolls were injured by stress conditions under the long-interval treatment. In 1935 the fruiting behavior and yields were not greatly different under the four treatments. Under the 28-day interval the bolls were reduced in size and the yield of the Pima plants was slightly reduced.

TABLE 9.—*Irrigation frequency, mean number of flowers produced, percentage of bolls shed and retained, and acre yields of seed cotton from Pima and Acala varieties in irrigation experiments at the United States Field Station, Sacaton, Ariz., 1933–35*

Year and variety	Plants examined	Irrigation frequency	Mean number of flowers produced per plant	Bolls shed	Bolls retained	Yield of seed cotton per acre
1933:	*Number*	*Days*		*Percent*	*Percent*	*Pounds*
Pima	25	5	42	22.3	77.7	977
Do	25	10	30	20.2	79.8	804
Do	25	20	38	12.3	87.7	1,322
Do	25	30	44	8.6	91.4	1,368
1934:						
Pima	10	7	69	14.5	85.5	1,919
Do	10	14	66	18.7	81.3	2,161
Do	10	21	54	18.5	81.5	1,782
Do	10	28	41	31.0	69.0	781
Acala	10	7	74	67.4	32.6	2,954
Do	10	14	77	71.8	28.2	2,379
Do	10	21	52	68.1	31.9	2,080
Do	10	28	43	67.4	32.6	1,230
1935:						
Pima	20	7	38	10.4	89.6	977
Do	20	14	31	14.7	85.3	850
Do	20	21	40	15.0	85.0	943
Do	20	28	34	17.8	82.2	690
Acala	20	7	52	67.5	32.5	1,759
Do	20	14	51	70.1	29.9	1,563
Do	20	21	48	68.4	31.6	1,920
Do	20	28	37	64.6	35.4	1,609

IMPROVEMENTS IN GINNING PIMA COTTON [6]

For many years complaints have been received from manufacturers regarding the poor ginning of Pima cotton as commonly performed in

[6] Prepared by J. S. Townsend, technologist, Division of Cotton and Other Fiber Crops and Diseases.

Arizona. Technologists of the Bureau of Plant Industry recognized early that one of the objectionable features was the ropy, tangled, and diverse appearance of the lint samples. It was obvious that a part of this could be attributed to the brush that on roller gins is commonly used to remove the lint from the leather- or rubber-fabric-covered roller. The lint is often packed and wadded between the brush and roller where it accumulates until pressure causes it to drop to the floor; or small wads may be squeezed a second time between the roller and the fixed knife causing the trouble known as backlash. In 1923 some tests were made in a growers' cooperative gin at Tempe, Ariz., with a device for replacing the objectionable brush. It was found that a rapidly revolving auxiliary roller with flexible fins or flaps and called a flapper roller could be used successfully in removing the lint without folding and crimping it.

In 1932 the cooperation of the Bureau of Agricultural Engineering was obtained in investigating the roller-ginning problem. Cylinders with brushes and also with metal doffers were constructed at the United States Ginning Laboratory at Stoneville, Miss., and shipped to Sacaton for a test. The metal doffer proved to be superior to the brush doffer and was adopted for further improvement.

In 1934 four roller-gin stands were equipped at the Stoneville laboratory with doffer cylinders of galvanized iron and enclosed in a housing of the same material. An upward current of air is created by the doffer, which revolves at high speed in the opposite direction from the roller of the gin, and this air current removes the lint from the roller and discharges it into a lint flue, where it is conveyed by suction to a condenser located near the bale press. The doffer obviates the difficulty of backlash, helps to prevent the high temperatures that are sometimes experienced when rubber-covered rollers are used, and saves the time used in frequently cooling the latter with moistened rags. The lint is kept much straighter and smoother and usually the grade is improved when the new method is used. Since all commercial gins have been forced to install elaborate mechanical cleaners to remove the excessive trash that is picked with the cotton, the adoption of the doffer and the suction condenser compensates in part for the tangling and knotting caused by the cleaner, as it tends to restore the fibers into a straightened condition as they were originally.

At the conclusion of the experimental work with these modified gins in February 1936, their operation was demonstrated to long-staple cotton ginners of the Salt River and Casa Grande Valleys, who expressed much interest in the attachments and admitted that marked improvement in the quality of the product had resulted from their application.

Another improved feature that has been introduced in the Sacaton gin tests and adopted by some commercial ginners is a vibrator on the grid through which the seed passes. The agitation of the grid by the vibrator prevents the frequent clogging of the grids that results from the presence of considerable fuzz on the Pima seeds. It is estimated that the vibrator increases the capacity of the gin stand about 25 percent.

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AMERICAN-EGYPTIAN COTTON [7]

THE S × P VARIETY

The most important recent event in the breeding work with American-Egyptian cottons has been the development, to the point of commercial production, of the S × P variety. This variety originated at Sacaton in a cross made in 1918 between a plant of Sakel, the leading long-staple variety grown in Egypt, and Pima, a variety of the American-Egyptian type that was developed at Sacaton and is still grown commercially in Arizona. By selecting the best plants in the hybrid progenies during the second, third, and fourth generations, a new variety was developed that had become relatively stable and uniform in the fifth generation. Yield tests and spinning tests, in comparison with Pima, were conducted during several years thereafter, and the results led to the conclusion that the new variety had certain advantages over Pima that justified its commercial production.

In 1933 an arrangement was entered into between the United States Department of Agriculture and W. K. Shaw, Jr., cotton merchant, by the terms of which Mr. Shaw agreed to finance the planting of 200 acres of S × P cotton near Chandler, Ariz., leaving the control of the seed produced in the hands of the Department. The results of this test planting were sufficiently encouraging to warrant increasing the area planted in the following year to 600 acres, in a district isolated from the main areas where Pima cotton is grown in the Salt River Valley. The 1934 plantings were made under a cooperative agreement to which the Department of Agriculture, the Maricopa County Farm Bureau Pure Seed Association, and Mr. Shaw were parties. The object of this agreement was to safeguard the seed supply so as to prevent indiscriminate distribution of the new variety and mixing of seed with the Pima variety. A further increase of the area planted, to about 1,700 acres, took place in 1935, this area being limited to the Chandler and Tempe districts, and with provisions for safeguarding the seed supply similar to those that had been found effective in 1934.

Seed sufficient to plant about 17,000 acres was produced in 1935. The field performance of the new variety was so satisfactory and the demand for the product on the part of spinners was so active, that all of this seed was purchased by growers in 1936. Some of the early plantings in 1936, however, failed to produce stands because of cold weather, and the final acreage for harvest was only about 9,000 acres.

The characteristics of the new variety that make it attractive from the standpoint of production, in comparison with the Pima variety, are: Superior productiveness, S × P having outyielded Pima, on the average, 18.5 percent in yield of lint per acre, in 13 comparative tests in different years and at different stations; somewhat earlier maturity; larger bolls, the seed-cotton weight of the S × P bolls having averaged about 7 percent greater than that of Pima, more abundant lint, S × P averaging about 2.5 percent higher in lint percentage and about 10 percent higher in lint index; and decidedly less fuzzy seeds, a feature that makes S × P much easier to gin than Pima.

The lint length of S × P cotton averages 1½ to 1⁹⁄₁₆ inches, as compared with a 1⁹⁄₁₆ to 1⅝ inches in the Pima parent and 1⅜ to 1⁷⁄₁₆ inches in the Sakel parent. S × P appears to be more uniform in length

[7] Prepared by T. H. Kearney, principal physiologist, in charge of the American-Egyptian cotton-breeding project.

than Pima, and this may account partly for the fact that, notwithstanding its shorter length, S × P makes a somewhat stronger yarn, in equivalent counts, than Pima. Since, in some of its properties, the lint of S × P resembles that of Sakel, it seems not improbable that it could be substituted, in part at least, for the large quantities of Sakel cotton that are now imported from Egypt.

OTHER DEVELOPMENTS OF THE BREEDING WORK

S × P was backcrossed on a selected strain of the Pima parent and, after selection during several generations, a stable and uniform variety was developed. This variety is designated, provisionally, P 11 × (S × P). Its most striking characteristics are the small size of the plant and the very early maturity. In a comparative yield test at Sacaton in 1934, the percentage of the total yield of seed cotton harvested in the first picking was 46 percent for Pima, whereas it was 73 percent for P 11 × (S × P). The lint of the new variety is intermediate in length between that of Pima and S × P, and it seems to possess much of the fine, silky character of the latter. The utility of the new variety has not yet been determined, but, on account of its earlier maturity, it should be well adapted to irrigated districts in the Southwest where the season is somewhat too short for the production of full yields of Pima and of S × P.

The complementary backcross of S × P on the Sakel parent was made in 1934 in the hope of obtaining a combination of the more desirable plant characteristics of S × P with the qualities of the Sakel lint that make it so attractive to spinners and, particularly, to manufacturers of sewing thread. The first generation (F_1) of this cross, grown in 1935, was of course uniform and offered no opportunity for selection. Search for the desired combination was made in the large F_2 population that was grown in 1936.

Hopi, a peculiar type of cotton grown by the Hopi Indians in northern Arizona, has attracted much attention because of its extreme fineness of lint. R. W. Webb of the Bureau of Agricultural Economics finds that, although it staples less than 1 inch long, its fibers are almost as fine as those of sea island, the finest and longest of the commercial cottons of the world.

Hopi cotton is unsuitable for commercial production, the bolls being not much larger than hazelnuts and the lint very sparse. With the objective of developing a variety that would be more satisfactory from the standpoint of production, but that would have the very fine lint of Hopi, the latter was crossed in 1934 with Acala, the variety of upland cotton that is best adapted to most of the irrigated valleys of the Southwest. Several thousand plants of the second generation of this cross were grown in 1936, and the combination desired is being sought among them.

PURE SEED MAINTENANCE

In cooperation with the University of Arizona and the Maricopa County Farm Bureau Pure Seed Association, cotton breeders from the Sacaton station continue to supervise the maintenance of the purity of the planting seed of Pima and S × P cottons. Several hundred acres are rogued early each summer, all hybrids and plants of other varieties being removed. The resulting seed is planted for increase in isolated districts, and the seed thus obtained is distributed for general planting the second year after the roguing was done. Consistent carrying out of this program has resulted in maintaining the varieties in question in a very satisfactory condition of uniformity.

GENETIC INVESTIGATIONS

Studies of the inheritance of characters in cotton, conducted at Sacaton, have added one more to the short list of simple Mendelian characters that have been recorded for this group of plants. This is a smooth boll, which originated, probably as a mutant, in a plant discovered in a field of Pima cotton by Claude Hope. The plant, otherwise normal, had the surface of the boll smooth as in upland cotton; not pitted as it is in Pima. The original plant bred true for the smooth condition and, when it was crossed with normal Pima, the first generation (F_1) was intermediate (very shallowly pitted) and the second generation (F_2) segregated in the ratio 1 pitted: 2 intermediate: 1 smooth. Another Pima plant, presumably a mutant and characterized by having the petals nearly white, as in upland cotton, rather than of the rich yellow color characteristic of the Pima variety, behaved similarly to the smooth-boll plant. It bred true, and when its progeny was crossed with normal Pima the segregation in F_2 of the hybrid was in the ratio of 1 full yellow: 2 somewhat lighter yellow: 1 "white."

The endeavor will be made, by crossing with improved strains of normal Pima, to develop new strains desirable from a practical point of view and possessing smooth bolls or "white" petals, since these characters would be very useful in roguing fields grown for increase of planting seed. The presence, in such fields, of plants having pitted bolls or yellow petals would show that contamination had occurred, either by cross-pollination or by accidental mixture of seeds.

Other characters of which the inheritance is under investigation at Sacaton are hairy bolls as contrasted with the normal hairless condition in both American-Egyptian and upland cottons, and presence or absence of a fringe of hairs on the calyx. In certain crosses involving the allelomorphs of these characters, monohybrid ratios are not obtained, indicating that more than one gene or factor is responsible for the expression of the character. In neither case, however, has the type of inheritance been worked out fully.

MISCELLANEOUS INVESTIGATIONS

POLLINATION AND FERTILIZATION

A method has been devised of storing cotton flower buds at relatively low temperatures in a refrigerator, that prolongs the viability of the pollen 48 hours or longer. This has proved very useful in the genetic investigations, making it possible to effect much more numerous cross-pollinations between plants of low fertility that flower only occasionally. Larger supplies of seed and hence larger hybrid populations are thus afforded.

Comparison has been made of the "thumbnail" method of emasculating cotton flowers for cross-pollination, in which all parts of the flower except the pistil are removed, with the method in use at Sacaton, in which only the anthers are removed with forceps, leaving the staminal column intact. The results indicate that with this method, although it is more rapid, there is much more boll shedding; therefore its superiority is questionable.

VARIATION IN LENGTH OF FIBERS

In endeavoring to determine what part of the total variation in length of fibers in a sample of cotton is due, respectively, to differences in the length on individual seeds, from boll to boll on the same plant, and from plant to plant in the population, analysis of variance was used. The results indicate that in Pima, a relatively very uniform variety, variation on the individual seeds accounts for about 95 percent of the total variation. The conclusion drawn is that breeding for greater uniformity of fiber length in this variety should be directed to reduce the variation on the individual seeds, and that selection of plants without regard to this factor is likely to prove ineffective.

COTTON DISEASE INVESTIGATIONS

ROOT ROT

The root rot fungus was found to have a natural distribution in the desert areas of the Southwestern States. Some infested areas in the watersheds of streams supplying water for irrigation projects appear to have been sources of infection for cultivated lands many miles down stream (fig. 8). In some of the irrigation projects the lands nearest the rivers and those with the oldest riparian rights show more extensive infestations than lands to which water was only recently applied.

The dams constructed during the last three decades to form storage reservoirs in important irrigation streams like the Rio Grande, Gila, Salt, and Colorado Rivers undoubtedly are serving as traps for sclerotia and other infective materials washed down by water erosion that in earlier times must have found lodgment in irrigated fields.

Under natural conditions in the desert, the presence of the fungus is not easily detected, as it seldom appears at the surface and only rarely kills a perennial host plant. The following is a list of plants which occur under natural conditions in Arizona and were found to be accommodating the fungus on their roots although in some cases they may not have served as true hosts. A division is made according to whether or not the roots showed severe destruction of tissues.

NATIVE ARIZONA PLANTS ON WHICH THE COTTON ROOT ROT FUNGUS HAS BEEN FOUND

Without severe injury:
- *Prosopis velutina* Wooton.
- *Opuntia arbuscula* Engelm.
- *Celtis pallida* Torr.
- *Lycium fremonti* A. Gray.
- *L. exsertum* A. Gray.
- *Condalia lycioides canescens* (A. Gray) Trel.
- *Gutierrezia lucida* Greene.
- *Franseria confertiflora* (DC.) Rydb.
- *F. deltoidea* Torr.
- *Cercidium torreyanum* (S. Wats.) Sarg.
- *Chilopsis linearis* (Cav.) Sweet.
- *Rumex hymenosepalus* Torr.
- *Trianthema portulacastrum* L.
- *Anisacanthus thurberi* (Torr.) A. Gray.

With severe injury:
- *Euphorbia albomarginata* Torr. and Gray.
- *Aplopappus heterophyllus* (A. Gray) Blake.
- *Sphaeralcea ambigua* A. Gray.
- *Platanus wrightii* S. Wats.
- *Populus fremontii* S. Wats.
- *Aster spinosus* Benth.
- *Fraxinus velutina* Torr.
- *Salix taxifolia* H. B. K.
- *Robinia neomexicana* A. Gray.
- *Argemone* sp.
- *Martynia parviflora* Wooton.
- *Pentstemon palmeri* A. Gray.
- *Cupressus arizonica* Greene.
- *Thurberia thespesioides* A. Gray.
- *Amaranthus palmeri* S. Wats.
- *Chenopodium album* L.
- *Malva parviflora* L.
- *Helianthus annuus* L.

FIGURE 8.—Airplane views of root rot spots in alfalfa and cotton fields at Sacaton and vicinity in November 1934. *A*, The four exceptionally dark strips represent plots of cotton that had received applications of organic manures in deep furrows for about 13 years, and show that most of the plants escaped infection. The four lighter strips represent the control plots on which a large proportion of the plants were killed. *B*, A large spot in an alfalfa field in which nearly all the plants have been killed.

CONTROL WITH ORGANIC MANURES

The investigations on control of cotton root rot during the period 1931–35 were confined principally to the use of organic manures which in previous studies (*6, 7, 8, 9*) had proved beneficial in reducing the root rot injuries to cotton plants (fig. 9). These present studies, which were made in the field and laboratory, demonstrated the likelihood that the benefits from manuring could be attributed to antibiotic relations between the organisms of decomposition and the parasitic root rot fungus. Practically all of the microfloral populations were found to be greater in plots to which barnyard or green manure had been applied for several years, than in alternate unmanured plots.

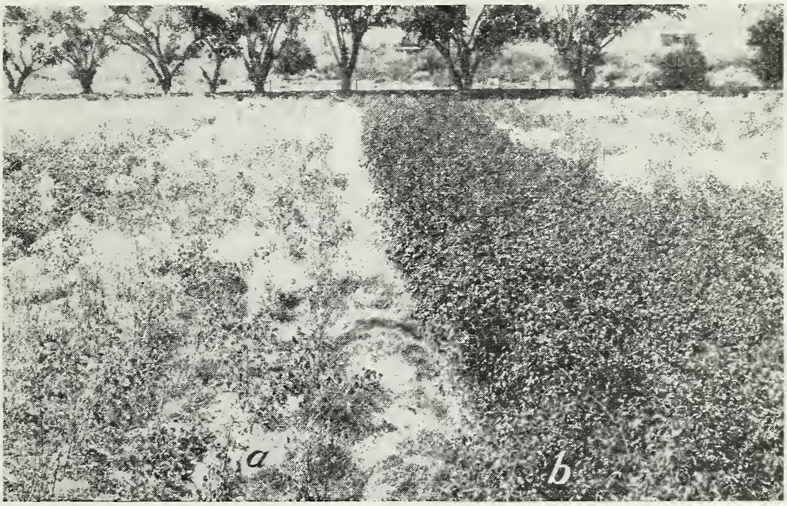

FIGURE 9.—Control of root rot in plots of Pima cotton by organic manures applied in deep furrows at the United States Field Station, Sacaton, Ariz., October 24, 1935. The plot at *b* had manure applications for 2 years; only a few plants were killed. The plot at *a* received no manure; most of the plants are dead.

The amount of carbon dioxide evolved from the manured plots was also much greater than from the unmanured plots indicating an increased activity of microorganisms.

The efficiency of manuring in reducing root rot infection increased as the treatment was maintained year after year. The number of cotton plants killed by root rot at intervals of 2 weeks in a series of nine plots, four of which were manured and five unmanured for several years, is shown in table 10. It will be noted that the total number of plants killed in the manured plots was almost negligible, but a large proportion was killed in the untreated plots (table 10 and fig. 8).

The yields per acre of Acala cotton grown on the manured and unmanured plots from 1932–35 are given in table 11.

TABLE 10.—*Number of cotton plants killed by root rot during 2-week intervals in ¼-acre manured and unmanured plots at the United States Field Station, Sacaton, Ariz., 1932–35*

Date of count	Number of plants killed under indicated treatment in plot No.—									Mean	
	C2–16 (unmanured)	C2–17 (manured)	C2–18 (unmanured)	C2–19 (manured)	C2–20 (unmanured)	C2–21 (manured)	C2–22 (unmanured)	C2–23 (manured)[1]	C2–24 (unmanured)	Unmanured plots	Manured plots
1932	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
July 20	7	0	7	1	4	0	0	0	18	7	0
Aug. 4	31	3	87	2	19	4	114	0	154	81	2
Aug. 18	60	3	134	0	33	1	176	4	552	191	2
Sept. 1	160	31	297	23	161	28	385	36	652	331	30
Sept. 15	153	24	198	6	210	46	274	53	449	257	32
Sept. 29	125	8	144	3	189	40	260	34	235	191	21
Oct 7	67	2	55	14	111	45	92	38	40	73	25
Total	603	71	922	49	727	164	1,301	165	2,100	1,131	112
1933											
July 27	21	0	17	0	18	0	26	0	54	27	0
Aug. 10	97	4	129	1	53	1	210	5	299	158	3
Aug. 24	292	4	361	12	85	2	580	29	935	431	12
Sept. 8	292	7	369	10	107	12	506	88	719	398	29
Sept. 22	200	14	305	10	75	17	223	74	159	192	29
Oct. 9	296	14	254	2	83	11	90	43	92	163	17
Oct. 23	74	9	66	14	70	6	82	35	33	65	16
Total	1,272	52	1,501	49	491	49	1,617	274	2,291	1,434	106
1934											
June 29	1	0	1	0	1	0	0	1	0	1	0
July 13	7	0	4	0	2	0	4	0	4	4	0
July 27	39	0	13	0	4	0	17	0	15	18	0
Aug. 13	86	0	91	0	17	0	171	2	233	120	0
Aug. 24	144	0	109	1	32	4	292	10	446	205	4
Sept. 7	307	3	194	2	66	5	419	50	577	313	15
Sept. 21	206	10	120	2	54	7	264	41	325	194	15
Oct. 5	178	4	120	2	53	2	236	20	149	147	7
Oct. 18	86	4	73	0	28	2	120	3	168	95	2
Nov. 2	20	1	9	0	13	2	30	15	16	18	5
Total	1,074	22	734	7	270	22	1,553	142	1,933	1,115	48
1935											
July 15	13	0	1	0	1	0	3	0	16	7	0
July 29	62	0	13	0	3	0	21	0	93	38	0
Aug. 12	417	3	75	0	54	3	177	0	639	272	1
Aug. 26	447	7	110	0	92	11	300	13	650	320	8
Sept. 9	192	0	70	1	83	1	269	7	342	191	2
Sept. 23	359	2	69	0	84	3	195	5	343	210	3
Oct. 7	426	5	121	5	177	25	239	20	166	226	14
Oct. 21	193	12	77	1	151	13	192	11	71	137	9
Total	2,109	29	536	7	645	56	1,396	56	2,320	1,401	37

[1] Manured with spoiled alfalfa in 1932 and 1933.

TABLE 11.—*Yields of Acala seed cotton from manured and unmanured plots affected by root rot at the United States Field Station, Sacaton, Ariz., 1932–35*

Treatment and plot No.	Yield per acre			
	1932	1933	1934	1935
Manured:	*Pounds*	*Pounds*	*Pounds*	*Pounds*
C2–17	2,177	2,474	3,515	2,141
C2–19	2,142	2,478	3,460	2,166
C2–21	1,964	2,665	3,344	1,999
C2–23	1,534	2,342	3,426	1,707
Average	1,954	2,490	3,436	2,003
Unmanured:				
C2–16	1,676	1,648	1,895	936
C2–18	1,389	1,181	2,187	1,545
C2–20	1,770	1,917	2,578	1,452
C2–22	1,323	1,319	1,643	945
C2–24	909	640	1,332	496
Average	1,413	1,341	1,927	1,075

CONTROL WITH AMMONIA AND AMMONIUM COMPOUNDS

The reports of effective control of cotton root rot in parts of Texas by the use of ammonium hydroxide (*10*) suggested the need of experiments with ammonium compounds under Arizona conditions. During the years 1932–35, 10 tests were made with ammonia water, ranging in strength from 2 to 6 percent, in the effort to restrict the spread of the disease from small centers of infection in cotton fields. Applications were made in circular basins surrounding the isolated infected plants. In most cases the basins were perforated with a soil tube 1¼ inches in diameter which insured a uniform distribution of the solution to a depth of 30 inches. In most cases the cotton plants were defoliated by this treatment, and made no further growth. With but few exceptions it was possible later to isolate the fungus from the roots of the treated plants, although the mycelium on the surface of the roots was killed. A less drastic treatment of pouring 2 or 3 quarts of 2-percent ammonia water in three or four 1-inch holes near the recently wilted plants gave no results in checking the spread of the fungus. Several tests were made in treating infected soil with 4-percent ammonia water before planting cotton. The quantity applied per acre was equivalent to 3,200 pounds of ammonia (NH_3) and was applied in basins 6 by 6 feet, which were perforated to permit uniform penetration, and then followed by a light irrigation. The disease failed to recur in one spot so treated in February 1935 but reappeared in 1936. In five other spots the disease reappeared the first season and extended its margins.

In 1933 an infested area of 1,080 square feet was prepared for subirrigation by placing horizontally perforated iron pipes at the depth of 20 inches beneath the rows of cotton, so there were seven rows 3½ feet apart and 44 feet long. One week after planting, a preliminary subirrigation was made with water containing 53 pounds of ammonia, or at the rate of 2,140 pounds per acre. After thinning the cotton plants on June 12, a solution of ½-percent ammonium carbonate equivalent to 706 pounds of ammonia per acre, was applied through the pipes. On July 6, a third irrigation containing ammonia equivalent to 2,000 pounds per acre was applied. A few plants were already dying from root rot when the application was made on July 6, and following it, about 10 percent of the plants died from ammonia injuries. The disease showed reduced activity for a few weeks, but by November 3 about 70 percent of the plants had been killed.

Contiguous to this treatment, another area consisting of seven rows 60 feet long received an application of granulated ammonium carbonate equivalent to 1,977 pounds of ammonia per acre on March 11 before planting. This was applied in furrows about 10 inches deep, and was covered and irrigated before planting. Concentration of the compound in the seedbed was so great that a poor stand of seedlings resulted, but on leaching some of it to greater depths the plants grew luxuriantly until attacked by the fungus. At the end of the season about 75 percent of the plants had been killed.

It is indicated from these tests that ammonia and ammonium compounds are not so effective in controlling root rot of annual plants in the highly calcareous soils of this area as reported for the nearly neutral clay soils of northeastern Texas (*10*). Streets (*13*), however, reported success under Arizona conditions in the use of ammonium hydrate and ammonium sulphate in treating root rot-affected deciduous fruit and pecan trees. The treatment proved most effective with pecans.

It was found that the ammonia applied as the hydroxide was rapidly nitrified or otherwise combined under the soil conditions at Sacaton. In 4 weeks after the application was made at the rate of 3,200 pounds per acre, only 144 pounds per acre could be recovered as ammonia by chemical methods. In 10 weeks only a trace of ammonia could be found in the same soil. When applied in furrows as a sulphate or as carbonate in concentrated bands the ammonia disappeared less rapidly.

CRAZY TOP

Investigations on the crazy top disorder of cotton during the period of this report were directed largely at methods of control. The disorder is a problem of importance in Arizona, especially in the Salt River Valley and in the Casa Grande section of the Gila River Valley. The results of most of the experiments up to 1934 were reported by Hope, King, and Parker (*4*). It was shown that crazy top could be induced on highly calcareous soils by withholding irrigation water at any period during the summer sufficiently long to cause a checking of growth and then supplying water to encourage a resumption of growth (fig. 10). The occurrence of crazy top was prevented when the plants were adequately and regularly irrigated.

In 1935 a single border strip 33 feet wide and 825 feet long was divided into basins by constructing cross checks or dikes every 25 feet, thus forming 33 basined plots each 825 square feet in area. After June 21 the following irrigation treatments were begun and continued until August 31: One series of nine plots was irrigated as the needs of the plants indicated, and three other series of eight plots each were irrigated at intervals of 7, 10, and 14 days. For comparison with these varied frequencies of irrigation, adjacent border 9 was divided into 33 basined plots, and all were subjected to early summer stress by withholding water for about 20 days, after which applications were made so as to promote continuous growth. Border 8 received the conventional or normal irrigation treatment of flood irrigation with cross dikes placed at intervals of about 200 feet to check the rate of the water flow.

A census of the number of plants affected with crazy top under the different treatments in these three borders was made on September 25. The results are given in table 12. None of the plants was affected in plots where the period of irrigation frequency was every 7 days, and the number affected under normal treatments and watered as plants indicated need was negligible. The average yields of seed cotton on the plots that were free from crazy top under the 7-day irrigation treatment were not greater than on those with longer intervals where crazy top occurred, but the yields were reduced by damage from the angular leaf spot disease (*Bacterium* (*Phytomonas*) *malvacearum* E. F. S.) which affected seriously the plants that were stimulated to luxuriant growth by the frequent irrigations. The lowest yields were obtained from plots that were stressed early in the summer in the effort to induce crazy top.

In another border a number of chemicals were applied at different rates to basined plots 825 square feet in area. These included aluminum sulphate, borax, ferrous sulphate, zinc sulphate, iron oxide, manganese dioxide, potassium sulphate, ammonium phosphate, and treble superphosphate.

FIGURE 10.—Pima cotton plants affected with crazy top at the seed farm, Sacaton, Ariz., in 1934. The disease was induced by severely checking the growth by withholding irrigation water and then stimulating to vigorous growth by providing abundance of water.

Both the treated plots and control plots were subjected to water stress early in the summer.

TABLE 12.—*Percentage of Pima cotton plants affected with the crazy top disorder and yields of seed cotton per acre under different irrigation treatments at the seed farm, Sacaton, Ariz., 1935*

Border No.	Basined plots	Treatment	Plants affected with crazy top	Irrigations of season	Yield of seed cotton per acre
	Number		*Percent*	*Number*	*Pounds*
8		Normal	0.05	15	1,665
9	33	Stressed	38.60		739
	8	14-day intervals	45.80	10	1,075
10	8	10-day intervals	20.70	12	1,154
	8	7-day intervals	0	15	1,139
	9	As plants indicated need	.03	12	1,369

Only a few of the plants became affected with crazy top, and there was no evidence of any effect from the chemicals upon the disorder.

The plants on the plots treated with ammonium phosphate and treble superphosphate made more growth and higher yields than those under other treatments, but there was no effect on the disorder.

ROOT KNOT

Root knot, caused by the nematode *Heterodera marioni* (Cornu) Goodey, in recent years has become a problem in the production of cotton in certain districts of Arizona. Some areas that formerly produced excellent yields of American-Egyptian cotton gradually lost their productiveness for that type of cotton, and in many cases without the farmers becoming aware of the real trouble. In previous publications King and Loomis (*9*) and King and Hope (*5*) reported that varieties of the American-Egyptian type, particularly Pima, showed a much greater susceptibility to root knot than the upland type. From observations and experiments made at several locations in Arizona and southern California, evidence was obtained that nematode injuries on Pima cotton are more severe than on upland, and yields decline more rapidly when infested areas are planted to cotton continuously (table 4).

Experiments on the control of nematodes have been conducted at the Sacaton field station for several years. Some soil treatments that gave mildly beneficial but temporary relief were heavy applications of calcium cyanamide, ammonium carbonate, ammonium hydroxide, and 2-percent formalin solution. The plowing under of heavy crops of mustard, reported beneficial for control of nematodes in the Orient, gave negative results. Moreover, nematode galls were developed on the mustard plants if allowed to grow until the nematode larvae became active in the spring. Rotating cotton with alfalfa was found to be effective in maintaining satisfactory yields of Pima cotton in severely infested areas, but the nematodes were not eradicated by this means. The maintenance of a clean fallow for 3 years, combined with frequent tillage during the hot summer, was effective in controlling root knot. Two plots which had received this treatment were planted to Pima cotton in 1936, and at the end of the season no galls could be found on the roots except on the outside rows, which were adjacent to the control plots planted continuously to cotton (fig. 11). These preliminary results indicate that nematodes may be eradicated by this method.

CROPS FOR SOIL IMPROVEMENT

For several years tests have been made at the field station to determine the cover crops that are best suited for soil improvement under Arizona conditions.

Alfalfa is well adapted to these conditions and is especially valuable for making soils more friable, for increasing the water-holding capacity, and for deepening the root zone. There is a demand, however, for quick-growing cover crops that may be grown in citrus orchards, or for the improvement of lands for truck crops where there is not time for rotation with alfalfa. The summer-grown crops that can be depended on to produce a large tonnage of organic matter are:

FIGURE 11.—Effect of fallowing and summer tillage on controlling root knot nematodes as affecting American-Egyptian cotton at the United States Field Station, Sacaton, Ariz.: *A*, Pima cotton in July 1936 after 3 years of clean fallowing combined with summer plowing and disking; *B*, Pima cotton seriously affected with root knot disease in a plot continuously planted to cotton.

Sesbania, cowpeas, tepary beans, and certain leafy strains of Hopi lima beans. Sesbania is the most rapid grower but must be turned under before the stems become too woody. The most satisfactory winter cover crops are bard vetch, Canada field peas, sourclover, and Trieste mustard. Winter rye, Canada field peas, and bard vetch especially have been successful under the soil conditions at the United States Field Station (fig. 12).

In 1931 the yields in tons per acre of green material in test plots were as follows: Bard vetch 10.9, Canada field peas 6.7, winter rye 7.4. In 1935 the yields in tons per acre were: Bard vetch 12.5, Canada field peas 11.7, and sourclover 7.6. The vetch produces best when planted during the period from September to November.

FIGURE 12.—A crop of Bard vetch suitable as a winter cover crop shown in pecan orchard at the United States Field Station, Sacaton, Ariz., in March 1936. The crop was saved for seed and produced at the rate of 1,541 pounds per acre.

ROTATION EXPERIMENT

A biennial rotation which had been in progress for 14 years was completed in 1932, and a different kind of rotation involving 2 and 3 years' rotations with alfalfa and cotton was begun in 1933. A continuous cotton experiment conducted for 26 years in connection with the biennial rotation test was continued.

The yields of the different crops in the biennial and continuous cotton tests to 1932 and the average cotton yields for 14 years are given in table 13.

TABLE 13.—*Acre yields of crops in biennial rotation experiments at the United States Field Station, Sacaton, Ariz., 1931, 1932, and 14-year average for cotton*

Crops grown	Plot No.	Pima seed cotton			Other crops	
		1931	1932	Average, 14 years	1931	1932
		Pounds	*Pounds*	*Pounds*	*Bushels*	*Bushels*
Cotton, continuous	D2-10	933	847	1,132		
Cotton, continuous (manure alternate years)	D2-11	1,060	999	1,421		
Cotton, alfalfa	D2-12		929	1,500		
Do	D2-13	999		1,465		
Cotton, corn	D2-14		801	1,305	31.8	
Do	D2-15	1,175		1,401		42.7
Do	D2-16		590	1,128	31.7	
Do	D2-17	1,003		1,333		35.1
Do	D2-18		371	997	23.0	
Do	D2-19	974		1,239		30.5
Cotton, milo	D2-20		689	1,235	23.5	
Do	D2-21	1,171		1,449		28.4
Cotton, Sudan grass	D2-22		918	1,439		
Do	D2-23	1,520		1,624		

The conclusions that may be drawn from these experiments are that cotton yields may be maintained to a slightly better advantage when the land is planted to other field crops in alternate years than if cotton is grown continuously. However, it seems apparent that alluvial land of fine or very fine sandy loam type in this experiment is not rapidly depleted of fertilizing elements when planted to cotton over a long period of years. The erratic yields appear to be due largely to the salinity of the soil, which was especially high in the continuous cotton plots.

Winter leaching with irrigation water proved beneficial in reducing the trouble. It was more difficult to obtain stands of cotton on the plots recently in alfalfa than in the other rotation plots, and this accounts for the fact that the influence of alfalfa did not show up to the usual advantage in comparison with other field crops and manure treatments.

COMPARATIVE EFFECTS OF COTTON AND ALFALFA CULTURE ON THE DISTRIBUTION OF SOLUBLE SALTS IN THE SOIL

In the course of an investigation on the effects of continuous cropping of cotton in comparison with rotations of cotton with alfalfa and other crops at the field station, a problem arose in connection with the concentration of the soil solution particularly in plots that were planted to cotton continuously. In some of these plots the salinity was so great at depths between 3 and 6 feet that the cotton roots failed to extend into that part of the root zone. In nearby plots on which the cotton was rotated biennially with alfalfa, the concentration was not nearly so great in the lower part of the root zone. From this and other observations the impression was created that alfalfa is more effective than cotton in maintaining the soil in a permeable condition suitable for leaching.

An experiment was begun in 1930 with the idea of obtaining more information on this point. Four quarter-acre plots 400 feet long, C2–10 to C2–13, which had been planted to cotton continuously since 1921 were divided into 200-foot sections in 1928 and the south half of each planted to alfalfa. In 1930, 1931, and 1932 both sections (A south, and B north) of the four plots were planted to cotton and in March 1933 the B sections were planted to alfalfa, which was maintained until 1936. Meanwhile the A sections were planted each year to cotton. With but few exceptions the alfalfa and cotton were irrigated on the same dates.

The cotton plots were plowed during each winter and the soil, being left in a loose, dry condition, may have absorbed a greater quantity of water with the initial irrigation before planting in April than the alfalfa plots. In spite of efforts to equalize the quantity for both crops and to effect deep penetration in the cotton plots it was not practicable to obtain as much water absorption in the cotton plots as in the alfalfa plots late in the summer. During the years 1933, 1934, and 1935 the cotton plots received 9, 10, and 10 irrigations, respectively, with an estimated total of 34 acre-inches of water applied per season. The alfalfa plots received 8, 8, and 10 applications, respectively, with an estimated total of 40 acre-inches applied per season.

Beginning in September 1930, soil samples were obtained for conductance determinations within a definite area in each plot, about 30 feet from the dividing line between the A and B sections. Each sample was a composite of three borings, and represented a 1-foot section to the depth of 4 feet.

At the beginning of the experiment, and occasionally thereafter, the percentage of water required to saturate the soil in each foot section in all of the plots was determined. The data from the most recent determinations made July 15, 1936, are recorded in table 14, since the original data could not be located. All the determinations, including the percentage of moisture to saturate the soil, were made according

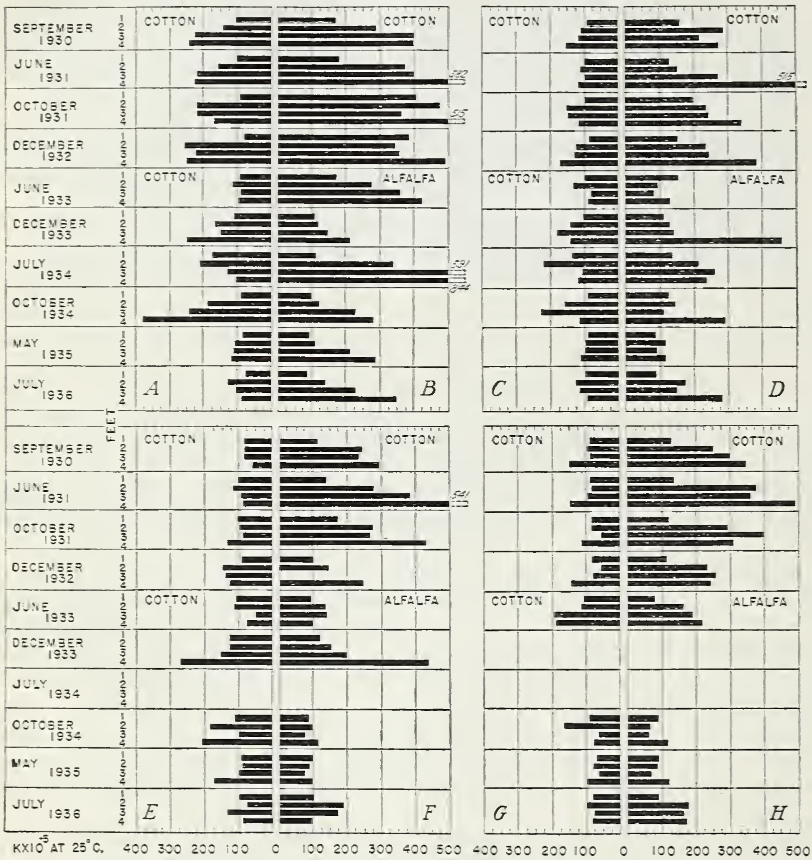

FIGURE 13.—Specific electrical conductance of saturated soil and salt equivalent on plots planted continuously to cotton for 7 years and 3 years, and followed with alfalfa at the United States Field Station, Sacaton, Ariz., 1930–36. The bars representing conductance for equivalent foot sections in the two crop treatments are placed opposite to depict field arrangement and to facilitate comparisons. *A*, Plot C2-10, A; *B*, plot C2-10, B; *C*, plot C2-11, A; *D*, plot C2-11, B; *E*, plot C2-12, A; *F*, plot C2-12, B; *G*, plot C2-13, A; *H*, plot C2-13, B.

to the method described by Scofield (*12*). The conductance determinations were made at 25° C., using a half-meter Wheatstone bridge equipped with microphone hummer and dry batteries, rheostat, telephone receiver, and hard-rubber cup as conductivity cell.

The conductance values expressed as reciprocal ohms $\times 10^5$ at 25° C., and salt equivalent, and the percentage of water required to saturate the soil are given in table 14. The conductance data are also given in diagrammatic form in figure 13.

The results are somewhat erratic, probably being influenced by the irregularities of soil texture and by the movement of salts as effected by irrigation. At levels of 3- and 4-foot depths the salt concentrations as expressed in conductance values are shown to be from 300 to 500 or greater in some samples. These high concentrations are believed to interfere to some extent with the normal functions of the roots of both cotton and alfalfa, but the relatively low concentrations in the upper 2 feet of soil and the movement and dilution of salts as effected by irrigations probably accounted for the fact that the cotton as well as the alfalfa plants were fairly productive.

From the results shown it is indicated that there was a slight reduction in the salinity in the upper 4 feet of the B-section plots after the alfalfa was planted. It is also apparent that there was no material increase in the salt content of the upper 4 feet in the continuous cotton plots during the period September 1930 to July 1936. The conclusion seems to be warranted that alfalfa culture is beneficial in preventing excessive accumulations of soluble salts at least in the upper part of the root zone in soils of this character.

TABLE 14.—*Specific electrical conductance (K) of saturated soil at 25° C. expressed in reciprocal ohms×10⁵, salt equivalent and the percentage of water to saturate soil from plot sections planted continuously to cotton for 7 years, and on plot sections planted to cotton 3 years and followed with alfalfa at the United States Field Station, Sacaton, Ariz., 1930*

Plot No.	Depth	Water to saturate		1930, September		1931				1932, December		1933, June	
						June		October					
		Section A	Section B	Section A, cotton	Section B, cotton	Section A, cotton	Section B, cotton	Section A, cotton	Section B, cotton	Section A, cotton	Section B, cotton	Section A, cotton	Section B, alfalfa
	Feet	*Percent*	*Percent*	*Ohms×10⁵*	*Ohms×10⁵*	*Ohms×10⁵*	*Ohms×10⁵*	*Ohms×10⁵*	*Ohms×10⁵*	*Ohms×10⁵*	*Ohms×10⁵*	*Ohms×10⁵*	*Ohms×10⁵*
C2-10	1	35	39	104	169	101	184	89	410	79	384	95	177
	2	41	37	139	288	158	374	221	478	254	343	115	281
	3	35	37	229	399	213	401	216	365	219	361	92	362
	4	39	39	243	399	226	582	167	515	249	495	95	427
C2-11	1	36	42	96	159	97	132	100	201	84	156	100	136
	2	41	35	110	288	114	154	152	234	127	234	132	96
	3	35	37	119	221	101	270	151	245	129	245	79	86
	4	35	40	157	275	118	515	121	335	169	383	87	132
C2-12	1	36	39	80	116	100	142	99	177	89	102	103	95
	2	33	37	81	243	117	278	96	280	143	143	112	136
	3	36	36	84	233	92	386	87	268	134	---	50	140
	4	39	34	62	295	87	541	132	437	123	250	73	101
C2-13	1	36	38	89	125	88	136	84	121	86	112	107	82
	2	36	35	97	252	85	373	85	287	61	230	115	159
	3	37	37	88	302	95	362	60	395	82	254	194	191
	4	36	35	149	344	150	492	114	306	145	240	191	213

Plot No.	Depth	Water to saturate		1933, December		1934				1935, May		1936, July	
						July		October					
		Section A	Section B	Section A, cotton	Section B, alfalfa	Section A, cotton	Section B, alfalfa	Section A, cotton	Section B, alfalfa	Section A, cotton	Section B, alfalfa	Section A, cotton	Section B, alfalfa
	Feet	*Percent*	*Percent*	*Ohms*$\times 10^5$	*Ohms*$\times 10^5$	*Ohms*$\times 10^5$	*Ohms*$\times 10^5$	*Ohms*$\times 10^5$	*Ohms*$\times 10^5$	*Ohms*$\times 10^5$	*Ohms*$\times 10^5$	*Ohms*$\times 10^5$	*Ohms*$\times 10^5$
C2-10	1	35	39	109	109	175	113	89	100	85	95	78	89
	2	41	37	166	119	209	346	191	127	108	108	130	141
	3	35	37	152	151	129	591	245	230	115	216	104	228
	4	39	39	251	217	107	844	379	284	120	292	92	352
C2-11	1	36	42	106	111	136	133	90	124	83	90	95	92
	2	41	35	140	130	213	213	156	143	95	114	123	176
	3	35	37	180	140	103	259	224	110	94	93	110	151
	4	35	40	140	459	121	234	117	289	110	115	92	283
C2-12	1	36	39	125	119	------	------	108	91	89	98	98	98
	2	33	37	127	155	------	------	183	100	90	90	75	187
	3	36	36	152	200	------	------	100	75	99	76	137	176
	4	39	34	271	437	------	------	207	114	169	97	91	94
C2-13	1	36	38	------	------	------	------	87	87	71	90	78	88
	2	36	35	------	------	------	------	167	67	83	82	94	180
	3	37	37	------	------	------	------	67	61	66	66	73	167
	4	36	35	------	------	------	------	75	114	93	118	82	176

OTHER FIELD CROPS

BARLEY[8]

Fourteen varieties of barley were grown at Sacaton (table 15) in field plot tests during the period 1931–35, but only Vaughn was grown for the entire 5-year period. This variety has produced consistently good yields since 1928. It is smooth-awned and has stiff straw. Scarab was introduced into the field plot tests in 1932 and its average yield slightly exceeded that of Vaughn for the 4-year period. Afghanistan, grown for this same period, produced an average yield of only 85.6 percent of Vaughn.

The station has continued to be used as a quarantine station for new introductions of barley and other cereals. The largest number of foreign introductions were tested in 1931 when most of J. G. Dickson's Russian collection was grown.

Since many of the foreign samples are not pure, selections of types often are made in the field the first year they are grown.

TABLE 15.—*Acre yields [1] of barley varieties grown at the United States Field Station, Sacaton, Ariz., 1931–35*

Variety	C. I. No.	1931	1932	1933	1934	1935	Average	Years comparable	Yield in comparison with Vaughn as 100 for the years grown
		Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Number*	*Percent*
Coast	690	55.3		53.3(2)			54.3	2	81.4
Club Mariout	261	55.3	75.5	42.7(3)		23.9(3)	49.4	4	71.4
Trebi	936	45.5		62.0	25.2(2)	40.4(3)	43.3	4	77.8
Vaughn	1367	58.8	85.8	74.6(4)	32.0(5)	57.2(3)	61.7	5	100.0
Hero	1286	60.7						1	103.2
Orel	351	32.6						1	55.4
Afghanistan	4125		79.6	54.1(2)	34.9(2)	45.1(3)	53.4	4	85.6
Multan	3401		74.1	52.2			63.2	2	78.7
India	4355–1		76.5	72.2(3)			74.4	2	92.7
Scarab	995		96.3	79.7(4)	31.2(5)	48.3(3)	63.9	4	102.4
Abyssinia	3909–1			38.1(4)	15.2(4)		26.7	2	50.0
Sacramento	41.08				16.4(4)			1	51.3
Common 6-Row	4625				31.0(3)	61.2(3)	46.1	2	103.4
Union Beardless	5976					43.2(3)		1	75.5

[1] Where the yields were computed from more than 1 plot the number of replications is shown in parentheses.

WHEAT[9]

Wheat was brought to what is now the Southwestern States by the Spanish missionaries by way of Mexico, and was first grown by the Indians in Arizona about 1700. It has continued to be one of the major crops grown by the Pima Indians. The testing of varieties was begun by the field station in 1917 and has been continued. Many varieties which showed no promise have been discontinued from the tests and new promising ones have been added. Yields of the varieties grown in the years 1917–35 are given in table 16. Considering both yield and quality for bread-making purposes, Baart is recommended for growing in the Gila and Salt River Valleys. Sonora is still grown

[8] Prepared by H. V. Harlan, principal agronomist in charge of barley investigations, Division of Cereal Crops and Diseases.
[9] Prepared by B. B. Bayles, agronomist in wheat investigations, Division of Cereal Crops and Diseases.

on a small acreage by the Indians, but although it is about equal to Baart in yield its quality is poor. Onas, Bobin, and Jenkin have given rather outstanding yields for the period tested, but are not yet recommended varieties for Arizona.

Small-grain and sorghum crops, grown continuously, soon deplete the fertility of soil and reduced yields result. This is especially true on the soils of the Gila River Valley which consist of alternate strata of fine sand and silt underlain with coarse gravel. Wheat, being a winter crop in this area, often can be grown successfully on soils of higher salinity than most summer crops would tolerate (fig. 14).

FIGURE 14.—Wheat varieties following alfalfa on highly saline plots at the United States Field Station in May 1933.

TABLE 16.—*Acre yields of wheat varieties grown at the United States Field Station, Sacaton, Ariz., 1917–35*

Class and variety	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Common white:											
Baart	36.6	44.5	45.3	------	53.5	38.2	42.5	54.7	40.8	25.2	50.3
Sonora	32.8	------	59.0	43.6	31.5	30.3	32.6	61.7	40.2	32.2	41.0
Dicklow	------	------	41.5	57.9	29.5	------	------	------	------	------	------
Pacific Bluestem	------	------	46.0	53.0	27.5	43.7	43.6	42.7	60.2	37.9	32.0
Hard Federation	------	------	------	53.3	31.0	28.0	30.8	34.5	------	------	------
White Federation	------	------	------	42.8	25.8	30.1	39.2	41.1	------	13.2	50.0
Federation	------	------	------	------	------	------	22.4	39.2	51.6	19.1	45.3
Hard red winter: Kharkof	------	39.0	47.5	61.9	44.0	41.5	------	------	------	------	------
Soft red winter: Triplet	------	------	44.8	56.7	43.0	33.9	27.8	------	------	------	------
Hard red spring: Marquis	------	------	46.8	33.8	36.7	36.1	41.2	36.8	45.4	40.5	36.6
Club:											
Little Club	------	------	55.9	52.0	46.2	26.2	52.2	56.5	------	32.4	32.7

TABLE 16.—*Acre yields of wheat varieties grown at the United States Field Station, Sacaton, Ariz., 1917–35*—Continued

Class and variety	1928	1929	1930	1931	1932	1933	1934	1935	Average (1920 omitted)	Average for Baart (same years)
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Common white:										
Baart	43.2	63.7	41.5	32.6	37.7	38.3	32.9	31.3	41.8	41.8
Sonora	51.2	67.6	52.4	24.1	51.5	31.0	28.9	------	41.7	42.3
Dicklow	------	------	------	------	------	------	------	53.7	41.6	43.4
Pacific Bluestem	55.1	56.9	42.1	27.2	49.4	28.8	34.9	40.0	41.8	42.0
Hard Federation	------	47.2	48.6	43.5	45.2	53.8	------	------	40.3	44.7
White Federation	44.2	51.4	42.1	27.2	55.3	54.0	33.1	------	39.0	42.6
Federation	------	44.3	------	------	------	49.7	36.5	39.0	38.6	42.2
Pusa No. 4	------	59.7	57.9	26.7	46.8	39.5	29.6	------	43.4	41.1
Onas	------	------	50.0	42.5	46.6	54.7	43.7	53.0	48.4	35.7
Bobin	------	------	------	------	------	------	36.2	40.3	38.3	32.1
South African	------	------	------	------	------	------	------	44.3	44.3	31.3
Hard red winter: Kharkof	------	------	------	------	------	------	------	------	43.0	45.4
Soft red winter: Triplet	------	------	------	------	------	------	------	------	37.4	44.9
Hard red spring: Marquis	44.9	41.8	27.6	17.5	36.9	31.2	26.0	23.6	35.6	42.0
Club:										
Little Club	------	52.6	42.1	35.0	36.8	36.6	29.5	------	41.1	42.8
Jenkin	------	------	------	------	------	45.7	40.4	52.6	46.2	34.2

SORGHUMS [10]

Both grain sorghums and sorgos are grown in southern Arizona, but the former greatly predominate. Dwarf hegari is the most popular grain sorghum. Its palatable stover makes it a valuable crop for both grain and forage. Double Dwarf milo is grown only for grain. Plot tests of sorghum varieties have been conducted at Sacaton continuously since 1928 (table 17). The yields of some of the tests were reduced by bird damage. Double Dwarf milo yielded an average of nearly 12 bushels per acre more than Dwarf hegari, but this difference perhaps is offset by the value of the hegari stover.

Fargo milo, although slightly outyielding the Double Dwarf, is somewhat undesirable because of its extremely tall stalks and late maturity. Double Dwarf milo is suitable for harvesting with a combine. Beaver, a dwarf erect-headed type of milo developed for combine harvesting, yielded somewhat less than the Double Dwarf but slightly more than Dwarf hegari during the 5 years they were grown. The average yield of Wheatland was less than that of any one of these three varieties. Grohoma yielded the same as Beaver.

The Honey sorgo (sweet sorghum) produced slightly more forage than the Gooseneck variety.

[10] Prepared by J. H. Martin, senior agronomist in charge of sorghum investigations, Division of Cereal Crops and Diseases.

TABLE 17.—*Acre yields of sorghum varieties grown at the United States Field Station, Sacaton, Ariz., 1928–35*

Class and variety	1928	1929	1930	1931	1932	1933	1934	1935	Average	Average for Double Dwarf milo, same years
Milo:										
Double Dwarf ---------bushels--	65.6	84.7	118.2	59.4	56.4	56.6	68.9	27.6	67.2	---------
Dwarf Yellow ------------do----	64.1	69.7	92.2	50.2	39.6	20.6	29.8	------	52.3	72.8
Fargo --------------------do----	110.8	109.9	103.3	68.3	45.6	61.8	39.8	------	77.1	72.8
Beaver -------------------do----	------	------	------	40.5	43.0	44.5	60.4	52.6	48.2	53.8
Wheatland ---------------do----	------	------	------	40.9	31.8	35.8	42.9	62.4	42.8	53.8
Sooner -------------------do----	------	------	------	------	------	------	24.4	------	------	---------
Other grain sorghums:										
Dwarf hegari -------------do----	57.3	51.7	105.7	61.4	33.9	45.1	45.8	43.3	55.5	67.2
Feterita -----------------do----	63.3	36.0	61.2	------	------	------	------	------	53.5	89.5
Texas Blackhull kafir -----do----	54.9	45.2	61.3	------	------	------	------	------	53.8	89.5
Club kafir ---------------do----	------	------	------	------	------	------	------	46.4	------	---------
Grohoma -----------------do----	------	------	------	55.7	32.9	37.4	62.6	52.4	48.2	53.8
Ajax ---------------------do----	------	------	------	------	------	------	------	67.1	------	---------
Chiltex ------------------do----	------	------	------	------	------	------	------	40.9	------	---------
Sorgo:										
Honey (green fodder) -----tons--	29.4	34.6	26.1	26.9	11.1	27.9	36.4	------	27.5	---------
Gooseneck (green fodder) -do----	23.7	31.7	27.0	21.6	9.7	25.4	39.8	------	25.6	---------

CORN [11]

The comparison of breeding methods with Sacaton June corn has been continued. Eleven inbred lines have been used as pollen parents on the cross-bred stock and the crosses compared with open pollinated cross-bred stock. All crosses outyielded the cross-bred, and in six the difference was statistically significant, ranging from 12 to 16 percent.

Thirteen crosses among inbred lines have been tested. The only significant departures from the yield of the cross-bred stock were two that exceeded the cross-bred by 17 and 18 percent.

It will be recalled that the cross-bred stock is a mixture of the successful progenies from earlier breeding-method experiments, all of which were more productive than the original variety, and it is to be expected that further improvement will be slow.

In these tests the estimated acre yield in bushels of shelled corn of the cross-bred stock was 53 bushels in 1932, 64 in 1934, and 33 in 1935. A partial failure of pollinations in 1932 prevented a yield test in 1933.

The production of a sweet corn having the relative freedom from corn earworm damage of Sacaton June corn has proved to be more difficult than was anticipated.

The character, sweet seeds, is controlled by a single recessive gene and gives monohybrid segregations in crosses of sweet with nonsweet varieties. It would seem a simple matter, therefore, to transfer this sweet character to a field variety by repeated backcrossing. This has been done without difficulty, and there are now a number of progenies with sweet seeds that are 87.5 or 93.75 percent Sacaton June. The plants of these progenies are indistinguishable from pure Sacaton June and show as little corn earworm damage as the pure variety, but as a table corn they are but little superior to the pure Sacaton June.

[11] Prepared by G. N. Collins, principal botanist, Division of Cereal Crops and Diseases.

To effect the transfer of the characters as rapidly as possible, plants grown from hybrid seed, which of course was nonsweet, were again crossed with the field variety, and this process was repeated without danger of losing the sweet gene, although after two backcrosses it was necessary to self a number of plants to be sure of including plants segregating for sweet. Two seasons are gained by this method, but there is no opportunity to select for desirable table quality.

The poor quality of the sweet strains recovered after this process indicates that the single gene, *su*, which produces wrinkled seed is but a part of the genetic complex that differentiates table varieties from field varieties. Individual selection among selfed plants of the later backcrossed generations show little improvement. The most obvious explanation is that factors essential to a superior table variety have been lost in the backcrossing process.

FIGURE 15.—Flax varieties at the United States Field Station, Sacaton, Ariz.: *A*, Abyssinian Yellow-seed; *B*, Punjab; *C*, Bison; *D*, Rio (Argentine). Photographed April 13, 1936.

In the light of the comparative failure of the continuous backcross method and this possible explanation it would seem a better method to selfpollinate or pure seed after each backcross and exercise selection among the homozygous sweet plants.

FLAX

Preliminary experiments with seed flax (linseed) conducted at Sacaton, Ariz., from 1916 to 1919 indicated that flax can be grown successfully as a fall-sown crop under irrigation. Because of the recent interest in flaxseed production in southern California and Arizona, varietal tests were again conducted at Sacaton in 1935 and 1936 (fig. 15).

Extensive varietal tests conducted at El Centro, Calif., and at Mesa, Ariz., have shown that the Indian type of flax, Punjab, C. I.

20, is better adapted as a fall-sown (winter) crop than the varieties commonly grown in the North Central States. Abyssinian Yellow-seed, C. I. 36, is also a promising variety in California. The varietal tests have shown that both varieties produce high yields of flaxseed of excellent quality if grown on clean fertile soil and irrigated properly. Early November appears to be the best time for seeding. Weeds are the principal problem and therefore only clean, well-cultivated soil should be used.

The flax yields for 1935 and 1936 are shown in table 18.

TABLE 18.—*Acre yields of flax varieties grown at the United States Field Station, Sacaton, Ariz., 1935–36*

Variety	1935	1936	Average	Oil content,[1] 1935
	Bushels	*Bushels*	*Bushels*	*Percent*
Punjab (C. I. 20)	36.9	27.2	32.1	39.2
Abyssinian Yellow-seed (C. I. 36)	28.8	16.4	22.6	38.5
Bolley Golden (C. I. 644)		23.6		
Rio (Argentine) (C. I. 280)		15.3		
Bison (C. I. 389)		15.3		
Linota (C. I. 244)		14.6		

[1] Oil content based on 8-percent moisture in the seed.

ORCHARD CROPS

CITRUS FRUIT

Citrus production has become one of the major agricultural industries in Maricopa and Yuma Counties. The total farm value of citrus fruits produced in these counties in 1935–36 was more than 2½ million dollars. The production of oranges for the entire State was 170,000 boxes in 1934–35 and 260,000 boxes in 1935–36. The production of grapefruit was 1,240,000 boxes in 1934–35 and 2,090,000 boxes in 1935–36. With nearly half of the Arizona grapefruit acreage under 6 years of age, it is expected that production will greatly increase during the next few years.

The citrus orchard at the seed farm (fig. 16), which is one of the earliest plantings in Pinal County, has continued to be fairly productive in spite of some slight injury from low winter temperatures. Table 19 gives a list of citrus varieties that are of commercial importance, or had promise of becoming of commercial value, the year the trees were planted; some of the yields from 1931–35 also are included.

Table 20 gives a list of miscellaneous types of citrus trees that are being grown at the seed farm to test their adaptation to the climatic conditions, and their value for home consumption or for commerce.

FIGURE 16.—Citrus variety planting at the seed farm, Sacaton, Ariz., in 1936. Most of the trees in the foreground are Marsh grapefruit about 4 years old.

TABLE 19.—*Yield per tree of citrus fruit from trees of different varieties and plantings at the seed farm, Sacaton, Ariz., 1931–35*

Type and variety	Year planted	Trees	1931	1932	1933	1934	1935
Grapefruit:		*Number*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Marsh	1919	4	262	(1)	(1)	205	281
Do	1923	2	25	(1)	30	149	276
Do	1927	3	46	(1)	(1)	108	106
Do	1930	12			4	37	80
Foster	1930	1			20	39	[2] 45
Oranges:							
Early Avery	1919	2	161	167	91	63	136
Parson Brown	1919	2	97	214	77	226	123
Washington Navel	1919	4	90	73	73	(1)	75
Valencia	1925	2	(1)	(1)	(1)	15	31
Do	1927	2		(1)	(1)	15	38
Do	1930	3					20
Do	1931	2					7
Lemons:							
Meyer	1927	4	16	23	88	77	70
Eureka	1930	1				[2] 3	[2] 15
Tangelo:							
Thornton	1919	2	(1)	171	141	67	(1)
Limequat:							
Eustis	1923	1	35	(1)	24	7	[2] 25
Tangerine:							
Dancy	1930	1					20

[1] Yields not recorded. [2] Yields estimated.

TABLE 20.—*Miscellaneous citrus trees at the seed farm, Sacaton, Ariz., 1935*

Type and variety	Number of trees	CPB No.[1]	Type and variety	Number of trees	CPB No.[1]
Grapefruit:			Orange—Continued.		
Clayson	5		Owari (Satsuma)	1	11498
Thompson	2	11490	Chamoudi	4	11894
Foster	2		Do	3	10056
Davis	1	11634	Kansu	1	11298
Marsh	7		Tangelo:		
Orange:			Sunrise	9	40693
Diller	5		Thornton	1	1282–H
McIlhenny	1		Do	2	1714–A
Washington Navel	3		Yalsha	1	52016–K–12
Valencia	13		Tangerine:		
Navalencia	3		Clementine	16	
Hamlin	1	11607	Lime:		
Navel Hybrid	1	45577	Bearss	1	
Swaton	2	14054	Sweet	3	1158
Do	1	110032			

[1] Refers to numbers assigned by the Division of Crop Physiology and Breeding now consolidated with the Division of Fruit and Vegetable Crops and Diseases.

DATES[12]

Date plantings in the warmer valleys of southern Arizona have been increased to some extent during the last 5 years, although the rate of expansion was checked by the financial depression. According to a census taken in 1934, 17,128 trees of standard varieties were being grown in Maricopa County, 4,500 in Yuma County, and 2,462 elsewhere in the State. Many of the palms have not reached bearing age, but the Arizona crop of 1935 was estimated at about 100,000 pounds.

The combined plantings of dates at the field station and at the seed farm total about 6 acres, comprising 80 varieties from the Old World and about 75 bearing trees from seed.

A roadside planting of the Hayany and Saidy varieties made at the field station in 1918 is shown in figure 17.

Observations during the past 5 years indicated that the Kustawi, Halawy, Khadrawy, and Hayany varieties are dependable for production of edible dates under the prevailing weather conditions.

Cooperative plantings with white growers are maintained at 11 locations in Maricopa, Pinal, and Yuma Counties. From these plantings, in the period covered by this report, 489 offshoots were received as the increase share of the Department of Agriculture, and a large part of them were planted for the Pima Indians at the seed farm in a nursery or directly in their yards or orchards (fig. 18 and table 2).

Less difficulty is experienced than formerly in rooting offshoots. The losses during the last 5 years in the favorably located seed farm nursery have been almost negligible.

Results were positive in an experiment designed to determine whether severed date roots are capable of regenerating new growth, disproving the common belief that roots cut in plowing or injured by rodents cease to function and eventually die. In practically all cases where roots were severed experimentally, apparently normal growth developed from the cut ends (*11*).

[12] Prepared by R. H. Peebles, associate agronomist, Division of Cotton and Other Fiber Crops and Diseases.

PECANS

The pecan industry in Arizona has been most successful in the Yuma Valley. Data obtained by the United States Bureau of Reclamations show that in 1934 there were 1,164 acres of bearing pecans in

FIGURE 17.—Date palms bordering a driveway at the United States Field Station, Sacaton, Ariz. The varieties shown are Hayany and Saidy, and were developed from offshoots cut in 1918 from original trees introduced from Egypt.

FIGURE 18.—Young date trees on the farm of a Pima Indian near Sacaton in 1933. The land had recently been cleared of desert vegetation.

the Yuma irrigation project with a production of 72,640 pounds. In 1935 the bearing acreage was 1,806 and the production 229,316 pounds. The chief advantages in the Yuma Valley are the favorable soil conditions, the comparative freedom from disease, and a climate which matures pecans for the Christmas market.

The pecan planting at the Sacaton field station began when a few trees were set out in 1908. This was one of the first plantings of named varieties of pecans in Arizona. Many of the trees from the earliest plantings at the station died in the young stages from various causes, but in recent years the losses of young trees that are well adapted to the hot climate have been small. In 1935 the planting at the field station consisted of 39 trees representing 16 varieties. All have reached bearing age, but the behavior of many is very erratic, some trees producing fairly good crops one season and perhaps only a few nuts the next. The yields per tree of a select group of the oldest trees are given in table 21. The Kincaid was the most consistently producing variety during the period 1931–35. The Alley, Texas Prolific, and Stuart also were fairly productive in some seasons.

It is believed that soil conditions exist in other places along the Gila River that are especially favorable for pecans. At the field station, strata of coarse sand and gravel occur at a depth of 5 to 7 feet and this, with the high salinity of the soil, may account in part for the low production as compared to that in the Yuma Valley.

Table 21.—*Yields per tree of dried pecan nuts from trees of different varieties at the United States Field Station, Sacaton, Ariz., 1931–35*

Field No.	Variety	Trees	1931	1932	1933	1934	1935
		Number	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
D2-7	Alley	1	24.0	7.5	18.0		30.1
D2-7	Centennial	2	1.0	1.0			
D2-6	Curtis	1	6.5				
C2-7 and D2-6	Delmas	4	10.0	3.3	9.9		21.1
C2-6 and D2-6	Frotscher	3	6.8		9.0		9.5
C2-7	Georgia Giant	2	11.5	9.8	5.0	2.3	7.3
On irrigation ditch	Haven	1	10.5	1.0			9.5
C2-6	Hickson	1		0.5			
C2-7 and irrigation ditch	Kincaid	3	30.5	11.7	38.2		58.4
C2-6	Pabst	3	2.7	1.1	3.0		6.2
C2-7	Russell	1			(1)		
C2-6 and D2-7	Schley	4			(1)		(1)
C2-7 and D2-6	Stuart	4	13.5	16.0	12.4	5.0	19.7
C2-7	Success	1	3.5	.8	3.0		2.5
C2-6	Teche	2	5.0	6.5	26.0	3.5	10.2
C2-7	Texas Prolific	2	19.5	6.8	14.5	2.6	30.9

[1] Few nuts.

GRAPES

During the past few years the grapevines in the station vineyard have become badly infested with the cotton root rot fungus and root knot nematodes. Many of the vines have died and others were so weakened that the yields have been greatly reduced. The Sultana (Thompson Seedless) and Sultanina Rosea, both of which are seedless varieties and are used as table grapes for making raisins in California, have been the best producers during the past few years. Satisfactory yields were obtained in 1931 and 1932 from the Black Muscat, Malaga, Dattier, and Black Prince varieties, but their yields have been greatly reduced as the severity of the root knot nematode disease increased.

The vineyard at the seed farm, which consists of 15 varieties, has produced very satisfactory yields. The best varieties in this planting are Sultana, Black Muscat, Dattier, and Malaga. Some of the other varieties, Black Monukka, Black Morocco, Black Malvoise, Olivette de Cadanet, and Olivette Blanche bear fair yields, but the berries are lacking in flavor and quality. The soil at the seed farm appears to be well adapted for grape culture if frequently fertilized. Roots of some of the vines show root knot nematode injury, but only two varieties, Flame Tokay and Chasselas de Fontainebleau, appear to be badly affected.

FIGS

Eleven varieties of figs are represented in the orchard at the seed farm. Some of the trees have died or are practically dead from root knot nematode injury. Satisfactory yields of good-quality fruit have been obtained from practically all varieties, especially the Black Spanish, Mission, Kaab el Gazal, Brown Turkey, and Pastiliere. As a fresh fig the fruit of the Pastiliere variety is of excellent eating quality, but the skin is so thin that the fruit is injured and spoils easily. The Celeste variety has produced good crops each year, but the fruit is too small to be of much value, except for preserving or pickling.

In plantings at the field station the Kadota proved to be a good producer until attacked by nematodes. Large commercial plantings of this variety near Casa Grande, however, have been abandoned owing to the low price of canned and preserved figs during the depression years.

PISTACHE [13]

Several 9-year-old trees of the Trabonella and Red Aleppo varieties at the seed farm produced good crops of nuts for the first time in 1932; in 1933, a single, large Red Aleppo tree yielded 20 pounds of dried nuts, hulls removed. The yield of three Trabonella trees averaged 19 pounds. Observations indicate that delayed foliation is responsible for the crop failures in other seasons.

Nursery stock was grown in 1934 from Trabonella, Red Aleppo, and trees of interspecific origin. All of the seedlings, irrespective of the character of the parents, showed great diversity in size of plant, vigor, and in leaf conformation.

The result from an experiment performed with Red Aleppo and Trabonella varieties in 1933 show effects of the different pollens used which can be ascribed only to metaxenia. The period of maturation differed greatly with the different pollens. On August 28 only 9.9 percent of the Trabonella nuts from *Pistacia chinensis* Bunge pollen had matured, whereas 80.8 percent had matured from seed fertilized with pollen from a hybrid tree. Small but apparently significant differences existed in the length of the shell and in dehiscence of the shell.

Owing to the erratic behavior of the pistache in producing nuts in this locality it has not seemed wise to encourage commercial plantings.

TRUCK CROPS

Tests conducted for many years at the field station and seed farm have demonstrated that a great variety of truck and garden crops may be grown successfully under the conditions which obtain on the Gila River Indian Reservation and the San Carlos irrigation project. On the alluvial soils near the Gila River precautions are necessary

[13] Prepared by R. H. Peebles, associate agronomist, Division of Cotton and Other Fiber Crops and Diseases.

to avoid, for truck crops, areas which contain a high proportion of soluble salts; and on the residual soils of the higher lands it is desirable to build up fertility with alfalfa or organic manures before planting.

On the reservation a small area is devoted to winter gardens, but the Indians are being encouraged by the United States Indian Extension Service to increase their plantings especially for home consumption.

The principal commercial truck crops in the section are Iceberg lettuce, muskmelons, carrots, peas, sweetpotatoes, tomatoes, and asparagus. In addition spinach, beets, chard, turnips, mustard, cauliflower, and radish do well as garden crops. Of the commercial crops lettuce occupies a greater acreage than any other truck crop, being grown chiefly in the Salt River Valley and in the Yuma district. In the fall of 1935 lettuce was planted on 13,000 acres and for the spring crop on 22,000 acres in these two areas (fig. 19). In the spring of

FIGURE 19.—A field of spring lettuce ready for cutting in the Salt River Valley, Ariz.

1935 the total lettuce shipments for the State were 5,504 cars with an average reported net return of $1.84 per crate. In the fall, about 3,625 cars were shipped, but the returns were not satisfactory because of a prolonged shipping period from competing areas in other States.

In 1935, 1,783 cars of muskmelons were shipped from 6,260 acres in the Salt River Valley and 1,216 cars from 3,760 acres in the Yuma district. The average net returns to the growers were reported as about 70 cents per crate. Muskmelon varieties that have proved well adapted for home consumption are Hales Best, Perfected Perfecto, Rocky Ford, Eden Gem, Tip Top, and Honey Ball. The Honey Dew, Persian, and Golden Beauty Casaba melons are good producers especially on fairly fertile soils.

The Pima Indians are heavy consumers of watermelons and are being encouraged by the United States Indian Extension Service to plant at least an adequate acreage for their own use. Damage from aphids is one of the factors that limit production on Indian plantings, which are often made late in the spring. Varieties that have produced well at the field station are Klondike, Striped Klondike, Angeleno, Kleckley Sweet, Chilian, Irish Gray, Tom Watson, Stone Mountain, and Georgia Rattlesnake.

The field station has maintained a select strain of yellow Bermuda onions on the reservation for more than 20 years. Each year a new selection of mother bulbs is made from the station crop and planted for seed production the following winter. The strain is very productive, and yields of 7 or 8 tons per acre are not uncommon. The Indians have maintained an interest in growing Bermuda onions for home use and some have been encouraged to grow them for sale.

Potatoes are not grown on a large scale commercially in the warmer irrigated valleys of Arizona, but experiments over a period of years have shown that they may be grown to advantage on a small scale for local consumption. The Irish Cobbler and the Bliss Triumph are the most reliable producing varieties at the field station. The Porto Rico is the most popular variety of sweetpotato in this section and is grown almost exclusively by commercial producers. The larger plantings are made on light, well-drained soils, and it has been found in recent years that the tubers keep well in such soils even after frost. As a rule they are allowed to remain in the soil and are dug from time to time in quantities to meet market demands.

Tomatoes may be grown in abundance in the Salt and Gila River Valleys. For early commercial use they are usually planted on the warmer lands during the winter months and the young plants are usually given some artificial protection, such as a partial covering of arrowweeds and papers. Diseases which often give trouble on tomatoes are root knot and *Phymatotrichum* root rot. The Morse 498, Dwarf Stone, and Dwarf Champion are the most reliable producers at the field station.

In table 22 are given some yields, dates of planting, and harvesting of some varieties of onions, potatoes, sweetpotatoes, and tomatoes grown at the field station during the period 1931–35.

TABLE 22.—*Dates of planting and harvesting and acre yields of various truck crops, United States Field Station, Sacaton, Ariz., 1931–35*

Crop and variety	1931			1932			1933			1934			1935		
	Planted	Harvested	Yield	Planted	Harvested	Yield	Planted	Harvested	Yield	Planted	Harvested	Yield	Planted	Harvested	Yield
			Lb.			*Lb.*			*Lb.*			*Lb.*			*Lb.*
Onion:															
Yellow Bermuda	Jan. 30	June 4	22,828						15,802			15,059		June 20	8,562
Potato:															
Bliss Triumph (red)	Feb. 20	June	4,006	Feb. 11	June	1,484				Feb. 21		3,396			
Irish Cobbler (white)	do	do	3,869	do	do	1,272				do		2,863			
Sweetpotatoes:															
Porto Rico	Apr. 17	Oct. 12–23	[1] 5,099			[1] 6,774	May 8	November	6,031	May 8	November	11,021	May 27	October	15,000
Tomato:															
Dwarf Stone	Mar. 30	July 3 to Aug. 4.	1,194												
Morse No. 498	do	June 14 to Aug. 4.	8,362				Mar. 31	June 16 to July 18.	6,025				Mar. 25	June 15 to July 30.	6,702
Dwarf Champion							do	June 26 to Aug. 4.	6,004				do	June 13 to Aug. 13.	7,855
Marglobe							do	June 27 to Aug. 4.	4,141						
Arizona Early													Mar. 25		258
Ponderosa													do	June 25 to July 29.	6,180

[1] Yields were computed from an average of 2 plots.

HOPI LIMA BEANS

It is known that a lima bean of the Hopi type was cultivated by the Pima and other Indians of southern Arizona for many years, but among the older Indians and Indian traders there is some disagreement as to its origin and its importance as a crop. During the period 1915–30 it had almost disappeared from the Gila River Indian Reservation and seldom was seen at the trading posts. Freeman (*3*) fails to mention the lima type, although he and his collaborators made extensive collections of beans on the Pima and Papago Reservations about 1909. The tepary type, however, is well-known among all the southern Arizona tribes and appears to be a more dependable producer than the limas and common beans.

About 1930 the workers at the field station began to investigate the possibilities of improving the Indian lima types so that they might be better suited to the climatic conditions of the warmer areas of the Southwest. Several color types were obtained from the Hopi Reservation in 1931 and the selected strains of white Hopi limas were obtained from the Agronomy Department of the University of California at Davis. Later, other collections were obtained from the Hopi Reservation, and in 1932 some samples of the Pima strain were obtained which have been designated as Hopi Pima lima. This strain, while containing some variation in color, is most typically light tan with black markings somewhat banded longitudinally. Selections were made from these strains, and some improvement has been noted in their ability to retain flowers and young pods during the hot weather and to resist spotting of the young beans (figs. 20 and 21).

In comparative plantings of unselected seed the Pima strain ordinarily is more productive than the native Hopi strain, but stocks increased from selections of the latter have given some of the highest yields obtained at Sacaton. In table 23 are shown some comparative yields of various strains of Hopi and Hopi Pima lima (Indian lima) and one strain of tepary beans, from 1931 to 1935.

The white strains show much greater susceptibility to the spotting and shriveling of the young beans than the reds, blacks, and those with flecked and banded markings. Nearly all of the Hopi and Hopi Pima lima (Indian lima) strains and selections show a greater resistance to root knot nematodes than do the various kinds of common beans and teparies, but some strains of lima show greater resistance than others and selections have been made in the effort to obtain a completely resistant strain.

Some of the vine types of lima beans possess value as a summer cover crop, and yield a greater tonnage of vines than the teparies which sometimes are used for that purpose.

Samples of the selected strains of the Hopi lima bean are distributed each year to the Pima Indians, who are showing much interest in making greater use of this type of bean as a food crop.

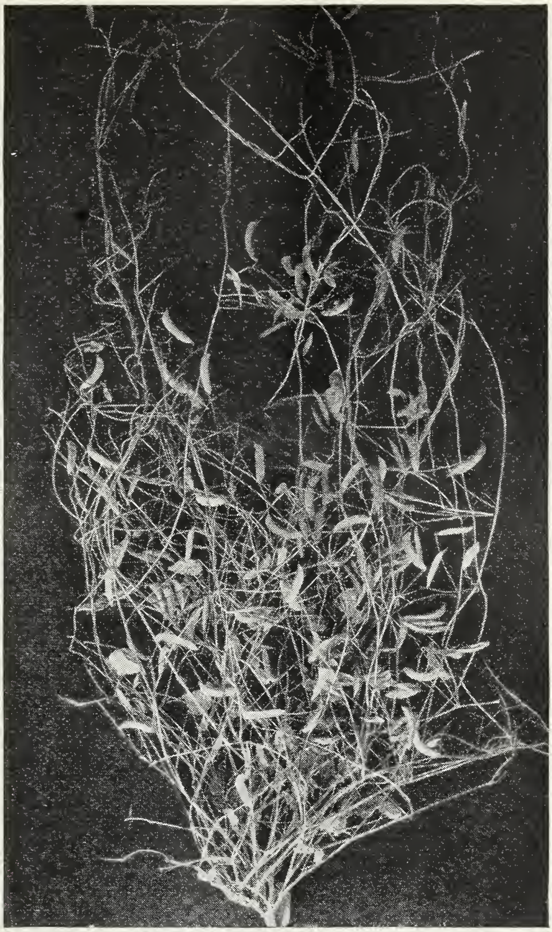

FIGURE 20.—A plant selection of white Hopi lima beans, from a breeding plot at the United States Field Station, Sacaton, Ariz. The original types from the Hopi Reservation do not produce well in the hot irrigated valleys and breeding work is required to develop productive strains.

TABLE 23.—*Acre yields* [1] *of Hopi lima bean varieties grown at the United States Field Station, Sacaton, Ariz., 1931–33 and 1935*

Variety	Color, markings and strain	Origin	Acre yields [1]			
			1931	1932	1933	1935
			Pounds	*Pounds*	*Pounds*	*Pounds*
Hopi, lima	White No. 54	Davis, Calif.	419	513(3)	497(5)	863
	White, No. 40	do	249	316	505	928
	White, No. 155	do	95	577	957	785
	White, Moencopi	Hopi Reservation		193	578	575
	Red, Polacco	do			1,463	473
	Reddish brown, flecked	do		445(2)		1,012
	Brown flecked (selected)	do			1,769	1,725
Hopi Pima lima	Light brown, flecked	Pima Reservation		742(3)	945(4)	1,164
Tepary	Reddish brown	do		605	533(2)	1,437

[1] Where the yields were computed from more than 1 plot the number of replications is shown in parentheses.

FIGURE 21.—Breeding block for Hopi lima beans at the United States Field Station, Sacaton, Ariz., in 1936.

ORNAMENTAL PLANTS AND SHRUBS

Many varieties and species of annual and perennial flowering plants, evergreen trees and shrubs, bulbs, corms, tubers, and rhizomes have been tried at the field station and those given in the following list have proved satisfactory adaptations to conditions at Sacaton.

Also a number of ornamental plants have been received from the Division of Plant Exploration and Introduction for trial at the field station. Some of these plants have proved very well adapted to Sacaton conditions and a list of these plants is also given. The most promising of these have been propagated and distributed to the Indian Agency for planting on the Indian school campus and reservation farms.

LIST OF CONIFEROUS EVERGREEN TREES AND SHRUBS, DECIDUOUS SHADE TREES, FLOWERING SHRUBS, EVERGREEN FLOWERING SHRUBS, AND ORNAMENTAL VINES ADAPTED TO CONDITIONS AT SACATON, ARIZ.

Coniferous evergreen trees and shrubs:
- *Cupressus arizonica* (Arizona cypress).
- *C. sempervirens* (Italian cypress).
- *Pinus halepensis* (Aleppo pine).
- *Juniperus sabina tamariscifolia.*
- *Thuja orientalis beverleyensis.*

Broad-leaved evergreen trees:
- *Casuarina stricta* (beefwood).
- *Ceratonia siliqua* (carob).
- *Eucalyptus rudis* (desert gum).
- *E. rostrata* (red gum).
- *Grevillea robusta* (silk-oak).
- *Olea europaea* (olive).
- *Parkinsonia aculeata.*
- *Schinus molle* (California peppertree).
- *S. terebinthifolius* (Brazilian peppertree).

Broad-leaved evergreen trees—Contd.
- *Sterculia diversifolia* (bottletree).
- *Sophora secundiflora.*
- *Tamarix articulata* (Athel tree).

Deciduous shade trees:
- *Catalpa speciosa* (western catalpa).
- *Cercis reniformis* (Texas redbud).
- *Fraxinus velutina* (Arizona ash).
- *Melia azedarach umbraculiformis* (Texas umbrella-tree).
- *Morus alba pendula* (weeping mulberry).
- *Morus nigra* (Persian mulberry).
- *Populus candicans* (balm-of-Gilead).
- *P. fremontii* (Arizona cottonwood).
- *Robinia pseudoacacia* (black locust).
- *Salix babylonica* (weeping willow).
- *Ulmus pumila* (Chinese elm).

Deciduous flowering shrubs:
- *Lagerstroemia indica* (crapemyrtle).
- *Malvaviscus arboreus* (turkscap).
- *Punica granatum* (dwarf and flowering pomegranates).
- *Spiraea vanhouttei* (bridalwreath).
- *Vitex macrophylla.*
- *V. negundo incisa.*

Evergreen flowering shrubs:
- *Buddleia alternifolia.*
- *Callistemon viminalis.*
- *Euonymus japonicus* (green and variegated burningbush).
- *Genista hispanica* (Spanish broom).
- *Hibiscus* sp. (double and single hibiscus).
- *Lantana camara* (dwarf, tall, and trailing lantana).
- *Ligustrum japonicum* (Japanese privet).
- *Myrtus communis* (Roman, dwarf, small-leaf, and variegated myrtle).

Evergreen flowering shrubs—Contd.
- *Nerium oleander* (double and single oleander).
- *Photinia serrulata.*
- *Pittosporum tobira* (Japanese pittosporum).
- *Pyracantha atalantioides.*
- *P. crenulata kansuensis.*

Ornamental vines:
- *Antigonon leptopus* (queen's wreath).
- *Bignonia chinensis* (giant trumpet vine).
- *B. tweediana* (yellow trumpet vine).
- *Buginvillea brasiliensis.*
- *B.* var. Crimson Lake.
- *Hedera helix* (English ivy).
- *Lonicera japonica* (honeysuckle).
- *Jasminum gracillimum* (pinwheel jasmine).
- *J. primulinum* (primrose jasmine).
- *Parthenocissus quinquefolia* (Virginia creeper).
- *Periploca graeca* (silkvine).

LIST OF FLOWERING ANNUALS, PERENNIALS, EVERGREENS, BULBS, CORMS, TUBERS, RHIZOMES, AND ROSES SATISFACTORILY ADAPTED TO CONDITIONS AT SACATON, ARIZ.

Summer and fall flowering annuals and perennials:
- Arctotis.
- Celosia.
- Chrysanthemum.
- Cosmos.
- Gaillardia.
- Lantana.
- Marigold.
- Mesembryanthemum.
- Portulaca.
- Petunia.
- Stokesia.
- Tithonia.
- Verbena.
- Zinnia.

Winter and spring flowering annuals and perennials:
- African daisy.
- Alyssum.
- Brachycome.
- Calendula.
- California poppy.
- Calliopsis.
- Candytuft.
- Centaurea.
- Clarkia.
- Coreopsis.
- Gaillardia.
- Gypsophila.
- Hollyhock.
- Larkspur.
- Linaria.
- Nasturtium.
- Nemesia.
- Nemophila.

Winter and spring flowering annuals and perennials—Continued.
- Painted daisy.
- Pansy.
- Petunia.
- Phlox.
- Pink.
- Poppy.
- Rudbeckia.
- Scabiosa.
- Scarlet flax.
- Shasta daisy.
- Snapdragon.
- Stock.
- Sweet pea.
- Venidium.
- Verbena.

Flowering bulbs, corms, tubers, and rhizomes:
- Anemone.
- Amaryllis.
- Brodiaea laxa.
- *Brodiaea capitata.*
- Daylily.
- Freesias.
- Gladiolus.
- Grape-hyacinth.
- Hyacinth.
- Iris.
- Mariposa lily.
- Montbretia.
- Narcissus.
- *Ornithogalum arabicum.*
- Ranunculus.
- Sparaxis.

Flowering bulbs, corms, tubers, and rhizomes—Continued.
- *Tigridia pavonia.*
- Tuberose.
- Tulip.

Roses:
- Ambassador.
- American Beauty.
- Betty Sutor.
- Caledonia.
- Countess Vandal.
- Crimson Queen.
- Dainty Bess.
- Duchess of Athol.
- Edith Nellie Perkins.
- Edward Mawley.
- E. G. Hill.
- Etoile de France.
- Etoile de Hollande.
- Fortune Double Yellow.
- Frau Karl Druschki.
- General MacArthur.
- Golden Dawn.
- Hadley.
- Hoosier Beauty.
- Imperial Potentate.
- Irish Charm.
- J. Otto Thilow.
- Kaiserin Auguste Victoria.
- Lady Hillingdon.
- Lady Margaret Stewart.
- Leslie Dudley.
- Lord Charlemont.

Roses—Continued.
- Los Angeles.
- Lulu.
- Maman Cochet.
- Mari Dot.
- Mme. Edouard Herriot.
- Mme. Jules Grolez.
- Mme. Leon Paine.
- Mrs. Erskine Pembroke Thom.
- Mrs. Henry Bowles.
- Mrs. Lovell Swisher.
- Mrs. Sam McGredy.
- President Hoover.
- Radiance.

Roses—Continued.
- Red Radiance.
- Rose Marie.
- Talisman.
- Climbers:
  - Blaze.
  - Cherokee.
  - Cecile Brunner.
  - Golden Emblem.
  - Gold of Ophir.
  - Lady Ashtown.
  - Mermaid.
  - New Dawn.
  - Paul's Scarlet Climber.
  - Rose Marie.

Roses—Continued.
- Climbers—Continued
  - Silver Moon.
  - Souv. de Claudius Pernet.

Evergreen flowering shrubs:
- *Cassia artemisioides.*
- Euonymus.
- *Genista hispanica.*
- Lantana.
- *Ligustrum japonicum.*
- Myrtus.
- Nerium (oleander).
- *Pittosporum tobira.*
- Pyracantha.

ORNAMENTAL PLANTS RECEIVED FROM THE DIVISION OF PLANT EXPLORATION AND INTRODUCTION THAT HAVE PROVED SATISFACTORY AT SACATON, ARIZ., 1931–35

No.	*Name*
94235	*Acacia giraffae.*
94236	*A. horrida.*
98367	*Buddleia lindleyana.*
51503	*Callistemon citrinus.*
92047	*Celtis sinensis.*
101003	*Damnacanthus indicus.*
95516	*Eucalyptus algeriensis.*
80415	*Myoporum acuminatum angustifolium.*
68170	*Populus maximowiczii.*
92522	*P. nigra betulifolia.*
58484	*P. suaveolens przewalskii.*
3298	*Punica granatum.*
40376	*Pyracantha crenulata kansuensis.*
94099	*P. crenulata rogersiana.*
55997	*P. crenulata.*
80408	*P. atalantioides.*
7284	*P. crenato-serrata.*
95067	*Rhus viminalis.*
22987	*Salvia mexicana minor.*
11322	*Severinia buxifolia.*
82488	*Zelkova serrata.*
22684	*Ziziphus jujuba.*

CACTUS GARDEN [14]

The cactus garden at the seed farm, which had its beginning with a few common species planted in 1920, has been gradually enlarged (fig. 22). In 1935 acquisitions totaled 975 plants. About 150 species are represented. Complete collection data are available for each plant so that the garden has considerable scientific value. In fact, its principal use at present is in connection with a taxonomic study of the Arizona species. Cacti of interest from adjoining States and those utilized as food plants by the Indians are included in the collection.

It has been found beneficial for the best development of most species to irrigate lightly several times during the dry season.

[14] Prepared by R. H. Peebles, associate agronomist, Division of Cotton and Other Fiber Crops and Diseases.

FIGURE 22.—A small section of the cactus garden at the seed farm, Sacaton, Ariz.

REFERENCE HERBARIUM [15]

The herbarium of the field station now comprises approximately 9,000 specimens of the native plants of Arizona, all identified and mounted on standard herbarium sheets. Many of these have been identified by specialists in difficult groups, which adds much to the value of the collection. It is gratifying to note that increasing use of this herbarium is being made, not only by the station staff but by botanists, entomologists, soil conservationists, and others who have occasion to identify plants that grow wild in the State. Photographs have been made of many of the more interesting species, especially of the cacti and large woody plants that cannot be represented adequately by herbarium specimens.

In addition to this use the herbarium is serving as a basis for the preparation of a publication on the flora of Arizona, a work that is urgently needed by foresters, soil conservationists, experts in range management, teachers of botany, and others. Arizona ranks high in the richness and diversity of its flora. It is a meeting ground for many different elements—the floras of the Great Plains, Rocky Mountains, Great Basin, California deserts, Sonora-Baja California region, and northern and central Mexico being well represented. There is even a considerable representation of species that are chiefly characteristic of the southeastern United States and of the coastal region of California, respectively. As yet, no list of the flowering plants of Arizona has been published. Identification of the native plants requires access to a library and to herbaria such as are available only at the largest botanical centers. An adequate flora of Arizona will be obviously a work of great utility.

[15] Prepared by T. H. Kearney, principal physiologist in charge, Egyptian cotton-breeding project, Division of Cotton and Other Fiber Crops and Diseases.

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