THE

State Agricultural College

OF COLORADO.

BULLETIN NO. 1.

REPORT

OF

EXPERIMENTAL WORK

IN THE DEPARTMENT OF

Physics and Engineering.

Fort Collins, Colorado, August, 1887.

FORT COLLINS, COLO:
LARIMER BEE PUBLISHING HOUSE.
1887.

THE STATE BOARD OF AGRICULTURE.

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ANNOUNCEMENT.

At the semi-annual meeting of the State Board of Agriculture, held in June, the secretary was authorized by resolution, to have prepared and to publish reports of experiments conducted at the State Agricultural College, by the different departments, for free distribution.

In compliance with the resolution of the Board, the accompanying report from Professor Mead, of the department of Physics and Engineering on "Experiments in Irrigation and Meteorology" is herewith presented, in the form of Bulletin No. 1.

It is the design of the State Board of Agriculture to disseminate information from time to time concerning the experimental work carried on at the State Agricultural College, so that the character and progress of these scientific investigations, closely connected with agriculture and the related industries of the state, may be studied and utilized at the earliest opportunity by all who are interested in such subjects.

Copies of this bulletin may be obtained from the secretary on application. FRANK J. ANNIS,

Secretary.

STATE AGRICULTURAL COLLEGE, FORT COLLINS, August 15, 1887.

REPORT

OF

EXPERIMENTS IN IRRIGATION

AND METEOROLOGY.

BY ELWOOD MEAD, B. S., C. E.,
Professor of Physics and Engineering.

INTRODUCTORY.

The object of this bulletin is to give an account of the experimental work for the present year of the department of Physics and Engineering, with the results obtained up to August 1. This work embraces meteorological observations, and experiments and investigations in subjects connected with irrigation. An increased knowledge of both subjects possesses for this state an exceptional interest and importance. The rapidity of the development of our irrigation interests by a people ignorant of the practice is without a counterpart, and has opened up many problems whose solution is urgently required, but which will require years of painstaking investigation. The study of our climate has both a commercial and scientific value. Greater attention is everywhere being paid to meteorological observations in connection with agricultural experiment work, but in this state the following facts lend additional importance to the work: We have a light rainfall and atmosphere of unusual dryness, solar and terrestrial radiation are very active, resulting in a considerable difference in temperature between day and night, while the number of hours of sunshine are nearly double that of some parts of the United States. The part that these exceptional conditions play in our agricultural successes and failures is worthy of attention.

While the settlement of all new countries produces a greater or less disturbance of existing conditions, the transformation wrought in the arid region by the development of its agriculture by irrigation is without a parallel. The wide spread belief that this has or is likely to result in a material change in our climate has aided in the agricultural development of the eastern part of the state where irrigation is not possible. The question of a change of climate can only be answered by careful observations running through a series of years. To give data for this work, as well as to obtain a record of the climate of some of the important agricultural districts of the state, auxillary stations were established the present season at Akron, Eastonville and Grand Junction. The first two being in the rain belt region, and the last on the western slope. The record for July appears in this bulletin. The rainfall record at Akron, is worthy of especial attention.

IRRIGATION EXPERIMENTS—DUTY OF WATER.

During the present season an accurate record has been kept of the volume of water used in the irrigation of two plats on the college grounds, in order to obtain data for an estimate of the "duty" of water. The college farm is not adapted to the conduct of experiments of this kind, the surface being uneven and the location of the numerous laterals such, that the area irrigated from each can not be clearly defined, an essential requisite. The original intention was to have one test consist in the measurement of the water on a field crop under ordinary cultivation; the other to be on the garden. In the test on field culture, however, I was restricted, by the difficulty before mentioned, to a portion of the experimental ground of Prof. Blount, composing 6.05 acres. This is divided up into plats of 42 rods, each planted with the various field crops, consisting of wheat, barley, oats and corn. The location of this plat is all that could be desired. The surface is even, with a gentle slope to the east. It is too high to be affected by seepage, the only water reaching it coming through the lateral where the measurements were made. The soil is stiff clay.

The record was kept by means of an automatic register, which recorded the depth of water passing over a weir placed in the lateral. The record after it was begun being continuous. The crest of the weir was of iron, filed true, and to a knife edge. In computing the discharge, the following formula was used:

Q=3.33 l h 3-2.

Q=Discharge in cubic feet per second.

L=Length on weir=17 inches.

H=Depth on weir in feet.

It is believed that the volume used is greater than that employed in ordinary irrigation, the watering of such small areas inevitably entailing considerable waste.

The soil of the college garden is a stiff clay, which has been loosened up somewhat by manures; it still, however, absorbs moisture very slowly. Nearly the whole of the garden has considerable slope, and in irrigating in furrows, from one-third to one-half of the water runs to waste. This fact should be kept in mind in considering tne volume required in its irrigation. The area of the plat is 2.1 acres; of this, .45 acre is experimental grasses and small fruits, the remainder being vegetables.

The water used on the garden was measured through a box invented by A. D. Foote, C. E., of Boise City, Idaho, the form of which is shown in the accompaning illustration, with the difference that the water passed out without pressure, the opening acting as a notch of adjustible width, the depth to remain constant. The depth of water passing through the box for April and May was fixed at six inches; after that at five inches. The form of the box is such that the regulation of the depth is very nearly automatic.

It was found that when the notch was more than two inches wide, the water in the lateral leading from it offered an obstruction to its free discharge. When the notch was six inches wide, the water in the lateral was about one inch above the bottom of the notch. A theoretical computation of the discharges under these conditions was not considered reliable, and a series of tests were made to determine this. The limits of this bulletin will not permit of a description of these tests, from which the following table of discharges was constructed:

Table Giving Discharges per Second and per Hour of the Measuring Box of College Garden Lateral.

Width of Notch in Inches.	Depth of water in inches.	Discharge per second in cubic feet.	Discharge per hour in cubic feet.
One-half	5	0.0450	162 00
One	5	0.0891	3 0.76
One and one-half	5	0.1153	415 08
Two	5	0.1515	545.40
Three	5	0.2202	792.72
Four	5	0 2889	1040.04
Five	5	0.3580	1288.80
Six	5	0.4271	1537.56
One	6	0.11623	418.33
One and one-half	6	0.16571	596.51
Two	6	0.21519	774 68
Three	6	0 29991	1079.67
Four	6	0 38463	1384.58
Five	6	0.47819	1721.48
Six	6	0.57176	2058.34

Table Giving the Dates of Irrigation and Quantity of Water Used in Irrigating the College Garden to August 1, 1887.

Date.	Number of hours run.	Width of notch in inches.	Volume discharged—cubic feet.	Total disch. for month—cubic feet.	Duty one cu. ft. per second—acres.
April 23	5 6	1	348.650	...	...
" 29	2½	6	5145.840	5494.49	...
May 1	3½	2	2506.245	...	...
" 6 to 7	14	3	15115.464	...	...
" 7	8	5	13771.872	...	...
" 9	4½	3	4858.542	...	...
" 9 to 10	13	5	22379.292	...	...
" 17	24	1½	7943.368	...	...
" 19 to 22	65	1½	36[illegible]83.080	...	...
" 25	4	1½	2269.728	105927.59	71.4
June 6	2½	1½	1082.700	...	...
" 8 to 11	72½	5	93438 000	...	...
" 11 to 12	19	3	14959 03	...	...
" 12 to 13	26¾	1½	115 4.89	...	...
" 13 to 16	78¼	½	12676.50	...	...
" 19 to 22	78	3	61832.16	...	...
" 22 to 24	50	1½	21654.00	217227.33	25.1
July 6	17	1½	7056.36	...	...
" 7 to 9	47	2	25633.80	...	...
" 9 to 12	83	3	65795.76	...	...
" 26 to 29	83	3	65795.76	...	...
" 30 to 31	27	3	21403.44	185685.12	30.3

**Table Giving Dates of Irrigation and Quantity of Water Used in Irrigating Experimental Plat on College Farm From June 1 to August 1, 1887.*

Date.	Number of hours run.	Mean depth on weir.	Volume discharged—cubic feet.	Total discharge for the month—cubic feet.	Duty one cu. ft. per second—acres.
June 1 to 6	144	2¼	204505.344	....	....
" 7	24	2	27124.128	....	....
" 8	24	2	27124.128	....	....
" 14	24	¾	6558.336	....	....
" 15	24	¾	6558.336	....	....
" 16	24	¾	6558.336	....	....
" 17	24	½	3570.768	....	....
" 20	24	¼	1261.152	....	....
" 21	12	¾	3279.168	....	....
" 22	15	¾	4098.960	....	....
" 23	11	¾	3005.904	....	....
" 24	18	7	5267.204	297911.764	52.7
July 5	24	¾	6558.336	....	....
" 6	24	1½	18553.392	....	....
" 7	24	1½	18553.392	....	....
" 8	24	1½	18553.392	....	....
" 9	12	1¾	11617.560	....	....
" 10	24	1¾	23235.120	....	....
" 11	24	2	27124.128	....	....
	8	2	9041.376	....	....
July 12	16	1	6732.576	....	....
	8	2	9041.376	....	....
	2	1½	1546.116	....	....
July 13	14	¾	3825.696	....	....
	11	1½	8503.638	....	....
July 14	13	¾	3552.432	....	....
" 15	24	1½	18553.392	....	....
" 16	24	½	3570.768	....	....
" 17	24	¼	1261.152	....	....
" 18	24	¼	1261.152	....	....
" 19 to 20	48	½	7141.536	....	....
" 21 to 23	72	1	[illegible]296.592	....	....
" 24	24	1½	18553.392	....	....
" 25	24	1¼	13969.296	....	....
	10	1¼	5820.540	....	....
" 26	14	1	5891.004	....	....
	12	1	5049.432	....	....
" 27	12	¼	630.576	....	....
" 28	24	½	3570.768	....	....
	9	½	1339.038	....	....
" 29	2	¼	105.096	230422.664	57.7

*Owing to a delay in the completion of the register, the record was not begun until June 1. Irrigation began about the middle of May.

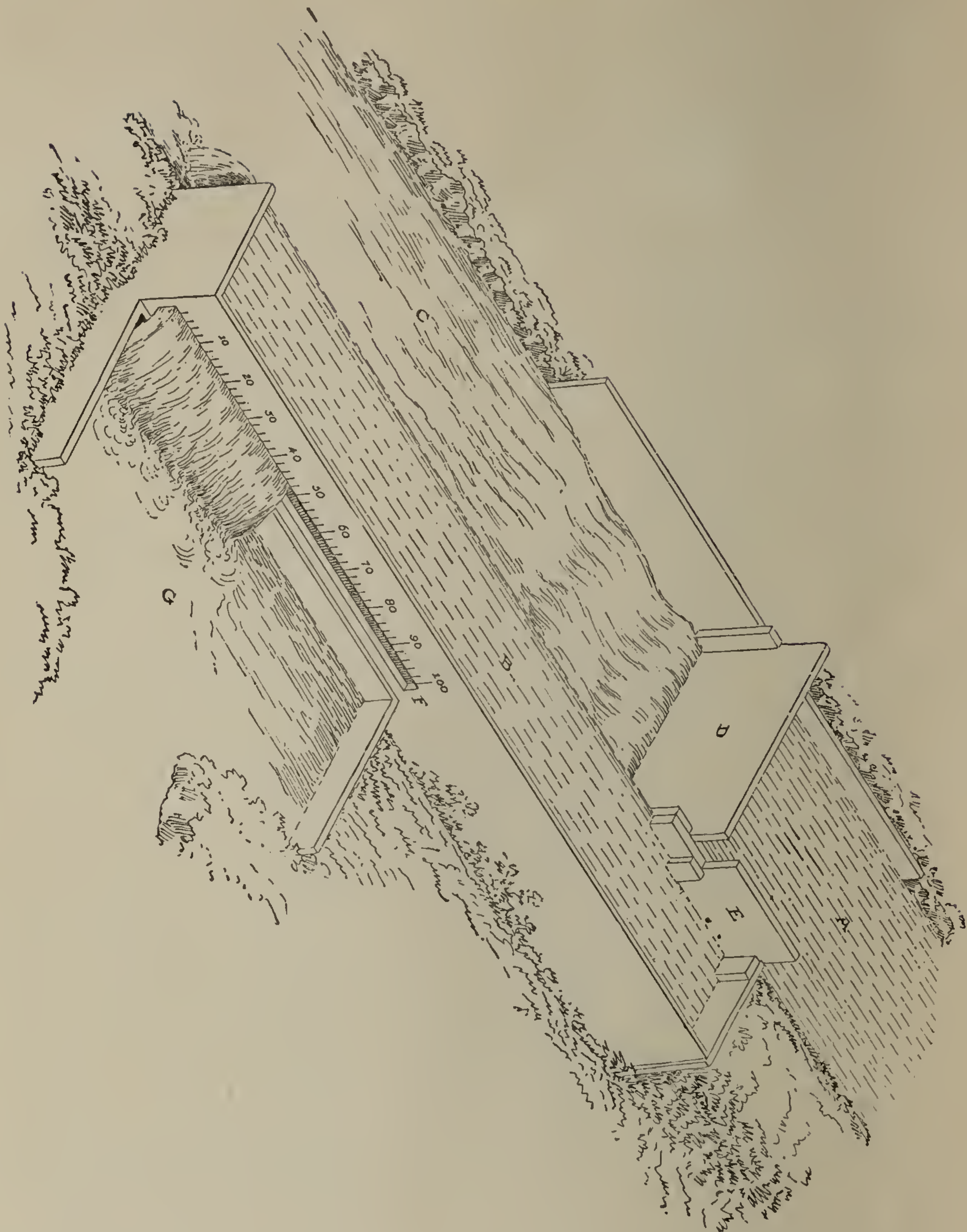
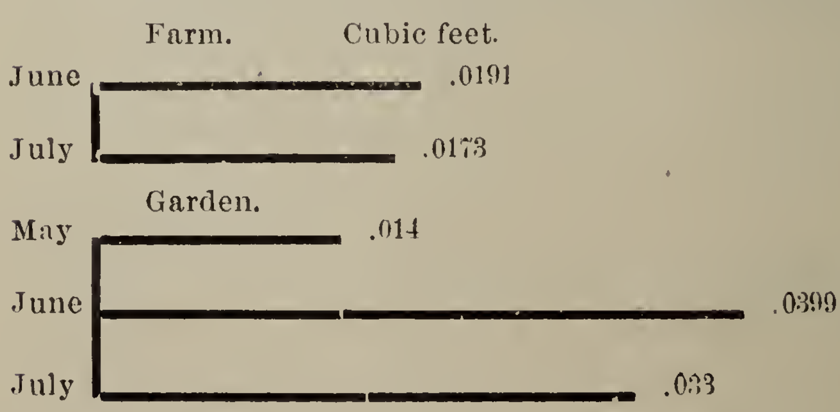


Diagram Illustrating Volume of Water Required.



NOTE—Length of line indicates the volume per second per acre.

ATMOSPHERIC EVAPORATION.

The record of the amount of evaporation from an exposed water surface has been continued since September, 1886. Since March 1st, of the present year, the record has included the loss for each day and hour of the day, an automatic register tracing the descent of the water surface by a pencil line on graduated paper. The register has thus not only served as an evaporometer, but as a rain guage as well. This continuous record, taken in connection with the meteorological observations of the college, has afforded an opportunity for studying the atmospheric influences which most affect the rate of evaporation, and as very little has been written on this subject, the principal causes will be stated:

The amount of vapor in the atmosphere.

The temperature of the air and water surface.

The pressure of the atmosphere.

Velocity of the wind.

Extent of water surface.

The diminished pressure of the atmosphere, at Fort Collins between one-fifth and one-sixth less than at sea level, tends to render the rate of evaporation excessive, as does the small amount of moisture in the air. Western winds increase evaporation by diminishing the amount of vapor in the air.

The box employed for holding the water was three feet square and two and one-half feet deep, sunk in the ground in an exposed place and kept filled with water to within six inches of the top. The small area of its surface would tend to make the rate of evaporation greater than from a reservoir, but this was compensated by the obstruction to the full effect of the wind.

Laying aside the disturbing actions of winds, the rate of evaporation depends on the difference between the force of vapor in the air and the maximum force of vapor for the temperature of the water surface, or it will be sufficiently accurate to say that other things being equal, the rate of evaporation bears a direct ratio to the difference between the temperature of the water surface and the dew point. When farthest apart, evaporation will be most rapid, and when together, it will cease.

The greatest recorded evaporation for twenty-four hours, was from noon, March 31st, to noon, April 1st, and was .4 inches. It was during the prevalence of a western, or "chinook" wind, which had already lasted two days. The mean temperature of the water surface was 53 degrees, and the mean dew point 9½ degrees. During the months of March and April, evaporation was very irregular, being greatest between the hours of 2 and 6 p. m., while frequently for several days there would be no perceptible loss. Since May, evaporation has gone on as rapidly during the night as during the day. The explanation which suggests itself is this: Irrigation began on the grounds surrounding the evaporation apparatus in May. During the day, when evaporation would otherwise be most rapid, the air is loaded with moisture by evaporation from the saturated soil. At night, owing to its more rapid cooling, evaporation from the soil ceases sooner than from the tank. To illustrate this, I have chosen a day at random, which happened to be July 23rd. The dew point for the hours of 7 a. m., 2 p. m. and 9 p. m., were 51, 62 and 55 degrees, respectively, and the temperature of the water surface for the same hours was 68, 82 and 74 degrees. The difference between the two temperatures, on which the rate depends, was respectively, 17, 18 and 19 degrees, showing that at 2 p. m. and 9 p. m. the rate should have been, and was, the same.

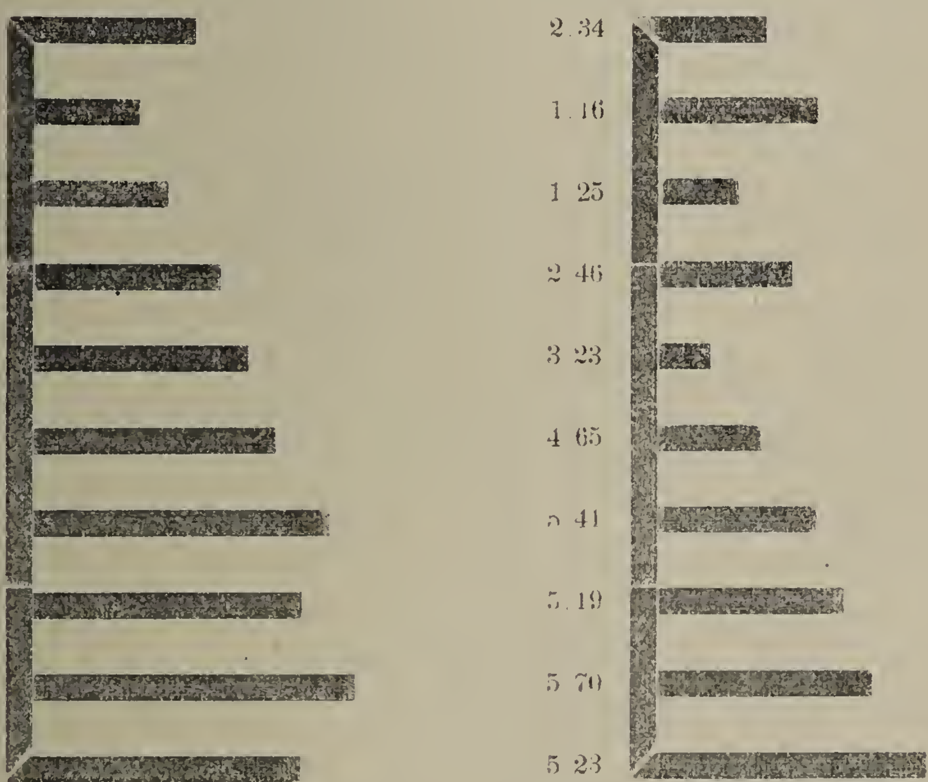
It is not probable that our mountain streams suffer any appreciable loss from evaporation, as their mean temperature is usually below that of the mean dew point. To test this matter, daily observations were taken at Fort Collins, of the temperature of the water of the Poudre River during June and July. For June, the mean temperature of the water was 59 degrees, while the mean dew point was 63 degrees. For July, the mean water temperature was 63, and the mean dew point 59 degrees. So that in the vicinity of Fort Collins, the river probably gained by its contact with the air during June, and lost during July. Below Fort Collins the increasing temperature of the water would cause the loss to be greater, while above, the reverse would be true.

The loss in canals varies with their location, size and velocity. The main loss from this source comes, however, after the water reaches the laterals here, and in flowing over the heated ground in irrigation the temperature is soon raised to a point where evaporation is greater than any here recorded.

That irrigation materially increases the humidity of our climate during the summer months is, I think, susceptible of proof.

Irrigating the ground surrounding the meteorological instruments sensibly affected the readings of the wet bulb thermometer, and I am confident that if the evaporation box had been situated anywhere in this vicinity outside the irrigated area, the loss for July would have been much greater. That any increase of the irrigated area will result in an increased rain fall for that area, is not to be believed, as owing to winds, rains seldom or never fall where their moisture is collected. Whatever change may be produced will be most likely to affect the country to the east of us, owing to the prevalence of western winds. During the months of June and July, the atmosphere takes up from the surface of the Poudre district at least one thousand cubic feet of water per second. Add to this the amount from the other districts, and it will be seen that several rains for some more favored region, accumulate on the Platte and its tributaries during the season.

Diagram Illustrating Evaporation Record.



	Inches per month.	Rainfall. Inches
1886 October	2.34	.69
November	1.16	1.18
December	1.25	.36
1887 January	2.46	.86
February	3.23	.23
March	4.65	.45
April	5.41	1.10
May	5.19	1.23
June	5.70	1.96
July	5.23	3.07
Total for 10 months	36.62	Total 12.13

NOTE—Observations continued for four years of the rate of evaporation from a box four feet square, three feet deep, near New York City gave a mean annual evaporation of 24.15 inches, the mean annual rainfall for the same time being 40 inches.

METEOROLOGICAL OBSERVATIONS.

The last report of this department gave a summary of the observations for the year, to June 1st. Only a few of the more important facts of the subsequent record, therefore, will be given in this bulletin.

The following instruments have recently been added to the equipment of the station: Self registering barometer and thermometer, solar and terrestrial radiation thermometers and sunshine recorder.

From the record of the registering thermometer, the coldest period at night is between 5 and 6 a. m., the temperature falling steadily to that hour. The hour of maximum temperature is not so well defined, but is usually about 3 p. m. The mean maximum temperature for June and July was 84 degrees, and the mean minimum temperature 53 degrees, giving a mean daily range of 31 degrees.

The mean maximum temperature in the sun was 148 degrees, or 64 degrees above that of the shade. The mean temperature of the terrestrial radiation thermometer was 45 degrees, or 8 degrees below the mean minimum.

Temperature and Rainfall Record for July.

Station.	Max temperature...	Min. temperature...	Mean temperature.	Relative humidity..	Days of rainfall....	Total rainfall-inches	Name of Observer.
Akron.............	100	60	72	58	7	6.1	Vance & Stephenson...
Eastonville	96	46	67	76	20	4.02	J. C. Plumb. ..
Grand Junction....	98	64	76	90	8	2.23	Dr. L. F. Ingersoll......
Fort Collins.......	97	50	69	69	9	3.07	....

THE

State Agricultural College

OF COLORADO.

BULLETIN NO. 2.

REPORT OF EXPERIMENTS

IN THE

FARM DEPARTMENT

ON

Grains, Grasses and Vegetables.

DECEMBER, 1887.

☞ Copies of this Bulletin may be obtained from the undersigned.

FRANK J. ANNIS, Secretary.
Fort Collins, Colo.

FORT COLLINS, COLO.:
THE COURIER POWER PRINTING HOUSE.
1887.

REPORT OF EXPERIMENTS

WITH

GRAINS, GRASSES AND VEGETABLES

ON COLLEGE FARM, 1887.

BY A. E. BLOUNT, A. M.,
Professor of Agriculture.

The following are reports of trials made with different varieties of vegetables, grains, grasses and forage plants on the College farm and experimental grounds for the season just closed.

In these departments, the facilities for extensive work have been limited, hence there is a limit to the work done and the results attained. So far as it has been carried on, however, it has been as well done and as extensive as circumstances would allow. The experimental work during the past season has been about in the same line as in years past, except that it has been more extended, successful, and attended with much more gratifying results. All the experiments, from which results have been compiled, have been in the line of testing different varieties of seeds for vitality, vigor, productiveness, adaptability to our soil and climate, and to determine their value as feed for stock and other purposes, as well as their probable success after acclimation. Many new seeds and plants have been introduced and tested one, two, three and four years. Among them are both native and exotic varieties grown in this latitude. For the past four years a very exact system of rotation has been observed on the experimental grounds, to keep up the fertility of the soil, so far as it is possible to do so by such operation. No fertilizers, either home made or commercial, have been used in connection with a single experiment, hence the results will show the real value of our mineral soil when treated to a regular and systematic course of rotation. In such a course, no plant was allowed to succeed itself, nor were the small grains grown except after hoed crops.

VEGETABLES.

BEANS.

Seventy varieties of table and and stock beans have been tested for three years in succession, the same seed being used each year. Most of these retained their vitality and their reproductive qualities to a remarkable degree, the average per cent. being 74.

The Green Flageolet and the New White Valentine ripened earliest, the Limas and the Black Pole Wax, latest. The Green Nonpariel, Long Pod Negro and Galega showed the greatest vitality, being 100, 99 and 98 per cent., the Limas, White Soja and Golden Wax the least vitality. The Galega and Dutch Case Knife were the most prolific, making 5 pounds 14 ounces from 99 seeds of the former, and from 77 of the latter, 5 pounds and 4 ounces. In the treatment and cultivation of these beans, the running varieties were not "stuck," nor had the soil on which they were raised ever been manured. Had the soil been moist when planted, they would have germinated readily, thereby making a greater per cent. in both vitality and productiveness. For snap varieties, the Wax and Southern Prolific are among the best. For shell beans, the Limas are very fine, but quite difficult to raise. In the culture of the running varieties, I find by selecting the pods for seed that grow lowest on the vine and ripen earliest, the vines can be materially shortened and still not lose their productive qualities; and also, I find, by selecting the last that ripen, and highest on the plant, the vines will not only grow longer, but the beans are a much longer time in ripening.

BEETS.

For three years the same seed of 22 varieties of table and stock beets havê been under cultivation. The Egyptian, Eclipse and the Early Blood are found to be the best for table use and market in summer, and for winter use, Bastian's Red is excellent. For stock, nearly all are good, the Mangels, Yellow and Red Globes taking the lead. For seed, specimens of all these were saved last year and set out this year in April. They produced an enormous quantity of seed—large, fine and heavy—far superior to that we buy.

CARROTS.

Of the many varieties of carrots in cultivation, only fifteen were considered worthy of a trial. The seed was three years old, and on account of the want of moisture in the soil, it had to be irrigated before germination, This operation often proves detrimental to small seeds. from the fact that many are exposed and killed by too much sunshine. Among the best for stock are the Danvers, White and the Yellow Belgian and Altringham. For table use and market the French Forcing, Early Scarlet Horn and the Half Long Red, are best.

PEAS.

Thirty-three varieties of garden and field peas were planted in April. The seed was received from Washington and New York, from Henry Lee and others. Those coming from the east brought the everlasting pea-weevil—a pest with which we had had no trouble until four years ago. But a single variety among all these has proved to be bug proof. The Canada Field not only resists the attacks of this insect, but it is the best pea in every other respect for field culture. Peas in some soils are much more difficult to raise than beans. More attention is required and better soil. Among the earliest varieties are Little Wonder, Tom Thnmb (true), Little Gem (new) and the old Tom Thumb. All the earliest kinds are smooth and have a taste quite foreign to the pea family, while the wrinkled peas are superior in all respects. The best of the latter are, for table use, American Wonder, Yorkshire Hero, Telephone and the Stratagem. The most prolific field pea, mentioned above, produced this year $8\frac{1}{2}$ pounds from 94 seeds planted. In field culture it produced at the rate of 23 bushels per acre on quite poor land and without manure. Similar experiments have been made with cabbage, fenugreek, mustard, onions, parsnips, rape, pumpkins, peanuts, okra, squashes, turnips, potatoes, cucumbers, tomatoes, egg plant, endive, Swiss chard, kohl rabi, peppers, lupins, radish, lentils, comfrey and other plants and seeds.

TEXTILE PLANTS.

FLAX.

For several years the common flax is the only variety that has been cultivated. This and last season the comparative value of four additional kinds have been tested for their yield and strength of fiber. The seed was sown in April and had to be irrigated before it would come up. After two cultivations and two irrigations they were harvested and threshed; the Common from 2 ounces seed making 12 pounds; King's from 2 ounces seed making 15 pounds; Royal from 3 ounces seed making 13 pounds; Russian from 2 ounces seed making 24 pounds; European from 4 ounces seed making 58 pounds. All except the last are cultivated for both seed and fiber, while the European is grown only for seed, it being short in growth and full of seed branches. On better land and by sowing thicker it has produced from 12 to 18 pounds per square rod.

HEMP.

Our soil and climate are well adapted to the cultivation of hemp. It grows vigorously, making remarkably good seed and strong fiber. The stalks of the female plant are large, tall and densely covered with seed, while the male stalk is quite inferior in every way.

The seed is double the size of that planted, much lighter in color and heavier. The bark is one of the most handy materials on the farm for tying purposes. Ramie, jute and cotton have been raised, but their period of maturity being too long, they failed to ripen either seed or fiber.

OTHER PLANTS.

BROOM CORN.

As broom corn is so valuable and the seed in such demand, six different varieties have been experimented with for several years. None doing so well as the Evergreen, it was selected to be improved and the rest were discarded. By very careful selection of seed, the Evergreen has been made much better in all respects. All the poor seed heads were cut away before ripening to prevent crossing their poor qualities upon the best, and the best has been bred up by a continued selection until it has so improved that the brush is much longer, finer and straighter and of a brighter color. The red rust, so often seen on broom corn and the aphis so often found under the sheaths of the leaves, do not infest this improved variety nearly so much as the poorer kinds.

KAFFIR CORN.

The Kaffir corn is a species of sorghum, non-sacharine and drought proof. For feed, both foliage and seed are very valuable. Branching profusely like Teosinte, it makes an enormous crop of fodder by the middle of July. On being cut, another crop can be made before frost. It produces much more seed than sorghum, single heads making sometimes a pound. It is like Doura, but larger, and is most excellent for stock. In Georgia, very fine flour, it is said, is made of it and is nearly or quite as good and nutritious as that made of wheat. The seed was received from Africa.

FIELD CORN.

Of 35 varieties of field corn, but two have been in any way improved. The Pride of the North and the Yellow Flint, having proved most valuable, have been selected for several years. The former is by far the most prolific and worthy. From a six ounce ear, received from Sibley, growing singly on the stalk, in five years, the ears have been made to average eight to ten ounces and have been doubled on the stalk. Reports from those who have planted the same seed are most flattering. The fodder is fine and when cut before frost and well cured, stock prefer it to hay. When selected for seed all stalks bearing two ears or more are left standing in the field until dead ripe, and when they are cut up the top ears only are saved, and only those that are well formed and have straight rows. By judicious selection of the first ears that ripen, the period of maturity has been materially shortened. This variety the first year was 141 days ripening. This year it ripened in 98, and in the fields of some farmers in 90 days.

GRASSES.

Since the College was opened in 1879, the tame grasses have received considerable attention. Much difficulty has been experienced in getting the seed to germinate. After repeated trials, however, good stands have been secured with all except 5 of the 34 species that have been tried. The leading and most valuable varieties that succeed best are Timothy, Orchard, Kentucky Blue, Redtop, the Fescues, English and Italian rye, Hungarian Brome and some others of no great value for feeding purposes. The best for pasture is a mixture of several kinds with clover.

CLOVERS.

Alfalfa stands at the head of all clovers in nearly all respects. It needs no comment. Its feeding value and success as a hay crop is excelled by no other plant. As hay, its value may be seen in the experiment made last year. Four steers were fed one month on it and one on red clover. They consumed each from 133 to 221 pounds more clover hay per month than alfalfa, and in no case was the per cent. of gain less in the alfalfa months, but considerably more. This fact may be clearly seen in the feeding experiment illustrated in the following table. Three steers were fed 4 months on alfalfa, clover, chop and roots. They consumed in

Oct. and Dec.		Nov. and Jan.	
2805 lbs alfalfa	Gain, 270 lbs	3858 lbs clover	Gain, 240 lbs
558 " chop		675 " chop	
1275 " roots		1830 " roots	

Each steer is credited the same amount of chop and roots inasmuch as they were given in limited quantities, but of the hay each had all he would eat. Taking, then, the hay as a base, the alfalfa made a difference in gain of 20 pounds and 1053 pounds less of it was fed, showing clearly its superior value for a feeding plant. As a fertilizer it has no superior, if reports from those who have tested it are true. It not only can be turned under, as red clover is turned, but in the operation it enriches the soil and at the same time is not itself at all impoverished but greatly benefited, even so far as to make a good crop itself the same year of hay and sometimes of seed.

RED CLOVER.

This year red clover on the same ground made two crops of seed, and that without water. Last year the first crop was saved for seed, being cut in July. It threshed out a few pounds more than five bushels per acre, and in October a crop of two tons per acre of hay was taken off. This year in July again, the first crop was saved for seed as was the second crop, cut in October. Both were threshed, the first crop making four bushels per acre and the second a few pounds over one; the two making only a few pounds more than the single crop of last year. The seed of the first crop weighed

63 pounds, of the second, 62 per bushel. Had the clover been irrigated, the yield would have been greater, but I doubt whether the seed would have been as good and heavy. The White clover, Alsike, Sapling, Crimson, Japan and Burr clovers, White and Yellow Bokhara, Spanish Trefoil and Sainfoin have all been carefully tested. The Bokharas and Trefoil are fine plants for bees, but poor for hay.

MILLETS.

From seed improved by careful selection, the German, Golden, Italian and Hungarian millets have given very satisfactory results this year, producing a large and greatly increased amount of hay and heavy seed. Nearly double the amount of hay and seed have been made by sowing the selected seed of the German and Hungarian.

The Common, French Red and White, the Pearl and Evergreen have also been under cultivation with no uncommon results, the two last failing to succeed—one to mature, the other to live through winter.

SORGHUM.

Fourteen varieties of both native and foreign sorghum seed were received from various sources to be tested at the College. All kinds from Asia and Africa have so far failed to mature the seed. The Early Amber, Orange and Minnesota ripen both seed and stalk, the former being much the best. The stalks and seed of them all are found to be excellent feed for cattle.

THE CEREALS.

BUCKWHEAT.

Only the Common Black and the Silver Hull varieties of buckwheat have been raised. The demand has has not yet been great enough to give much attention to the improvement of this grain; however, these two kinds have been greatly improved by selection of seed for two years, insomuch that the yield has nearly doubled under the same treatment. Planted in rows 16 inches apart, at the rate of only four pounds per acre, it made a stand as dense and thick as any crop heretofore raised. On being carefully cut early in the morning when wet, the seed is all saved. One pound, in this experiment, on 40 square rods, produced 340 pounds, which would be at the rate of 33 bushels per acre.

Much attention has been given to the improvement of wheat, barley, oats and rye. Experimental work has made a difference of not a few cents per bushel on them, benefiting not only the individual farmer by being able to produce more, but the State by putting better grain for the farm and for the mill in circulation. The experiments have been conducted in such a way that each variety has has been gradually improved in all respects. The milling and feeding elements have been improved by a systematic method and course of crossing and selection, and especially in the wheats, and they have also been rendered more hardy. Many varieties of wheat, the seed of which has been received from time to time from all sections and all countries, have been grown, selected and bred up, and their comparative value carefully noted each year, the better to know which to encourage and which to discard. In raising a crop from the seed received the first year, not a single kind but makes better looking and heavier grain than that received. This fact speaks well for our climate and soil. The wheats from Russia and Germany make the best grain for flour, while those from Africa are flinty and of a very low grade of gluten, making them poor milling varieties. Australian and Indian wheats, being nearly all bearded varieties, are strong in milling elements but are objectionable to millers on account of their deep crease and low grade of gluten. The following comments and tables serve to show how greatly small grain can be improved, how good seed can be made to increase the yield, how thin seeding is an advantage to the growth and quality of the grain, and how many other things in the operation of improving them favor their yield, vitality and vigor. These cereals have been sown in two ways—one as the farmer sows his grain, the other in the way it is done experimentally—in rows, every grain in its place and cultivated.

BARLEY.

One-fourth of an acre was sown as the farmer sows his seed, to barley. The variety was the Chevalier—a two-rowed brewing kind. It is considered and has proved to be the most prolific on the College farm. The seed sown was very carefully selected and saved last year, and $4\frac{1}{8}$ pounds of it was drilled in at the rate of only $16\frac{1}{2}$ pounds per acre. It was sown two inches deep at the rate of from 4 to 8 ounces in each double row 20 rods long.

Double	row	1—	4	ounces	seed	made	33 pounds.
"	"	2—	6	"	"	"	38 "
"	"	3—	8	"	"	"	$44\frac{1}{2}$ "
"	"	4—	6	"	"	"	26 "
"	"	5—	6	"	"	"	39 "
"	"	6—	4	"	"	"	$41\frac{1}{2}$ "
"	"	7—	6	"	"	"	56 "
"	"	8—	8	"	"	"	$45\frac{1}{2}$ "
"	"	9—	6	"	"	"	$42\frac{1}{2}$ "
"	"	10—	6	"	"	"	50 "
"	"	11—	6	"	"	"	40 "
			66	ounces.			456 pounds.

9.5 bushels, at the rate of 38 bushels per acre.

It will be noticed that the thin sowing in this experiment is not far below the thicker in yield. The small amount of seed sown shows clearly that improved seed is far better and more vital. Barley, like wheat, oats and rye, has habits that must be indulged, or the growth and yield will be injured. This habit of stooling in wheat, rye, barley and oats, should in all such plants be respected. A single grain of the above cereals will, when allowed enough space to carry out its habit of stooling, occupy at least a square 4 by 4 inches, or 16 square inches. When too thickly sown, these grains become their own worst enemies—that is, thick sowing crowds out what should be permitted to develop, viz., the stooling. A bushel of wheat contains all the way from 650,000 to 900,000 grains, which, when sown evenly over an acre, is about twice too thick. There are three requisites to thin sowing, viz., good seed, good soil and a soil in good condition.

RYE.

In the same manner has rye been improved, and $3\frac{7}{8}$ pounds were sown in 10 double rows of the same length, and from one to eleven ounces in each.

Double	row	1—10	ounces	made	$29\frac{1}{2}$	pounds
"	"	2— 3	"	"	$18\frac{1}{2}$	"
"	"	3— 9	"	"	29	"
"	"	4— 4	"	"	$20\frac{1}{2}$	"
"	"	5—11	"	"	$31\frac{1}{2}$	"
"	"	6— 3	"	"	$21\frac{1}{4}$	"
"	"	7— 8	"	"	22	"
"	"	8— 3	"	"	$19\frac{1}{2}$	"
"	"	9— 9	"	"	$34\frac{3}{4}$	"
"	"	10—20	"	"	$21\frac{1}{2}$	"
		62	ounces		248	pounds

Seed, $15\frac{1}{2}$ pounds per acre. 4.43 bushels.
Yield, 19.36 bushels per acre.

In this experiment the thin sowing has but little, if any, advantage over the thicker. The small yield of 19.36 bushels per acre is due more to the want of fertility and moisture to germinate the seed than to the thin seeding. The fertility of the soil had been kept up by rotation, no manure having in any way or at any time been applied.

OATS.

A fourth of an acre was given to oats—the Australian—a variety that has been improved for six years. Just 4 pounds were sown from 5 to 7 ounces in each double row 20 rods long.

Double row	1—	6	ounces	made	25	pounds
" "	2—	5	"	"	25	"
" "	3—	5	"	"	26	"
" "	4—	6	"	"	23	"
" "	5—	6	"	"	29	"
" "	6—	7	"	"	29	"
" "	7—	6	"	"	23	"
" "	8—	5	"	"	28	"
" "	9—	5	"	"	37	"
" "	10—	6	"	"	31½	"
" "	11—	7	"	"	28	"
		64	ounces		304½	pounds

Seed, 16 pounds per acre. 9.5 bushels.
Yield, 38 bushels per acre.

These oats are the largest and finest looking of any that have been raised in this section. They weigh as high as 52 pounds per bushel. They yield, under experimental treatment over 100 bushels per acre.

SPECIAL WHEATS.

Half an acre of very ordinary land was laid off in rows 20 rods long, and nine varieties of special improved wheats were sown at the rate of from one to five ounces in each single row. These wheats have been crossed and bred up for three, four and five years. They clearly show their breeding in their yield and growth. The seed, to make it the very best, was hand picked the year before. After wheats have been crossed making new varieties, it takes at least three years to "fix" them. When first planted after crossing, the half and half grain does not breed true. It follows both father and mother and sometimes will pick up a characteristic belonging to an ancestor still further back. The crossed grain has to be bred in line, as stock is, for three or four years, before it will come true, or before it becomes a standard.

College No. 300—	1 oz. made	16 lbs.	College No. 302—	3 oz. made	21 lbs.
" 300—	3 " "	12½ "	" 302—	2 " "	14¼ "
" 300—	2 " "	12½ "	" 302—	2 " "	18 "
" 300—	2 " "	19 "	" 303—	1 " "	18 "
" 301—	2½ " "	14½ "	" 303—	3 " "	14¾ "
" 301—	1½ " "	14½ "	" 303—	2 " "	13¾ "
" 301—	1 " "	15¼ "	" 303—	2 " "	16 "
" 301—	3 " "	13½ "	" 304—	1 " "	7½ "
" 301—	2 " "	19 "	" 304—	3 " "	11 "
" 301—	2 " "	13 "	" 304—	2 " "	11 "
" 302—	1 " "	16 "	" 304—	2 " "	14 "
				44 oz.	325 lbs.
Seed, 11 pounds per acre.					
Yield, 21.64 bushels per acre.				4.41 bushels.	

These wheats were put in under quite unfavorable circumstances. The soil was exceedingly dry and there was no water in the ditches to assist germination. A part of it came up within two weeks after it was planted, and the rest did not even germinate until after it had been irrigated. The table shows that thin seeding is again not far behind.

College No. 305—	2 oz. made	13¼ lbs.	College No. 307—	3 oz. made	18 lbs.
" 305—	2 " "	12½ "	" 58—	1 " "	24 "
" 305—	2 " "	21 "	" 58—	2 " "	17½ "
" 305—	2 " "	11½ "	" 58—	2½ " "	9 "
" 306—	2 " "	18 "	" 58—	3 " "	15½ "
" 306—	2 " "	13½ "	" 58—	3½ " "	14¼ "
" 306—	2 " "	18 "	" 58—	4 " "	11¾ "
" 306—	2 " "	16 "	" 58—	4½ " "	16 "
" 307—	1 " "	17¼ "	" 58—	5 " "	11 "
" 307—	2 " "	17½ "	" 58—	1 " "	24 "
" 307—	2½ " "	22½ "	" 58—	1 " "	18 "
				52 oz.	360 lbs.
Seed, 13 pounds per acre.					
Yield, 24 bushels per acre.					6 bush.

In these experiments, the yield is very arbitrary and quite puzzling withal. Each row and every variety were treated alike in every respect. The thickest sowing in this plat shows up poorly, while the thinnest (No. 58), shows the greatest yield.

The following list of wheats, oats and barley embody a few spring and winter varieties of wheat, some of the seed of which has been received from foreign countries, and others that have been changed and are being changed from Winter to Spring wheats. The table shows how many grains out of 100 planted, germinated, their yield in pounds and ounces, yield per acre and the number of days ripening:

WHEAT.

College No.	Names of Varieties.	No. Grains Germinating.	Yield, in lbs. and oz.		Yield per Acre.	No. Days Ripening.
			lbs.	oz.		
8	Defiance	89	3	8	28	127
34	Pringle's No. 4	85	3	8	28	136
42	Granite	89	3	12	30	137
57	Amethyst	78	4	...	32	117
171	Hebron	76	4	...	32	127
187	St. Leger	90	..	12	6	123
285	Dagar	81	3	4	26	139
322	Dayton	80	3	...	24	135
339	Egyptian Flint	68	3	...	24	140
342	India	69	3	...	24	140
323	Rochester	90	2	4	18	130
341	Martin's Amber	85	2	...	16	136

OATS.

College No.	Names of Varieties.	No. Grains Germinating.	lbs.	oz.	Yield per Acre.	No. Days Ripening.
1	White Dutch	81	3	8	52½	115
2	Board of Trade	82	3	8	52½	119
3	Australian	92	2	12	41¼	120
4	Black American	92	5	...	75	130
5	Pringle's Hulless	56	2	4	34	134
6	Pringle's No. 6	95	5	4	78¾	141
7	Pringle's No. 4	80	3	4	49	122
8	Pringle's No. 5	73	4	8	67½	142
9	Belgio Russian	81	4	8	67½	121
10	Schonon	80	4	4	64	133
11	Black Russian	84	4	4	64	134
12	Alexander	64	4	12	67½	119
13	New Zealand	87	5	8	82½	134
14	White Russian	92	5	12	86	137
15	Black Tartarian	77	4	...	60	111
16	Early Yellow	71	4	...	60	122
17	" Poland	90	4	...	60	124
18	Poland	65	4	4	64	124
19	Potato	65	4	...	60	140
20	Early Angus	71	3	...	45	130
21	Chinese Hulless	45	1	4	19¼	131
22	Triumph	72	4	8	67½	115
23	Pringle's Excelsior	70	1	...	15	129
24	Rust Proof	88	2	4	34	131
25	White Eureka	82	6	12	101	140
26	Welcome	74	3	8	52½	122
27	Novelty	89	6	...	90	141
28	South Carolina Black	89	3	8	52½	122
29	Golden Sheaf	81	5	4	78¾	121
30	Probstier	84	5	8	82½	122
31	Clydesdale	88	2	12	41½	121
32	Colorado Yellow	81	4	12	71	122
33	Austrian No 1	85	4	4	64	138
34	Austrian No 2	79	2	12	41½	119
35	American Beauty	83	3	...	45	117
36	Burpee's Welcome	89	3	8	52½	144
37	Bohemian	62	2	8	37	122
38	White German	90	4	...	60	119
39	Black Champion	50	3	8	52½	137

OATS—CONTINUED.

College No.	Names of Varieties.	No. Grains Germinating.	Yield, in lbs. and oz.		Yield per Acre.	No. Days Ripening.
			lbs.	oz.		
40	Monarch	84	1	12	26	115
41	Dakota	77	2	12	41¼	119
42	Race Horse	83	3	12	56	129
43	Canadian	91	4	8	67½	133
44	Black Swiss	78	3	8	52½	115
45	Victoria	73	3	...	45	122
46	Hopetown	72	4	8	67½	140
47	Waterloo	84	4	8	67½	130

BARLEY.

College No.	Names of Varieties.	No. Grains Germinating.	lbs.	oz.	Yield per Acre.	No. Days Ripening.
1	Smooth Hulless	84	3	...	30	114
2	Winnepeg No 1	83	3	8	35	114
3	Winnepeg No 2	80	3	8	35	123
4	New Zealand	82	3	8	35	121
5	Chevalier	84	5	8	55	112
6	Zealand	84	4	12	47½	112
7	Winter, 6-rowed	73	6	4	62½	126
8	Purple	72	3	12	37½	116
9	Melon	99	4	...	40	117
10	Nel Norte	76	4	12	47½	116
11	Triumph	67	4	12	47½	116
12	India	88	4	12	47½	116
13	Kilima	93	5	...	50	117
14	Scotch Annat	93	3	8	35	116
15	Black	96	6	...	60	116
16	Palestine	71	3	12	37½	117
17	Annat	93	3	8	35	127
18	Guyamale	82	4	12	47¼	116
19	Manchurian	66	3	12	37½	.....
20	Fricks	79	5	...	50	.....
21	Spring, 4-rowed	75	4	12	47½	.....
22	Eufurt	93	4	4	47½	.....
23	Nepaul	79	4	12	47½	.....
24	Winter, 4-rowed	76	4	12	47½	.....
25	Phœnix	77	4	12	47½	.....
26	Sibley's Improved	78	5	8	55	.....
27	Mansury	72	5	...	50	.....
28	Adam's Heavy	94	5	8	55	.....
29	Sibley's Pearl	92	2	12	27½	.....
30	Sibley's Purple	95	5	...	50	.....
31	Battledore	76	3	8	35	.....

In the cultivation of the above-named varieties of oats and barley, I find the same variety comes under different names. The White Australian oats, for instance, imported some ten years ago, appear now under as many as six different names, as follows: White Eureka, Welcome, Novelty, Clydesdale, American Beauty, Burpee's Welcome. The old Scotch Fife wheat appears as the Saskatchewan, Manitoba and Improved Fife.

THE

State Agricultural College

OF COLORADO.

BULLETIN NO. 3.

CONCERNING THE DUTIES OF THE SECRETARY

OF THE

STATE BOARD OF AGRICULTURE,

AND THE DISTRIBUTION OF

COLLEGE SEEDS AND PLANTS.

DECEMBER, 1887.

FORT COLLINS, COLO.:
THE COURIER POWER PRINTING HOUSE.
1887.

CONCERNING THE DUTIES OF THE SECRETARY

OF THE

STATE BOARD OF AGRICULTURE,

AND

DISTRIBUTION OF SEEDS.

The Secretary of the State Board of Agriculture desires to call attention, by means of this bulletin, to some of the provisions of the statute concerning the duties of his office, and which should be of general interest to the public, and more especially to those engaged upon the farm and garden. Among the duties imposed by law upon the Secretary are the following:

* * * "He shall keep and file all reports which may be made from time to time by the different agricultural and horticultural societies, and all correspondence of the office from other persons and societies, appertaining to the general business of husbandry; address circulars to societies and the best practical farmers in the state and elsewhere, with a view of eliciting information upon the newest and best methods of irrigation, and the culture of those products, vegetables, trees, etc., adapted to the soil and climate of this state; also on all subjects connected with field culture, horticulture, stock raising and the dairy. He shall encourage the formation of agricultural societies throughout the state, and purchase, receive and distribute such rare and valuable seeds, plants, shrubbery and trees, as it may be in his power to procure from the general government and such other sources, as may be adapted to our climate and soils."

* * * * * *

"He shall aid, as far as possible, in obtaining contributions to the museums and library of the State Agricultural College, and thus aid in the promotion of agricultural science and literature." (*Pt. Gen'l Sec.* 29, *Gen'l Laws* '83.)

* * * * * *

"The seeds, plants, trees and shrubbery received by the Secretary, and not needed by the College, shall be, as far as possible, distributed equally throughout the State, and placed in the hands of those farmers, and others, who will agree to cultivate them properly and return to the Secretary's office a reasonable proportion of the products thereof, with a full statement of the mode of cultivation, and such other information as may be necessary to ascertain their value for cultivation in this State." (*Gen'l Sec.* 30, *Gen'l Laws* '83.)

Since the organization of the State Agricultural College, in 1879, little has been done to carry into effect the foregoing provisions of the statute, owing to the limited means at the command of the State Board of Agriculture.

The Secretary wishes to open correspondence with the agricultural and horticultural societies of this State, with a view of securing their reports and information concerning the progress of husbandry in different parts of the State; and such parts as may be considered of general public interest will be published in the annual reports of the State Board of Agriculture to the Governor.

The State Board of Agriculture was created and organized for the purpose of not only giving its attention to the control and direction of the State Agricultural College, but that it might aid and assist in developing and giving strength to the general business of husbandry throughout the State.

This work is largely to be performed through the Secretary's office, as will be observed from the statutory provisions, and the business of that office has been arranged and this bulletin prepared with that end in view.

With the growth of the College, the two principal departments, of agriculture and horticulture, have been engaged in the selection and improvement of seeds and vegetables in their respective departments, and considerable has been accomplished in that direction.

The College has now on hand a general assortment of farm and garden seeds, which are held for free distribution. All applications for seeds should be addressed to the Secretary, and the name and post office address of applicant plainly written. All persons receiving seeds from the College are expected to comply explicitly with the conditions under which they are sent, and make the report on the form furnished by the Secretary.

The College has a large collection of different varieties of potatoes, a few pounds of each variety, which can be had upon application to the Secretary. The potatoes will not be distributed until early spring, on account of danger of being frozen in transit at this season of the year.

Applications will be received for shrubs and trees, and if the College has them to spare, they will be furnished under the same conditions as seeds.

It must be distinctly understood that this is not a bureau organized for the distribution of seeds and plants upon a charitable basis.

Considerable labor and much time and patient attention to details, will be required of those who undertake to experiment with the seeds and plants sent from the College. The keeping of the record and the faithful and honest return thereof to this office, will constitute the principal consideration for the favors extended by the College and the people of this State.

It is expected that from the correct and substantial information obtained concerning the utility and adaptability of these seeds and vegetables, throughout the different parts of the State, something will be added to the material growth of the farm and garden industries of the commonwealth.

Bulletins are being published, under the direction of the Board, of experiments conducted at the State Agricultural College, copies of which may be had on application to the Secretary.

FRANK J. ANNIS,
Secretary.

THE STATE AGRICULTURAL COLLEGE.
FT. COLLINS, COLO., DEC. 10, 1887.

The State Agricultural College

EXPERIMENT STATION.

BULLETIN NO. 4.

REPORT OF EXPERIMENTS WITH

POTATOES AND TOBACCO.

FORT COLLINS, COLORADO.

FEBRUARY, 1888.

The Courier Print, Fort Collins.

Report of Experiments with Potatoes and Tobacco.

BY JAMES CASSIDY,
Professor of Botany and Horticulture.

EXPERIMENTS WITH POTATOES.

Experiments have been conducted at this station for the past four years with garden crops in general, and with the potato in particular.

The scope of this work with the latter is indicated by the following synopsis of experiments:

First—A comparative test of varieties.
Second—Originating new varieties.
Third—Methods of seed cutting.
Fourth—Potatoes under mulch.
Fifth—Potatoes without irrigation.
Sixth—Application of fertilizers.
Seventh—Crosses.

The time at which this bulletin is issued precludes the consideration of that important element in determining the value of different varieties, *i. e.*, their cooking quality. A variety to rank high should stand well in this particular regard. Shape and color are to some extent important, but in a less degree than the quality mentioned.

The claim of best for each new kind is perhaps not altogether devoid of reason, because some varieties do better under certain conditions than others, and some kinds, too, seem to have their peculiarities so well fixed as not to be seriously affected by the most adverse conditions. There are probably some soils, too, in which particular varieties of the potato deteriorate, or, like some fruits, they are adapted only to the surroundings in which they originated. This would seem to be the case with some old varieties, like the Neshannock, which have lost their ability to bear tubers, unless grown under the most favorable conditions.

The soil on which these varieties have been grown continuously for three years is a clay loam. It has been enriched annually, and very liberally, with manures calculated to improve its tilth and fertility.

The varieties in competition were treated as nearly alike as possible, in regard to soil, seed, cultivation and irrigation. The seed pieces were confined to one eye sets of good substance, cut from large tubers, and were planted May 15th, in rows three feet apart, the sets one foot apart in the row. Ten hills of each kind were experimented with.

The best potato soils are loose, sandy loams, and if so situated as to be contiguous to irrigating ditches, as on side-hills, maximum crops may be raised with the minimum of labor and attention. Loose, friable, moist and cool soils are most congenial to the tubers of this plant. Its nature would suggest this, because the tuber must push the soil from around it during the process of growth, and if the soil be hard and lumpy, the tuber will be misshapen, and its vital forces seriously impaired. We irrigated three times, the frequency of which would depend upon such contingencies as the slope of the land, its position in reference to seepage, character of the soil, rainfall during the growing season, from all of which will be seen the difficulty present in attempting to estimate the quantity of water necessary to mature any given crop. The tendency of all irrigation is to bind more solidly all adhesive, fine-grained soils, so that the first requisite of success, as regards soil, is to see to its mechanical condition, and that no flooding of the soil occurs, as the potato is extremely impatient of this. The most prolific varieties are uniformly so from year to year. If they are not so, such result may justly be attributed to the accident of location, which so frequently results in their getting too much water.

The blight which attacked all varieties of the potato three years ago has reduced the average yield for three years, particularly of the late kinds. The following table exhibits results in detail. The varieties are arranged according to yield, to better facilitate a determination of comparisons:

Table No. 1.

Number.	NAME OF VARIETY.	Weight of Table Potatoes—lbs.	Weight of Small Potatoes—lbs.	Yield per Acre—Bushels.	Average Yield for Three Seasons—Bushels.
1	Watson's Seedling	39	8	1,304 1-15	717 1-10
2	Perfect Peachblow	40	......	968	925 3-5
3	Rase's Seedling	38	......	919 3-5	769 3-5
4	Red Elephant	34	4	919 3-5	475 14-15
5	Junkis	38	2	968	....
6	Knapp's Snowbank	36	......	871 1-5	641 5-10
7	Cayuga	31	4	847	573 1-20
8	Jones' Prize-Taker	28	6	822 4-5	490 1-20
9	Weld's No. 4	30	3	798 3-5	882 3-10
10	James Vick	28	5	798 3-5	499 14-15
11	Alpha	29	5	774 2-5	570 1-10
12	Carpenter's Seedling	26	6	774 2-5	460 4-5
13	Cap Sheaf	31	2	798 3-5	494 1-5
14	Chicago Market	27	3	726	429 4-5
15	La Plume	25	5	726	436 3-10
16	Early Kent	25	5	726	454 3-15
17	Parson's Prolific	24	6	726	392 3-10
18	Corliss' Matchless	24	8	774 2-5	503 3-10
19	Early Rose	25	3	677 3-5	447 2-10
20	Queen of the Valley	22	4	629 1-5	509 1-20
21	Newton's Seedling	28	......	677 3-5	....
22	Enos' Seedling	28	......	677 2-5	....
23	Ranel's No. 42	23	3	629 1-5	....
24	Charter Oak	28	......	677 3-5	451 3-15
25	Brownell's No. 55	21	4	605	....
26	Churchill's Seedling	25	......	605	....
27	Belle	26	2	677 3-5	415 1 4
28	State of Maine	22	6	677 3-5	433
29	White Elephant	24	3	653 2-5	394 3-5
30	Early Sunrise	24	3	653 2-5	427 3 5
31	American Giant	41	......	629 1-5	435 3-5
32	Perfect Gem	20	6	629 1-5	444 4 10
33	Silver Skin	24	2	629 1-5	335 3-10
34	Jordan's Russet	23	3	629 1-5	431 3-10
35	Beauty of Hebron	20	5	605	483 3-15
36	Mammoth Pearl	20	6	629 1-5	338 4-5
37	Dakota Red	20	4	580 2-5	506 3 5
38	St. Patrick	20	4	580 2-5	303 3-10
39	Morton White	20	4	580 4-5	354 14-15
40	Kennedy	20	4	580 4-5	384 4 5
41	Home Comfort	22	2	580 4-5	290 4-10
42	Arizona	24	......	580 4-5	428 1-15
43	Clark's No. 1	20	2	532 2-8	319 14-15
44	Lee's Favorite	23	......	556 3-5	422 3-10
45	Crawford's Seedling	17	6	539 14-15	472 2 10
46	Salt Lake Queen	18	5	539 14-15	400 1-2
47	White Star	16	7	556 3-5	250 1-15
48	Butter Ball	15	8	539 14-15	308 3-15
49	Brownell's No. 31	18	4	532 2-5	....
50	Burbank Seedling	22	......	532 2-5	....
51	Carter	21	......	508 1-5	....

Table No. 1—Continued.

Number.	NAME OF VARIETY.	Weight of Table Potatoes—lbs.	Weight of Small Potatoes—lbs.	Yield per Acre—Bushels.	Average Yield for Three Seasons —Bushels.
52	Manhattan	18	3	508 1-5	490 1-10
53	Bliss' Triumph	18	3	508 1-5	....
54	Putnam	16	4	484	....
55	Champion of America	14	6	484	317 14-15
56	Breezze's No. 6	17	3	484	339 5-10
57	Grange	16	4	484	391 1-2
58	Collum's Superb	17	3	484	367
59	Cook's Suberb	18	2	484	320 1-4
60	Compton's Surprise	16	4	484	320 1-4
61	Jordan's Russet	17	2	459 8-10	431 3-10
62	Boston Cracker	15	3	435 3-5	433 3-5
63	Irish Cup	18	......	435 3-5	335 2 5
64	Rhode Island	18	2	435	484
65	Paragon	14	4	435 3-5	....
66	Boston Market	17	......	411 2-5	474 14-15
67	Baker's Imperial	17	......	411 2-5	302 1-2
68	White Whipple	15	2	411 2-5	343 5-10
69	Bonanza	16	......	387 1-5	189 3-5
70	Diamond	12	4	387 1-5	368 14 15
71	Landreth's Garfield	16	......	387 1 5	368 3-5
72	Orange County White	15	......	363	258 3-15
73	Howard	15	......	363	411 1-10
74	Alamo	15	......	363	202 4-10
75	Early Telephone	14	......	338 4-5	429 3-10
76	Early Harvest	12	3	363	385 1-5
77	Peerless	15	......	363	463 4-10
78	Neshannock	14	......	338 4-5	177 3-10
79	Crandall's Beauty	12	2	338 4 5	....
80	Portage	7	6	314 3-5	....
81	Eclectic	10	2	290 2-5	326 1-2
82	Early Snowflake	12	......	290 2-5	371 1-5
83	Wall's Orange	7	3	242	281 1-3
84	Early Kent	8	2	242	434 3-15
85	Rubicund	7	4	266 1-5	275 1-15

The following notes on the most prolific varieties are submitted :

Perfect Peachblow—Tubers somewhat roundish, eyes few in number, and shallow. The most prolific late variety grown here.

Rose's Seedling—Tubers cylindrical, eyes few and shallow, color light red, foliage light green, much curled. A very prolific medium early variety.

Watson's Seedling—Tubers cylindrical, color light rose, foliage erect, light green and curled. A prolific medium early variety.

Charter Oak—Is a late variety with irregular, oval tubers, skin white, eyes large and shallow. Invariably a good yielder.

Lee's Favorite—One of the best earlies; stems decumbent, strong; tubers cylindrical, skin light rose.

Early Ohio—A very early variety, sure cropper, but inclined to be scabby on rich land. Tubers oblong, skin light, smooth to roughish.

Junkis—Have grown this variety but one season. It proved to be one of the most prolific. Tubers cylindrical, skin smooth and white.

Knapp's Snowbank—Is a prolific late variety, vines of great vigor, tubers roundish, large and borne close in the hill.

Weld's No. 1—Vines vigorous, tubers large, skin light pink, smooth, borne scattering in the hill.

Early Rose—Vines of medium vigor, tubers long and smooth, skin brown; early and prolific.

Jones' Prizetaker—Tubers long and smooth, skin brownish red, vines of medium vigor. An early variety of merit.

Jordan's Early Russet—Tubers long and flattened, eyes deep, skin white, russeted. A good second early sort.

Sunrise—Tubers long and smooth, skin brown red. An early prolific variety. Vines of medium vigor.

White Elephant—Tubers long, skin smooth and white. A medium early sort and prolific on loose soils.

Burbank—Tubers long and somewhat flattened, skin smooth, white in color. Vines vigorous. Medium early.

Big Benefit—Tubers purplish, smooth; eyes shallow. A prolific, medium early variety.

Cap Sheaf—Vines very vigorous, tubers long and smooth, skin light colored. A prolific, medium early variety.

Beauty of Hebron—A standard variety of great merit. Tubers of good size, shallow eyes, skin rose color. Vines of medium vigor.

Dakota Red—Tubers of medium size, very irregular deep eyes. A coarse, prolific, late variety.

Vick's Prize—A strong grower, tubers smooth, good size; skin light russet. A medium early variety of merit.

Clark's No. 1—This variety originated in New

Hampshire. Tubers long, of good size, skin white. A desirable very early variety.

Chicago Market—An early variety, resembling Early Rose. Skin flesh color. A heavy cropper.

Belle—Tubers quite large, slightly russeted, color rose. A strong grower and heavy yielder.

Manhattan—This variety originated in Kansas. Vines of medium vigor. Decumbent; tubers oval oblong, skin flesh color. A heavy cropper.

Queen of the Valley—Vines vigorous, erect. Tubers long and somewhat flattened; skin light rose. Borne close in the hill.

Perfect Gem—A variety of medium vigor and earliness. Tubers nearly round, skin white russeted. A good market sort.

Cayuga—A strong grower, medium early. Tubers cylindrical and some flattened; skin white. A very productive variety.

Salt Lake Queen—Medium early. Tubers quite long; skin white, and very smooth. Quite productive.

Corliss Matchless—Medium early. Tubers long, light pink. Handsome and productive.

Boston Market—Quite early. Tubers round to oblong, skin light pink. Very productive and of excellent quality.

James Vick—Medium early. Tubers long round, color nearly white, handsome and of excellent quality. A superior variety.

Baker's Imperial—Medium early. Tubers very long, flattened, color light red. A productive variety of good quality.

Early Telephone—Tubers oblong, considerably flattened. Color russety white. Moderately productive.

Early Kent—Tubers oblong oval. Color white, a little russeted. A strong grower and productive.

Parson's Prolific—Tubers oblong to round. Skin nearly white with pink eyes. A prolific variety of good quality and appearance.

SEEDLING VARIETIES.

Two thousand two hundred and ten seedling varieties of the potato were raised from seed sent out by the Department of Agriculture two years ago. Ninety-six of these varieties were saved for trial another season, with the results as exhibited in the accompanying table. The soil, treatment and general conditions were as nearly identical as possible with those surrounding the named varieties. As will be seen some of these varieties yielded fully as well as the best of the named kinds:

Table No. 2.

Number.	Weight of Table Potatoes—lbs.	Weight of Small Potatoes—lbs.	COLOR AND SHAPE.	Yield per Acre. Bushels.	Number of Hills Planted.
1	10	3	Roundish flat; color white	393 1-4	8
2	16	4	Cylindrical; color white	403 1-3	12
3	24	2	Round; color light	524 1-5	12
4	26	2	Flattened; skin white	376 1-2	18
5	10	4	Oblong; skin purplish	440	8
6	12	6	Oblong; skin purple	272 1-4	16
7	32	2	Cylindrical; color light	685 2-3	12
8	42	6	Oblong; color light pink	528	22
9	18	2	Oblong; skin light	816 2-3	6
10	5	2	Cylindrical; blue	211 11-12	8
11	17	3	Long; skin white	484	10
12	4	4	Irregular; color purplish	193 3-5	10
13	7	7	Oblong; skin light	338 4-5	10
14	8	4	Round; skin blue	290 2-5	10
15	12	4	Oblong; skin light	327 2-3	12
16	16	......	Oblong, flat; color white	327 2-3	12
17	11	4	Roundish, flat; white	453 4-5	8
18	16	3	Cylindrical; skin light	574 3-4	8
19	18	4	Round; skin much russeted	532 2-5	10
20	12	2	Roundish; color white	440	8
21	26	5	Oblong; skin white	584 5 6	12
22	6	3	Cylindrical; skin white	217 4-5	10
23	11	2	Oblong; skin light in color	524 1-3	6
24	10	3	Cylindrical; color light	154	22
25	20	2	Roundish, flattened; red	443 2-3	12
26	10	......	Roundish; skin blue	403 1 3	6
27	24	......	Cylindrical; color red	586 4-5	10
28	20	4	Oblong; skin white	580 4-5	10
29	36	......	Roundish flattened; purple	871 1-5	10
30	12	......	Oblong; color light	580 4 5	5
31	14	10	Cylindrical; color white	264	22
32	10	......	Oblong; color light	242	10
33	10	6	Oblong; skin white	327 2-3	12
34	18	2	Oblong; skin red	484	10
35	8	4	Oblong; eyes few and shallow; white	363	8
36	8	3	Roundish flat; skin blue	443 2-3	6
37	14	6	Round; skin light in color	403 1 3	12
38	12	......	Oblong; color purplish	303	8
39	30	......	Oblong; color white	726	10
40	12	6	Oblong; skin purple	435 3-5	10
41	16	4	Oblong; eyes few and deep; white	484	10
42	40	3	Cylindrical; color light	1,040 3-5	10

Table No. 2—Continued.

Number.	Weight of Table Potatoes—lbs.	Weight of Small Potatoes—lbs.	COLOR AND SHAPE.	Yield per Acre. Bushels.	Number of Hills Planted.
43	8	6	........Oblong; skin white in color........	242	14
44	5	4	..........Roundish; skin purple..........	272 1-4	8
45	25	4	..........Cylindrical; color white..........	701 4-5	10
46	18	10	.......Roundish; flattened; purple.......	338 4-5	20
47	26	6	............Roundish; color red............	484	16
48	20	4	..........Cylindrical; skin purple..........	580 4-5	10
49	38	4	........Roundish, flat; skin white........	847	12
50	17	8	.......Round, smooth; blue in color.......	504 1-6	12
51	7	4	.......Oval, eyes few and deep; red.......	266 1-5	10
52	12	......	..........Cylindrical; color white..........	363	8
53	8	3	......Flat, irregular, eyes deep; rose......	332 3-4	8
54	6	6	..........Cylindrical; color light..........	363	8
55	14	4	...........Irregular; color red............	435 3-5	10
56	18	4	............Roundish; skin light............	532 2-5	10
57	20	3	...........Oblong; color purplish...........	556 3-5	10
58	6	4	...........Cylindrical; skin red...........	242	10
59	10	4	............Oblong; color white............	423 1-2	8
60	14	3	...........Roundish; skin white...........	514 1-4	8
61	10	4	..........Roundish; color purple..........	338 4-5	10
62	16	4	.... Cylindrical; color reddish.........	605	8
63	12	3	.........Round; smooth, light skin.........	363	10
64	14	6	............Oblong; color white............	484	10
65	8	4	.............Oblong; color light.............	290 2-5	10
66	18	4	............Oblong, color white............	380 17-60	14
67	12	......	........Much flattened; skin purple........	484	6
68	10	......	...........Cylindrical; color red...........	302 1-2	8
69	18	4	............Oblong; color white............	443 2-3	12
70	13	3	.........Cylindrical; smooth white.........	484	8
71	5	2	.........Roundish flat; skin light.........	847	2
72	12	4	.......Round; skin smooth and light.......	387 1-5	10
73	6	6	.........Cylindrical, color purple..........	242	12
74	14	4	.........Much flattened; skin light.........	435 3-5	10
75	24	8	..........Roundish; color purple..........	258 2-15	30
76	30	4	...........Irregular; color white...........	822 4-5	10
77	14	4	........Round; color red and white........	435 3-5	10
78	16	4	...........Cylindrical; color red...........	484	10
79	26	......	.............Oblong; skin white.............	629 1-5	10
80	32	......	......Roundish, flattened; color light......	774 2-5	10
81	20	4	............Roundish; skin white...........	580 4-5	10
82	13	2	............Oblong; color white............	453 4-5	8
83	8	2	.............Oblong; light red.............	1,110	2
84	14	4	............Cylindrical; skin red............	574 1-2	8
85	16	4	...........Irregular; color white...........	403 1-3	12
86	6	4	.............Oblong; color red.............	302 1-2	8
87	6	......	........Oblong; skin light in color........	181 1-2	8
88	12	2	..........Cylindrical; skin purple..........	440	8
89	16	3	..........Roundish; color white...........	574 3-4	8
90	28	4	.........Much flattened; color red.........	774 2-5	10
91	22	4	.......Roundish, smooth; skin light.......	629 1-5	10
92	6	2	............Oblong; color white............	968	2
93	38	2	.........Shape oblong; color white.........	605	16
94	5	2	..........Cylindrical; color white..........	169 2-5	10
95	6	4	.............Round; skin white.............	201 2-3	12
96	108	14	....	492 1-5	60

METHODS OF CULTURE.

Table No. 3 gives the average yield for three seasons of various methods of seed cutting. Whole seed pieces give, from this brief trial, the largest aggregate yield, and the small cut seed (one eye) gave the largest individual tubers with the minimum of small ones. It is a well established fact that small cut seed has a lessened vitality, a factor not always recognized in considering conditions of growth and the probabilities of success. The large tubers that result from this method of cutting are due to the presence of but one or two stems during the growing season, instead of a great many, as in the case of the larger seed.

The small cut seed is, however, not practicable anywhere on a large scale, as usually the fertility and mechanical condition of the soil are not such as to assure the single eye the necessary conditions which result in a good stand.

The small yield of two separate eyes was due to an accident in watering, and which resulted unfavorably for this method of cutting last year.

Table No. 3—Average Yield of Three Seasons for Methods of Seeding.

	Whole Potato—Large.	Whole Potato—Small.	Seed End.	Stem End.	Two Separate Eyes.	One Eye to Hill.
Table potatoes......	296 2-5	254 1-5	284.15	242	157.18	314.36
Small potatoes......	115	121	60.30	48.24	24.12	36.20
Depth of planting...	4 inches	4 inches	4 inches	4 inches	4 inches	4 inches
Total yield........	411 2-5	375 1-5	344 3-15	290 2-5	181 1-2	350 14-15

POTATOES UNDER MULCH.

The potato has been grown in this way for three seasons, with results as exhibited in table No. 4.

Large and small whole potatoes show the highest average yield for three seasons, as in table No. 3, and the single eye next. The latter we have always cut from the largest potatoes, so as to assure a sufficiently vigorous growth that would break through the mulch, the latter always exercising a retarding influence on the growth of the top until the tuber is well above ground.

Mulch culture is only practicable on a small scale and in localities, soils and seasons unfavorable to the proper development of this plant under ordinary culture.

The best mulch is composed of either partially decayed materials or of clean oat straw.

The yield under mulch is ordinarily greater than without, especially in uncongenial soils, the shading of the ground furnishing the proper conditions of temperature and moisture at the root, as well as assuring the necessary mechanical condition of the soil, so desirable in securing uniformity and the greatest possible development of tuber.

A mulch, to be of any value in a dry climate, should be quite a foot thick, using large seed pieces, however, to enable the tops to push through the cover.

This year, instead of placing the mulch on the surface of the ground, we ploughed furrows three feet apart and placed whole tubers therein, of medium size, and one foot apart. The mulch, four inches thick, was placed in the furrow and earth to the depth of three or four inches on top covering all.

The area devoted to this patch was 0.17 acres, yielding 54 bushels, or at the rate of 324 bushels per acre. Neither the yield nor size of the tubers was equal to that secured from having the mulch on the surface of the ground.

Table No. 4—Average Yield of Potatoes Under Mulch for Three Seasons.

	Whole Potato—Large.	Whole Potato—Small.	Seed End.	Stem End.	One Eye to Hill.
Table potatoes..........	363	369.3	266.12	254.5	387.12
Small potatoes..........	145.12	187.33	139.8	96.45	48.24
Total yield...	508 1-5	556 3-5	405 2-10	350 5-10	435 3-5

POTATOES WITHOUT IRRIGATION.

A piece of side hill land, 0.27 of an acre in area, was planted to potatoes of mixed varieties, May 14th. The soil was naturally moist from seepage, in fact quite a third of it too much so for the best culture of this plant. The yield was 57 bushels, or at the rate of 220 bushels per acre.

The rows were opened with a plow, four feet apart, and the seed pieces placed about one foot apart and covered in the same way. The tubers were the largest and finest we have grown this season, and, where the soil was not too moist, entirely free from scab. The land had never been manured or in crop before.

The most profitable potato lands on old farms in this State are such as are so situated on side hills as to be sufficiently moist to mature a crop without irrigation. Such soils are loose and open, never bake, and maximum crops are raised with the minimum of labor and expense.

APPLICATION OF FERTILIZERS.

A knowledge of the special needs of our soils is an important factor in all profitable land culture, and this knowledge is only acquired by carefully conducted and oft-repeated experiments that shall determine the efficacy and profitableness of commercial fertilizers on Colorado soils.

Very early in the history of the culture of garden crops on our upland soils the necessity for the application of fertilizers was readily made apparent to the market gardener, so that to-day feeding the soil for garden crops is as necessary, desirable and profitable as anywhere else.

This necessity of the market gardener is as apparent and is as forcibly expressed on the older farms of this State by the crop returns, in comparison with earlier pioneer farming, as in the older States of the Union.

The fertilizers employed in this trial were manufactured and sold in this State. The soil, a clay loam, rather poor, had never been in crop before.

Whole seed pieces, of medium size, were planted in trenches dug eight inches deep; the fertilizers were mixed with 4 inches of soil and the sets placed on top.

The following table shows the fertilizers used, number of hills planted and the yield per acre:

Table No. 5—Application of Fertilizers.

Kind and Quantities of Fertilizers Used.	Name of Variety Grown.	Yield of 45 Hills —lbs	Estimated Yield per Acre—Bushels.
150 lbs Merle's Bone Superphosphate	Morton White	62	333 1-2
200 " plaster....................	"	68	365 1-2
200 " Mo. clay kalsomine..........	Ruby	60	322 2-3
250 " bone meal	"	117	629 1-5

The plat treated with bone meal exhibited a very decided advantage the whole season, and ripened its vines first.

The superphosphate plat had vines nearly as vigorous as the latter, but fell far short in yield of tubers.

The plaster plat gave the second best yield, but bore vines of only moderate vigor.

The experiment needs to be tried more fully and elaborately than has yet been possible here. The experiment would seem to show a slight advantage from the use of plaster, a very decided advantage for bone meal and but little gain for the other two.

THE WILD POTATO—CROSSES.

We have grown one of the native potatoes of this State (*Solanum Jamesii*) for the past two seasons. It did not prove fertile, however, until this season, which was due to our having grown it in rich soil. In procuring tubers of this species from the Montezuma valley last spring, a form with blue flowers and of compact habit of growth was secured at the same time, which has since been identified by Prof. Coulter as *Solanum Tuberosum var. boreale,* not hitherto supposed to be indigenous to Colorado. From J. H. Gregory we purchased another wild potato, which the same authority pronounces *S. Jamesii.* Having grown these three forms side by side the past season, and under exactly similar conditions, we fail to see more than a general resemblance between the two, and both are very distinct from *S. Tuberosum var. boreale.* In fact, neither would be recognized as a potato at all except by a botanist.

We have succeeded in obtaining two seed balls of *S. Jamesii*, three of *S. Species*, and eleven of *S. Tuberosum var. boreale*, pollenized by cultivated varieties, and three of the cultivated varieties Morton White and Ruby, pollenized by *S. Jamesii.*

Over two hundred crosses were made, *S. Tuberosum var. boreale* setting fruit freely when pollenized by the cultivated varieties, but our efforts to make some of the latter the seed parent when fertilized by this indigenous form, were not successful.

Some of the crosses for a time seemed to be successful, owing to the ovary attaining to quite half its full size before indications were observed that they were hollow within.

The tubers of *Solanum Tuberosum var. boreale* are quite large relatively to the other forms, oblong in shape, and of a dark brown color. We had only three plants of this type, and in consequence made no estimate of the yield. The tubers of *S. Jamesii* are next largest in size, and of the same color and shape as the last mentioned, while those of the form obtained of J. H. Gregory are small in size, roundish, color light, and extremely numerous, as will be seen by the yield. The usual care was exercised in effecting a cross, as both the cultivated varieties and the wild forms are capable of close fertilization before the corolla opens. In a few cultivated varieties the pistil is early protruded through the corolla, in some cases long before the latter has colored, hence early attention is indispensable, to ward off the presence of foreign pollen. The yield was as follows:

Table No. 6—Yield of Wild Potatoes.

Name.	Number of Hills Planted.	Yield in lbs.	Estimated Yield per Acre—Bushels.
Solanum Jamesii....................	16	4	60 1-2
" Species....................	36	24	161 1-3

RESULTS.

1. That for late potatoes, the best time to plant is about the middle of May.

2. That the best crops are raised on loose, moist side-hill lands, that need little or no irrigation.

3. That in regard to methods of cutting seed, our experience so far justifies the use of large seed pieces for field culture, and of small cut seed when tubers of exceptional size are desired, where exceptional care can be given the crop, and when the soil is in the best condition of tilth and fertility.

4. That the best culture of this plant requires that it be kept doing its best during the growing season, and not allowed to suffer a check, the result of which is supertuberation and the presence of ugly excrescences on the tubers.

5. That it is of importance in the care of seed to avoid its starting into growth too early in Spring, and the shriveling of the tuber before planting. Keep intact the main shoot from each eye.

6. That no rule can be laid down as to quantity or frequency of irrigation needed to mature this crop. Each must decide for himself, according to the character of the soil, its location in reference to seepage, the rainfall during the growing season, etc.

7. That in regard to varieties, the most desirable are such as produce medium-sized tops, bear their tubers close in the hill, necessitating deep planting, and showing a breeding in favor of the maximum early development of tuber, with a minimum vigor of top. The kinds making a good exhibit this year may be depended upon as being prolific croppers, particularly on soils adapted to the best culture of this plant.

8. That the fertilizer experiment exhibits nearly a doubling of the crop in favor of bone meal. That the use of land plaster gave an increase of over thirty bushels per acre over the bone superphosphate and clay kalsomine.

EXPERIMENTS WITH TOBACCO.

Experiments have been conducted at this Station for the past two years with varieties of tobacco sent out by the Department of Agriculture, Washington, D. C. The work done in 1886 was on too small a scale to determine definitely the question as to its availability as a farm crop in this State.

Eighteen varieties were grown the past season, all of which ripened thoroughly before the end of August. The first to ripen was the White Burley; the Improved Havanna and Vuelta Abajo, or low-land tobacco, next; then General Grant, a form of Big Orinoco, and Missouri Broad Leaf. The remaining varieties ripened about together.

The varieties grown may be distinguished into those with upright or horizontal leaves, as the Orinocos, and such as have drooping leaves, as do the various forms of Havanna tobaccos.

DESCRIPTION OF VARIETIES GROWN.

Isabella—This variety was imported from the Province Cayayan, in Luzon, one of the Phillipine Islands, in 1886. It is said to possess a delicate flavor, and is used exclusively in manufacturing cigars.

Caboni—This variety is grown in Virginia and in Cuba, where it attains a height of fourteen feet. It has a broad, ovate, thick leaf, developed from nodes very wide apart, and for this reason is not so well suited to this altitude as varieties that produce their leaves closer to the ground.

General Grant—This variety is said to be the earliest variety in cultivation, but did not prove so here this season. It produces immense leaves of fine texture, small veined, and very elastic.

Cienfuegos—This variety of cigar tobacco has been cultivated in Virginia since 1883, from seed imported from the Fiji Islands. It is early, of medium size, and of fine flavor.

Flanagan—Originated in Henry County, Virginia; is much used for making sweet fillers and mahogany-colored wrappers. It is a variety of the old sweet Orinoco, having broader leaves, a finer flavor, and of more vigorous habit.

White-Stem Orinoco—This is one of the best yellow varieties cultivated in the tobacco belt of Virginia and

North Carolina. It is of good size and weight, and early to mature.

Big Orinoco—A variety of great vigor; fine for mahogany and red wrappers.

Little Orinoco—This variety has long, tapering leaves, of fine texture, which stand up well, and is said to be the sweetest variety grown. Used principally for plug work and smokers.

Vuelta Abajo—Or low-land tobacco, is among the earliest varieties to mature here. Recommended for its delicate flavor.

Elkerson's Yellow—This is a very vigorous yellow variety, with thick, upright, ovate lanceolate leaves.

Havanna Saqua Le Grande—This variety was sent to the Department of Agriculture by the Consul General at Havanna in 1886. Used for wrappers, of medium vigor, drooping leaves.

One-Sucker Virginia—An early variety of vigorous habit and upright foliage. Needs but one suckering, and on this account desirable.

Improved Havanna—An early variety of but moderate vigor. Used for wrappers, and will bear quite close planting.

Missouri Broad Leaf—A standard sort of great vigor. Valuable for cigar wrappers, and very early to mature.

Yara—A variety largely grown in Virginia. Remarkable for the fineness of its foliage and great delicacy of flavor.

Golden Leaf—This sort resembles tha Missouri Broad Leaf in its habits of growth and general vigor. Used for bright wrappers.

White Burley—This is a standard sort, very highly thought of at the West, of unrivalled vigor, carrying its leaves near the ground, from short internodes. It was the earliest variety grown, being ripe on the hill August 16th. Used for bright wrappers.

Connecticut Seed-Leaf—This is a standard variety, similar in habit to the Burley and others. It proved to be vigorous and of a desirable habit of growth. Used for cigar wrappers.

Wilson's Prolific—Of this variety we had but a few plants. Its habit of growth and shape of leaf is similar to the Broad Leaf. It did not ripen so early as some others, because the plants were quite small when set out.

Fiji Oronoco—This variety of the Orinocos has a long and quite pointed leaf, very early, and of good habit and vigor.

SOWING SEED.

The different varieties were sown in a moderate hot-bed March 26th, and from here transplanted to the open ground May 25th. It is desirable in this climate to sow in a moderate hot-bed, because of the dry air and brisk winds at that time of year. Nor is it desirable to sow too early, because of the liability of the plants to damp off. Sow about April 1st, and very thinly; this will insure not only a roomy seed bed, but will also give stout plants of nearly equal vigor, and which will tend to uniformity in ripening. If sash are used, shade the glass slightly during the heat of the day, and this will render the necessity for watering less frequent than if the soil were exposed to the sun's heat.

The soil in which the seed is to be sown should be quite rich; it will push the growth of the plants. Thick seeding should be avoided, for two reasons: The first is, that weak, spindling plants is the result; and second, plants crowding each other in a hot-bed are very liable to damp off in the night, to avoid which, refrain from watering the seed bed late in the afternoon. It is important to observe that if plants are grown in a hot-bed, it is imperative that they be hardened off before setting out in the open air, which is attained by giving plenty of air, and inuring the plants to the sun's full power before transplanting.

SOILS.

The finest tobacco is raised on light, rich soils. If not naturally rich enough, it must be made so. Our unmanured upland soils will grow a fine leaf of any of the stronger growing varieties. The deeper the plowing, the larger the crop; sub-soiling would be better still. If the object is weight of leaf, use old, rich, heavy lands; the product, however, will be coarser, and bring a lower price in some markets than that grown on lighter and warmer soils.

VARIETIES.

There are as many varieties of seed-leaf tobacco as there are of Indian corn. Of all the kinds tried, the White Burley is the easiest to manage and earliest to mature. It becomes yellow on the hill, if not irrigated, by the middle of August, and when taken to the barn will quickly take on a rich brown color before losing its surplus moisture. Other varieties nearly as easy to handle are the General Grant, Connecticut Seed Leaf, Vuelta Abajo and Missouri Broad Leaf —all cigar tobaccos.

PLANTING OUT.

We planted out May 25th, in rows six feet apart, the plants three feet apart in the rows. This is too far apart even for the more robust kinds; a better disposition of the plants would be, for the large kinds, rows four feet apart, plants three feet in the rows. The Havanna varieties, with drooping leaves, rows three feet apart, and plants two feet.

Before planting out, remove all covering from the plants, to harden them, and then thoroughly soak the bed with water.

CULTIVATION.

When the plants have become established, cultivation must be begun, and be kept up until the plants show a disposition to ripen. Frequent use of the cultivator will render less necessary the operation of irrigation, and will hasten the maturity of the crop.

IRRIGATION.

The tobacco plant, while a great feeder, is very impatient of too much moisture in the soil. We irrigated but twice, and believe that once would have been sufficient. Rich land, with efficient and timely cultivation, will go far toward maturing a crop of this plant in this State. In fact, if irrigated much, it will not ripen. No crop is so effectually destroyed on wet lands as tobacco, and none is so little affected by drought.

INSECTS.

The insects particularly injurious to tobacco are the caterpillar of the tobacco moth, which appeared here June 21st this year, but not in large numbers, and a cut worm. The latter attacks the plants as soon as set out, their mutilated condition suggesting its presence. The only remedies are vigilance and industry on the part of the grower. The early part of the day is the best time to find the cut worm; later in the day they retire deeper into the soil, and are difficult to catch. All plants injured by the cut worm should be replaced from the seed bed. The tobacco worm is also injurious to the potato and the tomato, but prefers the tobacco plant, perforating and eating the leaves. When at rest it lifts up its head and the fore part of its body, remaining in that position, apparently lifeless. From its resemblance, while in this position, to an Egyptian sphinx, Linnaeus gave to it the name Sphinx. The larva should be diligently sought for during the entire season, as much of the value of the crop depends upon how well this is attended to in this regard.

PRIMING.

Priming is another operation to be attended to, and consists in removing such leaves as lay on the ground. If left on, these produce an inferior quality of tobacco, called "lugs," because they get soiled and blackened.

TOPPING.

Topping the plants is had recourse to when the top of the flower stalk is large enough to be taken out. There is no particular height to top at. The usual topping, however, leaves twelve to sixteen leaves, the result of which is to throw the whole strength of the plant into the remaining leaves, and induces the growth of leafy shoots from the base of each leaf, called suckers.

SUCKERING.

Suckering follows as the result of topping, and is done for the same purpose—to concentrate the whole strength of the plant in the remaining leaves, and must be attended to diligently until the crop is housed. The operations of priming, suckering and topping must not be done during a rain-storm, or when the plants are wet at any time, or the result will be rust spots on the leaves, which will ultimately destroy them.

CUTTING AND HARVESTING.

The plant is ripe when the leaves assume a mottled appearance, and when in doubling up the leaf it breaks, instead of bends. It should not be allowed to get overripe, or it will cure up spotted, instead of a solid color.

The plants in this experiment were split down the center while growing in the ground, and then cut off close to the latter, and and left on the ground to wilt. We found that one hour was as long as it was safe to allow the more vigorous kinds to so remain without scorching, and about half that time for the thinner-leaved Havannas. It is best, however, to cut either during a cloudy day or in the morning or afternoon, not allowing the plants to remain out over night.

Having cut and wilted the plants, they are now ready for housing, first placing them straddled across sticks for convenience in hanging up to cure. Tobacco sticks are round, or are split out like lath about one inch square at one end, and generally a few inches longer than the distance between the joints of the tobacco house.

BARN.

In this structure the tobacco is hung up to cure. It should be strong enough to carry the plants and to resist storms. The inside of the shed is divided up by rails into widths, to accommodate the laths, and also into tiers, far enough apart to allow the different tiers to hang free of each other.

CURING.

It is during the process of curing that the chief differences occur in the management of this plant from that which obtains at a lower and moister altitude than this. It will not do to allow drafts of air to strike it, or it will dry up very quickly, when it will be found impossible to color it. The drying of the leaf is due to our very dry atmosphere, and must be counteracted, or the leaf will not color. To get over this difficulty, we lay the tobacco in thin layers on the ground, and cover with straw or sacking, watching it frequently, and turning it to prevent its heating. This will partially color the leaf, when it is taken to the barn and crowded somewhat closely together, where the coloring is completed. As the leaves dry, it will pay to keep crowding it together, for the best colored leaf will be found in the center of the tiers of sticks. If the shed is dry, wet the floor, and keep it so until the leaf is completely finished, which will be accomplished by the latter end of October. The Havanna tobaccos require most care to get the leaf to color. The Burley and General Grant will take on a bright color in the barn, by simply keeping it close, and without piling it in layers in the field.

STRIPPING.

When the leaf is thoroughly cured it is ready for stripping, which consists in stripping the leaves from the stalks and tying them in bundles, called "hands." Before doing this, it is necessary to dampen the floor, to get the leaf pliable enough to handle. In tying into "hands," the leaves are sorted according to color and size. The bright colored, large and perfect leaves are of the best quality, and are tied by themselves. The second quality is a grade below this, and is the red or brown tobacco. The third grade is called "lugs," and consists of the lower and damaged leaves, and is also kept separate. The "hands" are tied on sticks until ready for sweating.

SWEATING.

The plant is not tobacco until fermentation has taken place, commonly called sweating, and is accomplished by laying the tobacco side by side in a conical heap; the butts of the "hands" outside, about as wheat is stacked. The process of sweating must be conducted with care, for on this depends the color of the leaf, and to a great extent its flavor.

BOXING.

The leaf having been sweated, is now ready for boxing, in which shape it is sent to market. The "hands" are packed, and pressed firmly by means of a lever.

If tobacco should become too dry for boxing or baling, it may be brought in "case" by sprinkling it with warm water by means of a small corn-broom, but it must not be wet, or it will be ruined if it has to remain boxed or baled very long.

This ends the round of attention and labor experienced in the management of this crop. The following tables exhibit results in detail in regard to the varieties grown:

Table No. 1—Tobacco on Manured Land.

Number.	Name of Variety.	No. of Plants Experimented With.	Weight in lbs.—Green.	Weight in lbs.—Cured.	Estimated Yield per Acre in lbs—Green.	Estimated Yield per Acre in lbs—Cured.	Average Weight of Plants.
1	Connecticut Seed Leaf	13	44	9⅜	7,568	1,720	3.40
2	One Sucker Virginia	7	24	5½	8,295	2,070	3.42
3	Fiji Orinoco	14	63	15	10,884	2,581	4.5
4	Vuelta Abajo	14	30	6	5,162	1,032	2.14
5	Isabella	18	51	10½	6,834	1,892	2.83
6	Improved Havanna	14	30	7	5,162	1,204	2.14
7	Golden Leaf	14	63	12½	10,836	2,065	4.5
8	Big Orinoco	14	54	11¼	9,288	2,064	3.85
9	White Burley	10	66	16½	15,972	3,872	6.6
10	Yara	8	28	7	8,456	2,114	3.5
11	Gen. Grant	8	50	11½	15,100	3,322	6.11
12	Caboni	6	26	5½	10,478	2,015	4.33
13	Elkerson's Yellow	6	20	5	8,060	2,015	3.33
14	Flanagan	15	18	4	2,898	644	1.20
15	White-Stem Orinoco	33	70	13	5,110	949	2.12
16	Fiji Golden Leaf	13	34	7	6,324	1,302	2.61

Table No. 2—Tobacco on Unmanured Land.

Number.	Name of Variety.	No. of Plants Experimented With.	Weight in lbs.—Green.	Weight in lbs.—Cured.	Estimated Yield per Acre in lbs—Green.	Estimated Yield per Acre in lbs—Cured.	Average Weight of Plants.
1	Improved Havanna	20	28	6¼	3,388	726	1.36
2	Golden Leaf	14	30	6½	5,220	1,044	2.32
3	Isabella	22	30	5¾	3,300	660	1.48
4	Fiji Orinoco	13	37	7½	6,882	1,302	2.82
5	Fiji Golden Leaf	6	16	3½	6,448	1,209	2.66
6	White Burley	5	18	5¼	8,712	1,936	3.06
7	Sagua Le Grande	10	28	6	6,776	1,452	2.80
8	Vuelta Abajo	17	34	7½	4,828	994	2.00
9	Caboni	17	44	12	6,248	1,704	3.17
10	Missouri Broad Leaf	10	47	11	11,374	6,248	4.70
11	Connecticut Seed Leaf	8	32	9½	9,664	2,718	4.06
12	Big Orinoco	15	36	3¾	5,796	644	2.40
13	Elkerson's Yellow	24	66	13¼	6,666	1.313	2.75
14	One-Sucker Virginia	8	22	5½	6,644	1,510	2.75
15	Yara	12	20	6½	4,040	1,212	1.66
16	Cienfuegos	4	16	4	9,680	2,420	4.00
17	Flanagan	13	20	8½	3,720	1,488	2.20

The varieties in the above tables were planted about equally on land that had been well manured for two seasons and on land that had never previous to this season been in crop, but which, from the gardener's standpoint, would be considered poor land.

The tables emphasize in a marked manner the superiority of a few kinds, whether on manured or unmanured land, for general cultivation. The yield of both green and cured leaf is very much larger than is claimed for the older tobacco growing regions. In fact, the yield may be said to be phenomenal for the method of planting—rows six feet and plants three feet apart.

In regard to high winds, we would say that the only varieties affected in the least were the Improved Havanna and Caboni. The latter is a large variety that yields heavily, but not suited to this climate, because too tall, and it carries its leaves too far apart on the stem. It would be advisable, however, we believe, to plant a few pole beans, or some other quick-growing plants, if one had a very exposed situation and were growing the Improved Havanna or other thin-leaved kinds.

The ideal varieties of tobacco for this region are the Burley, General Grant, Connecticut Seed Leaf and Missouri Broad Leaf—all of which are of close, compact habit, with leaves close together on the stem; they are really self-protecting.

The following letter from a well-known Denver cigar manufacturer speaks for itself. There is no market, apparently, in Colorado, for the shipping or cheaper grades of tobacco, as yet. Messrs. Thies & Gonzales are, however, willing to purchase Colorado grown Havanna seed-leaf at current market rates:

OFFICE OF FRITZ THIES,
MANUFACTURER OF CIGARS,
DENVER, COLO., January 27, 1888.

Mr. James Cassidy, Fort Collins, Colo.:

DEAR SIR:—The Havanna seed-leaf samples left with me have been thoroughly examined and put to the usual test. The cigars made from the leaf prove to be superior to anything grown in those districts which are supposed to yield our finest native-grown Havanna seed-leaf. Other tobacco experts who have tested the cigars made from your samples, say the flavor of the cigars will compare very favorably with the Havanna-grown leaf. I have no doubt but a large demand exists at the present time in Colorado for tobacco of this class. The market will by no means be confined to our home demand. You have sent me other samples of leaf, grown from Eastern seed. Same, however, do not possess the good quality that the Havanna seed-leaf contains.

Respectfully, yours,

FRITZ THIES.

CONCLUSIONS.

As the result of experiments with this plant for the past two years, we have reached the following conclusions:

1. That tobacco of any variety may be grown and matured at this altitude by September 1st.

2. That the best quality of cigar tobacco is that grown on our upland sandy loams.

3. That of the varieties tested, the most desirable and valuable for Colorado are the forms of Havanna seed-leaf; our soil and climate producing a quality of leaf not equalled by that of any tobacco-growing State in the Union.

4. That usually one irrigation, with good cultivation, will be sufficient to mature the crop. If the plants are irrigated late in the season, the leaf will not ripen before frost.

5. That in raising plants, thin seeding is expedient, as this will give strong plants, resulting in the early and uniform maturity of the leaf.

6. That the plants should be raised in a moderate hot-bed in this climate, sowing the seed last week in March, observing that previous to transplanting the last week in May, that the plants have been thoroughly exposed to the open air in the hot-bed.

7. That the cutting and wilting of the plants should be effected either quite early or late in the day, as the leaf is much more easily scorched here than at a lower altitude and in a moister climate.

8. That in curing Havanna, or other thin-leaved tobaccos, in this climate, it is necessary to lay the plants, after cutting, in thin layers on the ground, and cover with straw or burlaps for twenty-four to forty-eight hours, until the leaf has partially colored, observing not to allow the plants to heat, or the leaf will be ruined. Afterwards remove to a close, dark shed, or barn, and keep close in a damp atmosphere until the leaf is fully colored. The philosophy of this treatment is to prevent the too rapid drying of the leaf, and thus facilitate and assure its uniform coloring.

The Agricultural Experiment Station of Colorado.

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The State Agricultural College

EXPERIMENT STATION.

BULLETIN NO. 5.

REPORT OF

EXPERIMENTS IN APIARY.

1887.

FORT COLLINS, COLORADO.
OCTOBER, 1888.

The Courier Print, Fort Collins.

BULLETIN NO. 5.

EXPLANATORY.

The material in this bulletin was ordered printed by the State Board of Agriculture at its December meeting, 1887; and in connection with this it was thought best to make a general announcement with reference to the work of the Experiment Station.

The departments now recognized and organized as the Experiment Station are:

1. Agriculture.
2. Horticulture, Botany and Entomology.
3. Chemistry.
4. Meteorology and Irrigation Engineering.
5. Veterinary Science.

These Sections, wishing to give information or direction with reference to their work, have each prepared a brief circular.

The public in their communication with the Station with reference to work or information, will please be guided by these circulars.

Bulletins will be issued at least quarterly, corresponding to the months of October, January, April and July.

If there be matter of special importance, it will be issued at once, without waiting for the regular quarterly issue.

Address all correspondence to

THE AGRICULTURAL EXPERIMENT STATION,
Fort Collins, Colorado.

The Agricultural Section.

To all applicants for seed the Station is now prepared to send in small quantities, all kinds of spring and winter wheats, oats and barley; also corn, buckwheat, rye and other farm and field seeds, such as beans, beets, peas, broom-corn, pumpkins, squashes, flax, hemp, canary seed, millet — German, French and American — sunflower, lupins, lentils, vetches, milo maize, dourra, speltz, red clover in quantity, alfalfa, sorghum, kaffir corn and fenugreek.

These seeds have been very carefully improved for some years on the College farm, and are true to name and genuine so far as it is possible to make them.

With all who receive these seeds, correspondence is solicited, and reports asked for as to the manner of seeding, culture, production, success and failure, and causes of same, adaptability to soil and climate, and their yield.

In connection with this, such questions as the following might be reported, viz: Thick and thin seeding, deep and shallow planting, hill and flat culture, time of planting and irrigation, irrigation by flooding and in furrows, amount of water applied and number of irrigations during the season, and fertilizers, if any, used. Also, comparative value for feeding purposes of the clovers, tame and wild grasses, corn fodder, value of field peas, pumpkins, squashes, beets, turnips and other forage and root plants.

All distributions of seeds are made through the Hon. Frank J. Annis, Secretary of the State Board of Agriculture, to whom all applications should be made. This Section would be pleased to receive from any source, available samples of new varieties of seeds to grow, by way of trial and comparison.

Section of Botany, Horticulture and Entomology.

DIRECTIONS FOR SENDING SAMPLES OF SEEDS AND SPECIMENS OF PLANTS AND INSECTS.

Sound seed true to name, and free from the germs of noxious weeds, is essential to successful agriculture.

The germinating value of farm and garden seeds is determined by the examination and testing of a small average sample.

This the Experiment Station is now prepared to do, free of charge, for the farmers and gardeners of the State, subject to the following conditions.

1. Of small seeds, such as grass and clover seed, send two ounces; of cabbage, beet or turnip seed, four ounces; and of the larger seeds, as of wheat, peas and other legumes, eight ounces.

2. Samples may be sent by mail or express, prepaid, in stout paper bags, with the sender's name plainly written thereon, and should fairly represent the whole amount from which it was taken.

3. A letter of advice should accompany the package, giving the name of the variety sent, from whom purchased, by whom, and in what year grown, and whatever else may be deemed of value by the sender.

4. A record will be kept of all examinations made, and a report mailed to the sender.

Seeds should be forwarded some time before needed, as it takes time to complete the tests.

SENDING INSECTS FOR NAME.

The larvae (worms, caterpillars, etc.) of insects, should be sent in a tight tin or wooden box containing a good supply of their appropriate food plant.

Specimens, if dead, should be packed in cotton or wool, inclosed in a stout box.

The wings of butterflies and moths should be handled as little as possible, that their peculiar markings may be the better preserved, and the species more readily determined.

Send as full an account as possible of the habit of the insects about which you desire information.

In sending pinned specimens of insects, always secure them safely in a box, to be inclosed within a larger box, the space between the two to be packed with cotton, to prevent too violent jarring.

SENDING PLANTS FOR NAME.

Plants may be sent by mail, placed between sheets of thin paper, and protected with stout card board; or, they may be wrapped in moist paper or moss, and sent in a stout paper box.

Small plants should be sent entire, including the root, flowers and fruit; of larger plants, send a portion of the stem with its leaves, flowers and fruit.

In writing, state the character of the soil on which the plant grew, and whether it is moist, wet or otherwise.

Section of Meteorology and Irrigation Engineering.

This Section wishes to study Meteorology principally from the standpoint of agriculture, and will, therefore, pay more especial attention to those observations which are of influence on, or throw light upon, the laws of plant growth.

Among the observations which can be easily made, and which give valuable results for the labor expended, are those on the rainfall. A fair idea of the amount of rain falling in a shower may be obtained by putting out a vessel with vertical sides—as the ordinary two-quart pail, or a tin fruit can—and measuring the rain after the shower. But when the rainfall is slight, such measurement is difficult to make directly. In instruments made directly for the purpose, the rain is conducted to a smaller vessel, whose area is one-tenth of the collecting vessel. Thus a rain of one-tenth inch will stand one inch deep in the measuring vessel. By this means a small fall may be accurately measured.

The rain gauge adopted by the U. S. Signal Service consists of a circular funnel-shaped collector, eight inches in diameter, which discharges into the measuring vessel 2.53 inches in diameter. This latter has then an area one-tenth of that of the collecting vessel. The measuring vessel is some over twenty inches in length. At the exact height of twenty inches an overflow notch is cut, and in order to catch the overflow, if the fall should exceed two inches, the whole is placed in a second vessel six inches in diameter.

Gauges like this could be made from tin by a careful tinsmith, and painted, and would give satisfactory results. They may be purchased for a small sum.

In placing rain gauges, care needs to be taken that they be placed on a level surface, as far as possible from trees or buildings, or anything that would interfere with the free access of the rain, or cause eddies in the air currents. The distance from a tree or other obstruction should be twice its height.

The gauge should be from six to eighteen inches above the ground.

Rain observations may be taken with very little trouble or expense, and this Section invites co-operation and correspondence from all who are willing to undertake them. Stations are desired on the plains and in the mountains, especially toward the headwaters of the principal streams furnishing water for irrigation.

Among data which can be furnished without instruments, are the data of first and last frosts, times of planting, blossoming of the various crops, dates of blossoming of common plants, etc. All observations of this kind are invited. Such data will be preserved with proper credit, and will form a valuable storehouse of information as observations increase.

Correspondence is invited on topics connected with irrigation engineering, and data regarding irrigation is requested; description and plans of ditch, measuring flumes, headgates, etc., whether peculiar to your locality or not; means taken to economize water or to increase the duty; of trials in sub-irrigation; of attempts at reclaiming alkali lands by drainage or otherwise; of reservoirs, especially any data that bear upon the loss of water by evaporation or seepage, or both; of the effect of irrigation upon the soil; height of the water table before and since irrigation, etc. All such data, or any other bearing upon the irrigation system of our State, is asked for, and such information as is furnished will be at the service of the citizens of the State.

Veterinary Department.

Experiments to determine the cause, nature, symptoms and post-mortem appearances of the so-called loco disease in this State, are about to be commenced at the Experiment Station.

Answers to the following questions are requested from all who have suffered loss from this disease, and who have had personal experience of the affection.

1. When was the disease first observed to affect your animals, and at what season of the year?

2. What symptoms are observed, and how long does the disease last, on an average?

3. How many animals have you lost from the loco disease?

4. How many animals have you now sick from this disease?

5. What is your opinion as to the cause of the disease?

REPORT ON APIARY.

1887.

(NOTE.—The following report of the Apiary Section of the Horticultural Department was an experiment, only in the sense that every line of work on which accurate and full notes are taken, is an experiment. The Board of Agriculture, deeming the history of the work, and development in the Apiary that year, of prime importance and interest, desired to place it before the people in a bulletin. The report was prepared by C. Max Brose, Assistant Horticulturist, in charge, and read before the Board December 14, 1887.)

Took charge of the bees April 10, 1887, and found two swarms, out of eight stands, alive; one was fair, and the other a very weak swarm. The weather being backward, the willows did not bloom until the latter part of the month, when the bees commenced to gather pollen; then, as the maple began to open here on the grounds, the bees were very active, and the queens commenced laying. The strongest swarm was doing fairly well, but the weak one dwindled badly. Being in hives of two different patterns, we had no chance to strengthen the weak one by giving it a frame of brood from the stronger one.

May 10, we adopted the Simplicity hive, and ordered stuff for new hives, and also comb foundation for brood chamber. The bees commenced working on apple bloom, but there being several frosty nights, destroyed the same, and gave the bees a severe check in consequence. By some mistake in the shipping, the hives ordered were delayed on the road, and did not arrive here until June 5.

June 6, united the two swarms, and transferred the same to a new hive, finding some drone brood. The transferring gave the bees another check, but they soon commenced to work again on the raspberry. We fed all the honey we found in the old stands, which stimulated the queen and bees, so that by the 10th of June there were six frames full of brood, and we felt safe to start our nuclei.

A nucleus is a small hive holding two or three frames, in which you rear young queens. We started two, taking from the old hive two frames full of brood and fresh-laid eggs, with all the bees adhering to them. Each frame was placed in a nucleus with two frames of empty comb; we also replaced the two frames taken from the old hive, with two frames of empty worker comb.

If a swarm of bees lose their queen at any time of year when there are fresh-laid eggs in the comb, less than three days old, the bees will at once procced to supply themselves with a new queen; this they do by constructing a number of queen cells, sometimes as many as twenty, generally from five to twelve; in each they place a worker egg or larva, and feed it on what is called "royal jelly." This egg, if left in a worker cell, and fed upon worker food, would have grown to be a worker bee; but with the royal jelly as food, develops into a queen. In eight days from the laying of the egg, the bees seal up her cell to allow her to undergo the final transformation. On the sixteenth day from the egg, the queen is full grown, and if left undisturbed will hatch a perfect queen. The best way is, to take the queen away from an old swarm of bees, and after they have started their queen cells and have them sealed over, to cut the same out and insert these into the comb of the nucleus; but, having only one swarm to start with, we could not do this without destroying our chance for increase.

The morning after the nuclei were started, there were several queen cells in progress of construction.

June 20, started another nucleus in the same manner, only cut a queen cell out of one of our first nnclei, and inserted the same into the comb of the new one, so that on June 20, we had three nuclei with virgin queens.

In from two to five days the young queen will take her bridal flight, after which she returns to her hive and commences laying eggs within two or three days.

A young, vigorous queen will lay from 2,000 to 3,000 eggs every twenty-four hours, during the season of a good honey flow.

On the 30th of June, we found fresh-laid eggs in one of the nuclei. The old swarm, by this time, had gained in strength. The queen, being a good layer, had nearly all the combs filled with eggs and brood in all stages of maturity, so that we felt safe to make a new swarm; this was done on the first day of July, in the following manner: About noon, when the bees were flying heavy, we moved the old swarm about ten feet away, took the nucleus which had a laying queen, transferring the same, with bees and comb, into a new hive, and filling in with frames in which had been placed comb foundation. This was placed on the same stand where the old swarm had been; all the bees returning from the field went back to their old stand, but into the new hive, took to their new queen kindly, and by night we had a good swarm, with a laying queen.

On the second day of July, we found fresh-laid eggs in the other nucleus, but had to wait at least eight days before we could make another new swarm, which we did on the 10th day of July, as before.

By this time clover commenced to bloom, and the bees were doing their best. We found the young queens good and vigorous layers, so that by the twentieth day of July we made another swarm from our first young one, in the same manner as before; we also started two more nuclei, which had laying queens by the 10th of August. We also killed the queen in the original hive, for we did not know her age, and inserted a queen cell.

The three young swarms by this time had done exceptionally well. The brood chambers were full of bees, brood and honey, and the upper stories nearly filled, so that by the

20th of August we made two more swarms; this we did by giving the nucleus three or four frames of brood out of the four hives, and also by filling in with frames full of honey from their upper stories, so that we then had six strong swarms, besides sixty pounds of comb honey, which would make an account showing as follows:

The original swarm.	$10 00	
To 5 hives, at $2.50	12 50	
To 5 lbs comb foundation, at 50 cents	2 50	
		$25 00

CONTRA.

By original swarm	$10 00	
By 5 new swarms, at $10.00	50 00	
By 60 lbs comb honey, at 15 cents	9 00	
		$69 00—Balance, $44 00

This account, as you see, shows a net profit of $44.00. Of course, we did not work our bees for honey, having only one swarm with which to start. Our object was to increase the number of swarms of bees.

Later on, I fed the bees what surplus honey we had after the frost stopped the honey flow, which kept the bees busy until late. The queen kept laying, and went into winter quarters with plenty of young bees.

We put the bees into winter quarters October 15, in the following manner: The hives were left on their summer stands, about four inches from the ground. We filled the upper story with chaff, to absorb the moisture which always generates in the hive during the winter, and banked the hives with dirt all around, closing the entrance so that only one or two bees could come out at a time. A better way is to have a double-walled hive filled in with chaff all around, as this serves to absorb all moisture, while forming a warm and equable protection for the bees during sudden changes of temperature during the winter.

THE

State Agricultural College

The Agricultural Experiment Station.

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NOTES ON

INSECTS AND INSECTICIDES

1888.

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NOTES ON

INSECTS AND INSECTICIDES

1888.

BY JAMES CASSIDY,
Botanist and Horticulturist.

The season just closed has been remarkable for the introduction of some insect pests new to our State. We speak especially of the garden web worm (*Eurycreon rantalis*); the squash bug (*Coreus tristis*); and the false chinch bug (*Nysius angulatus*).

Nothing short of prompt attack with approved remedies could save seedling crops against these foes of agriculture, and the lesson to be derived from the season's work is that cultivators of the soil should be more prompt to avail themselves of those remedies demonstrated to be effective and to use them promptly, if they would succeed in growing crops with any degree of certainty in the future.

We took the first specimen of *Pieris rapae* March 17th; *Pieris protodice* was flying at this time, and also one of the "skippers" (*Eudamus tityrus*), *Vanessa antiopa* and *Milberti* were seen in numbers March 7th.

The codling moth (*Carpocapsa pomonella*) was plentiful toward the end of the month of April, but the hackberry butterflies and white lined morning sphinx moth, so plentiful last season, almost disappeared this year.

Some species of genus *Grapta* were as early and as numerous as ever. The imported currant borer (new here) appeared in force May 26th.

The apple leaf beetle appeared May 7th, and toward the latter part of the month attacked the foliage of the grape.

The moths of the garden web worm appeared early in April and the false chinch bug and squash bug the first week in June.

The parsnip butterfly was a common species in the plains region throughout the State, and to some extent in the mountains late in May. The tomato worm appeared June 1st, feeding on the tomato and tobacco, in particular.

I am indebted to Prof. Howard, of the Department of Agriculture, and Prof. Cook, of the Michigan Agricultural College, for the identification of the garden web worm, and to a number of friends for specimens and facts in regard to some of the species mentioned.

The people of our State may aid much in reaching a better knowledge in regard to the injurious insects of this region by furnishing specimens and information from their several localities. The State is so large and offers such a diversity of climate and agricultural productions, that associated effort of this nature is more imperatively necessary here than elsewhere.

To further this end and to make this section of the Experiment Station as useful as possible to those interested, correspondence and specimens are solicited.

INSECTICIDES.

Remedies used for the destruction of insect life are designed to be effective in either of two ways, according to their structure and mode of life. These may be arranged into two classes: First, arsenical poisons, or such as kill through the stomach; the second represented by alkalies, acids and oil mixtures, which are effective only as they come in direct contact with the insect to be destroyed.

All insects which eat the structure of plants may be readily destroyed by the first mentioned; those which suck the juices only, can be destroyed by the second.

In some cases insect ravages are due to an unthrifty condition of the plant attacked, the result of soil exhaustion, or other untoward conditions resulting in stunted growth, which invites their attack.

Cabbages and cauliflower, if grown in soil lacking in available plant food, are soon overcome by the aphis peculiar to them. Beets, if grown in soil rendered hard and impervious by irrigation and lack of cultivation, soon become a prey to insect attack, whereas had the conditions been favorable these plants oftentimes overcome their insect enemies by their own inherent vigor. It pays therefore to have healthy, vigorous plants only, to keep them doing their best during the growing season, and to adopt a judicious rotation of crops.

INSECT LIFE.

Before considering remedies in detail we will first notice the four stages in insect life, commencing with the egg, from which hatches the larvæ commonly known as grub, caterpillar, maggot, etc. It is in this stage that insects are most injurious, feeding voraciously until they have attained full size, when they change their form, cease to eat and enter the third stage, when they are called pupæ.

Having remained in this stage for a greater or less length of time, they burst their cases and emerge perfect insects to lay eggs and begin again the same round of life.

In some cases these changes are well marked; in others the transformations are less complete, as in the case of plant lice and grasshoppers.

ARSENICAL POISONS.

The various forms of arsenic are beyond doubt the most practical insecticides known to science, especially Paris green and London purple. White arsenic should never be used, because its color is apt to lead to fatal mistakes, nor can it be as readily mixed as the forms just mentioned.

We have had best success with Paris green, as it acts more promptly than London purple, and is less likely to brown the foliage of the plants treated with it.

We use both mixed with water in the proportion of one pound of the poison to 100 gallons of water. If the solution be made too strong the foliage is injured, and it acts rather as a repellant to the insect.

The exact quantity should be measured out and mixed with warm water into a paste; this is especially desirable for London purple, to secure proper diffusion with the liquid.

These poisons should always be applied through a fine nozzle, and with force; Paris green should especially be frequently agitated to keep the powder in suspension.

Upon vegetables and fruit bearing trees and vines it is important to remember that it can be used with safety only very early in the season.

As a remedy against foliage eating insects, it is simply invaluable.

The intelligent use of these forms of arsenic has rendered possible the cultivation of a wide range of useful plants, which otherwise would be impossible in the presence of the countless enemies of the plant growth of to-day.

WHITE HELLEBORE.

White hellebore is a vegetable poison. It is obtained from the powdered leaves and flowers of *Veratrum alba.* It is less dangerous as a poison than Paris green, but will without doubt cause death if inhaled in quantity. It is a specific against the currant worm when promptly applied, but is much less effective against other insects, and is best used in the dry, undiluted form. It should be kept in a closed vessel, and be applied with a bellows, thus bringing it in contact with all portions of the plant.

PYRETHRUM.

This insecticide is procured from the powdered flowers of two species of pyrethrum. Its ability to destroy insect life resides in a volatile oil, which acts on the nervous system of the insect, and which is readily lost on exposure to the atmosphere—hence the difficulty often experienced in procuring it sufficiently fresh and of the desired strength. It is inocuous to man and the higher animals, and kills insect life only by contact. We have had success with this remedy under glass structures, and when it could be procured fresh have had success with it against smooth-bodied caterpillars out doors. We have not used it this season because of the difficulty in obtaining a fresh article. In using, it should be diluted one to three parts of finely slaked lime or flour, and applied with a bellows. This should be kept in a closed vessel for a day at least, to assure the best result. One pound of the powder properly diluted will treat an acre of cabbage, and if fresh will be effective against the insects mentioned.

ONGARTH'S TREE PROTECTOR.

This is a California remedy, tried here this season for the first time with success. It proved to be very effective against the squash bug, cabbage caterpillars and false chinch bug, or wherever the kerosene emulsion would be effective. Its cost, however, would not permit of its profitable application on ordinary crops as against the kerosene emulsion, which is nearly as effective and much cheaper.

KEROSENE.

This is one of the most efficient remedies against all insect life not affected by the arsenical poisons, causing death by suffocation or by its corrosive action, and its cheapness places it within easy reach. To be applied successfully, however, it must be diluted with water, several formulae for which have been devised by various parties. We have used the formula of Prof. Riley, of the Department of Agriculture, which is as follows:

Kerosene, 2 gallons.
Water, 1 gallon.
Soap, ½ pound.

The water and soap to be boiled and added to the kerosene, churning the whole violently with a syringe or pump until the materials have assumed the consistence of cream. The emulsion is then diluted, using one part of the latter to nine parts of water. In using it on the young leaves of plants, it is desirable to have a greater proportion of water.

The plant grower must use his own judgment in regard to this. In some cases, as against the woolly aphis on the roots of apple trees, it may be used stronger than ordinarily recommended.

Cultivators should, to avoid the hurry of the growing season, prepare this emulsion in some quantity early in spring before the rush of work, and put in a large vessel, to be corked tightly until needed.

Future work in the arid region will exhibit a necessity for its use on many occasions before a season's work is completed. A prompt application will always prove invaluable in any contest with insect enemies.

APPLYING INSECTICIDES.

Much thought and ingenuity have been given to devising apparatus for the economic and safe application of insecticides.

We have used the Woodason double-cone bellows, and while it is far from being perfect, being liable to clog, still it is the best we know of at present for the application of poisons in the dry form.

To apply insecticides in the liquid form, a force pump is required, which for work on a small scale may be used by hand. On a larger scale we have used this season a Field force pump attached to a tank, the latter placed on the seat form of a two-wheeled cart, drawn by a horse, one of the wheels operating the pump. This apparatus does satisfactory work on level ground; if the land is rough and the horse unsteady, one is very liable to have accidents in the breaking of minor parts of the gearing. The nozzle used was the "Boss" nozzle, which did satisfactory work. To spray potatoes and not injure the vines, a six-foot axle was used, that the wheels might cover three rows and the horse walk between two rows. This arrangement proved very satisfactory. The tank sent out by this firm is too large for one horse to draw with ease. I see no reason why this pump and two-wheeled cart should not prove an acquisition to potato growers on a large scale, on level ground.

NOTES ON INSECTS.

THE CURRANT MEASURING WORM (*Eufitchia ribearia*).

This caterpillar defoliated a large planting of the Houghton gooseberry, leaving untouched the Downing. The larvæ appear early in May, are white, striped with yellow and dotted with black, and when full grown, late in June, measure nearly one and a half inches in length. This caterpillar moves by looping, or measuring, and dropping by a silken thread, when disturbed. In about two weeks the moths appear, which are of a yellowish, or cream color, with dusky spots or bands on the wings; these lay eggs on the twigs, where they remain until the following season.

THE EUROPEAN CABBAGE CATERPILLAR (*Pieris rapæ*).

This insect was very common this season over a large portion of Colorado, hovering over the cabbages in vast numbers. Our first specimens appeared early in March, and toward midsummer it was one of our most common species. This butterfly is white, spotted with black, resembling somewhat the Southern cabbage butterfly, but the black spots are better defined and the ground color lighter. The larva is pale green, finely dotted with black. This butterfly is two-brooded, the first appearing early in the spring (March in this region), depositing its eggs, after pairing, on the under side of the leaves; the second brood appears in June, and is most injurious, this brood pupating during the winter.

Remedies—On July 15th and on the 26th of the same month, we made separate trials of the kerosene emulsion and Ongarth's liquid tree protector with success against cabbage worms. The latter was particularly effective, the worms dying whenever struck by the liquid.

THE SQUASH BUG (*Coreus tristis*).

This well known insect appeared in this region in numbers for the first time this season, and proved a serious drawback to the culture of the squash and pumpkin. It hibernates as a perfect insect, and in May appears as the vines are well above ground, feeding on the leaves by day, and depositing their eggs in clusters, glued to the under side of the leaf. The larvæ feed voraciously, soon wilting even the most vigorous vines, and rapidly attain full size. These live throughout the winter, to repeat the season following the work of the previous year.

Remedies—It is of importance, in the case of all insects that hibernate in the perfect state, that we attack them early, when their numbers are limited, and this is especially true of this enemy. The kerosene emulsion and Ongarth's liquid tree protector kept them in subjection.

THE CODLING MOTH (*Carpocapsa pomonella*).

The larva of this moth is the chief pest of our apple orchards in Colorado, as elsewhere, and although a native of Europe, is now found in almost all parts of North America.

The moth is a beautiful object; the fore wings are marked by irregular, heavy bands of pale brown on a grayish ground color, the apex being marked by a tawny, brown spot, streaked with coppery lines. The first specimens are taken here early in March, the moth continuing to come forth for two months later, according to the temperature of the place in which they have wintered.

As the apple is forming the female deposits a single egg, usually in the eye or calyx of the forming fruit; from the egg a larva is produced, with black or brownish head, the body sprinkled with elevated dots, from each of which emanates a minute hair. In about one month the larva, having eaten its way through the core of the apple, revealing its presence by a mass of reddish brown exuviæ protruding from where it entered, leaves the fruit, reaches the ground by means of a silken thread which it spins, and seeking the trunk of the tree spins its cocoon. The early brood change to a chrysalis in three days, and in about two weeks the perfect moth escapes. This second brood is on the wing late in July, the female generally selecting the late apples in which to deposit its eggs. These larvæ mature late in autumn, and spin their cocoons in come secure place, remaining in the larval state until early the following spring, when they change to a brown chrysalis, soon after which the moth appears to begin the work of the season.

Remedies—The old method of bandaging the trunks has been abandoned, as it signally failed to accomplish its purpose, for various reasons. Recourse is now universally had to spraying with Paris green or London purple. This remedy is not only very efficient, but inexpensive and easy of application. We applied London purple April 28th, and again twelve days later, in the proportion of one pound of the purple to 100 gallons of water, using the Field force pump and tank, mounted on the platform of a two-wheeled cart. Every alternate tree in a row of Duchess of Oldenburg was thus treated. This was too strong, as it hurt the foliage considerably. Probably half a pound of the purple to the same amount of water would be quite efficient, making two applications ten or twelve days apart. A similar application of Paris green in the same proportion was made in another orchard April 28th and on May 10th. This proved to be satisfactory; the foliage was uninjured, and but few fruit affected by the codling moth was found. Careful analysis of the calyx of the fruit was made by Dr. O'Brine, Chemist of the Station, and no trace of arsenic was found—the usual winds and rains of the season secured its dispersion.

For work on a small scale, an ordinary pail and small force pump will do efficient work. The spray is produced by a flat, perforated nozzle, or the cyclone nozzle for large trees, and where many have to be sprayed we use and prefer the "Boss" nozzle. The time to make the first application is as soon as the fruit is formed, and while erect on its stem.

Another good effect of the application of the arsenites at this season is the destruction of all other leaf-eating larvæ, some of which are so injurious to the apple tree in this region during the months of April and May. It is a great gain to fruit-growers in this dry region to know that the arsenites may be safely applied to the foliage of the apple tree without danger to human life when the fruit is fit for table use.

THE APPLE-LEAF BEETLE (*Graptodera foliacea*).

This brassy-green apple insect has been injurious to the foliage of apple grafts and small apple trees for several years in Colorado. It confines its work, however, mainly to the nursery, never working high above the surface of the ground. It does not touch the pear, although working in numbers on apple grafts, on either side of them. It shows, with us, a partiality for some varieties over others, and is sometimes as destructive to the grape as to the apple. It is a pest in every valley in the State where the apple is grown. It also feeds in great abundance on the native species of the genus *Gaura*, so plentiful in this region.

Remedies—Fortunately it is easily overcome. We have to contend with it annually, and find no difficulty in getting rid of it with the arsenical preparation already noted. On a small scale, a teaspoonful of the poison to a pail of water is sufficient. More than one application may be necessary, however, during the period at which it is active. The first application may be made the last week in May, and in two weeks more another may be necessary, as the beetles fly well and are very numerous. The species may be easily identified by its highly polished brassy-green color, its jumping habit on being alarmed, and its partiality for the apple, although it will occasionally attack the grapevine, riddling its foliage, leaving the framework of the leaf as it does that of the apple.

THE EIGHT-SPOTTED FORESTER (*Alypia octomaculata*).

The larva of this beautiful moth attacks the foliage of the grape annually, in some sections of the State, in large numbers. There are two broods, the first moths appearing in May, and the second in August. The wings of the moth, when spread, expand nearly one and a half inches. It is bluish black in color, with two large, light yellow spots on each of the fore wings, and two white spots on each of the hind wings. It is so strongly marked that it is readily recognized. The larva is a dull white with eight black lines on each segment, and a series of white spots on each side close to the under surface.

Remedies—I have always succeeded in destroying the larvæ of the first brood with a weak application of Paris green in water, in June. For the second brood, if the vines are in bearing, it will not do to apply the poison, but if the first attack has been promptly met, there will not be much trouble from the second.

THE IMPORTED CURRANT BORER (*Ægeria tipuliformis*).

For a few years past the larva of this moth has been injurious to the red currant bush in this State, appearing in this region from the middle to the last of the month of

May. The moths of this family are frequently very injurious to useful plants and are readily recognized by their wasp-like appearance, quick movements, and by the brush-like arrangement at the tip of the body. The moth is nearly one-half an inch long, color deep blue, having three yellow bands across the abdomen, a yellow collar, and yellow and blue markings on the eyes. It flies rapidly, in the hottest sun, but is easily captured. The females deposit their eggs near a bud of the current season's growth, and preferably on the outer branches. The larva, as soon as hatched, eats its way to the center of the stem, where it remains until the following summer, when the moths again appear, to repeat the work of destruction.

Remedies—The presence of the larva may be known by the sickly color of the leaves and the smallness of the fruit. The only practical remedy known, is to prune off and burn the affected branches in early spring. The pruning will also serve an additional purpose in assuring larger and better fruit.

THE GARDEN WEB WORM (*Eurycreon rantalis*).

The most remarkable insect visitation of the year to Colorado was the presence of this insect. The moths appeared in immense numbers late in April, covering the plains and reaching well up into the mountains, and embracing the greater portion of the State. The larva was first described by Dr. Riley in 1873, prior to which time it was unknown.

It is a widespread and very variable species, extending throughout the United States. The general color of the moth is a light or dark gray, marked by two irregular transverse pale lines, and a dark reniform spot on the discal cell. The perfect insect, larva and pupa, are accurately figured by Dr. Riley in the report of the Department of Agriculture for 1885. The larva fed upon a great range of plants—its favorite native food plants being species of the genus *Chenopodium*, although it fed indiscriminately upon the native weeds here. Among cultivated plants, it attacked all vegetables, except squash, egg plant and Irish potatoes. An acre of tobacco was untouched, but field and sweet corn, wheat, oats, alfalfa, clover and strawberry plants were devastated. On alfalfa, it fed to its tops, and in some cases defoliated young plum trees four feet from the ground. The first larvæ were noticed May 29 (then quite small); from this date to July 15, larvæ of all sizes were working together, and were injurious as late as July 4. The cocoons were readily found in the rubbish at the collar of the plants attacked. The larvæ appear to be gregarious, as they fed in numbers on the same plant, over which they spun an intricate web, along which they traveled with alacrity when disturbed.

Remedies—We made our first application of Paris green June 1st, using one pound of the poison to one hundred gallons of water, which proved to be very effective and not injurious to the plant, but we had to make a second application on the 20th of June, and finally on July 3rd, after which, garden plants that had been treated were not further troubled, although mature larvæ were to be obtained for some days afterwards on fields of alfalfa. We used a hand machine to spray a six-acre garden. On a large scale, and by using the barrel or tank and pump and a good cyclone nozzle, much quicker and cheaper work could be accomplished. Although we have had a formidable visitation of this insect, we do not consider it at all difficult for the gardener to control. The farmer, because of his broad acres and general lack of preparation to meet such contingencies, is apt to suffer most.

PEA WEEVIL (*Bruchus pisi*).

This weevil continues to damage field and garden peas considerably. Our seeds of all the varieties grown this season are affected more or less. The imagoes are leaving the affected seeds in large numbers this fall, so that our crop of these pests will be lessened next season. The habits of this weevil are generally well understood by gardeners, so that a brief description of its mode of life will be sufficient. The weevil passes the winter in the peas, emerging therefrom about seeding time. As soon as the pods are formed and the seeds set within them, the weevil punctures the pod opposite each pea, and inserts therein an egg which becomes a grub, feeding on the rich store of food within. Here they remain during the winter, changing to the perfect insect in the fall, or before planting time in the spring.

Remedies—The only known remedy for this enemy of the pea is based upon a knowledge of its habits. These insects usually remain in the peas all winter, so that if the affected stock is kept over another season in tight vessels, the beetles are of course destroyed. This is a simple remedy, and if those having stock affected would unite to do this, the evil would be very much lessened in this State.

THE SOUTHERN CABBAGE BUTTERFLY (*Pieris protodice*).

The larva of this butterfly is the most injurious of the cabbage caterpillars to the gardener in Colorado. It was present in this State the past season in force, flitting over fields of cabbages in increased numbers over previous years. Of other cabbage worms we noted: *Pieris orleracea, Pluvia brassicæ and Ceramica picta,* though not in numbers sufficient to cause much damage. The latter species I have taken on the soft maple. The color of the male of protodice is a white with dark bars and spots on the front wings, hind wings without spots; on the underside the bars and spots are repeated, the tips tinged greenish yellow; the veins of the hind wings behind are greenish yellow, spotted with brown scales. The female is of the same color, the dark markings intensified and showing a tendency to blend. The larva is at first a uniform orange with black head, changing to a greenish blue ultimately, with four longitudinal stripes.

Remedies—Against these caterpillars we applied successfully, on July 26, the kerosene emulsion and Ongarth's liquid tree protector. The latter is the more effective of the two, as it sticks to the foliage better, and, while killing when it comes in contact with the caterpillar, it also seems to render the plant obnoxious to insect life. On the same date applied hellebore as a powder unmixed, and diluted one tablespoonful to two gallons of water. This was not nearly so successful as the others.

THE FALSE CHINCH BUG (*Nysius angustatus*).

This insect appeared in market gardens in this vicinity last June for the first time. It first appeared on radishes, clustering in large numbers in the shade of the leaves near the ground. It next attacked a field of turnips, showing a preference for certain varieties, but avoiding all varieties of the rutabaga. It also did some damage to cabbage and cauliflower, but confined itself particularly to the two plants mentioned. It bears a striking resemblance to the chinch bug proper. The latter, however, has a dark head and thorax and two conspicuous black spots on the front wings. The true chinch bug feed almost entirely on the cereals and grasses, whereas the species under consideration favors cruciferous plants, and is of a paler and more uniform brown color.

Remedies—This is by far the most difficult insect with which I have had to contend the past season, because of its rapid movements and great numbers.

Applied the kerosene emulsion, diluting the latter with nine parts of water; also applied Ongarth's liquid tree protector, and hellebore, both as a powder and mixed with water. The first two are very effective whenever the liquid comes in contact with the insect, but owing to their vast numbers and ability to fly, only a small proportion of them could be killed at one application. These insecticides were applied on July 26th, August 3rd, 11th and 21st. The hellebore seemed to be far less effective than the other two remedies. We consider this the most dangerous insect with which we have had to contend for years. There are probably two or three broods annually, and it passes the winter as a perfect insect, hence it would be desirable to burn all weeds and tops of vegetables, so as to afford them as few hiding places as possible.

FOREST TREE INSECTS.

The cottonwoods are defoliated annually by the larva of the cottonwood beetle (*Plagiodera scripta*), but are held in check by the common blackbird.

Several species of *Pemphigus* cause galls to form on the stems and leaves of the species of cottonwood. The poplar gall louse wanders in immense numbers up and down the stems and trunks of the smooth bark cottonwood in fall.

In Southern Colorado the poplar borer (*Saperda calcarata*) is injurious to *Populus angulatus* and the Lombardy poplar.

The larva of the moth *Tortrix roseana* is a general feeder, but works particularly on the young leaves of the apple in May.

The box elder is defoliated annually by the leaf-rolling caterpillar (*Cacœcia senifera*). The larva is green with two longitudinal white stripes. The blackbird feeds on them in large numbers.

The elm-leaf caterpillar (*Vanessa antiopa*) feeds on the elm and willow, and occasionally on the cottonwood. The larvæ are gregarious while feeding, and present a formidable appearance. It is the earliest butterfly to appear in spring, being on the wing in favorable weather in March.

Pear-tree slug (*Selandria cerasi*). This insect seems to prefer the leaves of the plum; it but rarely attacks the cherry or the pear in Colorado. There are two broods annually, one late in June and another in August. The slug feeds on the lower as well as the upper surface of the leaf, completely skeletonizing it. The last brood is especially injurious.

Larvæ of the butterflies *Grapta interrogationis* and *Grapta progne* feed on the foliage of the elm and native hop vine.

Larvæ of the forest tent caterpillar feeds on the foliage of *Populus angulata.*

The common elm aphis disfigures the foliage of that tree annually.

The large caterpillar of *Telea polyphemus*, one of the silk worm moths, feeds on the apple and the elm in this locality.

NOTES ON MISCELLANEOUS INSECTS.

Rhyncites bicolor, a beetle with bright red body, black legs and sides, feeds upon roses and the raspberry in large numbers. The mature insect is sluggish, drops to the ground when disturbed; hence is not difficult to destroy.

Systena mitis, a leaf-eating beetle, has been destructive to a variety of plants for two seasons. The potato, beet, bean and tomato were seriously injured. The beet and other *Chenopodiaceæ* suffered most. The beetle (*Chrysomela exclamationis*) bears a general resemblance to the potato beetle, and is very numerous in the State, generally feeding, however, on no useful plant, confining itself to the species of sunflower, so numerous on the plains.

Collops nigriceps, a beetle with reddish thorax and abdomen, feeds on the beet, but not in large numbers.

Conotrachelus leucophaetus, a dark brown beetle resembling a dried bud, and a near relative of the plum weevil, feeds on the beet, but not in large numbers here.

Selandria rubi, the raspberry saw fly, a four-winged hymenopterous insect, appears in this region early in

May, laying its eggs beneath the skin of the raspberry leaf. The larva is the color of the leaf, but its work reveals its presence. It may be destroyed by hellebore, an ounce to a pailful of water.

The cabbage and turnip aphis are always destructive in a dry climate. The kerosene emulsion will kill them whenever they can be reached. It is not difficult to counteract them, if the work is begun in time. The work of these aphidæ may, however, be lessened by planting those plants in rich ground only. If they once become stunted, then this insect will work their destruction.

The blister beetles (*Lytta cinera* and *Lytta attrata*) we received from the Arkansas Valley this season. They feed voraciously on the potato, beans and other garden vegetables. We are annually more or less troubled with the striped flea beetle (*Haltica striolata*). These beetles are very small, but active, and are present usually in great numbers on cabbage, radish and turnips, while the plants are still small. We made one application of Paris green on June 2nd, and succeeded in saving the plants.

Grasshoppers were very injurious in various portions of the State, owing to lack of rain on the range, rendering the latter destitute of green herbage.

The corn worm (*Heliothis armigera*), is annually injurious to corn in the ear wherever the plant is grown in the State. The moths were abundant in the month of October in Southern Colorado this year.

The bee killer (*Trupanea apivora*). This fly is numerous enough on the plains and in the mountains. It is said to prey especially on the honey bee. We have witnessed it the past season at high elevations in the mountains attacking and killing dragon flies (*Libellulidæ*). It seizes these powferful flies on the wing, and, after a severe struggle, both fall suddenly and with force to the ground, where both are readily captured.

The three-lined leaf beetle (*Lema trilineata*) was noticed in numbers on the tomato and potato. The larva is readily distinguished by its covering itself with its own excrement. The beetle is difficult to take, as it flies quickly in the hot sun.

Two undetermined species of *Erythroneura* work on the foliage of the apple and grape throughout the growing season.

The species on the grape affects the smooth leaved varieties most. As the insect hibernates in the perfect state, clean culture by burning all decaying vegetation in the fall will aid much in their suppression. As a remedy we have used the kerosene emulsion with success, applying it early in the day, when the insects are sluggish.

Circular of the Chemical Section.

The Station is prepared to analyze and test fertilizers, cattle food, soils, milk, butter, water and other agricultural materials and products, and to give information on various subjects of agricultural science, for the use and advantage of the citizens of Colorado.

The Station makes these analyses *free of charge* for the citizens of Colorado, only on the following conditions:

1. That the results are of use to the public, and are free to be published as a part of the Station report.

2. That all questions in regard to the articles will be *truthfully answered* by the party or parties sending them.

3. That the sample be selected according to the instructions of the Station for sampling the same, and the person sending it sign the certificate.

Work done for individual benefit will be charged for at moderate rates.

All other chemical work proper to the Experiment Station, that can be used for the public benefit, will be made free of charge.

The Station will undertake no work, the results of which are not at its disposal to use or publish, if deemed advisable for the public good.

Results of analyses or investigations that are of general interest will be published in bulletins, and can be obtained of the Secretary, Hon. Frank J. Annis, Fort Collins, Colorado.

INSTRUCTIONS FOR PROCURING SAMPLES.

Samples of water to be analyzed should be, for *ordinary* water analysis, one gallon; for *mineral* analysis, three gallons and should be put up in *clean glass vessels*, with a *clean*, *new cork*, and completely filled and sealed.

Samples of milk should not be less than one pint, and should be *thoroughly mixed* before being taken.

Samples of rocks, coal or minerals should be selected by pulverizing twenty pounds to the size of hickory nuts, and selecting from these one pound.

Samples of fertilizers are made by taking a sample from the unbroken package at the top, middle and bottom; these are intimately mixed on paper, and a quart selected and put in a clean, dry bottle and well corked. *All expenses must be prepaid to the Station.*

In justice to manufacturers, dealers and consumers alike, the Station will make gratuitous analyses of the commercial fertilizers, only on samples taken by the agent of the Station, or on such other samples as are fully described on the Station forms for description, and taken in accordance with the Station instructions for sampling, and, furthermore, are properly authenticated by the certificate of the person drawing the same, and in addition, a witness who is a responsible person in the community, or the dealer from whose stock the sample is taken.

Send with each sample any printed circular, pamphlet, analysis or statement that accompanies the article, or is used in its sale.

As soon as an analysis is made, a copy of it is sent to the party who furnished the sample and also to the manufacturer, in order that there may be opportunity for explanation or protest, if desirable, before the results are published in the bulletin.

Samples of soils are taken according to the object of analysis, either, (1) from *one* or from *several* spots in the field. (2) In case several portions of earth are taken from points distributed in a regular manner over the field, all of which are carefully mixed together and ten to fifteen pounds of the mixture, free from any large stones, are preserved as the average sample.

"Have a wooden box made six inches long and wide and from nine to twelve inches deep, according to the depth of the soil and sub-soil of the field. Mark out in the field a space of about twelve inches square; dig round in a slanting direction a trench, so as to leave undisturbed a block of soil, with its sub-soil, from nine to twelve inches deep; trim this block or plan of the field, so as to make it fit into the wooden box; invert the open box over it, press down firmly, then pass a spade under the box and lift it up, gently turn over the box and nail on the lid. The soil will then be received in the exact position in which it is found in the field. In case of very light, sandy and porous soils, the wooden box may be at once inverted over the soil and forced down by pressure, and then dug out." The above directions are issued by the Royal Agricultural Society for samples of soil for analysis.

Samples will be analyzed as promptly as possible, in the order in which they are received.

It is important that samples for analysis should be taken at the time when the fertilizer is purchased, and *immediately sent* to the Station.

I, the undersigned, certify that the accompanying sample, marked ———, was taken by me from full packages, and in accordance with the Station's instruction for sampling, and, to the best of my knowledge and belief, fairly represents the stock from which it was drawn, and that said stock when sampled was properly housed, and in good condition. I also certify that the foregoing description is correct.

Signature.

Postoffice address.

The above described sample was taken in my presence.

Signature.

Postoffice address.

Each sample sent for gratuitous analysis must be accompanied by a description made by filling out legibly and as fully as possible the blanks below.

1. Sampler's mark or name.
2. Brand.
3. Name and address of manufacturer.
4. Name and address of dealer.
5. Date of taking this sample.
6. Price per pound, ton or package.
7. For what purpose it is used.
8. The percentage of valuable ingredients, if known.
9. Such other information as the Station may require.

Copies of bulletins issued by the Station may be had on application to

THE AGRICULTURAL EXPERIMENT STATION,
Fort Collins, Colorado.

—— THE ——

STATE AGRICULTURAL COLLEGE

The Agricultural Experiment Station.

BULLETIN NO. 7.

POTATOES AND SUGAR BEETS

1888.

FORT COLLINS, COLORADO.

APRIL, 1889.

INTRODUCTORY.

It has long been supposed that the arid region presented such new and changed conditions of soil and atmosphere, that nearly all plants grown under these conditions would change in one way or another from their normal condition as grown in Eastern States in different latitudes. This has been found to be true of the wheat plant, and to some extent the other cereals. The Experiment Station of Colorado has undertaken the examination of other plants. It has carried on the work begun two years ago in potatoes, and added the chemical analysis of 303 varieties for the content of starch, in order that some general comparison could be made with Eastern and Southern grown varieties. Within a few years Colorado potatoes have become well known for their elegant table quality. It is the aim of this Station to grow, comparatively, many varieties, and to originate from seed new ones, in order to improve upon those we now have, if possible to do so. The work has been well done, and we hope will meet the needs of the State. The investigation of the sugar producing problem is important, and will be continued.

C. L. INGERSOLL,
Director.

Potatoes and Sugar Beets.

BY JAMES CASSIDY, B. S.,
Horticulturist and Botanist,
AND
DR. D. O'BRINE, D. Sc.,
Chemist.

POTATOES.

The potatoes in this experiment were planted May 11, on a clay loam soil, that had been in clover sod for two years previous, and was plowed in the fall of 1887, and again in the spring of 1888. The area in crop was half an acre, in two plats of one-fourth of an acre each. The tubers of the named kinds were cut to one-eye sets of fair substance; but with seedlings, whole tubers of medium size were used. The planting was in rows three feet apart, with the pieces or tubers one foot apart in the rows. The plants from whole tubers appeared above ground five days earlier than those from the one-eye pieces, and, in agreement with previous experience, gave the largest yield and the most vigorous development of tops. The yield was very light and the tubers small for this region, owing to the extreme high temperature which prevailed in July and August, and the lack of the usual midsummer rains. The seedling varieties are the best of over 2,000 kinds raised here during the past three years from seed, very largely of our own saving, some varieties of which in other hands and in peculiarly favorable soils yielded better crops and larger individual tubers the past season, than standard varieties grown in this region under the same conditions. Most of the named kinds were untried here, hence the past season cannot be called a good or sufficient test of their real value under our conditions. Although so many kinds were a failure, and none were up to our expectation, yet, on the whole, the test is not unprofitable, because it has enabled us to see what varieties do best under adverse conditions.

While the yield of tubers is of great importance, yet the quality is of still greater moment. The chemical composition of the potato varies with the soil in which it is grown, the season, the nature of the fertilizers used, its size and maturity. The best tubers contain about 20 per cent. of starch, which is formed in the leaves; hence, to have potatoes of good quality, the leaves must be uninjured during the season of growth. The varieties are arranged in the accompanying table in the order of content of starch; the average per cent. of starch for the seedlings is 18.85 per cent.; for the named kinds, 17.17 per cent. The soil best adapted to the potato is one that is cool, loose and friable, its mechanical condition being more important, in connection with irrigation, than its fertility.

The plats were irrigated four times, cultivated four times, sprayed with Paris green three times, and all were dug by September 21. Land more level and having a greater affinity for water than our clay loam soils, has often a sufficiency in two waterings, and in certain cases, even, without any moisture but the usual rains. The tables give the number of hills planted of each kind, the yield in pounds, the per cent. of starch, and the condition of the tubers April 1, in regard to sprouting. All were treated exactly alike in the field, and were wintered in a basement cellar, the temperature of which ranged from 35° to 45° Fahrenheit.

The most prolific among the named kinds were Stray Beauty, Red Elephant, Grange, Bliss' Triumph, Summit and Jordan's Russet, in the order named. These varieties yield profitable crops of tubers in congenial soils, and in seasons not favorable to the best development of this plant in all soils and situations.

The best yields of seedlings were Nos. 72, 44, 38, 105 and 58, in the order named.

POTATOES—Named Varieties.

VARIETY.	*No. of Hills.*	*Yield in Pounds.*	*Per Cent. of Starch.*	*Condition April 1st, 1889.*	REMARKS.
Solanum Jamesii			22.95	Unsprouted	This species exhibits no improvement under cultivation.
Spaulding	9	6½	22.50	Sprouted	Tubers round, eyes shallow.
Jordan's Russet	10	11¾	22.48	Sprouted	Tubers irregular, eyes deep.
Michigan Late Rose	11	12	21.25	Sprouted	Tubers irregular, roundish, eyes prominent.
White Beauty of Hebron	6	7	21.15	Sprouted	Tubers irregular, eyes deep, rather coarse.
Early Pearl	52	33	21.01	Sprouted	Tubers round, eyes deep, skin smooth.
Delaware	30	25	20.83	Sprouted	Tubers flat, irregular, skin smooth, eyes shallow, fine.
Vanguard	39	35	20.47	Sprouted	Tubers pointed at seed end, eyes shallow.
Rural Blush	39	30	20.44	Sprouted	Tubers roundish, eyes deep.
New Eximus	10	8½	20.43	Sprouted	Tubers round, skin rough, eyes deep.
Chicago Sun	6	4	20.25	Sprouted	Tubers oblong, eyes shallow, skin smooth.
California White	6	3¾	19.89	Sprouted	Tubers irregular, eyes shallow, skin smooth.
Sterling	8	5½	19.89	Sprouted	Tubers irregular, eyes shallow, skin smooth.
Big Benefit	8	5	19.80	Sprouted	Tubers irregular, eyes shallow, skin smooth.
Watson's Seedling	39	22	19.80	Sprouted	Tubers irregular, eyes prominent.
Pearl of Savoy	55	35	19.80	Sprouted	Tubers oblong, eyes deep, skin smooth.
White Sport	28	13	19.57	Sprouted	Tubers round, eyes deep, skin rough.
Beauty of Hebron	28	25	19.57	Sprouted	Tubers oblong, irregular, eyes deep, skin smooth

POTATOES—Named Varieties—(*Continued*).

VARIETY.	*No. of Hills.*	*Yield in Pounds.*	*Per Cent. of Starch.*	*Condition April 1st, 1889.*	REMARKS.
American Giant	28	14½	19.39	Sprouted	Tubers round, eyes deep, skin rough, rather coarse.
Grange	9	12	19.39	Sprouted	Tubers round, eyes deep, skin smooth.
Stray Beauty	22	30	19 35	Sprouted	Tubers round, eyes deep, desirable.
Early Perfection	8	7	19.21	Sprouted	Tubers long, eyes shallow, good.
President Cleveland	15	9	19.20	Sprouted	Tubers roundish flat, skin smooth.
Yankee Nation	19	7	19.20	Unsprouted	Tubers cylindrical, eyes deep, skin rough.
Randall's Rose	44	36	19.08	Sprouted	Tubers oblong, eyes shallow, skin smooth.
Rochester Favorite	12	9	19.08	Sprouted	Tubers oblong, eyes prominent, skin smooth.
Rubicana	11	8¾	19.08	Sprouted	Tubers round, eyes deep, skin rough.
Garrison's No. 8	7	5½	19.08	Sprouted	Tubers roundish, irregular, eyes shallow, smooth.
Empire State	54	36	19.08	Sprouted	Tubers long, skin smooth, eyes deep.
Hoag's Seedling	40	25	19.08	Unsprouted	Tubers long, tapering to seed end, eyes shallow.
Queen of the Valley	61	....	19.03	Sprouted	....
Queen of the Roses	9	9	18.80	Sprouted	Tubers long, pointed at seed end, eyes deep.
Rose's Beauty of Beauties	29	26¾	18.80	Sprouted	Tubers irregular, eyes deep, a desirahle kind.
Tremont	8	5½	18.76	Unsprouted	Tubers round, eyes shallow.
Vermont Champion	12	9	18.76	Sprouted	Tubers oblong, eyes deep, skin smooth.
Shannon's Seedling	12	9	18.72	Sprouted	Tubers round, eyes shallow, desirable.

El Paso	11	9	18.50	Sprouted	Tubers round, eyes shallow, skin smooth.
Newton	11	7½	18.45	Sprouted	Tubers irregular, eyes shallow, rough skin.
Norway White Rose	8	7	18.45	Sprouted	Tubers roundish flat, eyes shallow, desirable.
Durham	7	7½	18.45	Sprouted	Tubers irregular, eyes shallow, skin smooth.
Beauty of Sheba	42	31	18.45	Sprouted	Tubers irregular, eyes few and shallow, skin smooth.
Bliss' Triumph	10	12½	18.45	Sprouted	Tubers irregular, eyes deep, skin smooth.
Hercules	10	7½	18.45	Sprouted	Tubers long, eyes shallow, skin smooth.
Magnum Bonum	6	5	18.30	Sprouted	Tubers irregular, eyes deep, rough skin.
Early Sunrise	45	30	18.20	Sprouted	Tubers long and tapering, eyes deep, skin smooth.
Champion of America	10	7	18.13	Unsprouted	Tubers round, skin smooth, eyes deep, color red.
New Champion	9	10	18.13	Sprouted	Tubers roundish flat, eyes deep, skin smooth.
Early Ohio	20	18½	18.13	Sprouted	Tubers roundish, skin rough, a desirable early variety.
Summit	22	24	18.10	Sprouted	Tubers oblong, eyes prominent, fine.
Superb Beauty	6	6	18.00	Sprouted	Tubers oblong, eyes few and deep, skin smooth.
Paragon	10	5	18.00	Sprouted	....
Perfect Peachblow	10	5¼	18.00	Sprouted	Tubers irregular, skin spotted, desirable.
Leopard	7	4	18.00	Sprouted	Tubers round, eyes deep, skin smooth and spotted.
Brigham	9	5¾	18.00	Sprouted	Tubers irregular, eyes shallow, rough skin.
Early Ease	35	17¾	18.00	Sprouted	Tubers roundish, flat, eyes deep, skin smooth.
Rand's 42	10	9	18.00	Unsprouted	Tubers irregular, eyes deep.
Putnam's New Rose	11	5	18.00	Sprouted	....
Climax	6	5¼	18.00	Sprouted	Tubers round, eyes deep, skin rough.

POTATOES—Named Varieties—(*Continued*).

VARIETY.	*No. of Hills.*	*Yield in Pounds.*	*Per Cent. of Starch.*	*Condition April 1st, 1889.*	REMARKS.
California Red	12	10½	18.00	Sprouted	Tubers irregular, eyes deep, skin rough.
Agnoth's Favorite	8	8	17.98	Sprouted	Tubers round, eyes deep, skin rough.
Maine Champion	8	6	17.95	Sprouted	Tubers round, eyes shallow, skin smooth.
Fearnaught	62	52½	17.85	Sprouted	Tubers irregular, eyes deep, skin smooth, good.
Green Mountain	65	37	17.84	Sprouted	Tubers irregular, eyes deep, skin rough.
Rase's Seedling	18	8	17.55	Sprouted	Tubers irregular, eyes deep, skin spotted red.
Cream of the Field	6	7	17.55	Unsprouted	Tubers irregular, eyes deep, skin smooth.
O. K. Mammoth	28	17	17.55	Sprouted	Tubers irregular, skin smooth, eyes deep.
Rosy Morn	7	7	17.55	Sprouted	Tubers irregular, eyes shallow, skin smooth.
Mammoth Pearl	28	22	17.55	Sprouted	Tubers roundish, flattened, eyes few.
Early Howard	7	5	17.55	Sprouted	Tubers oblong, eyes deep, skin smooth, fair.
Early Electric	10	6¼	17.55	Sprouted	Tubers round, eyes shallow, dark red, skin smooth.
Ohio Queen	7	2	17.50	Sprouted	Tubers oblong, skin smooth.
Early Telephone	10	5	17.48	Sprouted	Tubers oblong, eyes shallow, skin smooth.
Burbank	50	42	17.20	Sprouted	Tubers long, eyes deep, skin smooth.
Howard	10	9½	17.10	Sprouted	Tubers long, eyes shallow, good.
Late Snowflake	7	4½	17.10	Sprouted	Tubers irregular, roundish, eyes deep.
Corliss Matchless	10	3¼	17.10	Sprouted	....

Lion	8	5½	17.10	Sprouted	Tubers oblong, eyes deep, color red.
White Mercer	9	5½	17.10	Sprouted	Tubers irregular, eyes deep and red, skin smooth.
Baker's Imperial	36	8½	17.10	Sprouted	Tubers cylindrical, eyes rather deep.
Golden Age	9	5	17.10	Sprouted	Tubers long, eyes deep, skin smooth.
Steuben Beauty	9	6	17.05	Sprouted	Tubers round and course.
Snowflake	11	7	17.00	Sprouted	Tubers round, eyes shallow, skin smooth.
Brownell's No. 55	10	5	16.78	Sprouted	Tubers round, eyes prominent.
Collum's Superb	13	9	16.65	Sprouted	Tubers long, irregular, skin smooth, eyes prominent.
Chicago Market	36	30	16.65	Sprouted	Tubers irregular, eyes shallow, skin smooth.
Portage	6	3½	16.65	Sprouted	Tubers oblong, eyes shallow, desirable.
Ohio Fancy	10	10	16.65	Sprouted	Tubers round, eyes deep, skin rough.
Weld's	18	10	16.33	Sprouted	Tubers roundish, eyes deep, rough.
Golden Flesh	24	11	16.29	Sprouted	Tubers irregular, eyes deep, skin rough.
Seek no Further	6	5	16.06	Sprouted	Tubers oblong, eyes deep, skin smooth.
Canfield Seedling	11	7	16.06	Sprouted	Tubers irregular, eyes prominent and shallow.
Ladies' Favorite	10	6	15.84	Sprouted	Tubers round, eyes shallow, skin smooth, fine tubers.
Blue Victor	8	5½	15 84	Sprouted	Tubers irregular, eyes deep, rough skin.
White Star	32	22	15.75	Sprouted	Tubers cylindrical, eyes deep, skin rough.
Irish Cup	6	1	15.75	Sprouted	Worthless.
Early Maine	11	11	15.60	Sprouted	Tubers oblong, skin smooth, eyes shallow, good.
St. Patrick	43	32	15.52	Sprouted	Tubers oblong, eyes deep, skin rough.
Hampshire Beauty	38	24	15.52	Sprouted	Tubers long, eyes shallow, smooth skin.

POTATOES—Named Varieties—(*Continued*).

VARIETY.	*No. of Hills.*	*Yield in Pounds.*	*Per Cent. of Starch.*	*Condition April 1st, 1889.*	REMARKS.
Iroquois	9	7	15.52	Sprouted	Tubers round, eyes deep, smooth skin.
California Rose	8	6½	15.30	Sprouted	Tubers oblong, eyes deep, skin smooth.
Thunderbolt	52	35	15.00	Sprouted	Tubers round, eyes shallow, skin smooth.
Red Elephant	8	15	14.98	Sprouted	Tubers irregular, eyes deep.
Mayflower	43	26	14.98	Sprouted	Tubers roundish, flat.
Early Puritan	10	10	14.85	Sprouted	Tubers oblong, eyes deep, skin fairly smooth.
Arizona	10	6¼	14.85	Sprouted	....
Junkers	10	10½	14.85	Sprouted	Tubers long, skin smooth, eyes shallow—fine.
Early New Zealand	8	8	14.85	Sprouted	Tubers long, eyes shallow, smooth skin.
Gold Flake	6	8	14.58	Sprouted	Tubers round, eyes shallow, skin smooth and spotted.
Farina	8	8	14 53	Sprouted	Tubers long, eyes shallow, smooth skin.
Early Excelsior	5	1½	14.40	Unsprouted	Tubers irregular, eyes deep, skin rough—poor.
Late Ohio	7	5¾	14.40	Sprouted	Tubers oblong, eyes shallow and red, skin smooth.
Pride of Japan	6	3	14.40	Sprouted	Tubers round, eyes deep, skin smooth.
Early Albion	10	8¼	14.38	Sprouted	Tubers oblong, eyes deep, skin rough.
Lady Finger	20	4½	14.31	Unsprouted	Tubers long, eyes deep, skin smooth.
White Elephant	10	8	14.22	Unsprouted	Tubers long, eyes deep, skin smooth.
Early Snowflake	8	4	14.04	Sprouted	Tubers round, eyes shallow, skin smooth.

Charles 1	10	6⅛	14.04	Sprouted	Tubers irregular, skin smooth, eyes deep.
Crandall's Seedling	18	12¼	13.50	Sprouted	Tubers oblong, skin smooth and spotted, eyes prominent.
Dakota Red	32	17	13.50	Unsprouted	Tubers irregular, skin rough, eyes deep.
Pride of America	9	9	13.48	Sprouted	Tubers long, eyes prominent, skin rough.
White Boston Market	10	3½	12.60	Sprouted	Tubers long, eyes shallow, skin smooth.
Early Prolific	6	7	10.44	Sprouted	Tubers long, irregular, eyes deep, smooth skin.
Mullaly's White	8	7	10.35	Sprouted	Tubers irregular, eyes deep, skin rough.
Churchill's Seedling	10	7½	6.88	Sprouted	Tubers round, eyes prominent, smooth skin.
Early Jinks	5	6¼	6.40	Sprouted	Tubers oblong, irregular, eyes deep, skin smooth.
Early Sunrise	30	18	6.30	Sprouted	Tubers irregular, eyes deep, skin smooth.

POTATOES—Seedlings.

VARIETY.	*No. of Hills.*	*Yield in Pounds.*	*Per Cent. of Starch.*	*Condition April 1st, 1889.*	REMARKS.
No. 80	10	10	25.00	Sprouted	Tubers roundish, eyes few, desirable.
" 11	10	12	24.97	Sprouted	Tubers long, smooth, eyes few, shallow, good.
" 31	10	14¾	24.80	Sprouted	Tubers long, smooth, eyes shallow, desirable.
" 22	10	3½	24.60	Sprouted	Tubers oblong, a poor variety this year.
" 82	10	18	23.67	Sprouted	Tubers oblong, smooth, prolific.
" 3	10	9½	23.53	Unsprouted	Tubers roundish, flat, smooth, eyes deep.
" 75	10	13¾	22.95	Sprouted	Tubers irregular, eyes shallow, good.

POTATOES—Seedlings—(*Continued*).

VARIETY.	No. of Hills.	Yield in Pounds.	Per Cent. of Starch.	Condition April 1st, 1889.	REMARKS.
No. 52	10	15½	22.95	Sprouted	Tubers smooth, eyes medium deep, desirable.
" 38	10	18	22.50	Sprouted	Tubers oblong, eyes deep, prolific.
" 69	10	12	22.50	Unsprouted	Tubers rough, eyes deep.
" 91	10	14¾	22.50	Sprouted	Tubers roundish, smooth, eyes few and shallow.
" 70	10	8	22.50	Unsprouted	Tubers irregular, eyes shallow, desirable.
" 72	10	20⅛	22.50	Unsprouted	Tubers cylindrical, smooth, desirable.
" 4	10	9	22.50	Sprouted	Tubers roundish, flat, fairly smooth, eyes shallow.
" 51	10	12½	22.50	Sprouted	Tubers oval, eyes deep, rough.
" 23	10	4½	22.50	Unsprouted	Tubers oblong, pointed at seed end, eyes shallow.
" 71	10	8	22.50	Sprouted	Tubers roundish, smooth, desirable.
" 1	10	16	22.30	Sprouted	Tubers oblong, smooth, eyes shallow, fine.
" 57	10	6½	22.30	Sprouted	Tubers oblong, rather rough, eyes deep.
" 40	10	5¾	22.00	Sprouted	Tubers irregular, poor.
" 12	10	7⅛	21.60	Sprouted	Tubers long and smooth, eyes many, deep.
" 79	10	5¾	21.60	Sprouted	Tubers oblong, smooth, eyes shallow.
" 93	10	5	21.42	Sprouted	Tubers oblong, eyes deep, poor.
" 45			21.15	Sprouted	
" 102	10	16	20.83	Unsprouted	Tubers oblong, smooth, eyes few, good.

No. 28	10	8	20.83	Sprouted	Tubers oblong, smooth, eyes shallow.
" 6	10	5½	20.83	Unsprouted	Tubers oblong, skin rough, eyes deep.
" 39	10	5¼	20.70	Sprouted	Tubers irregular, eyes deep, rather rough.
" 13	10	5¾	20.70	Unsprouted	Tubers smooth, eyes medium deep.
" 103	10	7	20.47	Sprouted	Tubers oblong, smooth, eyes few.
" 65	10	11	20.45	Sprouted	Tubers long, smooth, desirable.
" 42	10	12	20.29	Sprouted	Tubers long, eyes deep, prolific.
" 98	10	11½	20.25	Sprouted	Tubers irregular, eyes deep, prolific.
" 44	10	19½	19.89	Sprouted	Tubers long, rather rough, prolific.
" 34	10	12¾	19.80	Sprouted	Tubers oblong, eyes few and shallow, fine.
" 90	10	4¼	19.80	Sprouted	Tubers oblong, smooth, eyes few.
" 33	10	12	19.57	Unsprouted	Tubers oblong, smooth, eyes shallow.
" 94	10	11¾	19.57	Sprouted	Tubers long, slender, smooth.
" 47	10	6¼	19.57	Sprouted	Tubers roundish, irregular, eyes deep, skin smooth.
" 46	10	7	19.40	Sprouted	Tubers irregular, eyes deep, poor.
" 14			19.39	Sprouted	
" 78	10	4½	19.39	Sprouted	Tubers oblong, eyes deep.
" 50	10	5¾	19.39	Sprouted	Tubers roundish, eyes deep, rough.
" 15	10	7¼	19.39	Sprouted	Tubers oblong, irregular, eyes medium deep.
" 43	10	13½	19.35	Sprouted	Tubers oblong, smooth, desirable.
" 35	10	7¼	19.35	Sprouted	Tubers oblong, flat, eyes shallow, skin smooth.
" 74	10	10	19.03	Sprouted	Tubers irregular, eyes shallow, good.

POTATOES—Seedlings—(*Continued*).

VARIETY.	*No. of Hills.*	*Yield in Pounds.*	*Per Cent. of Starch.*	*Condition April 1st, 1889.*	REMARKS.
No. 105	10	17	19.03	Sprouted	Tubers irregular, eyes shallow, desirable.
" 100	10	7	18.72	Unsprouted	Tubers oblong, eyes deep, rather rough.
" 62	10	10⅛	18.58	Sprouted	Tubers long and smooth, eyes few, desirable.
" 59	10	5½	18.45	Unsprouted	Tubers oblong, eyes few and shallow.
" 83	10	7	18.45	Unsprouted	Tubers oblong, smooth, eyes medium deep.
" 97			18.45	Sprouted	
" 92	10	9½	18.45	Unsprouted	Tubers oblong, smooth, eyes shallow, desirable.
" 21	10	6½	18.27	Sprouted	Tubers roundish, rough, eyes deep.
" 36	10	8½	18.27	Sprouted	Tubers roundish, flat, smooth, desirable.
" 48	10	7½	18.00	Sprouted	Tubers oblong, smooth, desirable.
" 98	10	11⅛	17.90	Unsprouted	Tubers irregular, eyes deep, prolific.
" 85	10	9½	17.90	Sprouted	Tubers irregular, eyes deep.
" 29	10	8	17.90	Sprouted	Tubers long, flattened, smooth, eyes prominent.
" 67	10	3⅛	17.90	Sprouted	Tubers roundish, flat, a failure this season.
" 54	10	2¾	17.90	Unsprouted	Tubers cylindrical, poor.
" 19	10	5¼	17.80	Sprouted	Tubers roundish, eyes deep, skin rough.
" 77	10	14	17.55	Unsprouted	Tubers long, smooth, desirable.
" 25	10	11½	17.30	Sprouted	Tubers smooth, eyes medium deep.

No. 88	10	15¾	17.14	Sprouted	Tubers oblong, smooth, desirable.
" 10	10	6½	16.92	Sprouted	Tubers oblong, irregular, eyes deep, poor.
" 66	10	7	16.90	Unsprouted	Tubers oblong, flattened, good.
" 101	10	9	16.70	Sprouted	Tubers slender, oblong, smooth, eyes few.
" 5	10	7	16.65	Sprouted	Tubers oblong, rather smooth, eyes shallow.
" 32	10	10½	16.65	Sprouted	Tubers irregular, eyes shallow and few.
" 87	10	7½	16.65	Sprouted	Tubers oblong, eyes medium deep.
" 99	10	6¾	16.40	Unsprouted	Tubers irregular, eyes deep.
" 104	10	6	16.29	Sprouted	Tubers roundish, eyes shallow.
" 68	10	14	16.20	Unsprouted	Tubers roundish, flat, desirable.
" 89	10	4½	16.06	Unsprouted	Tubers irregular, rather rough.
" 61	10	6¾	16.06	Sprouted	Tubers roundish, eyes medium deep.
" 53	10	7	15.97	Unsprouted	Tubers irregular, eyes deep.
" 58	10	16¼	15.95	Sprouted	Tubers cylindrical, eyes deep, fine.
" 30	10	8¾	15.84	Unsprouted	Tubers oblong, smooth, eyes shallow.
" 20	10	3½	15.61	Unsprouted	Tubers irregular, eyes deep, skin smooth.
" 27	10	2¾	15.52	Unsprouted	Tubers oblong, small and undesirable.
" 18	10	6½	15.48	Sprouted	Tubers irregular, eyes deep.
" 55	10	6½	15.30	Sprouted	Tubers irregular, eyes deep.
" 96	10	7	14 98	Sprouted	Tubers irregular, eyes deep.
" 49	10	8¾	14.89	Unsprouted	Tubers roundish, flat, skin smooth, fine.
" 37	10	13	14.50	Unsprouted	Tubers roundish, irregular, eyes few, desirable.

POTATOES—Seedlings—(*Continued*).

VARIETY.	*No. of Hills.*	*Yield in Pounds.*	*Per Cent. of Starch.*	*Condition April 1st, 1889.*	REMARKS.
No. 2	10	12	14.04	Sprouted	Tubers irregular, eyes deep.
" 24	10	6½	13.81	Sprouted	Tubers oblong, rough, eyes deep.
" 81	10	8	12.28	Sprouted	Tubers roundish, eyes deep.
" 14			12.19	Sprouted	
" 26	10	3	11.97	Sprouted	Tubers roundish, eyes deep, poor.
" 64	10	6¾	11.70	Unsprouted	Tubers oblong, smooth, desirable.
" 41	10	5	11.70	Sprouted	Tubers oblong, eyes deep, poor.

CHEMICAL SECTION.

The following method (Sachsse's) was used for determining the starch in potatoes:

Ten grams of potatoes, cut from a section through the center, were grated fine and pulverized in a mortar, and 200 cubic centimeters of water added, 20 cubic centimeters of hydrochloric acid (sp. gr. 1.125), and the flask heated 100° C. on a water bath for three hours. The flask is provided with a glass tube, three feet long and one-fourth inch in diameter, fastened in the cork, to act as a condenser. After cooling, enough sodium hydroxide is added to nearly neutralize the acid, and the liquid made up to 500 cubic centimeters. An alkaline copper solution, made as follows: Solution No. 1 contains 173 grams of Rochelle salts and 125 grams of caustic potash, dissolved in 500 cubic centimeters of water. Solution No. 2 contains 34.69 grams crystalized copper sulphate, dissolved in 500 cubic centimeters of water. Five cubic centimeters of No. 1 and five cubic centimeters of No. 2 are mixed in a casserole and heated to boiling, the boiling being continued while the solution of dextrose is being added from a burette, until all the copper is precipitated as a sub-oxide. The end reaction being tested for copper by acetic acid and ferrocyanide of potassium. The amount of dextrose multiplied by 9-10 gives the weight of starch, according to the formula C 6 H 10 O 5. The analyses were completed about the 1st of January, 1889.

COMPARATIVE METHODS.

A number of methods of determining starch were tried, for the purpose of comparison of results. It has long been claimed by some chemists that the direct heating of agricultural products, as potatoes, grain, etc., with acids, changes the cellulose into dextrose, and may render some of the ash ingredients soluble, and that in that condition they might afterward precipitate the copper solution. In order to test the accuracy and also the convenience of the many methods proposed, the following experiments were tried; the same sample of potatoes (Lady of London) being used in each case. Only the per cent. of starch in the potato was estimated, as, other things being equal, the greater the per cent. of starch, the greater their nutritive value; the richer in starch, the poorer, generally, in protein; the more watery it is, the less the percentage of starch and the greater, as a rule, is the amount of protein, and, usually, also of ash. Grown in a very rich soil, or in a wet place, the same variety of potato contains far less starch, but is richer in protein than when grown in sandy soil or a sandy loam. Manuring generally lessens the percentage of starch and increases the percentage of protein. The ash of the potato contains considerable phosphoric acid and is rich in potash, but has only a little lime and soda; this must be borne in mind when they are used for feeding milch cows or young and growing animals. The following table gives the composition of the ash:

Carbonic anhydride	21.06
Sulphuric anhydride	2.77
Phosphoric anhydride	5.72
Potash	53.47
Soda	Trace
Chloride of Sodium	Trace
Calcic carbonate	.84
Magnesic carbonate	3.53
Calcic sulphate	Trace
Tri-calcic phosphate	3.36
Tri-magnesic phosphate	9.25
Basic ferric phosphate	Trace
Silica	Trace
Total	100

First—In regard to the time the potatoes were on the water bath, all the other conditions being alike:

Time of heating.	Per cent. of starch.
1 hour	17.79
2 hours	17.78
3 hours	17.74
6 hours	17.70
9 hours	17.20

This shows that for three hours the starch was practically what was obtained before (17.75), and that for longer time there was diminution in the per cent. of starch.

Second—In regard to heating the potatoes under pressure, all the other conditions being alike:

Strong glass beer bottles were used, and the cork securely fastened so as to admit of no escape of vapor; they were placed in water bath and heated as before described.

Time of heating.	Per cent. of starch.
3 hours	17.80
6 hours	18.40
9 hours	18.00

This shows that putting the potato under pressure while heating increased the per cent. of starch, or possibly it renders other matters soluble, that assist in reducing the copper solution.

Third—Potato starch was made by grating the potatoes and pulverizing them in a mortar, and washing out the starch upon a fine linen filter; the starch was dried at 100° C. Three-tenths of a gram was taken and treated as in Sachsse's method for starch.

Time of heating.	Per cent. of starch.
3 hours	.309 grams
8 hours	.306 grams
12 hours	.304 grams

Theoretically there should be only 3-10 gram, and the small error may be due to the starch not being absolutely pure.

Fourth—The potatoes were washed clean, dried with a towel and placed in a solution of common salt, in which some would sink and others float. The specific gravity of the solution ascertained with a hydrometer, which would give the specific gravity of potatoes. The tables giving the specific gravity and the corresponding per cent. of dry matter, and also of starch, varied so much that no dependence could be placed upon them. Compare J. J. Pohl, Watt's Dictionary of Chemistry, article Potatoes, also Biedermann Chemiker, Kalender, the table of Behren's Marker, und Morgen :

	Watt's Dictionary.	Biedermann's.	Found.
Sp. gr.	Starch.	Starch.	Starch.
1.094	17.52	16.90	17.75

The most complete table is that of Heideprien, (Jour. Chem. Soc., vol. xxxii.–233).

Parke's Hygiene, 6th edition, p. 260, states that when potatoes have a specific gravity below 1.068, the quality is very bad; between 1.068 and 1.082, inferior; between 1.082 and 1.105, rather poor; above 1,105, good.

Fifth—Two experiments were tried comparing sulphuric with hydrochloric acid, all other conditions remaining the same :

Time.	Sulphuric acid.	Hydrochloric acid.
3 hours	17.50	17.76
6 hours	17.46	17.71

Besides the per cent. of starch being less with sulphuric acid, the dark color on prolonged heating is decidedly against its use.

Sixth—Five kilograms (11 lbs.) of potatoes were grated and pulverized in a mortar and the starch washed out through a linen towel, to see what per cent. of starch could be obtained by this method.

Starch washed out.	Starch by Sachsse's method.
16.84 per cent.	17.75 per cent.

The above was washed twenty-four times with water and the process extended over a period of two days.

Seventh—Allihn's method was tried, which in substance, consists in reducing the sub-oxide of copper to the metallic form by heating it to redness in a stream of hydrogen, to prevent oxidation. From Allihn's table, the weight of dextrose corresponding to the weight of copper was found :

Allihn's method.	Sachsse's method.
17.79 per cent.	17.75 per cent.

The filtering and reducing of metallic copper involves a loss of time overbalancing, in our judgment, the increased accuracy. The accuracy was greater in using an alkaline copper solution freshly mixed than one which had stood some time; the length of time the solution is boiled influences the result. Prolonged boiling increases the per cent. of starch. The analysis of potatoes by the Kentucky Agricultural Experiment Station is given by way of comparison: Bulletin No. 9, page 9. Highest yield (Empire State), 15.48 per cent.; lowest yield (Dakota Red), 12.05 per cent. of starch.

SUGAR BEETS.

Seeds of four varieties of sugar beets were received from the Department of Agriculture, and were sown April 15, on 1-4 of an acre of ground. The planting was in rows three feet apart, the seeds being sown with a drill. The soil was a clay loam which had been in clover sod for three years previous, and was broken in the fall of 1887. The plants were irrigated four times, cultivated six times and hoed twice. The estimated yield per acre is based upon the product of an average row of each kind 450 feet long.

DESCRIPTION OF VARIETIES.

Lane's Imperial—Roots very smooth, skin white, shading to red above—growing well below ground; yield per acre, 30.45 tons.

Excelsior Sugar—Roots smooth, skin dull white, growing under ground; yield per acre, 29.04 tons.

Vilmorin Sugar—Roots smooth, skin white with a purplish tinge, somewhat wrinkled—growing below ground; yield per acre, 25.09 tons.

Improved Imperial Sugar—Roots rough, skin dull orange, growing one-half above the surface of the soil; yield per acre, 24.15 tons.

CHEMICAL ANALYSIS.

Preparation of the Sample—The beets were washed and dried with a towel; then weighed, the top and small rootlets cut off, again weighed and this loss carefully noted. Three average beets were taken and quartered parallel to the axis; a quarter from each beet was selected, and successive slices made lengthwise of each quarter were taken, in all amounting to 200 grams (about 4-10 lb.); this was reduced to a fine pulp by grating, and afterward pulverized in a mortar; the juice was extracted by a strong filter press, and the marc moistened with boiling water, the pressure renewed and this operation repeated until all soluble matter had been extracted and the residue was dry, care being taken to avoid undue diluting of the solution. We have found the best results from solutions containing from 1-2 to 3-4 of a per cent. of sugar; the coloring matter was precipitated by tannin and acetate of lead; it was filtered and the grape sugar determined as before described under potatoes. The sugar in the beet is principally cane sugar, containing a small per cent. of grape sugar; the cane sugar was inverted (process of hydrolysis) by heating the solution with dilute (1 to 5) hydrochloric acid, on the water bath for fifteen minutes; about a drop of the dilute acid was used for each c. c. of the sugar solution. The solution was neutralized with sodium carbonate and the sugar again determined; the difference between the results gives the per cent. of cane sugar present in each variety.

The per cent. of cane sugar is 95-100 of the grape sugar produced by inversion of the cane sugar.

NAME.	Grape Sugar.	Cane Sugar.	Total Sugar.	Loss on Dressing.
Excelsior	.11	9.47	9.58	7
Lane's Imperial	.25	11.83	12.08	12
Vilmorin	.21	11.18	11.39	11
Imperial Improved	.10	8.73	8.83	7

The following table shows the yield of sugar in pounds per ton of beets, and also the relative yield per acre, as computed from the above results of chemical analysis :

YIELD OF SUGAR.

VARIETY.	Tons Beets Per Acre.	Lbs. Sugar Per Ton of Beets.	Lbs. Sugar Per Acre.
Excelsior	29.04	190	5,517.60
Lane's Imperial	30.45	240	7,318.00
Vilmorin	25.09	227	5,695.43
Imperial Improved	24.15	176	4,250.40

From the above it will be seen that there is quite a wide variation in sugar content in the four varieties tried last season. Enough, however, has been developed to create a lively interest in the cultivation of the sugar beet in this state for purposes of sugar production. The serious drawback seems to be the cost of the diffusion plant, as quite a large amount of capital is required to prepare a suitable plant and furnish adequate machinery.

THE

STATE AGRICULTURAL COLLEGE

The Agricultural Experiment Station.

BULLETIN NO. 8.

ALFALFA:

ITS GROWTH, COMPOSITION, DIGESTIBILITY, Etc.

FORT COLLINS, COLORADO.

JULY, 1889.

The Agricultural Experiment Station.

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ALFALFA.

The perennial plant known and called alfalfa by the Spanish, and by the French, lucerne, has been grown extensively and for many years in the Southwest under the name of Chilian, or California clover.

Its botanical name, *Medicago sativa*, from the Greek, *Medike*, is derived from that language, meaning fodder plant. It was known by the Greeks and Romans 2,300 years ago, and was used as a forage long before the Christian era.

Columella, Virgil and Cato speak of it in their writings. When the Roman Empire flourished it furnished food for the war horse. Grecian cattle cropped it upon the hillsides, and the Spanish cavalier fed his horse upon it. The Romans brought it from Media 470 B. C., hence its generic name.

It was introduced into Mexico in the time of the Conquest; thence into South America, and from Chili into California in 1854, where it has been grown more successfully and in greater quantities than elsewhere. It found its way into Colorado early in the sixties, having been raised for the first time in the State in the Platte valley, near Denver.

It flourishes at all altitudes below 7,000 feet, and in all soils that will produce other good crops. Sandy and clay loams are best adapted to its habits. Soils underlaid with shale, or hard pan, are not conducive to its successful growth, inasmuch as the roots of the plant must penetrate the sub-soil until they find moisture. Where surface drainage is good, and the land not too wet or too alkaline, it readily secures a stand, and the first season makes a crop of one or two tons per acre—often without an irrigation in this arid climate.

It is the most tenacious of all forage plants, enduring more harsh treatment, more dry weather, heat and cold, after making a stand, than any of the others. It is, indeed, "a child of the sun," defying the hottest suns, the driest soils and the greatest variations of temperature—in fact, it keeps fresh and green while all other plants dry up and die around it.

Its growth is exceedingly rapid. In some soils and under certain conditions it makes a growth of thirty to forty-five inches a month, and in some localities a cutting every month in the summer season. The first cutting is ready about the middle of June—just before blooming—and is considered the best for working teams, inasmuch as it contains more fattening elements, and hence is a stronger food. The second crop is cut in July, and the third in September, and if the fourth is cut, it is ready in October. The second crop, and particularly the third, is better for milch cows, and animals that do not work, inasmuch as it is more succulent, contains fewer coarse stems and is more easily masticated.

The feeding value, as seen in the tables given, is clearly demonstrated in practical stock feeding. No other clover, grass or forage plant compares with it, or contains a greater per cent. of protein substances.

Horses grow fat on it alone; cattle make fat, flesh and milk; sheep thrive and are perfectly healthy when fed on it, and even hogs, when pastured on it, need no other food.

The preparation of the soil for sowing alfalfa is about the same as for clover, turnips, or other small seeds; if quite moist, good stands are secured on the raw sod merely by harrowing, or drilling the seed. The condition of the soil is everything, in rapid and successful germination. Being a rapid grower, and very succulent, it requires a large amount of moisture to start it successfully and keep it growing until well rooted, as when once rooted it is safe.

The amount of seed per acre necessary to secure a good stand for hay, is twenty to twenty-five pounds; for seed, twelve to sixteen pounds are sufficient. As the plant bears its seeds so differently from red clover, thick seeding is detrimental to the propagation of a large yield on account of its growing not on the top like red clover, but upon the entire plant, from bottom to top. For hay, the seed on sandy soil should be sown alone; on cloddy, clayey soils, wheat, oats or barley in small quantity can be sown with it for shade. Timothy and orchard grass, when sown with alfalfa, serve to keep it from lodging, and when in sufficient quantities, they become a preventive of hoven in the feeding and pasturing of cattle and sheep. The seed should be sown with a drill, as it is much more evenly and uniformly distributed, and after drilling, a light harrowing crosswise assists in an even stand, and hastens germination. The time to sow depends very much on the soil and climate. So soon as all fear of frost is gone and the soil is moist and warm, sow—about April 20 to May 10. Even earlier sowing has proved very successful in some soils and seasons, especially where it is done in old wheat or oat stubble, without previous preparation.

CUTTING AND CURING.

Alfalfa should be cut just before blooming, somewhat earlier than red clover. At that stage of its growth the plant contains the greatest amount of valuable feeding substances.

When slightly wilted it should be raked into winrows, and then put into small cocks to be cured. If left to cure before raking, the stems become hard and dry, the leaves drop off, the color is lost, and much of the hay is rendered unfit for feed. Curing is the most important operation of all in making alfalfa hay.

IRRIGATION.

On the low land, where the roots have access to moisture continually, alfalfa needs little or no irigation. When water is applied, it should be done before cutting, for two two reasons—it stimulates the growth of the next crop, and in the cutting the mower does its work much better and more effectively, the stems being more pliable and easily cut.

In the experience of many farmers, alfalfa is the best renovator and the best green crop for fertilizing soils of any thus far tried. It not only kills all noxious weeds, but puts into the soil in quantities manurial elements found to be invaluable to the growth of any crop. Many experiments among farmers, but not at the Experiment Station, have proved it to be fifty per cent. better than red clover. The roots being very large and long, not only enrich, but make the soil porous and well suited, not only to its own growth, but the growth of any other plant.

Just why alfalfa has, when fed green or wet, a greater tendency to bloat cattle and sheep than other forage, has not yet been fully or satisfactorily explained. Whether it is due to the alkali of the soil absorbed by the plant, or to its very succulent growth, or to its quality, remains yet to be demonstrated. It is a fact that it is a dangerous pasture for cattle and sheep, unless the weather is very dry, or unless the stock are first fed with dry feed before being driven upon it.

ALFALFA PARASITES.

The dodder (*Cuscuta*) are annual, leafless, climbing plants that twine around the plant destined to be the foster parent, and into the structure of which they send out aerial sucker-like roots at the points of contact, and through these imbibe the sap of the host plant.

The stems of the dodder are orange or reddish colored, and consist of small, fleshy tendrils twisted around a branch. At the base of the flowers and at the joints of the stems may be found minute scales. These are rudimentary leaves; but the plant in its present stage of development has no need of green leaves, as it finds its food already prepared in the host plant.

The flowers appear in clusters around the stem, which very soon form fruit; the latter consists of four seeds, which do not split into lobes, but open and put forth a little spiral body, which is the embryo. The seeds are destitute of cotyledons, and so are dependent for their development, for a short time, on the albumen stored up in the seed. The number of flowers in each cluster ranges from ten to twenty, and the seeds are of a pale gray color, difficult to detect with the naked eye, and hence the rapid spread of the plant.

When the seed falls to the ground, it usually remains dormant until the following spring—sometimes, however, it germinates the same season, if the conditions are favorable.

With the return of spring, the embryo begins growth by sending one end into the soil, and with the other it sends up a stem turning from right to left, or contrary to the sun's apparent motion. Up to this stage its growth is like that of any ordinary plant, but its existence is brief, if no friendly stem be within reach. If it touch some living branch or stem, it seizes it by means of sucker-like roots, which it at once throws out, and then it goes on twining and fastening itself to the foster plant and to other plants in its vicinity.

It now ceases to have any connection with the soil, and is a true parasite, feeding on the juices of the plant it has seized upon.

The dodder will obtain a foothold upon any plant whose stem is not too large for it to encircle, but it is particularly injurious to clover, alfalfa and hops. They are natives of the temperate regions of both hemispheres, and the seeds possess acrid and purgative properties.

In this region, where seeds rarely perish from untoward conditions, the dodders may become an enemy to the growth of the plants mentioned.

As it is an annual, however, it can be destroyed before it has seeded, which may be done by cutting the infected portion of the crop close to the ground and then burning it.

But this would have to be done thoroughly, as, in the case of alfalfa, the dodder flowers quite close to the ground, where it cannot easily be seen, and a few seeds remaining continues the plant another year.

It is, however, much easier to prevent its introduction than to get rid of it; for, when such a plant has obtained a foothold, it has been shown to be extremely difficult to exterminate, or to keep in check.

Alfalfa seeds are about two lines long and about one and one-fourth broad, while dodder seeds are little more than half the size.

If clover and alfalfa seeds are well sifted through a seive of proper size, the dodder will be readily separated. If crops are to be free from the dodder pests, the farmer must see to it that the seed for the crop is clean.

Our native flora is said to embrace six species and one variety. The species parasitic on alfalfa in this vicinity are *Cuscuta epilinus*, the flax dodder (introduced), and *Cuscuta Gronovii*, a species abundant in wet, shady places from the Rocky Mountains to the Atlantic States, and also parasitic on *Ambrosia trifida* and other compositæ.

CHEMICAL SECTION.

The question of the composition and digestibility of alfalfa, the chief forage crop of Colorado, has, from time to time, engaged the attention of the agricultural press, and the leading farmers of this region; in addition to this, the proper time to cut alfalfa in order to secure the greatest amount of nutriment, has never been definitely settled where the plant was grown under irrigation; in order to answer these questions satisfactorily, alfalfa was cut at four different periods of *growth* and *maturity*, viz.: When,

1. Beginning to bud.
2. In full bloom.
3. When bloom was half ripened.
4. When seed was fully ripe.

The samples were cut, immediately weighed, and dried on canvas in the open air on the barn floor to a constant weight.

The amount of water lost was approximately 50 to 78 per cent. in the different periods, and the exact quantity for each is noted in the column of remarks in the table. The water named in the column headed "water," in the table, is the amount of moisture driven off when the substance was heated in an air bath to 100° C. The samples from the San Luis Station were from the farm of Mr. David Best, near Del Norte, Colorado, while those from Bent Station were from the farms of several persons near Rocky Ford, Colorado.

The analyses were made in duplicate, and the method pursued was that adopted by the Association of Official Agricultural Chemists in convention at Washington, D. C., August 9-10, 1888.

EXPLANATION OF THE ANALYSES OF FEEDING STUFFS.

Water—The amount of water in forage plants is constantly changing with the temperature and the dryness of the air to which it is exposed, and no just comparison of samples can be made unless the amount of water be known. The water is expelled by heating a weighed quantity in the air bath at 100° C. until the weight is constant—the loss is water. A refinement of this method is to dry the sample in a stream of hydrogen gas until no further loss occurs.

Ash—Ash is what is left after the combustible matters of the analysis in question are burned away, at a low red heat; there is usually a little charcoal and also some sand that has been washed or blown upon the plants; these are sometimes called accidental inpurities.

Fat, or Crude Fat—Includes everything which can be extracted from the feeding stuff by absolute ether; in this list is commonly included chlorophyll (the green coloring matter of plants) fat, wax and fat oil.

Albuminoid Nitrogen (*Protein*)—This includes all those nitrogenous substances which resemble white of egg, flesh, fibrin, milk casein (curd). The amount of nitrogen found is multiplied by 6.25; this number is based upon the fact that albuminoids contain about 16 per cent of pure nitrogen; this is but an approximation, but it is sufficiently accurate for practical purposes and is the number generally agreed upon; it is well known that nitrogen is found in other combinations than albuminoids, viz., in amides, alkaloids, nitrates, etc., but in these it is usually in small proportion, and does not materially influence the result.

Crude Fiber, or Cellulose—Is the essential part of the walls of vegetable cells. It is in quite a pure state in cotton fiber; it is quite insoluble, and remains as a residue when the feeding stuff has been treated with acid and alkali.

There is another constituent called carbohydrate or nitrogen free extract, and it includes such bodies as gum, starch, sugar, etc. These are extracted by water or dilute acids, but they are always indirectly determined by subtracting the sum of ash, fat, albuminoids and crude fiber from the total dry matter.

We are now prepared to consider the table containing the results of the analyses of alfalfa, clover, grass and wheat bran conducted in the Colorado Experiment Station laboratory:

TABLE OF ANALYSES.

No.	Substance.	Where Grown.	When Cut.	Water.	Ash.	Fat.	Albuminoid Nitrogen.	Crude Fiber.	Nitrogen, Free Extract.	REMARKS.
1	Alfalfa	College Farm	June 4, 1888	8.11	11.62	3.61	18.19	12.88	45.59	Beginning to bud; 77.65 per cent. of water.
2	Alfalfa	College Farm	June 20, 1888	9.37	11.68	3.34	15.22	14.65	45.74	Full bloom; 69.71 per cent. water.
3	Alfalfa	College Farm	July 13, 1888	9.59	11.90	3.85	12.87	18.01	43.78	Bloom half turned; 60.89 per cent. water.
4	Alfalfa	College Farm	Sept. 11, 1888	8.56	8.43	3.92	11.67	20.23	47.18	Fully ripened seed; 49.30 per cent. water.
5	Alfalfa	College Farm	....	8.50	7.46	2.85	15.17	22.06	43.96	From bay in College barn.
6	Alfalfa	Bent Station	Third Crop	9.91	10.35	2.68	19.79	16.72	40.55	Twenty-six days from previous cutting; without irrigation.
7	Grass	Bent Station	Ripe	8.80	9.20	1.70	3.82	21.81	54.67	Bouteloua racemosa.
8	Alfalfa	Bent Station	Sept. 25, 1888	8.77	7.23	3.84	11.20	22.32	46.64	Cut for seed.
9	Alfalfa	San Luis Station	Third Crop	6.62	8.47	2.25	11.50	24.59	46.57	Very coarse.
10	Wheat Bran	Fort Collins	....	9.39	4.84	5.35	16.60	4.10	59.72	Bran and shorts, sold as bran, from Harmony Mills
11	Alfalfa	San Luis Station	July 15, 1888	9.31	10.20	2.30	10.55	14.00	53.64	Irrigated one week after first cutting; in bloom; 1½ tons per acre.
12	Alfalfa	San Luis Station	June 6, 1888	8.46	9.02	2.63	12.35	19.18	48.36	Adobe land, no irrigation; yield 2½ tons per acre.
13	Alfalfa	Bent Station	July 25, 1888	8.33	7.32	1.81	11.33	22.90	48.31	Irrigated June 1 and July 15, 1888; yield, 2 tons per acre.
14	Alfalfa	Bent Station	July 25, 1888	9.12	7.75	2.59	10.27	21.90	48.37	Irrigated May, 1888; yield, 2 tons per acre.
15	Alfalfa	College Farm	Second Crop	9.75	7.87	2.35	11.64	19.92	48.47	From bay, College barn.
16	Red Clover	College Farm	Second Crop	8.64	7.28	3.51	10.32	18.04	52.21	From bay, College barn.

In addition to the determinations above noted, the ash of specimen No. 1 was analyzed, showing the following composition:

Silica (Si O 2)	47.33
Carbon (C)	.57
Sulphuric acid (S O3)	4.38
Iron oxide (Fe2 O3)	1.37
Chlorine (C1)	4.00
Magnesium oxide (Mg O)	4.15
Calcium oxide (Ca O)	16.18
Phosphoric acid (P2 O5)	7.15
Potassium oxide (K2 O)	14.25
Sodium oxide (Na2 O)	.25
	99.98

The proportion of ash ingredients in the plant is varible within a limited range, such variation being due to various circumstances, as the green or ripened condition of growth, the different parts of the plant taken, the soil on which the plant has been grown, the species of plant and its treatment in culture.

The question is often asked, at what period of its growth should grass be cut for hay? The albuminoids being the most desirable part of the plant, the greater the per cent. of albuminoids, other things being equal, the more nutritious the grass.

A glance at the table will show that the albuminoids *decrease* as the grass matures, but on the other hand, it will be seen that the amount of dry hay increases with the age; it will be noticed, too, that the crude fiber increases with the age of the plant. The analyses show that about the time of bloom, or a little later, is the most economical time to cut grass for hay. That alfalfa is no exception to the rule, is shown by numerous analyses of forage plants made by the Department of Agriculture, one of which has been selected by way of comparison with alfalfa:

Phleum Pratense. (Timothy.)	Ash.	Fat.	Albuminoids.	Crude Fiber.	Nitrogen, Free Extract.
Head not out..........	....7.94....	....1.97....	...10.97....	...29.19....	...49.93....
Before Bloom....	....7.64....	....2.27....	... 7.80....	...29.65....	...52.64....
In Bloom..............	....7 05	....2.18....	... 5.52....	...32.26....	...52 99....
After Bloom...........	....6.63....	....2.55....	... 5.57....	...31.32....	...53.93....
Early Seed............	. . 5.95....	....3.74....	... 4.84....	...24.70....	...60.77....

We can now take up the comparison of alfalfa with other grasses. This part of the work is necessarily incomplete, as but few comparisons are made. A full comparison of alfalfa with other forage plants and food stuffs involves a consideration of two factors—the yield per acre and the ease with which each can be cultivated.

In the first place, alfalfa stands pre-eminent, as, with its three and often four cuttings, it is an easy task to average five or six tons per acre over large areas. Much larger yields have been realized in exceptional cases. In the second place, alfalfa is an easy plant to cultivate when once started, and even in the beginning, is not more difficult to start than other small-seeded plants, as red clover and the grasses. When a good stand has been secured, with any ordinary care, it does not kill by freezing or other hardship, provided irrigated in fall and reasonably early in the spring. This being the case, all can see what an advantage alfalfa has over other forage plants in the arid region. This does not argue for its exclusive cultivation, for other forage plants, as millets, corn, should supplement alfalfa, the main support in mixed farming.

DIGESTIBILITY.

In connection with the chemical analysis of the alfalfa, the following feeding experiment was tried to test its digestibility.

Two steers were selected. No. 1 was a seven-eighths Shorthorn, and was 30 months old, and weighed 1,050 pounds. No. 2 was one-half Devon, and was 23 months old, and weighed 1,075 pounds. The animals were healthy and in good condition; they were fed two weeks on the alfalfa before the experiment was begun, the object being to clear the digestive canal of previous food. During the experiment they were kept in stalls in the basement of the barn, and were taken out once a day to be weighed; they were watered and fed alfalfa three times a day, eight pounds at each feed. One day the feed of alfalfa was increased to nine pounds, but, as the animals showed signs of bloating, it was reduced to eight pounds. The dung and urine for twenty-four hours were weighed at noon each day, also the steers before they were watered or fed. A harness was provided for the animals, to which rubber bags were attached to collect the dung and urine; the animals were watched day and night to see that all the excrements were saved as soon as voided, and placed in suitable vessels to receive them. An accident occurred with No. 1, causing two days' results to be rejected.

The refuse hay was carefully collected after each feed, and each day's refuse kept by itself. The dung, urine, refuse hay and water were weighed to a half ounce; the animals to a pound. One-tenth part of all the dung and urine was saved in large salt-mouth, glass-stoppered bottles that were air tight; one-tenth part of this was carefully sampled and analyzed, by the method before described for alfalfa. Kjeldahl's method was used for the urine, in the manner recommended by the nitrogen committee, Bulletin No. 19, for the determination of nitrogen; a comparison was also made by the Knop Hufner method.

The following table of ingesta and excreta by days, shows the general course of the experiment, with daily results:

TABLE.

Day.	NO. 1.								NO. 2.							
	Water.		Urine.		Dung.		Loss.		Water.		Urine.		Dung.		Loss.	
	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.	lbs.	oz.
1	75	12	23	8½	54	9½	35	14½	65	..	27	..	41	13	24	15½
2	95	8	24	..	51	1½	34	½	69	8	22	6	58	8	22	3
3	93	12	23	15½	54	2	19	6	90	8	22	6	50	8½	11	6
4	73	..	25	7	58	2	28	..	69	4	26	9	48	6½	22	13½
5	99	..	27	4½	58	5½	21	15	92	12	25	3½	49	11½	36	9½
6	91	8	24	9	44	6½	40	15½	73	12	27	3½	48	1	22	5
7	accid'nt		accid'nt		accid'nt		accid'nt		95	8	28	15	48	12	33	8½
8	94	8	27	1	53	10½	32	8½	86	..	24	14½	50	..	24	15½
9	106	4	28	4½	51	2½	35	7	69	4	25	3	53	4½	29	10½
10	79	4	28	½	58	6½	31	8½	81	..	27	7	46	8½	15	14½
11	99	12	27	12	60	10	25	2½	81	8	29	12	46	12½	28	14
12	90	12	29	9	56	14½	33	½	82	4	27	4	47	1½	21	13
13	accid'nt		accid'nt		accid'nt		accid'nt		82	4	25	15½	45	14	34	2½
14	95	4	30	5	57	15½	25	13½	92	12	29	3½	49	1½	28	4
15	95	12	26	1	51	8	37	½	70	8	27	..	45	13½	36	6½
AV	91	9	26	9	54	10	30	13	80	2	26	10	49	5	26	15

The original weight, . . .	1,050 lbs.
Ate hay in 24 hours, . . .	24 lbs.
Drank water, 24 hours, . .	75 lbs., 12 oz.
Total, ...	1,149 lbs., 12 oz.
Refuse hay for that day, . .	11½ oz.
Total, ...	1,149 lbs., ½ oz.

The dung weighed, . . .	54 lbs., 9½ oz.
The urine weighed, . . .	23 lbs., 8½ oz.
The animal weighed, . . .	1,035 lbs.
Total, ...	1,135 lbs., 2 oz.

The animal, food and water weighed, ...	1,149 lbs.,	½ oz.
The animal and excrements weighed	1,113 lbs.,	2 oz.
Loss, ...	35 lbs.,	14½ oz.

Prof. Carpenter kindly furnished me with the relative humidity of the atmosphere during the experiment, and his table shows that there is no connection between this loss and the humidity of the atmosphere; so this loss must have passed off through the skin and lungs. I have not been able to obtain any information of this loss in the ox. In the human subject there are recorded many instances. Flint's Human Physiology, 1876, page 153. Valentin's Experiment gives one and one-fifth pounds as a daily exhalation from the lungs. Valentin found that the pulmonary transpiration was more than doubled in a man immediately after drinking a large quantity of water. Landois and Sterling, Human Physiology, 1885, Vol. 1., page 255. "The expired air is saturated with watery vapor," page 264. "A healthy man loses by the skin in twenty-four hours, one sixty-seventh of his body weight (Seguin), which is greater than the loss by the lungs in the ratio of three to two." (Valentin, 1843).

Chemistry of Common Life, Johnston, 1880, page 501: "The quantity of water which is thrown out into the air from the lungs of a healthy man is very variable. It is modified by season and climate, by individual constitution and state of health, by the amount of exercise taken, by the quality of the food, by the quantity of liquid consumed, and by a variety of other circumstances. Generally speaking, however, the quantity given off by the lungs and skin together, is equal to about one-third of the weight of the whole food, solid and liquid, which is taken into the stomach. Now, the skin alone of a full-grown man exhales in twenty-four hours, in ordinary circumstances, from one and one-half to two pounds of water in the state of insensible perspiration. The difference between the weight and that of one-third of the whole food, solid and liquid, represents the quantity of water daily discharged from the lungs. It is not far from the truth to say that for every one and one-half pounds discharged from the skin, about one pound is given off from the lungs." Those desirous of pursuing the subject further, can consult Ziemssen on Skin Diseases, page 67; Pepper, Practice of Medicine, Vol. 4, page 436; Tidy's Legal Medicine, Vol. 2, page 197; Storer's Agriculture, Vol. 1, pages 481-489; Armsby's Manual of Cattle Feeding, pages 198, 206, 234, 239; Foster's Physiology, page 606.

While we cannot compare the human subject with the domestic animals, it is reasonable to infer that the causes that influence one will influence the other. Selecting the average, it will be seen that the loss is about one-third of the water drank; that the amount of urine voided was practically the same, while the dung of No. 1 was 54 pounds, 10 ounces, it contained 82.9 per cent. of moisture, or 17.1 per cent. of dry matter; while the dung of No. 2 was 49 pounds, 5 ounces, it contained 81.7 per cent. of moisture, or 18.3 per cent. of dry matter.

The dry dung of No 1 was 43.2 per cent. of the hay eaten, while the dry dung of No. 2 was 41.8 per cent. of the hay eaten. The increased gain of 15 pounds of No. 2 over No. 1 was due, as shown by the above figures, to No. 2 being a better feeder, he having digested 1.4 per cent. more of the dry substance of the alfalfa and assimilated it. The refuse hay, which amounted to but a few ounces a day, was taken into account in the above calculation. The urine when analyzed was slightly alkaline in both cases, and had the same specific gravity, 1040.

URINE ANALYSIS.

	No. 1.	No. 2.
Water,	923	926
Solids,	77	74
Ash,	25	27
Organic matter,	52	47
Alkalies,	17.2	15.05
Calcium and Magnesium,	2	2
Sulphuric acid,	2	1.9
Silica,	Traces	Traces.

There was no phosphoric acid in the urine. The nitrogen in the urine of both animals was the same, 8.6 parts in 1,000, equal to 1.85 per cent. of urea.

The total solids of dry dung was 4½ times as much as the solids of the urine.

The amount of water drank was, in the case of No. 1, 3.81 times the hay eaten; in the case of No. 2, 3.33 times.

The live weight includes the food eaten, the dung, urine, etc.

When the stomach alone will hold 100 to 150 pounds of water, and the excretion of the dung and urine is more or less irregular, we may expect a variation of from twenty to fifty pounds a day. In the experiment this was obviated, as much as possible, by weighing the dung and urine at noon and the animals at the same time, before they were fed or watered.

The following table gives the live weight and refuse hay each day:

Day.	NO. 1.		NO. 2.	
	Live Weight. Lbs.	Refuse Hay. Ozs.	Live Weight. Lbs.	Refuse Hay. Ozs.
1	1,035	11½	1,070	3½
2	1,045	6	1,060	6½
3	1,065	4½	1,090	3½
4	1,050	7	1,085	7
5	1,065	7	1,090	3½
6	1,070	9	1,090	2½
7	Accident		1,100	4½
8	1,065	4	1,105	3
9	1,080	6	1,090	2
10	1,065	4½	1,105	2
11	1,075	3½	1,105	1½
12	1,070	4	1,115	1½
13	Accident		1,115	4
14	1,065	2	1,125	3
15	1,070	2½	1,110	4
	Original Weight, 1,050 lbs.		Original Weight, 1,075 lbs.	

It will be noticed that it was the third day before the animals came back to, or exceeded, the original weight; this may be due to the animals taking some little time to get accustomed to the rubber bags and harness attachment to hold them in place, and to the excitement it would naturally cause. The average refuse hay of No. 1 was 5 6-13 ounces a day, and was about 1-77 of the hay fed. The average refuse hay of No. 2 was 3 7-15 ounces a day, and was about 1-128 of the hay fed. The ether extract of dung of No. 1 was colorless, containing no chlorophyll, while the ether extract of No. 2 was distinctly green.

The ash of the dung was as follows:

	No. 1.	No. 2.
Sand and Silica (Si O2)	14.70	15.40
Carbon (C)	1.28	.83
Iron and Alumina oxides	6.48	6.01
Lime (Ca O)	34.75	36.00
Magnesia (Mg O)	7.04	7.03
Sulphuric acid (S O3)	6.99	6.38
Chlorine (C1)	9.44	9.54
Phosphoric acid (P 205)	6.77	6.38
Alkalies	12.50	12.46
	99.95	100.03

The analysis of the dung was as follows:

DUNG ANALYSIS.

	Water.	Dry Matter.	Ash.	Ether Extract.	Crude Fiber.	Albuminoid Nitrogen.	Nitrogen Free Extract.
No. 1.......	82.9	17.1	12.4	.99	22.47	7.05	57.09
No. 2.......	81.7	18.3	12.23	1.04	21.95	7.31	57.49

The ash of the moist dung of No. 1 was 2.11 per cent.; of No. 2, was 2.23 per cent. of the whole.

The analysis of the refuse hay was as follows:

REFUSE HAY ANALYSIS.

	Water.	Dry Matter.	Ash.	Ether Extract.	Crude Fiber.	Albuminoid Nitrogen.	Nitrogen Free Extract.
No. 1.......	7.37	92.63	6.54	1.71	23.6	8.13	60.02
No. 2.......	7.14	92.86	6.85	1.77	28.6	8.52	54.26

The ash of the dung is about double that of the refuse hay. The alfalfa fed was the second crop, and the chemical analysis shows that it was too ripe when cut; alfalfa cut earlier would show better results as to its feeding qualities. It took, in the case of No. 1, 18 pounds of hay to make one pound of increase of live weight; in the case of No. 2, it took 10⅓ pounds, or an average of both animals of 14 pounds.

By way of illustration, the digestibility of the crude fiber is worked out for No. 1 for the 13 days:

No. 1 ate 312 pounds of hay; it contained 9.75 per cent. of moisture; equals 281.58 pounds of dry hay; this hay contained 19.92 per cent. of crude fiber=56.09 pounds of crude fiber. The refuse hay was 5 6-13 ounces a day=4.43 pounds. This refuse hay contained 23.6 per cent. of crude fiber=1.04 pounds. Subtracting this from 50.09 pounds, leaves 49.05 pounds of crude fiber the animal ate. The dung averaged 54.625 pounds a day, or 710.125 pounds; it contained 17.1 per cent. of dry dung =121.43 pounds; this contained 22.47 per cent. of crude fiber=27.28 pounds of crude fiber; subtracting this from the amount of crude fiber in the hay, leaves (49.05–27.28) =21.77 pounds digested by the animal, or, expressed in per cent., equals 44.3 per cent.

In a similar way, all the other ingredients were worked out.

A few words might be said as to the chemical changes that take place in the digestive tract of the animal.

The digestion takes place in the alimentary canal, consisting of the mouth, gullet, stomach, small and large intestines. The mouth secretes saliva and a ferment known as ptyalin, which changes the starch to some form of sugar. The stomach of ruminants consists of four compartments; the partially chewed mass passes into the largest division, called the paunch, and partly into the second stomach, or recticulum; here the food remains for a time, acted upon by the fluids of the stomach; the dissolved portion passes through the other divisions of the stomach; when swallowed the second time, it goes into the first and second stomach, and into the third stomach, omasum, or manifolds. From the third stomach it passes to the fourth stomach, abomasum, or rennet, there to undergo the ordinary process of digestion. The gastric juice and pepsin change the albuminoids into a soluble form called peptones, and the mass into chyme, which can be absorbed more or less into the circulation. We have traced it into the intestines, which in the ox is nearly 20 times as long as the body. The chief digestive fluids are the bile, which acts upon the fat; and the pancreatic juice, which has three ferments—diastase, which converts the starch into sugar; trypsin, which acts upon the albuminoids, and a ferment which separates fats into glycerin and fatty acids. By the action of these various digestive fluids, the chyme is converted into chyle, or, in plainer language, the process of digestion is essentially a process of solution, the soluble portion being assimilated by the animal, and the waste portion excreted as dung. It is rarely possible to have a complete digestion of all the nutrients of the food, portions nearly always escaping digestion, especially when a rich food is given, or when we strive for large or rapid production of organic substances, such as milk. This has given rise to the old adage, "the richer the food, the better the manure." Some have thought that the fat, fiber and nitrogen free extract, act as the fuel acts to the steam engine; that the albuminoids, acting as the materials of construction and repair, can be easily made over by the animal into its own substance. The fiber, from its very composition, cannot restore the waste of the animal It has been found that there is a certain relation between the albuminoids, fat, fiber and nitrogen free extract, which is the best and most economical; this is known as the nutrient ratio.

It is found that only a certain per cent. of the fat, crude fiber, albuminoids, etc., is assimilated by the animals, the rest passing off as dung. The per cent. assimilated is called the digestion coefficient. I have selected from various sources the digestibility of some grasses, etc., by way of comparison with the alfalfa.

DIGESTIBILITY OF FEEDING STUFFS. (DIGESTION COEFFICIENT).

	Albuminoids.	Crude Fat.	Fiber.	Nitrogen Free Extract.
Alfalfa (experiment),	77	54	49	64
Wheat Bran,	78	69	33	77
Clover hay (good),	62	60	47	70
Clover hay (medium),	55	51	45	65
Pasture clover (very young),	78	64	67	78
Alfalfa, before blossoming, and in flower,	74	39	43	67
Potatoes,	65		55	93
Oats,	77	82	17	74
Corn,	79	85	62	91

The table can be best illustrated by means of an example. Suppose you wish to know how much digestible food is contained in a ton of wheat bran. By referring to the table (No. 10), wheat bran contains:

Dry matter,	90.61
Albuminoids,	16.60
Fat,	5.35
Nitrogen free extract,	59.72
Fiber,	4.10
Ash,	4.84

And from the table of digestibility of feeding stuffs, we find in wheat bran, that

78 per cent. of albuminoids,
69 per cent. of fat,
33 per cent. of fiber,
77 per cent. of nitrogen free extract,

are digestible by oxen. Multiplying the amounts of the different constituents by the digestion coefficients, gives the actual amounts of digestible matter.

Digestible fiber,	4.10x.33= 1.353 ℔s.
Digestible nitrogen free extract,	59.72x.77=45.984 ℔s.
Digestible albuminoids,	16.60x.78=12.948 ℔s.
Digestible fat,	5.35x.69= 3.691 ℔s.

If it is desired to estimate the amount per ton (2,000 ℔s.), we have simply to multiply these numbers by 20.

To determine the nutritive ratio in any feeding stuff, add together the amounts of digestible fiber and nitrogen free extract and the amount of digestible fat multiplied by 2½, and divide the sum by the amount of digestible albuminoids. This can be illustrated by the nutritive value of the wheat bran in question:

Digestible fiber,	1.35
Digestible fat (3.69x2½),	9.22
Digestible nitrogen free extract,	45.98
	56.55

56.55 divided by 12.94 (digestible albuminoid)=4.37.

Or, the nutritive value of wheat bran is 1 : 4.37. The nutritive ratio of the alfalfa in the feeding experiment is 1 : 4.90.

After all, the vital question to the farmer is, "Does it pay?"

This experiment shows that the nutritive ratio of alfalfa is quite good, and that average animals, like those fed in the experiment, will gain seven pounds weight for every 100 pounds of hay consumed, or a gain of 140 pounds weight for each ton of alfalfa. In determining final results, there are three important factors brought in question—the price of alfalfa, the cost of transportation, and the price obtained for the beef when placed on the market. Whether it will pay, or not, is a problem which can be solved only by the farmer or stockman, each in his own locality, after a knowledge of the preceding data.

To conclude, we believe alfalfa to be the best forage plant for Colorado, and the whole arid region, for the following reasons:

1. It is easy to raise and secure a fine stand of plants, if the soil be put in proper condition.

2. Its staying qualities are good, as the oldest fields show no diminution in growth or yield; neither does it kill by winter exposure, if given the least care and irrigation at the proper time.

3. The quantity produced by the many cuttings make it much more valuable than the other clovers or grasses.

4. It is as digestible as clover hay, constituent by constituent.

5. Its chemical composition shows that it is a rich, strong food, when properly cured.

6. Its feeding qualities are excellent, being relished by all farm animals.

It is also an excellent flesh and milk producer. In general, it will do to say that it has about all the good qualities of a forage plant, with very few poor ones. It has shown a tendency to split up, or diverge into several well marked varieties, under careful cultivation.

In a future bulletin, these, together with the rooting proclivities, with and without irrigation, will engage our attention.

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FERTILITY, IRRIGATION, Etc.

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SOILS.

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Soils are formed by the natural disintegration of rocks, to which is added the black mould caused by the decay of animal and vegetable matter. This disintegration is assisted by the atmosphere. The oxygen of the atmosphere is capable of uniting with some of the constituents of rocks, by which their cohesion is weakened or destroyed. This is the cause of the rapid disintegration of some varieties of granite. The iron is oxidized, its volume is increased, and portions of the rock are separated from the mass. When granite or limestone contains sulphuret of iron, the oxygen of the atmosphere, in the presence of moisture, combines with the sulphur and forms sulphuric acid, that decomposes limestone and the feldspar of granite. The carbonic acid of the atmosphere is another decomposing agent. Water charged with this gas is capable of decomposing calcareous rocks; it is, for this reason, that caves occur in limestone formations. The moisture of the atmosphere has a decomposing action. Rocks which are exposed to frequent alternations of dryness and moisture soon crumble into fragments; in this connection, the mechanical action of the falling rain must not be forgotten. Variations of temperature, especially above and below the freezing point, have great influence in the destruction of rocks. When a rock is saturated with water and the water freezes, it expands, and this expansion tends to enlarge the interstices and in time to separate particles of the rock. It is an observed fact that in the region of perpetual snow the surface of the mountain masses is covered with rocks in a disintegrated state, in greater abundance than below the snow line. Chemical action plays an important part in soil formation. It manifests itself on a large scale in the formation of various mineral species. Some of the older rocks cleave freely in planes not parallel with the stratification, and possibly mineral veins may be due to the same cause. By the instrumentality of organic agency—aqueous, aqueoglacial and igneous action—extending down through the ages, the rocks have been transformed into soil. The operation is to-day practically illustrated by the transformation of solidified lava from recent volcanic eruption into a plant-supporting soil. Geology teaches that the earth was once a molten mass, that it has cooled by the radiation of heat and become igneous rock. Through the agencies of the causes before mentioned, it begins to disintegrate; and soon the simplest forms of microscopic vegetable life appear, that find all they require upon their rocky home and the atmosphere; these, when they have served their purpose, finally die. The remains of these organisms accumulate upon the inhospitable home where the plants flourished. This is continued for generations, until the accumulated organic matter has covered the rock mass and transformed it into soil. The quantity of organic matter absolutely necessary as a constituent of soils for the production of plants is very small. Peat may contain 70 per cent. of organic matter, prairie and gardens 25 per cent. The Mississippi bottoms have about 10 per cent.; the average of good land is not over 6 per cent. Most crops are produced upon soils containing far less.

Oats, rye and buckwheat thrive with the lowest amount of organic matter, requiring from 1 to 2 per cent. Wheat and tobacco seem to require most among the common agricultural products, and do their best upon soils containing from 5 to 8 per cent. of organic matter. This organic matter is sometimes termed *humus.* The plants decay and add organic matter or *humus* to the soil, and the roots of plants have the power to decompose the rocks themselves, and there is a constant accession of mineral matter or soil. From the putrefaction or decay of organic matter, the elements form new combinations; the carbon combines with the oxygen to form carbonic acid; the nitrogen combines with the hydrogen to form ammonia; this ammonia undergoes a further decomposition called *nitrification*, resulting, like the original putrefaction, from the action of oxidizing *microbes*, and changes the ammonia into nitric acid. Plants are capable of receiving food, either in the form of gas through the instrumentality of their leaves, or in solution by their roots. Of the total weight of the plants, about 5 per cent. is of soil or mineral origin; the remaining 95 per cent. is wholly of atmospheric origin; most of which becomes added to the soil mass on the death and decomposition of the plants. The following elements are found in plants: Carbon, hydrogen, nitrogen, oxygen, sulphur, phosphorus, chlorine, silicon, potassium, sodium, calcium, magnesium, iron, manganese, and in rare cases a few others that may be called accidental. Of these, the carbon, hydrogen, nitrogen, oxygen, sulphur and phosphorus are grouped together to form the various organic compounds furnished by plants. The remaining elements are generally arranged in the following forms: Chlorides and silicates of potassium and sodium, calcium sulphate, phosphates of iron, calcium, magnesium and ammonium (and possibly manganese), salts of potassium, sodium and calcium, with vegetable acids. When plants are burned, the mineral elements remain as the ash. The amount of the different elements may vary. For instance, Sachs showed that the amount of silicic acid in the ash of Indian corn could be reduced from 18 per cent. to .7 per cent., without injurious effect upon the plant. The virgin soil is generally productive, but when in time it comes under tillage, the crops raised upon it are consumed by animals and removed to a distance, so that the mineral food contained in the soil is by degrees exhausted, and unless it is restored the soil becomes barren. The object of manuring is to restore the fertility of the soil, which consists in adding to the soil some substance which shall itself serve directly as food for the plant, or shall so modify, by chemical action, some material already present in the soil, as to convert it into a state in which the plant may take advantage of it. The length of time before fertilizers must or should be used, depends upon the character and amount of the soil. The character of the soil is caused by the different geological formations disintegrated, the rule being that primitive and igneous rocks yield soils rich in potash, while the fossiliferous rocks yield soils rich in phosphoric acid.

The amount of soil that covers the rocks will depend upon the slope of the ground, and the activity of those natural agencies that cause the disintegration. The soil may be so thin as barely to cover the rocks, or in other cases very thick, as in the drift material; the former are called soils of disintegration, the latter soils of transportation. A soil is commonly named from the preponderance of one of its constituents—as, if composed of sand, it is called sandy soil. Soils rest upon a sub-soil, which is tougher, more compact, and contains rubbly and stony debris. Soils differ not only in chemical composition, but also in physical characteristics, as coarse or fine, its power to absorb or retain the volatile and soluble parts of manure, etc.

PHYSICAL PROPERTIES.

The physical properties of the soil have a great deal to do with the growth and nutrition of the plants.

Schubler gives the weight in pounds of one cubic foot of dry soil:

Sand,	110
Sand and clay,	96
Common arable soil,	80 to 90
Heavy clay,	75
Vegetable mould,	78
Peat,	30 to 50

Ordinary soils, under cultivation, have an average specific gravity of 1.2; when free from air, specific gravity about 2.5.

The color of the soil depends exclusively on its composition; humus forming a nearly black soil, while sand gives a light yellow, and iron oxide produces a red color. The darker soils, other things being equal, have the highest absorptive power toward solar heat; this is shown when muck is applied to the surface of snow in the spring.

The porosity of the soil is of the greatest importance in influencing the results of cultivation. It is a fully accepted fact that, other things being equal, soil is *invariably* most fertile which exists in the finest state of division, whose particles are the smallest. The finer the particles, the greater the surface exposed to the action of the dissolving medium. As plants assimilate food only from solutions, the importance of this statement can be estimated. A too fine state of division may cause the soil to become impacted. The structure of the soil should be such as to allow self-drainage. The water capacity of different soils has been very carefully determined by Meister. By water capacity is meant the ability to retain a definite quantity of water by absorption, without losing it or becoming super-saturated.

As soils are rarely *saturated* with water, as there is in most cases an outlet at the bottom, Mayer has shown that the ordinary water capacity is much less than the saturated capacity :

		Quartz.	Clay.	Saw-dust.	Heavy Spar.
Saturated, . .	per cent.,	49	46	76.4	39.2
Water capacity,	" "	13.7	24.5	45.6	11.7

During dry weather plants require a soil which is retentive and absorptive of atmospheric moisture. The amount of this retention is generally in direct ratio to two factors, viz., the amount of organic matter and its state of division. The capillary water of the soil is very closely related to its percolating power, since all waters in the soil are governed in their movements by what is known as capillary force. Liebenberg has shown that this movement may be either upwards or downwards, according as the atmosphere is dry or supplies soil-saturating rain. The water absorbed by the roots passes into the plant circulation, and the greater part is evaporated from the leaves. Where the supply of water is insufficient, the plant wilts, and if the evaporation long continues in excess of the supply obtained from the soil, the plant must die. The experiments of Hellriegel have shown that any soil can supply plants with all the water they need, and as fast as they need it, so long as the moisture within the soil is not reduced below one-third of the whole amount that it can hold. The quantity of water required and evaporated by different agricultural plants during the period of growth has been found to be as follows:

One	acre	of	wheat	exhales	409,832	lbs	of	water.
"	"	"	clover	"	1,096,234	"	"	"
"	"	"	sunflowers	"	12,585,994	"	"	"
"	"	"	cabbage	"	5,049,194	"	"	"
"	"	"	grape-vines	"	730,733	"	"	"
"	"	"	hops	"	4,445,021	"	"	"

Dietrich estimates the amount of water exhaled by the foliage of plants to be from 250 to 400 times the weight of dry organic matter formed during the same time.

Cultivation conserves soil moisture. It must be remembered that this water contains soil ingredients in solution. Hoffman has estimated that the quantity of matter dissolved from the soil by water varied from .242 to .0205 per cent. of the dry earth. The experiments of Humphrey and Abbot have shown that about one-sixth of the total sediment of the Mississippi river is *soluble in water.* Another important fact is the relation between the soil and heat. The heat comes from three sources: Solar heat, as the sun's rays; heat of chemical decomposition within the soil, and the original heat of the earth's interior. The latter cannot be of any value to plants; the heat of chemical decomposition is not of any value, except in a few special cases. The sun, therefore, remains the only source of heat of practical importance in relation to the production of crops from the soil. Dark-colored soils, absorbing most and radiating the fewest rays, must attain the highest temperature. Schubler's classical researches on soil temperature, show that there is a difference of over 7° C. between white and black soils, all other conditions being alike. The ease with which a soil receives and retains solar heat is largely due to the specific heat of the soil. The specific heat of a body is expressed by a number which shows the amount of heat necessary to raise a given weight of the body one degree (0° to 1° C.) of temperature, as compared with the amount necessary to raise the same weight of water one degree. The specific heat of the soil is usually between .20° and .25°; while that of water is taken as the standard, or 1°, or four or five times as high. It must follow that the *moisture* of the soil possesses great influence on the soil temperature—so much so, that a dry, light-colored soil may attain a greater degree of warmth than a moist, dark-colored one. The action of water in reducing soil temperature is easily explained. In our latitude, we see the water in all its forms—solid, liquid and gaseous—and we know that these forms are the direct result of temperature. The changing of water from the solid to the liquid or gaseous form, is performed at the expense of heat; the more water evaporated from the soil, the more heat must be extracted from the soil for the evaporation. Therefore, the more water contained in the soil, the lower must be its temperature, because of the greater evaporation and consequent exhaustion of heat. The experiments of Liebenberg, Pattner, Schubler and Dickenson have practically settled all the questions of soil temperatures. The radiation of heat from the soil, and the consequent cooling propensity of the latter, are directly proportional to the absorptive power of the soil. Two soils of like absorptive power towards heat possess equal radiating power. But it does not follow that soils most rapidly warmed are likewise most rapidly cooled again; because the sun's rays are of two kinds, illuminating rays and heating rays, and substances absorbing or radiating one kind of ray may be inactive toward the other.

In a general way, it can be said the greater the heating capacity and conductivity of a soil, the more readily and rapidly does it give off its heat and become cooled, clay being the most slowly affected and sand the most readily influenced. There are many modifying circumstances, as the properties of the atmosphere and protective covering of various kinds—snow, vegetation and the clouds. In this connection, the explanation of the formation of dew upon the plants has been radically changed. The old theory presupposed the coldness of the soil and the warmth of the atmosphere. Now, the *facts* in the case show that the soil at the place dew is deposited is *generally warmer* than the surrounding vapor-containing atmosphere. The temperature of the soil is modified by many circumstances, as the vegetation, condition of the atmosphere, clear or cloudy, the angle of contact between the sun's rays and the soil surface. Even the electrical condition of the soil must not be overlooked, for Fischer has shown that the electrical current possesses the property of acting upon the soil constituents, rendering the insoluble ingredients more soluble; besides, it is the most active ozone former in nature, and shows its invigorating effects upon vegetable and animal life in every recurring thunder-shower.

CHEMICAL PROPERTIES.

Only very general statements can be made in regard to the kinds of plant food required by the different crops. Cereal crops feed on silicates, and contain a less amount of nitrogen than either root or leguminous crops, but they are improved by nitrogenous manure. The phosphoric acid is concentrated in the grain, and is the most constant of all the constituents of the crop. Root crops contain a large amount of potash, and are very exhausting to the soil; they take up more nitrogen than the cereals, besides other ash constituents, as phosphoric acid. The leguminous crops contain twice as much nitrogen as do the cereals, and potash and lime in large quantities, while silica is nearly absent. They respond readily to potash manures.

Chemical analysis of the ash of plants reveals the character of the mineral matters which they absorb from water and soil; the office of each constituent is ascertained by what is known as water culture. The plan of the operation is quite simple. The seeds are germinated upon some clean support, as a sponge or piece of cotton; they are placed in clean glass vessels and the vessels filled with pure water, so as to cover the roots. It has been found that if the water is pure, only a certain development will be produced; but if, now, certain salts of the elements are added, the plant commences to thrive; for instance, potash has been found necessary to the formation of starch, and the chloride of potash gave the best results. Calcium (lime) has been thought to serve as a vehicle for sulphuric and phosphoric acid and in fixing the oxalic acid, which is poisonous to the plant, and rendering it harmless. Phosphorus has been thought to assist in the transfer of soluble albuminoids. Iron is necessary to develop the chlorophyll granules and give the plant its green color. The nitrogen in combination is always present in active cells. Protoplasmic matters in plants contain about 15 per cent. of nitrogen in combination. At different stages in the life of a cell, its protoplasmic matters may pass through considerable changes of form and structure, as indicated in an examination of a ripening seed; but under all these varying conditions, nitrogen in combination is never absent from the living substance of the plant. For the formation of new protoplasmic matters in the plant, supplies of nitrogen in an available form must be furnished; for healthful growth, these supplies must be adequate in amount, hence the importance of a fertilizer containing nitrogen, either as ammonia or nitric acid. Having seen that the soil, the principal medium in which roots extend, possesses the power of absorbing and retaining water, saline matters and gases, we must direct our attention to the conditions upon which the root hairs (fibrous roots) can abstract from it the matters requisite for the plant. These conditions are (1) presence of free oxygen, (2) certain temperature, (3) the presence of saline matters in an available form in the soil.

The fertility of the soil depends upon many conditions, as temperature, rainfall, elevation above the sea level, etc., as well as its chemical composition. The experiments of Messrs. Laws and Gilbert have shown that most soils have a natural fertility and can raise the same crop for a number of years with but little diminution in the crop.

There are two kinds of soil analysis: Mechanical and chemical. Great stress was formerly laid upon the mechanical analysis of soil. The principle is quite simple. Water is commonly made use of to separate the soil into coarse and fine particles, or the same thing can be accomplished by metal sieves ranging from 10 to 100 meshes to the square inch, a weighed quantity of the soil being taken, and the portion remaining on each sieve being collected and weighed. The chemical analysis is quite long and tedious, and the *selection* of the soil is one of the most *important* operations to be performed. It is almost impossible to select a single sample of soil that will fairly represent a field; when to this is added the small quantity taken for analysis, as compared with, say even one acre, the difficulties are increased.

The soil of an acre of land taken to the depth of one foot will weigh about 4,000,000 pounds. About 1-10 of one per cent. is the usual limit of chemical analysis in this kind of work. One thousand pounds of guano would contain about 150 pounds of nitrogen, 150 pounds of phosphoric acid and 30 pounds of potash, making 330 pounds of fertilizing ingredients; then we have $\frac{330}{4,000,000} = \frac{1}{12,100}$ or within the limits of chemical analysis. It is possible that the droppings of a bird flying over it, if it happens to be in the sample analyzed, would make an unfair statement of the chemical analysis. If it were the place to discuss it, there are many questions that the chemical analysis of a soil cannot answer.

The following samples of soil were analyzed. The method of analysis is described in Bulletin No. 10, Division of Chemistry, of the Department of Agriculture:

No. 1—Arkansas Valley Experiment Station, from the orchard—sandy soil.

No. 2—Arkansas Valley Experiment Station, from nursery—clay loam.

No. 3—Arkansas Valley Experiment Station, from farm—adobe.

No. 4—Yuma, Colorado—adobe land.

No. 5—College farm, average of two places.

No. 6—College garden, average of two places—beets grown on soil, not manured.

No. 7—College garden—tobacco land.

No. 8—College garden—beets grown, manured.

No. 9—San Luis Experiment Station—sandy, gravelly loam.

No. 10—San Luis Experiment Station—sandy, gravelly loam.

No. 11—San Luis Experiment Station—sandy, gravelly loam.

SOIL ANALYSES.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.
Moisture	3.15	3.47	3.39	2.77	2.40	3.43	2.78	2.66	1.66	1.72	2.31
Insoluble Silica	79.19	82.24	74.17	84.52	74.21	78.58	82.71	82.40	83.24	83.09	82.20
Hydrated Silica	7.56	4.53	6.66	5.82	3.36	4.79	7.07	5.12	4.12	5.02	5.46
Soluble Silica	.08	.06	.04	.04	.08	.07	.04	.04	1.00	1.20	.07
Iron (Fe_2O_3)	3.30	3.05	3.42	2.16	3.16	3.47	3.37	2.99	4.78	4.17	6.22
Alumina (Al_2O_3)	4.53	5.23	4.23	3.98	5.59	5.07	4.29	3.59	5.59	6.45	6.02
Phosphoric Acid (P_2O_5)	.23	.22	.21	.14	.16	.15	.21	.29	.23	.23	.14
Calcium (CaO)	2.80	1.28	3.69	1.46	3.58	2.17	.70	.91	.67	.81	.68
Magnesia (MgO)	.97	.97	1.61	.69	.73	1.00	.85	.69	.54	.56	.67
Potash (K_2O)	.23	.27	.59	.39	.56	.62	.41	.66	.41	.27	.14
Soda (Na_2O)	.41	.21	.88	.29	.66	.71	.71	1.04	.69	.39	.30
Sulphuric acid (SO_3)	.08	.05	.08	.05	.09	.07	.08	.11	.04	.05	.03
Chlorine (Cl)	.008	.01	.012	.008	.008	.004	.012	.007	.004	.008	.005
Carbonic acid (CO_2)	4.97	3.68	5.41	4.40	5.47	5.38	2.79	2.95	2.13	2.13	2.66
Volatile and organic matter	3.39	3.05	5.45	2.01	5.01	3.73	4.53	5.03	1.39	1.39	1.59
	100.20	100.33	99.81	100.17	99.77	100.10	100.73	100.72	100.74	100.77	100.24
Nitrogen	.04	.02	.03	.01	.01	.02	.02	.03	.01	.01	.02
Coarse Gravel	10.30	12.41	19.25	16.39	36.36	34.32	34.72	24.39	30.00	24.26	36.95
Fine Material	89.70	87.59	80.75	83.61	63.64	65.68	65.28	75.61	70.00	75.74	63.05

The vital question for the farmer is, What are the important elements of plant food that the soil contains, and in what proportion? This is best shown by a comparison of the analysis of average barnyard manure with the analysis of the soil. The average barnyard manure (Ville) contains:

Water	80.00	(1)
Carbon	6.80	(2)
Hydrogen	.82	(2)
Oxygen	5.67	(2)
Silica	4.42	(3)
Chloride	.04	(3)
Sulphuric acid	.13	(3)
Oxide of iron	.40	(3)
Soda	--	(3)
Magnesia	.24	(3)
Lime	.56	(3)
Phosphoric acid	.18	(4)
Potassa	.49	(4)
Nitrogen	.41	(4)
	100.00	

In the above classes, the elements found in Nos. 1, 2 and 3 are in great abundance in the atmosphere, and in most soils, and therefore form elements of little value as manures; but the elements in the 4th class, as you will see by examining the analysis, the soil contains in very limited quantities, and for this reason the return of them becomes necessary, as they are the most *essential elements* of plant food. Soils containing these elements in large quantities, other things being equal, must be the most productive. In the above analyses the nitrogen ranges from .01 to .03; the phosphoric acid from .14 to .29, the potash from .14 to .66. In many of the States *trade values* are agreed upon for nitrogen, phosphoric acid and potash in the fertilizers bought and sold, the nitrogen being worth about 18 cents a pound, the phosphoric acid 9 cents, and the potash 7 cents, these elements being the "trinity of excellence" in any soil. A glance at the table will show that soil No. 8 contains the elements of plant food in the greatest proportion, and the notes accompanying it show that it is a rich garden soil that had been manured for experiments with sugar beets. Another important fact in connection with soils and fertilizers is that this plant food must be in a *soluble* or *available* form to do any *immediate* good to the crops.

ALKALI SOILS OF COLORADO.

The name *alkali soils* is applied, in the arid region, to all soils containing a large amount of mineral matter, usually occurring as a white powder or crust upon the surface. The first rain dissolves it and carries it into the watercourses and back into the soil, to rise again at the recurrence of dry weather. The rain that falls upon the soil may be divided into three parts: One part that rushes immediately off the surface, and causes the floods of rivers and small streams; another part that sinks into the earth and, after doing its chemical work of soil-making, reappears as springs, and forms the supply of streams and rivers, and a last portion that reaches the sea by subterranean channels. The amount of the rainfall that is carried off by the rivers has been estimated by Humphrey and Abbott, in the cases of the Mississippi and Ohio rivers, to be about one-fourth of that furnished by the rains; for the Missouri, 15-100. It is not far from the truth to say that about one-fourth the rainfall is carried off by the rivers. The other three-fourths goes off by evaporation and as subterranean water. A well is nothing but a hole in the ground a little below where the ground is *saturated* with water. Engineers call the upper surface of this ground water the "water-table," and they are familiar with the fact that it lies at very different depths in different soils and places and at different seasons of the year. Sometimes the water-table is at the very surface of the ground, or at a depth of no more than a few inches or a few feet, while in other situations it may lie, perhaps, hundreds of feet below the surface of the land. Much depends on whether the soil is porous or compact, whether or not the upper soil is underlaid by impermeable strata, and whether or not there is ready opportunity for the water to flow out sidewise and so escape from the soil.

The height of the ground water, that is to say its distance from the surface of the earth, varies greatly at different times in any given soil, according to the permeability of the soil and the time which has elapsed since heavy rains. When people speak of wells and springs as being "full" or "low," they mean the ground water is up or down. The proper height at which ground water should stand in order best to conduce to the prosperity of the growing plant, is an important question in some localities. The rice, cranberry and ribbon grass flourish with their roots actually wet. There are two kinds of movements of water in the soil: First, the movement of percolation of the ground water towards the sea, which is, on the whole, a downward movement; and secondly, a movement by force of capillarity, which is, or may be, a movement in any direction. A great amount of valuable work has been done in this line by Pettenkofer at Munich, also by the lamented W. R. Nichols in his book on "Water Supply."

When rain or snow falls upon the earth, it is speedily subjected to the influence of capillarity and dragged downward. The capillary power of soils has been worked out in great detail by Zenger. It takes a heavy shower for the rain to penetrate as such to the depth of an inch. The water in passing through the soil dissolves it, and when this water is again brought to the surface, it carrries with it the saline matters—in our case the alkali; and as it is evaporated from the surface, leaves this alkali as a white crust or coating on the soil. The alkali is not peculiar to Colorado or this arid region, but is found in many countries—Greece, Patagonia, India, California and other places.

It is easily seen that the more water that is evaporated from the surface of the soil, the more alkali will be drawn to the surface within a certain limit, which is a problem for another section of the Experiment Station; a greater rainfall will bring up a larger amount of alkali, provided the rainfall is not sufficient to wash the alkali into the water-table before alluded to, and so be washed or carried off as drainage. It will be readily seen that it will make no difference in what form this water is, whether rain or irrigation, that the same result would be true. The amount of this water to accomplish one or the other of the above results will depend largely upon the soil, as clay or sand, and upon the underlying strata. There must be an *inverse* relation between the rainfall or irrigation and the prevalence of the alkali in the soil.

The alkali effects plants in two ways: First, by bringing the upper roots and crown roots of the plants grown upon the soil in contact with its corrosive action; second, by destroying the tilth of the soil Alkaline solutions render the soil like well-worked potter's clay, instead of the flocculent condition that it should be in, with innumerable openings and channels for the passage of the rootlets.

The composition of the alkali will vary with the locality from which it is obtained.

The following account is from the Department of Agriculture, 1870, p. 96: "Dr. Edward Palmer brought to the laboratory, from Western Kansas prairies, a sample of what is called 'alkali' of the Western plains. It was in the form of a dry, milk-white powder, mixed with bleached leaves and coarse grass. It did not effervesce with acids, nor did it exhibit an acid reaction to test paper. It contained:

Water	3.6
Insoluble clay	1.5
Chloride of sodium	traces
Sulphate of sodium	94 6
	99.7

"It is consequently a native sulphate of soda, which, from the small amount of water present, may be classed as anhydrous. There is no evidence to show that it is a product of volcanic action. It differs from the varieties of mirabilite of Dana in the small amount of water, which we may conjecture, has been lost during the prolonged heat of summer. It may owe its origin to the decomposition of sulphate of lime, which is so largely present in the soils at the foot of the Rocky Mountains and Sierra Nevada series, by means of carbonate of soda occurring as efflorescence on soils. The usual origin of sulphate of soda is either directly from volcanic sources, or by the delivery of springs containing the salt derived from pre-existing sedimentary beds. In a few cases it is derived from the oxidation of sulphur in bituminous strata, or in pyritiferous beds, which, reacting on common salt, produces thenardite or other forms of sodic sulphate."

The sample of alkali analyzed in the laboratory came from Mr. Black's farm, three miles north of Fort Collins, and it contained:

Water at 100° C.	53.8	per cent.
Silica (Si O2)	12.72	per cent.
Iron and alumina oxides	traces	
Lime (Ca O)	.10	"
Magnesia (Mg O)	1.16	"
Chlorine (C1)	5.23	"
Sulphuric acid (S O3)	48.92	"
Soda (Na2 O)	31.97	"
	100.10	"

It was neutral to test paper, and did not effervesce with acids. The analyses show but little difference The sample analyzed by the Department at Washington was a sulphate of soda, while the alkali here was both a *chloride* and a *sulphate of soda.* The question that the farmer is interested in is, How can he best reclaim his land? Where the alkali is in small quantities, *deep tillage* will help it. Where deep tillage will not accomplish the purpose, as in cases where the alkali is very abundant, then resort must be had to *underdrains,* where the alkali water is carried off before it comes to the surface. The roots of the plants, where it is underdrained, will go deeper for what moisture they require, with no injury to the crop; and a small quantity of water, when applied at the proper time, will carry off the alkali from the surface soil. To my mind, the question of the drainage of the alkali has been practically settled by the experiment of Prof Cassidy, on the College farm. Before it was drained, the ground was covered with a white incrustation of alkali, and the field looked as though it was covered with snow. Now there is not a particle of alkali to be seen. Drain tiles were laid thirty feet apart and three and one-half feet under ground, and they emptied into an open ditch.

The question has often been asked, "Is there any thing, or substance, that can be put upon the soil that will kill the alkali?" Neutral alkaline salts, like those found in the alkali, are not very injurious except when present in large quantities, and in our alkali they must be *washed out by some means.* If the composition of the alkali was mainly earthy and metallic sulphates and chlorides, such as chloride of calcium, alum, copperas and the like, the cheapest and most practical antidote would be lime. Alkaline carbonates, like those found in Southern California, are from ten to twenty times as injurious to vegetation as the same amount of neutral alkaline salts. In most cases lime or gypsum, with *deep tillage*, will be of great benefit to the land. The presence of a *carbonate* of potash or soda can be known to the farmer by the alkali effervescing with *strong* vinegar, or by the fact that it dissolves the vegetable humus of the soil, and this dissolved humus is more or less black in color, and is what is commonly called "*black alkali*."

One of the most important considerations in the alkali question is the *water used to irrigate* the land. If this water is pure, as it is about Fort Collins, where the water comes from the melting of the snow upon the mountains, but little danger need be anticipated; but if, on the other hand, the water used, as in some parts of California, is itself a dilute solution of alkali, and in some cases not very dilute, the farmer is but adding fuel to the flame.

The kind of crop that will shade the soil and prevent evaporation from the surface will be best adapted to alkali soils. It may be said that an accumulation of alkali around the roots of the crops would be injurious, but it must be remembered that the solution is very *dilute* and could not injure the crop. When the ground is hoed during a dry time, the capillary pores are cut off at the surface and evaporation is prevented, or at least very much lessened; therefore, a hoed crop would be valuable on alkali soil. Owing to the expense, the question of *sub-irrigation* has not been tried in a practical way where I have had an opportunity to examine it. There are two arguments in favor of sub-irrigation, viz: It would prevent the rise of the alkali and accomplish a saving of all the water lost by evaporation. If the farmer wants to reclaim his valuable bottom land, he must provide a system of drainage by which the surplus subsoil water is carried off to the rivers and other places, or he will share the fate of the people of India and their "*reh*" (alkali) lands. It is to be hoped, some day in the near future, that the Government will build reservoirs to store the water that now escapes during the spring and fall Should that ever be consummated, another question may arise, viz: Will this water get contaminated with alkali? This is a very pertinent question.

Bulletin No. 82, of California Experiment Station, gives the total solids of Lake Tulare, in January, 1880, as 81 grains to the gallon; in June, 1888, 204 grains; in February, 1889, 303 grains, and that the fish in the lake were dying in large quantities It would seem that the lakes on the upper San Joaquin valley are being concentrated into a strong alkaline lye, too strong for animal life, as before described. In our case the water that is available for storage comes from our mountain streams, from the melting of the snow, and rivals in purity the water of the Alpine lakes of Switzerland, as is shown by the following analysis:

The sample was taken May, 1889, where the river leaves the last foothills. Found 6.4 grains solid matter to the gallon.

The *solids* contained moisture, at 100° C., 8.01 per cent.

Iron and alumina (Fe_2O_3 + Al_2O_3)	1.65	per cent.
Lime (CaO)	38.45	"
Magnesia (MgO)	16.60	"
Sulphuric acid (SO_3)	2.75	"
Carbonic acid (CO_2)	38.09	"
Chlorine (Cl)	1.20	"
Alkalies (Na_2O)	1.16	"
	99.90	"

With a view of ascertaining what changes had taken place in the river water by going down the stream, the water was analyzed about twenty miles lower down. Found 68.8 grains of solid matter to the gallon. The sample was taken July 16, 1889:

Iron and alumina (Fe_2O_3 + Al_2O_3)	1.197	per cent.
Lime (CaO)	13.200	"
Magnesia (MgO)	7.358	"
Sulphuric acid (SO_3)	45 850	"
Carbonic acid (CO_2)	15.637	"
Chlorine (Cl)	.210	"
Alkalies (Na_2O)	16.300	"
Phosphoric acid (P_2O_5)	.085	"
	99.83	"

It will be noticed that the alkali has increased over fourteen times, and the presence of phosphoric acid would be another proof of seepage. It will also be noticed that the total solids have increased over ten times. In this case the seepage water was largely diluted with the river water. A sample of seepage water was taken from the garden of the College farm, 50 feet from the Town Ditch. Found 240.4 grains of solid matter to the gallon:

Iron and alumina (Fe_2O_3 + Al_2O_3)	2.80	per cent.
Calcium (CaO)	13.50	"
Magnesia (MgO)	5.72	"
Sulphuric acid (SO_3)	50 12	"
Chlorine (Cl)	2.42	"
Carbonic acid (CO_2)	11.08	"
Alkalies (Na_2O)	14.22	"
	99.86	"

It will be noticed that there is quite an agreement between the river water and the seepage water in the proportion of sulphuric acid, carbonic acid and alkalies present, the seepage water having about four times as much solid matter to the gallon.

The condition of the well water was examined with reference to alkali. A well was selected five miles from the foothills, away from surface drainage; it was fourteen feet deep, and when the sample was analyzed (April, 1889) had eighteen inches of water. It had a slightly alkaline taste. It contained 84 grains to the gallon of solid matter:

Sulphuric acid (SO_3)	38.28	per cent.
Iron and alumina ($Fe_2O_3 + Al_2O_3$)	2.50	"
Magnesia (Mg O)	7.25	"
Calcium (Ca O)	13.17	"
Carbonic acid (CO_2)	19.00	"
Alkalies (Na_2O)	19.17	"
	99.90	"

The analysis shows about 38 per cent. of carbonate of soda in the residue. It was contemplated in the experiment to have a field so arranged that the seepage water could be used over and over again, to see what effect it would have upon the crops, and to ascertain its *composition* and the amount of solid matter when it became useless for irrigating purposes. Such a field was not available this year. To guide the farmer as to the *least* amount that could be detected by the taste, one gallon of distilled water was taken and the alkali before analyzed added until it was manifest to the taste. As the result of three experiments, it was found that 300 grains to the gallon must be added before it could be detected. There are about Fort Collins a number of reservoirs. The water in three of these was analyzed.

Reservoir No 2 is about five miles from the foothills. The water is carried from the river in an open ditch about twenty miles long. It was analyzed in May, 1889, when it was being filled. Found 52 grains of solid matter to the gallon :

Iron and alumina ($Fe_2O_3 + Al_2O_3$)	2.10	per cent.
Lime (Ca O)	14.00	"
Magnesia (Mg O)	42.65	"
Sulphuric acid (SO_3)	22.10	"
Carbonic acid (CO_2)	14.41	"
Chlorine (Cl)	3.54	"
Alkalies (Na_2O)	1.09	"
	99.89	"

Claymore lake, one-half a mile from the foothills, is fed by an open ditch about eight miles long. The water was taken when it was very *low*, in May, 1889. Found 69.6 grains of solid matter to the gallon :

Iron and alumina ($Fe_2O_3 + Al_2O_3$)	3.00	per cent.
Lime (CaO)	15.50	"
Magnesia (MgO)	8.55	"
Sulphuric acid (SO_3)	31.25	"
Carbonic acid (CO_2)	21.44	"
Chlorine (Cl)	10.14	"
Alkalies (Na_2O)	9.94	"
	99.82	"

Warren's lake, five miles from the foothills, is fed by an open ditch eleven miles long. The water was taken in July, 1889, when it contained a *medium* quantity of water. Found 26.4 grains to the gallon of solid matter:

Iron and alumina ($Fe_2O_3 + Al_2O_3$)	1.72	per cent.
Lime (CaO)	13.85	"
Magnesia (MgO)	7.72	"
Sulphuric acid (SO_3)	36.72	"
Carbonic acid (CO_2)	22.00	"
Chlorine (Cl)	2.96	"
Alkalies (Na_2O)	14.90	"
	99.87	"

The chemical analyses show that the reservoir waters are purer than the well water examined. This does not include the organic matter that may be present, which would be an advantage to the land irrigated. The water used to fill up the reservoirs is taken from the river, and it takes but a relatively short time to run in the ditches to its destination; while the water in the well, uncontaminated with surface drainage, must take a great deal longer time in its underground channel, and must correspondingly have more alkali dissolved in it. Suppose the well water in question is used for irrigation, what amount of alkali would accumulate near the surface? Dr. Hilgard, of California, says that ten inches of water is the usual estimate of what is required in a year to perfect a crop; if this be true, 6⅔ gallons of water per square foot is equal to 10 inches depth of water. The solid contents of the well water was 84 grains to the gallon; this quantity, upon evaporation, would leave 84x6⅔ = 560 grains, or a little over 1⅛ ounces of alkali on each square foot. It is known that in Colorado much more water is used to raise a crop than in California. It can then be readily seen that this operation could not be repeated many years without disastrous results. Sufficient experiments have not been tried to draw any very accurate conclusions as to the extreme limit of the per cent. of alkali that a soil can contain and be productive. A California soil was productive that contained over two ounces of carbonate of soda to the cubic foot, and had, possibly, three or four ounces of other ingredients, making, in all, over six ounces to the cubic foot. The alkali is caused by the yearly evaporation of enormous quantities of water, whose dilute solutions have been allowed to concentrate upon the soil. These facts should impress upon the farmers the importance of providing proper drainage for their lands, so they will not be compelled to abandon, in many cases, the most valuable and productive portions of their farms.

CONCLUSIONS.

To summarize, the analyses of Colorado soils and waters seem to justify the following conclusions:

1. That the physical properties of the soil influence its fertility.

2. That the fertility of a soil is not always thoroughly shown by chemical analysis.

3. That the fertility of a soil depends largely upon

the per cent. of phosphoric acid, potash and nitrogen present in available condition for plant food.

4. That the soils of Colorado compare favorably in fertility with productive soils everywhere.

5. That alkali soils can be reclaimed where drainage is possible.

6. That the alkaline carbonates are much more injurious to the soil and plant growth than are the neutral sulphates.

7. That water from canals and reservoirs is much better for purposes of irrigation than that from wells, as it contains less alkali.

8. That strong alkali water cannot long be used upon land without producing a soil highly charged with alkaline salts, unless drainage be employed.

— THE —

State Agricultural College.

The Agricultural Experiment Station.

BULLETIN NO. 10.

TOBACCO.

FORT COLLINS, COLORADO.

JANUARY, 1890.

Bulletins are free to all persons interested in Agriculture in any of its branches. Address the Director, Fort Collins, Colo.

The Agricultural Experiment Station.

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INTRODUCTION.

The question of raising tobacco in Colorado was first discussed in a conversation between the Director and the late Horticulturist and Botanist of the Agricultural College—James Cassidy—some time during the year 1883, and, in the following year, a few plants were raised, but were not properly ripened or cured. The experience of that year was so encouraging that each year following some tobacco was raised. Leaf tobacco was raised that was pronounced by experts to be excellent, and samples, which were sent to various places to be examined, bore out the previous testimony as to its good quality.

Tobacco was not grown in quantity until 1888 and 1889, after the organization of the Experiment Station, under an act of Congress. The results of the two years work are recorded briefly in this bulletin. The chemical analysis of the several varieties raised is also tabulated for comparison and reference, and shows a quality that is good from the chemical standpoint. Cigars have been made from the crop of 1888, which have been tested by many persons. One box was manufactured and presented to the Denver Manufacturers' Exchange, for use at their annual banquet, January, 1890, where only Colorado products, so far as was possible, were used.

The people of the State will be pleased to know that the work has been carried to a successful conclusion. One more money-making crop has been added to the varied crops heretofore produced; one which will bring to the producer, if well cared for and well cured, as much cash return per acre as many acres of wheat, and as every new article produced within our State adds to its wealth producing power, so this crop will put money in the hands of the farmers, either from that retained within the State by means of a home production, or from exported surplus.

It is a pleasure for me to state that the work, from first to last, was in the hands of Prof. James Cassidy, who closed his life and his labors November 21, 1889, just as he was closing his labors for the year. The value of this work cannot be estimated to-day; in the next half century some approximation may be attempted.

With the issue of this bulletin the State Experiment Station closes its work with tobacco, for the present at least, hoping that its other lines of work, when completed, may lead to as valuable results as this has done.

Respectfully,

C. L. INGERSOLL,

Director.

TOBACCO.

The cultivation of tobacco was continued the past season. Only three varieties were grown—Havana, White Burley and Golden Pryor. The area devoted to the main crop was one-half acre, which was set out exclusively to Havana. The White Burley and Golden Pryor were planted in single rows 100 feet in length, merely at the request of New York parties, with a view to test the quality of the same. Tests were also made with tobacco grown on poor soil and rich soil, to determine the quality by chemical analysis. The results appear in the report of Dr. O'Brine, the Chemist of the Station. The cultivation of the plant was nearly the same as in the previous year, with these exceptions (see Annual Report, 1888). The raising of plants in hot-beds is expensive, and a rather difficult matter for anyone but a gardener, for it takes great care and experience to keep the small plants while they are in the seed leaf from damping off. To overcome this we started a cold frame, covered with cloth. Seed was sown April 9, ten days later than those sown in the hot-bed. The plants raised were set out about a week later than the others, but the tobacco ripened about the same time. Our soil is a clay loam that was heavily manured with well-rotted stable manure and coarse spoiled hay and rubbish. The latter were burned off, so as to give the soil the potash, so essential to the raising of a good tobacco. The planting was done May 28 and 29, in rows three feet apart, plants one foot apart in the row. Our aim this year was to grow a finer leaf, more suitable for wrappers. In this we succeeded, by crowding the plants closer together, 8,000 being needed to set a half acre. The weight of stalk and leaves, when harvested, was 5,842 pounds.

CURING.

This season we did not place the tobacco in layers on the floor, when it came from the field. The tobacco was hung up at once, and the room closed. In this way we succeeded in obtaining a leaf of firmer texture and more uniform color. We also saved considerable labor. Care must be taken to keep the tobacco house closed and the air moist until the leaf has attained a deep yellow color, when a little ventilation will be necessary. This is to be increased as the curing process advances.

BULKING.

After the leaves were stripped and tied in bundles, called hands, the tobacco was piled in a conical heap, butts out, to go through a sweat or process of fermentation. A year ago we deferred this fermentation until the following spring by breaking up these heaps as soon as they became warm, but found that we were unable to bring the tobacco to a sweat without artificial means. The heat soon rises (in from two to three days), and it is of the most importance to watch this fermentation closely. If the heat rises above 130° F., the heaps must be opened up. It is advisable to break up the bulks after the first fourteen days, and again a month later. Change the hands by bringing the center on the outside, and the outside ones in the center. The tobacco may now remain in bulk until there is a chance for sale, when it is packed in boxes. The tobacco grown from our own seed, raised here a year ago, proved to be much inferior to that grown from imported seed, and it would not pay to raise such tobacco. The experiences of this year show that nothing but Havana seed leaf should be grown in this region. A fine Havana leaf will always command a ready sale at a good price. The expense of raising the crop was somewhat greater than a year ago, and we think it would be of interest to compare the crop of 1888 with that of 1889:

	Green Tob., lbs.	Cured Tob., lbs.	Expense.	Relative Expense Per Acre.
1888	4,858	850	$52.34 ⅔a.	$69.79
1889	5,842	732	39.25 ½a.	78.50

The price offered for the crop of 1888 was 17 cents per lb., which would make the following showing:

850 lbs. tobacco at 17 cts.	$144.50
Expense of raising	52.34
Net profit, two-thirds acre,	$ 92.16

Or the rate of $138.24 net per acre.

A computation for the crop of 1889 would show the following result:

732 lbs. at 17 cts	$124.44
Deduct expense of raising	39.25
Net profit, one-half acre	$ 85.19

This would make a net profit at the rate of $170.38 per acre for the crop of 1889, although the cost of raising the one-half acre in 1889 was more than that of raising the two-thirds acre in 1888, yet the net results are relatively greater in 1889.

It will also be seen that this year's crop has a much lighter leaf than the tobacco raised in 1888, as it weighed 1,000 pounds more green, but over 100 pounds less when cured.

[Extract from report of 1889, Section of Botany and Horticulture.]

Chemical Section.

In 1888 and 1889, there was undertaken by this Section of the Experiment Station, a study of the tobaccos grown by the Section of Horticulture. This was to comprise an analysis of the ash of each variety, for purposes of comparison; and, also, analyses of the same variety when grown upon rich (fertilized) soil and poor (unfertilized) soil.

Before giving the results of such work, a few words as to the work heretofore performed, and results attained, may not be out of place, as showing how this crop is affected by various circumstances.

In general, it has been found that the plant varies in texture and quality with the climate, the soil, the fertilizer used, and, perhaps, from other circumstances attending its growth and cultivation.

CLIMATE.

The climate has more influence on the quality of tobacco than soil or manner of cultivation. The proper degree of heat, of moisture, and the influence of sunlight have much to do with the development of the aromatic principle for which certain brands of tobacco are so highly esteemed. Colorado has excellent conditions for producing tobacco of fine quality. The summer climate is superb, giving that heat and dryness so essential, and with water of irrigation to produce the proper moisture, while the greater number of hours of sunlight in connection with the foregoing, gives peculiar and advantageous conditions of growth.

THE SOIL.

The soil here is formed from the disintegrated rocks of the adjacent foothills and mountains. The College garden has a soil quite similar to a majority of this region, and was that upon which the varieties of tobacco were grown. Its analysis shows the following constituents present, and the per cent. in which each was found:

Moisture	2.78
Insoluble silica	72.71
Hydrated silica	7.07
Soluble silica	.04
Iron, $Fe_2 O_3$	3.37
Alumina, $Al_2 O_3$	4.29
Phosphoric acid, $P_2 O_5$	.21
Calcium, CaO	.70
Magnesia, MgO	.85
Potash, $K_2 O$	.41
Soda, $Na_2 O$	.71
Sulphuric acid, SO_3	.08
Chlorine, Cl	.12
Carbonic acid, CO_2	2.79
Volatile and organic matter	4.53
	100.66

of which .02 is nitrogen.

Coarse gravel	34.72
Fine material	65.28

FERTILIZERS.

We have already noticed the fact that fertilizers affect the tobacco plant. Heavy manuring increases the quantity per acre, but the tobacco is generally of an inferior quality. We are indebted to Schloesing and Nessler for the action of manures upon tobacco ground. Their experiments show that potash salts, sulphates and carbonates act beneficially upon the quality, while the chloride injures it. Nessler shows that gypsum has an excellent effect upon the burning quality of tobacco, possibly by liberating potash. Farm-yard manures, when well rotted, are excellent; wood ashes also. It is for this reason that lands recently cleared of heavy timber are excellently suited for the crop.

BURNING QUALITIES.

The burning qualities of tobacco determine its relative value. Schlœsing found that a soil with but little potash produced a tobacco with poor burning qualities, and that this was improved by using potassium carbonate, sulphate or nitrate. A soil rich in nitrogenous matter also produces a strong tobacco, which burns poorly. Nessler's experiments prove that potassium carbonate, as manure, produced the best tobacco; with the sulphates one of poorer quality, and the chloride, the worst of all. The Connecticut Experiment Station (see Report, 1884) says that the most potash and the least lime were found in the tobacco which burned badly. In comparing the burning quality of the upper with the lower leaves of the same plant, Nessler found that the former were the better. In studying the burning of tobacco and the composition of the ash, several difficulties arise. Many organic acids, when burned, yield carbonates. Salts that fuse at the temperature of burning must hinder the process, while if there be present a large amount of cellulose (woody tissue) this fact must give a good burning quality.

VARIETIES AND ANALYSES.

The following varieties were cultivated in 1888 and 1889:

1—Landreth. 2—Veulte Abajo. 3—Spandona (imported from Italy). 4—Wilson's Prolific. 5—Dele de Sumatra (imported seed). 6—Havana Seedling. 7—Spagnola. 8—Cienfuegos. 9—Fiji Orinoco. 10—Spanish Hybrid. 11—Persian Rose Muscatella. 12—Isabella. 13—Benta (imported, Italy). 14—Dele de Sumatra (Missouri seed). 15—Golden Pryor. 16—Havana (rich soil). 17—Havana (poor soil). 18—White Burley.

The analyses were made from the stripped leaves; the dry and ground tobacco was burned at a low red heat in a platinum dish to obtain the crude ash. The amount of pure ash is obtained by subtracting the water, carbonic acid, silica and carbon from the crude ash. The silica present might be called an accidental impurity, as most of it consists of fine sand which has blown upon and adhered to the plant. There is nothing in the method of analysis worthy of especial mention, except that the method of soda lime for nitrogen determination gives results below that of Kjeldahls' method. The nicotine in No. 5 was determined after the method of Schlœsing, and 2.85 per cent. was found present. Following is the table of results found in analysis of the eighteen varieties of tobacco grown upon the College farm, at the State Experiment Station:

ANALYSES OF TOBACCO ASH.

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Moisture, 100° C	8.27	8.40	8.30	7.80	6.50	8.00	7.50	7.04	6.49	7.68	8.70	7.64	7.25	8.60	6.08	13.60	14.00	9.35
Ash	23.63	25.01	27.00	24.00	22.60	27.00	28.00	25.00	25.80	27.05	26.40	26.00	23.10	25.90	17.90	24.90	26.07	25.85
Silica, SiO2	13.79	18.70	12.22	12.06	19.80	22.26	16.83	18.80	18.60	18.50	16.40	18.60	18.80	18.60	19.80	8.36	17.30	20.42
Carbon, C	.47	4.19	6.01	2.05	1.00	2.00	.65	1.01	3.59	.57	2.01	1.47	3.50	2.29	3.78	5.38	6.08	6.04
Iron and Alumina, Fe2 O3 + Al2 O3	5.46	3.55	4.08	.16	.94	2 02	5.42	.81	4.74	4.01	4.15	3.41	4.42	2.60	4.60	4.58	6.83	7.17
Lime, Ca O	18.03	20.27	20.83	17.38	16.56	24.34	20.69	21.21	19.06	18.43	21.17	18.93	18.00	18.80	15.56	21.03	19.05	16.54
Magnesia, Mg O	7.81	4.68	4.74	9.20	11.71	.59	Lost	.17	1.43	7.13	4.16	4.07	7.65	10.75	7.86	4.38	1.78	.84
Potash, K2 O	21.70	16.46	19.15	25.50	18.46	19.60	17.50	26.30	18.70	16.99	16.03	17.46	15.20	17.70	15.30	19.96	12.67	15.45
Soda, Na2 O	.29	.40	.65	.54	.37	.61	.75	.58	.49	.76	.79	.49	.39	.81	.52	3.73	5.77	4.08
Phosphoric Acid, P2 O5	2.84	2.81	2.68	3.12	1.46	1.42	2.33	1.66	2.31	2.79	3.26	2.55	1.86	1.44	2.79	2.64	3.88	2.86
Sulphuric Acid, SO3	5.65	4.15	7.34	2.64	4.89	3.90	5.93	2.29	4.87	7.99	7.63	6.64	4.77	5.28	6.70	5.29	8.18	4.90
Carbonic Acid, CO2	20.50	20.85	19.14	23.80	22.25	22.10	24.31	24.87	22.85	21.20	22.72	21.30	22.70	18.50	21.24	24.51	17.85	21.23
Chlorine, Cl	4.48	5.17	4.06	4.65	3.34	2.45	6.87	2.87	4.30	2.06	2.17	6.49	3.53	4.30	3.64	1.12	.64	.98
	101.02	101.23	100.90	101.10	100.78	100.69	101.28	100.57	100.94	100.43	100.49	101.41	100.82	101.07	101.79	100.98	100.03	100.51
Oxygen equivalent to Chlorine	1.01	1.16	.90	1.05	.75	.55	1.55	.65	.97	.46	.49	1.46	.79	.97	.82	.25	.14	.22
	100.01	100.07	100.00	100.05	100.03	100.14	99.73	99.92	99.97	99.97	100.00	99.95	100.03	100.10	99.97	100.73	99.89	100.29

Lithium was found in the ash of all the samples by the spectroscope. It possibly came from the lepidolite of the neighboring foothills.

The reader will please note the difference in composition of tobaccos grown on rich and poor soils respectively. But one analysis was made of the acids present in tobacco. By qualitative test there were found acetic, pectic, citric, malic and oxalic acids. Resinous and fatty substances were found in considerable quantities. Of their nature little is known. The active principle of tobacco is a volatile, highly poisonous liquid alkaloid, known as nicotine (C_{10} H_{14} N_2). Nessler says that this substance increases as the plants ripen, but again decreases when the plants are allowed to become overripe. When the tobacco is smoked the nicotine is partly decomposed, and the resulting products, together with those of the other constituents of the leaf, unite with the nicotine, which is unaltered, to produce the physiological effects which occur while smoking. If the tobacco burns well, a greater amount of nicotine is decomposed; but when it burns poorly, even though the sample may contain less nicotine, a less quantity is decomposed, and a greater narcotic effect is produced on the human system. The amount of nicotine present in the plant depends upon several considerations. The climate, the soil, the treatment during growth and curing, have each an influence. The finer tobaccos usually contain the smaller percentages.

CONCLUSIONS.

1. For conclusions, with reference to particulars in growth and after-treatment, see Bulletin No. 4 and First Annual Report, 1888.

2. Cigars manufactured from the crop of 1888 have been tested by many persons. The uniform testimony is that Colorado-grown tobacco makes a cigar of fine flavor with excellent burning qualities.

3. The chemical examination of the samples grown shows, by comparison with Connecticut grown tobaccos,

and those reported upon by Moore, Special Census on Tobacco, that, chemically, these tobaccos were good and fully up to the average of tobaccos produced elsewhere.

4. That tobacco is a profitable crop for the farmers of Colorado to raise; one which, if well grown and cured, will add much to the productive wealth of the State.

DAVID O'BRINE,

Chemist.

—— THE ——

State Agricultural College.

The Agricultural Experiment Station.

BULLETIN NO. 11.

SUGAR BEETS

FORT COLLINS, COLORADO.

APRIL, 1890.

Bulletins are free to all persons interested in Agriculture in any of its branches. Address the Director, Fort Collins, Colo.

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SUGAR BEETS.

The beet (*Beta vulgaris*), a plant of the order *Chenipodiacæ*, has long been cultivated for food. It is a native of Egypt and the Mediterranean border, where it is found growing in its wild state. Under cultivation, we find several well-marked varieties, which differ in their quality, color, sweetness, etc. The beet is a lover of a sandy, quick soil, in which the roots can easily penetrate; and as an aid to this, good, deep plowing and a finely pulverized seed bed are essentials to success. The climate also has quite an influence on the final result. The spring should be warm and dry, with plenty of moisture as the season progresses, and not too much heat. In Colorado, where irrigation is practiced, the two conditions above named are perhaps more nearly realized than elsewhere.

In Spon's Encyclopedia, Vol. V., 1882, it is stated that the beets are usually sown about sixteen inches apart, on land that has not received fresh fertilizers or manures, as these cause the plants to take up too much nitrogen, and thus the sugar content is much reduced. It is thus much better to manure a preceding crop well, and, preparing the soil thoroughly, use no fertilizers for the beets. In this State, it is easy to raise very large crops of beets. Not only is the total yield heavy, but the single specimens often grow to wonderful size.

In the countries of Continental Europe, the effort is to grow beets that shall weigh from two and one-half to four pounds, as by experiment, these give the greater per cent. of sugar. The same authority also states that the formation of sugar is favored by dry weather and unclouded sky in autumn. Here again is a condition which is found in perfection in Colorado, and should give us a high per cent. of sugar in our beets, provided all other conditions and circumstances are carefully noted. In general for Colorado:

1. Prepare a deep and well-pulverized seed bed.

2. Sow in drills about eighteen to twenty inches apart, so as to admit of horse culture between the rows, using from seven to eight pounds of good seed per acre.

3. Irrigate judiciously and keep clear of weeds. Cultivate thoroughly during their early growth.

4. When well up, thin so that there shall be one thrifty plant every six or eight inches (some say ten to twelve), and take care not to injure the plants in this process.

5. In cultivation take care to preserve the leaves and to throw some earth to the plants each time. The portion of the beet which grows above ground does not contain much sugar.

6. Harvest when ripe, and preserve free from frost.

Every person who secures a good stand should have no difficulty in producing at the rate of twenty-five tons per acre. (The average for Europe is said to be twenty-three tons). Indeed, the effort must be to produce twenty-five rather than forty tons.

In practice, sugar has been extracted in various ways:

First—By means of pressure to extract the juice after crushing, slicing or grating the beets.

Second—By means of maceration in hot water until all the saccharine matter is extracted.

Third—By the process of diffusion, which is a modification of the second, and an excellent means of breaking up the cell walls and extracting the sugar.

This process is sure to revolutionize the method of sugar production from cane and sorghum, as well as with beets. Our sister State Kansas (see Report State Board of Agriculture, January, 1890) has published the results of beet sugar production at Medicine Lodge, in that State; 4.7 acres were raised, which produced 60.23 tons cleaned beets, from which were manufactured 10,158 pounds of sugar and 380 gallons of syrup. The production was more than one ton of sugar per acre, and not under the most favorable circumstances. A skilled expert from Germany was engaged to look after the culture and manufacture of the crop. The appliances not being the best, he claims that the best results were not obtained.

Where sorghum can be raised, the same company can manufacture sorghum into sugar until the heavy frosts come, when the beet crop can be worked with the same diffusion plant, as most of the machinery can be used for both.

The sugar sold readily at the factory for six cents per pound, and the demand exceeded the supply.

What has been accomplished in Kansas can also be performed in Colorado and Nebraska; and near Grand Island, in the Platte Valley of the latter State, a large area of sugar beets will be raised this year (1890), and a large and costly plant will work the crop for sugar.

The experience in Kansas has taught them that there should be an expert chemist with every diffusion plant, in order to insure good results; that there must be a beet-sugar expert to take charge of the work, for while such a person can easily make sugar from sorghum, a sorghum or cane sugar worker will have great difficulty in getting good results with beets, on account of the particular treatment they require. Prof. Cowgill, State Sugar Inspector to the Kansas State Board of Agriculture, recommends the following conditions, which are as valuable for us in Colorado as for the farmers in Kansas:

"Select carefully the location as to ability to supply good cane or beets, and an abundance of good water.

"Provide sufficient ready capital.

"Contract with a thoroughly competent and responsible machinery company.

"Secure the best business management.

"Secure competent, skilled operatives.

"Contract with reliable, careful farmers.

"Secure carefully selected seed of known purity.

"Observe the above requirements, and you have gone a long way on the road to success. The absence of any one of these conditions will entail loss, and probable failure."

The single success and several failures prove the truth of the above position.

C. L. INGERSOLL,

Director.

Chemical Section.

The subject of sugar from sugar beets was continued from the year 1888; the result of the work of that year being embodied in Bulletin No. 7.

In 1889, it was proposed to grow beets on poor (unfertilized) soil and on rich (fertilized) soil, and to note the difference, if any, in the substances present in the ash; to compare the specific gravity of the expressed juice, and the per cent. of sugar present.

It was expected to determine the relation of the sugar content in the beet to weight of top, and the feeding value of the top as well as that of the roots.

The early frost killed the tops, and thus prevented the completion of that part of the experiment.

In order to study the amount of material removed from the soil by the different kinds of beets—both when the beets were grown upon rich soil and poor soil—analyses have been made of the ash of the beets, as shown in the following table:

COMPOSITION OF ASH.

	Silician on Poor Soil. Per Cent.	Silician on Rich Soil. Per Cent.	Imperial on Poor Soil. Per Cent.	Imperial on Rich Soil. Per Cent.
Total ash	1.08	1.28	.801	1.234
Silica, SiO_2	1.59	2.24	2.49	2.60
Carbon, C	4.75	4.42	6.44	5.05
Iron and Alumina, $Fe_2O_3 + Al_2O_3$	5.85	.27	2.43	2.06
Calcium, CaO	2.60	1.92	2.78	2.30
Magnesia, MgO	2.84	3.49	3.94	3.55
Potash, K_2O	31.48	32.76	30.10	32.62
Soda, Na_2O	13.54	12.45	10.42	10.80
Phosphoric Acid, P_2O_5	7.64	4.82	8.25	7.80
Sulphuric acid, SO_3	3.49	4.12	4.47	4.29
Carbonic acid, CO_2	22.27	26.00	24.50	23.70
Chlorine, Cl	3.28	7.60	4.56	5.60
Total	99.33	100.09	100.38	100.37

It will be noticed that the amount of ash was greater in the beets raised on rich soil, while the amount of iron and alumina, calcium and phosphoric acid was the greatest in those raised on the poor soil.

Of course, the farmer must return the mineral substances used up by the beets and found in the ash, in order to obtain the best results in successive crops, and prevent impoverishing the soil.

There may come some misunderstanding between the manufacturer and grower of sugar beets. It would be unfair to both, to buy and sell according to weight. A better way would be to take an average sample and have the juice extracted. An increased density, other things being equal, would indicate an increase of sugar. In many places it has been customary to take a specific gravity of 1.055 (7.27° Baume) as to the standard.

The Societe Centrale de l'Agriculture, du Pas-de Calais, have agreed upon the following standard:

Specific	gravity	1.045	yields	8	per	cent.	sugar.
"	"	1.050	"	9	"	"	"
"	"	1.055	"	10	"	"	"
"	"	1.060	"	11	"	"	"
"	"	1.065	"	12	"	"	"

This standard must be unfair, as the yield of sugar is increased disproportionately in rich juice; on the other hand, the juice may be high in other salts and poor in sugar.

The highest specific gravity as given by Dr. Wiley in the analyses of ten samples of the best California sugar beets is 1.075 White Imperial, and it corresponds to 15.19 per cent. of sugar; while there is one sample, White Silician, having specific gravity 1.074, which gives 15.85 per cent. of sugar; and another, White Imperial, specific gravity 1.067, which gives 15.19 per cent of sugar. For the reason above given, the specific gravity is not always a correct index of the per cent. of sugar, as the following analyses of varieties raised on the College garden will show:

NAME.	Loss on Dressing, in Grams.	Weight taken, in Grams.	C. C. Juice obtained.	Sp. Gr. of Juice.	Per Cent. of Juice.	Total Sugar, Per Cent.
Silician on poor soil	25	820	550	1.055	70.7	9.66
Silician on rich soil	26	1550	1025	1.050	70	10.47
Imperial on poor soil	23	755	550	1.059	77	10.44
Imperial on rich soil	40	1705	1100	1.049	70	9.07
Velmorin	18	1696	1275	1.050	78.8	8.11

The classical researches of Scharcht, Walkhoff, Champagnon, Pellet, Bretschneider and Decaisne have shown that in a cross section of the beet the inner zone is the richest in sugar. The neck, above the ground, is usually filled with crystals. Those in the samples analyzed resembled crystals of potash. Below the ground the crystals gradually disappear. If the sugar beet contained nothing but a solution of sugar, the operation of sugar making would be quite simple.

The epidermic tissue is composed mostly of cellulose. The beet contains tannin, and this tannin combines with the albuminoids to form an insoluble compound that is a valuable thing for the sugar makers.

Payen has shown that the sugar beet contains malates of potash, lime, soda and ammonia; also the oxalates of potash, soda and ammonia, and several other compounds in small quantities. These compounds are mostly found in the neck of the beet, and it is now an accepted statement that the amount of sugar varies indirectly proportional to these salts. The formation of sugar in the beet seems to be mainly due to the leaves. The amount of sugar present is greatly influenced by the weather, fertilizers, size, soil and the variety grown. The sugar increases from the top to the bottom, as shown by the following analyses. The sections were made across the beet, one inch apart, and are numbered from the top down:

PER CENT. OF SUGAR IN SECTIONS OF THE BEET.

SECTION.	Silician on Poor Soil.			Silician on Rich Soil.			Imperial on Poor Soil.			Imperial on Rich Soil.		
	Grape Sugar, Per Cent.	Cane Sugar, Per Cent.	Total Sugar, Per Cent.	Grape Sugar, Per Cent.	Cane Sugar, Per Cent.	Total Sugar, Per Cent.	Grape Sugar, Pet.	Cane Sugar, Per Cent.	Total Sugar, Per Cent.	Grape Sugar, Per Cent.	Cane Sugar, Per Cent.	Total Sugar, Per Cent.
1.....	.02	7.40	7.42	.019	9.10	9.11	.019	9.10	9.11	.080	7.96	8.04
2.....	.023	10.5	10.52	.024	10.30	10.32	.017	10.50	10.52	.096	8.02	8.12
3.....	.035	10.9	10.93	.026	11.00	11.02	.023	11.20	11.22	.071	7.32	7.40
4.....	.065	11	11.06	.015	11.30	11.31	.030	11.60	11.63	.080	9.48	9.56
5.....	.060	11.1	11.16	.034	11.40	11.43	.030	11.70	11.73	.069	10.86	10.93
6.....	......	......	......	.023	11.45	11.47	......	......	......	.066	11.80	11.87
7.....	......	......	......	.027	11.70	11.72	......	......	......	......	......	......
Av.	......	......	9.66	......	......	10.74	......	......	10.44	......	......	9.08

FEEDING VALUE.

In connection with the per cent. of sugar, the feeding value of the beet has been estimated. The amount of water in any article of food must diminish its value, for two reasons: First, a large per cent. of water means a small per cent. of dry matter in the food; second, in the winter season, when root crops are usually fed, this water must be raised from the freezing point to the temperature of the animal. There has been found a certain relation between the amount of dry food and water consumed by animals. In Bulletin No. 8, page 18, it is given for steers as about four parts of water to one of dry food. Where the experiments have been conducted with sheep, they require only two parts of water to one of dry food. These facts show that root crops, like beets, would be better for food for cattle than for sheep. The following table gives the feeding value of the roots:

NAME.	Moisture.	Crude Ash.	Fat.	Alb'min-oid Nitrogen or Crude Protein.	Crude Fiber.	Nitrogen-Free Extract.
Silician, poor soil	87.17	1.08	.24	.925	.830	9.75
Silician, rich soil	86.31	1.28	.27	1.77	.68	9.69
Imperial, poor soil	87.88	.801	.14	.808	.587	9.78
Imperial, rich soil	89.80	1.234	.18	1.44	.433	6.91
Velmorin	88.69	1.131	.175	1.159	.618	8.22

The large per cent. of water reduces the feeding value of beets very much, there being only about twelve per cent. of dry matter in the beets. The method of analysis for feeding value was that described by the Association of Official Agricultural Chemists. The amount of sugar present was determined by Scheibler's polariscope, which we have found to be one of the best in the market.

CONCLUSIONS.

1. It is found that there is a greater per cent. of ash present in beets grown on rich soil than in those grown on poor soil.

2. The per cent of iron, aluminum, calcium and phosphoric acid present in the ash was greatest in beets from poor soil.

3. The specific gravity of the expressed juice of the beet is not a correct index to the per cent. of sugar present, as various salts in solution, and often accidentally present, produce increased specific gravity when there is no corresponding increase of sugar.

4. An examination of the beet by horizontal sections shows a somewhat regular increase in sugar content from the top downward.

5. The average per cent. of sugar present in the crop of 1889 (9.98 per cent.) was but little less than that of 1888 (10.45 per cent), but the greater yield of beets per acre, in 1889, more than compensated for the less per cent. of sugar present.

DAVID O'BRINE, *Chemist.*

THE

State Agricultural College.

The Agricultural Experiment Station.

BULLETIN NO. 12.

Some Colorado Grasses

AND THEIR CHEMICAL ANALYSIS.

1889.

FORT COLLINS, COLORADO.

JULY, 1890.

The Agricultural Experiment Station.

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INTRODUCTION.

This bulletin is the result of work undertaken early in 1889 by the Experiment Station, to study the grasses of the arid region, and more particularly of Colorado, in order to find, if possible, some varieties which would furnish more and better forage than those now cultivated. The chemical work was undertaken to show the comparison in composition of these species as grown in their native habitat, and afterward under cultivation; first, without irrigation, and second, under irrigation. The botanical work has been almost exclusively performed by our late Professor James Cassidy, and the chemical work by Dr. David O'Brine, Chemist.

The results of the work, as herein published, are of a two-fold character; first, scientific, and second, practical. Because the Hatch law contemplates both lines of work, we must necessarily have the descriptions of the several species in technical language, while the observations in the field are of a very practical nature, and are intended for the direct benefit of the farmers and those interested in agriculture in this region. The bulletin deals with grasses almost exclusively; however, a few rushes

(*Juncæ*) and sedges are mentioned, as well as two lupins, all of which are eaten by stock while grazing, and are sometimes cut for hay.

There are mentioned: 122 species of grasses; 3 species of sedges and rushes; 2 species of lupins; 1 species of clover.

Hoping that the subject matter of this bulletin will be but the beginning of a valuable work, which may be carried forward to completion, we submit the same for the benefit of the public.

C. L. INGERSOLL,

Director.

SOME COLORADO GRASSES

AND THEIR CHEMICAL ANALYSIS.

By JAMES CASSIDY, *Botanist and Horticulturist.*

AND

Dr. DAVID O'BRINE, *Chemist.*

The grasses are, without doubt, the most important order of plants in the vegetable kingdom. A technical knowledge of them is, however, difficult of acquirement, owing to the complexity of the details of their structure. Stockmen in this region invariably confound the rushes and sedges with grasses, but no plant can be called a grass that is not a member of the order *Gramineæ*, no matter what its common name may be.

The sedges resemble, more or less, the grasses, as do some members of the rush family (*Juncus*), but it is not very difficult to distinguish between them on close inspection.

The more obvious distinctions between grasses and and sedges are as follows:

The stems of grasses and rushes are hollow and commonly round, while the sedges have, usually, angled and solid stems. The sheaths of grasses are split down the entire length, but in sedges the sheaths are united above the joint. The flowers of sedges are in a solid spike, while in grasses they are displayed in spike racemes or panicles.

Grasses are classified as follows:

I. The cereal grasses, comprising wheat, oats, barley, corn and rice.

II. Hay and pasture grasses, including the well-known orchard grass and timothy.

III. Cane grasses, as sorghum, sugar cane, etc.

IV. Ornamental grasses, such as the pampas grass.

V. Weedy grasses, represented in burr grass, (*Cenchrus tribuloides*), pigeon grass, chess, etc.

The number of known species is about thirty-five hundred, widely distributed the world over, being especially predominant in temperate regions, where they carpet the surface of the earth with a soft green turf, but in tropical countries, their habit disappears, the grasses growing in isolated tufts, having broader leaves and more showy flowers.

All the grasses contain, in a greater or less degree, especially before blooming, a sugary mucilage. The creeping root stocks, too, are generally demulcent and mucilaginous, besides being invaluable in securing the stability and permanancy of shifting sands.

And every tiller of the soil recognizes their importance in the production of hay and pasturage. In the United States, we have a great variety of conditions, of both soil and climate, with which to contend, and the number of species of grass in cultivation is less than a dozen.

The following characteristics of grasses are explained here, that observing persons may be the better prepared to recognize the leading species without great difficulty:

The root consists of many strong fibres branching through the soil in various directions, often binding it into a matted turf. Its function is the appropriation of food from the soil, to be conveyed to the stem and leaves.

The stem is technically called a culm, because hollow between the joints. It is divided, at intervals, by thickened portions called nodes, which give it additional strength. The stem is sometimes horizontal and subterranean, when it is botanically known as a rhizoma. In a few cases the stem exhibits a bulbous enlargement at its base, in which is stored nutriment for the plant's use under adverse circumstances.

The leaves are in two vertical ranks, parallel veined, the lower portion of the leaf sheathing the stem, but with the edges free. The expanded portion above is the blade. It is either filiform, linear or lanceolate.

At the junction of the sheath and blade is a short membrane, called the ligule or tongue, answering to stipules in the higher plants.

The inflorescence may be in the form of a spike, more or less dense or more spreading, as in the receme, or still more branching, as in the panicle. It is sometimes of importance to note whether these branches are in 1s, 2s, 3s or 5s.

The flowers are collected in little clusters called spikelets. One of the latter, separated into all its parts, would be found to consist of two scales at the base, standing opposite each other, of equal or unequal length, called the outer glumes, and one or more such is a spikelet.

The flower consists of two scales standing opposite each other. The largest is called the flowering glume, and is of a coarser texture than the smaller, called the palet.

Between these two scales there are usually three stamens, with delicate filaments and versatile anthers, and the pistil, with its two feathery stigmas.

Fertilization is effected in grasses by the wind wafting the pollen to the feathery stigmas.

To secure this end, grasses occur in great areas, and owing to the great superabundance of pollen, the pistils are certain of fertilization, either from their own or from foreign pollen.

On the treeless plains a set of conditions obtain not paralleled elsewhere, to meet which, by clothing them with plants showing some adaptation to these conditions, and at the same time be more productive than such as naturally exist there at present, has long been a leading factor in the work of the Department of Agriculture.

In fact, the possible agricultural value of some of our native species has been a subject of interest and inquiry for some time, especially to the people of the West and South.

Some of the native species yield an excellent growth of herbage when not over-fed or tramped out. Others, however, are too meagre of top to admit of their successful cultivation, as against more thrifty kinds.

The plains grasses are of a dwarf, spreading habit, and present a magnificent sight in June, clothed in the richest green. These grasses are cured during late summer, the result of a high temperature, and the absence of rain dissipating the stems and leaves of their surplus moisture. The absence of wet snows, the high day temperature and the protection afforded by the hills, renders the wintering of stock a safe problem.

In order to collect some information in regard to the distribution of particular kinds, their behavior under irrigation in the native meadow, and to collect seeds in quantity of such as were deemed of possible value in the plains region, an expedition was undertaken by the writer, at the instigation of the Department of Agriculture and of the State Experiment Station, accompanied by Mr.

Holmes, agent of the department, and by Mr. Hoag, of Fort Collins, who has given considerable attention to the native grasses.

The route traversed was a northerly one, through the Virginia Dale country to the Laramie plains. The irrigated and non-irrigated meadows were carefully examined. Thence by Fort Halleck to North Park by Pass plains and Big Creek, to Middle and Ægeria Parks by the Arapahoe, Muddy and Gore Passes.

Haying had begun when we started, and was continuous until we reached higher mountain meadows.

Whatever of open range there is is very much overdone, and in many cases the native grasses have given way to *Chenopodium Fremontii* and the varieties.

Cattle ate so plentifully of these plants that, in the "round-ups" many cases of hoven resulted, all of which were fatal unless the animals received attention. On the Laramie plains the native meadows consist of *Agropyrum glaucum*, the type with glaucous leaves and one with dark green leaves; *Kœleria cristata*—the latter, when irrigated, is fully three feet high; *Poa andina* and sparsely leaved forms of *tenuifolia*. In very wet spots are found *Aira caespitosa* and *Poa laevis*; in alkaline soils *Sporobolus airoides* and *Distichlis maritima* are the prevailing species. At high elevations *Poa tenuifolia* is at its best in two forms, the glaucous-leaved form being especially desirable; also, two forms of *Agropyrum violaceum*, a magnificent hay grass. *Elymus Americana*, four to seven feet high, occurs in large patches in openings in the timber. The dry plains and high parks abound in *Artemesia tridentata*, *Bigelovia albicaulis* and "greasewood."

Willows of several species—the aspen, alder, birch, *Rhus aromatica*, var. *trilobata*, mountain mahogany, serviceberry, *Amelanchier* and *Heuchera*, with some species of currant and gooseberry—abound in the bottoms along streams. *Cowania* (the cliff rose) abounds on the banks of the Poudre. Among the rocks, in good soils, growing in tufts, are *Elymus Sibericus, Agropyrum divergens* in two forms. *Bouteloua racemosa,* on the east face of the mountains. At one place only was *Festuca Kingii* seen.

The several species of "loco" occur at all elevations. *Oxytropis Lamberti* occurs at all elevations in a variety of forms. *Sophora sericea* most abundant at 5,000 feet, and in heavy soils. It is affected with a fungus in this locality. *Astragalus bisulcatus,* with flowers of various shades of red and white, abounds in moist ground. *Astragalus caespitosa* was seen only in one place. *A. Haydenianus* and *Drummondii* are abundant in the foothills of the Medicine Bow range.

The best mountain meadows seen were, in all cases, those but recently cleared of under-brush and irrigated but one or two seasons, but owing to the very imprudent use of water in all of the meadows seen, these desirable species are drowned out and their places taken by foxtail (*Hordeum*), *Agrostis scabra,* and by many species of rushes and sedge.

The method of irrigating seems to be to turn on the water early in the season and allow it to run until within a few days of haying. Applying water to plants should be managed so as to occur while the plants are in active growth. When a sufficient irrigation has been given the water should be taken off, as all the finer grasses and useful plants are impatient of standing water about their roots. The number of irrigations and the quantity can only be determined by the owner. His judgment will be based upon the rainfall during the early part of the season, when hay is made, and the character of the soil and subsoil.

All the sedges seem to be known to ranchmen as wire grass. The species most highly valued is *Carex* *rupestris.* Of the rushes (*Juncus*), the species most valued are *Balticus* and *Mertensiana.* The last mentioned is thought to be the most desirable. This rush is considered by stockmen as being more valuable for hay than any of the grasses. Stock certainly relish the heavy-seeded capsules of this species.

Seeds were collected of 120 species, but in quantity only of kinds thought to be profitable.

The most promising grasses for pasture are *Festuca scabrella, Oryzopsis cuspidata, Elymus sibericus, Agropyrum divergens, Stipa viridula,* of some of the finer forms.

For hay: *Agropyrum glaucum* and *violaceum, Poa tenuifolia, Sporobolus depauperatus, Elymus Americanus, Deyeuxia stricta, D. Canadensis, Hilaria Jamesii.*

While many of the native species are very deficient in top, still it must be acknowledged that they improve wonderfully in vigor with irrigation. This is notably so in the case of buffalo grass (*Buchloe dactyloides*), which more than holds its own in meadows where alfalfa has been thinly seeded and which are irrigated two or three times a year.

Some of the grasses collected must prove valuable in regions having a sufficient rainfall, or where irrigation can be had. Nothing can be finer, in the way of a hay grass, than the glaucous-leaved form of *Poa tenuifolia,* or the two forms of *Agropyrum violaceum.*

Of the species most likely to succeed on the dry plains, the following are the most promising: *Elymus Sibericus, Agropyrum divergens* in two forms, *Hilaria Jamesii, Festuca scabrella, Oryzopsis cuspidata, Koeleria cristata, Sporobolus airoides, Muhlenbergia Wrightii, gracilis, Bouteloua oligostachya* and *B. racemosa,* and a few others.

Faithful experiment is needed to determine the agricultural value of all the species collected, both with irrigation and on the dry plains, where the kinds will be sustained by the limited rainfall alone.

The following is a list of the kinds of grasses and forage plants and the quantities of seeds secured. The difficulties and labor attending the collecting of seeds in quantities of some of the native grasses can be appreciated only by those who have made the attempt. The more rare species are to be had only in the most limited quantities, and even this is affected by the character of the season, in regard to rainfall and the number of stock on the ranges to be worked over. The past four seasons have been disastrous to the ranges west of the Medicine Bow, owing to lack of rain or sufficient snow. As a result, grasses are scant, except in places difficult of access, and the number of stock of all kinds effectually prevents their seeding:

POA LÆVIS (Vasey).

Stems wiry, geniculate at base; leaves linear to filiform, scabrous, striate above, pubescent below; ligule elongated, lacerate; panicle diffuse, 4 to 8 inches long, branches capillary, in 3s or 5s, finely scabrous; spikelets small, appressed, three to five-flowered; outer glumes very unequal, the upper three-nerved at base; flowering glume rounded on the back, obscurely five-nerved, somewhat webby below the middle, and with broadly scarious apex; palet shorter than the glume, acute or truncate.

This grass grows in stout tufts in wet meadows, on the plains and in the mountains, and while stock eat it with avidity, it must be considered as having but little agricultural value.

POA ALPINA (L.).

(Alpine Meadow Grass.)

Stems very smooth and scaly, growing in short tufts 6 to 12 inches high; stem leaves smooth, flat; panicle short and broad, branches solitary or in pairs, spreading; spikelets three to nine-flowered; glumes scarious and bronzy purple at apex.

Occuring at high elevations and in exposed situations. It is to small to have much agricultural value.

POA COMPRESSA (L.).

(Flat-Stemmed Meadow Grass; Wire Grass.)

Stems much flattened, decumbent, pale, wiry, about 1 foot high; leaves finely pubescent, striate on the upper surface; ligule truncate, hairy; panicle narrow, contracted; branches solitary or in pairs; spikelets nearly sessile, about five-flowered, finely pubescent; glumes with purplish apex; palet equal, obtuse.

This grass is too small to have much value.

POA CAESIA (Smith).

Stems slender, wiry, rigid, 6 to 20 inches high; leaves very small, involute, scabrous; ligule short-pointed; panicle oblong or pyramidal, loose; branches in 2s, 3s or 5s, very scabrous; spikelets bronzy, three-flowered; outer glumes unequal, very acute, three-nerved, finely scabrous, rough on the keel; flowering glume obtuse, with broadly scarious apex, sparsely hairy on the mid-rib and margins; palet smaller than the glume; apex truncate, finely ciliate.

This grass is well distributed in the mountains. It occurs in the shade of rocks along water courses, and is a constituent of native meadows in Middle Park.

POA ANDINA (Nutt).

Culms tufted, wiry, smooth, 6 to 18 inches high; radical leaves half as long as the stem; stem leaves about 2 and the blade about 1 inch long, or almost wanting; panicle 2 or 3 inches long, one sided, very slender; branches in pairs, scabrous, erect; spikelets three to seven-flowered; outer glumes acute, rough on the keel, scarious margined, the lower one-nerved, the upper three-nerved at base; flowering glume obtuse, five-nerved at base, softly pubescent below the middle, and with a broadly scarious erose, sometimes purplish apex; palet as long as the glumes, pubescent on the nerves.

Abundant at 6,000 feet in the mountains, where it forms a chief constituent of the native meadows, when not too wet. Its agricultural value has not been determined.

ANALYSIS.

Moisture	3.22
Ash	8.41
Fat	1.80
Albuminoid nitrogen	4.06
Crude fiber	22.78
Nitrogen-free extract	62.95
Total	100.00

Poa Andina.

POA CÆSIA, var. STRICTA (Gray).

This variety occurs with the species, and is about 12 inches high, with a slender, purplish-red panicle, 3 to 4 inches long; leaves small, especially on the culm; ligule short, truncate or pointed; outer glumes very acute, especially the lower; flowering glume hairy on the margins, and mid-rib below the middle; apex bronzy, scarious; palet about equalling its glume, ciliate on the nerves.

Too small to be of value.

POA ALSODES (Gray).

(Tall Spear Grass; Wood Grass; Wood Spear Grass.)

Culms very slender, erect, 2 to 3 feet high, acutely two-angled at base; sheaths loose, retrorsely scabrous; leaves about three on the stem, broadly or narrowly linear, 3 to 4 inches long; panicle 1 foot long, branches chiefly in 4s, whorled, widely spreading, capillary, pendent, flowering toward the apex; outer glumes acute; flowering glume keeled, apex scarious, acute, cob-webby below the middle on the nerves; palet shorter than its glume, two-toothed.

This species in rich soils in the shade of willows along water courses, at 6,000 feet. Probably of no agricultural value.

ANALYSIS.

Moisture	8.72
Ash	9.73
Fat	2.13
Albuminoid nitrogen	3.32
Crude fiber	23.30
Nitrogen-free extract	61.52
Total	100.00

POA PRATENSIS (L.).

(JUNE GRASS; KENTUCKY BLUE GRASS, ETC.)

Stems slender, smooth, 1 to 3 feet high, somewhat geniculate below, from running rootstocks; sheaths loose, very smooth; ligule truncate; panicle oblong or pyramidal, sometimes one-sided; spikelets about three-flowered, nearly sessile; outer glumes very acute, obscurely three-nerved at base, nearly equal, rough on the keel; flowering glume acute, distinctly three-nerved, densely woody for two-thirds its length, the apex especially; the keel scabrous.

This is the mountain type of this well-known grass. It occurs in North Park in quantity, at an altitude of 9,000 feet, in the shade of *Pinus balfouriana*, var. *aristata*. It is always much inferior to *Poa tenuifolia*.

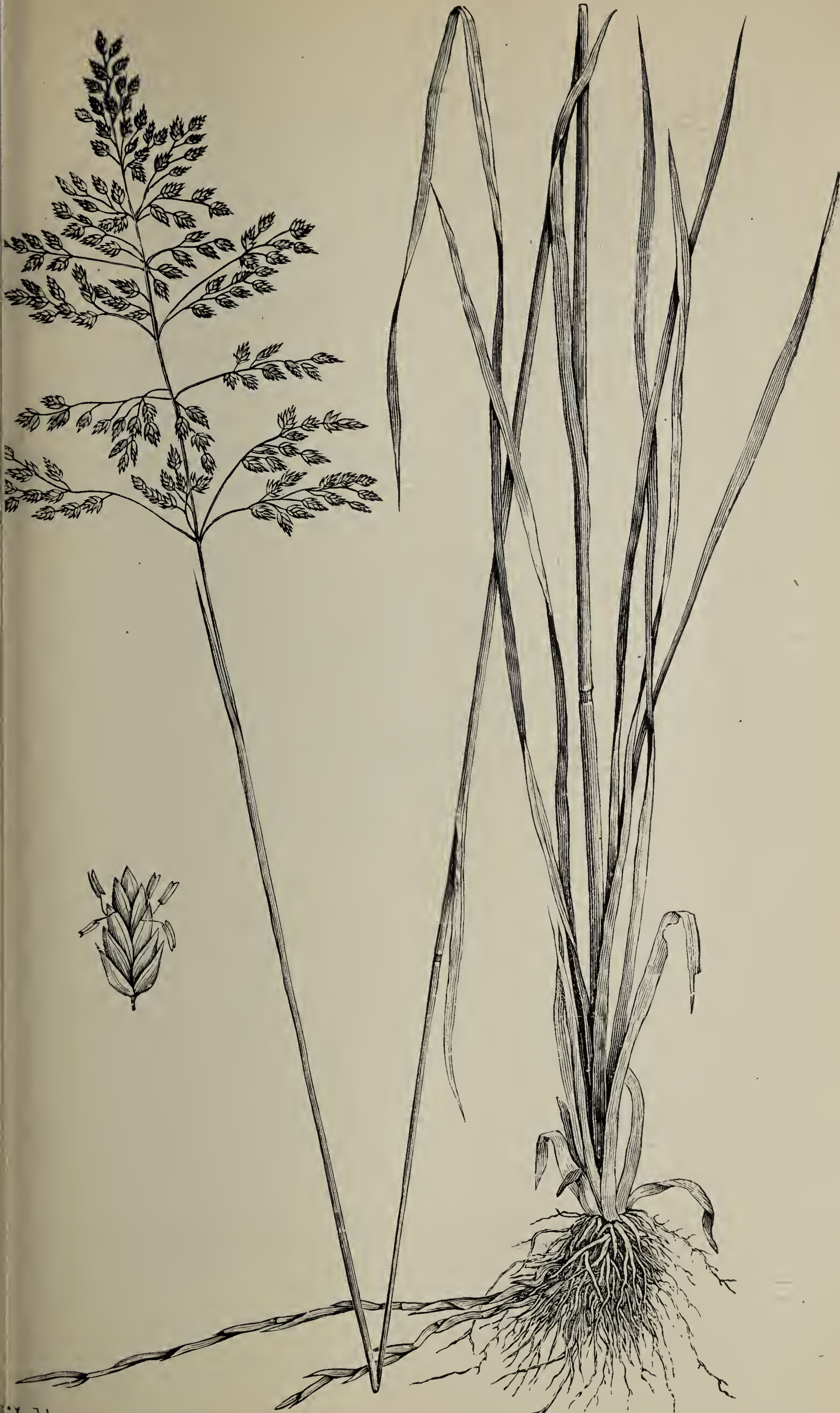
[See cut on opposite page.]

POA LAXA (Haenke).

(WAVY MEADOW GRASS.)

Stems erect, slender, wiry, 10 inches high, the lower joints geniculate; leaves narrowly linear, about two on the stem, smooth; sheaths shorter than the nodes, smooth; ligule elongated, pointed; panicle oblong, 1 to 3 inches long; branches smooth, ½ to 1 inch long, erect; spikelets purplish, three or four-flowered; outer glumes glabrous, very acute, unequal, one-nerved; flowering glume puberulent all over, five-nerved, apex acute, scarious, bronzy; palet equal, purplish, two-toothed.

This species in the mountains on dry hillsides. Too small to be of much value.



Poa Pratensis.

POA FLEXUOSA (Muhl), var. OCCIDENTALIS (Vasey).

Stems erect, tufted, from running root-stocks, 1 to 2 feet high; leaves flat, 1 to 4 inches long, hairy above; sheaths scabrous, the upper one enclosing the base of the panicle; ligule short, with broad, rounded apex; panicle slender, spreading with age; branches mostly in 5s, from ½ to 2 inches long, scabrous, flower-bearing about half their length; spikelets two to three-flowered, purplish; outer glumes nearly equal, acute, the lower one-nerved, the upper three-nerved; flowering glume distinctly three to five-nerved, webby at the base, villous on the keel and margins below the middle, scabrous above; apex acute, scarious, and somewhat bronzy; palet narrow, shorter than its glume, distinctly two-toothed.

This species in the shade of rocks in the foothills, flowering early in May.

ANALYSIS.

Moisture	7.42
Ash	5.91
Fat	2.58
Albuminoid nitrogen	7.05
Crude fiber	17.45
Nitrogen-free extract	67.01
Total	100.00

POA SEROTINA (Ehrh).

(False Red Top; Fowl Meadow Grass.)

Culms slender, smooth, 2 to 3 feet high; leaves narrowly linear, smooth, about six on the stem, 2 to 4 inches long; sheaths shorter than the nodes; ligule elongated, pointed; panicle slender, nodding, 4 to 10 inches long; branches in 5s, capillary, scabrous, 1 to 3 inches long; spikelets two to four-flowered; outer glumes narrow, very acute, rough on the keel; flowering glume obscurely five-nerved, pubescent on the keel and margins, apex bronzy, obtuse; palet equal, acute.

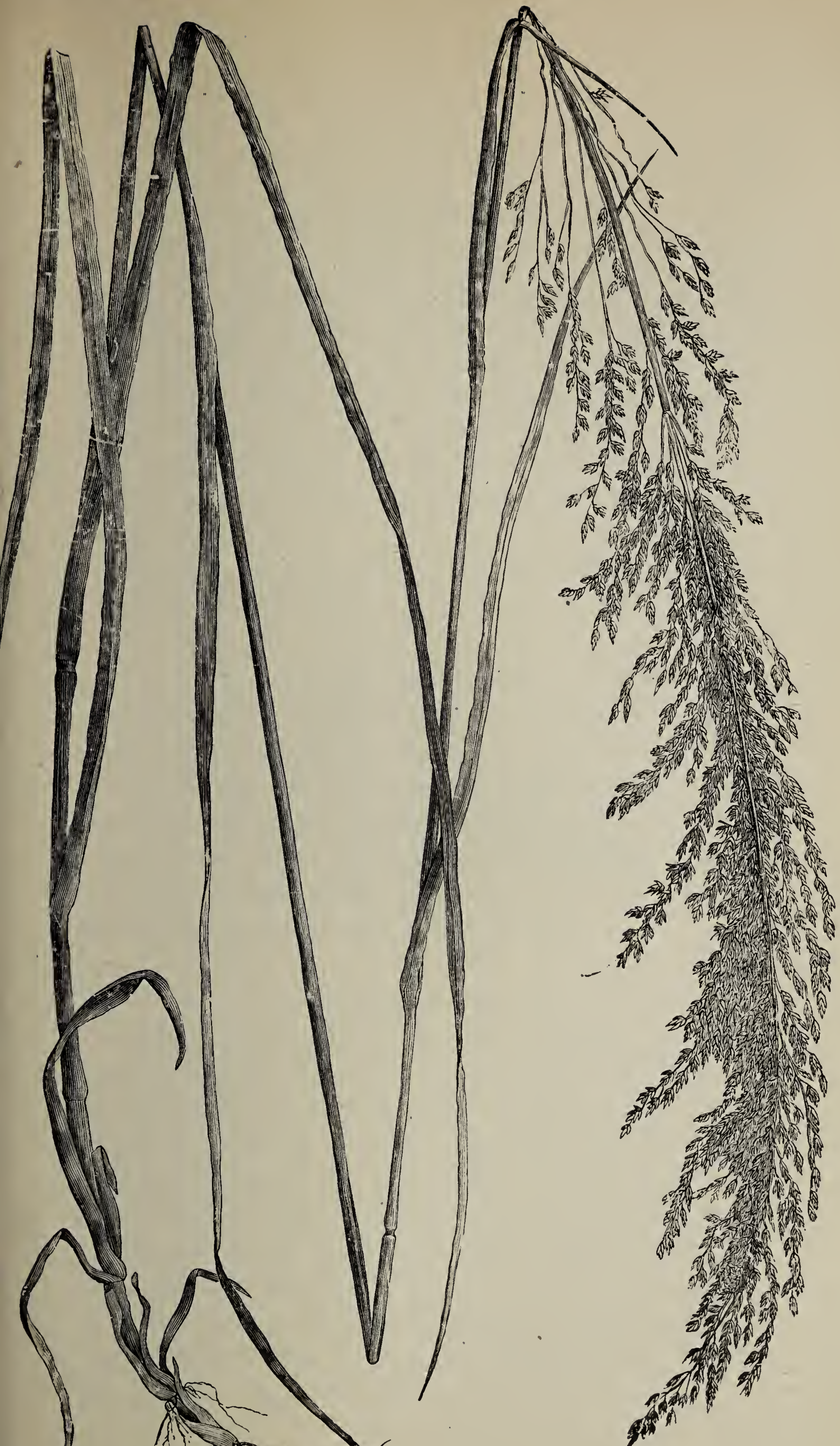
The species is abundant on the plains, especially near irrigating ditches. It is considered valuable where cultivated.

[See cut on opposite page.]

POA (Species ?).

Stems tufted, smooth, erect, from fibrous roots, about 1 foot high; leaves flat, scabrous only on the margins, 3 to 6 inches long, the sheath of the upper leaf enclosing the base of the panicle; ligule conspicuous, pointed; panicle slender, loose, 6 inches long; branches capillary, smooth, in 2s or 3s, distant, widely spreading, flower bearing only at the apex; spikelets three to four-flowered; outer glumes unequal, lanceolate, acute, rough on the keel, scarious margined, the lower one-nerved, the upper and larger three-nerved; flowering glume three-nerved, sparingly webby on the mid-rib and margins, apex obtuse, scarious; palet equalling the glume, obscurely two-toothed.

This species occurs in the foothills in the shade of rocks, blooming in May and June. It probably has no value.



Poa Serotina.

POA SYLVESTRIS (Gray).

Culms erect, flexuous, flattish, leafy; leaves smooth, 3 to 6 lines long; ligule elongated; panicle close; branches very scabrous; spikelets two or three-flowered; glumes purple tipped, scabrous on the mid-rib, nearly equal, acute; flower glumes obscurely nerved, hairy on the lower half of mid-vein and margin, webby at base; palet acute, two-nerved, margined, ciliate, but little shorter than its glume; panicle pale green, slender, branches mostly in 5s.

This is a pale green, slender grass, growing in meadows. It is worthy of trial.

POA EATONI (Watson).

Stems tufted, purplish at base, 2° high, from fibrous roots; ligule elongated; sheaths and upper surface of leaves minutely scabrous; panicle close, narrow; branches solitary or scabrous, in 2s, rarely in 3s; outer glume acute, rough on the keel; flower glumes with broad, scarious, bronzy apex below, purple and very hairy on the nerves, especially the mid-rib and at the margins.

POA ARCTICA (R. Br.).

Culms slender, wiry, purplish, glabrous, 1° high; ligule elongated, sheath almost smooth; leaves linear, smooth, small, 2 or 3 on a stem; panicle of 3 or 4 long branches, capillary, in 2s, scabrous; spikelet three-flowered; florets large; outer glumes ovate, keeled, scabrous, purplish apex, acuminate, scarious; flower glume five-nerved, acute, scarious, brownish apex; palet equals glume, toothed, scarious.

This species would be worthy of trial. Found in dense shade on Gore Pass, with a fungus on it. A tufted *Poa* from running root-stock.

POA TENUIFOLIA (Nutt).

(Bunch Grass.)

Stems slender, tufted, 2 to 4 feet high; leaves glaucous or green, narrowly linear, finely scabrous in the glaucous type, and glabrous in the green-leaved type; ligule elongated, pointed; panicle narrow, loose, few to many-flowered, nodding; branches slender, scabrous, in 2s or 3s, flower bearing for about half their length; spikelets about five-flowered; outer glumes unequal, very acute, rough on the keel; flowering glume lanceolate, with broadly erose or acute, bronzy apex; puberulent in one type; silky, hairy on the margins and mid-rib, below the apex, in another; palet about equalling its glume, bidentate at apex.

This valuable hay grass occurs in two well-marked forms in the mountain meadows. It is the finest of the *Poas*, and should prove valuable under cultivation.

ANALYSIS.

Moisture	8.30
Ash	9.45
Fat	2.92
Albuminoid nitrogen	8.76
Crude fiber	19.40
Nitrogen-free extract	59.47
Total	100.00

Poa Tenuifolia.

PANICUM DICHOTOMUM (L.).

(Panic Grass.)

Stems robust, widely spreading, almost cæspitose; leaves lanceolate, flat, somewhat hairy on the upper surface; ligule a fringe of hairs; lateral panicles included in the sheaths; terminal panicle usually free, equalled by the upper leaf; spikelets oblong; outer glumes unequal, the outer broadly ovate, scarious; upper equalling the flowering glume, which is seven-nerved; palet shorter than its glume.

This species on adobe soil near Pueblo. Not generally distributed in the State.

ANALYSIS.

Moisture	8.06
Ash	9.55
Fat	3.20
Albuminoid nitrogen	9.45
Crude fiber	16.24
Nitrogen-free extract	61.56
Total	100.00

PANICUM VIRGATUM (L.), var. GLAUCEPHYLLA.

Not so plentiful as the species from which it differs in the glaucous leaves and sheaths; hairy on the margins.

PANICUM VIRGATUM, (L.).

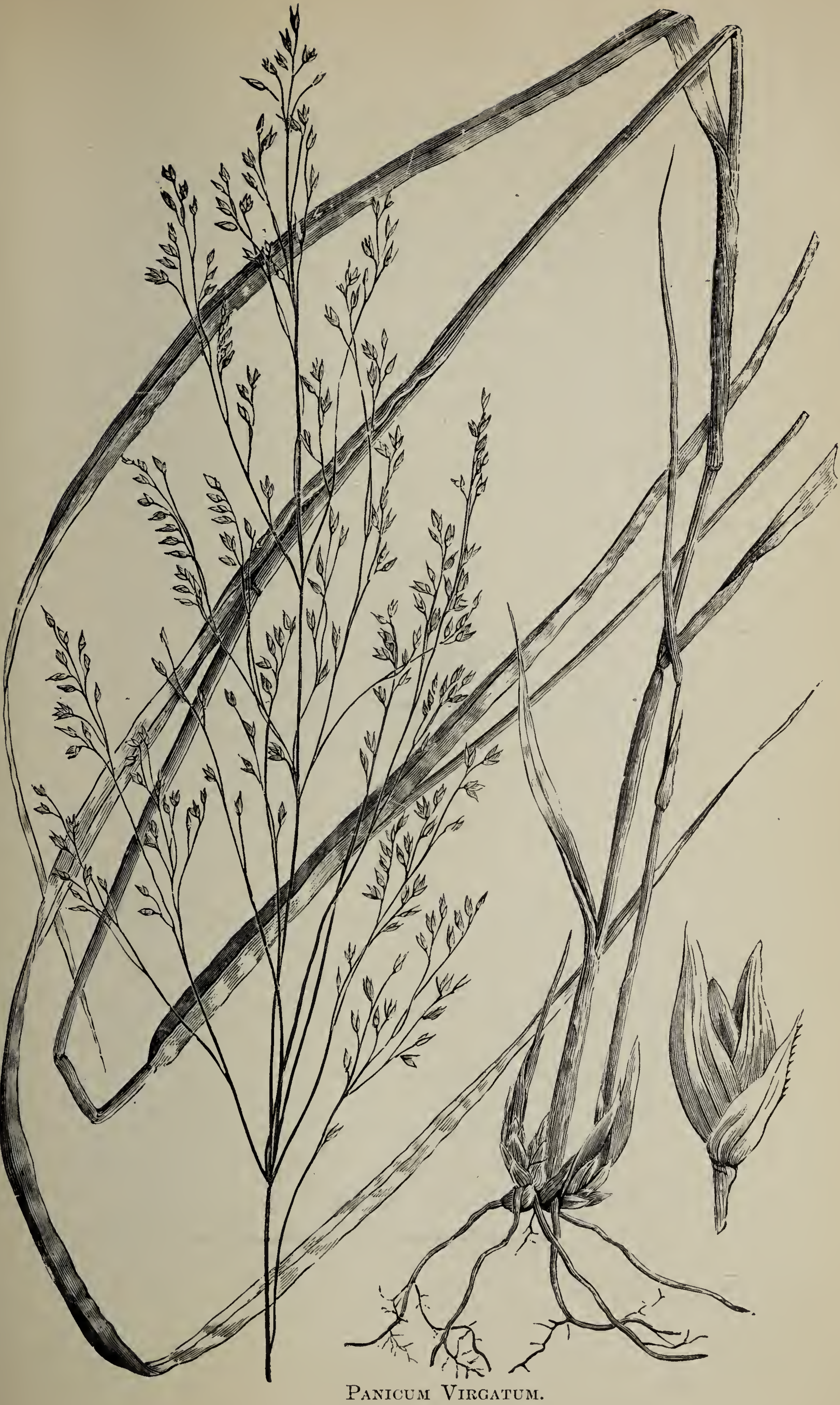
(Tall Panic Grass; Switch Grass.)

Stem stout, smooth, unbranched, growing chiefly in stout clumps in moist soils on the plains, 1 to 5 feet high; leaves ample, flat, hairy at base above, sometimes rough on the margins; ligule a fringe of hair; sheaths longer than the nodes; spikelets distant, purplish; outer glumes very unequal, pointed, the lower five-nerved, the upper seven-nerved; male flower seven-nerved; palet smaller, two-nerved; perfect flower, small, smooth, obtuse.

This species is one of the most promising of the native hay grasses. It yields heavily to the acre, but should be cut young, as the ripened stems become woody and are then unpalatable to stock. Depauperate forms are met with in the mountains up to 7,000 feet.

ANALYSIS.

Moisture	8.75
Ash	9.63
Fat	3.58
Albuminoid nitrogen	12.36
Crude fiber	19.50
Nitrogen-free extract	54.93
Total	100.00



Panicum Virgatum.

PANICUM CAPILLARE (L.).

(OLD WITCH GRASS.)

Culms erect or spreading, 6 inches to 2 feet; sheaths and leaves hairy; the upper sheath enclosing the base of the panicle; the latter very diffuse, compound, with long capillary branches.

Abundant in cultivated ground late in summer. A bad weed.

ANALYSIS.

Moisture	8.50
Ash	9.70
Fat	2.78
Albuminoid nitrogen	12.34
Crude fiber	18.71
Nitrogen-free extract	56.47
Total	100.00

PANICUM CAPILLARE (L.), var. MINIMUM (Engel).

Culms 3 to 4 inches high; leaves less than 1 inch long, scarious and ciliate on the margins; sheaths smooth, striate, twisted; ligule truncate, erose; branches of the panicle very rough, spreading; spikelets on long pedicels; outer glumes linear, acute, whitish, about equal, rough on the mid-vein; sterile flower, keeled, mucronate; fertile flower, obtuse or bidentate.

Common on the plains on moist, alkaline meadows; flowering late in June. Of no value.

PANICUM GLABRUM (Gaudin).

Stems prostrate, ascending, branching from the base; leaves glabrous, very short, flat; sheaths—the lower hairy at the throat; spikes 2 to 4 in pairs, slender; spikelets in 2 rows, ovate; glume and palet pubescent, becoming purplish with age; ligule purplish.

This species flowers in the latter part of August and through September, and occurs chiefly in lawns, where it quickly affects the stand of blue grass, with its spreading, dense stems and leaves. This grass is persistent and widely distributed in lawns in Northern and Southern Colorado.

ANALYSIS.

Moisture	7.40
Ash	12.50
Fat	4.58
Albuminoid nitrogen	10.80
Crude fiber	16.11
Nitrogen-free extract	56.01
Total	100.00

PANICUM CRUS-GALLI (L.), var. ECHINATUM (Torr).

(Barn-Yard Grass.)

This form has the glumes blackish, and beset, especially on the margins, with stiff hairs; glumes blackish, the margins clothed with stiff hairs; one of the outer glumes awned.

It is considered to be of value. There are two forms here, those with green glumes and those with black. In wet places it attains a height, late in summer, of 6°. It is readily eaten by horses. In gardens, it proves a formidable weed among slender rooted plants.

PANICUM SANGUINALE, (L.).

(Crab Grass; Finger Grass.)

Culm 1 to 2 feet, smooth, geniculate and rooting at the lower joints, bearing 4 to 12 slender, spreading, purplish spikes.

An introduced annual grass, seen occasionally in cultivated ground. Said to be valuable at the South.

FESTUCA MICROSTACHYS (Nutt).

(Small Fescue; Western Fescue.)

Culms about 1° high, slender, growing in tufts, smooth or pubescent; leaves short and narrow; ligule very short and small; panicle 1 to 4′ long, spicate, purplish; branches in pairs, one of them nearly sessile; glumes pulverulent, the outer acute, keeled; flower glume rounded on back, keeled at apex and terminated by a short, scabrous awn; palet equal to the glume, short awned.

This grass is too small to be of any value.

FESTUCA TENELLA (Willd).

Culms filiform, about 1 foot high; leaves filiform, 1 to 4 inches long, panicle contracted, somewhat one-sided; outer glumes subulate, unequal; flowering glume rough, involute, awned.

This species occurs in company with *Festuca scabrella* and *Festuca ovina*. It is not abundant, so that but a small amount of the seed was procured. It cannot have much value, owing to its lack of size and leaves.

FESTUCA OVINA (L.), var. BREVIFOLIA (Watson).

(Sheep's Fescue.)

Culms and sheaths smooth, erect, tufted, from numerous fibrous roots; leaves setaceous, the radical 2 inches long, those of the culm smaller; ligule two-lobed; panicle racemose; spikelets about four-flowered; outer glumes unequal; flowering glume pubescent, purplish at apex, tipped with a short, rough bristle; palet equal, toothed at apex.

This dry land Alpine form from Ægeria Park. It has no agricultural value.

[See cut on opposite page.]

FESTUCA KINGII.

Culms about 2 feet high, stout, leafy, from running root-stocks, the bases of the culms clothed with the sheaths of dead leaves; leaves ample, glaucous, striate above, glabrate below, the upper leaf usually enclosing the base of the rigid, narrow; spicate panicle; ligule truncate, lacerate; branches of the panicle in 2s or 3s, appressed and flower bearing for about half their length; spikelets about three-flowered; outer glumes lanceolate, acute, with broadly, scarious margins; flowering glume prominently five-nerved, finely pubescent under the lens; apex very acute, the keel scabrous; palet shorter than the glume, acutely two-toothed.

This grass grows in broad patches in broken ground on hillsides, in company with *Elymus Sibericus* and *Agropyrum divergens.* It was seen in one place only, at about 8,000 feet, on the North Poudre, and was out of bloom August 1st. It is a promising species.

Festuca Ovina.

FESTUCA ELATIOR (L.).

(Tall Fescue Grass.)

Stems smooth, erect, from a geniculate base, 3 feet high; leaves narrow, rough on the margin, 3 to 10 inches long; ligule very short; panicle slender, narrow, branches solitary; outer glumes narrow, long pointed; upper five-nerved, lower one-nerved; flowering glume faintly five-nerved, obtuse; palet thinner, obtuse or acute.

An introduced grass occasionly seen in cultivated fields. It often attains a height of 2½ feet, with irrigation.

AGROSTIS ALBA (L.).

(White Bent Grass.)

Stems slender, smooth, about 3 feet high, geniculate, at base; leaves linear, rough, those of the culm 2 or 3 inches long; ligule elongated, pointed; panicle slender, spreading in bloom, purplish in all the mountain specimens, greenish white at lower altitudes; outer glumes lanceolate, acute; flowering glume shorter, thinner, obscurely three to five-nerved.

Found abundantly all over the State, in cultivated regions. *A. vulgaris* (red top) differs from *A. alba,* chiefly in the former having a truncate ligule.

ANALYSIS.

	DURANGO.	FORT COLLINS.
Moisture	8.31	8.12
Ash	10.80	10.80
Fat	2.31	2.09
Albuminiod nitrogen	5.45	7.10
Crude fiber	19.74	20.29
Nitrogen-free extract	61.70	59.72
Total	100.00	100.00

AGROSTIS EXARATA (Trin).

(NORTHERN RED TOP: MOUNTAIN RED TOP.)

Stems tufted, root fibrous, 1 to 2 feet high, clothed at base with many broadish leaves; sheaths loose and smooth; ligule elongated, lacerate; leaves flat, scabrous, especially on the upper surface; panicle slender, narrow, loose, purplish; outer glumes of about equal length, acuminate, rough on the keel; flowering glume one-third shorter than the outer ones, scarious, five-nerved, the apex about four-toothed; the palet, if present, very minute.

This species in moist places in the mountains, and exceedingly variable. Not abundant in the region traveled over. Its value is not known, but it can hardly prove superior to *Agrostis vulgaris*.

ANALYSIS.

Moisture	7.84
Ash	8.98
Fat	2.85
Albuminoid nitrogen	8.25
Crude fiber	20.22
Nitrogen-free extract	59.70
Total	100.00

Agrostis Exarata.

AGROSTIS SCABRA (Willd).

(HAIR GRASS.)

Stems tufted, slender, decumbent, pale green, 1 to 2 feet high; leaves narrow, scabrous, the lower becoming involute; sheaths shorter than the nodes; ligule short, truncate; panicle loose, spreading, purplish; branches scabrous, capillary, flower-bearing near the apex; outer glumes equal, linear, acuminate, rough on the keel; flowering glume hyaline, three to five-nerved at base; palet absent or very small.

This worthless species is abundant in wet meadows, at all elevations.

ANALYSIS.

Moisture	9.50
Ash	6.03
Fat	2.41
Albuminoid nitrogen	7.66
Crude fiber	19.78
Nitrogen-free extract	64.12
Total	100.00

AGROSTIS CANINA (L.).

(BROWN BENT GRASS.)

Culms three-leaved, slender, very smooth, bearing a spreading, slender panicle, not very scabrous, of small flowers; leaves mainly clustering at the ground, short and narrow, those of the culm about 1′ long; branches of the panicle capillary, in pairs or even solitary; spikelets on short, hair-like pedicels; outer glume very acute, membranous or scarious, nearly equal; flowering glume three-nerved, straight, awned from the apex or near it; palet very minute.

This is abundant in the mountains, and exhibits a great variety of forms where it makes a sod, but it is so small as not to be considered of agricultural value.

LOLIUM PERENNE (L.).

(Rye Grass.)

A native perennial grass of Europe. Stems are 2 to 3 feet high, leafy, carrying a spike-like panicle 6 to 8′ in length; spikelets ¾′ long, seven to eleven-flowered, placed edge-wise to the stem; outer glume half as long as the spikelets, inner one usually absent.

Worthy of trial here. Considered a valuable grass by those who have tried it at the East.

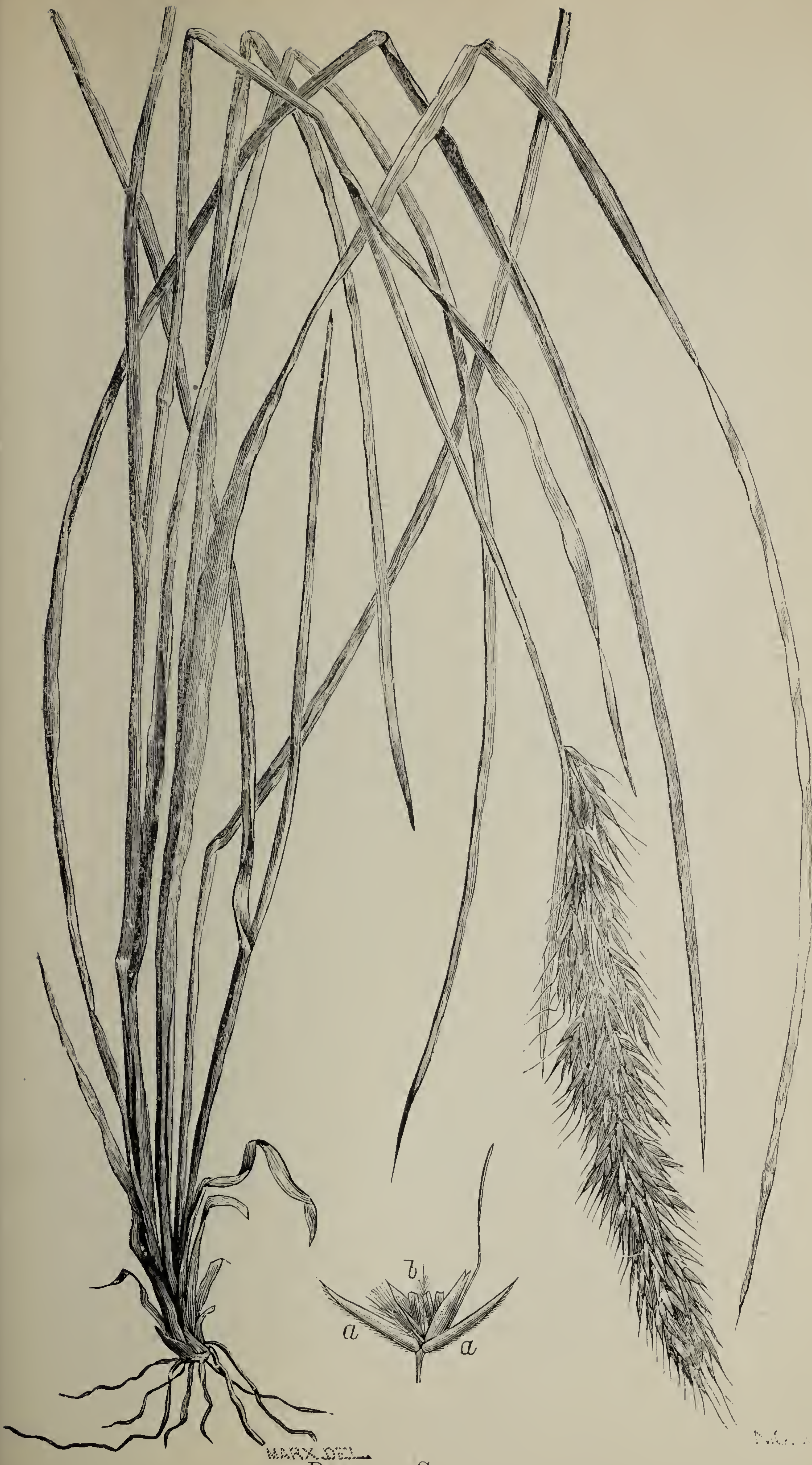
ANALYSIS.

Moisture	8.50
Ash	8.81
Fat	3.44
Albuminoid nitrogen	10.44
Crude fiber	21.26
Nitrogen-free extract	56.05
Total	100.00

DEYEUXIA SYLVATICA (Kth.).

Culms 1 to 2 feet high, rigid, leafy; radical leaves as long as the panicle, stem leaves becoming gradually shorter, scabrous, involute, acuminate, pointed; panicle dense, spike like, 3 to 6 inches long; rays usually in 5s, rough; outer glumes nearly equal, lanceolate, pointed; the upper three-nerved, the lower one-nerved; rough on the keel, longer than the floret; flowering glume three or four-toothed, grooved on the back; the divergent rough, stout, awn bent and twisted below the middle; hairs copious, silky, unequal, longest at the sides.

[See cut on opposite page.]



Deyeuxia Sylvatica.

DEYEUXIA LAPPONICA (Kth.).

Lower glume scarious, almost equal, alternate at apex, scabrous on keel and purplish below; flowering glume of similar texture, shorter than glume, two-toothed at apex; furnished with a yellowish, twisted awn, bent about the middle, and purplish; palet very narrow, two-toothed, hyaline; anthers purplish; rhachis protruding beyond the flower, into a villous bristle. In this plant the outer glumes are very much shorter than the flowering glume; sheaths and leaves finely sulcate, scabrous; ligule lacerate, oblong, rounded and truncate; outer glume lanceolate, very acute, scabrous on keel; flowering glume two or three-toothed, perhaps lacerate, with awn; lower outer glume three-nerved, upper one-nerved; flowering glume with lacerate, two-cleft apex, shorter than glume, furnished on back with a bent, diverging awn, a tuft of silky hairs on each lower margin; a silky bristle standing opposite the palet, which is narrow, thin and 2 to 4′ long; panicle close, spicate, branches in 5s; plant 1 foot high.

Found near Little Muddy in unirrigated meadow.

DEYEUXIA STRICTA (Trin).

Culms 3 to 5 feet high, stout, leafy; sheaths loose and smooth; leaves narrow, involute, pale, finely scabrous; ligule elongated, lacerate; panicle loose, densely flowered, 3 to 6 inches long; branches erect, appressed in 5s or 7s, very scabrous; outer glumes nearly equal, scabrous all over, very acute, the lower three-nerved, the upper and longer one-nerved; flowering glume prominently five-nerved, two to four-toothed at apex, shorter than the glumes; a slender, straight awn—little, if at all, exceeding it, from near the middle; the ring of fuscous hairs copious and nearly the length of the glume; palet small, narrow, two-nerved.

This very robust species is found at high elevations in the mountains, growing in moist, but not shady, situations. It is a promising hay grass, but it is difficult to procure seeds in quantity, because of its scarcity.

DEYEUXIA CANADENSIS (Beauv.).

(Blue Joint; Small Reed Grass.)

Culms 3 to 6 feet high, and with the sheath finely scabrous; leaves very rough, 6 to 15 inches long; sheaths shorter than the nodes, hairy at the throat; ligule elongated; panicle oblong or pyramidal, spreading, purplish, 6 inches to 1 foot long; branches in 5s, very scabrous; outer glumes equal, lanceolate, scabrous; flowering glume hyaline, toothed at apex, bearing a slender awn, about the length of the glume; hairs at base copious, equaling the glume; palet shorter than its glume.

This is one of the most robust and leafy of the native grasses. It is confined chiefly to the mountain regions, where it grows in isolated clumps along streams or in moist meadows. Its agricultural value is not known.

ANALYSIS.

Moisture	7.98
Ash	13.20
Fat	3.46
Albuminoid nitrogen	7.80
Crude fiber	18.85
Nitrogen-free extract	56.69
Total	100.00

Deyeuxia Canadensis.

BROMUS CILIATUS (L.).

Stems 2 to 4 feet high; leaves pale green, somewhat rough; sheaths loose, shorter than the nodes, densely wooly; ligule truncate; panicle nodding, branches in 3s or 5s, widely spreading; lower outer glume narrow, one-nerved, upper three-nerved, mucronate; flowering glume silky, villous on the margins, the mid-rib terminating in a short, rough awn; palet equal, obtuse or two-toothed.

This grass occurs in shade or among rocks, in stout tufts, at nearly all elevations. [Varies to old variety *B. purgans, L.*].

ANALYSIS.

Moisture	8.07
Ash	7.19
Fat	3.10
Albuminoid nitrogen	4.73
Crude fiber	28.66
Nitrogen-free extract	56.32
Total	100.00

BROMUS BREVIARISTATUS (Thurb).

Culm 2 to 3 feet high; leaves flat, scabrous above, often 8 inches long on the stem; sheaths shorter than the nodes, the lower ones downy, the upper smooth; ligule elongated; panicle slender, loose, erect; branches solitary or in pairs; spikelets scabrous, compressed, sharply two-edged, six to eight flowered; outer glumes narrow, acuminate, five to seven-nerved; flowering glume obscurely nine-nerved, tipped with a bristle 1 line long.

Abundant along the east face of the Rocky Mountains.

BROMUS UNIOLOIDES (Willd).

(Schrader's Grass. Syn.—B. Schraderi; Festuca Unioloides.)

Culms erect, smooth, 3 feet high; sheaths loose and glabrous; leaves flat, linear, scabrous on both sides; ligule very short; panicle loose, rigid, compound; branches in 2s or 3s, very scabrous; spikelets two-edged, very flat, about ten-flowered; outer glumes unequal, acute, the lower four or five-nerved, the upper about seven-nerved, canescent with silky, spreading hairs, both with scarious margins; flowering glume similar, about nine-nerved, the keel terminating in a rough, straight awn; palet equal, acutely two-toothed.

This species in a natural meadow at Virginia Dale.

ANALYSIS.

Moisture	8.00
Ash	7.58
Fat	4.70
Albuminoid nitrogen	8.26
Crude fiber	26.00
Nitrogen-free extract	53.46
Total	100.00

BROMUS MEXICANA (Beal).

Culms 2° high; nodes frequently geniculate; leaves almost smooth; sheaths and leaves silky, villous; panicle nodding, loose and open; branches in 5s, rough; 1 to 2 spikelets on extremity of each branch, 1′ long on longish, flexuous, slender pedicels; glumes all strongly nerved; outer glume three-nerved; upper glume seven to nine-nerved; flowering glume cleft at apex, rough and short. The diverging awn is the most noticeable feature of the florets.

BROMUS KALMII (Gray), var. PORTERI.

(Brome Grass.)

Stems slender, smooth, 1 to 2 feet high; leaves and sheaths scabrous; panicle compound, drooping; spikelets silky, hairy, seven to nine-flowered; outer glumes obtuse, three-nerved; flowering glume about seven-nerved, terminating in a straight awn about 2 lines long.

This species was procured at Del Norte, where it is said to be abundant and valuable for winter feed.

ANALYSIS.

Moisture	7.91
Ash	7.68
Fat	2.30
Albuminoid nitrogen	9.40
Crude fiber	15.19
Nitrogen-free extract	65.43
Total	100.00

BROMUS SECALINUS (L.).

(Chess or Cheat.)

Culms erect, 2 to 4 feet high, rough below, hairy at the nodes; leaves linear, hairy above; sheaths shorter than the nodes, rough; ligule short, laciniate; panicle spreading, with nodding spikelets; outer glumes unequal, the lower five-nerved, the upper seven-nerved, finely scabrous all over; flowering glume five to seven-nerved; apex two-toothed; awn straight, rough or absent; palet slightly exceeding its glume, two-toothed.

This ornamental, but worthless, grass is now common on the plains, in waste places.

ANALYSIS.

Moisture	7.00
Ash	10.86
Fat	2.27
Albuminoid nitrogen	8.89
Crude fiber	19.20
Nitrogen-free extract	58.78
Total	100 00

ELYMUS CONDENSATUS (Presl.).

(Giant Rye Grass.)

Culms large, coarse, 6 to 12° high; sheaths rough; also, leaves on both sides; flowers in a rigid spike less than 10′; spikelets three to five, sessile at each joint, three to five-flowered; outer glumes scabrous, bristle like, shorter than the glume; flowering glume five-nerved, mucronate, having palet shorter than its glume.

A coarse grass; cut early for hay, otherwise of but little value.

[See cut on opposite page.]

ELYMUS SIBERICUS (L.).

Stems tufted, very leafy, 2 to 3 feet high; leaves large, glabrous or scabrous; spike erect, nodding with age; spikelets in pairs or rarely solitary; ligule very short; sheaths shorter than the nodes; outer glume subulate, setaceous, rough; flowering glume five-nerved, scabrous above and terminating in a rough, straight awn; palet obtuse or two-toothed at apex, ciliate on the nerves.

This grass grows in stout tufts in rocky soils and arid situations. It is considered to be valuable, by dairymen, for winter feed.

ANALYSIS.

Moisture	7.93
Ash	10.25
Fat	2.62
Albuminoid nitrogen	5.24
Crude fiber	20.85
Nitrogen-free extract	61.04
Total	100.00

ELYMUS CONDENSATUS.

ELYMUS AMERICANUS (V. & S.).

Culms erect, leafy, smooth, 3 to 7 feet high; leaves ample, scabrous, glaucous; ligule short, truncate; spike dense, cylindrical, 3 to 5 inches long; spikelets two at each joint of the rhachis, each three-flowered, 2 of them on short pedicils, the upper one imperfectly developed; outer glumes nearly equal, scarious margined, three-nerved, scabrous, apex bristle tipped; flowering glume rounded on the back, obscurely five-nerved above, finely scabrous, apex terminating in a rough, straight awn, much longer than the glume; palet equal, narrow, ciliate on the margins, apex obtuse.

This promising species is abundant on the Arapahoe Pass, in rich soils where it is partially shaded by pines and quaking asp.

ANALYSIS.

Moisture	8.87
Ash	8.06
Fat	2.32
Albuminoid nitrogen	12.86
Crude fiber	19.79
Nitrogen-free extract	56.97
Total	100.00

ELYMUS CANADENSIS (L.).

(Wild Rye; Lyme Grass; Terrell Grass.)

Culms 1 to 4 feet high, leafy; leaves lanceolate, very rough; ligule very short; spike loose, cylindrical, nodding above; outer glumes subulate, two to four-nerved, terminating in a short, rough awn; flowering glume five-nerved, two-toothed, rough, hairy, terminating in a scabrous, spreading awn, longer than itself; palet shorter than its glume, two-toothed, ciliate on the margins.

The variety *glaucifolius, Gr.*, is less common than the species in this locality.

This grass is common in this region, except at high altitudes. It should be cut young, as the whole plant becomes very harsh and rough when mature.

ANALYSIS.

Moisture	8.03
Ash	10.75
Fat	2.03
Albuminoid nitrogen	7.09
Crude fiber	19.88
Nitrogen-free extract	60.25
Total	100.00

Elymus Canadensis.

ELYMUS (Species ?).

(Lyme Grass.)

Culms smooth, 2 to 3 feet high; geniculate at base and at some of the upper nodes; leaves flat, finely scabrous, especially above; sheaths smooth, shorter than the nodes; ligule nearly obsolete; spike slender, densely flowered, nodding or very rigid; spikelets in pairs, about three-flowered; outer glumes three, subulate, finely scabrous, terminating in an awn the length of the spike; flowering glume glistening, rounded on the back, obscurely nerved, tipped with a rough, straight awn; palet minutely toothed.

Along streams, east face of Rocky Mountains and at Canon City.

ANALYSIS.

Moisture	7.39
Ash	5.34
Fat	2.54
Albuminoid nitrogen	10.33
Crude fiber	21.99
Nitrogen-free extract	59.80
Total	100.00

ELYMUS SITANION (Schult).

Stems in tufts, very smooth, growing in moist meadows or in the shade of woods, where it attains a height of 3 feet; leaves ample, sharp pointed, glaucous or hairy, the upper leaf often enclosing the base of the panicle; spike rigid, purplish when young; glumes long awned, much reflexed with age.

This grass resembles *Hordeum jubatum* in a general way, and with it is a worthless weed. It is found in all of the mountain meadows, but is not abundant anywhere.

ANALYSIS.

Moisture	8.00
Ash	6.95
Fat	2.29
Albuminoid nitrogen	4.98
Crude fiber	19.10
Nitrogen-free extract	66.68
Total	100.00

CATABROSA AQUATICA (Beauv.).

Culms 6′ to 2° high, very smooth and leafy to the panicle; leaves flat and glabrous, except on margin; ligules large, membranous; panicle close, thin, of five or more, distant, divided branchlets; outer glumes unequal, scarious; flowering glume four-nerved; apex scarious, truncate, erose.

This is an aquatic, creeping grass; flowers jointed at base; soon deciduous.

AGROPYRUM VIOLACEUM (Beauv.).

Culms 2 to 5 feet high, densely tufted, geniculate below, fibrous rooted; leaves flat, glaucous or green, scabrous, especially on the upper surface; spike 2 to 6 inches long, rigid; spikelets three to five-flowered, purplish; outer glumes strongly five-nerved, equal, both short, pointed and rough; flowering glume short awned, obscurely five-nerved, two of the latter extending into short teeth; palet equal, truncate or two-toothed.

There are two forms of this species, differing chiefly in the color of the leaves and stems. Both are valuable hay grasses, enduring more moisture than *Agropyrum glaucum.*

ANALYSIS.

Moisture	8.30
Ash	5.74
Fat	2.24
Albuminoid nitrogen	7.10
Crude fiber	21.14
Nitrogen-free extract	63.78
Total	100.00

AGROPYRUM UNILATERALE.

Culms erect, smooth, 3 to 4 feet high; leaves ample, very scabrous; ligule truncate, very short; panicle slender, spicate, secund, nodding; spikelets three to four-flowered; rhachis hairy; outer glumes linear, four to six-nerved, tipped with a rough awn $\frac{1}{2}$ inch long; nerves scabrous; flowering glume finely scabrous, flattened and obscurely nerved below; apex rougher, acutely two-toothed, the mid-nerve terminating in a rough, straight awn 2 inches long; palet shorter than the glume, obtuse or retuse, ciliate on the nerves.

This species grows in stout tufts along the banks of streams, at from 7,000 to 8,000 feet. The culms are very leafy and robust; hence, perhaps of some value.

ANALYSIS.

Moisture	8.41
Ash	4.21
Fat	3.13
Albuminoid nitrogen	5.69
Crude fiber	17.90
Nitrogen-free extract	69.07
Total	100.00

AGROPYRUM TENERUM (Vasey).

(Wheat Grass; Clump Wheat Grass.)

Stems from fibrous roots, smooth, slender, geniculate at the lower joint, often 4 feet high; leaves flat, scabrous, 3 to 6 inches long, about four on a stem; sheaths smooth, shorter than the nodes; ligule nearly obsolete; spike slender, nodding, 4 to 8 inches long; spikelets about five-flowered, appressed to the rhachis; outer glumes equal, prominently five to seven-nerved, obtuse; flowering glume obscurely five-nerved above, rounded below, very scabrous all over; palet shorter than its glume, truncate.

A hay grass maturing early. Common in this region in moist meadows and in waste places.

ANALYSIS.

Moisture	7.86
Ash	6.28
Fat	2.04
Albuminoid nitrogen	6.15
Crude fiber	20.20
Nitrogen-free extract	65.33
Total	100.00

AGROPYRUM DIVERGENS (Nees).

Stems wiry, slender, erect or sometimes geniculate, 2 to 3 feet high, from running root-stocks; sheaths loose, striate, shorter than the nodes; ligule very short, truncate; leaves narrowly linear, glaucous or green, numerous; panicle slender, nodding; spikelets about five-flowered; outer glumes nearly equal, scabrous, three-nerved, short, rough awned; flowering glume scabrous, rounded on the back, obscurely five-nerved, the apex terminating in a rough, divergent awn; palet shorter than its glume, truncate.

This species grows in stout clumps in the clefts of rocks in exposed situations, in company with *Elymus Sibericus* and *Festuca Kingii.*

ANALYSIS.

Moisture	8.40
Ash	8.70
Fat	2.31
Albuminoid nitrogen	6.87
Crude fiber	23.52
Nitrogen-free extract	58.60
Total	100.00

AGROPYRUM STRIGOSUM (Beauv.).

About 1 foot high, growing in tufts; sheaths smooth; stem leaves narrow, strigose, pulverulent on the upper surface, smooth below, glaucous; spike 6′ long, slender; outer glumes acute; flowering glume five-nerved, with rough, divergent awn.

This species at high elevations, usually, and in dry soil. Worthy of trial, perhaps, as a dry land grass. Said not to have a running root-stock.

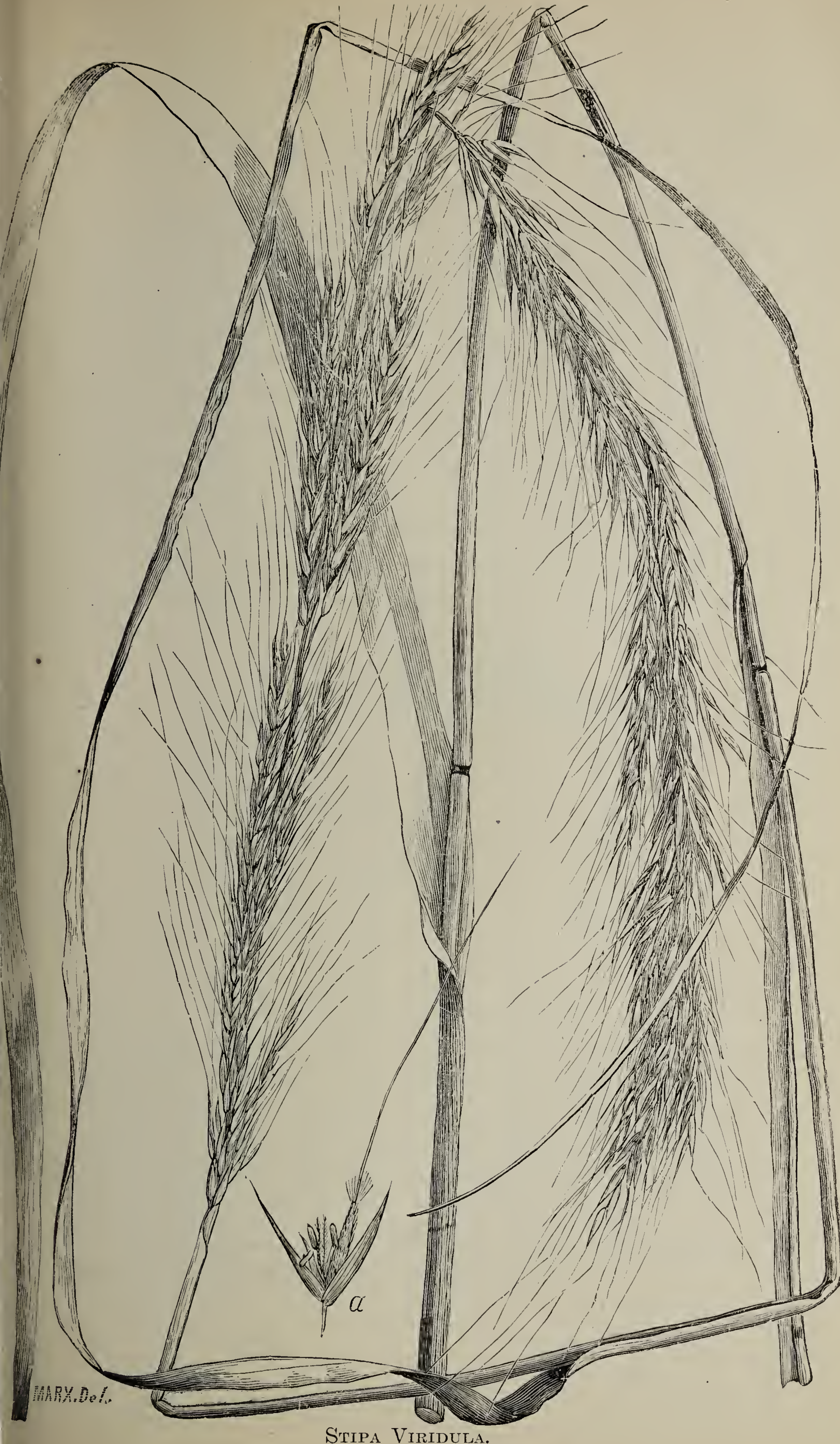
STIPA VIRIDULA (Trin).

Culms 2 to 4 feet high, leafy, clothed at base with the sheaths of dead leaves; sheaths loose, hairy on the margins, striate, the uppermost enclosing the base of the panicle; leaves linear, soon involute, glabrous, except on the margins; ligule small, truncate; panicle 4 to 12 inches long, loose and very narrow; branches usually in pairs, hairy at base, erect, appressed; spikelets one-flowered, short pediceled; outer glumes about equal, bristle pointed, membranous, three-nerved; flowering glume clothed with short hairs, which are somewhat longer at the toothed apex, terminating in a slender, twice bent, pubescent awn, which is also twisted below the middle; palet shorter than its glume, by which it is involved.

This grass grows in tufts, in dry soils, with *Festuca scabrella* and *Festuca ovina*, or, it may occupy large areas almost alone. It is eagerly sought for by stock.

ANALYSIS.

Moisture	8.30
Ash	7.75
Fat	2.28
Albuminoid nitrogen	9.47
Crude fiber	19.38
Nitrogen-free extract	61.12
Total	100.00



Stipa Viridula.

STIPA SPARTEA (Trin).

(Porcupine Grass.)

Stems tufted, smooth, 2 to 3 feet high; leaves 6 to 10 inches long, involute, long pointed, smooth; sheaths shorter than the nodes, loose, hairy on the margins; ligule very short, truncate erose; panicle slender, spicate, about 1 foot long; branches in 5s, erect, appressed 1 to 3 inches long; outer glumes lanceolate, bristle pointed, the lower three-nerved, the upper five-nerved, rough on the keel; flowering glume villous bearded, especially at the acute callus and apex; awn 1 to 2 inches long, bent near the middle, short appressed, hairy below, scabrous above.

This species occurs in the foothills and on the plains, along irrigating ditches. Stock seem to eat it only in winter.

ANALYSIS.

Moisture	9.00
Ash	4.78
Fat	2.46
Albuminoid nitrogen	8.34
Crude fiber	23.81
Nitrogen-free extract	60.61
Total	100.00

STIPA MONGOLICA (Turez).

Stems smooth, leafy to the panicle, purplish, wiry; leaves filiform, those of the culm 1 to 2′ long, radical 3 to 4′ long; panicle purplish, 1 to 3′ long; outer glume lanceolate, purplish, shining, glabrous, equaling the florets; flowering glume silky, hairy, especially at apex, terminating in a twisted, (1 or 2) bent awn over 1′ long.

This appears to be a tufted, dry land grass, with the remains of many dead sheaths at base.

STIPA COMATA (Trin).

Stems stout, smooth, 2 to 3 feet high, some of the lower joints geniculate; sheaths loose, finely scabrous; panicle included at base by the upper sheath; outer glumes whitish, three-nerved, about equal, long pointed; flowering glume villous at the pointed callus, appressed, silky, hairy above; awn 4 to 6 inches long, stout, twisted below, twice bent at the middle, rough.

This grass is common in dry soils and exposed situations, up to 8,000 feet. It is readily recognized in early summer by its bleached appearance.

ANALYSIS.

Moisture	7.76
Ash	8.80
Fat	3.37
Albuminoid nitrogen	4.72
Crude fiber	24.92
Nitrogen-free extract	58.19
Total	100.00

STIPA (Species ?).

Culms tufted from fibrous roots, wiry, purplish, smooth, about 2 feet in height; leaves narrow, involute, 6 to 10 inches long, scabrous above; sheaths shorter than the nodes, smooth; ligule almost none; panicle slender, erect, 2 to 3 inches long; branches solitary or in pairs, appressed to the axis; outer glumes lanceolate, very acuminate, membranous, purplish, the lower somewhat the longest; flowering glume silky, villous, callus obtuse, apex terminating in a twisted, usually twice bent, scabrous awn 1 inch long.

This *Stipa* was seen but once, near the Lulu Pass, growing among rocks in an exposed situation.

DESCHAMPSIA FLEXUOSA (Beauv.).

Stems smooth, slender, tufted, nearly naked, 1 to 2 feet high; leaves bristle like, chiefly in radical tufts, 1 to 4 inches long; ligule elongated, pointed; panicle slender, spreading; branches in 4s or 5s, very smooth; spikelets two-flowered; outer glumes ovate-lanceolate, shorter than the florets, apex scarious, bronzy, the lower glume three-nerved at base, the upper and shorter one-nerved; flowering glume four-nerved, purplish, silky, hairy below, apex scarious, four-toothed; awn attached below the middle, finely ciliate, somewhat divergent, but not bent; palet shorter than its glume, two-toothed.

This species on the east face of the Rocky Mountains, at high elevations.

DESCHAMPSIA DANTHONIOIDES (Munro).

Culms from 6 inches to 2 feet high; leaves narrow, very rough; sheaths also very rough, shorter than the nodes, twisted; ligule elongated; panicle densely flowered, spicate; branches in 5s, 1 inch long, flowered to the base; outer glumes equal, membranous, lanceolate, acuminate, much longer than the florets, the lower one-nerved, the upper three-nerved, both scabrous on the keel; flowering glume with a few short hairs at base, conspicuously five-nerved, apex two-toothed; awn exserted, attached and bent below the middle; palet hyaline, two-toothed.

This grass was seen on the Arapahoe Pass, partly in the shade of pines, but not in any quantity.

DESCHAMPSIA CÆSPITOSA (Beauv.).

(Hair Grass.)

Culms smooth, erect, tufted, from fibrous roots; leaves chiefly in radical tufts, linear, involute, 3 to 12 inches long, scabrous on the margins; ligule elongated, pointed; panicle slender, virgate, nodding, 6 to 12 inches long; branches capillary, scabrous, spreading, distant, $\frac{1}{2}$ to 4 inches long; spikelets oblong, purplish, two-flowered; outer glumes about equal, lanceolate, acute, the lower one-nerved, the upper three-nerved at base, slightly exceeding the florets; flowering glume with truncate, four or five-toothed, scarious apex, and a few, short, silky hairs at base; awn straight or slightly geniculate at the middle, scabrous, inserted at the base of the glume and slightly exceeding the outer ones.

This species is confined to moist meadows and shady situations in the mountains, where it forms a large portion of the native hay. The culms are too light to make the best hay, but it affords a large amount of good pasturage, as its radical leaves are numerous and ample in the more robust forms.

ANALYSIS.

Moisture	8.15
Ash	13.86
Fat	1.77
Albuminoid nitrogen	8.05
Crude fiber	27.40
Nitrogen-free extract	48.92
Total	100.00

SPOROBOLUS DEPAUPERATUS (Vasey).

Culms slender, tufted, branching from the ground, geniculate below, 6 to 18 inches high; leaves setaceous, glabrate, 1 to 3 inches long; sheaths longer than the nodes; panicle linear, very narrow, 1 to 4 inches long, the terminal one sometimes included at base; branches in 2s or 3s, interrupted below; outer glumes nearly equal, scarious; flowering glume somewhat scabrous, blackish above, and tipped with a short mucro; palet of same texture, nearly equal.

This species grows in tufts, from numerous underground stems. It spreads rapidly in newly irrigated soils, forming a fine bottom for the taller *Agropyrums*. It is a desirable grass for meadows. On dry hill-sides it attains a height of about 6 inches.

SPOROBOLUS ASPERIFOLIUS (Thurb).

Culms 2° high, smooth, purplish, robust; leaves long, alternate, minutely scabrous on the margins; panicle spicate, purplish, included at base, 3 to 6′ long; branches in 2s or solitary; outer glumes unequal, somewhat scabrous on the strong nerve.

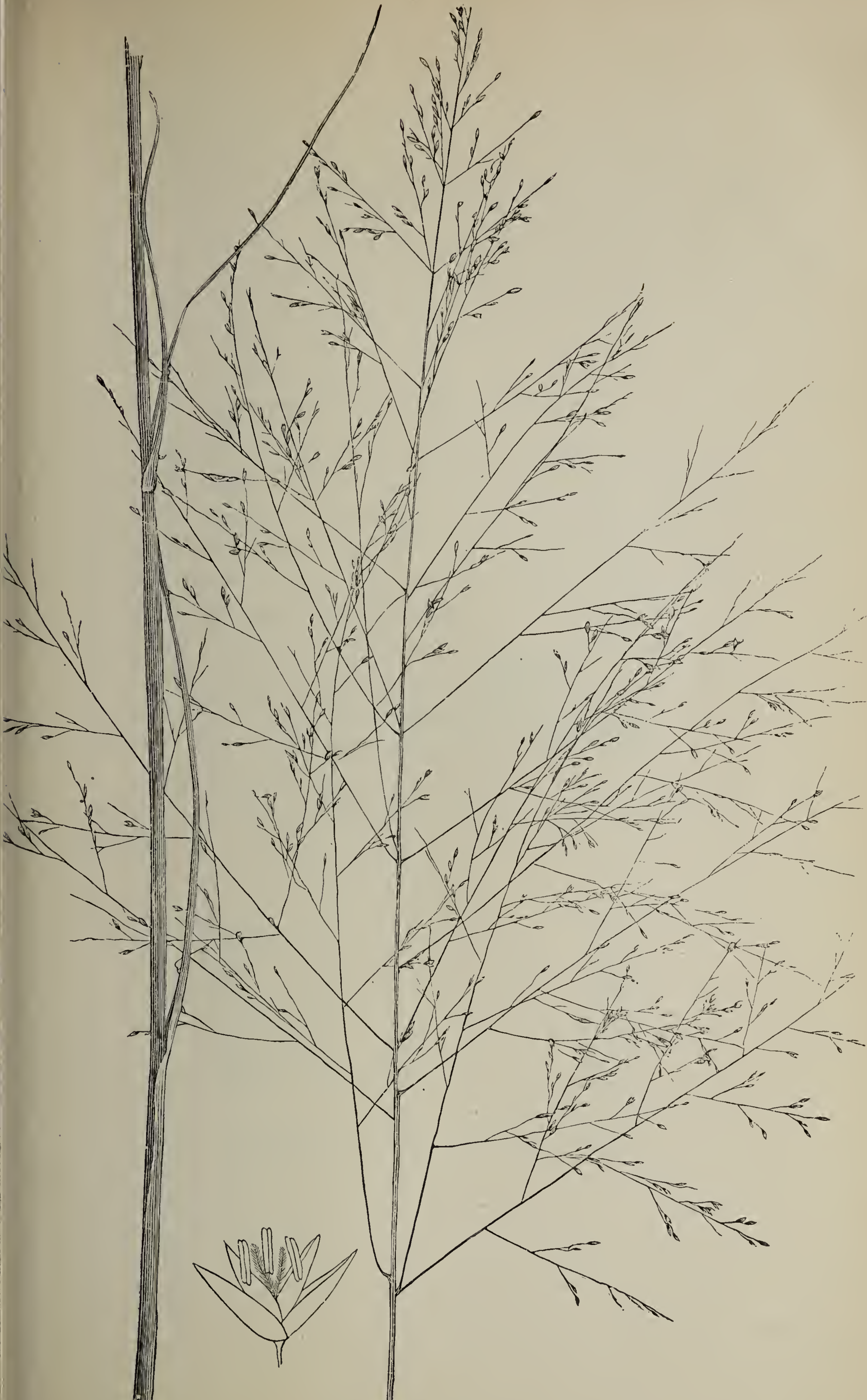
SPOROBOLUS AIROIDES (Torr).

Culm stout, smooth, thickened at the base, from stout, creeping root-stocks; leaves linear, soon involute, long pointed, rough on the margins; sheaths smooth, shorter than the nodes; ligule a fringe of hairs; panicle pyramidal, soon exserted, diffuse, 1 foot long; rays mostly solitary, smooth, much branched and few flowered above the middle, naked below; spikelets purplish, one-flowered; outer glumes unequal, acute, the upper and larger obscurely three-nerved; flowering glume oblong, keeled, acute; palet nearly equal, obscurely two-toothed.

This grass occurs in alkaline soils on the plains and in the mountain parks. It is abundant in North Park, Pass plains, and near Laramie City. Its is a pasture grass, the culms being too light and naked to make it valuable for hay. It grows in densely sodded, leafy patches, from underground stems. Stock of all kinds like it.

ANALYSIS.

Moisture	7.92
Ash	8.98
Fat	2.25
Albuminoid nitrogen	7.32
Crude fiber	14.80
Nitrogen-free extract	66.65
Total	100.00



Sporobolus Airoides.

SPOROBOLUS CUSPIDATUS (Torr).

Culms geniculate, erect, from running root-stocks, 2 to 3 feet high; leaves narrowly linear, flat, becoming involute, scabrous, especially on the margins; sheaths bearded at the throat and on the margins, mostly shorter than the nodes; ligule a short, ciliate fringe; panicle often 1 foot long, narrow, pyramidal, its base enclosed by the long sheath of the upper leaf, finally exserted; spikelets lead colored, small; outer glumes unequal, acute, finely scabrous; flowering glume ovate, acuminate, rough on the greenish keel; palet shorter than its glume, acute.

This grass is abundant at 5,000 feet, in Northern Colorado. It occurs in the mountain parks, but in less quantity.

ANALYSIS.

Moisture	8.16
Ash	9.43
Fat	2.66
Albuminoid nitrogen	10.88
Crude fiber	17.32
Nitrogen-free extract	59.71
Total	100.00

SPOROBOLUS CRYPTANDRUS (Gr.).

Culms 2 to 3 feet high, less purplish than *Cuspidatus*; leaves scabrous, especially on the margins, linear to filiform at apex, 1 foot or more long above, shorter at base, hairy at base; sheaths shorter than the nodes, the lower with membranous margin; ligule an extremely short, ciliate fringe; panicle lead color, enclosed in the sheath of the upper leaf; rays mostly in pairs; outer glume unequal, acute.

This in tufts, from root-stocks.

[See cut on opposite page.]

ERAGROSTIS PURSHII (Schrad.).

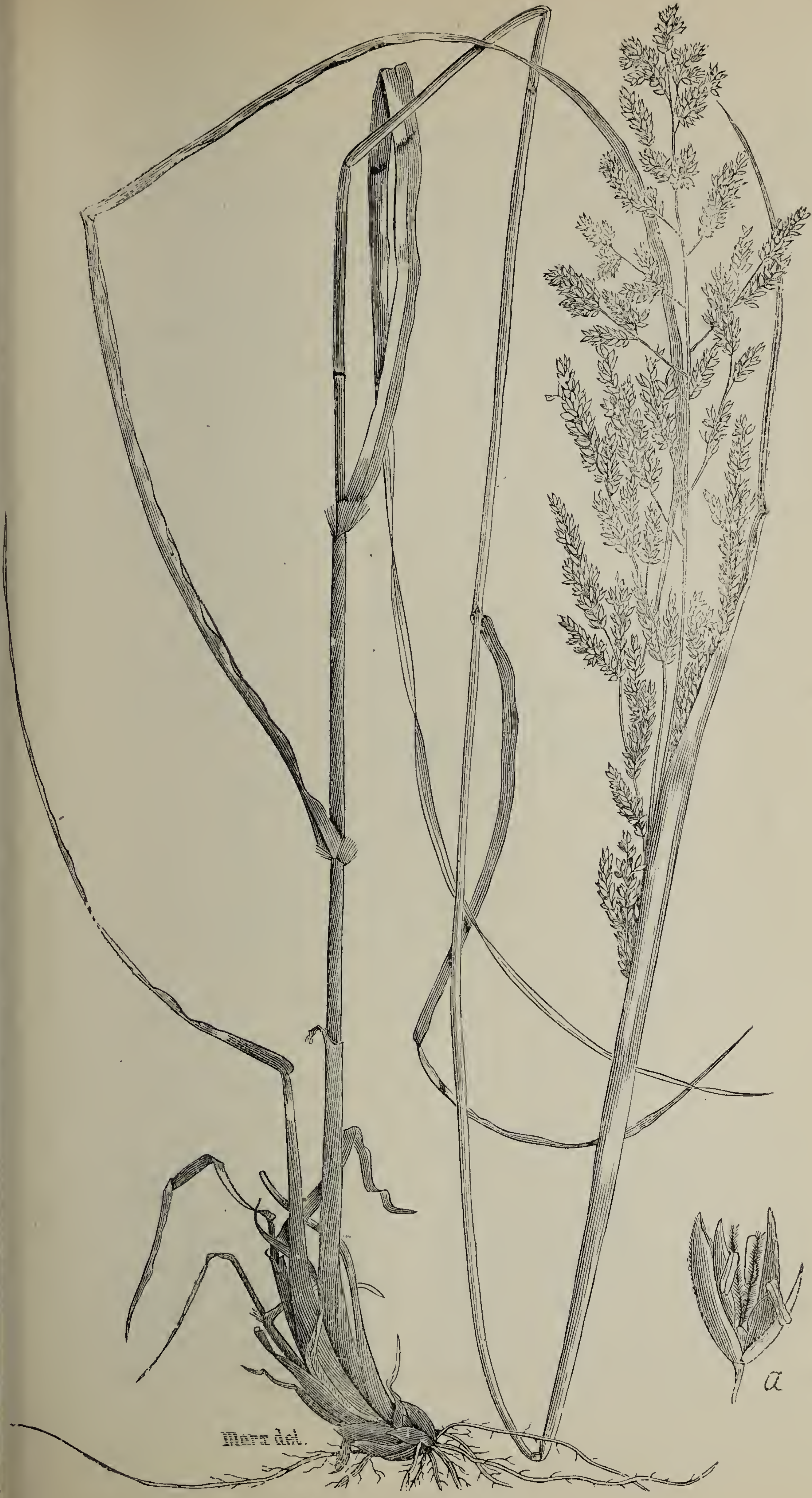
Stems geniculate at base, branching, about 2 feet high; leaves linear, smooth; sheaths villous at the throat; panicle slender, spreading, elongated; lower branches hairy in the axils; pedicels capillary; spikelets five to eighteen-flowered; outer glumes ovate, acute; flowering glume three-nerved.

This species is abundant in garden soils, in company with *Eragrostis poæoides*, var. *Megastachya*, at Canon City.

ERAGROSTIS POÆOIDES (Beauv.).

Growing in tufts in rich garden soils; culms geniculate, decumbent, 1 to 2° long; sheaths pilous at throat; ligule short, bearded; panicle spreading; branches capillary, solitary or mostly in pairs; spikelets about twenty-flowered; pilous in the exils.

This species has a peculiar odor. A weed in rich garden soil. Of no agricultural value.



Sporobolus Cryptandrus.

ERAGROSTIS POÆOIDES (Beauv.), var. MEGASTACHYA (Link).

(PUNGENT MEADOW GRASS.)

Culms decumbent at base, 1 to 2 feet high; sheaths pilous at throat; ligule short, bearded; panicle spreading, oblong or pyramidal; branches capillary, solitary or in pairs, flowering nearly to the base; spikelets about twenty-flowered, pilous in the exils; outer glumes about equal, very acute, rough on the keel; flowering glume acute, smooth, strongly three-nerved; palet much shorter than its glume, hyaline, with rounded or obtuse apex and ciliate margin.

Abundant in garden soils in Northern and Southern Colorado. It has a disagreeable odor and comes to maturity late in the season. It has, probably, no agricultural value.

ANALYSIS.

Moisture	7.44
Ash	14.53
Fat	2.60
Albuminoid nitrogen	8.93
Crude fiber	17.70
Nitrogen-free extract	56.24
Total	100.00

MUHLENBERGIA GLOMERATA (Trin.).

Culms leafy, erect, wiry, much branched, 2 to 3 feet high, from underground stems, the bases clothed with the sheaths of dead leaves; leaves flat, small, 2 to 3 inches long, rough; sheaths longer than the nodes, loose; ligule a short, truncate fringe; panicle narrow, slender, lobed, spicate; spikelets sessile in the clusters; outer glumes linear, tapering to a long, rough awn, margins scarious to the rough keel; flowering glumes one-third shorter than the outer, conspicuously three-nerved, acute; palet acute, nearly equaling the glume.

This grass is common on the plains and in the mountains, up to 7,000 feet. On the plains it favors shaded, rather moist localities, but in the mountains it occurs in exposed situations in the clefts of rocks. It is a desirable species.

ANALYSIS.

Moisture	7.24
Ash	9.31
Fat	2.37
Albuminoid nitrogen	6.80
Crude fiber	19.50
Nitrogen-free extract	62.02
Total	100.00

MUHLENBERGIA WRIGHTII (Vasey).

Stems erect, branching, pale, finely scabrous; sheaths much shorter than the nodes; ligule short, truncate; leaves involute, rigid, pungently pointed, rough; panicle spicate, 2 to 6 inches long; branches solitary, appressed, flowering their whole length, the lower two somewhat distant; outer glumes scabrous on the keel, bristle pointed, nearly equal; flowering glume finely scabrous, blackish, pungently pointed; palet acute, shorter than the glume.

This grass occurs in dry, rocky, exposed situations, at about 7,000 feet. It is a desirable species for trial.

ANALYSIS.

Moisture	7.81
Ash	7.58
Fat	3.29
Albuminoid nitrogen	7.31
Crude fiber	19.00
Nitrogen-free extract	62.82
Total	100.00

MUHLENBERGIA GRACILIS (Trin.).

Stems rigid, 1 to 2 feet high; leaves filiform, pale, very scabrous; sheaths also finely scabrous, longer than the inter-nodes; ligule elongated, long pointed; panicle slender, 3 to 6 inches long, bronzed or blackish; rays solitary, erect; lower outer glume acute, upper three-toothed, both scarious and rough on the nerves; flowering glume scabrous above, villous at the small callus, apex terminating in a slender, rough awn; palet hairy, equaling the glume and of similar texture.

A dry land grass, of possible value, growing in the clefts of rocks in the mountains.

ANALYSIS.

Moisture	8.12
Ash	5.12
Fat	2.59
Albuminoid nitrogen	6.85
Crude fiber	25.72
Nitrogen-free extract	59.72
Total	100.00

MUHLENBERGIA GRACILIS, var. BREVIARISTATA (Vasey).

Stems tufted, growing in circular patches, which decay in the centre, the bases clothed with the sheaths of dead leaves; leaves 1 to 3 inches long, erect, narrow, involute, scabrous; sheaths loose, with broadly scarious margins; ligule large, pointed or lacerate; panicle 1 to 4 inches long; branches solitary or in pairs, each with one to three spikelets; outer glumes scarious, the lower keeled, acute, the upper three-nerved and three-toothed, both scabrous on the nerves; flowering glume three-nerved, scabrous, hairy on the nerves below the middle, apex mucronate; palet similar, acute, shorter than the glume.

This form is abundant on dry, gravelly hillsides, at 8,000 feet. Its value has not been determined.

MUHLENBERGIA GRACILLIMA (Torr.).

Stems about 6 inches high, forming ring-like patches, which kill out in the centre; leaves very fine, involute, curled at maturity, growing in tufts; panicle slender, purplish, spreading, few-flowered; branches capillary, solitary or in 3s; outer glumes unequal, very acute, rough on the keel; flowering glume glabrate, three-nerved, bifid, with a straight, slender awn; palet of similar texture, the acute apex toothed.

This grass abundant on light, dry soils on the plains. It is too small to have much economic value.

ANALYSIS.

Moisture	6.62
Ash	22.93
Fat	2.28
Albuminoid nitrogen	7.93
Crude fiber	17.60
Nitrogen-free extract	49.26
Total	100.00

TRISETUM SUBSPICATUM (Beauv.).

Stems tufted, slender, smooth, 6 inches to 2 feet in height, varying with the altitude; leaves flat and smooth, or with the sheaths very scabrous; ligule rounded, laciniate; panical slender, cylindrical, purplish, interrupted below, 6 inches long; spikelets two to three-flowered; outer glumes unequal, acuminate, rough on the keel; flowering glume acutely two-toothed at apex, bearing a stout, divergent awn, longer than its glume; palet equal, finely toothed, the nerves ciliate.

This grass grows in stout tufts in the shade of pines on gravelly soils, at high elevations. It furnishes a large amount of pasturage in some localities.

NOTE.—There are 3 species in the Rocky Mountains, viz: *subspicatum*, var. *molle;* also, *Montanum.*

TRISETUM SUBSPICATUM.

DANTHONIA INTERMEDIA (Vasey).

(WILD OAT GRASS.)

Stems smooth, not tufted, 6 to 24 inches long; leaves smooth; sheaths loose, hairy at the throat; panicle narrow, nodding; rays solitary, two to three-flowered, hairy at the points of the axis; outer glumes much exceeding the florets, acuminate; flowering glume conspicuously two-toothed and very villous below the middle, especially on the margins; the awn coarse, divergent, flat and twisted below the middle; palet scarious, acuminate, two-toothed and two-nerved.

This grass occurs at from 8,000 to 9,000 feet. At the latter elevation it is much reduced in size. Its value has not been determined.

ANALYSIS.

Moisture	8.38
Ash	4.68
Fat	2.56
Albuminoid nitrogen	9.48
Crude fiber	18.71
Nitrogen-free extract	64.57
Total	100.00

DANTHONIA CALIFORNICA (Boland).

Culms 1 to 2 feet high, with narrow, pointed, scarious leaves; sheaths hairy, especially at the throat; panicle 2 to 3′ long, of three to five, nearly sessile, erect spikelets; outer glumes unequal, three-nerved, purplish, somewhat scarious, acute, keeled above, nearly equal and exceeding the florets of the spikelet; flowering glume smooth on the base, margins below fringed with long, white hairs (silky), acutely cleft at the apex; a divergent awn, with broadish, twisted, ciliate base, from the base of the cleft.

This grass is indigenous to California, Oregon and Rocky Mountains. Probably of not much agricultural value.

PHALARIS ARUNDINACEA (L.).

(Canary Grass.)

Stems and sheaths finely scabrous, 2 to 5 feet high, branched or simple; leaves flat, lanceolate, finely scabrous, the margins rougher, 6 to 12 inches long; ligule short, rounded above; panicle oblong, dense, somewhat one-sided, 3 to 6 inches long, interrupted below; rays much branched, spreading in bloom, contracted, spicate with age; outer glumes whitish, equal, lanceolate, three-nerved, very acute; flowering glumes ovate, shorter than the outer glumes, obscurely nerved, hairy on the back; rudiments pilous.

This species was seen at all elevations, except the high mountain passes, growing in partial shade in moist ground. On the plains it is more abundant, occurring in quantity along irrigating ditches, regardless of shade. It is considered a desirable grass for trial.

ANALYSIS.

Moisture	8.44
Ash	7.16
Fat	3.40
Albuminoid nitrogen	7.12
Crude fiber	19.15
Nitrogen-free extract	63.17
Total	100.00

PHALARIS CANARIENSIS (L.).

(Canary Grass.)

Culms geniculate at base, striate, leafy, 1 to 2 feet high, from fibrous roots; leaves flat, lanceolate, very rough; ligule conspicuous, lacerate; sheaths loose, rough; panicle spicate, ovoid, 1 to 2 inches long; glumes whitish, greenish veined, very scabrous, strongly keeled.

Occasionally seen in cultivated ground, but not common. The seeds are the chief food of canary birds.

PHALARIS ARUNDINACEA.

PASPALUM GLABRUM.

Stems prostrate, ascending, glabrous, 8 to 12 inches long; leaves glabrous, lanceolate, linear, shorter than the sheaths; the upper sheath enclosing the base of the panicle, the lower ones hairy at the throat; ligule truncate, lacerate, enfolding the stem; spikes two to four, slender, about 2 inches long; glumes equaling the purplish flower, both hairy.

This grass is a persistent weed, and is widely distributed in Northen and Southern Colorado. In lawns it quickly takes possession, subduing all competitors for the occupancy of the soil.

ANALYSIS.

Moisture	9.10
Ash	16.98
Fat	2.17
Albuminoid nitrogen	6.68
Crude fiber	16.23
Nitrogen-free extract	57.94
Total	100.00

ALOPECURUS ARISTULATUS (Michx.).

Culms geniculate, smooth, ascending from a decumbent base, often rooting at the lower joints; sheaths inflated, loose; ligule prominent; leaves linear, acute, somewhat glaucous, rough on upper surface; spike cylindrical, very slender, pale green; glumes hairy outside, obtuse; flowering glume truncate, glabrous; anthers yellow; awn straight.

This species grows along ditch banks and is very leafy.

ORYZOPSIS CUSPIDATA (Benth.).

Stems about 2 feet high, smooth, growing in stout, rigid clumps, some of the lower joints geniculate; leaves linear, involute, 6 to 8 inches long, scabrous on the upper surface, the upper leaf enclosing the base of the panicle; panicle 6 to 12 inches long, loosely spreading; branches in 2s, divergent; spikelets one-flowered, on capillary pedicels; outer glumes pubescent, inflated, conspicuously five-nerved, the apex attenuate into a beak; flowering glume ovate, covered with a profusion of long, silky hairs, and tipped with a stout awn; palet smaller, of similar texture.

This grass seems to succeed best at an altitude of 5,000 feet. It occurs in the high mountain parks, but only in isolated, dwarfed specimens, and not in stout tufts. It is one of the most valuable of the dry land grasses.

ANALYSIS.

Moisture	8.60
Ash	7.83
Fat	2.72
Albuminoid nitrogen	7.36
Crude fiber	15.05
Nitrogen-free extract	67.04
Total	100.00

Oryzopsis Cuspidata.

ALOPECURUS ALPINUS (Sm.).

Culm erect, smooth, over 1 foot high; nodes brown; leaves lanceolate, smooth; the upper sheath inflated; ligule elongated; flowers in a dense, cylindrical, soft spike; outer glumes strongly three-nerved, acute, densely silky, villous; flowering glume equals the outer one; awn nearly straight, exserted.

In moist soils only, and at high elevations.

MELICA SPECTABILE (Scribner).

Stems slender, bulbous at base, about 2 feet high, few leaved; leaves linear, smooth; panicle slender, nodding, few-flowered; branches distant, spreading, flexuous, rough; outer glumes unequal, scarious, the lower three-nerved, the upper five-brownish-nerved; flowering glume about nine-nerved, thin, with a broadly scarious, acuminate apex; palet shorter than its glume, two-toothed and purplish tipped.

This grass was seen only on the Gore Pass, at 11,000 feet, in the shade of pines. It has, probably, no agricultural value.

GRAPHEPHORUM WOLFII (Vasey).

A tufted perennial grass with culms densely pubescent, 1° or more high; leaves somewhat scabrous; panicle spicate, purplish when young; spikelets two-flowered, with a rudiment of a third; glumes with scabrous margins, the outer ones unequal, acuminate, keeled, obscurely one to three-nerved at base; flowering glume being at the base, obscurely nerved, two-toothed at apex.

This grass from a high altitude.

ANDROPOGON FURCATUS (Muhl.).

(ANDROPOGON PROVINCEALIS (LAM.).

Stems 1 to 6 feet high, terminating by two to five, usually three digitate spikes; leaves long and ample, scabrous on the margins, those of the culm 4 inches long, hairy at base; ligule ciliate; spikelets appressed, approximate; outer glumes 4 lines long, the upper ones terminating in a short awn; awn of the fertile flower long and bent.

This grass, in two forms, is abundant on the plains and in the mountains, on rocky hillsides, up to 7,000 feet. In some places it is cut extensively for winter feed. It gives promise of value.

ANALYSIS.

Moisture	8.71
Ash	4.51
Fat	2.06
Albuminoid nitrogen	3.80
Crude fiber	21.66
Nitrogen-free extract	67.97
Total	100 00

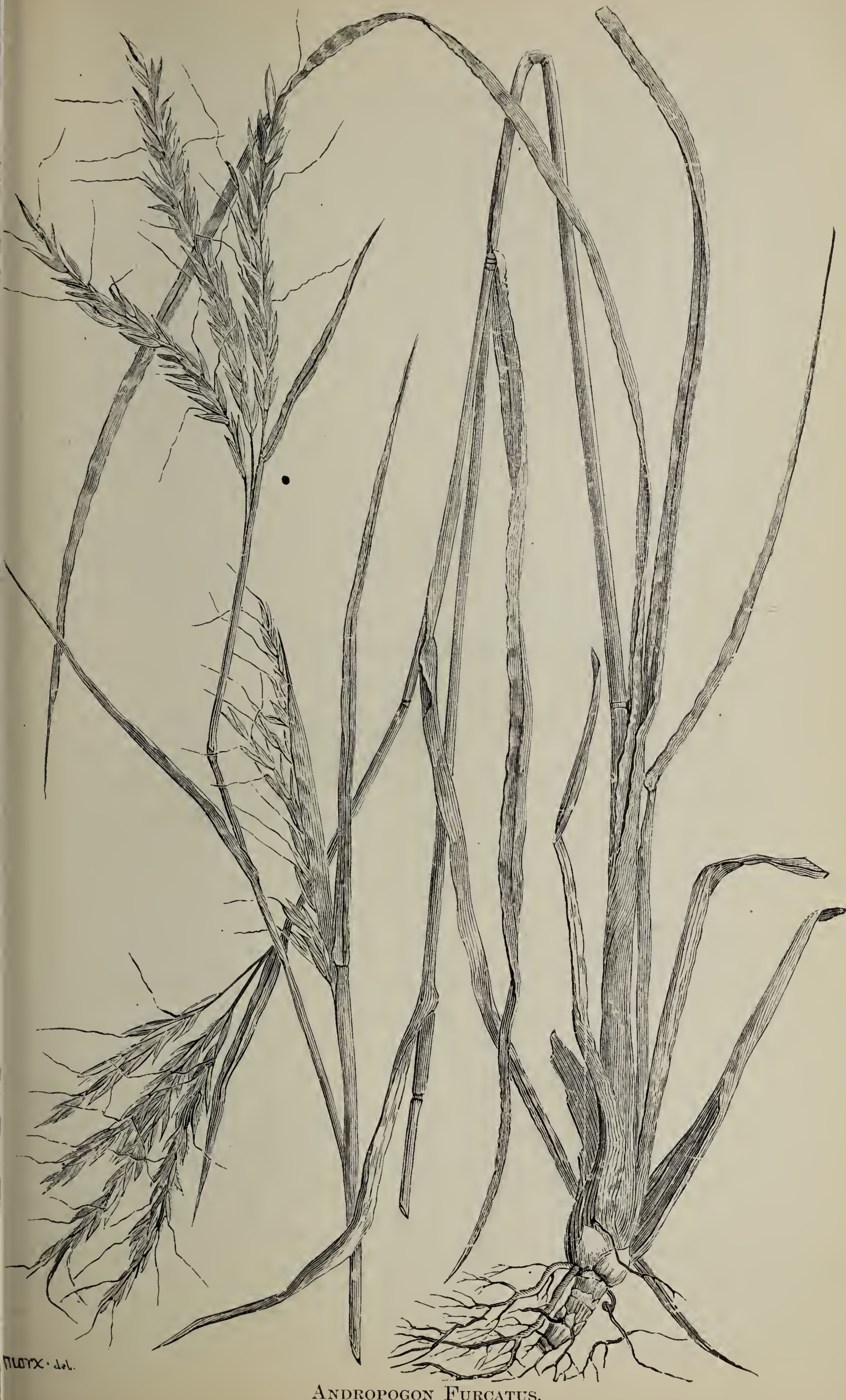
[See cut on opposite page.]

ANDROPOGON SCOPARIUS (Michx.).

(LITTLE BLUE STEM.)

Culms 2 to 4° high; spikes in clusters, on slender pedicels; flowers in August.

A large constituent of native meadows, yielding a fair amount of hay.



ANDROPOGON FURCATUS.

AMMOPHILA LONGIFOLIA (Vasey).

Culm smooth, reed-like, 3 to 6 feet high, from running root-stocks; leaves smooth, rigid, involute, long pointed; sheaths loose, longer than the nodes, hairy on the margins; panicle slender, whitish, 6 to 10 inches long; branches erect, smooth, solitary or in 2s or 3s, about 2 inches long, flower-bearing for half their length; outer glumes about equal, obscurely nerved; flowering glume lanceolate, very acute, scabrous on the strong keel, hairs at the base copious, spreading; palet obtuse or acute, shorter than its glume.

This species occurs in isolated specimens in moist, alkaline soils on the plains and in the mountains, up to 7,000 or 8,000 feet. It is thought to be too coarse to have much value.

POLYPOGON MONSPELIENSIS (Desf.).

(Beard Grass.)

Culms simple, decumbent at the branching base, 1 to 2 feet high; leaves flat, acutely pointed, downy; panicle spicate, densely flowered, the long awns of the flowers being very conspicuous; spikelets one-flowered; outer glumes nearly equal, pubescent, long awned; flowering glumes shorter, with a slender awn from the toothed apex; palet small, not awned.

Very common on the plains in wet soils. An ornamental grass of but little agricultural value.

ANALYSIS.

Moisture	8.40
Ash	11.88
Fat	2.95
Albuminoid nitrogen	12.33
Crude fiber	21.89
Nitrogen-free extract	50.95
Total	100.00

GLYCERIA NERVATA (Trin.).

Culms leafy, 2 to 4 feet high; leaves flat, finely scabrous, the longest 1 foot or more long; ligule truncate, short; sheaths not closed; panicle somewhat one-sided, 6 to 8 inches long, slender and pendulous from the weight of the seeds; branches flexuous, solitary or in 2s or 3s, scabrous; spikelets five to seven-flowered, brown or purplish; outer glumes small, unequal; flowering glume seven-nerved, finely scabrous, apex convex; palet equal, elliptical in outline, finely ciliate on the nerves.

Abundant in moist, shady locations, at high elevations. The panicles are relished by stock.

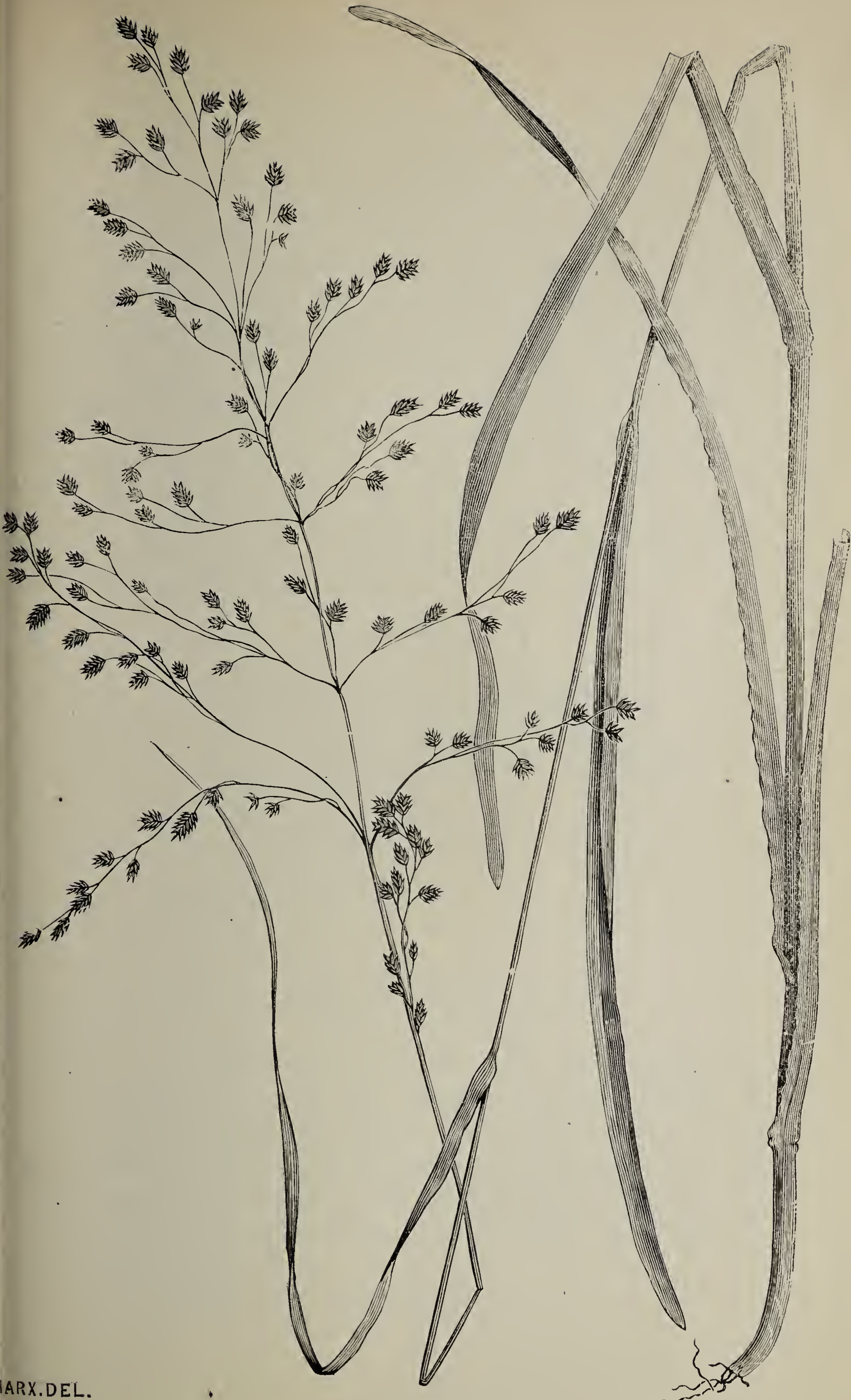
ANALYSIS.

Moisture	8.10
Ash	8.65
Fat	2.59
Albuminoid nitrogen	6.44
Crude fiber	19.15
Nitrogen-free extract	63.17
Total	100.00

[See cut on opposite page.]

GLYCERIA PAUCIFLORA (Presl.).

Culms leafy, 2 to 4 feet high, from running rootstocks; sheaths smooth, split; leaves somewhat scabrous; ligules prominent; panicle 3 to 6′ long; branches in 2s or 3s, erect, flowering for more than half their length; spikelet two-flowered [book says four to six]; flowering glume seven or eight-nerved, convex near apex, finely scabrous, tip scarious and toothed; panicle sparsely flowered; sheaths split.



IARX.DEL.

Glyceria Nervata.

GLYCERIA AQUATICA (Smith).

(Reed Meadow Grass.)

Culms leafy, 3 to 6 feet high, two-angled, very stout, glabrous; leaves 1 to 2 feet long, rough on the edges; ligule truncate; panicle purplish, much branched, spreading; branches in half whorls, naked below; spikelets on capillary pedicels, five to nine-flowered; outer glumes ovate, unequal, one-nerved, whitish; flowering glumes entire at rounded apex, seven-nerved; palet equaling its glume, two-nerved, two-toothed.

This grass is found in wet places at all elevations. In the mountains it furnishes a considerable amount of rough feed during winter.

ANALYSIS.

Moisture	8.00
Ash	19.06
Fat	2.98
Albuminoid nitrogen	9.45
Crude fiber	22.21
Nitrogen-free extract	46.30
Total	100.00

GLYCERIA DISTANS (Wahl.).

(White Spear Grass.)

A stout, tufted, perennial grass, from running root-stocks, 1 to 2 feet high; branches in 5s below and 3s above, unusually pubescent; leaves smooth, broad; lower glumes very unequal, membranous, the smaller acute, the larger erose, rounded; flowering glume prominently four or five-nerved, scarious tipped; upper palet emarginate, lower one truncate.

This grass has but little value.

SETARIA VIRIDIS (Beauv.).

Culms smooth, leafy; sheaths loose, twisted, hairy on the margins; leaves broad and rough, margins serrulate; spike 1 to 3 inches long, cylindrical, nodding, green; outer glumes conspicuously greenish-nerved; flowering glume longitudinally striate and finely corrugated under a lens.

In cultivated and waste places everywhere on the plains, where it is a well-known weed.

ANALYSIS.

Moisture	8.00
Ash	12.15
Fat	2.87
Albuminoid nitrogen	8.67
Crude fiber	16.40
Nitrogen-free extract	59.91
Total	100.00

SETARIA GLAUCA (Beauv.).

Stems leafy, flattened, geniculate at base; leaves carinate, broad, finely scabrous above, villous at base; ligule ciliate; spike cylindrical, tawny; fertile flower, transversly rugous.

Not common in this region.

ANALYSIS.

Moisture	8.10
Ash	13.32
Fat	4.34
Albuminoid nitrogen	9.46
Crude fiber	16.97
Nitrogen-free extract	55.91
Total	100.00

SETARIA ITALICA (Kunth.).

(MILLET; BENGAL GRASS.)

Culms compressed, bent at the lower nodes; spikes 2 to 6′ long, compound, interrupted at base, purplish, nodding; bristles two or three in a cluster.

This escaped from cultivation. Somewhat common in this region.

LEERSIA ORYZOIDES (Swartz).

This species grows in very wet soils only; it has retroversely scabrous stems; leaves lanceolate, very rough on the margins: panicle branching, very diffuse, sheathed at base.

Not of much value, although sometimes cut for hay.

DISTICHLIS MARITIMA (Raf.).

(SALT GRASS: ALKALINE GRASS.)

Culms smooth, slender, leafy, from running rootstocks; 6 to 12 inches high; leaves flat, narrow, villous on the upper surface; ligule a fringe of hairs; panicle oblong, spicate; spikelets diæcious, compressed, about ten-flowered; outer glumes narrow, keeled, smooth; flowering glumes larger, obscurely nerved, smooth.

This grass forms a dense, close sod, on alkaline soils on the plains. It never attains a height sufficient to justify cutting it for hay, and stock never pasture it from choice.

ANALYSIS.

Moisture	7.95
Ash	7.98
Fat	2.72
Albuminoid nitrogen	7.56
Crude fiber	22.80
Nitrogen-free extract	58.94
Total	100.00

HIEROCHLOA BOREALIS (R. & S.).

(HOLY GRASS; VANILLA GRASS.)

Stem about 2 feet high, smooth, from creeping rootstock; leaves lanceolate, flat; panicle one-sided, pyramidal; spikelets three-flowered, chestnut colored; staminate flowers pubescent on the margins; fertile flower hairy at the tip.

This species occurs in the mountains only, and in moist meadows. It is found in some quantity in Estes Park, but has not been seen elsewhere by the writer.

[See cut on opposite page.]

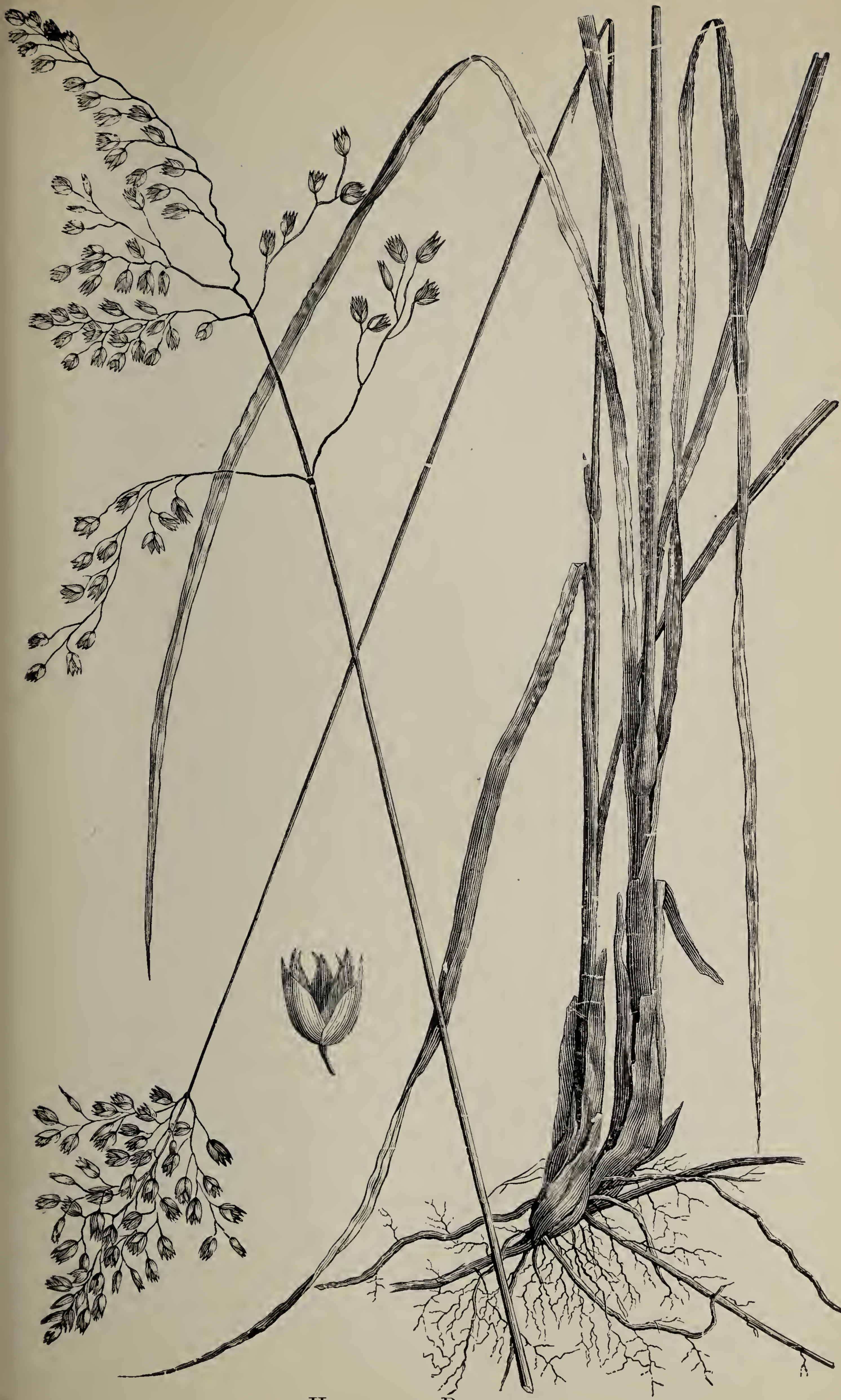
EATONIA OBTUSATA (Gray).

Stems 1 to 3 feet high, some of the lowest joints geniculate, blackish; leaves flat, 4 to 8 inches long, ½ inch wide, scabrous; sheaths shorter than the nodes, rough; ligule truncate, laciniate; panicle 6 inches long, contracted, spicate, much lobed; spikelets crowded on the very short branches; outer glumes unequal, the lower one linear, scabrous all over, especially on the keel, upper glume obovate, rounded at apex, with broadly scarious margins; flowering glume similar; palet small, hyaline, minutely two-toothed.

This species was seen at nearly all elevations, but not in any considerable quantity. It is worthy of trial.

ANALYSIS.

Moisture	8.14
Ash	12.94
Fat	3.98
Albuminoid nitrogen	6.38
Crude fiber	24.19
Nitrogen-free extract	52.51
Total	100.00



Hierochloa Borealis.

LOLIUM PERENNE (L.), var. ITALICUM (Braun).

(Italian Rye Grass).

Culms often 3 feet high, leafy, terminating in a rigid spike-like panicle, nearly a foot long; spikelets seven to eleven-flowered, placed edgewise in a groove of the rhachis; inner and lower empty glume ovate, reduced in size or absent; upper empty glume linear, equaling the spikelet; flowering glumes five-nerved, roughish, tipped with a straight awn.

This introduced grass is occasionally seen in irrigated meadows on the plains. It is in flower about the middle of July. It is considered the most valuable of the rye grasses, standing drought remarkably well.

ANALYSIS.

Moisture	8.98
Ash	7.27
Fat	2.09
Albuminoid nitrogen	8.68
Crude fiber	20.00
Nitrogen-free extract	61.96
Total	100.00

DIPLACHNE FASCICULARIS (Benth).

Culms tufted, geniculate, branching, 1 foot high; leaves 3 to 6 inches long, rough, the uppermost enclosing the base of the panicle; sheaths loose, smoothish; panicle 6 to 10 inches long, crowded, consisting of numerous appressed, spike-like branches; spikelets five to ten-flowered; outer glumes linear, unequal, scabrous on the green mid-rib; flowering glume lanceolate, one-nerved, silky, hairy on the margins, apex rough awned, two-toothed; palet thin, two-nerved.

In alkaline soils near the foothills, but not common.

KŒLERIA CRISTATA (Pers.).

Culms erect, from a somewhat geniculate base, about three-leaved; leaves flat, 2 to 4 inches long, scabrous above; ligule lacerate, obtuse; sheaths loose, striate, exceeding the nodes, glabrous or downy; panicle narrow, spicate, interrupted below, downy at the joints of the rhachis; outer glumes unequal, scabrous on the keel, acute; flowering glume similar, apex usually mucronate; palet equaling the glume, hyaline, acutely two-toothed.

This grass is abundantly distributed in the mountains on dry hillsides; also, in the partial shade of timber and in the native meadows, when not wet. The more robust forms attain a height of 2½ feet. It is a promising species.

ANALYSIS.

Moisture	8.15
Ash	7.96
Fat	3.93
Albuminoid nitrogen	6.85
Crude fiber	22.58
Nitrogen-free extract	58.68
Total	100.00

[See cut on opposite page.]

SPARTINA CYNOSUROIDES (Willd.).

(Cord Grass.)

Culms 3 to 6 feet high; leaves 2 to 3 feet long, pointed; panicle 1 foot or more long, occupied by from five to twenty spreading flower-spikes, hispid on the angles; outer glumes unequal, the lower linear, the upper broader, rough on the keel and tapering to a stout point; flowering glume rough on the keel above; palet thin, two-nerved, longer than its glume.

Abundant in wet soils or on the banks of irrigating ditches. It is rejected by stock, unless cut when young. It has, probably, but little value.

H.H.NICHOLS

T.TAYLOR.DEL.

Kœleria Cristata.

PHLEUM PRATENSE (L.).

(Timothy; Cat's Tail Grass.)

This well-known grass is cultivated to a small extent in the mountains and on the plains. It is found along roads or trails over the highest passes, sometimes in considerable quantity. It is readily recognized by its superior vigor, the upper leaf often subtending the greenish, cylindrical spike.

Stockmen unite in saying that the spike becomes much reduced in size from mountain-grown seed.

PHLEUM ALPINUM (L.).

Culms 1 to 2 feet high, smooth, leafy, geniculate at the lower joints; leaves linear, smooth; ligule short, truncate; sheaths shorter than the nodes, inflated, loose; spike oblong, 1 to 2 inches long, dark purple at high elevations, greenish when growing in partial shade, in good soil, at lower altitudes; outer glumes compressed, coarsely fringed on the mid-rib, scabrous all over; apex bristle pointed; flowering glume thinner, obscurely nerved, apex truncate and toothed; palet small, hyaline.

At high elevations only, and in partial shade. It is less vigorous than the cultivated species, but is said, by an observer in Iowa, not to rust in that State.

ANALYSIS.

Moisture	7.87
Ash	6.30
Fat	2.60
Albuminoid nitrogen	10.67
Crude fiber	16.91
Nitrogen-free extract	63.52
Total	100.00

HILARIA JAMESII (Benth.).

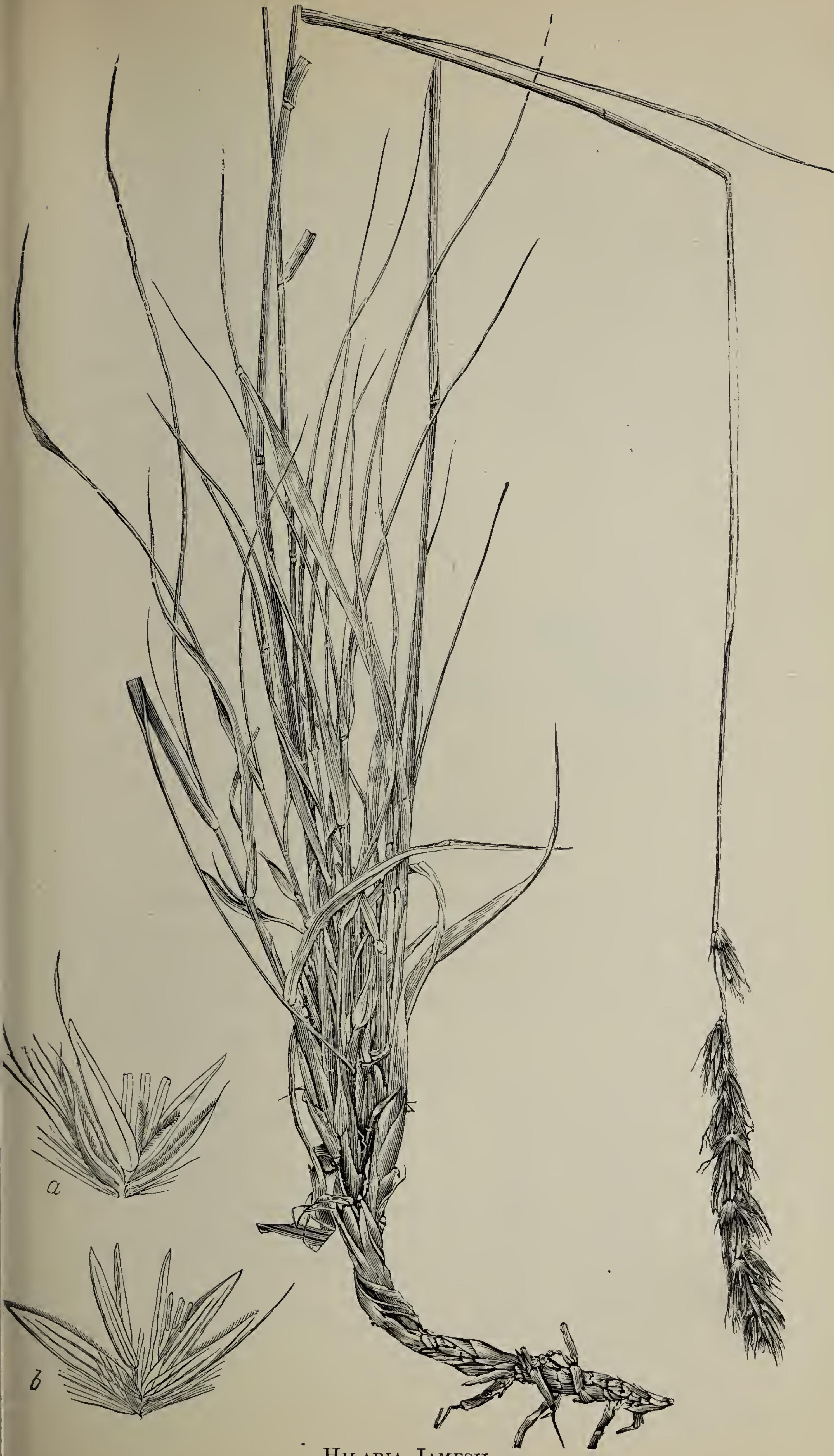
Stems branching from the ground; nodes hairy; ligule short, laciniate; leaves glaucescent, scabrous, striate, hairy above; flowers in a strict spike; the spikelets in 3s, sessile, from a tuft of silky, spreading hairs, the lateral ones staminate, the central one perfect; outer glumes of the sterile flowers scabrous, especially on the keel, the outer half of each glume prominently three to four-nerved, sometimes with a divergent awn from near the middle; outer glume of the perfect flower narrow, cuneate, ciliate on the margins, deeply two-cleft, lobes about six-bristled, the one below the cleft the longest; flowering glume three-nerved, membranous, cuspidate from near the apex; palet nearly equaling the glume, two-toothed.

This grass grows in stout clumps from underground stems, attaining a height of from 2 to 3 feet. It occurs near Pueblo, on adobe soils, flowering as late as the first week in October. Nothing is known of its economic value.

CINNA ARUNDINACEA (L.), var. PENDULA (Gray).

Stems reed-like, 3 to 7 feet high, with prominent, brownish nodes; leaves broad and very rough; sheaths finely scabrous; ligule very prominent; panicle 1 foot long, slender, drooping at apex; rays distant, capillary, unequal, in 4s or 5s, the longest flower-bearing above the middle; spikelets one-flowered, much flattened; outer glumes narrow, rough, especially on the keel, scarious margined, acute, the upper glume longer than the floret; flowering glume usually two-toothed, terminating in a short, straight awn, from near the apex; palet one-nerved, much shorter than the glume.

This robust species was seen near Rock Creek, Wyo., at an elevation of 9,000 feet, growing in deep shade in moist ground. Its agricultural value is unknown.



Hilaria Jamesii.

ARISTIDA BASIRAMEA (Engelm).

Culms leafy, erect, slender, over 1 foot high; leaves nearly 1 foot long, sparingly hairy on the margins; sheaths softly pubescent; ligule almost obsolete; panicle loosely flowered, 3 to 4 inches long, its base enclosed by the upper sheath; outer glumes linear, one-nerved, long awned; flowering glume terete, blackish, sparingly hairy at the obtuse or acute callus, apex three-awned, the middle one 1 inch long.

Abundant near the foothills, in dry soil.

ANALYSIS.

Moisture	9.16
Ash	10.09
Fat	2.29
Albuminoid nitrogen	4.06
Crude fiber	16.28
Nitrogen-free extract	67.28
Total	100.00

CENCHRUS TRIBULOIDES (L.).

(SAND BURR; BURR GRASS.)

This weedy, troublesome grass occurs only in loose, open soils. It is particularly abundant near Canon City. The culms are spreading, 1 to 2 feet long, yielding quantities of prickly burrs, which adhere to the bodies of animals, especially sheep.

ANALYSIS.

	No. 1.	No. 2.
Moisture	9.45	7.50
Ash	9.24	10.96
Fat	3.60	2.15
Albuminoid nitrogen	10.53	6.58
Crude fiber	14.14	16:69
Nitrogen-free extract	60.49	63.62
Total	100.00	100.00

PHRAGMITES COMMUNIS (Trin.).

(Reed Grass.)

Resembles broom corn at a distance. Stems reed-like, very leafy, 5 to 12 feet high; leaves ample, smooth, 1 or 2 inches wide; panicle loose, nodding, 1 foot or more long; spikelets three to five-flowered; outer glumes unequal, strongly keeled, acute; flowering glumes narrow, membranaceous.

This very coarse grass is comparatively rare in Northern Colorado and Central Wyoming, but is very common along the banks of the Arkansas, between Pueblo and Canon City. It has no value for agricultural purposes.

HORDEUM JUBATUM (L.).

(Squirrel Tail Grass.)

Stems 6 inches to 2 feet high; leaves flat, 2 to 4 inches long, margins often scabrous; flowers in a dense spike, pale green at 5,000 feet, purplish at higher altitudes; lateral flowers abortive, short awned; perfect floret, bearing a spreading, capillary awn, 2 inches long; awns very bad for stock, in feeding, causing throat difficulties.

This grass has become a serious pest in wet, alkaline meadows in the Rocky Mountain country. Its spread is entirely the result of over irrigation.

ANALYSIS.

Moisture	7.29
Ash	13.05
Fat	2.71
Albuminoid nitrogen	7.51
Crude fiber	15.72
Nitrogen-free extract	61.01
Total	100.00

Phragmites Communis.

Stuart del.

BOUTELOUA RACEMOSA (Lag.).

(Grama Grass.)

Stems tufted, smooth, from underground stems, 1 to 2 feet high; leaves 6 to 10 inches long, narrow, involute, rough on the upper surface; sheaths shorter than the nodes; ligule truncate, very short; flowers in a one-sided raceme; spikelets numerous, reflexed; outer glumes lanceolate, acuminate, the upper and larger scabrous all over, the lower very narrow, rough on the keel; flowering glume rounded below, apex two-toothed, the mid-rib terminating in a mucro; sterile flower of one or two scales, three-awned, the middle one conspicuous.

Abundant in localities in the foothills. Less common on the plains near the mountains.

BOUTELOUA HIRSUTA (Lag.).

(Grama Grass.)

Stems slender, smooth, geniculate at base, 1 to 2 feet high; leaves narrowly linear, flat; ligule a hairy fringe; spikes one to four; outer glumes linear, acuminate, the lower narrower, membranous, ciliate on the acute keel, upper glume scabrous all over, dotted with dark, warty glands below the middle on the flattened keel, from each of which, occasionally, arises a short hair; flowering glume very villous below the middle, apex two-toothed and bristle-pointed; palet equal, acutely two-toothed, nerves prominent; sterile flower on a short, glabrous pedicel, exceeding the glumes and equaling the fertile flower.

This species has much greater vigor than the preceding, but is not so widely distributed. It ought to be a valuable grass.

BECKMANNIA ERUCAEFORMIS (Kost.).

(WATER GRASS.)

Stems usually very stout, smooth, 2 to 4 feet high; leaves rough, flat and broad, 6 inches to 1 foot long; sheaths loose, inflated, the upper enclosing the base of the panicle; ligule long; panicle in stout specimens, 1 foot long, rigid, secund; branches flower-bearing to the base; outer glumes boat-shaped, scarious margined; apex mucronate; flowering glume strongly keeled, apex cuspidate; palet equaling its glume, acutely two-toothed; sterile floret very minute, stipitate under a good lens.

There is no grass in the Rocky Mountain region that stock like any better than this perennial aquatic. On the plains, along ditch banks, it is always present in quantity.

It occurs, sparingly, in the mountains up to high elevations.

ANALYSIS.

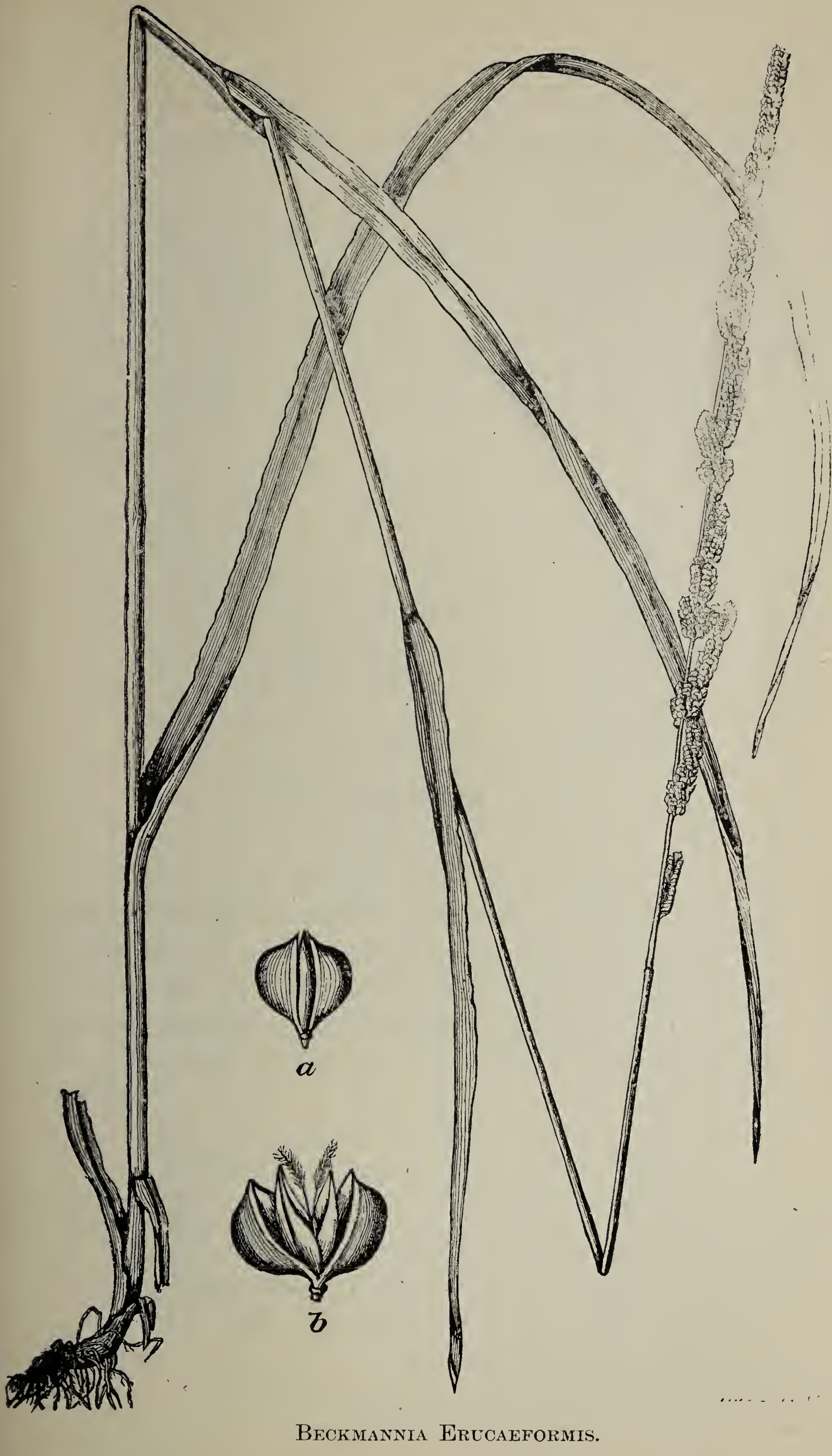
Moisture	8.36
Ash	6.21
Fat	3.05
Albuminoid nitrogen	8.53
Crude fiber	22.65
Nitrogen-free extract	59.56
Total	100.00

SCHEDONNARDUS TEXANUS (Steud.).

(TEXAS SPIKE GRASS.)

Stems branching, procumbent, curved above, 6 to 20 inches high, very rough; panicle of three to ten, recurved, distant, three-angled, naked spikes; spikelets one-flowered, partly immersed in an excavation of the rhachis; outer glumes acuminate; flowering glume linear, acuminate, keeled; palet shorter and narrower than its glume.

Abundant in dry soil on the plains, flowering late in June. Of no agricultural value.



Beckmannia Erucaeformis.

TRIFOLIUM ERIOCEPHALUM (Nutt).

(Clover.)

Stems 12 to 20 inches high, villous, with spreading hairs or glabrate; leaflets oblong, acuminate, glabrate, serrulate; flowers whitish, in densely-flowered heads; calyx teeth spreading, very narrow, villous; ovary hairy.

This plant is a chief constituent of the native irrigated meadows, in North Park. Stockmen consider it valuable.

ANALYSIS.

Moisture	9.96
Ash	7.29
Fat	3.96
Albuminoid nitrogen	19.25
Crude fiber	14.15
Nitrogen-free extract	55.35
Total	100.00

JUNCUS BALTICUS (Dethard).

(Wire Grass.)

Scapes from creeping root-stocks, naked, the basal sheath leafless and with broad, scarious margins; sepals almost equaling the triangular, mucronate capsule, the inner shorter than the outer, and with more pronounced, scarious margins; seeds ovate, three-angled.

Abundant in wet meadows and valued highly by stockmen.

ANALYSIS.

Moisture	8.68
Ash	6.38
Fat	3.15
Albuminoid nitrogen	8.55
Crude fiber	34.35
Nitrogen-free extract	47.57
Total	100.00

JUNCUS MERTENSIANUS (Meyer).

(BOG RUSH.)

Stems compressed, leafy, erect, about 2 feet high, from matted root-stocks; leaves compressed and equitant, erose form; sheaths loose, scarious, margined with ligules; heads solitary, densely flowered, shining, dark brown; sepals pungently pointed with broad, scarious margins, exceeding the capsule; stamens six; capsule obovate, three-lobed.

This is highly valued in common with other species of the same genus. All are known, by stockmen, as wire grass.

ANALYSIS.

Moisture	8.30
Ash	6.15
Fat	1.95
Albuminoid nitrogen	9.00
Crude fiber	38.66
Nitrogen-free extract	44.24
Total	100.00

JUNCUS BUFONIUS (L.).

Stems tufted, slender, branching from the base, 3 to 6′ high, mostly with one-sided, dichotomous branches; outer sepals greenish, nerved, acute, longer than the three inner and entirely scarious sepals; seeds somewhat angled, very small, obtuse; pods oblong, obtuse.

In North Park. Too small to be of any value.

MUNROA SQUARROSA (Torr.).

(FALSE BUFFALO GRASS.)

Annual, with fasciculute branches; leaves 1′ or less in length, veiny, scarious and scabrous margined tip; spikelets mostly three-capitate; outer glume one-nerved, small; flower three-nerved, the central prolonged into an awn.

This is a weed, and widely distributed in thin pastures and native meadows.

CAREX RUPESTRIS (All.).

Culms obtusely angled, from a spreading base, 1 foot high; leaves channeled, long pointed, shorter than the culm; spike terminal, single, light brown, clavate; perigynium, upright, plano-convex, contracted above into a stout, truncate, two-toothed beak, covered by the pale brown, strongly keeled, acuminate scale; akene ovate, somewhat flattened.

A chief constituent of wet meadows in the mountains, growing in broad, conspicuous patches, and furnishing considerable winter feed.

ANALYSIS.

Moisture	8.59
Ash	9.12
Fat	1.96
Albuminoid nitrogen	8.08
Crude fiber	32.33
Nitrogen-free extract	48.51
Total	100 00

LUZULA SPADICEA (D. C.), var. SUBCONGESTA (Watson).

(Wood Rush.)

Stems 1 to 2 feet high, smooth; leaves broad, hairy at the base; inflorescence nodding, exceeding the tracts; perianth dark brown, the segments all pointed, except the two lower; capsule very acute.

Abundant in localities in the mountains, where it furnishes some of the native summer grazing.

EUROTIA LANATA (Moq.).

(WHITE SAGE OR WINTER FAT.)

An under-shrub (*stellatelty tomentose*) growing on dry, deep soils, from a stout tap-root; stems virgate, densely flowered at the apex; leaves linear to lanceolate, white tomentose, with revolute margins; flowers in spicate clusters; fruiting tracts nearly covered with four dense tufts of whitish, spreading hairs, and beaked above with two short horns.

This well-known plant grows only on the best soils and in dry situations, retaining its foliage and fruit through the winter, which are considered valuable for fattening stock.

ANALYSIS.

Moisture	9.80
Ash	9.00
Fat	4.52
Albuminoid nitrogen	12.27
Crude fiber	17.30
Nitrogen-free extract	56.89
Total	100.00

LUPINUS ARGENTENS (Pursh).

Stems tall, hoary, yellow-green; leaflets six to six, linear, lanceolate, smooth above; flowers pale or dark blue, standered with darker spots in two irregular rows; inner margin of keel villous with spreading hairs; seeds two to six.

This is a tall species; nearly out of bloom July 12th.

LUPINUS ARGENTENS (Pursh), var. ARGOPHYLLUS (Watson).

This differs from the species in the leaves being hairy on both sides, spurred calyx, and somewhat larger flowers, and by its blooming somewhat earlier.

CHEMICAL SECTION.

The following list of analyses was made, consisting mostly of selected forage plants, not elsewhere reported in this bulletin. The exceptions are the "wheat weed," the "poverty weed" and the "lemon plant" or weed. These were analyzed with a view to note the constituents and their proportions, in order, if possible, to see if this would account in part, at least, for the action of these in apparently robbing other plants of the food in the soil. These analyses seem to indicate that this is true to some extent, at least:

ANALYSES.

NAME.	Moisture.	Ash.	Fat.	Albuminiod Nitrogen.	Crude Fiber.	Nitrogen-Free Extract.
Lupinus plattensis	9.87	9.17	1.98	13.68	17.93	57.24
Lupinus leucophyllus	9.10	5.12	3.64	13.84	15.76	61.64
Lupinus leucophyllus	8.92	5.32	3.81	13.82	15.86	61.39
Lupinus ———	8.93	7.66	3.04	11.20	21.64	56.46
Millet / Setaria Italica	7.78	11.66	2.36	10.61	17.48	57.89
Setaria Italica	8.00	10.80	2.26	6.14	21.89	58.91

ANALYSES—CONTINUED.

NAME.	Moisture.	Ash.	Fat.	Albuminoid Nitrogen.	Crude Fiber.	Nitrogen-Free Extract.
Lactuca ludoviciana	10.80	12.56	7.12	18.67	14.00	47.65
Lactuca ———	8.40	15.66	6.65	6.16	17.02	54.51
Sainfoin, Onobrychis sativa	9.08	11.45	4.56	11.70	18.16	54.13
Melilotus alba	8.75	7.39	3.65	17.85	14.04	57.07
Medicago sativa	10.92	17.27	7.69	8.00	16.16	58.88
Trifolium Incarnatum, Italian clover	9.15	14.17	3.75	10.98	15.36	55.74
Japan clover	10.10	9.38	4.60	9.15	14.20	62.67
Yellow trefoil clover	13.17	11.00	4.42	14.85	12.23	57.50
Bokhara clover	9.05	7.56	2.80	9.54	15.00	65.10
Alsike clover	11.71	12.05	4.55	13.68	14.82	54.90
Agropyrum	8.42	5.00	2.30	3.32	32.20	57.18
Agropyrum glaucum	7.91	7.09	2.57	7.32	19.65	63.37
Hordeum nodosum	7.34	6.35	2.10	5.16	22.42	63.97
Dactylis glomerata, Durango, stems and seeds	7.95	8.64	1.83	5.43	18.76	65.34
Dactylis glomerata, Orchard grass	7.27	7.42	2.05	5.40	20.75	64.38
Bouteloua oligastachya	7.33	7.31	1.73	7.51	14.62	68.83
Bouteloua dactyloides	7.80	10.33	2.25	7.54	14.59	65.29
Sorghum nutans	7.80	6.33	1.13	3.06	24.38	65.10
Rye grass, Lolium perenne	9.50	11.48	5.75	9.82	18.60	54.35
Cleome integrifolia	8 41	10.12	9.00	16.84	17.00	47.04
Poterium Sanguisorba, Burnett grass	13.40	9.33	6.26	16.86	13.60	59.95
Euphorbia	9.20	10.20	5.76	10.99	20.60	52.45
Franseria discolor, Wheat weed	9.00	20.55	4.02	20.98	11.10	43.35
Iva axillaris, Poverty weed	9.40	20.62	6.36	14.35	11.60	47.07
Lemon plant, Weed in Southern Colorado	12.61	17.84	4.80	8.86	11.60	56.90

The methods of analyses and terms used are described in Bulletin No. 8, pages 9 and 10. For this bulletin, ninety-nine samples of grasses and forage plants were analyzed. When anything unusual in the analysis occurred, the analysis was duplicated. Eighteen samples, in part or in whole, were thus duplicated. Some of the samples were very ripe, others were at their best. Two samples were treated with petroleum ether, as a comparison with absolute ether, for fat. The petroleum ether gave, in one case, .2 per cent. too small; in the other case, .7 per cent. too small. The high ash of some samples, rivaling that of tobacco, must be due to the same cause, viz., fine sand mechanically blown upon the gummy plant. In determining crude fiber we have found that it filters quicker if it is treated, *first*, with caustic potash, and then with sulphuric acid. There is no difference in the results. It is reasonable to expect some unusual results from such grasses. The following table contains some of the extremes of the analyses:

RICH IN CRUDE PROTEIN AND CRUDE FAT, POOR IN CRUDE FIBER.

NAME.	Crude Protein.	Crude Fat.	Crude Fiber.
Franseria discolor	20.98	4.02	11.10
Trifolium ericephalum	19.25	3.96	14.15
Lactuca ludoviciana	18.67	7.12	14.00
Melilotus alba	17.85	3.65	14.04
Poterium Sanguisorba (Burnett)	16.86	6.25	13.60
Cleome integrifolia	16.84	9.00	17.00
Yellow trefoil clover	14.85	4.42	12.23
Iva axillaris (poverty weed)	14.35	6.36	11.60
Lupinus leucophyllus	13.84	3.64	15.76
Lupinus, species	13.82	3.61	15.86
Alsike clover	13.68	4.55	14.82

In the analyses the moisture had the *least* variation, ranging from a little over 3 per cent. to a little over 13 per cent., the majority ranging from 7 per cent. to 9 per cent.

The lowest ash is 4.51 per cent. There are forty-eight samples 9 per cent. and over, and seven samples over 15 per cent. of ash.

The fat ranges from 1.13 per cent. to 9 per cent. The 9 per cent. fat was duplicated and contained a large quantity of gum, etc. Thirty-eight samples contained over 3 per cent. of fat.

The albuminoid nitrogen ranged from 3.8 per cent. to 20.98 per cent. But seventeen specimens had over 12 per cent.

The lowest crude fiber was 11.10 per cent.; the highest 38.66 per cent. Fifty-seven samples were over 18 per cent.

The lowest nitrogen-free extract was 44.24 per cent.; the highest was 68.83 per cent.; the average from 50 per cent. to 60 per cent.

The average of *all* the analyses was as follows: Moisture 9.53; ash 9.43; fat 3.15; albuminoid nitrogen 9; crude fiber 19.60. In the analyses it was a singular fact that those that gave good results were plants of small size.

The following table gives the average analyses of each genus and the number in each genus analyzed:

Number Analyzed.	NAME.	Moisture.	Ash.	Fat	Albuminoid Nitrogen.	Crude Fiber.	Nitrogen-Free Extract.
5	Panicum	8.10	10.61	3.30	11.11	17.61	57.37
2	Setaria	8.05	12.74	3.60	9.07	16.68	57.91
2	Andropogon	8.77	5.08	2.10	4.19	23.58	65.05
3	Stipa	8 35	7.11	2.70	7.51	22.71	59.97
4	Muhlenbergia	7 45	11.23	2.62	7.23	20.47	58.45
2	Agrostis	8.67	7.50	2.63	7.96	20.00	61.91
2	Sporobolus	8.04	9.20	2.46	9.10	16.06	63.18
3	Eragrostis	7.96	12.04	2.34	7.16	19.24	59.22
4	Poa	6.92	8.37	2.37	5.79	20.74	62.73
4	Bromus	7.75	8.33	3.09	7.82	22.26	58.50
6	Agropyrum	8.22	6.16	2.43	6.07	22.45	62.89
2	Hordeum	7.32	9.70	2.40	6.34	19.07	62.49
5	Elymus	8.09	7.82	2.50	7.15	20.34	62.19
3	Lolium	9.00	9.19	3.76	9.64	19.96	57.45
2	Sorghum	7.90	8.56	1.70	4.60	23.14	62.00
2	Dactylis	7.62	8.03	1.94	5.42	19.75	64.86
9	Clovers	10.93	9.94	4.17	13.64	14.17	58.08
4	Lupinus	9.40	6.82	3.07	13.13	17.80	59.18
2	Vicia	8.98	7.25	2.18	12.27	18.45	59.85
3	Sedges	8.52	7.22	2.35	8.55	35.11	46.77
2	Weeds	9.20	20.58	5.20	17.66	11.35	45.21
2	Lactuca	9.60	14.11	6.88	12.42	15.51	51.08

There are three factors in the raising of grass for hay or pasture: The *ease* with which it can be cultivated, the *yield* per acre and the *value*, as determined by chemical analysis. A grass may show a very good chemical analysis, but it may be difficult to raise, or the yield may be very small, either of which would make it worthless from an economic standpoint. It must be, then, that *all these factors* must be taken into consideration in determining the feeding value of any sample. We have determined but *one* factor in the chemical analysis, the other factors will be determined in this and the following years by the grass station.

It is eminently proper that some tribute should be made to the *last work* of the lamented Prof. Cassidy. The memory of many other treasured things in this life will grow old, fade away and be lost, long, long, ere I shall forget his kindness. His benign influence, his Christian virtues, his gentlemanly deportment and his scholarly attainments, will always find a green spot in my memory.

DAVID O'BRINE,
Chemist.

*APPENDIX.

BOUTELOUA OLIGOSTACHYA (Torr).

(Grama Grass.)

Stems slender, 5 to 15 inches high, smooth; cauline leaves three or four; sheaths smooth, shorter than the internodes, very hairy at the throat below, naked above; blades 1 to 2½ inches long, narrow, involute, edges scabrous; radical and sterile stem leaves 1½ to 3 inches long, 1 line wide, involute; spikes one to four, usually two; rhachis flat, with the spikelets sessile in two crowded rows on one side, hairy at base, glabrous above; spikelets with one perfect flower, and one pediceled, abortive flower, consisting of two small, hyaline, empty glumes and three stiff awns, which nearly equal the glume of the perfect flower in length; the pedicel villous, tufted at the summit; empty glumes very unequal, both sparingly hairy on the back, one-nerved, the lower hyaline, the upper purple, awn-pointed; flowering glume lanceolate, trifid, the divisions subulate, copiously hairy on the back; palet two-nerved and two-pointed, hyaline, enclosed by the glume.

This grass is quite abundant in this locality, both on the plains and in the mountains. On the mountain ranges visited, it is so closely fed that I failed to find plants in bloom, but, in places on the plains, the bloom is abundant.

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* Prepared by Prof. C. S. Crandall, Botanist and Horticulturist since January 1, 1890.

BUCHLOE DACLYTOIDES (Engelm.)

(Buffalo Grass.)

Growing in broad mats and spreading by stolons diœcious; stems of the male plant very slender, 2 to 5 inches high, smooth; sheaths, except the uppermost, nearly as long as the internodes, glabrous, striate; blades 1 to 1½ inches long, 1-20 to 1-10 inch wide, sparingly covered, both sides, with long hairs; spikes two or three, short, one-sided; spikelets alternate in two rows, sessile, usually three-flowered; empty glumes membraneous, obtuse, the lower oblong, one-nerved, the upper twice as long as the lower, broadly lanceolate, one-nerved, equaling the flowering glume; flowering glume ovate, three-nerved, convex, nearly surrounding the two-nerved, hyaline palet, which nearly equals the glume in length; anthers three, large, on long, slender filaments.

In the female plant the fertile stems are very short, usually about 1 inch, occasionally 1½ inches long; leaves as in the male plant, except that the throat of the sheath is strongly bearded, and the blades are rather more hairy; spikes capitate, surrounded and exceeded by the leaves; branches of the rhachis two to five each, bearing two spikelets; spikelets one-flowered; empty glumes large, united below, the lower bifid or sometimes trifid, the upper trifid, both becoming indurated; flowering glume ovate, lanceolate, three-nerved, nearly entire, terminating in a short, stiff awn; palet two-nerved, hyaline, enclosed by the flowering glume, the distinct styles plumose, long exserted.

This, the true buffalo grass, which once formed so large a portion of the prairie tuft, is now found in this region only in isolated patches. The largest area I have seen of it is some five miles north of Fort Collins, in a hollow on the prairie; it may cover a half acre. Small mats, of from 5 to 15 square yards, are quite common. At this season, these mats may be readily distinguished, from a distance, by their yellowish green color.

MUHLENBERGIA GLOMERATA (Trin.).

(Spiked Muhlenbergia.)

Stems rather slender, 1 to $3\frac{1}{2}$ feet high, leafy; cauline leaves seven to eleven; sheaths smooth; blades linear, 2 to 4 inches long, 1 to 3 lines wide, scabrous; sterile stems 4 to 8 inches long, leafy to the top; panicle 2 to 4 inches long; branches sessile, contracted into an interrupted spike; spikelets crowded, one-flowered; empty glumes equal, membranous, one-nerved, tipped with awns equaling the glumes in length, and with awns one-third longer than the flowering glume; flowering glume ovate, lanceolate, acute, entire, not awned, membranous, three-nerved, hairy near the margins, enclosing the nearly equal, hyaline, two-nerved palet.

On ditch banks and in native meadows in the valley of the Poudre. Valued as a forage grass.

FESTUCA SCABRELLA (Torr.).

(Bunch Grass.)

This grass forms the largest bunches of any of the so-called bunch grasses. The specimen bunch, which I have before me, measures 12 inches across at the base. It is very compact; the stems are numerous, 34 to 38 inches long, slender, smooth, two to three-leaved; the blades of the stem leaves have all fallen, leaving the naked, scabrous sheaths; radical leaves very numerous, 12 to 24 inches long, very narrow, involute, scabrous; panicle 4 to 7 inches long; branches 1 to $1\frac{1}{2}$ inches long, single or in pairs, rhachis scabrous; spikelets three to five-flowered; empty glumes membranous, the lower one-nerved, one-third shorter than the three-nerved, upper one; flowering glume acute, tipped with a very short awn, five-nerved, scabrous, scarious margined; palet two-nerved, bifid, equaling the glume.

In the mountains, at 6,000 to 8,000 feet. Much valued as a range grass.

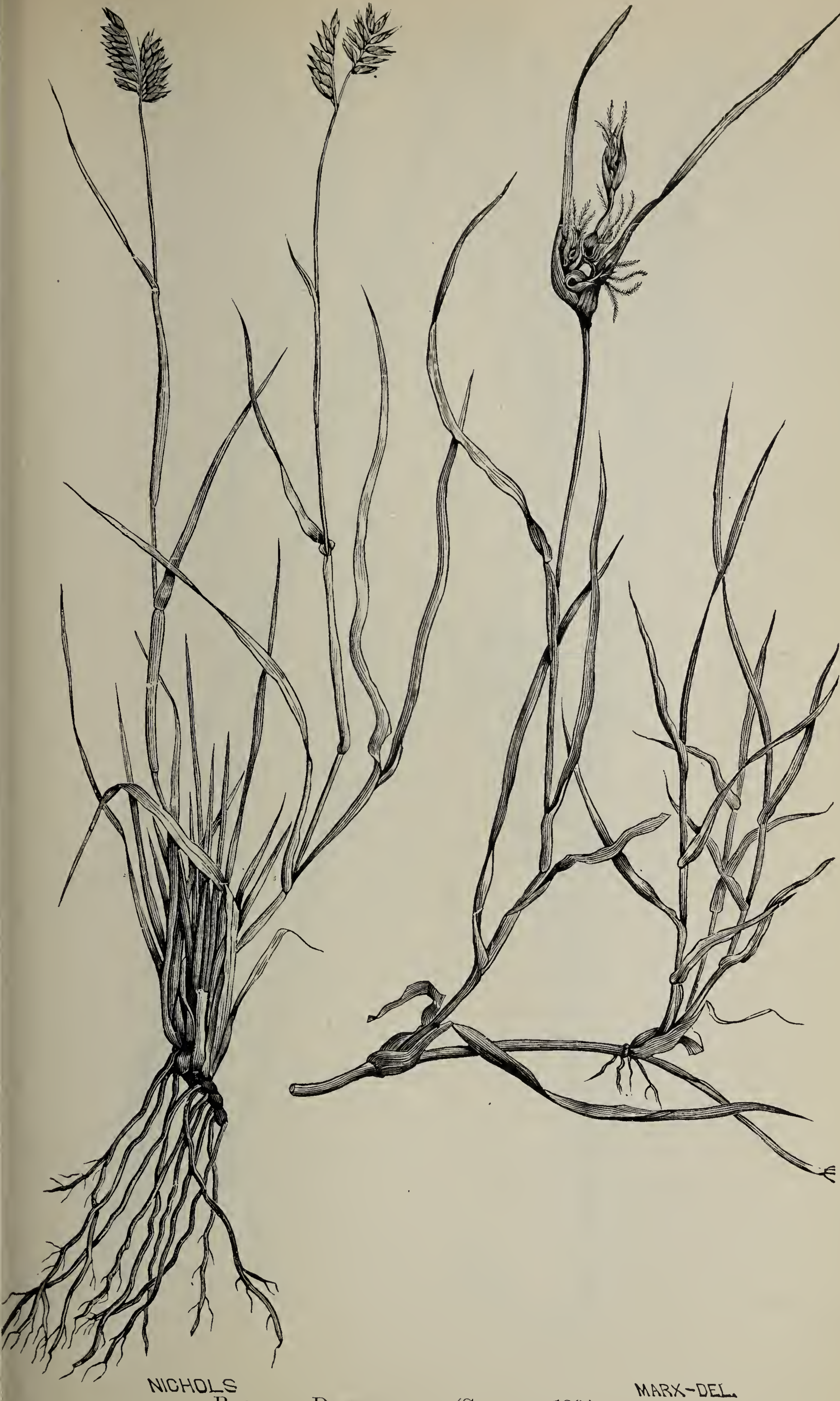
AGROPYRUM GLAUCUM (R. & S.).

(Colorado Blue Stem.).

Stems 10 to 30 inches high, erect, rigid, smooth; cauline leaves about four; sheaths as long as the internodes below, shorter than the internodes above, smooth; ligule short, truncate; blades 4 to 6 inches long, smooth below, scabrous above, flat or involute for half the length; the whole plant has a characteristic bluish-green color; spikes 2 to 5 inches long; spikelets compressed, arranged in two rows; flat side to the rhachis, five to eight-flowered; empty glumes nearly equal, lower three-nerved, upper, three or obscurely five-nerved, lanceolate, acuminate; flowering glume five-nerved, oblong, tipped with a short awn, scarious margined; palet two-nerved, hyaline, bifid, nearly equaling the glume.

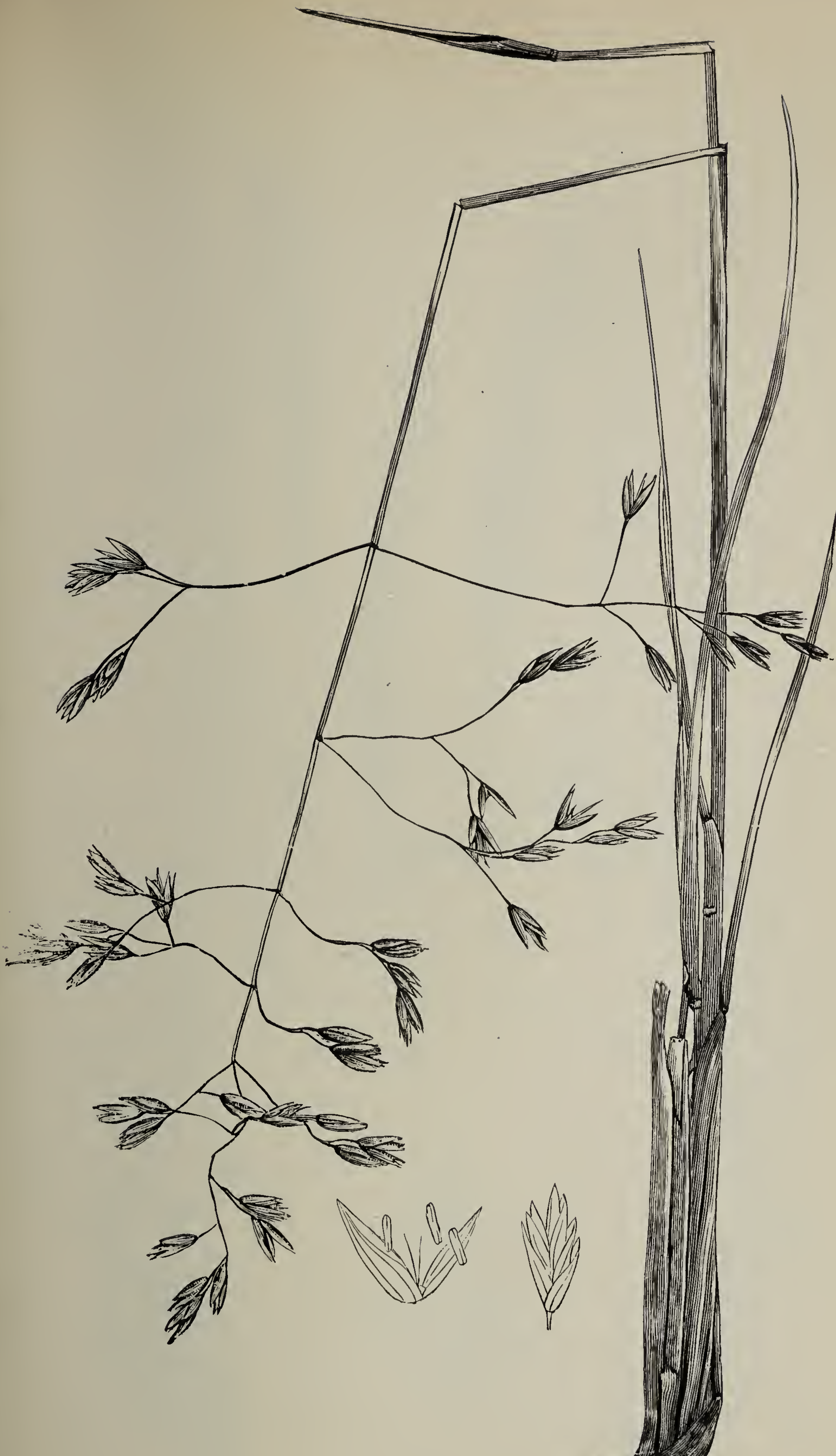
This grass abundant on the prairies and in the mountains. In the higher mountain meadows it makes but small growth. On lower land and along streams it grows vigorously, and in many places is cut for hay. Stockmen speak highly of it.

BOUTELOUA OLIGOSTACHYA. (See page 135.)



BUCHLOE DACTYLOIDES. (See page 136.)

Muhlenbergia Glomerata. (See page 137.)



Festuca Scabrella. (See page 137).

AGROPYRUM GLAUCUM. (See page 138.)

INDEX.

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THE MEASUREMENT AND DIVISION OF WATER.

FORT COLLINS, COLORADO.

OCTOBER, 1890.

Bulletins are free to all persons interested in Agriculture in any of its branches. Address the Director, Fort Collins, Colo.

The Agricultural Experiment Station.

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On the Measurement and Division of Water.

One of the most important as well as one of the most difficult problems of irrigation is that of making a just distribution of water. Therefore, in passing over the lines of ditches with superintendents, from time to time, I have made it the object of special inquiry to find the methods used in measuring or dividing water among the consumers. In many cases, even on important enterprises, there was no attempt, save by the eye; in others the methods varied, from the crudest to others which gave some approach to accuracy. Where water has been plentiful in the streams, or where the ditches had more water than was needed for the consumers under the ditch, there has been no necessity for any close division or measurement, for there has been water to supply the demands of all. But with the greater demand for water, pressure is being brought upon the canal organizations, and many are being led to consider more economical means of distribution and more efficient means of measurement.

The prevention of waste is a matter of public importance. With more land than water, the agricultural future of Colorado will depend on the use of her existing water supply to its fullest capacity. The building of storage reservoirs, the stopping of waste, improved methods in irrigation, together with the changes consequent on irrigation, which makes less water necessary, will increase our water supply in effect, if not in amount.

It is safe to say that a good system of measurement will save a large amount of water, just as a close account of expenditures will make money go farther without wronging any one. Without measurement the practice is necessarily to give the consumer enough to stop complaint. The tendency to improvidence runs to the last consumer, for, if the water is not valuable enough to measure carefully from the canal, what inducement is there for the consumer to prevent waste. With water plentiful, the system—or lack of system—works without much friction. But in time of scarcity it is of great moment that each has no more than he is entitled to. If one man gets more than his share, some one else gets less. And this often means ruin to his crops.

This bulletin is the result of the study of the measuring devices as seen in Colorado and of those used in Italy. It cannot be said that any are free from objection, but some are noticeably better than others. On this subject the experience of Italy is useful. She has the accumulated experience of 600 years of irrigation ; we of thirty. While the progress made here in this time by a people dependent practically upon native wit for their knowledge of irrigation has been marvelous, it is unquestionably true that we may learn much from the experience of other countries. The laws governing the flow of water, the principles involved in distribution and division, are the same here as there. We are finding from our experience the necessity of laws and regulations which they have long had in practice. In other ways our experience is likely to be parallel to theirs. The Italian modules have been various, but most of them based upon one principle, which has been introduced into Colorado under the form of the statute inch. The need for modules being felt before the rise of hydraulic science, these boxes were based upon empirical principles, without the knowledge of the flow of water which we now have. That they have been used so long with even a fair degree of satisfaction reflects great credit upon Soldati and the magistrates of Milan who so firmly grasped the conditions of the problem. That these measures are no longer satisfactory is evidenced by the fact that none of the large modern canals have adopted them. The Cavour Canal, the Canale Casale, the Canale Villoresi have all adopted systems depending upon the weir. The insufficiency of the old measures is further evidenced by the fact that the Italian Government required in one of its acts of concession a proposition for a new module for the measure and sale of water.

The one proposed and adopted by this canal—the Canale Villoresi—will be especially described, because it seems to dispose of some of the difficulties which have made the weir system objectionable.

In the measurement of water there are two distinct classes of measuring boxes, different in their object. One is the dividing box, whose object is to give to each consumer some definite portion of the water flowing in the ditch. This box is found especially in the laterals owned in common by two or three neighbors, or in the smaller canals owned and operated by the stockholders. The other class is the measuring box which has in general for an object to give the consumer a certain definite quantity of water, as one cubic foot per second. These need to be adjustable, so that in times of scarcity the amount may be reduced proportionately as the quantity in the canal decreases. To this last class the Italians give the name of *module.* The French writers on irrigation, and to a limited extent the English, have adopted the word, and, as such a word is needed in our irrigation vocabulary, the term is here used. *Module* will therefore be used to designate those boxes or devices, whatever their form, whose object it is to measure the quantity of water delivered, or to give a constant flow. The word *divisor* will be restricted to the first class, whose only object it is to divide the water. A module may evidently serve as a divisor, for if the amount to be divided is known it is a simple mattter to determine the quantity to which each is entitled and to regulate the module accordingly. There will always be cases where divisors will be by all means the most convenient, but these cases will be mostly in the small ditches from which few take water. In all other cases modules of one kind or another will be found the better.

DIVISORS.

As ordinarily constructed, the division can rarely be exact, but frequently the convenience of an approximate division more than counterbalances any inaccuracy there may be. The larger ditches rarely have occasion to use divisors, for, even if the ditch has to pro rate the water, a better distribution can be effected by means of modules. If the water is to be divided into two equal portions, by placing the two lateral ditches in identical relations to the main ditch, in a straight and uniform channel, the division is exact. Emphasis should be laid on the *identical* relation, for many divisions are seen where the conditions are not the same, as, *e. g.*, one man's ditch may continue straight, the other may make an abrupt turn, one may pass through a covered box, etc. In these cases some advantage will be given to the party having the freer discharge. The effect of these differences is greater than is generally supposed. It is, however, generally easy to fill these conditions if the parties desire. In the same way the water may be subdivided into four, eight or sixteen equal parts. But where it is required to divide the water into two unequal, or into three or more portions, equal or not, the division becomes one of approximation only. The difficulty arises from the fact that the water has not uniform velocity; that near the center has greater velocity than that near the banks. If, therefore, equal openings be made across the current, those near the center have the greater discharge. Making the central openings smaller only partially evades the difficulty, for as the relative velocities of the center and sides differ with different depths, this arrangement would still be inexact for any one depth except that for which the opening is made.

In its most common form the divisor consists of a partition dividing the channel into two portions in proportion to the respective claims. This, in effect, assumes that the velocity is uniform across the whole cross-section, which is not the case, even in a uniform channel, and much less so in one irregular or in poor repair. Such a division is to the disadvantage of the smaller consumer.

The nearer the velocity is uniform across the whole channel the better this method of division, evidently. Accordingly means are frequently taken, by weir-boards or otherwise, with this object in view, but generally with indifferent success. A screen would accomplish this one object better, but the objections to its use are too many in most places to render it practicable. One form often used

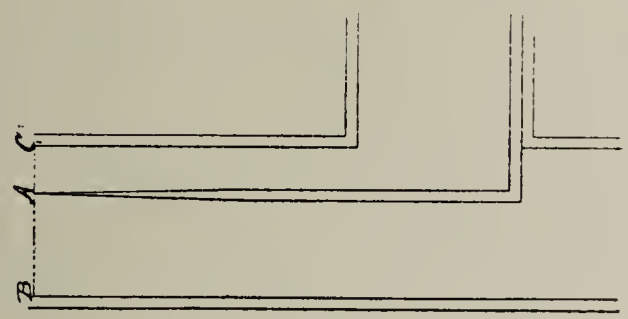

FIG. 1.—A COMMON DIVISOR.

and seen in various places has a movable partition board, A, as in the figure, so that the user who gets his water through L can move A out to some distance, according to the amount of water he needs. A cleat of some kind is generally used to prevent the board being moved beyond a certain distance. The Lariat ditch of the San Luis valley, which is broad and shallow, uses a simple truss across the ditch at the height of the division board and a depending cleat prevents more than a certain movement. In some cases at B C there is put a board, placed vertically, with the edge raised a few inches above the bottom of the channel. This then keeps the channel where the division is made of uniform depth, but it is of little benefit in equalizing the flow.

The latter idea is in some places better developed. The water is brought to a state of approximate rest by a weir-board of some height—8 inches in one seen on the Farmers' Union ditch, San Luis Valley—with a sharp crest on the up-stream side. The partition board extends lengthwise of the ditch and has its upper end sharpened. As the water falls over the weir it flows away in the respective ditches.

If water is brought to a complete state of rest, or very nearly so, and if the water flows over the weir without lateral contraction, this method will give as satisfactory results as any divisors with which I am acquainted. An increase in the size of the ditch just at the division box will aid in bringing the water to rest.

Boxes of this kind were used by Hon. B. S. LaGrange near Greeley as early as 1871.

Since the above was written Aymard's "Irrigation du Midi du l'Espagne" has been received, in which he describes a divisor used at Elche, based on the same principles. It is due to the Moors, and has been in use on this canal since their expulsion from Spain some hundreds of years ago. It differs from the one last described in having two drops instead of one, and in taking more pains with the canal of approach. For 150 or 200 feet above the divisor the canal has a very slight fall, in order that the water may have almost no velocity of approach. The canal is paved for about 10 feet above the divisor. There are two drops about three feet apart, the upper one of 10 inches, the lower one slightly more. The division is made at the upper drop by a movable beak of wood, which may vary the width of the opening or entirely close it. The second drop is for the purpose of producing a constant current away from the point of division.

MODULES.

It is not possible to secure a module satisfactory in every respect. Some may be available in some localities where there is a heavy fall, and not in others where there is no fall to spare.

If a module fulfills the following conditions it may be reputed perfect. All the conditions not marked are essentially the same as those given by Buffon in his "Des Canaux d'Irrigation de l'Italie Septentrionale," Vol. I., p. 445–6 :

*1. Its discharge should be easily converted into absolute measure, *e. g.*, cubic feet per second.

2. Modules intended to give equal discharges should always discharge the same quantities of water in a given time wherever placed.

*3. The ratio indicated by the module to the discharges from two outlets should be the actual ratio.

4. The flow should remain sensibly unaffected by variations in the level of the supplying canal.

5. It should be as reliable with large as with small quantities of water.

6. Any attempt to alter its discharge should leave traces easy to recognize.

7. It should require but a moderate degree of intelligence to use it.

8. Calculation ought not to be necessary to regulate the discharge of different modules or to determine how much they are discharging.

9. It should occupy but small space.

*10. It should require but little fall or expense.

These conditions are evidently not of equal importance, and under different circumstances the weight given to each condition may vary. As water becomes more scarce those relating to accuracy become relatively more important. A module which has been satisfactory may become unsuited when these conditions become more important.

The old Italian modules are mostly based on an orifice of determinate size, with a constant pressure. Our statute inch is such a module. Some are circular, as the *acqua Paola*, but most are rectangular, of various dimensions. Those of the same kind had the same height of orifice and the same pressure. Different amounts were given by giving greater horizontal lenght to the orifice. The *Milanese module*, due to the engineer Soldati, is the most celebrated. The canals of that province having fallen into great disorder, the magistracy of Milan attempted to regulate them, and gave twelve conditions which a module should satisty.† In response to these, Soldati proposed the module which has ever since been known as

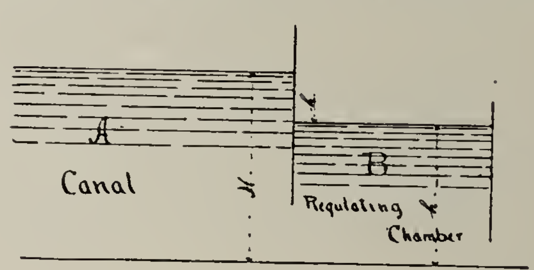

FIG. 2.

the Milanese module. The first thing he considered important was to insure that the water should flow with uniform pressure. This he attempted to do by the following principle:

† NOTE.—The history of this event and the trouble is given in Bruschelti's "Storia del Irrigazioni del Milanese," in his collected works, Vol. II., pp. 118–135, condensed in Buffon. The conditions are all included in those given above.

If two chambers are connected, as in the diagram, the water in the second chamber will be lower than that in the first by an amount depending on the size of the orifices. But the amount the water in the first is above that in the second bears a constant ratio to the depth in the second. Thus, if the depth in B is 6 inches and the water in A is 12 inches deeper, if the water in B becomes 6 inches deeper the excess of A over B would increase by twice 12, or 24 inches. Its depth would then be 36, while before it was 18 inches. Under these circumstances an increase of depth of 18 inches in A causes one-third as much in B.

By means of such a regulating chamber, therefore, the variations in the height of the water in the canal are lessened in the regulating chamber, which is intended to furnish the water under constant pressure. While apparently avoiding the difficulty, this really does not do so. As a matter of fact, the flow *will increase in the same ratio for a given increase in depth of the main channel, whether the orifice comes direct from the main channel or from the regulating chamber, provided it be at the same level.*

The reason is this; The velocity of water flowing from an orifice varies with the square root of the depth, and consequently the discharge for the same opening will vary with the square root of the depth or pressure. While the variation in the regulating chamber is less by considerable than in the main canal, the head is less than it would be if the orifice were pierced at the same level in the canal, in the same ratio. As in the numerical example given, while the pressure in the regulating box doubles, or changes from 6 to 12 inches, that in the canal changes from 18 to 36 inches. In consequence, an orifice in the main canal, at the same level, would change its discharge in the same ratio as one at the lower end of a regulating box.

It follows from this that if such a module is not adjusted from time to time it is of no value as a regulator. This, however, does not take away from its value if properly attended, for it affords a ready means of arranging that the pressure shall be a certain amount. But it should be kept clearly in mind *that unless regulated with every variation in the level of the supplying canal it does not assure a constant flow*, which has been its supposed principal merit. This module consisted essentially of two parts, that already described for attempting to maintain a constant pressure, and other apparatus, so that the water should reach the outlet without velocity. For this purpose a variety of means has been adopted, mostly by varying the chambers in length and breadth, but, according to Baird Smith, the object is very imperfectly accomplished.

This method was used in various Italian units, with openings of different size and shape under different pressures. The units were called "Oncia." No less than ten, some of them circular, are given in Carton and Marcolongo's "Manuale del Ingegnere Agronomo," 1888.

In this State the same principle has been extensively used in the Max Clark box, as it is called, named from its introducer. The box has been extensively used in the older portions of the State, and has fulfilled a useful purpose. It has the same faults as the Milanese module added to the fact that the shortness of the box is such that the movement of the water is imperfectly stopped and cannot but have a great influence on the discharge.

As the term oncia was given to the Italian unit, so the term inch has been used throughout this western country for the corresponding unit. The statutes of Colorado prescribe that water shall be measured through an orifice 6 inches in height, with a pressure of water of 5 inches above the opening, and that the number of inches shall be the same as the number of square inches in the orifice. But the term is not confined to the statute inch. On some ditches water is measured with a pressure of only two inches, on others without any, but the same term is used in all.

An inconvenience which was soon discovered was that the discharge through the Milanese module was not in proportion to the nominal discharge. A person, for instance, drawing 100 inches receives more than ten times one who draws 10. This was so noticeable that it was not long before the discharge from any one orifice was restricted to a certain number of oncia, generally six. The oncia varies from 33 to 47 litres per second, according as the orifice discharges one or six, according to Herrison. The same thing is true of the statute inch of this State—the advantage is entirely in favor of those who draw the large quantities. The reason for this difference comes from the different ratio which the perimeters of the openings bear to the areas in the different cases. For example, one drawing 24 inches has an orifice 4x6 inches, the perimeter is 20 inches. The orifice discharging 96 inches is 16x6 inches, with a perimeter 44. The ratio is less than $\frac{1}{2}$ in the last case, nearly 1 in the first, and friction affects the smaller opening much more than the larger.

There are other causes of variation, as in the distance the opening is above the bottom of the regulating box, in the thickness of the sides, in the manner of its discharge. All of which render this module, excellent as its service has been in the past, inaccurate and unreliable and is leading to its abandonment.

A module based on an entirely different principle is that of the Marseilles canal, one of the most costly in the world, considering the amount of water it carries. The device adopted by them is therefore of some interest, irrespective of the novelty of the plan.

In their module the water enters a hollow vertical cylinder whose upper edge is kept at a constant distance below the surface of the water. The water then flows in with constant pressure. As the level of the water rises or falls the cylinder likewise rises or falls vertically, passing through a water-tight packing. It would seem that the packing required to make the joint water-tight would interfere with its free movement up and down, and thus render the module insensitive. It seems to be used with satisfaction, however. The amount given to different users is regulated by the depth the cylinder is below the water. A simpler device for keeping the orifice a certain distance below the surface was tried on the Montrose canal, in the western part of the State. The orifice rose or fell with the water of the canal, being supported by a float, and was connected with the lateral by a pipe and a flexible joint. The trouble in such an apparatus is to make a joint which shall be water-tight and at the same time flexible enough to be moved by a moderate-sized float when the water rises or falls. If this can be done it would satisfactorily solve the problem of giving a constant flow.

On the Isabella I. canal, of Spain, another form of module has been proposed. Instead of having an orifice at a constant depth as on the Marseilles canal, the orifice varies in size as the head of water changes. With a small depth of water the orifice is large, with a large head it is small. The orifice is made larger or smaller by the water itself. In a circular hole in the bottom of the head of the lateral is a plug of iron, supported by a float. This is roughly conical in shape, with the largest diameter at the bottom. As the water rises in the canal the plug is lifted, partially stopping the orifice by the large diameter. As the water falls the orifice is opened. If the diameters of the plug are properly proportioned—and it is easy to calculate them—this module ought to be a very satisfactory one. It has the disadvantage of requiring a considerable fall, but it avoids the friction which must interfere with the action of the Marseilles module. For a discharge of 1.44 cubic feet per second, generally estimated enough for 80 acres, with a hole 12 inches in diameter, the following would be the diameters for the given depths from the top of the plug:

	Diameter in feet.
3 inches	0.53
6 "	0.70
12 "	0.80
2 feet	0.87
4 "	0.91
9 "	0.94

THE SPILL-BOX OR EXCESS WEIR.

Another means of procuring a constant head is one due to A. D. Foote, of Idaho, recently in charge of the Snake River Division of the Irrigation Survey, a cut of which is given in the *Engineering News* of November, 1886, and more fully described in the transactions of the American Society of Civil Engineers, Vol. XVI.

In fig. 3, A is the main ditch, with a gate forcing a portion of the water through box B. This has a board on the side towards the main ditch, with its upper edge at such a height as to give the required pressure at the orifice. Then if water be forced through B, the amount in excess of this pressure will spill back into the ditch. If the box B is made long enough and the spill-board be sharp edged, nearly all the excess will spill back into the ditch, thus leaving a constant head at the orifice. Mr. Foote gives this the name of excess weir. He constructed one for trial purposes. To Mr. W. H. Graves, of Monte Vista, is due its introduction into use on the large canals, with the necessary modifications. He terms it the spill-box, a more suggestive name than that proposed by Mr. Foote. In use, Mr. Graves constructs a weir in the canal and places the box at one side, always using two if possible, one at each side, to save fall and expense. The spill-box is about 16 feet long, 14 inches wide, set perfectly level. The crest next the canal is brought to a sharp edge, and

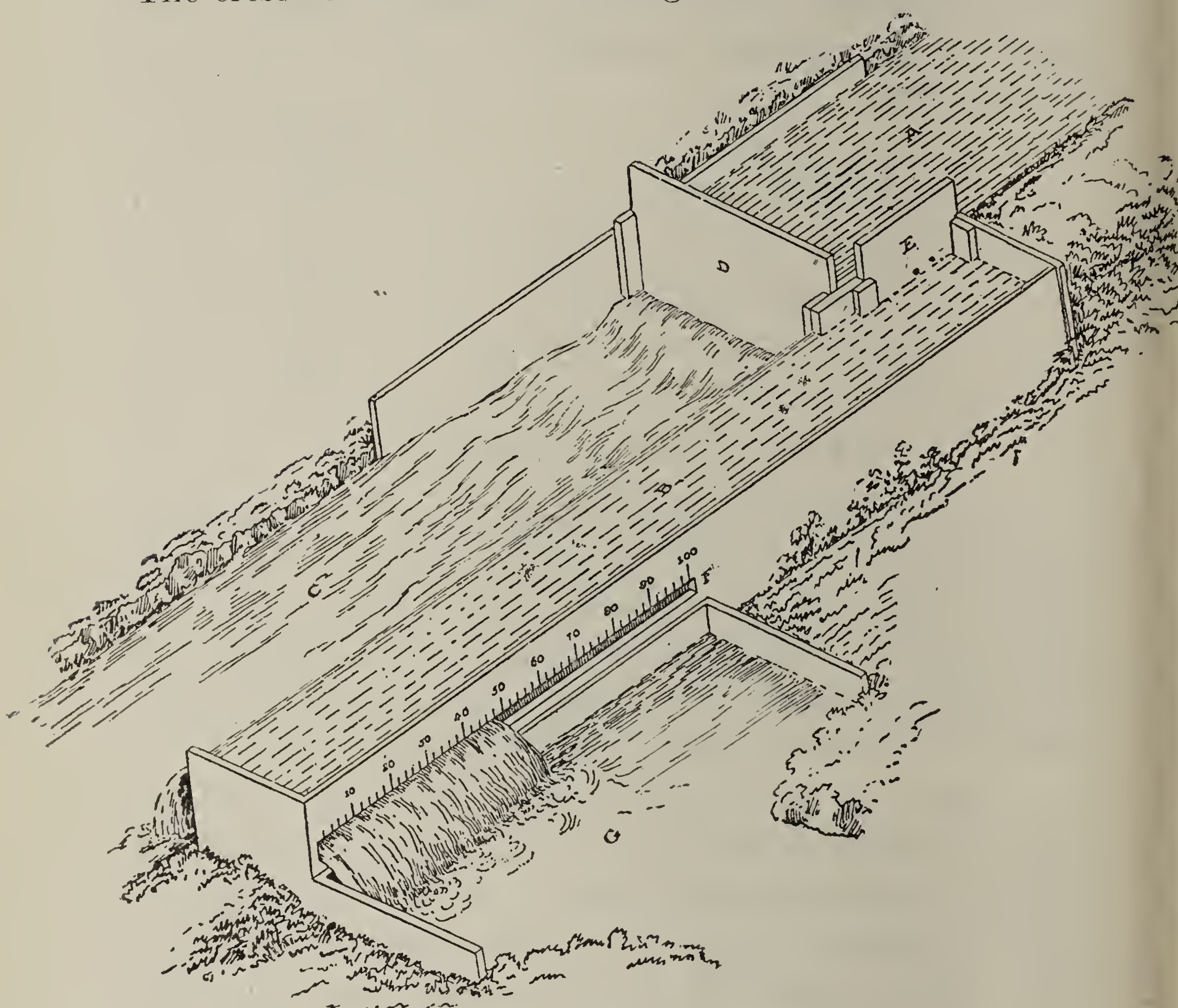

FIG. 3.

so are the 2x4 pieces on that side of the box. The gate for opening the orifice is of galvanized iron, worked by a rod and wing nut from the end of the box, so that it may be adjusted to any desired opening and locked. The side of the opening is protected by strips of galvanized iron, with the double purpose of protecting the orifice from surreptitious enlargement and furnishing a groove for the gate to slide in. Mr. Foote thinks that the main ditch need not lose more than a few inches fall—enough to have the excess spill back. Mr. Graves prefers at least a foot.

These have been introduced on the canals of which Mr. Graves is the Chief Engineer—the Monte Vista or Citizens' canal, the Rio Grande or Del Norte, the Grand River and the Montrose, which include the largest canals in the State. The farmers whom I questioned in the San Luis Valley expressed themselves as perfectly satisfied with its fairness.

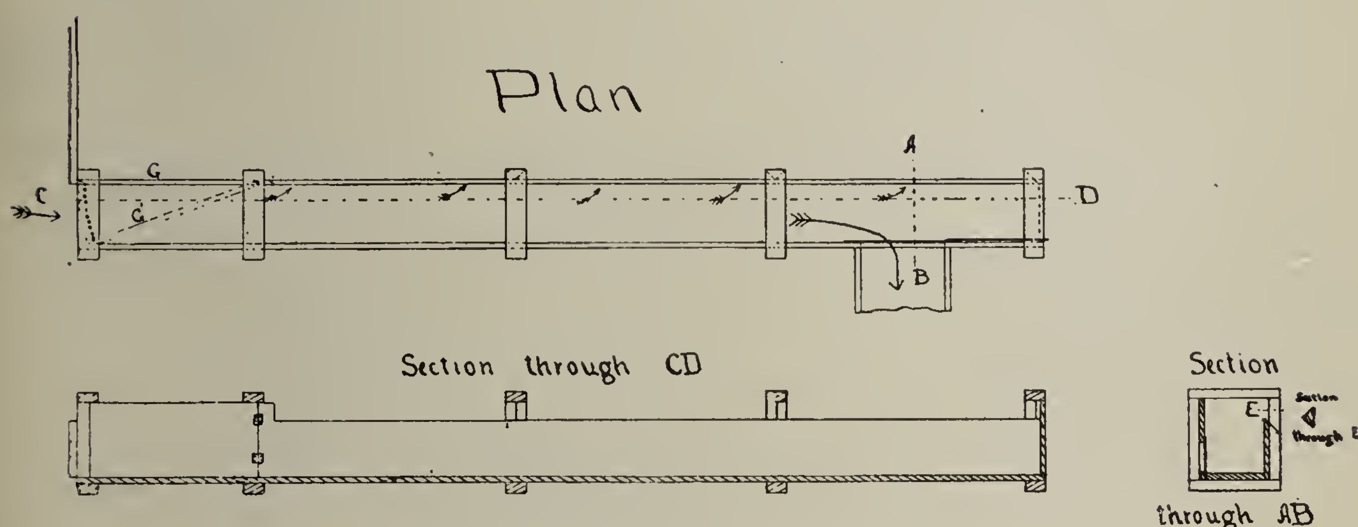

FIG. 4.—PLANS OF THE SPILL-BOX.

C is the entrance of water from the ditch ; G a gate which serves to admit as much water as is desired ; B the outlet furnishing water to the user.

The success of the device for maintaining the head constant is nearly perfect. Under circumstances purposely made unfavorable—when there was a strong head of water in the canal, no regulation of the gate B, and with obstructions so placed on the weir as to force nearly all the water into the upper end of the box—the depth flowing over opposite the orifice was less than two inches. Under normal conditions the variations in head in the box will be very slight and the flow practically constant. When the flow from openings of different sizes are compared, however, besides the difference in favor of the larger user from causes already spoken of, there must be a velocity of approach which being greater as the discharge is greater would again be to the advantage of the large consumer. On a delivery of 100 inches the effect of this velocity would be to increase the amount by some 5 per cent. over that due to the head proper. This could be lessened by proportioning the size of the box to the amount it is expected to discharge.

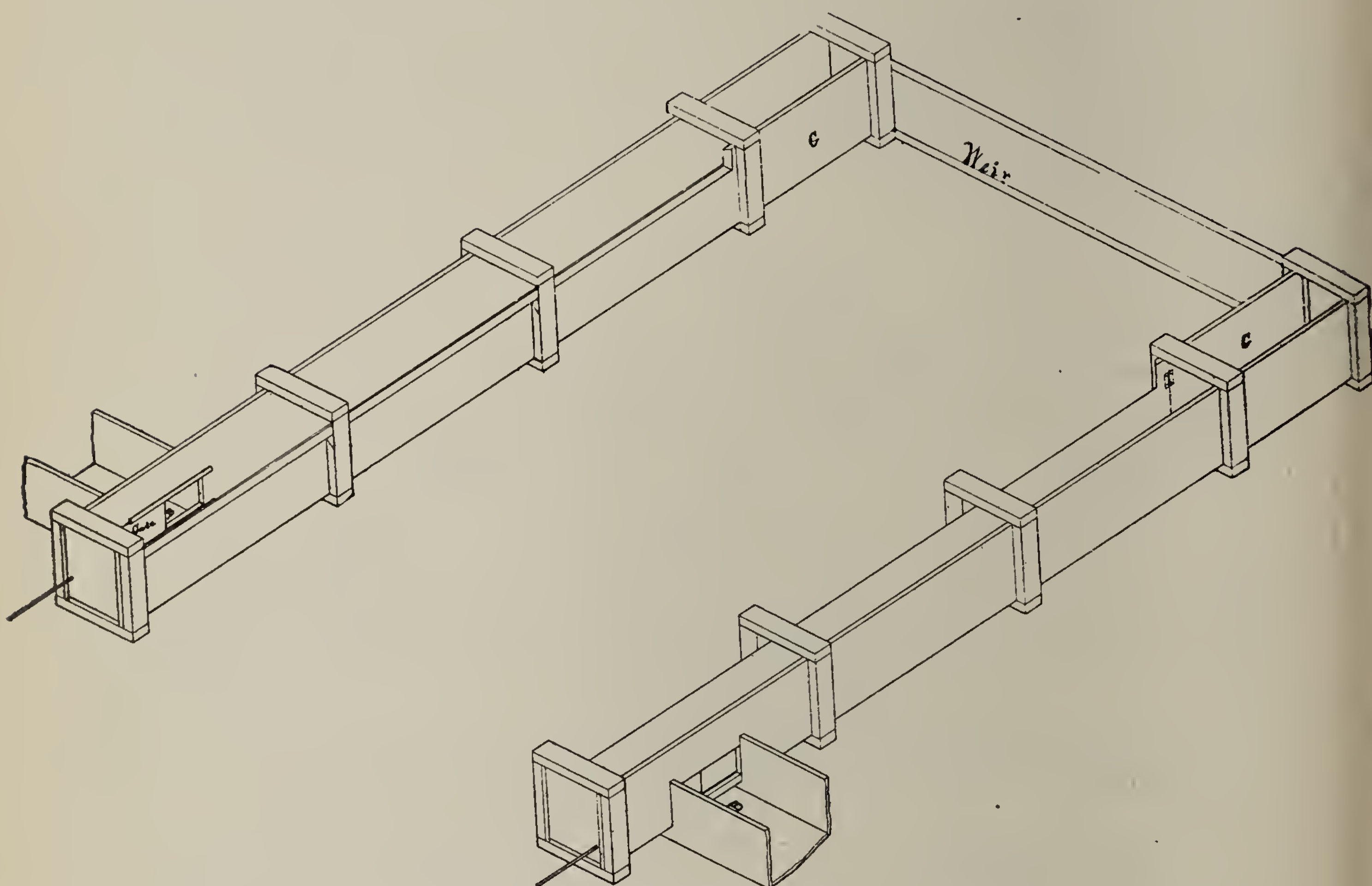

FIG. 5.—THE SPILL-BOX.

(As usually placed, in pairs.)

The weir is placed across the ditch, making the ditch lower below than above, giving opportunity for the water to spill back into the ditch. G is a movable gate to regulate the amount of water admitted at different stages of water in the canal.

Though used on these canals to measure in statute inches, there is no reason why the device should not be used with the weir system, especially of the Villoresi form, shown in fig. 7, and have the superior advantages of the weir.

THE WEIR MODULES.

The form of module which best satisfies the conditions of accuracy is that of the overfall or sharp-crested weir. Other forms might be as accurate, but no other has been subjected to such exhaustive experimental investigation. Besides, its conditions are easily met, so that one may place weirs satisfying these conditions and feel confident that the actual discharge will be close to the calculated.

Because of these facts and the growing importance of accuracy, the coming module will be based upon the weir. It is gradually displacing other types. Australia is using it, exclusively, we think; India, and even in Italy, the originator of most of our measures, the newer canals are using it to the exclusion of the Milanese module. The old canals will probably continue the use of the old module, for rights have become vested in measurement by them, and consumers are jealous of change. A large proportion of the newer canals in Colorado provide that measurement shall be made over a weir. So far as learned no canal has abandoned its use. Cippoletti, who was commissioned by the Canale Villoresi to propose a new module in obedience to the requirement of the Italian Government, says in regard to the weir:

"It is indisputably demonstrated that in weirs with complete contraction, constructed and observed with the necessary accuracy, the *coefficient of contraction remains constant,* and Francis' formula guarantees the exactness of the discharge with an error not greater than *one-half of one per cent.* for depths of water from 3 to 24 inches; providing the length of the weir is not less than three—or better yet, four—times the depth of water flowing over the weir." (Cippoletti, Canale Villoresi Module per la dispensa delle acqua, Milano, 1886, p. 35.)

Cippoletti would, however, use a slightly different coefficient.

The weir is worthy of special attention. Two forms will be considered and tables given for their discharge—the rectangular weir, whose sides are vertical, which is the one ordinarily meant when weir is spoken of, and the one which has been the subject of experiment; and the trapezoidal weir proposed by Cippoletti, after a thorough investigation. Its sides are inclined at a slope of one-fourth horizontal to one vertical.

WEIRS.

The most complete experimental investigation of the flow of water over weirs was made by an American, J. B. Francis, of Lowell, Mass. At that point were located a number of manufacturing enterprises drawing their water from the Merrimac River, with a combined capital of over thirteen millions of dollars. It became necessary to determine more definite measurement of the water, and Francis' experiments were instituted for this purpose. Carried on with all the appliances and conveniences which the capital interested would warrant, the experiments were performed with such care and such attention to minute sources of error that they are above criticism.

One difficulty in such experiments is to obtain a suitable basin in which to measure the water. In this case Francis was fortunate in having one suitable in the Lower Locks, into which the water could be deflected at will after passing the weir. The lock was carefully prepared. Cracks were filled, leaks stopped, even the depressions about nail heads cemented up. The remaining leakage was ascertained by experiment. The slight increase in capacity due to bulging when full was ascertained. The total capacity of the basin when 9½ feet deep was over 12,000 cubic feet.

A preliminary set of experiments was made for determining the proper form of the equation, and after this was determined the main experiments were devoted to finding the value of the coefficient of the formula. The formula indicated by his experiments has since been standard within the limits indicated by him. If one observes the flow of water through an orifice he will observe that the stream becomes narrower, or is subject to lateral contraction. If over a weir, the sheet of water becomes thinner immediately below the crest, as in fig. 6, or is subject to a vertical contraction. By taking separate account of these two contractions Francis succeeded better than previous experimenters in producing a formula which represented the discharge. The form of the equa-

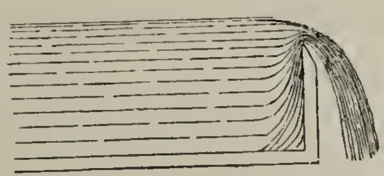

FIG. 6.

tion indicated by theory and agreeing closely with Francis' experiments is of the form,

$$Q = a \, L \, H^{\frac{3}{2}}$$

Where Q = the quantity of water flowing in cubic feet per second, L = the effective length of the weir in feet. This is not necessarily the same as the actual length of the weir.

H = the depth of water flowing over the weir in feet. Because of the contraction shown in fig. 6, this must be measured far enough from the weir to be free from its influence. If the water approaches with a current this depth needs to be increased by a correction indicated by theory. This correction is troublesome to make. In practice it is better to so reduce the velocity of the current that the correction may be neglected.

a is a numerical coefficient which is needed to multiply the result obtained by the indicated operations in the measured quantities, in order to give Q the discharge.

From his experiments Francis adopted for this coefficient the value, $a = 3.33$; though 10-3 would agree more closely with his results, and it seems to the writer to be more convenient for calculation.

The formula of Francis then becomes

$$Q = 3.33\ L\ H^{\frac{3}{2}}$$

where the letters mean the same as in the formula on the previous page, and with the same restrictions.

END CONTRACTION.

An additional word needs to be said regarding L, the effective length of the weir. The contraction of the stream passing over the weir has already been mentioned. The contraction is said to be complete when the sides and walls are so far away as not to affect it; incomplete when so affected, or no contraction, as when the weir is in the lower end of the flume and extends the whole width.

The contraction should be complete or none at all.

If no contraction the full measured length of the weir is used.

If complete, the length of the weir is diminished by one-tenth of the depth for each contraction. The contractions usually occur in pairs, one on each side of the opening. If the opening be broken into two parts or bays there may be four contractions. Thus, in Series A of Francis' experiments, given on page 24, the length of the weir being 10 feet and the depth 1.56 feet, the two contractions reduce the length by 2-10 of 1.56 feet, the depth, or 0.31 feet. L, the effective length to be used in the calculation, is then 9.69 instead of 10 feet.

It is best to have complete contraction, the conditions of securing which are given in Nos. 4 and 5 of the following conditions. While it is generally believed that this formula is accurate, it is not so generally understood that it is safe to apply it only within the conditions of the experiments on which it is based.

CONDITIONS OF THE RECTANGULAR WEIR.

If the weir be placed so as to meet the following conditions, the formula above given and the tables attached to this bulletin, may be used with confidence that the result is correct within 1 per cent:

First—That the water shall not exceed 24 nor be less than 6 inches in depth. Experiments subsequent show that it is practically safe to 3 inches.

Second—That the depth of water on the crest shall not be more than one-third the length of the weir.

Third—The crest of the weir itself should be horizontal; the sides vertical; with both crest and sides brought to a sharp edge on the up-stream face. The least rounding increases the discharge. The up-stream face should be vertical.

It is also necessary to secure:

Complete contraction.
Free discharge.
And the approach of water to the weir without perceptible velocity, cross currents or eddies.

Hence the following additional conditions:

Fourth—The distance from the side walls to the crest should be at least equal to the depth on the weir, in order to secure contraction.

Fifth—The distance of the crest above the bottom of the channel should be at least twice the depth of the water flowing over it, in order to avoid the effect of the bottom on the crest contraction.

Sixth—The air must have free access under the falling sheet.

Seventh—The approaching channel should be made much larger than the weir opening, to bring the velocity of approach within low limits.

A fuller consideration of the proper conditions and the effects of their neglect is given with the Villoresi module on page 27. These apply equally well to the rectangular weir. The experimental foundation of the formula is shown in the following

ABSTRACT OF FRANCIS' EXPERIMENTS ON WEIRS.

[Depth has in all cases been corrected for velocity. Supply canal 14 feet wide.]

Serial No.	Depth of Water on Weir in Feet.	Coefficient for the Experiments.	Length of Weir, ft.	No. Contractions.	COMMENTS.
1–4	1.56	3.318	10	2	SERIES A. Crest of weir is 5 feet above bottom of channel of approach.
5–10	1.25	3.334	10	2	
11–33	1.00	3.322	10	2	
56–61	0.80	3.325	10	2	
72–78	0.62	3.328	10	2	
36–43	1.06	3.353	10	2	SERIES B. Same as A except that crest is only 2 feet above bottom of channel.
62–66	0.83	3.340	10	2	
79–84	0.65	3.326	10	2	
44–50	0.98	3.341	10	0	SERIES C. Canal made same width as weir, suppressing contraction, otherwise as in A.
67–71	0.80	3.339	10	0	
51–5	1.00	3.327	10	0	SERIES D. Water cannot expand after passing weir.
34–5	1.02	3.360	8	4	SERIES E. Water 5′ deep.
85–8	0.68	3.337	8	4	Water 2′ deep. Two bays, separated by partition 2′ wide, giving 4 contractions.

Series C and D correspond to weirs erected in flumes, C at the lower end, D in the middle, each of full width of flume.

As a general thing, the coefficients increase slightly as the depth decreases, so that for small depths, less than three inches, the discharge will generally exceed the computed amount by one or two per cent.

A table giving the discharge for different depths over weirs of various lengths is given in the appendix, which will be useful to those already using this system.

THE CIPPOLETTI OR CANALE VILLORESI MODULE.

A module based on the same principles and experiments, but differing in shape, is the module of the Canale Villoresi. The Canale Villoresi—so named from the engineer who projected it—is the latest great Italian canal. Constructed in 1881–4, it waters some 65,000 ettare, or 160,000 acres, between the Ticino and Adda rivers. So important a public benefit did the project seem to be, that the Provincial Council of Milan voted the money to construct it. Its cost was fully one fourth as much as all the canals in Colorado to-day. The various modules in use had long been unsatisfactory, principally, according to Herrisson, for the reason that they favored the large users.

In the act of concession, the government imposed the condition of proposing a module for the measurement and sale of water. The government required that it should be founded on the theory of the weir with free fall, and that it should give ample guarantees of security and accuracy. The problem was put in the able hands of Cesare Cippoletti, the director of the works. Much of the following is condensed from his work: "Canale Villoresi; Modulo per la Dispensa delle Acqua, etc., Milan, 1886," published by the direction of the Societa Italiana per Condotte d'Acqua. The problem Cippoletti proposed to himself was, while preserving the simple and convenient form of the formula of Francis, and a constant coefficient, to determine the form and conditions of a weir such that no single cause would produce more than one half of one per cent. error between the actual discharge and that given by the formula.

His investigations were based principally upon the experiments of Francis, supplemented in certain directions by some of his own.

His work is interesting and valuable, from the thorough study he has given to the various disturbing causes, and the means of lessening their effect.

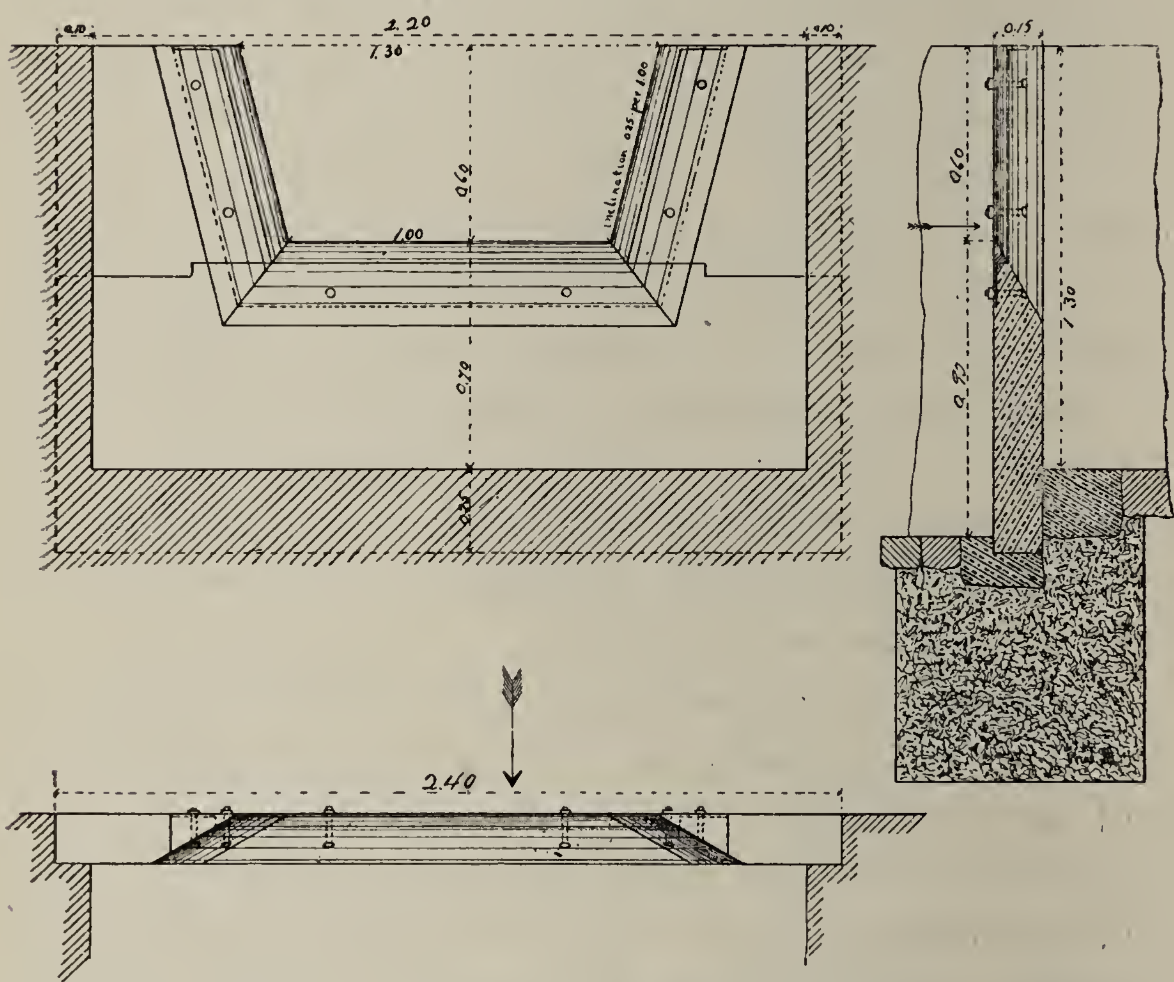

FIG. 7.—THE VILLORESI OR CIPPOLETTI TRAPEZOIDAL MODULE.
The dimensions are given in decimals, with the length of the sill as the unit.

The effective length of the rectangular weir, as already noted, becomes less as the depth of water becomes greater. Also, the effective length of two weirs is not in the ratio of their lengths. These facts form objections to the rectangular weir.

Cippoletti's improvement consists principally in automatically overcoming, by the shape of the opening, this contraction, so that the effective length of the same weir remains the same, and the discharge from two weirs for the same depth will be in the ratio of their lengths—one twice as long discharging twice as much.

The weir which he adopted is of the trapezoidal shape, the sides being inclined at one-fourth horizontal to one vertical, as shown in fig. 7. This inclination was adopted from theoretical and experimental considerations, so that with complete contraction the added area of the triangles would just make up for the contraction; consequently the discharge through the weir would be the same as through the rectangular weir of the same length, but without contraction. The actual length of the weir is therefore used, and simplifies calculations very much.

The conditions Cippoletti attempted to meet, then, were:

1. To place the weir in such condition that all causes affecting its discharge shall not cause an error greater than one-half per cent.

2. To eliminate automatically the lateral contraction, so as to preserve the simple formula:

$$Q = a\ L\ H^{\frac{3}{2}}.$$

(a) with the coefficient a, constant for all depths
(b) and so that the discharge shall be rigorously proportioned to the length of the weir.

In order that no cause shall produce an error greater than one-half per cent., it is necessary:

1. That the weir be preceded by a straight channel of constant cross-section, with its axis passing through the middle of the weir, and perpendicular to it; this straight reach to be of such length that the water goes

with uniform velocity without internal agitation or eddies. In ordinary cases fifty or sixty feet is sufficient.

2. Only by making the contraction complete in the whole perimeter can a definite value of the numerical coefficient not subject to doubt be attained, and for this it is necessary,

(*a*) that the opening of the weir be made in a plane surface, perpendicular to the course of the water;

(*b*) that the opening itself have a sharp edge on the up-stream face, and the walls cut away so that their thickness at the point of discharge shall not be above 1-10 the depth for depths below 5 inches, nor above $\frac{1}{4}$ the depth for depths from 5 to 24 inches;

(*c*) that the distance of the sill of the weir from the bottom of the canal be at least three times the depth on the weir, and at least twice the depth on the weir from the sides;

(*d*) that the lateral contraction remaining undisturbed, the length of the weir shall be three, or better four, times the depth of the water;

(*e*) that the depth of water flowing over the weir shall not be less than 3 inches.

3. The velocity of approach must be very small; for weirs one meter (40 in.) long and depth of 12 inches it ought not to be greater than 6 inches per second; for weirs of two meters ($6\frac{1}{2}$ ft.) long and depth of 24 inches it ought not to be above 8 inches per second. In all these cases the cross-section of the canal of approach ought to be at least seven times that of the weir. For the other conditions, if *c* and *d* of No. 2 be fulfilled, they are also in the present case.

4. The layer of falling water should be perfectly free from the walls below the weir, in order that air may freely circulate underneath. For short weirs it is sufficient that the lateral walls of the lower canal be free

from the sides of the weir. The level of the water in the lower canal has no influence on the discharge of the weir, unless it may reach the plane of the sill.

5. The depth of the water should be measured with accuracy where the suction of the flow does not affect the height and where it is free from influences which can affect the true level of the water, as the wind or the movement of the water. The height should be read to within 1-300 of the depth in order that the error may be within $\frac{1}{2}$ per cent.

6. The weir ought to be constructed with care and carefully located. It should not vary more than 4° from being perpendicular to the channel. Its sill should be horizontal.

Effect of Disturbing Causes.

All the disturbing causes may be divided into three categories: First—Those which may increase or decrease the discharge. Second—Those which always tend to increase the discharge. Third—Those which always tend to decrease the discharge.

The height of water measured may be too great or small, and, as it is as likely to be one as the other, the errors due to this may be neglected.

The effect of obliquity of the weir, or eddies, is to decrease the flow.

Velocity of approach, nearness of sides and bottom to the crest, of incomplete contraction, of a crest not perfectly sharp, of air not having free access beneath the sheet of falling water, etc.—the effect of each of these is to increase the discharge.

The causes tending to increase the discharge evidently outnumber those decreasing it, and are, all things being taken into account, more difficult to overcome. The combined effect of all taken together is evidently to increase the discharge; Cippoletti therefore increases Francis' coefficient by 1 per cent. to allow for the preponderance of accidental causes increasing the discharge, thus making the equation become

$$Q = 3.36\tfrac{2}{3}\ L\ H^{\frac{3}{2}}$$

where Q, L, H, represent the same quantities as on page 21, except that L is here the actual length of the weir.

This form seems to possess some very advantageous qualities, rendering it much more simple in use than the rectangular weir and dispensing with some of the objections which have not rendered the weir popular. The effective length to be used in calculation is the same for all depths, while in the rectangular weir, with complete contraction, every change in depth alters the effective length and makes the calculation inconvenient and laborious. The discharge also being in proportion to the length, very nearly, makes it convenient for application with such a device as the spill-box, where the opening may be made of this form instead of that used by Graves. Then, if one person is entitled to one-half as much as another, the sill may be made half as long, or a moveable gate may reduce the width with an error probably very small, and if any error it is in favor of the smaller user.

The amount of water available and our apparatus at present available for testing the flow of water is not sufficient to test this to any great extent. The flow over 6-inch and 12-inch weirs has been measured. These seem to indicate that the correction to Francis' formula for these lengths would be nearer 2 than 1 per cent. It would be less for larger weirs. The experiments are sufficient to show that the Cippoletti weir may be used under the conditions stated, with confidence that the error will not be likely to exceed 1 per cent.

One difficulty which arises in the use of the Cippoletti form, as well as the rectangular weir, in muddy waters, is the sediment which may deposit in the still water in front of the weir-board, but this in most places will not be a serious difficulty.

While this module cannot be said to be free from objection or disadvantages, it seems to possess the most merits of any known to the writer at present.

A table follows giving the discharges over various weirs of the Cippoletti form. It will be noticed that the discharge over the two-foot weir is twice that over the one-foot for the same depth, and that in general the discharge is in proportion to the length.

TABLES OF DISCHARGE.

In the following tables of discharge over rectangular weirs and over trapezoidal weirs of the Cippoletti form, the tables hold true, with but small error, for weirs placed so as to satisfy the conditions given on page 27.

For that portion of the table printed in bold-faced type, the difference between the actual and calculated discharges will not be likely to exceed 1 per cent.

For small depths the actual discharge may exceed the amount here given by 2 to 5 per cent.

L. G. CARPENTER.

DISCHARGE OVER CIPOLETTI'S TRAPEZOIDAL WEIRS OF VARIOUS LENGTHS AND WITH VARIOUS DEPTHS.

$$\text{Formula, } D = 3.3\tfrac{2}{3}\, L\, H^{\frac{3}{2}}.$$

Depth of water on crest.		DISCHARGE IN CUBIC FEET PER SECOND OVER WEIR.						
In Ins.	In Feet.	1 ft. Long.	1½ ft. Long.	2 ft. Long.	3 ft. Long.	4 ft. Long.	5 ft. Long.	10 ft. Long.
.3	.025	.0135	.0202	.0269	.0404	.0539	.0673	.1347
.6	.05	.0377	.0566	.0754	.1131	.1508	.1885	.3771
.9	.075	.0690	.1035	.1380	.2071	.2761	.3451	.6902
1.2	.10	.1064	.1596	.2128	.3192	.4256	.5319	1.0639
1.5	.125	.1488	.2232	.2976	.4464	.5952	.7440	1.4881
1.8	.15	.1956	.2934	.3912	.5868	.7824	.9780	1.9560
2.1	.175	.2464	.3697	.4929	.7393	.9858	1.2322	2.4644
2.4	.20	.3010	.4515	.6020	.9029	1.2039	1.5049	3.0098
2.7	.225	.3592	.5388	.7184	1.0777	1.4369	1.7961	3.5922
3.0	.25	.4208	.6312	.8417	1.2625	1.6833	2.1041	4.2083
3.3	.275	.4855	.7282	.9709	1.4564	1.9419	2.4273	4.8547
3.6	.30	.5531	.8297	1.1063	1.6594	2.2126	2.7657	5.5314
3.9	.325	.6238	.9358	1.2477	1.8715	2.4954	3.1192	6.2384
4.2	.35	.6972	1.0459	1.3945	2.0917	2.7890	3.4862	6.9724
4.5	.375	.7730	1.1595	1.5460	2.3190	3.0920	3.8649	7.7299
4.8	.40	....	1.2777	1.7035	2.5553	3.4071	4.2588	8.5177
5.1	.425	....	1.3993	1.8658	2.7987	3.7316	4.6645	9.3290
5.4	.45	....	1.5246	2.0328	3.0492	4.0656	5.0820	10.1640
5.7	.475	....	1.6534	2.2045	3.3067	4.4089	5.5112	11.0225
6.0	.50	....	1.7854	2.3805	3.5708	4.7610	5.9512	11.9025
6.3	.525	....	1.9210	2.5614	3.8420	5.1227	6.4034	12.8068
6.6	.55	....	2.0599	2.7465	4.1198	5.4930	6.8663	13.7326
6.9	.575	....	2.2018	2.9357	4.4036	5.8715	7.3393	14.6787
7.2	.60	....	2.3472	3.1293	4.6939	6.2585	7.8231	15.6463
7.5	.625	....	2.4955	3.3274	4.9911	6.6548	8.3185	16.6370
7.8	.65	....	2.6462	3.5283	5.2924	7.0565	8.8206	17.6413
8.1	.675	....	2.8007	3.7343	5.6014	7.4686	9.3357	18.6715

DISCHARGE OVER TRAPEZOIDAL WEIRS—Continued.

Depth of water on crest.		Discharge in cubic feet per second over weir.					
In Ins.	In Feet.	2 ft. Long.	3 ft. Long.	4 ft. Long.	5 ft. Long.	7 ft. Long.	10 ft. Long.
8.4	.70	3.9437	5.9156	7.8874	9.8593	13.8030	19.7186
8.7	.725	4.1565	6.2347	8.2930	10.3912	14.5477	20.7824
9.0	.75	4.3733	6.5599	8.7466	10.9332	15.3065	21.8665
9.3	.775	4.5942	6.8912	9.1883	11.4854	16.0796	22.9708
9.6	.80	4.8177	7.2265	9.6354	12.0442	16.8619	24.0885
9.9	.825	5.0453	7.5679	10.0906	12.6132	17.6585	25.2264
10.2	.85	......	7.9154	10.5738	13.1923	18.4692	26.3846
10.5	.875	......	8.2669	11.0225	13.7781	19.2893	27.5562
10.8	.90	......	8.6234	11.4973	14.3723	20.1212	28.7446
11.1	.925	......	8.9850	11.9800	14.9749	20.9649	29.9499
11.4	.95	......	9.3516	12.4688	15.5860	21.8204	31.1720
11.7	.975	......	9.7233	12.9644	16.2054	22.6876	32.4019
12.0	1.00	......	10.1000	13.5667	16.8333	23.5667	33.6667
12.3	1.025	......	10.4808	13.9744	17.4679	24.4551	34.9359
12.6	1.05	......	10.8666	14.4888	18.1110	25.3554	36.2220
12.9	1.075	......	11.2575	15.0100	18.7624	26.2674	37.5249
13.2	1.10	......	11.6524	15.5365	19.4206	27.1888	38.8412
13.5	1.125	......	12.0513	16.0684	20.0855	28.1198	40.1711
13.8	1.115	......	12.4553	16.6071	20.7588	29.0624	41.5177
14.1	1.175	......	12.8644	17.1525	21.4406	30.0168	42.8812
14.4	1.2	......	13.2764	17.7019	22.1274	30.9784	44.2548
14.7	1.225	......	13.6936	18.2581	22.8226	31.9517	45.6453
15.0	1.25	......	14.1148	18.8197	23.5246	32.9344	47.0492
15.3	1.275	......	14.5410	19.3880	24.2349	33.9289	48.4699
15.6	1.3	......	......	19.9603	24.9503	34.9305	49.9007
15.9	1.325	......	......	20.5394	25.6742	35.9439	51.3484
16.2	1.35	......	......	21.1238	26.4047	36.9666	52.8095
16.5	1.375	......	......	21.7123	27.1404	37.9966	54.2808
16.8	1.4	......	......	22.3075	27.8844	39.0382	55.7688
17.1	1.425	......	......	22.9082	28.6352	40.0893	57.2704
17.4	1.45	......	......	23.5128	29.3910	41.1474	58.7820
17.7	1.475	......	......	24.1242	30.1552	42.2178	60.3105

DISCHARGE OVER TRAPEZOIDAL WEIRS.—Continued.

Depth of water on crest.		DISCHARGE IN CUBIC FEET PER SECOND OVER WEIR.			
In Inches.	In Feet.	4 ft. Long.	5 ft. Long.	7 ft. Long.	10 ft. Long.
18.0	1.5	24.7396	30.9245	43.2943	61.8490
18.3	1.525	25.3604	31.7005	44.3808	63.4011
18 6	1.55	25.9866	32.4833	45.4766	64.9666
18.9	1.575	26.6182	33.2727	46.5818	66.5455
19.2	1.6	....	34.0685	47.6959	68.1870
19.5	1.625	....	34.8702	48.8183	69.7405
19.8	1.65	....	35.6782	49.9495	71.3565
20.1	1.675	....	36.4913	51.0878	72.9826
20.4	1.7	....	37.3111	52.2355	74.6222
20.7	1.725	....	38.1376	53.3926	76.2752
21.0	1.75	....	38.9691	54.5568	77.9383
21.3	1.775	....	39.8074	55.7304	79.6149
21.6	1.8	....	40.6515	56.9121	81.3030
21.9	1.825	....	41.5009	58.1013	83.0018
22.2	1.85	....	42.3577	59.3008	84.7154
22.5	1.875	....	43.2179	60.5031	86.4358
22.8	1.9	....	....	61.7211	88.1730
23.1	1.925	....	....	62.9442	89.9203
23.4	1.95	....	....	64.1720	91.6743
23.7	1.975	....	....	65.4116	93.4452
24.0	2.0	....	....	66.6560	95.2228
25.5	2.125	....	....	72.999	104.285
27.0	2.25	....	....	79.541	113.63
28.8	2.4	....	....	87.619	125.17
30.0	2.5	....	....	93.156	133.08

DISCHARGE OVER RECTANGULAR WEIRS OF VARIOUS LENGTHS AND WITH VARIOUS DEPTHS OF WATER, WITH COMPLETE CONTRACTION.

Formula, $D = 3\frac{1}{3}\,(l - .2H)\,^{\frac{3}{2}}.$

Depth of Water on Crest.		DISCHARGE IN CUBIC FEET PER SECOND.						
		With two Complete Contractions.						Correction to be *added* to each of the preceding to give discharge with *no* contraction.
In Inches.	In Feet.	1 ft. Long.	1½ ft. Long.	2 ft. Long.	3 ft. Long.	5 ft. Long.	10 ft. Long.	
0.3	.025	.0133	.0200	.0267	.0400	.0677	.133	.0000
0.6	.050	.0369	.0556	.0743	.1116	.1863	.3726	.0001
0.9	.075	.0674	.1015	.1350	.2040	.3410	.6830	.0010
1.2	.1	.1033	.1550	.2078	.3132	.5240	1.0519	.0021
1.5	.125	.1438	.2175	.2912	.4385	.7332	1.4695	.0037
1.8	.15	.1879	.2817	.3816	.5743	.9627	1.9312	.0058
2.1	.175	.2355	.3575	.4795	.7235	1.2115	2.4315	.0085
2.4	.2	.2861	.4352	.5843	.8824	1.4787	2.9690	.0119
2.7	.225	.3399	.5177	.6956	1.0513	1.7627	3.5412	.0160
3.0	.25	.3959	.6042	.9126	1.2293	2.0227	4.1462	.0208
3.3	.275	.4543	.6946	.9350	1.4157	2.3771	4.7803	.0264
3.6	.3	.5149	.7287	1.0725	1.6103	2.7057	5.4441	.0328
3.9	.325	.5775	.8863	1.1952	1.8129	3.0488	6.1368	.0401
4.2	.35	.6420	.9871	1.3423	2.0226	3.4032	6.8547	.0483
4.5	.375	.7079	1.0905	1.4732	2.2385	3.7691	7.5956	.0574
4.8	.4	....	1.1974	1.6160	2.4623	4.1489	8.3655	.0674
5.1	.425	....	1.3070	1.7689	2.6926	4.5400	9.1585	.0785
5.4	.45	....	1.4189	1.9221	2.9874	4.9410	9.9725	.0905
5.7	.475	....	1.5333	2.0790	3.1703	5.3529	10.8094	.1036
6.0	.5	....	1.6500	2.2392	3.4177	5.7748	11.6672	.1178
6.3	.525	....	1.7689	2.4029	3.6709	6.2069	12.5469	.1331
6.6	.55	....	1.8899	2.5698	3.9295	6.6489	13.4474	.1496
6.9	.575	....	2.0129	2.7395	4.1928	7.0995	14.3658	.1671
7.2	.6	....	2.1381	2.9128	4.4621	7.5607	15.3072	.1859
7.5	.625	....	2.2646	3.0881	4.7351	8.0291	16.2641	.2059
7.8	.65	....	2.3929	3.2663	5.0130	8.5064	17.2399	.2271
8.1	.675	....	2.5234	3.3478	5.2965	8.9939	18.2374	.2496

DISCHARGE OVER RECTANGULAR WEIRS.—Continued.

Depth of Water on Crest.		DISCHARGE IN CUBIC FEET PER SECOND.				
		With Two Complete Contractions.				Correction to be *added* to each of the preceding to give discharge with *no* contraction.
In Inches.	In Feet.	2 ft. Long.	3 ft. Long.	5 ft. Long.	10 ft. Long.	
8.4	.7	3.6313	5.5536	9.4882	19.2497	.2733
8.7	.725	3.8170	5.7747	9.9801	20.2786	.2984
9.0	.75	4.0052	6.1702	10.5002	21.3252	3248
9.3	.775	4.1961	6.4704	11.0190	22.3905	.3525
9.6	.8	4.3884	6.7734	11.5434	23.4684	.3816
9.9	.825	4.5833	7.0810	12.0764	24.5649	.4121
10.2	.85	4.7806	7.3929	12.6175	25.6780	.4410
10.5	.875	4.9792	7.7075	13.1641	26.8056	.4774
10.8	.9	....	8.0257	13.7177	27.9477	.5123
11.1	.925	....	8.3473	14.2779	29.1044	.5483
11.4	.95	....	8.6725	14.8451	30.2766	.5864
11.7	.975	....	9.0012	15.4192	31.4642	.6258
12.	1.0	....	9.3333	16.0000	32.6667	.6637
12.3	1.025	....	9.6679	16.5859	33.8809	.7091
12.6	1.05	....	10.0058	17.1784	35.1099	.7531
12.9	1.075	....	10.3471	17.7777	36.3532	.7988
13.2	1.1	....	10.6890	18.3825	37.6110	.8460
13.5	1.125	....	11.0370	18.9916	38.9731	.8949
13.8	1.150	....	11.3863	19.5080	40.1615	.9455
14.1	1.175	....	11.7396	20.2303	41.4573	.9977
14.4	1.2	....	12.0935	20.8569	42.7654	1.0516
14.7	1.225	....	12.4507	21.4893	44.0358	1.1072
15.	1.25	....	12.8103	22.1269	45.4184	1.1645
15.3	1.275	....	13.1733	22.7713	46.7663	1.2237
15.6	1.3	....	13.5375	23.4189	48.1224	1.2846
15.9	1.325	....	13.9047	24.0727	49.4927	1.3473
16.2	1.35	....	14.2744	24.7318	50.8753	1.4117
16.5	1.375	....	14.6450	25.3936	52.2651	1.4779

DISCHARGE OVER RECTANGULAR WEIRS.—Continued.

Depth of Water on Crest.		DISCHARGE IN CUBIC FEET PER SECOND.		
		With Two Complete Contractions.		Correction to be *added* to each of the preceding to give discharge with *no* contraction.
In Inches.	In Feet.	5 ft. Long.	10 ft. Long.	
16.8	1.4	26.0625	53.6710	1.5460
17.1	1.425	26.6355	55.0870	1.6160
17.4	1.45	27.4122	56.5122	1.6878
17.7	1.475	28.0950	57.9515	1.7615
18.	1.5	28.7814	59.3999	1.8371
18.3	1.525	29.4719	60.8584	1.9146
18.6	1.55	30.1675	62.3290	1.9940
18.9	1.575	30.8681	63.8116	2.0754
19.2	1.6	31.5727	65.3042	2.1588
19.5	1.625	32.2809	66.8059	2.2441
19.8	1.650	32.9935	68.3185	2.3315
20.1	1.675	33.7093	69.8393	2.4207
20.4	1.7	34.4295	71.3710	2.5120
20.7	1.725	35.1546	72.9146	2.6054
21.0	1.75	35.8827	74.4662	2.7008
21.3	1.775	36.6151	76.0286	2.7984
21.6	1.8	37.3520	77.6020	2.8980
21.9	1.825	38.0709	79.1614	3.0196
22.2	1.85	38.8341	80.7716	3.1034
22.5	1.875	39.5812	82.3717	3.2093
22.8	1.9	40.3321	83.9816	3.3174
23.1	1.925	41.0860	85.5995	3.4275
23.4	1.95	41.8436	87.2271	3.5399
23.7	1.975	42.6045	88.8635	3.6545
24.	2.0	43.3665	90.5061	3.771
27.	2.25	....	107.41	5.06
30.	2.50	....	125.16	6.59
36.	3.00	....	162.79	10.39

THE

State Agricultural College.

The Agricultural Experiment Station.

BULLETIN NO. 14.

PROGRESS BULLETIN ON

SUGAR BEETS

FORT COLLINS, COLORADO.

JANUARY, 1891.

Bulletins are free to all persons interested in Agriculture in any of its branches. Address the Director, Fort Collins, Colo.

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PROGRESS BULLETIN

ON

SUGAR BEETS

By DAVID O'BRINE, *Chemist.*

Last October, in company with the Director of the Station, we visited the beet sugar manufactory at Grand Island, Nebraska, for the purpose of making ourselves better acquainted with the working details of the manufacture of sugar from beets. The factory is situated about two miles from Grand Island; a street car line makes connection with the city every half hour. As we approached the factory, wagons could be seen coming from every direction, loaded with sugar beets. Henry T. Oxnard, President of the company at Grand Island, Nebraska, has given a description of the plant, and we copy from the Western Resources, taken from the *Tribune*, the following facts:

"Past attempts have, in most part, been made by nothing less than adventurers who lacked both capital (they had plenty of capital in Illinois) and experience to go on with the work. Men who knew literally nothing about cultivation of the beet or the process by which sugar is extracted from it, jumped into a big undertaking, and, of course, failed. There has been a wonderful progress in the industry in the last fifty years. In 1829 the sugar beet yielded only 2½ per cent of sugar to the weight of the beet. Ten years ago 9 per cent was the average, while 14 per cent. was taken (on an average) from the German crop of 1889. Every additional per cent. means an increase of twenty pounds of sugar per ton, or 300 pounds additional to the acre. In Nebraska 315 analyses of different beets gave me an average of 16.10 per cent. In a field of beets, you will find sections which yield more than others, but they won't vary more than 1 per cent., and I may say the average is 14 per cent.

"We have a method by which we are enabled to secure the best results in the beet cultivation, and that is by proper propagation of the plant. We weed out those that we know would produce inferior results, and we keep on watching with great care and allowing nothing to produce seed that will not enhance the valuability of the seed. Producers are ascertained by boring out a quantity of the meat of a beet, after which the hole is plugged and a stake driven into the ground to mark that particular vegetable. If, from an analysis, the beet gives promise of rare quality it is allowed to go to seed. No seed is taken from beets the quality of which is not proven to be of the highest order, and we desire to attain this degree of excellence in the propagation of the beet seed from which to grow our sugar producers."

TO CULTIVATE SUCCESSFULLY.

"The ground being carefully prepared, the seed is drilled in rows at distances from 16 to 18 inches apart, and 1 inch deep, after which the surface is smoothed with a roller. When the plants have grown from 4 to 6 inches they must be separated, leaving a single plant from 6 to 8 inches apart, in rows according to the fertility of the soil. This work is of the greatest importance, and if delayed will result in reducing the yield.

"It requires about twenty pounds of seed to sow an acre, the sowing being done about the same time that corn is planted. There are 56,000 plants to the acre, and 5 to 10 per cent. of which is said to fail. The contract stipulates that the progress of cultivation must be under the direction of the company, which from time to time will instruct the planters as to the best manner of successful treatment. A machine made especially for this purpose is used, with which the ground is made loose until the plants grow to such a height as to cover the space between rows and plants, when further cultivation is not required. In the fall, the beets are plowed up with an instrument especially adapted to the work. The leaves, in accordance with the contract, are cut off and left on the ground for fertilizing purposes. The beets are then hauled to the factory, where they are paid for in proportion to the saccharine matter contained, which is ascertained by an analysis made from slices of a half dozen beets taken from the load, as follows: $3 a ton for beets having 12 per cent. sugar, with coefficient purity of eighty, and twenty-five cents for each additional per cent. of sugar. Beet roots having 20 per cent. sugar bring $5 per ton. Very large beets, or those grown mostly above the ground, are rejected for sugar, as are also those that have been frozen, or diseased. The average yield to the acre is fifteen to twenty tons, and brings the planter about $45 and $60 an acre. Considerable expense is incurred in thinning, for which purpose men, women and children are employed during the season.

"It requires about two and one-half days to take the juice out of a beet and run it into a barrel in the shape of sugar in the grain. The beets are unloaded alongside a hydraulic canal, in which they are rolled about till they are thoroughly cleansed, and are carried by the washing process to an elevator and taken aloft and deposited in a huge weighing machine holding just one ton of beets. This, upon receiving the last ounce, automatically empties the vegetables into a slicer, in which revolving knives quickly cut the beets into long slices. These, in turn, fall into the diffusion battery, consisting of twelve cells, and there undergo the juice-extracting process, becoming more and more of the character of molasses as each cell is passed. Defacation by lime and heat is then commenced, after which the lime is removed by carbonic acid gas. The mass is then filtered by double process, evaporated to crystallize, and the sugar finally separated from the molasses. The first molasses is evaporated again to furnish a second crop of sugar, and a third and a fourth crop is subsequently obtained. The final molasses is too offensive for food, and is converted into potash. The pulp is disposed of for cattle-fattening purposes."

"With reference to what is being done in California in the way of beet culture for sugar purposes, it was learned that last year in the vicinity of Watsonville the yield was 14,000 tons, bringing to the planter an average of $5.04 per ton. It costs fifteen cents a ton to plow up, forty cents a ton to top (a woman can top four tons a day), fifteen cents a ton to load and from fifty to seventy-five cents a ton to haul a distance of two and a half miles. It costs about $29 to harvest an acre, which yields a crop valued at $110, so that the planter gains $81 for planting and thinning. One man residing three miles from the factory gives the following as the result of the cultivation of a ten-acre field:

Plowing	$ 50.00
Thinning	190.00
Topping	153.00
Hauling	150.00
Total	$543.00
Yield, tons, 154, value	$972.80
Outlay	543.00
Profit	$429.80
Profit per acre	$ 42.90

"Another Watsonville man who lives two miles from the factory and cultivated eleven acres, reports a yield of 170 1-20 tons, which netted him a profit of $35.08 per acre."

When we were at Grand Island we learned that the plant there cost about $500,000. About 200 men are employed, 100 on each shift, running night and day. There are six batteries of boilers, two in each battery. We noticed that they made their own lime on the ground. They used up about 250 tons of beets a day. It was about 11 a. m. when we visited the packing rooms, and the workmen told us that they put up 110 sacks (100 pounds in a sack) that morning, or, at that rate, about 400 sacks of sugar a day. The plant runs as long as there are beets to be had—say from three to five months.

It is apparent from the numerous inquiries about sugar beets, that a great many farmers do not understand the terms used by chemists and others in describing the work. This may be due to the fact that the previous bulletins (Nos. 7 and 11) have not fallen tnto their hands. We find it necessary, even at the cost of repetition, to explain the terms used:

Coefficient of Purity—Is the term used to denote the ratio per cent. of the total sugar (sucrose) in the juice to the total solids. Suppose, for instance, that the juice contained 15 per cent. total solid and 11 per cent. sugar (sucrose), the coefficient of purity would be $11 \div 15 =$ 73.3 per cent. It must follow that the higher the coefficient of purity the easier it is for the manufacturer to make the sugar from the juice of the beet.

Marc—Is the name applied to the dried residue or chips that remain after the sugar and juice have been extracted. It is used to some extent as a cattle food, and sold in Grand Island, Nebraska, at twenty-five cents a ton.

Loss on Dressing—Is the loss occasioned by cutting off the part of the beet grown above ground. The per cent. of sugar increases from the top of the beet to the bottom.

The part above ground contains relatively more salts of potash, lime, etc., than the rest of the beet, and these salts increase the specific gravity, lessen the coefficient of purity, and interfere with the extraction of the sugar present. It is for these reasons that it is removed. The sugar in the juice of the sugar beet consists mostly of cane sugar, with a small per cent. (one or two-tenths) of grape sugar. The methods of analysis may be briefly sketched. Average beets are taken, washed, dried and weighed. The part grown above ground (crown) and small rootlets are removed, and again weighed, and the loss carefully noted. The beets are quartered parallel to the axis, and successive slices made lengthwise from each quarter of the different beets selected. These slices are grated on an ordinary tin grater, and the whole well mixed. A weighed quantity is taken, the sugar extracted, the coloring matter precipitated with basic lead acetate, and the amount of sugar determined by a saccharimeter.

The per cent. of sugar in the sugar beets depends upon, (1) the kind of beets, and (2) upon the cultivation.

Many of the beets sent to the Station for analysis were very large, and poor in sugar. They were sent with the mistaken idea that a large, overgrown beet of immense size and weight (11 pounds) was a good sugar beet. The following analyses show that the size of the beet is in inverse ratio to its sugar content. It must follow from this that as the beets increase in size and weight, say above 3 pounds, the per cent. of water increases and the sugar decreases. The following beets were raised upon the same soil (by the Horticultural Department), had the same cultivation, and were harvested at the same time. They were selected only with reference to their size—large, medium and small:

NAME.	Size.	Weight, in Grams.	Loss on Dressing, Grams.	Cane Sugar.	Grape Sugar.	Total Sugar.
Bulteau Desprez	Large	1,245	170	12.7	.13	12.83
Bulteau Desprez	Medium	285	20	13.98	.12	14.10
Bulteau Desprez	Small	43	3	15.83	.14	15.97
Kleinwanzleben	Large	1,015	135	14.03	.09	14.12
Kleinwanzleben	Medium	240	20	14.15	.13	14.18
Kleinwanzleben	Small	42	2	16.93	.18	17.11
Dippe's Vilmorin	Large	860	70	14.25	.12	14.37
Dippe's Vilmorin	Medium	280	35	14.67	.17	14.84
Dippe's Vilmorin	Small	42	2	16.43	.21	16.66
Bulteau Desprez No. 2	Large	980	110	14.13	.13	14.26
Bulteau Desprez No. 2	Medium	375	30	15.53	.15	15.68
Bulteau Desprez No. 2	Small	89	5	15.96	.13	16.09
Simon Le Grande, Vilmorin	Large	1,150	150	11.88	.29	12.17
Simon Le Grande, Vilmorin	Medium	150	10	12.73	.15	12.88
Simon Le Grande, Vilmorin	Small	43	3	13.30	.22	13.52
Florimond Desprez	Large	1,310	170	12.82	.17	12.99
Florimond Desprez	Medium	175	10	15.43	.11	15.54
Florimond Desprez	Small	30	3	16.92	.13	17.05

The size of the beet can be controlled, at least to an extent, by thick seeding and judicious thinning. Manufacturers think that the per cent. of sugar in the sugar beets should not go below about 13 per cent. It is an important point for the farmers to have their sugar beets run high in sugar, as the price paid for them depends upon it. The seed used by the Horticultural Section was furnished by the Department of Agriculture at Washington, and samples of the beets were sent to Dr. H. W.

Wiley, Government Chemist, for analysis. Prof. Wiley reports to Prof. Crandall, October 2, 1890, the following results:

Name of Kind.	Per Cent. of Sugar.
Kleinwanzleben	15.11
Simon Le Grande	11.15
Florimond	15.39
Bulteau Desprez No. 1	15.20
Bulteau Desprez No. 2	14.75
Vilmorin	12.92

Later in the season, November 12, some of the same lot of beets were sent to Grand Island, and their chemist, under date of November 12, 1890, reports the following per cents. of sugar:

Name of Kind.	Per Cent. of Sugar.
Excelsior Sugar	7.4
Improved Imperial	8.2
Bulteau Desprez	14.4
Dippe's Vilmorin	14.7
Kleinwanzleben	13.5
Florimond	13.2
Simon Le Grande	13.5

The analysis shows practically the same results when allowance is made for the fact that when sent to Washington they were taken from the soil, and when sent to Grand Island they had been dry some time. In our analyses of the same, taking the average of the medium and small, we have:

Name.	Small.	Medium.	Average.
Bulteau Desprez No. 2	16.09	14.10	15.03
Bulteau Desprez No. 1	15.97	15.68	15.88
Kleinwanzleben	17.11	14.18	15.64
Dippe's Vilmorin	16.66	14.84	15.75
Florimond	17.05	15.54	16.30

The following additional analyses of sugar beets from different portions of the State were made:

ANALYSES OF SUGAR BEETS.

NAME.	Grams, weight.	Loss on Dress'g	Cane Sugar.	Grape Sugar.	Total Sugar.	WHERE AND BY WHOM GROWN.
Colorado Imperial	670	70	8.02	.07	8.09	A. R. Black, Lamar, Colorado.
California Sugar Beet	340	50	13.03	.1	13.13	" " " "
Colored Vilmorin Desprez	470	65	11.07	.19	11.26	" " " "
Imported Florimond	415	35	8.45	.24	8.69	" " " "
Kleinwanzleben	550	60	11.04	.17	11.21	" " " "
Vilmorin	837	55	10.38	.13	10.51	Stimson, Nebraska.
Simon LeGrande's White Imperial	278	46	15.59	.17	15.76	San Luis Experiment Station, Del Norte, Colorado.
Bulteau Desprez	270	30	11.82	.09	11.81	" " " " " " "
Vilmorin	320	50	14.14	.28	14.42	" " " " " " "
Vilmorin Desprez	315	40	12.25	.16	12.41	" " " " " " "
Kleinwanzleben	540	80	13.35	.14	13.49	" " " " " " "
Red Top	1482	117	11.84	.10	11.94	Arkansas Valley Exp. Station, Rocky Ford, Colorado.
Simon Le Grande	870	125	13.28	.16	13.44	" " " " " " "
Dippe's Vilmorin	685	55	14.09	.20	14.29	" " " " " " "
Florimond Desprez	825	55	14.72	.23	14.95	" " " " " " "
Bulteau Desprez	760	60	12.89	.10	12.99	" " " " " " "
Kleinwanzleben	750	40	13.66	.11	13.77	" " " " " " "
Name unknown	1830	330	6.72	.12	6.84	Probst, Sterling, Colorado.
" " "	895	195	7.65	.11	7.76	Zetzell, " "
" " "	4360	910	8.18	.15	8.33	Snyder, " "

ANALYSES OF SUGAR BEETS—Continued.

NAME.	Grams, weight.	Loss on Dres'g.	Cane Sugar.	Grape Sugar.	Total Sugar.	WHERE AND BY WHOM GROWN.
Name unknown	3320	790	6.55	.22	6.77	Snyder, Sterling, Colorado.
" "	1850	280	6.74	.17	6.91	Perkins, " "
" "	1500	285	9.16	.14	9 30	J. Silver, " "
" "	780	175	11.26	.26	11.52	G. Lee, " "
Improved Imperial	2250	445	8.70	.14	8.84	Agricultural College garden, Fort Collins, rich soil.
Imperial	1735	315	9.75	.10	9.85	" " " " " " "
Excelsior	1940	410	6.95	.11	7.06	" " " " " " "
Kleinwanzleben	515	25	12.57	.12	12.69	Agricultural College garden, Fort Collins, Colorado.
Bulteau Desprez	205	7	13.37	.14	13.51	" " " " " "
Florimond Desprez	415	30	12.90	.19	13.09	" " " " " "
Dippe's Vilmorin	415	25	14.20	.09	14.29	" " " " " "
Bulteau Desprez	335	20	14.18	.13	14.31	" " " " " "
Simon Le Grande	640	55	11.38	.12	11.50	" " " " " "
Kleinwanzleben	1085	80	11.11	.09	11.12	" " " " " "
Bulteau Desprez	682	52	10.97	.16	11.13	" " " " " "
Florimond	755	90	9.82	.21	10.03	" " " " " "
Dippe's Vilmorin	970	70	12.74	.08	12.82	" " " " " "
Bulteau Desprez	530	30	11.12	.11	11.33	" " " " " "
Simon Le Grande	950	60	9.26	.17	9.43	" " " " " "
Imperial	500	20	14.08	.12	14.20	Chas. Green, Del Norte, Colorado.
"	335	15	14.76	.13	14.89	A. S. Halsted, " " "
Lane Imperial	1520	..	11.30	.22	11.52	Chas. Schielman, La Junta, Colorado.
" "	....	..	15.68	.09	15.77	....

Besides these analyses, twelve others were made with special reference to the specific gravity of the juice as an index of the per cent. of sugar. In all cases 200 grams of the beets were reduced to a pulp, and the washings made up to 750 C C., with the following results:

Name.	Specific Gravity.	Per Cent. of Sugar.
Grown by Probst	1.012	6.84
" " Snyder, red	1.012	6.77
" " Zetsell	1.0125	7.76
" " Perkins	1.015	6.91
Bulteau Desprez, Rocky Ford Station	1.02	12.99
Imperial	1.02	9.85
Kleinwanzleben	1.02	12.69
Simon Le Grande, Vilmorin	1.022	12.17
Bulteau Desprez, College	1.022	14.31
Dippe's Vilmorin	1.025	14.84
Bulteau Desprez, College	1.125	14.26
Bulteau Desprez, College	1.02	12.83

These results are confirmatory of those of last year. During the past season seventy-three analyses of sugar beets were made. In many cases the yield per acre was not given, nor the kinds of beets raised, which detracts a great deal from the value of the analysis. We would ask, as a favor, those sending anything for analysis to give *all* the facts. For sugar beets, give the name, yield per acre in tons, time sown and time harvested; also, the method of cultivation, the kind of soil and all other facts that will throw any light upon the subject. The average of the seventy-three analyses gives 11.56 per cent. of sugar, a coefficient of purity of 83.1 per cent. The yield per acre on the College garden was:

Excelsior	29	tons
Vilmorin	27	"
Imperial	22.5	"

An average of over twenty-six tons per acre for the three kinds. Taking into consideration the unfavorable kinds (large) sent for analysis, the per cent. of sugar is very good.

It has been estimated that the per cent. of sugar in the sugar beets in Germany last year averaged 12.55 per cent., and the average yield, according to Mr. Licht, was 14 tons per acre. In this respect Colorado compares favorably, as the average of those raised by the Horticultural Section was over 15 per cent., and the yield per acre over 26 tons. The cost of land in Germany being about ten times what it is in Colorado, gives our State another advantage. With the proposed bill recently introduced in the Legislature, giving a bounty on sugar made from sugar beets of one cent a pound, it must be an inducement to the manufacturer to invest his money in our midst, provided it becomes a law. A correspondent of the Portland *Advertiser* has very truthfully stated that the sugar beet industry conflicts with no other industry: "There is no interest that it would injure, while it would be difficult to find one that would confer so many, so great and so general advantages upon the country."

It must always be a source of gratification to a country to supply, or be able to supply, its own wants. From the official figures it has been estimated that over one million tons of sugar have been imported into our country during the last year. We could raise this surplus and have some to spare, on two million acres of land. It would give profitable employment to nearly one fourth of a million of men, women and children, while the capitol required to manufacture it would be counted by the hundred millions.

CONCLUSION.

We believe that it has been established that the soil and climate of Colorado are favorable to the production of sugar beets, and that they can be successfully and profitably raised to the advantage, both of the farmer and manufacturer.

—THE—

State Agricultural College.

The Agricultural Experiment Station.

BULLETIN NO. 15.

TWO INSECT PESTS,

The Codling Moth and The Grape-Vine Leaf-hopper.

FORT COLLINS. COLO.

April 1891.

The Agricultural Experiment Station.

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TWO INSECT PESTS.

The Codling Moth and The Grape-vine Leaf-hopper,

BY

C. P. GILLETTE, *Entomologist.*

INTRODUCTION.

As the writer has been but a few months in Colorado it is impossible that the present bulletin should present new matter which is the result of personal investigation here.

The chief object of the bulletin is to give needed information on two insect pests, the Codling Moth and the Grape-vine Leaf-hopper, concerning which many complaints have been received at the experiment station.

A secondary object of the bulletin is to solicit the co-operation of the people of the state in the work of investigating insect ravages upon plants and animals. Whenever insect injuries are noticed, specimens of the insects doing the damage with the fullest information possible concerning them should be forwarded to the experiment station. Such communications will receive prompt attention and the best known remedies will be recommended in return.

When insects are sent by mail, they should be inclosed, with a supply of their natural food, in a strong tight box. Holes in the box for air are unnecessary and should not be made.

THE CODLING MOTH,

Carpocapsa Pomonella, L.

The Codling Moth is not a native of America but was imported from Europe about one hundred years ago. As a large number of the worms of the fall brood do not leave the apples until the latter are stored in cellars or in barrels, this insect is unavoidably introduced wherever apples are shipped. Consequently it has spread rapidly, not only in this country, but to nearly all parts of the globe where apples are grown from cold Siberia to sub-tropical regions.

LITERATURE.

The amount of literature that has accumulated on the Codling Moth in this country is very great and, in a considerable part, especially that occuring in local news papers, is of little value. It would be useless to endeavor to give anything like a full bibliography of this insect in the present paper, but, for the benefit of those who wish to go deeper into the subject, I will recommend the following articles as being especially valuable and easy of access:

Miscellaneous Essays on Economic Entomology, by Dr. S. A. Forbes, State Entomologist of Ill., 1886.

Report of the United States commissioner of Agriculture for 1887, page 88. Paper by Mr. L. O. Howard.

Bulletin 39 of the Michigan Experiment Station by Prof. A. J. Cook.

First Annual Report of the Kansas Experiment Station, page 1. Paper by Prof. E. A. Popenoe, Mr. C. L. Marlatt and Mr. S. C. Mason.

Bulletin 3, Second Series, of the Ohio Experiment Station by Dr. C. M. Weed.

Bulletin 7 of the Iowa Experiment Station by C. P. Gillette.

POPULAR DESCRIPTION.

The mature insect is, as the popular name implies, a moth, or, as such insects are often called, a miller. Figure 1, f and g are illustrations of the moth. About two thirds of the basal portion of the anterior wing above is ashen gray crossed by narrow broken lines of brown. Near the outer margin of the wing there is a large brown area occupying nearly one third of the wing surface within which are numerous gold or bronze colored scales and also a few scales that are entirely black.

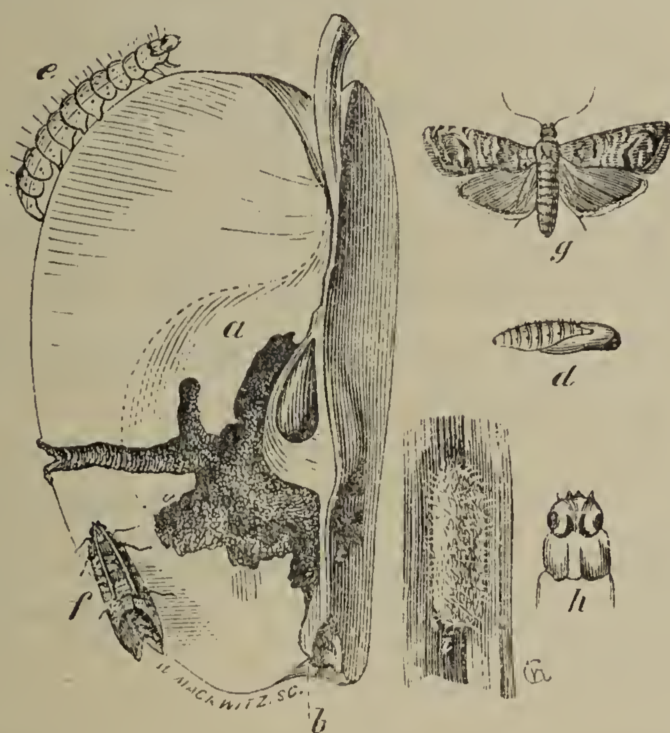


Fig. 1.

The posterior wings are of a dingy brown color being lighter near the body.

The larva, or worm, is too well known to need a careful description. All who have eaten apples have seen the apple worm (Fig. 1, e.) of a pinkish or flesh color and about three fourths of an inch in length when full grown.

The brown shining chrysalis is shown in the cut at *d*, and the silken cocoon that always surrounds it at *i*.

All of the illustrations in the figure are natural size.

LIFE HISTORY.

Professor James Cassidy, in Bulletin 6 of this station, page 2, says that in that year (1888) the moths were plentiful towards the end of April. According to the meteorological record of that year April was a very warm month at this place, the lowest morning temperature being 38° and the noonday temperature being, much of the time, above 70°. The time of appearance will always depend on the earliness of the season and upon the warmth of the particular place in which the insect winters. There is also a considerable difference of opinion among writers as to the time when the moths begin to deposit their eggs.

From careful observations made in Iowa the writer concluded * that the eggs did not hatch there until a month, at least, after the flowers fell from (Duchess) apple trees.

As bearing upon this subject I quote the following from an article that appeared in the Pacific Rural Press of June 8th 1889 from the pen of Mr.

* *Bulletin 7 of the Iowa Experiment Station, Page 277.*

D. B. Wier, a well known writer upon horticultural subjects. Mr. Wier says:

"I looked over an orchard very carefully on May 26th, and could find no instance where a larva had penetrated an apple. * * * * To-day, May 28th, in the same orchard, a search of an hour rewarded me with 20 apples in which the larvæ had penetrated the fruit sufficiently to make a showing; they were from an eighth to a twentieth of an inch in length, showing that they were only from one to four days from the egg. * * * * To-day the apples here at Petaluma are well grown, averaging over 1½ inches in diameter."

The exact time at which the moths begin to deposit their eggs, will also vary greatly in different years but it is quite safe to say that egg-laying does not take place to any considerable extent until the flowers have fallen from the late varieties of apple trees. The eggs are deposited one in a place in the blossom or calyx end of the apples and it has been estimated that each moth deposits at least 50 eggs. Within a few days after the deposition of the egg, the time dependent on the temperature, the larva hatches. It feeds for a short time within the calyx and then begins to burrow towards the core of the fruit within and about which it feeds until fully grown when it gnaws an opening, usually at the side of the apple, and escapes to go in search of a suitable place to spin its cocoon and transform to the pupa or chrysalis state. About two weeks later, probably about the 5th of July in Colorado, the moths of the second brood begin to appear which soon begin to lay eggs for a second brood of the worms. This brood does far greater harm than the first unless the first have been mostly destroyed, in which case there are comparatively few moths to lay eggs to produce a second brood.

FOOD PLANTS.

The Colding Moth, though partial to the apple, also attacks the pear, quince and wild haw and has, in rare cases, been reported as feeding in pit fruits as peaches, plums and apricots.

NATURAL ENEMIES.

Nature's checks upon this insect are numerous but very ineffectual. The more important natural enemies are insectiverous birds, and two species of insect parasites belonging to the family Hymenoptera to which family belong all our ants. bees and wasps.

ARTIFICIAL REMEDIES.

Under this head I will mention first the use of the arsenites, London purple and Paris green, as they are by far the most important.

Who first used arsenic in any of its forms for the destruction of Codling Moth larvæ it is impossible to say. Among those who were early in bringing London purple and Paris green into popular use for the destruction of this pest are Prof. A. J. Cook of the Michigan Agricultural College, Dr. S. A. Forbes of the Illinois State Laboratory of Natural History, and Prof. E. S. Goff formerly of the State Experiment Station, at Geneva, N. Y.

Within the past few years a great many entomologists and practical fruit growers have used these arsenites for the destruction of the apple worm and, so far as I can learn, there has been but one verdict where a fair trial has been made and that is in favor of the application.

* Professor Goff in his experiments in 1884 sprayed six trees three times with Paris green and compared them with four trees not treated. All of the apples, 9,198 in number, that grew on these ten trees were examined and it was found that 69 per. cent. of the injury was prevented on the treated trees. That is, there were but 31 wormy apples on the treated trees where there would have been 100 wormy apples in the absence of the treatment.

Dr. Forbes, in 1885 conducted a similar but more extensive experiment from which he concluded as follows:

"The experiments above described seem to me to prove that, at least, seventy per cent. of the loss commonly suffered by the fruit growers from the ravages of the Codling Moth or apple worm, may be prevented at a normal expense, or, practically, in the long run, at no expense at all, by thoroughly applying Paris green in a spray, with water, once or twice in the early spring, as soon as the fruit is fairly set, and not so late as the time when the growing apple turns downward on the stem."

While employed at the Iowa Experiment Station in 1889 I conducted experiments for the destruction of Codling Moth larvæ by using London purple and Paris green and reported upon them in Bulletin 7 of that station. In one of these experiments three Duchess apple trees were sprayed once, May 18th, with a mixture of London purple in water in the proportions of one pound to 128 gallons and two other trees of the same variety were

* *Fourth Annual Report of the State Experiment Station, page 218.*

Miscellaneous Essays on Economic Entomology p. 26. Also XV *Annual Report of the State Entomologist of Illinois, page 7.*

sprayed with the same mixture May 18th and again May 7th. Four other Duchess trees adjoining the above, not treated, were used as checks. At the end of the season it was found that the treated trees had 68 per cent. less of wormy fruit than those not treated, or, there were but 32 wormy apples on the treated trees where there would have been 100 If the treatment had not been made. The percentage of apples saved agreed remarkably well with the results obtained by Professors Goff and Forbes above mentioned. I also tried in 1889 a new method of applying the poison to apple trees which was to mix Paris green very thoroughly with common land plaster in the proportion of one pound of the poison to 100 pounds of plaster and throw the mixture over the trees from the top of a step ladder in the early morning while the dew was still on the foliage. Two trees were treated in this experiment and when brought into comparison with the check trees showed a saving of over 94 per cent. of the fruit that would have been wormy in the absence of treatment. I do not suppose it would be advisable to apply the poison in this manner on a large scale but it may be a desirable method where a few trees are to be treated and no force pump is at hand.

That it pays and pays richly to spray apple trees for the destruction of the Codling Moth larvæ there can be no doubt. It is the unanimous verdict of thousands of practical orchardists in the East who have given this subject a thorough trial and come to consider the spraying of their fruit trees quite as essential to the production of a good crop of apples as cutting the weeds from their garden for the production of a crop of vegetables. As to the form of the poison to use, and the method and time of application that will produce the best results, there is still much to be learned.

THE POISON TO USE.

Some of the earliest experiments * with poisons for the destruction of the apple worm were made with white arsenic in solution and seemingly with good results. This substance, however, is objectionable because of its color which makes it liable to be mistaken for culinary articles, because, unless dissolved, it mixes with much difficulty in water and when mixed settles quickly to the bottom of the vessel and, because, when in solution it is very injurious to foliage, as proven by a large number of experiments by myself which were reported in Bulletin 2 page 30 and Bulletin 10 page 413 of the Iowa Experiment Station,

London purple and Paris green are the two substances most commonly recommended and used for insecticidal purposes and, of these two, the former seems to be growing in favor on accounnt of its being cheaper, less liable to adulteration and lighter, so that it remains longer in suspension in water. On the other hand, experiments ** go to prove that Paris green is less injurious to foliage than London

**See paper by Hon. J. N. Dixon in Rep. of Iowa State Horticultural Soc. for 1882.*

***Bul. 53, page 6, of the Mich. Exp. Sta. Also Bul. 10 page 404 of the Ia. Exp. Sta.*

purple when applied in the same proportion. But I found from my experiments * of last year and the year before that the injury which London purple usually does to foliage can be almost wholly prevented by the addition of a small amount of quick lime to the water, enough to make it appear quite milky when stirred.

Strength to Apply.—Whether London purple or Paris green is employed I would recommend that it be used in the proportion of one pound to 160 gallons. If London purple is used, I would recommend the addition of the lime as mentioned above. If a second application is made, do not use stronger than one pound to 200 gallons.

The liquid should be stirred frequently, especially if Paris green is used, to keep the poison well mixed through it.

Time to Apply.—It is alomst universally recommended that spraying should take place as soon as the flowers fall. I am satisfied that in case of early varieties, there are two or three weeks, at least, after the flowers fall before the worms begin to eat into the fruit.

I found ** in 1889 that Duchess apple trees dropped their bloom fully one month before the worms entered the fruit.

As the calyx closes very much after the apple begins to form, so that less poison would be retained there, and, as the apples soon turn downward on

**Bul. 10, page 412, Ia. Exp. Sta.*

* * *Bul. 7, page 277, Ia. Exp. Sta.*

the stem after forming, it is probably advisable to make the first application not later than one week after the flowers fall. If the application is thoroughly made, and no heavy rain follows to wash away the poison, a second application will hardly be needed. If a heavy rain does follow soon after the first application, the trees should be sprayed again with a some what weaker solution than at first.

As to pumps and other machinery with which to make the applications see article on spraying machinery.

COLLECTING UNDER BANDS.

Next to the arsenites the use of bands fastened around the trunks of the trees about the last of June, under to which to collect the larvæ of the first brood for the purpose of destroying them is probably most useful if faithfully attended to. The bands may be of hay, paper, burlap or other cheap material that will form a good hiding place for the insects while in the pupa state. These bands must be inspected every three or four days and the larvæ and pupæ found beneath them destroyed. In this manner the second brood, will be largely prevented from appearing.

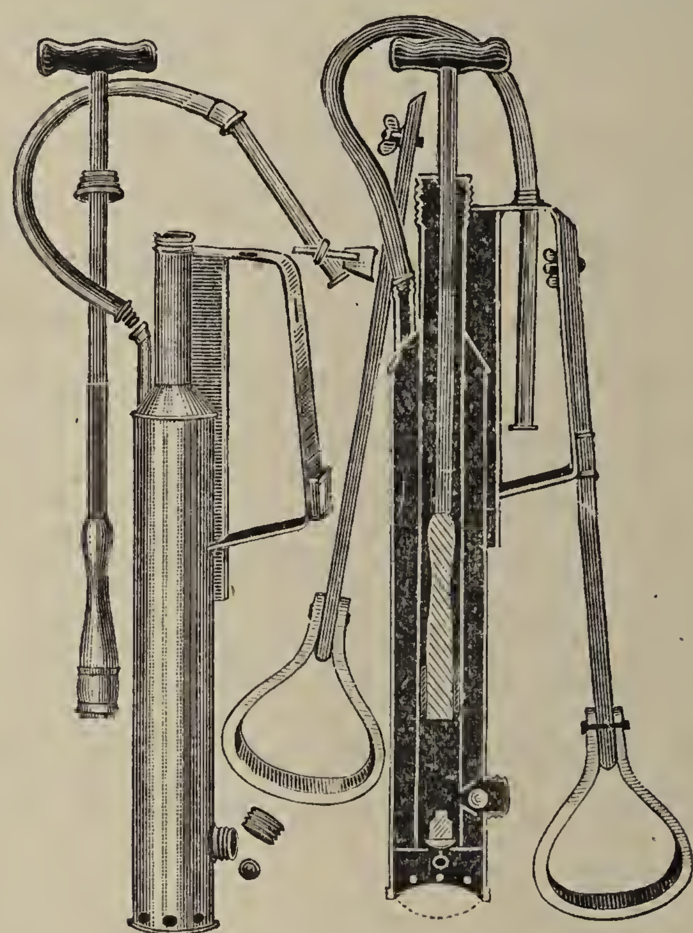
Another partial remedy is to allow sheep or swine to have the run of the orchard as they will destroy large numbers of the worms that are in the apples when they fall.

USELESS REMEDIES.

There are many who suppose the moths may be easily captured in dishes of sweetened water or of milk, or about lights put in an orchard. These supposed remedies are of no value whatever as the Codling Moth never flies to sweets or to light. The large number of moths that are taken in these ways are of other species, largely those of cut-worms.

SPRAYING MACHINERY.

The question, "Where can I get suitable pumps to do my spraying?" is so often asked that it seems best to mention a few of the pumps in common use that have been tried and known to be good.



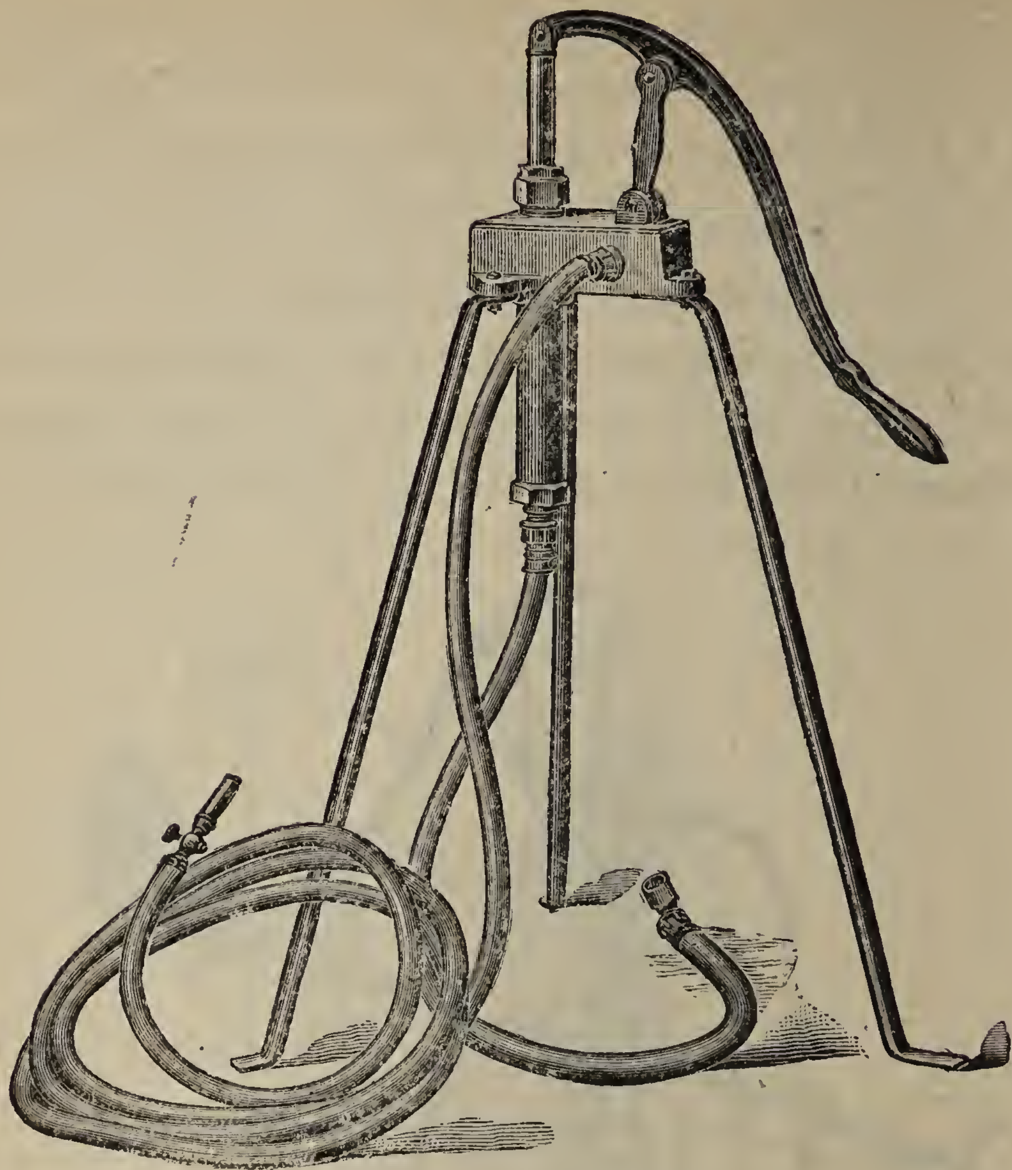
(Fig. 1.)

Figure 1 is representation of a force pump made of heavy tin with valves all of metal that I have found very satisfactory where a small amount of spraying was to be done. It is very durable and light and costs about ($2.00). It is the best cheap pump that I know of. It is manufactured by I. W. Numan, Canton, Ohio.

The Nixon Nozzle and Machine Co., Dayton, Ohio, manufacture pumps in a variety of styles for spraying purposes. I have had opportunity to test, personally, most of their pumps and have found them to be of first-class workmanship. The spraying nozzles manufactured by this company are, it seems to me, the best made for general purpose spraying. Figure 2 represents one of the Nixon

(Fig. 2.)

pumps which is strongly, made of iron and brass. This illustration shows the pump complete with hose and nozzle ready for operation. Its list price is $10.00.

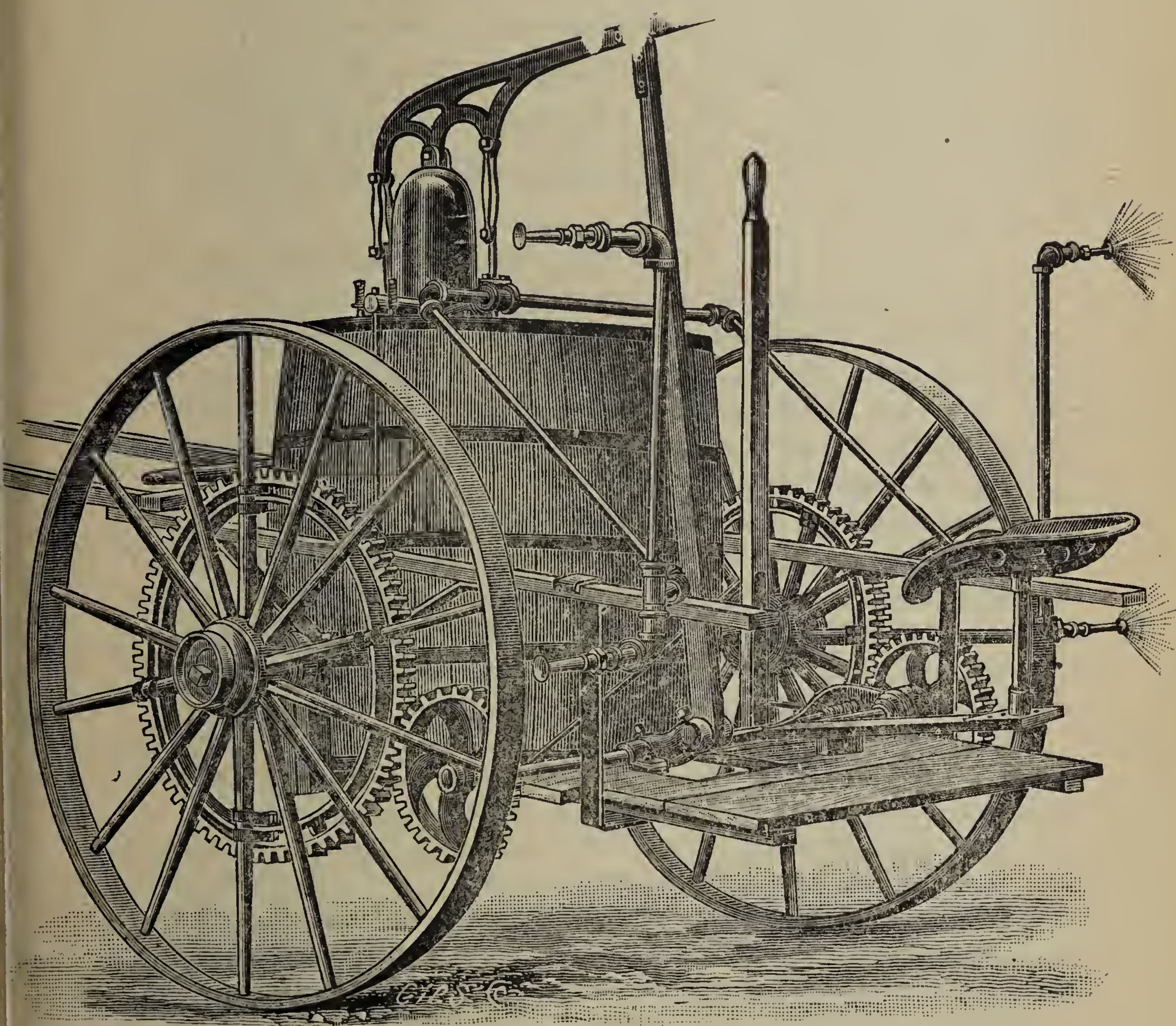


(Fig. 3.)

Figure 3 is a representation of a little heavier pump manufactured by the same company. This pump is arranged so that by removing the legs it can be fastened to the head of a barrel. With hose and two nozzles it is listed at $15.00. This company also manufacture several styles of spraying machinery among which is a pump and tank mounted on two wheels so that the pump is run by means of gearing and is suitable for field or orchard work.

The Field Force-pump Co., Rochester, N. Y., manufacture a pump, (Figure 4,) similar to the preceding which costs $65.00, and also a cheaper pump which can be attached to a common wagon wheel and, by fastening the pump to a barrel, the expense of tank and wheels is saved.

If only a small amount of spraying is to be done, and that upon low plants or shrubs, a bellows atomizer, manufactured by Thomas Woodason, 451 East Columbia street, Philadelphia, Pa., will be found to do good work and to be very economical of material. Mr. Woodason also manufactures a



(Fig. 4.)

bellows duster, that is excellent for applying vegetable powders as pyrethrum or hellebore upon plants or for the destruction of flies in-doors.

If local dealers do not handle the above mentioned articles, they may be procured directly from the manufacturers.

THE GRAPE-VINE LEAF-HOPPER.

Typhlocyba vitis, Harr.

The Grape-vine Leaf-hopper, often spoken of by vineyardists as the "Thrip," seems to be a very serious enemy to grape-vines in Colorado.

The following extract from a letter recently received from Mr. W. B. Felton, President of the State Bureau of Horticulture, will be of interest in this connection:

CANON CITY, COLO., MARCH 18th, 1891.

"*Prof. C. P. Gillette,*

DEAR SIR:—Am glad to know that your are going to investigate the Leaf-hopper. It is the great pest of the grape grower here and also on Wheat Ridge and in other parts of the State. It will be a great blessing to have a bulletin from you giving a reliable and thorough method of extermination.

The hoppers that we have do not touch the buds. They appear at the base of the vine in the spring and as the foliage comes out go up and attack the under side of the leaves and breed there. They suck the substance from the leaves and about the time that the grapes would commence ripening the leaves are only skeletons, and the maturing of the grape ceases.

They attack by preference foreign varieties, Delaware and other tender-leaved vines, but when the more toothsome varieties are defoliated, they will attack Concord and other tender-leaved vines.

After a considerable experimenting I found that an emulsion of one gallon of kerosene, one pound of soap and fifteen gallons of water would kill the hoppers and not hurt the foliage I used this emulsion through the season and the hoppers did not get the better of me, but the emulsion took the bloom off the grapes and left a stain that injured their appearance for the market. Yours truly,

W. B. FELTON."

The Grape Leaf-hopper was first described by Dr. T. W. Harris in 1831 under the name *Tettigonia vitis*. From Dr. Harris' Insects Injurious to Vegetation I copy the following popular description:

"In its perfect state it measures one-tenth of an inch in length. It is of a pale yellow or straw color; there are two little red lines on the head; the back part of the thorax, the scutel, the base of the wing covers and a broad band across the middle, are scarlet; the tips of the wing covers are blackish, and there are some little red lines between the broad band and the tips. The head is crescent-shaped above, and the eyelets are situated just below the ridge of the front."

This insect varies a considerable in coloration and several varieties have been described but all have the same habits and can be kept in check by the use of the same remedies.

REMEDIES.

The writer has never lived where the Grape Leaf-hopper was numerous enough to make it seem necessary to apply any remedy and consequently has had no experience in combating it. But from experiments conducted for the destruction of the Apple Leaf-hopper (*Empoasca mali*) which is a very near relative, and a knowledge of the life-habits of the grape-feeding species, it is believed that a course of treatment can be recommended that will greatly lessen, if not entirely prevent its injuries.

The applications that the writer has found effectual in destroying the Apple Leaf-hopper are kerosene emulsion, whale-oil soap and pyrethrum. The cheapest and most effectual of these, the materials for which are always at hand, is kerosene emulsion.

I would recommend that the emulsion be made by the Hubbard formula as follows: Dissolve one half pound of ordinary hard soap in one gallon of water by boiling; remove the soap solution from the fire while boiling hot and immediately add two gallons of kerosene and agitate the whole as violently as possible for a few minutes when it should be a frothy creamy mass that may be diluted to any extent with water. A good way to emulsify the mixture is to use a small force pump and pump the material forcibly back into the vessel that contains it. If a small amount is to be emulsified I have found nothing better to use than an egg-beater.

For the destruction of the Grape Leaf-hopper, I would put one part of the emulsion as above made in about 20-parts of water, which would make the emulsion a little more than 3 per cent. kerosene. The ingredients in a gallon of such an emulsion would cost less than one cent. If it is found on application that this strength is not sufficient to kill the hoppers, the strength can be increased until it will kill them.

The application of the emulsion should be made as soon as the young hoppers hatch and the spray should be directed as much as possible on the under side of the foliage and with a good deal of force. It would also be well to make one application early in the season before the leaves are out for the destruction of the old hoppers, provided they congregate on the vines in large numbers.

The treatment should be repeated as often as necessary to keep the vines comparatively free from the hoppers up to the time of the setting of the grapes. If it becomes necessary to treat the vines later than this, I would recommend using a pyrethrum tea in the proportion of one ounce of the pyrethrum to three gallons of water to be applied the same as kerosene emulsion as this will not injure the grapes.

Pyrethrum powder is also sold as Buhach, Persian Insect Powder, Dalmatian Insect Powder, and Insect powder. The Buhach Manufacturing Co., Stockton, Cal., make what is usually considered the best article. It can be procured directly from the company or through local druggists. Care should be taken to procure a pure article.

Tobacco-water is often recommended for the destruction of leaf-hoppers but it is not as cheap as the emulsion and it would be liable to stain the fruit after the latter had set. Where vines are under glass or can be confined under a tent, these insects may be completely destroyed by fumigating with tobacco or pyrethrum.

Great numbers of the mature hoppers may be captured upon a sheet smeared with printer's ink, tar or other sticky substance and held along the leeward side of the trellis while some one gives the vines a sudden jar.

Great numbers can also be destroyed at night by carrying torches through the vineyard or by burning lanterns over dishes of water as the hoppers are much attracted by light.

Mr. Felton, in the letter above quoted, spoke of a plan he tried last fall of heaping up leaves about the vineyard for the hoppers to collect under and then, on a cold day, sprinkling kerosene over the leaves and burning them. This plan or some modification of it, for the destruction of the mature hoppers, is what I should recommend as being next to the kerosene emulsion in importance, as mature insects seek such winter protection as is afforded by old leaves, straw or grass.

Whatever plan is adopted, there must be persistent and united action on the part of all the vineyardists in a given locality if any thing like extermination is to be expected.

It is to be hoped that all who try any of the above or other remedies will report their success or failures to the experiment station that others may get the benefit of their experience. If opportunity is offorded, experiments will be conducted at the station for the purpose of determining the relative values of the different methods of overcoming this insect and the results will be given to the people of the state through the bulletins of the station.

THE

State Agricultural College.

The Agricultural Experiment Station.

BULLETIN NO. 16.

THE

Artesian Wells of Colorado,

AND THEIR RELATION TO IRRIGATION.

Fort Collins, Colorado.

JULY, 1891.

Bulletins are free to all residents of the State interested in Agriculture in any of its branches, and to others as far as the edition will permit. Address the Experiment Station, Fort Collins, Colorado.

The Agricultural Experiment Station.

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The Artesian Wells of Colorado.

AND THEIR RELATION TO IRRIGATION.

By L. G. CARPENTER.

This bulletin has arisen from the investigation of artesian and other phreatic waters of the plains which was ordered by Congress in April, 1890, and put in the charge of the Department of Agriculture, with Richard J. Hinton, special agent in charge, Robert Hay chief geologist and E. S. Nettleton chief engineer. The writer had to do with the collection of information in Colorado and New Mexico, and from the data then collected, most of that which pertains to the region east of the mountains is derived, with the permission of the Department. That in regard to the San Luis Valley, which was beyond the limit set for that investigation, is largely derived from personal investigation, mostly made since the close of the investigation referred to. The reports of the Congressional investigation are contained in Executive Document No. 222 of the Fifty-first Congress, first session. In this report some seventy pages are given to the wells of Colorado, especially those of the Denver basin, and as they are described in detail, it will not be attempted to describe them here. It may be added that the above investigation, with increased scope, is being continued under the same gentlemen, and promises information of much value in regard to the water resources and possibilities of the Western plains.

By an artesian well is ordinarily meant a flowing well. The name was associated with the province of Artois, in France, from which a knowledge of them spread throughout Europe. They were, however, known and sunk in other countries centuries before, and sometimes of extreme depth.

The cause of the water rising to the surface and flowing, is an illustration of the familiar tendency of water to seek its own level. If the source of the water is higher than the surface of the ground where it is set free, the water rises with a force depending on the height of the source above that point, other things being equal. Whether a well flows or not will then depend on whether the mouth of the well is below or above the source. In many regions, where the ground gradually rises, there is an area outside of which the wells do not flow, because the surface is too high. Examples may be found where the water rises almost to the surface, and where the lowering of the surface a single foot, as by digging a trench, would render it a flowing well. There is evidently no essential difference between the two cases, but according to the ordinary usage one is artesian while the other is not. In both wells the water rises above the stratum where encountered. This characteristic was taken as the basis of the meaning of the word as used by the U. S. Artesian Wells Investigation of 1890. To make a distinction between the two classes, which is practically important, it has been proposed to distinguish them as positive artesian, or simply artesian, and negative artesion—the former indicating those which flow.

The conditions for the existence of an artesian well basin are, that there should be some source of water supply higher than the location of the well, and that there should be a porous stratum which is confined by impervious strata both above and below. These strata must be continuous. In general, the water should have no means of escape lower than the point where the well is, but when the distance to an outlet is considerable, the friction in the intervening distance may be more than sufficient to make up for the difference in level. The pervious stratum may consist of any material which will allow water to pass through it, but most commonly it consists of sand or sandstone. The more open and porous this stratum is, the more abundant will be the flow with any given pressure. No rocks are perfectly impervious, but thickness will compensate to a great extent for a slight porosity. The confining stratum generally consists of clay or shale.

The region where artesian wells are found is generally spoken of as an artesian basin, largely because the typical form of such a region is a genuine basin, with the rim higher than the center. A section of the Denver basin is of this form. The figure may represent an exaggerated section of such a basin, with the porous strata outcropping at B, D, C and A. Anywhere lower than the line AK flowing wells might be expected if the strata are continuous, but as we reach K, or some point nearer B, it will be found that water comes only to the surface, and still higher it may fail to reach the surface. It is also evident that while at P flowing water will not be obtained from the upper stratum, by going deeper it may be secured, because the outcrop of the stratum which furnishes it is higher.

The figure also shows why the pressure is generally greater as the depth is greater. This fact has given rise to a popular belief that if one only goes deep enough flowing water will surely be obtained. Unless the proper conditions are present this is not true, and it is useless to expend money in that hope.

The supply of water which comes from a well or series of wells is never unlimited, though it may be very large, as in the wells of Dakota, or in some of those in the San Luis Valley. Its limit is set by the amount which is supplied to or absorbed by the water-bearing stratum, from water which falls on or flows over the edges of the strata. Where the strata reach the surface at a small angle, the area exposed to absorption or to rainfall is much greater, and the case is more favorable than where the angle is great. The capacity of the wells is limited by the amount these edges can absorb, or to the supply which may fall upon them. The edges may be covered by surface soil, or may be less pervious, in which case the conditions are less favorable for a large supply. If the number of wells is increased largely in any basin, there generally arise indications of a limitation of the supply in the effect of one well upon another, or on the general flow. When such a point is reached, it is time that some consideration be given to the conditions, for the value of such a supply cannot be overestimated. Its value becomes greater with the increase of population. When many wells are put down in a small area, the decrease which is generally noticeable may not indicate that the general supply is overdrawn, but that the local supply is; that is, that the water flows from the wells faster than the supplying strata furnish it.

Very little attention has been given to artesian wells in Colorado as a source of supply for irrigation. In the basins yet developed the conditions are perhaps not favorable for this use. But, it is to be remembered that with a growing population and greater need, but with a limit to the water supply, the value of water constantly increases. That the sinking of wells for this purpose is practicable is witnessed by the experience of many countries besides our own. In some portions of China it has been practiced from early ages. India derives no small portion of her supply from wells. The French have sunk many wells in the Algerian Sahara, and around these spots the desert gives way to garden spots. Some 60,000 acres are irrigated from them in California. Whether the sinking of wells for this purpose is economically practicable or not, will evidently depend upon the cost of sinking and upon the amount of water to be obtained, and the cost will depend upon the depth as well as upon the character of the strata which it is necessary to pass through.

As to how much one might venture, opinions would naturally differ, but the value of water in this State is indicated by the price of the water rights. In the older settled districts, the water right for eighty acres rarely brings less than $1,200, even in some of the ditches which do not have water in times of scarcity. Such a right generally means 1.44 cubic feet of water per second. This is considerably reduced, except in periods of high water, so that the amount actually received, as a rule, is but a small fraction of the nominal amount. Assuming the flow to be the full amount, the prices for the rights would be about $780 per second foot; but based on the actual amount of water received, they would probably be four times that. As an indication of the value of water in a community older than the average in Colorado, there are one or two instances in the Greeley community, where farming has now been carried on for twenty years. One landowner, Governor Eaton, drained a few years since a piece of land which had become soggy and wet. The drainage, which formed a constant stream, was wasted for some time in one of the canals near by. After a year or two, some of the farmers below this point, and who already had rights in the Cache la Poudre Canal No. 2, one of the best in the valley, deemed this water of sufficient value to them to purchase it for $5,000. This present summer the amount of this drainage water did not exceed 1¾ cubic feet per second, and as the purchase was made three years ago when there was still less, the rate was something like $3,000 per second foot. The owners think it was one of the best investments they ever made.

If water has reached such value in a community not more than twenty years old, and that, too, where tropical fruits or the large returns of a more torrid climate cannot be expected, it may well suggest that before many years it may pay to expend sums for the development of supplies which would not now be thought of, and it impresses the economic importance of conserving such supplies as we have, and of utilizing them to the fullest extent.

One advantage in the artesian wells is in their continuous flow, as in the case of the drainage water above mentioned. In most streams of the State the water is high for a short time only during the season, and during July and August it becomes scanty, so that late crops often suffer in consequence. The surplus water of June runs to waste. Where the flow is uniform throughout the season, a duty of some three or four times that used as the basis of water rights in Colorado may be expected.

The flow from many of the wells is small, so small that the owners think it is of no use in irrigation, and therefore allow the water to run to waste. We have not yet learned how to utilize the small but constant flows as the natives of some of the Eastern countries, like Armenia, where Mr. Nahikian, a native of that country, and a former student of the Agricultural College, says a small stream as large as a pencil is highly prized. The stream alone could effect no irrigation of consequence, but by running into a small reservoir it can be stored, and then a large head used for a short time. The greater effectiveness of a large head is well known in Colorado. In a similar way the water from many of the wells, which now runs uselessly away, could be made to perform a service which would be considerable in the aggregate. Some are already being utilized in this way to a greater or less extent, but generally without storing.

The cost of sinking generally increases more rapidly than the depth, so that except in exceptional cases, such as extremely easy boring, as in the San Luis Valley, or great supplies of water, as in Dakota, it will not pay to attempt deep wells for irrigation purposes. The temperature increases with the depth, which is an advantage if the water is to be immediately applied; but the water is also more mineralized, which is a disadvantage or not, according to the character of the solids present.

Throughout the artesian basins of the State it is the rule, rather than the exception, to meet with wells whose flow is decreasing. This may be due either to the increase in the number of wells, so as to overdraw the local supply, or to defects in the individual well. When the latter, it is generally due to a partial filling of the well with particles, which may have been brought in with the water, or may have fallen from the walls above. In either case, the flow is partially stopped, and may generally be recovered by cleaning.

The prevailing troubles of this kind arise mostly from the common practice of casing the well imperfectly, or sometimes not at all. Usually in the San Luis Valley, and in large numbers of the Denver wells, the casing extends only through the loose surface soil to the first clay stratum. And cases are not unknown where this consists simply of stovepipe, or a tube of boards made on the spot. Such construction has generally been dictated by motives of economy, but it hardly needs to be said that it is a false economy, which may risk the whole supply.

But more serious than the danger to the individual well in such a practice is the damage done to the whole basin. A consideration of the general character of the conditions will show the reason. The lower stratum has generally the greater pressure. There may be strata which are dry and do not furnish water. If a hole be bored through the intervening clay layers, there is a chance for much of the force of the water to be lost, and such loss affects not only the individual well, but the whole surrounding basin.

The different strata rarely furnish water at the same pressure, and sometimes there may be strata without any. The effect of opening an uncased hole through the confining layers, is simply to give the water an opportunity to escape into the dry layers, or into those of lower pressure, which it will as certainly do as it will flow to the surface. The effect is to not only lessen the flow at the surface in this individual well, but it may lessen the pressure in all surrounding wells.

Equally important is it that the casing be carefully packed where it passes through the impervious stratum, both above and below, if it extends through the lower confining bed. Some of the failures in securing flowing water are due to the lack of such packing.

The importance of preserving such supplies of this character as we have cannot be too strongly dwelt upon. The need for this water, whether for irrigation or for domestic use, will not grow less. Its loss for the latter would render some regions almost uninhabitable. And any practice which tends to lessen the efficiency of the whole basin cannot but be strongly condemned.

In some cases the upper confining stratum has been pierced and the well abandoned; perhaps the casing drawn up. This allows the water to waste uselessly into the upper strata or in the surface soil, to the detriment of the whole basin. Where once done, it is next to impossible to henceforth find the hole and stop it, even if it should become desirable.

The public importance of preserving such supplies and the ultimate effect of such practice, is such that it ought by law be required that every well that is sunk should be completely cased, and that no well should be abandoned or the casing withdrawn without plugging the hole at the impervious strata.

There should also be some means of limiting the sinking of wells whenever the further boring affects the flow from those already sunk.

As it is of importance to know of any change in the pressure, as showing such a limit, it is advisable for all those having wells to test them occasionally when circumstances are such as to render it possible. When arranged with hose connections, as many are, it is easy to do so with the moderate pressures which prevail in this State. Attaching the hose so that there is no leak, the end may be raised until the water ceases to flow. If it be lowered, the flow will begin again at the same height, or close to it. This measurement, or the mean of the two, referred to some fixed object, can be used as a means of comparison with other measurements, and if occasionally repeated, will show any change in the pressure, and may indicate the cause of any decrease. For example, a partial filling of the bore, while lessening the flow, will not affect the static pressure, as thus determined. Pressure, as thus determined, may be reduced to pounds per square inch by dividing by $2\frac{1}{4}$.

THE ARTESIAN WELLS OF COLORADO.

The discovery of artesian water in Colorado was an accident. There had been those, however, who believed in its existence, and who make attempts to find it. Probably the earliest was made by General W. J. Palmer, who, while manager of construction of the Union Pacific Railway, made an attempt at Kit Carson in 1871. The Government sunk wells at Akron, Fort Lyon and Cheyenne Wells in 1881-2, but without success, other than a small flow at Fort Lyon. Before this the Pioneer Oil Company, while sinking a well on the bottoms at Pueblo, struck water January 1, 1880. This well, now known as the Clark Mineral Spring Well, is still used, and has led to other trials in the same vicinity, all with small flow.

General attention was attracted to this source of water supply by the discovery of water in North Denver in 1883 while prospecting for coal. The water was so much purer than that in use that it immediately led to the sinking of many others for a domestic and manufacturing supply. This led other communities to bore for water, and some very deep wells, as at Greeley and Loveland, have been sunk in the search. The latter town has still outstanding some $8,000 of bonds which was used in the trial. Other attempts have been made at Colorado Springs, Longmont, Walsenburg, Rouse Junction, Stout, and on the plains at Calhan, Otis, Thatchers, etc. The supply has in no case been large, and in most places the attempt was unsuccessful.

Water has been found east of the range at Denver, Pueblo, Greeley, Stout, Florence, and in the Arkansas Valley near the Kansas line. The only important basins

DENVER, COLORADO
ARTESIAN BASIN.
JULY, 1890.

S Ex. 222 51

as yet developed are those of Denver and the San Luis Valley, the latter of which is the most important, and one of the most important in the country, whether judged by its extent, the ease and cheapness of sinking, or the amount of water found.

THE DENVER BASIN.

It was in this basin that the first development to any extent of artesian water in the State was made. Reports upon this basin have been made by the Colorado Scientific Society in 1884, and in the U. S. Artesian Wells Investigation previously referred to. As the writer has there described the wells in detail, it will be here referred to only to illustrate some of the characteristics of basins which are plainly shown by experience therein.

The basin is shown by the map, which is reduced from one given by the writer in the Government report. The location of the wells is shown by the small circles. Where the water did not reach the surface the circle is underlined, and the figures attached indicate the distance the water came from the surface. The limits of the flowing wells are indicated by the dotted line, on each side of the Platte.

The basin is instructive, because it shows the effect of putting down many wells in a small area.

The early wells were nearly all put down for domestic purposes, and were small in size. The water was excellent for boilers, and the increased demand led to the putting down of larger wells and to the use of pumps for factories, hotels and other large users. The result has been that nearly all have ceased to flow. In the Charles well, which was the first to reach the 600-foot stratum, the pressure was quite constant, and about 70 pounds per square inch. When the Daniels & Fisher well was sunk to the same depth not far away, the pressure was immediately reduced to about one-fourth as much. The sinking of the McClelland well still further reduced it. The well is now pumped.

This is only one of many instances.

In the country the wells are not so close together, and the decrease is generally due to other causes. In case of partially filling up, cleaning recovers much of the flow. Thus in the well of the Barclay block, the following measurements were made by Charles M. Dwelle, who had charge of it during the process of cleaning, in 1884:

May 14, 10½ gallons per minute (before cleaning).
May 15, 4 a. m., 17 gallons per minute (after cleaning was begun).
" " 6 a. m., 22 " " "
" " 9 a. m., 32 " " "

The gathering area of this basin is limited, and with the large number of wells it is not surprising that variation is noticed with the seasons. On the Barclay well, as measured by Mr. Dwelle, the flow from the deeper stratum was as follows:

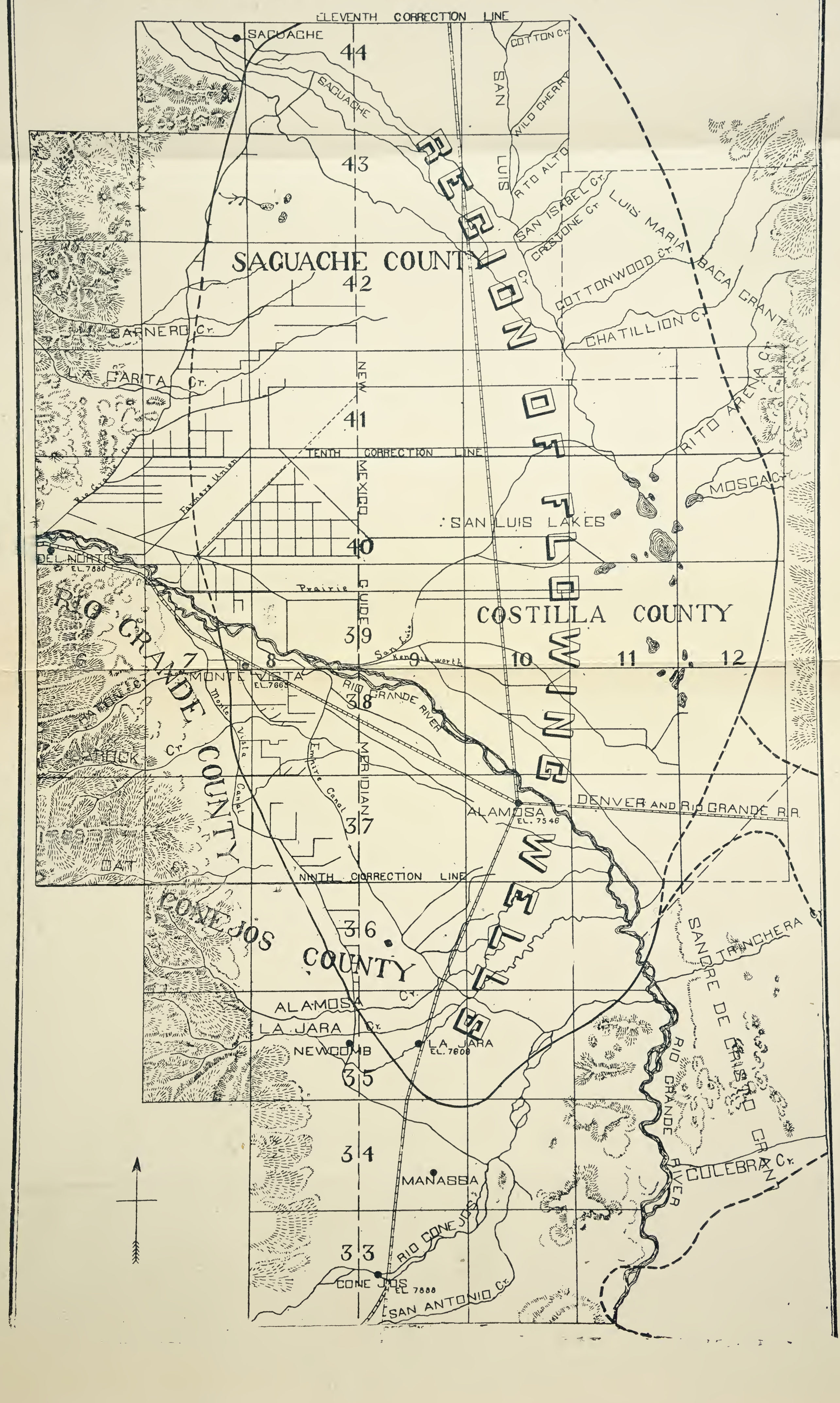
Aug. 4,	1884,	36	gallons	per	minute.
Jan. 24,	1885,	51	"	"	"
Mar. 9,	"	40	"	"	"
Nov. 8,	"	35½	"	"	"
Jan. 27,	1886,	12	"	"	"
Feb. 6,	"	14	"	"	"
Feb. 9,	"	27	"	"	"
April 8,	"	12	"	"	"
May 14,	"	10½	"	"	"

A part of this variation is due to other wells in the vicinity, but aside from this a fluctuation is noticeable. The variation with the seasons has been plain enough to be remarked in other wells as well.

The flow of the wells frequently increases for a time after being sunk, which is due to the fact that a small reservoir or cavity is nearly always formed. These are usually small, but sometimes the amount of sand brought up is as much as two or three cubic yards.

SAN LUIS LAKES
MOSCA
DEL NORTE
EL. 7883
RIO GRANDE
COSTILLA COUNTY
FLOW
40
39
7
8
9
10
11
12

MAP OF SAN LUIS PARK, COLORADO.



The wells of the Denver basin have been put down almost exclusively for domestic water. There has been comparatively little thought given to their use for irrigation, nevertheless many of the wells are irrigating areas of from one to ten acres. Nearly all those in the country are used to irrigate gardens. Some are used for the raising of fish. The cost of the well, taken with the small amount of water obtained as a rule, prevents many being sunk for irrigation.

THE SAN LUIS BASIN.

The San Luis basin is the most remarkable of any yet developed in the State. Though here the water was found by accident by S. P. Hoine as recently as the Fall of 1887, while sinking a sand point for an ordinary drive well, the ease and cheapness of sinking have been such that there are now probably as many as 2,000. They are so numerous that the residents give no more than a passing glance to one, aud as they are frequently sunk in less than half a day with the simplest of outfits, it is not remarkable that it is impossible to secure any kind of complete list even for a limited locality. Wells are often sunk for $25, and they range from this price upward, according to circumstances. In consequence, it is cheaper to bore artesian wells than it is to attempt to dig wells of the ordinary kind, without the added inducement of the purer water. Hence within the limits of the flowing area nearly every occupied quarter section has a well, and sometimes more. The town of Monte Vista has 88; La Jara at least 17; Alamosa over 25; D. E. Newcomb, 17; S. E. Newcomb, 8, and wells in corresponding numbers are found over all the valley.

To the eye the valley is level as a floor, though it has a slight slope, so uniform that the prevailing practice in ditch construction is to follow the lines of the Government surveys, sometimes for long distances, as in the case of the Prairie Ditch, which runs on a section line for twenty-six miles. Though at a mean elevation of over 7,500 feet, agriculture is a success, and attention has been attracted to its large crops of the cereals and potatoes. The second premium crop of the *American Agriculturist* of 1890, over 800 bushels of potatoes to the acre, was raised near Del Norte.

The valley is surrounded on all sides by the highest mountains of the State, so that the rainfall in the valley is scanty and irrigation is more than ordinarily necessary. The streams, which come principally from the West, soon sink, with few exceptions, and in consequence have built their beds higher than the surrounding plain with the sediment and *debris* which has been left as the waters have sunk. This is true of the Rio Grande as well, as is evident by the canals shown on the map, which run nearly at right angles to the river.

The uniform appearance of the valley, as well as the conditions which have made it an artesian basin, is due to the fact that in former geological times it was an immense lake, formed by the damming of the Rio Grande by the large mass of basalt in the lower end of the valley, and which is probably also the cause of the abrupt bending of the Conejos and other rivers to the north. In consequence of the lake formation, the characteristics are fairly uniform over the whole area, though there is much variability, as is to be expected, in the thickness and number of the strata. Near the ancient bed of the Rio Grande there is especially great variation; elsewhere there is great uniformity over considerable distances. The water is found everywhere, so far as learned, above the rock, which, in the western part of the basin, is comparatively near the surface, but at Alamosa is not found in the well which is 1,000 feet deep. The wells are sunk so easily and rapidly that few records are kept of the strata passed through, but the following, taken by J. M. Chritton, in Township 39 N., Range 9 E, is typical of the whole district:

Strata.	Thickness, feet.	Depth, feet.	Flow
Dark, sandy loam	7	7	
Coarse sand and gravel	13	20	
Fine light-yellow sand	22	42	
Yellow impervious clay	18	60	
Blue clay or soft slate	98	158	
Black sand	1	159	Small flow.
Blue clay	4	163	
Fine black sand	3	166	Fine flow.
Blue clay	45	211	
Fine black sand	12	223	Flow.
Blue clay	53	276	

Black sand; flow so strong that with our pump we could not go deeper.

The accompanying map shows the extent of the basin, the supposed limits being indicated by the heavy line. These limits were fixed as the probable ones from the data in my possession. In some places they are quite exact. They were drawn before having seen the map given by F. M. Endlich in Hayden's Geological Report for 1875, where the limits of the ancient lake, there called Coronados Lake, are given. The artesian basin agrees so closely with the boundaries of the ancient lake, that it may be taken as its map. In the southeastern portion, a region not visited by myself, Endlich's map shows an extension of the lake to the south and east around the mass of basalt, striking the present course of the Rio Grande again in Township 33. As the accompanying map was completed before seeing the above mentioned map, it was impossible to show more than a portion of this extension of the ancient lake bed, which is indicated by the dotted lines. As the limits of the ancient lake and the artesian basin are practically identical for the upper portion of the valley, and as the same conditions which make the upper portion an artesian basin hold true for the lower, it is probable that artesian water will be found in this extension as well, though I have yet to learn of any borings in this portion.

At Monte Vista the flow which is used is from 107 to 111 feet; at La Jara the first flow is found at about sixty feet, the second at ninety, and the third at 130, the amount found at the same depth being, to some extent, different for different wells, but the temperature being the same.

The shallower wells are, as is to be expected, colder than the deep ones. The temperature of nearly a hundred in different parts of the valley was taken. They varied from 46.2°, from eighty-five feet, a few miles north of La Jara, to 74.7°, from 932 feet, at Alamosa. The shallowest well observed, forty-five feet, had a temperature of 51.8°, but this was in the southeastern part of the basin, near the bend of the Conejos, near which are the Les Ojos Calientes, or warm springs, of Judge McIntire, with temperatures from 74° downwards.

The measurements, as a whole, indicate an increase of one degree Fahrenheit for thirty-four feet increase in depth, which is somewhat more than the average as found by measurements over a large portion of the earth's surface.

The wells with the lower temperatures would seem to be too cold for the best results in irrigation, but where the water is stored in reservoirs and exposed to the sun for a time its temperature would be increased. The warm water from the deep wells could be very beneficially applied, and might render possible, to a limited extent, the growth of crops which could not ordinarily be raised in the valley, or could assist in forcing early crops.

The pressure at none of the wells is great. At Monte Vista and vicinity it was from twelve to fourteen feet when first sunk for depths of from 100 to 135 feet; at La Jara, thirty feet, according to the measurements of Mr.

Carrico; twelve feet in the shallow wells south of Alamosa, and in the deepest wells at Alamosa, fifty-six feet.

The amount of water to be obtained depends upon the character of the strata as well as upon the pressure. If water passes through a stratum with difficulty, there may be wells of high pressure but small flow, and as there is a limit to the rapidity with which water can pass even through sand, the flow is not necessarily in proportion to the size of the pipe. The flow frequently increases for a time after the well is sunk, due to the formation of a pocket or small reservoir at the bottom, which, by increasing the area of the supplying surface, renders a greater flow possible with the same pressure. In general, the deeper wells have the greater flow, because of the greater pressure.

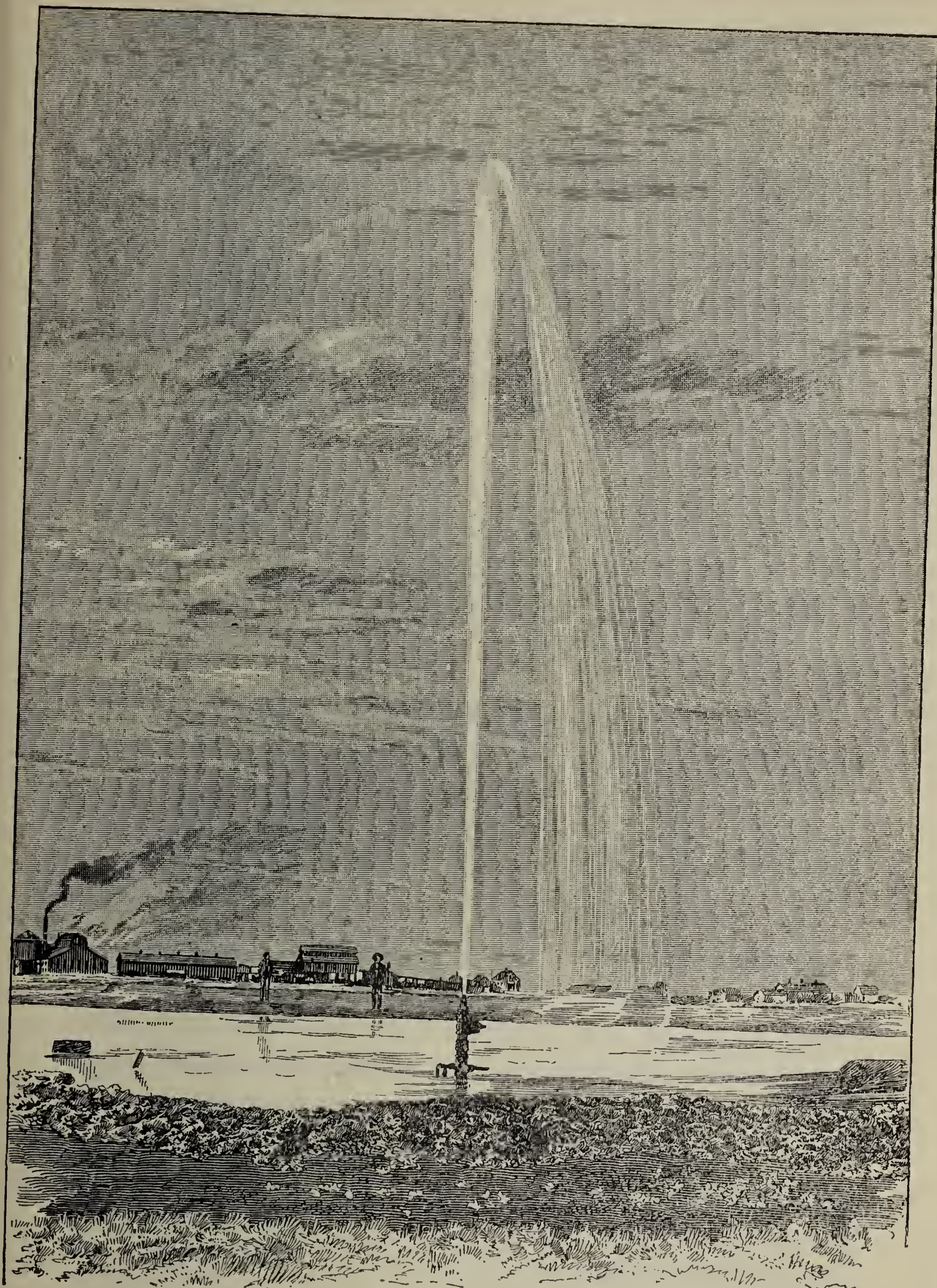
The small wells, which are generally of two-inch bore, flow from five to twenty-five gallons per minute, the latter being considered a good flow, and the cost for the same wells is from $25 to $75. The two deepest and largest wells in the valley are at Alamosa. One, the town well, which flows into a small reservior perhaps forty feet square, was measured by passing the water over a rectangular weir. The weir was placed in an opening in the bank and left for some time, until the water seemed to be neither rising nor falling in the reservoir, when the measurement was taken. The weir was 24 5-16 inches long and the depth flowing over, measured several feet from the weir, was 3 1-12 inches. Allowing a small correction for velocity of approach, this corresponds to a flow of 400 gallons per minute, or nearly one cubic foot per second.

Not far from the town well is that of Conrad Bucher, which was sunk in the summer of 1889, for oil. This was the first deep well sunk in the valley, and has the largest flow. It is nearly 1,000 feet deep, but secures the heavy flow from 932. It has a double casing, the outer one extending to between 500 and 600 feet. The water is run into a reservoir, and is devoted to the raising of carp. With the time at my disposal, it was not possible to arrange it so as to make a satisfactory measurement. When the six-inch inner pipe is reduced to three inches, it throws the stream nineteen feet into the air, and when reduced to one inch it is projected over forty feet. The accompanying view represents this well reduced to one inch. The two flows, from 932 and from 500 feet, together amount to probably 600 gallons per minute. The town well cost $1,865, the latter $2,700, a large part of the expense being for the casing.

The flow of a three-inch well of A. T. Clark, a few miles west of La Jara, which was 166 feet deep and was sunk in one-half day by six men, was ninety-five gallons per minute. The water rose seven inches above the casing.

In Township 42 north, Range 8 east, is the three-inch well belonging to Celso Espinosa, 265 feet deep, which throws a solid stream the full size of the casing 33¾ inches high. This seems to have decreased some, as Mr. Dawson informs me that he had measured it when it threw a stream forty-one inches high. The flow was between two and three hundred gallons per minute. Several others in the same neighborhood, which is near where the Carnero sinks, are reported as having flows corresponding to this.

Most of the wells have been sunk for domestic use only, and irrigation has not been specially considered in connection with them. Where the flows are large they are used to some extent, and sometimes small reservoirs have been built for storage. The three-inch well of Espinosa, already mentioned, is said to irrigate some 100 acres of hay land. J. M. Chritton writes that he was irrigating sixteen acres in 1889 from one well. L. W. Smith, a few



THE CONRAD BUCHER WELL, AT ALAMOSA, COLO.

miles west of Alamosa, irrigated forty acres of crops, consisting of oats, wheat, barley, rye and potatoes, from two three-inch wells in 1889, and stated that he intended to farm 100 acres during the present season by using a reservoir of one and one-half acres. Several wells in the vicinity of Espinosa's furnish water for irrigation.

The supply of water from the river is not yet fully used, so there is not so much inducement to consider means of using water in the quantities furnished by most of the wells, but with the closer settlement of the valley there is no doubt they will be of considerable importance in the aggregate.

The water furnished by the Bucher deep well at Alamosa exceeds one cubic foot per second, and the cost was $2,700, so that if water should reach the value it has in the older farming communities, such a well might be considered a good investment.

Whether the water is intended for irrigation or for domestic use, the supply is so important that it is a matter of great concern to know whether the limit of the supply is being reached, and whether it is affected by increasing the number of wells or not. There is a limit to the number of wells which may be sunk in any basin, which, if exceeded, will cause a decrease in all the existing wells, and may cause some to stop flowing. Because a well ceases to flow is not necessarily an indication that this limit has been reached, for the stoppage may come from other causes. The best practical test is the observation of the pressure, which depends principally on the height of the water level above the point where the test is made. If this level remains the same, the pressure is unchanged. But if this level falls, as in case so many perforations are made that the water flows out faster than it enters, the pressure falls until equality between the flow into the strata and out through the wells is again attained. A diminution of the pressure is therefore to be looked upon with some anxiety.

It becomes a question, then, of considerable importance to know whether there are indications of any lessening of the pressure. The large number of wells at Monte Vista, eighty-eight, in not over a square mile, caused particular attention to be given to that locality. Most of the inhabitants questioned had noticed no decrease, but there seems to be clear evidence there has been. When the wells were first sunk, according to Mayor Mead and others, the head was about fourteen feet. In 1889 it was still sufficient to run water into the sprinkling carts, or it was still over seven feet. Some who were supplied by pipes from this well had to lower the outlet, in order to have running water. In the fall of 1890 the head was not sufficient to force the water four feet above the ground. The well of Capt. C. S Aldrich, editor of the *Graphic*, when first sunk had a head of fourteen feet, but when measured by myself, in 1890, it was barely five feet. I measured the well of Olando Bonner in January, 1889, and again in September, 1890, and in the meantime it had lost over one-half its force.

This should be a cause of grave concern to this community, for it indicates that if the wells are greatly increased in number in that local area, or, if some should begin pumping, their experience would follow that of the Denver and the Greeley basins, and the water would cease to flow.

The fact that such a decrease has been noticed in one place in the valley suggests the importance to the other places of keeping close watch for similar symptoms. How the pressure may be measured has already been explained.

The source of the supply for the wells is to be found at no great distance, in the streams from the mountains which pour their waters into the sands of the western part of the valley, and to a lesser extent from the streams of the eastern side. These have gradually raised a delta of sand where they enter the plain, higher than the basin proper and consisting of the coarser debris which has been brought down. Farther out in the valley, the beds of clay begin. All of the smaller streams are entirely lost in these beds of debris, as the map shows. Of those which do not disappear, it would be interesting to know whether there is any marked diminution of their volume in passing over this absorbing area. Except in high water, the streams do not extend as far as the map indicates. The watershed of the smaller streams from the west, which entirely disappear, is some 460 square miles, of the Saguache and San Luis creeks about 1,300. The amount brought into the valley by means of these streams is unknown, but the ratio it bears to the area of the watershed will be approximately the same as in the case of the Rio Grande. Through the courtesy of the State Engineer, we have been furnished with the discharge of the latter river for 1890, and by taking the area of the watershed from Hayden's maps with a planimeter, we find that the discharge of the Rio Grande, as measured at Del Norte, corresponds to a depth of twelve inches very nearly over the whole watershed. Assuming the same depth as the amount flowing off from the smaller streams, their total flow would average about 330 cubic feet per second. An unknown amount comes from the San Luis and Saguache creeks and from the mountains of the east. If we assume that this may be as much more, as seems a reasonable estimate, the total amount available would be some 600 cubic feet per second.

Taking all these sources into consideration, it seems safe to conclude that while the supply will most likely exceed 600 feet per second, it is not apt to reach 1,500.

The average flow of the present wells in the valley may be taken as twenty-five gallons per minute, whence their combined flow is in the neighborhood of 110 cubic feet per second.

It is probable, therefore, that the number of wells may be increased until the flow is six times as great, but not likely that it may become fifteen times as great.

Assuming the smaller amount as the amount of water eventually available, if it were all used in irrigation, it might irrigate, at seventy acres to the second foot, some 42,000 acres; and, if used with storage, three or four times as much.

ARTESIAN WELLS ON THE PLAINS.

A word may be said in answer to the numerous inquiries which come as to the probability of finding artesian water on the plains of Colorado. We all know that it would be of great importance if it could be found even in comparatively limited quantities. Attempts have been made at several places, widely scattered, to considerable depths. At Fort Lyon a flow of three gallons per hour was met at 430 feet, but no other to the depth of 700 feet, where the boring was stopped. At Akron, no flowing water was found. Water from a depth of 1,155 feet came within fifty-five feet of the surface. At Otis, not far east of Akron, a boring was made to the depth of 2,400 feet, but no water of any kind is reported. At Kit Carson no water was found within 1,500 feet. A well was sunk at Sheridan Lake, no water; also at Calhan, with the same result. At Cheyenne Wells two have been sunk, but without finding flowing water, though one is pumped for a railroad supply. There may be local areas, similar to the one at Coolidge, in the Arkansas valley on the Kansas line, where flowing water may be obtained, but geological evidence, as well as that obtained from these wells, show that it is improbable that artesian water will be found in any extensive area within a practicable depth.

Besides the wells already referred to, several have been struck on the western side of the range, as at Montrose and on the line of the D. & R. G. Southern. All through the mountains it is probable that small areas, with greater or less amounts of water, will be found, but the area and economic importance is not apt to be great.

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State Agricultural College

The Agricultural Experiment Station.

BULLETIN NO. 17.

A PRELIMINARY REPORT

ON THE

Fruit Interests of the State.

Fort Collins, Colorado.

OCTOBER, 1891.

Bulletins are free to all residents of the State interested in Agriculture in any of its branches, and to others as far as the edition will permit. Acknowledgment will be expected from all non-residents. Address the EXPERIMENT STATION,
Fort Collins, Colorado.

The Agricultural Experiment Station.

FORT COLLINS, COLORADO.

A PRELIMINARY REPORT

ON THE

FRUIT INTERESTS OF THE STATE.

By CHARLES S. CRANDALL.

The year just closing has been a successful one among the fruit growers of Colorado. The experiences of the year have furnished practical demonstration of the fact that extended areas in different portions of the State are especially adapted to fruits. Crops have been large, ready markets have been found within our own borders, and prices have been generally satisfactory. Growers have shown a creditable pride in the exhibition of their products at the various fairs. The exhibits have been large, and the quality and beauty of the fruits shown has made it clear to all observers that the future possibilities of fruit growing are most flattering.

The success attained in this and the three or four preceding seasons has encouraged preparations for the enlargement of existing plantations, and many men who have been in doubt as to the possibility of raising fruit are now setting their first orchards. The area of orchards planted in 1890 was large, that of 1891 still larger, and the indications are that the planting for 1892 will be the largest in the history of fruit planting in the State.

The men whose names now appear in the lists of exhibitors at fairs are the pioneers—men who are now reaping the reward of that faith which, several years ago, induced them to plant orchards, regardless of the commonly expressed sentiment that fruit could not be grown in Colorado. This sentiment was at first general, applying to the whole State. Gradually its fallacy was shown up, by the production of excellent fruit, first in one section, then in another, until now it is held only locally. One gentleman, writing from the San Luis Valley, informs me that the "croakers," who asserted that nothing could be grown in the valley, have been forced to recede from their position by excellent agricultural crops, until they are now intrenched behind the statement that "fruit cannot be grown," and "this in the face of the fact that a few men *are* growing good fruit."

Much credit is due these pioneers in fruit growing for their persistence during the experimental stages; with no precedents to guide them, they were obliged to learn by experience all the steps in fruit growing by irrigation. Costly errors in choosing varieties or in methods of treatment were now and then made, but they were not discouraged, and now they have demonstrated that success will attend properly directed efforts in fruit growing. Those who plant now for the first time can, by taking advantage of the experiences of these pioneers, avoid their mistakes and may choose varieties and follow methods which are reasonably sure of success.

Climatic conditions vary greatly in different portions of our State, these differences being due partly to the range of latitude, which is four degrees, partly to differences in altitudes, which range from 4,000 feet above the sea level to way above the possible limits of agricultural or fruit crops, and partly to the influences of mountain ranges; so that while some portions of the State are adapted to the more tender fruits, other portions must be limited to the hardier varieties of the hardy fruits. As no planting can be surely successful without irrigation, fruit raising must be confined to those districts which have a supply of water and the means of distributing it to the lands.

In considering the present status of fruit growing, it will serve our purpose to divide the State into three districts:

A Northern District—To include all territory lying east of the range and north of the divide.

A Southern District—To include the territory east of the range and south of the divide.

A Western District—To include the territory west of the range.

The Northern District embraces the basin of the South Platte and its tributaries—Bear Creek, Clear Creek, Boulder Creek, St. Vrain, Big Thompson, Little Thompson and the Cache la Poudre.

So far as we are informed, fruit growing within this district is confined to the counties of Arapahoe, Jefferson, Boulder, Larimer and Weld. The conditions of altitude and climate prevailing in this district are such as to preclude the possibility of success with the tender kinds of fruit. Peaches have been grown in Jefferson and Boulder counties, and Black Hamburg grapes have been ripened as far north as Fort Collins. We must, however, consider these as exceptions due to a favorable season, or to favorable local conditions of soil and exposure. Past experience reveals nothing that would warrant planting the fruits mentioned. The restrictions of climate arise, not from extreme low temperatures, but from the great range of temperature and the sudden changes which take place. Occasionally injury may result from late frosts which come after trees have been encouraged to bloom by the warmth of early spring, but this difficulty occurs less often in the Northern District than it does further south.

The apple is *the* orchard fruit of the district. Pears are planted to some extent, as are also plums and cherries, but these fruits occupy but a small area as compared with the apple. That the pear and some varieties of plums and cherries will do well in many places in the Northern District there can be no doubt, because some orchardists have succeeded with them; they have succeeded by giving that extra care which the young trees demand. The standard varieties of pears will, when once established, endure as adverse conditions of climate as most varieties of apples. It is in the first years after planting that special care and culture must be given in order to insure continuous healthy growth.

An estimate made early in the season by Dr. Shaw, Secretary of the State Bureau of Horticulture, places the area in fruit in the Northern District at 2,850 acres. From observation and extended inquiry, I am led to regard this estimate as conservative, and as nearly accurate as can be made from the data at hand.

The area in fruit in Arapahoe County is about 600 acres, confined to the extreme western part of the County, and mostly to the immediate vicinity of Denver. The oldest orchard in the county is that of Mr. L. K. Perrin, in North Denver; the largest that of Messrs. Stark Bros., near Littleton, which covers ninety-three acres, and contains about 12,000 trees, mostly apple. As further examples of successful orchards near Denver, I may mention the Col. A. C. Fisk orchard, in the southern suburbs, which contains 3,000 apple, 1,500 plum and 50 cherry trees; also the fifteen-acre orchard at Elitch's Gardens. In the neighborhood of Brighton, near the county line, north of Denver, are several small orchards, which give every promise of success. A sufficient degree of success has been attained in the county to demonstrate that where water is available, apples, pears, most varieties of plums, and the sour cherries can be profitably grown.

Jefferson County is credited with an area of 700 acres devoted to fruit, a considerable portion of this being in young orchards not yet in bearing. In this county were planted some of the first orchards in the state. The early attempts were failures, owing mostly to the condition of the trees on their arrival from the long overland journey in wagons. A few men, holding tenaciously to the idea that fruit could be grown, planted again, and now the County can boast some of the finest orchards in the northern section of the State. A number of orchards now standing were started as long ago as 1868; these received additions at various times, and now they are sources of annual profit to their owners. Prominent among the successful fruit growers of Jefferson County are David Brothers, John Tobias, William Lee and Henry Lee. Mr. Brothers' apple crop this season amounts to 1,000 barrels.

A close estimate of the land occupied by fruit in Boulder County in 1890 placed the area at 500 acres. In the spring of 1891 a large amount of planting was done, and the present area may be safely placed at 700 acres, the major portion of which lies in the valley of the St. Vrain. In the immediate vicinity of the city of Boulder there are some orchards, but mostly small ones. The attention here is mainly given to strawberries, grapes and other small fruits. Growers have attained marked success in the culture of these fruits. The plantations are numerous and extensive, and large quantities of fruit are shipped to the Denver market and to the mountain towns.

The first introduction of fruit trees along the St. Vrain dates back to 1866; but little now remains of this first planting, which was made under all the adverse circumstances with which the pioneer has to contend. Further plantations were made in 1870, and these formed the nucleus about which have grown up the now profitable orchards which dot the valley. As an index of this

County's fruit interests, I here give the statement of production for 1890, as compiled from the Assessor's returns, and furnished me by Hon. C. S. Faurot, Chairman of the Board of County Commissioners:

Acres in orchard	500
Apples, number of bushels	29,616
Peaches, " " "	168
Pears, " " "	198
Strawberries, number of quarts	53,765
Blackberries, " " "	57,150
Raspberries, " " "	54,110
Gooseberries, " " "	47,920
Currants, " " "	49,200
Cherries, " " "	5,850
Plums, " " "	3,955
Grapes, number of pounds	265,990
Wine, number of gallons	1,035
Grove and forest trees, acres	86

Mr. Faurot adds, "The increase in the acreage has been very great in the last year, also in apples and grapes. The grape crop is double that of last year."

It will be seen from the foregoing, that fruit already forms an important item in Boulder County productions. The industry is growing rapidly, and when we consider the smallness of the arable area in the County, the showing is an exceptionally good one.

Weld County, while ranking high as an agricultural County, has but a small area in fruit. This is not because fruit cannot be grown, but is due to the fact that the interest has been directed to farm crops, to the neglect of tree planting.

The early planting about Greeley consisted mainly of crabs, and most of the plantations were left to take care of themselves. In recent years these trees have suffered greatly from blight. Some crab orchards have been entirely dug out, others badly effected must soon follow.

The Siberian varieties, the Transcendant and the Whitney, are everywhere being exterminated by this disease.

Five or six years ago, some degree of interest was awakened in fruit culture, and as a result, there are now quite a number of small orchards of standard fruit just coming into bearing. The marked success of some of these small orchards is encouraging further planting. Mr. Geo. J. Spear, proprietor of the Greeley Nursery, has a large stock on hand, and he informs me that his sales of trees and small fruit plants for spring planting already amount to nearly $3,000. Other dealers have sold over $2,000 worth, and some stock will be shipped to individuals. It would thus appear that considerably more than $5,000 worth of fruit plants will find their way to Weld County farms in the spring.

It is to be hoped that those who plant will give their trees that care which is essential to success. In riding through the County, I was impressed with the idea that the average farmer was too much absorbed with his potato and grain crops to be successful with fruit. Many small orchards show evident signs of neglect, and little can be hoped for from them. Fruit trees will no more take care of themselves than will potato or corn crops; but they will respond to good care as readily as any other plants. That it pays to care for fruit trees properly, the experience of those who have tried it fully demonstrates. At Eaton, six miles north of Greeley, Mr. A. J. Eaton is deriving pleasure and profit from a three-acre plantation of fruit. Besides small fruits in good variety, he has Martha and Whitney crabs, the latter much effected with blight, and soon to be discarded; the former thrifty, free from blight and bearing good crops; Oldenburg, Excelsior and a few other varieties of apples; several varieties of plums, besides a number of native wild varieties. The wild plums yield enormously and the fruit sells readily. Mr. Eaton's surplus brought one dollar per tree this season. The three acres, after bountifully supplying his own needs, gave a money return of $300. Among Mr. Eaton's small fruits, are a few dewberries, of which he speaks in the highest terms.

The estimated area of lands occupied by fruit in Larimer County is 600 acres. Nearly all of this area is in small farm orchards of from two to ten acres. There are but few large commercial orchards. The first fruit planting in the County was done by the early settlers in the valley of the Big Thompson, commencing in 1863. The early experiences in this valley were similar to those on the St. Vrain, and of the orchards now standing, none trace their beginning further back than 1867. Most of the trees now bearing were planted at various times from 1873 to 1880. The good and profitable crops obtained from these orchards has given encouragement to further planting, and during the last three years the additions have been large. From present indications, the planting for 1892 will exceed that of any previous year.

In the valley of the Cache la Poudre, the first planting of fruit trees in Larimer County of which I have definite information was made in 1874. It is probable that a few trees may have been planted in the neighborhood of La Porte at an earlier date, but of this I am not certain, The early planting about Fort Collins was done in direct opposition to the very generally expressed opinion that fruit planting was useless. This sentiment grew out of the early failures at Greeley, and it was several years before successful ventures in fruit growing finally overcame it. That there is now an established confidence in the success of fruit growing, may be seen in the many young orchards scattered all through the valley.

Among the pioneers in fruit growing are: Mr. A. N. Hoag, who planted his first trees in 1874, and who for several years conducted a nursery business. Mr. Hoag now has eleven acres of orchard, containing 550 apple trees of several varieties, twenty-seven varieties of plums, six of cherries, six of pears, besides a number of seedlings of various kinds.

Mr. J. S. McClelland, of Fossil Creek, began planting in 1876. His orchard now covers forty acres and contains 4,000 trees. He has ninety-two varieties of apples, twenty of crabs, twenty-one varieties of plums and about fifty varieties of grapes. A considerable portion of Mr. McClelland's orchard has been in bearing for several years, yielding satisfactory crops.

Mr. W. F. Watrous has about six acres of bearing orchard, besides a considerable area in small fruits. His orchard contains about 500 trees, representing thirty-five varieties of apples, five of pears and twelve of plums.

Mr. J. E. Plummer makes a specialty of plums, and is very enthusiastic regarding the future of plum culture in Larimer County. He has 600 bearing trees, representing twenty-six of the leading varieties. The coming spring he will set 500 more. There are also in his orchard 300 apple trees and seventy cherry trees.

In Pleasant Valley, Mr. C. E. Pennock is developing a good nursery business. He has now eight acres occupied and will in the spring greatly enlarge this area. Mr. Pennock grows most of his stocks, does his own propagating and has as clean and thrifty trees as are to be found anywhere. There are now represented in his nursery 150 varieties of apples, thirteen of pears, twenty-one of plums, sixteen of grapes, twenty-two of strawberries, nine of red raspberries, six of black raspberries, two of yellow raspberries, four of blackberries and two of dewberries, besides many shrubs and ornamental plants.

In what we may call the Southern District, embracing the territory south of the divide and east of the range, the fruit lands are mainly in the valley of the Arkansas. There are about 3,150 acres now in fruit in this district, dirtributed through nine Counties. Fremont County leads, with 1,000 acres. It has been called the "banner" fruit County of the State, and deservedly, so far as apples are concerned. Here are some of the oldest and finest orchards in the State.

* "The first fruit trees were set out in Fremont County in 1867. Mr. W. C. Catlin went to Pueblo for an invoice of trees which had been ordered by himself and by Gov. Anson Rudd, Mr. W. A. Helm and Mr. Jesse Frazier. They had been brought across the plains in a wagon to Pueblo, and Mr. Catlin brought them to Canon; something over $500 worth of trees occupying a small space in his wagon. A few of these trees, and only a few, are still living. After his first attempt, which was almost a total failure, Jesse Frazier procured several thousand root grafts and set them out in nursery rows. When they became large enough, he transplanted them into his orchard." Thus was started what is now the largest bearing apple orchard in the State. This orchard has amply repaid the care and labor bestowed upon it. It is now in its prime, and will continue to be a source of great profit to Mr. Frazier. His crop for the year 1888 was estimated at 15,000 bushels, bringing the total production for the first ten years of its bearing existence above 53,000 bushels.

President Felton, of the State Horticultural Society, gives the following as the returns from his orchard at Canon City for the year 1889:

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* Judge W. B. Felton before State Horticultural Society. See Report 1887-88, page 275.

From five and one-half acres—

3,250 bushels apples marketed, 1,500 bushels apples made into cider and vinegar	$4,361 61

From four and one-half acres—

Pears	$553 43	
Grapes	373 64	
Strawberries	460 75	
Plums	144 46	
Cherries	56 50	
Gooseberries, Mulberries, Raspberries, Blackberries, Currants, Peaches and Quinces	73 50	
		$1,662 28
		$6,023 89
Deduct expenses		2,467 00
Leaving net receipts		$3,556 89

This statement speaks for itself, and needs no comment.

The success of fruit culture in Fremont County is beyond question. The area in fruit is rapidly increasing, and each year will show an increase in product as the younger orchards reach bearing age.

As a further exhibit of the importance of Fremont County's fruit interests, I may mention that there were shipped this season from two stations, by the Denver & Rio Grande Express Company, 720,817 pounds of fruit, divided as follows:

From Canon City—

	Pounds.	
Apples	163,674	
Pears	32,748	
Grapes	172,840	
Strawberries	151,800	
Other berries	77,764	
Plums	63,968	
Peaches	3,018	
		665,812

From Florence—

Apples	50,150	
Berries	2,870	
Grapes	1,985	
		55,005
		720,817

The lower valley of the Arkansas is as well suited for fruit as is the upper, and as the faciltties for irrigation are extended, we may look for a large increase in the area of orchards in those Counties adjacent to the valley.

Mr. L. M. Campbell, writing from Las Animas, Bent County, says that the fruit industry is yet in its infancy, but farmers are so well pleased with results thus far obtained that very many of them are preparing to extend their plantations. "Our County fair, last September, would lead one to believe that we had a fruit County beyond a doubt. We are trying every variety. The Early Harvest, at three years after planting, is wonderful. Missouri Pippin, Winesap and Ben Davis have all shown their colors. Plums, pears, peaches and grapes have done well, as have also the small fruits. We could not reasonably ask for better returns."

The Western District embraces the valleys of the Uncompahgre, the Gunnison, the North Fork of the Gunnison, and the Grand Rivers. In this territory three

Counties have become prominent in the matter of fruit growing, namely: Montrose, Delta and Mesa.

The development of these Counties has been phenomenal. In the tenth year after the removal of the Ute Indians and the opening of the reservation to settlement, the fruit growers of these Counties place before the public the largest and finest exhibition of fruits ever shown in the State, and the best the writer ever saw in any State. The first planting of fruit was made in Delta County in 1882, and soon after small areas were planted in Mesa County. It was not, however, until the year 1886 that planting became general. The wonderful growth and precocity exhibited by the trees first planted on the North Fork and about Grand Junction and Fruita served to prove the adaptability of the soil and climate to the raising of fruit, and a large area was that year planted.

In Montrose County, the early settlers devoted themselves entirely to the raising of farm crops and vegetables, up to the year 1886; then fruit planting commenced, and the County now has 600 acres of growing orchards, with every indication that this area will rapidly increase. Trees seem to do equally well, whether on the adobe soil of the river bottoms, or on the red, sandy loam of the higher mesas. So universally successful is the growing of fruit, that the industry bids fair to surpass all other industries of the County.

Orchards vary in size from two or three acres, to 100 acres. The trees are thrifty, clean and unmarked by disease or the ravages of insects. As examples of Montrose County orchards, I may mention those of Mr. Wm. B. Upton, Judge John C. Bell, and Bell Brothers.

Mr. Upton's orchard, on adobe bottom, at an altitude of 5,800 feet, covers twenty-five acres. He began by setting a few trees in 1886, and has each year made additions, until now he has:

1,000 apple trees, 300 of which began bearing this season, producing 20 barrels.
600 pear trees, 40 of which bore this season.
300 plum trees, with 60 in bearing.
100 cherry trees, half of them in bearing.
100 apricots, 25 in bearing.
900 peach trees, 150 of which began bearing this season, producing 50 boxes.

Judge Bell's orchard is situated on mesa land, at an elevation af 6,700 feet. It covers sixty-five acres, was planted in 1889, and contains 3,000 apple trees, 3,000 peach trees, besides 500 pear trees, 75 cherry trees, 50 apricot, 50 plum and a few miscellaneous trees.

Bell Brothers' orchard, at the same elevation, contains forty acres set with 2,500 trees, mostly apples and peaches. In writing of this orchard, Judge Bell says: "Many four-year-old peach trees bore sixty-five pounds each of marketable peaches, which sold at an average of 7 cents a pound; apricots, 5 cents; grapes, 6 cents. All varieties have done splendidly. I have also pears, quinces, nectarines, etc. I have a tree loaded with Champion quince, now ripe, and as fine as I ever saw."

The fruit shipment by express from Montrose this season, aggregated 31,225 pounds.

The planting of fruit trees in Delta County, which was inaugurated by Messrs. Coburn, Wade and Hotchkiss, in 1882, has gone steadily on. The North Fork orchards have multiplied in number and have largely increased in size. Orchards have been planted about Delta, and the County now has an area of 600 acres in orchards.

W. S. Coburn's orchard on the North Fork, at an elevation of 5,500 feet, covers forty-five acres, and contains 3,260 trees, divided as follows:

Apple—1,600 trees, 350 in bearing; yield this season, 500 bushels.

Peach—800 trees, 400 in bearing; yield this season, 700 bushels.

Pear—300 trees, 95 in bearing; yield 10 bushels.

Apricot—100 trees; all bore this year, yielding 50 bushels.

Nectarine—10 trees, set in 1887; all bore this season, yielding 10 bushels.

Plum and prune—350 trees, 50 in bearing; yield this season, 100 bushels.

Cherry—100 trees; 10 trees bore this season 10 bushels of excellent fruit.

In addition to the above, Mr. Coburn has a vineyard containing 1,000 vines, representing sixty varieties. His grape crop this season was 5,000 pounds. In sending me the above data of his orchard, Mr. Coburn adds: "Peach trees have produced five successive full crops and are still in a healthy, thriving condition, and, with proper pruning and care give promise of a long life. Prunes and plums are among the surest and best paying crops that can be planted, and observation leads me to believe they can be very successfully grown over a large portion of the State. The pear succeeds and grows to perfection, with no symptoms of disease. Cherries are thrifty and produce heavy annual crops. Nectarines are productive. All varieties of apples bear in abundance. Grapes never fail to produce heavy annual crops."

Near Delta is the orchard of Mr. W. O. Stephens. It contains 2,400 trees—950 apple trees, 1,150 peach trees and the balance divided between pears, plums, quinces and apricots. A few of these were set in 1886, but the major portion in 1888 and 1889. Twenty-five of the apple trees bore this season, producing 25 bushels. Fifty peach trees bore 200 bushels of fruit. In 1887, Mr. Stephens set out 1,200 grape vines. These are now bearing, and this season yielded 12,000 pounds of excellent fruit, which sold readily at from 3 to 5 cents per pound.

From Delta there were shipped this season, by the Denver & Rio Grande Express Company, 198,680 pounds of fruit, mostly peaches and apples.

The estimated area of Mesa County orchards is 1,500 acres. The largest orchards in the State are in this County, and, at the present rate of planting, this area will soon be doubled. A few orchards are planted on the bottom lands of the Grand River, but the mesa lands back from the river are considered the most desirable, and it is here that most of the orchards have been planted. Near Fruita is the eighty-acre peach orchard of Rose Brothers & Hughes, containing 12,000 trees, now in their prime and bearing abundantly. The shipments from this orchard this season aggregated 92,000 boxes. Adjoining is the large orchard of Mr. A. B. Johnson, one of Mesa County's most successful fruit growers. Here also is the newly planted orchard of Kiefer Brothers, covering 160 acres. A few miles up the river, above Grand Junction, is the orchard of Mr. C. W. Steele. It would be difficult to find thirty-five acres as productive and well cared for as are those occupied by this orchard. In writing of his experience, Mr. Steele says: * "I commenced planting fruit trees in the spring of 1886. All my trees were one year old from the graft. The season of 1889 I had a full crop of peaches. Some of my trees yielded 100 pounds each, and brought 10 cents per pound, wholesale, for the best varieties. The Rome Beauty, Ben Davis and Missouri Pippin apple trees commenced bearing, the Missouri Pippin proving the first early bearer The apricot, almond and plum trees were full of fruit." Mr. Steele has now marketed three crops, each larger than

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* *Colorado Farmer*, January 20, 1891.

the preceding, and the orchard has not yet reached its most productive age.

When the writer visited this orchard, late in September, early varieties had been harvested. Late peaches and apples were still on the trees, and served as an index to the general productiveness. The branches were bending to the ground, loaded to their utmost capacity with large, highly-colored fruits. Both fruits and trees were entirely free from the marks of disease or of insects, and in general, the orchard exhibited that thriftiness and cleanness of trunk and branch which is characteristic of well cared for orchards in Colorado.

At Whitewater, on the Gunnison, eight miles above Grand Junction, are a number of fine orchards; among them those of Mr. J. S. Coffman, Mr. J. S. Penniston and Mr. R. W. Shropshire.

Mr. Shropshire began planting in 1883. In 1885 he made some additions, bringing the number of trees up to 1,335, divided as follows:

Apples, 1,250; pears, 35; cherries, 50; these are all now in bearing.

In 1890 he enlarged his orchard to sixty acres, and planted 2,040 apple trees, assorting the varieties as follows:

Ben Davis, 1,040; Northern Spy, 500; Mann, 500. In the earlier planting were 250 each of Rhode Island Greening, King, Scott's Winter and Missouri Pippin, and thirty each of Wolf River, Utter's Red, Ben Davis, Winesap, Haas, Bellflower and Oldenburg.

When asked regarding productiveness, Mr. Shropshire gave me an example, taken from his orchard in 1890. Of several Ben Davis trees equally well loaded with fruit, he selected one, carefully picked all the fruit, measured and weighed it, and found the yield to be sixteen bushels.

The tree was set in 1883, and was, therefore, in its seventh year from planting in the orchard.

Additional evidence of the large proportions already attained by the fruit industry of Mesa County is seen in their express shipments. The Denver & Rio Grande Express Company handled this season:

From Grand Junction	217,767	pounds.
From Fruita	131,282	"
From Whitewater	85,100	"
A total from the County of	434,149	pounds.

As an example of the more recent fruit ventures, I may mention the Gov. Crawford orchard, on Rapid Creek, above Grand Junction. This covers sixty acres. It was set by and is in charge of Mr. D. C. Hawthorne, an experienced fruit grower. The orchard contains 6,000 trees and 8,000 grape vines, set in 1890, and 2,000 trees set in 1891. All the leading varieties of apples, pears, peaches, plums, cherries and nectarines are represented. Of the grapes, 6,000 vines are of the European varieties, including Emperor, Musatel, Gordo Blanco, Muscat of Alexandria, Flame Tokay, Sultana and others; 2,000 vines are of American varieties, mostly Concord, Worden and Niagara.

Sixty miles above Grand Junction, extending along the banks of Grand River, in Garfield County, is Grass Valley, said to be admirably adapted to fruit culture; already 250 acres are occupied by fruit trees, and ground is being prepared for further planting in the spring. The experience thus far points to a successful future for fruit growing in this valley.

Of the extreme southern and southwestern portions of the State, we can at present say but little. We have not been able to visit this region, and information obtained has been meager. In the estimate of fruit area for the State, Huerfano County is credited with 100 acres, Las

Animas with 200 acres and La Plata with 300 acres, and I am advised that in all of these Counties the area is being extended.

In the San Luis Valley the small fruits are successfully cultivated, and in some places the hardier varieties of apples are doing well; but, owing to the altitude, which is 7,500 feet, and to the short seasons, late spring frosts and cold nights, it is doubtful if any extended culture of tree fruits will be possible. In the valleys of La Plata County, fruit culture is attracting much attention. The climate admits the culture of the more tender fruits, and those who have planted orchards are meeting with success. The express shipments from Durango for this season aggregate 80,374 pounds, a sufficient indication that the fruit industry is becoming an important one. Mr. S. W. Carpenter writes, regarding Montezuma County, that "the first planting was done in 1887. The present area in fruit is about seventy-five acres in all. All the fruits grown anywhere in Colorado seem to do well here, so far as I can judge."

From the observations and collected facts embodied in the foregoing, it would appear that the fruit industry of our State is already an important one; that it has been developed within a comparatively short time, and that it is each year assuming greater proportions. It must not be understood, however, that our fruit growers meet with no discouragements, but I may safely say that the difficulties encountered are no greater than in other fruit growing regions. Here, as elsewhere, the measure of success is in most cases in direct proportion to the care and attention bestowed upon the trees. Some men succeed, others fail, and most failures can be traced to a lack of care or to errors in judgment. In all localities east of the mountains there is yet entire freedom from fungus diseases, with the exception of the occasional appearance of plum pockets (produced by *Taphrina pruni*) on native wild varieties. The bacterial disease, variously known as "pear blight," "apple tree blight," "twig blight," is prevalent, and in some sections has done great damage. Our insect enemies are numerous, and their attacks must be met by persistent warfare on the part of the fruit grower. The best line of attack against most of these pests is well understood, but remedies for some of the newer ones are yet matters for experiment.

In the Western District, diseases and insect troubles are at present unknown, but it can hardly be hoped that the immunity now enjoyed will continue. Growers in that district should prepare themselves to profit by the experience gained elsewhere and meet the first attacks with determined efforts at extermination.

The rapid advancement of the fruit industry has already called forth the prediction of over-production. There is nothing, however, to cause apprehension of this. As yet, the home market is not nearly supplied, as is shown by the fact that in 1890 very nearly all of the 654 car-loads of green fruits shipped into Denver by freight came from other States. We have a rapidly increasing population, which will insure increased home demand for fruit. When production exceeds the home demand, there is no reason why the Colorado product cannot enter the larger markets of the country in competition with other fruit producing regions. California growers market with profit in the Eastern cities; our growers are enough nearer these great markets to make competition easy. The markets of the South also offer an excellent and easily accessible outlet for much of the fruit that can be raised here; but I apprehend that with all our increase of production, it will yet be some years before markets need be sought abroad. There is a possible danger in sight—it is the danger of overstocking the market with inferior fruit. As fruit becomes more abundant, buyers become more critical, and look closer at quality. Our growers must, therefore, learn to give careful attention to quality and to attractive packing, in order that their product may successfully pass critical inspection.

Observation leads to the conclusion, that as yet, this matter is not receiving the attention it should. The fact that appearance largely influences sales, is not fully appreciated.

A word regarding the purchase of trees may not be out of place here. Buy only of nurserymen of known reliability, and give preference, so far as possible, to home enterprise and home-grown trees. In this remark, I but reiterate the advice that has been frequently given. It is, however, good advice. To order a dozen varieties of grapes, care for them, and on fruiting, find them all Concords, or to buy a dozen varieties of apples, which after several years of waiting, prove to be all Ben Davis, may not be a total loss to the buyer, but the transaction is not altogether satisfactory; yet these, and even worse, experiences have been related. Mistakes cannot always be avoided, but we believe following the advice above given will greatly lessen the liability of their occurrence. Your home nurseryman may charge a little more for trees than they can be bought for elsewhere, but, if you can depend upon his integrity, it is better to take his guarantee of trueness to name and pay the advanced price, than to meet disappointment and possible loss when your trees reach bearing age.

This report is preliminary. It is the intention to follow, during the coming year, with one aiming at a more complete presentation of the fruit interests of the entire State, and to embody therein such details of orchard management, tests of varieties and other information as may be deemed useful to fruit growers. We desire to make the statistical information as full and complete as possible, and to secure this, we ask the co-operation of fruit growers and others interested.

I wish here to express my obligation to Mr. G. W. Kramer, Manager of the Denver & Rio Grande Express Company; to Dr. Alexander Shaw, Secretary of the State Bureau of Horticulture, and to Secretary Olney Newell, of the Denver Chamber of Commerce, for statistical information furnished from their respective offices.

PRELIMINARY LIST OF FRUITS

GROWN IN THE

STATE OF COLORADO.

The following list of fruits is only preliminary; it does not pretend to be complete. It contains such varieties as I have found mentioned as growing within the State, and using the division of the State into districts, as noted on page 5, I have indicated where the varieties are grown. In attempting to give the origin of the different varieties, we may be in error in some cases.

We ask the aid of the fruit growers of the State in correcting and completing this list, with the view of publishing a complete descriptive catalogue of our fruits during the coming year:

APPLES.

VARIETY.	Origin.	STATE DISTRICT.		
Alexander	Russian	Northern	Southern	Western
Anis	"	"	....	....
Anisovka	"	"	....	....
Anisim	"	"	....	....
Antonovka	"	"	Southern	Western
Aport	"	"	....	....
Aport Orient	"	"	....	....
Arabka	"	"	....	....
Arcad	"	"	....	....
Arnold Russett	....	"	....	....
August Sweet	American	"	....	....
Autumn Strawberry	New York	"	Southern	Western
Babuschins	Russian	"	....	....
Bailey's Sweet	American	"	Southern	Western
Baldwin	Massachusetts	"	"	....
Barkoff	Russian	"	....	....
Barloff	"	"	....	....
Ben Davis	American	"	Southern	Western
Benoni	Massachusetts	....	"	"
Biel	Russian	Northern	....	....
Blessed Calville	"	"	....	....
Blue Pearmain	....	"	....	....
Bogdanoff	Russian	"	....	....
Borovinca	"	"	....	Western
Borsdorf	"	"	Southern	"
Breskovka	"	"	....	....
Broadwell Sweet	Ohio	....	Southern	....
Buckingham	American	Northern	....	....
Canada Black	....	"	....	....
California Red	....	"	....	....
Carmine	....	....	Southern	....
Carolina June	....	Northern	....	....
Carter's Blue	Alabama	....	Southern	....
Charlamoff	Russian	Northern	....	....

APPLES—Continued.

VARIETY.	Origin.	STATE DISTRICT.		
Charlottenthaler	Russian	Northern	....	....
Chenango Strawberry	New York	"	....	....
Clark's Orange	....	"	....	....
Clayton	Indiana	"	....	....
Cluster	American	"	....	....
Coat's Sweet	"	"	....	....
Cole's Quince	Maine	"	Southern	....
Colorado Favorite	Colorado	"	....	....
Colorado Orange	"	....	Southern	....
Colorado Red	"	....	"	....
Colorado Seedling	"	....	"	....
Congress	Massachusetts	....	....	Western
Cooper	....	....	Southern	....
Cooper's Early	American	....	"	....
Cooper's Early White	"	....	"	....
Cooper's Market	"	....	"	....
Cross	Russian	Northern	....	....
Delaware Sweet	....	"	....	....
Delaware Winter	....	"	....	Western
Domine	....	....	Southern	....
Dyer	France	....	....	Western
Early Cinnamon	Russian	Northern	....	....
Early Champaign	"	"	....	....
Early Harvest	American	"	Southern	....
Early Pennock	"	"	"	....
Early Red	....	"	....	....
Early Sweet	Ohio	"	....	....
Early Strawberry	New York	"	....	....
English Golden Russet	England	"	....	....
Enormous	Russian	....	....	Western
Empress	"	....	....	"
Excelsior	Minnesota	Northern	Southern	....
Fallawater	Pennsylvania	....	"	....
Fall Orange	Massachusetts	Northern	"	....

APPLES—Continued.

VARIETY.	Origin.	STATE DISTRICT.		
Fall Pippin	American	Northern	Southern	....
Fall Queen	"	....	"	....
Fall River	....	....	"	....
Fall Spitzenburg	Vermont	Northern	"	....
Fall Stripe	....	"	....	....
Fall Wine	American	"	....	....
Fameuse	French	"	Southern	Western
Family	Georgia	....	"	....
Fink	Ohio	Northern	....	Western
Flora	American	....	Southern	....
Flushing	New York	Northern	....	....
Fonaric	Russian	"	....	....
Fourth of July	German	"	....	....
Fuller	....	....	Southern	....
Fulton	Illinois	Northern	"	....
German Calville	Russian	"	....	....
George Webster	Colorado	"	....	....
Gideon	Minnesota	"	Southern	....
Gilpin	Virginia	....	"	....
Gipsy	Russian	Northern	....	....
Golden Pippin	England	"	....	....
Golden Russet	American	"	Southern	....
Golden White	Russian	"	....	....
Golden Sweet	Connecticut	"	....	....
Good Peasant	Russian	"	....	....
Goss' Beauty	Colorado	"	....	....
Greasy Pippin	....	"	....	....
Green New Town Pippin	New York	"	....	....
Green Sweet	Russian	"	....	....
Grimes' Golden	Virgina	"	Southern	Western
Grindstone	....	"	....	"
Haas	....	"	Southern	"
Hare Pipka	Russian	"	....	....
Harvest Queen	....	"	....	....

APPLES—Continued.

VARIETY.	Origin.	STATE DISTRICT.		
Hibernal	Russian	Northern	....	Western
Home	....	"	....	....
Howard	Russian	"	....	....
Huntsman's Favorite	....	"	Southern	....
Hubbardston	Massachusetts	....	....	Western
Hygiene	Colorado	Northern	....	....
Imperial	Russian	....	Southern	....
Iowa Blush	Iowa	....	....	Western
Isham Sweet	....	Northern	Southern	"
Jarminite	Ohio	"	....	....
Jefferis	Pennsylvania	....	Southern	....
Jeniton	Virginia	Northern	....	....
Jennetting	England	"	Southern	Western
Jersey Sweeting	....	"	....	....
Jonathan	New York	"	Southern	Western
Kalkidon	Russian	"	....	....
Kentucky Red Streak	American	....	Southern	....
Keswick Codlin	England	Northern	"	Western
Kluevskoe	Russian	"	....	....
King	American	....	Southern	....
Kruder	Russian	Northern	....	....
Krusk Reinette	"	"	....	....
Lady	French	"	Southern	....
Lady Finger	....	....	"	....
Lady's Sweet	....	Northern	....	....
Landon	American	....	....	Western
Large Romanite	Pennsylvania	....	Southern	....
Lawyer	American	Northern	"	Western
Lead	Russian	"	....	....
Ledenets	"	"	....	....
Lijanka	"	"	....	....
Limber Twig	American	"	Southern	Western
Lipin	Russian	"	....	....
Livland Raspberry	"	"	....	....

APPLES—Continued.

VARIETY.	Origin.	STATE DISTRICT.		
Long Arcad	Russian	Northern	....	....
Longfield	"	"	....	....
Longmont	Colorado	"	....	....
Lou	....	"	....	....
Lowell	....	....	Southern	....
Maiden's Blush	....	Northern	"	Western
Mammoth Black Twig	Russian	"	....	....
Mann	New York	"	....	Western
Maverack's Sweet	South Carolina	....	Southern	....
McIntosh Red	American	Northern	....	....
McMahon's White	....	"	....	Western
Melonen	Russian	....	Southern	....
Milam	American	....	"	Western
Missouri Pippin	"	Northern	"	"
Moscow Pear	Russian	"	....	"
Mountain Sweet	Pennsylvania	....	Southern	....
Muscat Reinette	German	Northern	....	....
Newtown Pippin	New York	"	....	....
Newtown Spitzenburg	American	"	....	....
New York Greening	"	"	....	....
New York Pippin	"	"	....	....
Nickajack	"	....	Southern	....
Nonesuch	England	....	....	Western
Northern Spy	New York	Northern	Southern	"
Northern Sweet	Vermont	....	Southern	....
Northwestern Greening	....	Northern	....	....
Oconee Greening	Georgia	....	Southern	....
Oldenburg	Russian	Northern	"	Western
Peach	....	"	....	....
Pearmain	England	....	Southern	....
Peck's Pleasant	American	Northern	....	....
Pennock	Pennsylvania	"	Southern	....
Perry Russet	American	"	"	....
Pewaukee	Wisconsin	"	"	Western

APPLES—Continued.

VARIETY.	Origin.	STATE DISTRICT.		
Pineapple	England	Northern	....	....
Plumb's Cider	American	"	Southern	Western
Polish Cinnamon	Russian	"	....	....
Porter	American	....	Southern	....
Pound	Russian	....	"	....
Princess Royal	"	Northern	....	....
Primate	American	"	....	Western
Prolific Sweet	Connecticut	"	....	....
Pryor's Red	....	"	....	....
Pumpkin Sweet	American	....	....	Western
Quince	"	Northern	....	....
Rambo	Delaware	"	Southern	Western
Rambour Reinette	Russian	"	....	....
Raspberry	"	"	....	....
Rawle's Genet	Virginia	"	Southern	Western
Rebecca	Delaware	"	....	....
Red Anis	Russian	"	....	....
Red Astrachan	"	"	Southern	Western
Red Beitigheimer	"	"	....	....
Red Canada	....	"	....	....
Red June	American	"	Southern	Western
Red Pearmain	New Jersey	....	"	....
Red Repka	Russian	Northern	....	....
Red Titka	"	"	....	....
Red Streak	England	....	Southern	....
Red Wine	....	....	"	Western
Red Winter Pearmain	....	....	"	....
Repka Malenka	Russian	Northern	....	....
Repolovka	"	"	....	....
Rhode Island Greening	American	"	Southern	Western
Richard's Graft	New York	"	....	....
Romanite	American	"	Southern	....
Roman Stem	New Jersey	"	"	....
Rome Beauty	Ohio	"	"	Western

APPLES—Continued.

VARIETY.	Origin.	STATE DISTRICT.		
Rosy Aport	Russian	Northern	....	....
Royal Table	"	"	....	....
Roxbury Russet	Massachusetts	"	Southern	Western
Rubets	Russian	"	....	....
Russian Gravenstein	"	"	....	....
Russian Transparent	....	"	....	....
Salome	Illinois	"	....	....
Sandy Glass	Russian	"	....	....
Scott's Winter	American	"	....	....
September	Minnesota	....	....	Western
Shackelford	....	....	Southern	....
Shaker Pippin	New Ham'shire	Northern	....	....
Sheriff	....	"	....	....
Smith's Cider	Pennsylvania	"	Southern	Western
Smokehouse	"	....	"	"
Sops of Wine	....	Northern	"	"
Spice Sweet	....	....	"	....
Stark	American	Northern	....	Western
St. Lawrence	....	"	....	....
St. Peter's	Russian	....	....	Western
Stump	American	....	Southern	....
St. Vrain	Colorado	Northern	....	....
Sutton Beauty	Massachusetts	....	....	Western
Swarr	New York	Northern	....	....
Sweet Bough	American	....	....	Western
Sweet Cross	Russian	....	Southern	....
Sweet June	American	Northern	"	....
Sweet Pear	Russian	"	"	....
Sweet Pipka	"	"	....	....
Sweet Romanite	....	....	Southern	....
Sweet Russet	....	....	"	....
Sweet Vandevere	American	Northern	....	....
Switzer	Russian	"	....	Western
Talman Sweet	Rhode Island	"	Southern	"

APPLES—Continued.

VARIETY.	Origin.	STATE DISTRICT.		
Tetofsky	Russian	Northern	Southern	Western
Tiesenhausen	"	"	....	"
Titus	"	....	....	"
Twenty Ounce	Connecticut	Northern	Southern	....
Ukraine	Russian	"	....	....
Utter	....	....	....	Western
Vandevere	Delaware	....	Southern	....
Vandevere Pippin	....	Northern	"	....
Vargul	Russian	"	....	....
Virginia Greening	....	....	Southern	Western
Voronesh	Russian	Northern	....	....
Wagener	New York	"	Southern	Western
Walbridge	....	"	"	"
Watermelon	Russian	"	....	....
Water	Pennsylvania	"	....	....
Wealthy	Minnesota	"	Southern	Western
Webster's Beauty	Colorado	"	....	....
Westfield Seek-no further	Connecticut	"	Southern	....
White Astrachan	Russian	"	....	....
White Bellflower	....	"	....	....
White Borodovka	Russian	"	....	....
White Pigeon	"	"	....	....
White Pippin	....	"	....	Western
White Winter	Pennsylvania	....	Southern	....
White Winter Pearmain	....	Northern	"	Western
Whitewater Sweet	Ohio	....	"	....
Willow Twig	Virginia	Northern	"	Western
Wine	Delaware	"	"	....
Winesap	New Jersey	"	"	Western
Winter Glass	Russian	"	....	....
Winter Pearmain	....	....	Southern	....
Winter Queen	....	Northern	....	....
Wolf River	Wisconsin	"	Southern	Western
Yellow Anis	Russian	"	....	....

APPLES—Continued.

VARIETY.	Origin.	STATE DISTRICT.		
Yellow Bellefleur.............	New Jersey	....	Southern	Western
Yellow Ingestrie.............	....	Northern	....	....
Yellow Sweet.................	Russian	"	.. ..	....
Yellow Transparent..........	"	"	Southern	Western
Zolotareff.....................	"	"	....	....

APPLES—CRABS.

VARIETY.	Origin.	STATE DISTRICT.		
Briar Sweet..................	Wisconsin	Northern	Southern	....
Sheriff.........................	French	"	....	....
Florence	Minnesota	"	Southern	.. ..
General Grant...............	American	"	....	....
Hyslop	"	"	Southern	Western
January	Minnesota	"	....	....
Lake Winter	American	"	....	....
Martha	Minnesota	"	Southern	Western
Montreal Beauty	American	....	"	....
Orange	"	....	....	Western
Orion...........................	England	....	Southern	....
Hall's Imperial...............	....	Northern	....	....
September	Minnesota	"	....	....
Red Siberian.................	Foreign	"	Southern	Western
Soulard........................	Missouri	....	....	"
Telfer Sweet..................	....	....	Southern	....
Transcendent	American	Northern	"	Western
Whitney.......................	Illinois	"	"	"
Yellow Siberian..............	Foreign	....	....	"

APRICOTS.

Alexander.....................	Russian	Northern	Southern	Western
Alexis..........................	"	"	"	"
Budd...........................	"	"	"	"
Catharine	"	"	"	"
Gibb............................	"	"	"	"
Nicholas........	"	"	"	"

BLACKBERRIES.

VARIETY.	Origin.	STATE DISTRICT.		
Ancient Briton................	Arkansas	Northern	Southern	Western
Early Harvest................	Illinois	"	"	"
Kittatinny....................	New Jersey	"	"	"
Lawton......................	New York	"	....	....
Snyder	Indiana	"	Southern	Western
Stone..........	Wisconsin	"	....	....
Taylor.......................	American	"	Southern	Western
Wilson	New Jersey	"	"	"
Wilson's Early	"	"	"	"
Wilson, Jr....................	"	....	"	"

CURRANTS.

Cherry	European	Northern	Southern	Western
Fay's	New York	"	"	"
Red Dutch	European	"	"	"
Versaillaise..................	French	"	"	"
Victoria	England	"	"	"
White Dutch..................	European	"	"	"
White Grape..................	"	"	"	"

CHERRIES.

VARIETY.	Class.	Origin.	STATE DISTRICT.		
Bigarreau	Bigarreau	European	....	....	Western
Black Eagle...........	Heart	England	Northern	....	....
Early Richmond......	Morello	European	"	Southern	Western
Empress Eugene......	Duke	French	"	....	....
Governor Wood........	Heart	Ohio	....	....	Western
Late Richmond	Morello	European	Northern	....	"
May Duke.............	Duke	"	"	....	....
Montmorency	Morello	"	"	....	....
Morello...............	"	"	"	Southern	Western
Napoleon.............	Bigarreau	"	....	....	"
Olivet	Duke	....	Northern	....	....
Ostheim..............	Russian	Russian	"	....	....
Reine Hortense.......	Duke	French	"	....	....

GOOSEBERRIES.

VARIETY.	Origin.	STATE DISTRICT.		
Crown Bob	England	Northern	Southern.	....
Downing	New York	"	"	Western
Houghton	Massachusetts	"	"	"
Industry	European	"	"	"
Lancaster Red	England	....	"	....
Whitesmith	French	Northern	"	"

GRAPES.

VARIETY.	Color.	Species.	Origin.	STATE DISTRICT.		
Agawam, Rogers' No. 15	Red	Lab.-Vin.	Mass.	Northe'n	Southern	Western
Bacchus	Black	Lab.-Rip.	N. Y.	"	....	....
Black Eagle	"	Lab.-Vin.	"	"	....	....
Black Hamburg	"	Vinifera	Europe	....	Southern	Western
Bland	Red	Labrusca	Va.	Northe'n	....	....
Blood's Black	Black	"	....	"	....	....
Brighton	Red	Lab-Vin.	N. Y.	"	Southern	Western
Catawba	"	"	N. C.	....	"	"
Champion	Black	Labrusca	Am.	Northe'n	"	....
Chasselas	White	Vinifera	Europe	....	"	Western
Clinton	Black	Riparia	N. Y.	Northe'n	....	"
Concord	"	Labrusca	Mass.	"	Southern	"
Creveling	"	Lab.-Aest.	Penn.	"	....	....
Delaware	Red	Lab.-Vin.	N. J.	"	Southern	Western
Diamond	White	Labrusca	N. Y.	"	....	....
Diana	Red	Lab.-Cin.	Mass.	"	....	....
Downing	Black	....	N. Y.	"	....	....
Dracut Amber	Red	Labrusca	Mass.	"	....	Western
Duchess	White	Lab.-Vin.	N. Y.	....	Southern	....
Early Victor	Black	Labrusca	Kansas	Northe'n	....	Western
Eaton	"	"	Mass	"	....	....
Elvira	White	Rip-Lab.	Mo.	....	Southern	Western
Emperor	Red	Vinifera	Europe	....	....	"
Empire State	White	Lab.-Rip.	N. Y.	Northe'n	....	"

GRAPES—Continued.

VARIETY.	Color.	Species.	Origin.	STATE DISTRICT.		
Etta	White	Rip.-Lab.	....	Northe'n	....	....
Eumelan	Black	Labrusca	N. Y.	"	Southern	....
Flame Tokay	Red	Vinifera	Europe	....	"	Western
Goethe	"	Lab.-Vin.	Mass.	Northe'n	"	"
Golden Chasselas	White	Vinifera	Europe	....	"	....
Grein's Golden	"	....	....	Northe'n	....	....
Gordo Blanco	"	Vinifera	Europe	"	Southern	Western
Hartford	Black	Labrusca	Conn.	"	"	"
Hayes	White	....	Mass.	"	....	....
Iona	Red	Labrusca	N. Y.	"	....	....
Isabella	Black	"	S. C.	"	Southern	....
Ives	"	"	Ohio	....	....	Western
Janesville	"	"	Am.	Northe'n	Southern	"
Jefferson	Red	Lab.-Vin.	N. Y.	....	....	Western
Jessica	White	....	Canada	Northe'n	....	....
Jewell	Black	Aest.-Lab.	Kan.	"	....	....
Lady	White	Vin.-Lab.	Ohio	"	Southern	....
Lady Washington	"	Lab.-Vin.	N. Y.	....	....	Western
Lindley, Rogers' No. 9.	Red	"	Mass.	Northe'n	....	Western
Martha	White	Labrusca	Penn.	"	Southern	"
Massasoit, Rogers' No. 3.	Red	Lab.-Vin.	Mass.	"	....	....
Mission	Black	Vinifera	....	"	Southern	Western
Missouri Riesling	White	Lab.-Rip.	Mo.	....	....	"
Moore's Early	Black	Labrusca	Mass.	Northe'n	Southern	"
Muscat of Alexandria	White	Vinifera	Europe	....	"	"
Niagara	"	Labrusca	N. Y.	Northe'n	"	"
Noah	"	Rip.-Lab.	Illinois	"	....	....
Perkins	Red	Lab.-Aest.	Mass.	"	Southern	....
Poughkeepsie	"	Lab.-Vin.	....	"	....	....
Pocklington	White	Labrusca	N. Y.	"	Southern	Western
Prentiss	"	"	"	"	"	....
Rose of Peru	Black	Vinifera	Europe	....	....	Western
Salem, Rogers' No. 53.	Red	Lab.-Vin.	Mass.	Northe'n	Southern	"
Sultana	White	Vinifera	Europe	....	"	....

GRAPES—Continued.

VARIETY.	Color.	Species.	Origin.	STATE DISTRICT.		
Sweetwater............	White	Vin.	Europe	Northe'n	Southern	Western
Taylor's Bullet.........	"	....	Ky.	"	....	"
Telegraph....	Black	Labrusca	Penn.	"	....	"
Triumph	White	Lab.-Vin.	Ohio	"	....	....
Ulster............... ..	Red	Labrusca	N. Y.	"	....	....
Vergennes.............	"	"	Vt.	"	....	....
Woodruff Red	"	....	Mich	"	....	....
Worden	Black	Labrusca	N. Y.	"	Southern	....
Wyoming Red..........	Red	....	....	....	....	Western
Zinfindel	Black	Vinifera	Europe	....	Southern	....

PEACHES.

VARIETY.	Origin.	STATE DISTRICT.		
Amsden	Missouri	....	....	Western
Chinese Cling................	....	....	....	"
Crawford's Early.............	New Jersey	....	Southern	"
Crawford's Late..............	"	....	....	"
Elberta..........	....	....	....	"
George Fourth	New York	....	....	"
Governor Garland	....	....	....	"
Heath Cling..................	Maryland	....	....	"
Henrietta.	Dist. Columbia	....	....	"
Keyport	American	Northern	....	....
Oldmixon Cling...............	"	"	....	Western
Salway.......................	England	....	....	"
Smock	New Jersey	....	....	"
Snow.........................	American	....	....	"
Stump........................	New Jersey	....	....	"

PEARS.

VARIETY.	Origin.	STATE DISTRICT.		
Angouleme	French	Northern	Southern	Western
Anjou	"	"	"	"
Bartlett	England	"	"	"
Belle Lucrative	Belgium	"	....	....
Buerre Bosc	"	....	Southern	....
Buffum	Rhode Island	....	"	....
Clapp's Favorite	Massachusetts	Northern	"	....
Edmonds	New York	....	....	Western
Flemish Beauty	Belgium	Northern	Southern	"
Howell	Connecticut	....	"	....
Indian Queen	....	Northern	"	Western
Kieffer	American	"	"	"
Lawrence	New York	"	"	....
Lawson (Comet)	"	....	"	....
LeConte	American	....	....	Western
Louise bonne de Jersey	French	Northern	Southern	....
Madeleine	"	"	....	....
Monarch	England	....	Southern	....
Mount Vernon	Massachusetts	....	"	....
Orange	American	....	"	....
Osband's Summer	New York	Northern	"	....
Rosteizer	European	....	"	....
Seckel	Pennsylvania	Northern	"	Western
Sheldon	New York	"	"	....
Souvenir du Congres	French	....	"	Western
Sugar	American	Northern	"	....
Tyson	Pennsylvania	"	....	....
Urbaniste	Belgium	....	Southern	....
Vicar of Winkfield	French	Northern	"	....

PRUNES.

Burgundy	European	Northern	....	....
German Prune	"	"	Southern	Western
Hungarian (Syn-Pond)	England	"	....	....

PLUMS.

VARIETY.	Origin.	STATE DISTRICT.		
Botan	Japan	Northern	....	....
Bradshaw	American	"	....	....
Claude de Bavay	French	....	Southern	Western
Coe's Golden Drop............	England	Northern	....	....
Damson	American	....	Southern	Western
De Soto	American	Northern	Southern	Western
Duane's Purple....	New York	....	"	....
Forest Garden................	American	Northern	"	Western
Forest Rose	"	"	"	"
Green Gage....................	European	"	"	"
Imperial Gage................	New York	"	"	....
Kelsey........	Japan	....	....	Western
Lombard	New York	....	Southern	"
Mariana......	Texas	Northern	....	....
Miner	Pennsylvania	"	....	Western
Monroe........................	New York	....	Southern	....
Moore's Arctic	American	Northern	"	Western
Peach........	European	"	....	....
Pond	England	....	Southern	Western
Prince Albert	"	Northern	....	....
Prince Engelbert..............	Belgium	"	....	....
Purple Egg...	European	....	Southern	....
Prince's Yellow Gage	New York	....	"	....
Rollingstone	American	Northern	"	Western
Shippers' Pride..............	"	"	....	....
Shropshire Damson......... ..	England	"	....	....
Smith's Orleans..............	New York	....	Southern	....
Washington........	"	Northern	....	....
Weaver........................	American	"	Southern	Western
Wild Goose	"	"	....	"
Yellow Egg....................	....	"	Southern	"

QUINCE.

Orange..........	....	Northern	Southern	Western

RASPBERRIES.

VARIETY.	Color.	Origin.	STATE DISTRICT.		
Caroline	Yellow	New York	....	Southern	....
Clark	Red	Connecticut	Northern	....	....
Crimson Beauty	"	Kansas	....	....	Western
Cuthbert	"	New York	Northern	Southern	"
Davidson's Thornless	Black	"	"	....	"
Golden Queen	Yellow	New Jersey	....	....	"
Gregg	Black	Indiana	Northern	Southern	"
Hansel	Red	New Jersey	"	....	"
Mammoth Cluster	Black	New York	"	Southern	"
Marlboro	Red	"	"	....	....
Rancocas	"	....	"	....	....
Reliance	"	New York	"	Southern	....
Shaffer	Purple	"	"	"	Western
Souhegan	Black	New Ham'shire	"	"	"
Turner	Red	Illinois	"	"	"

STRAWBERRIES.

VARIETY.	Sex.	Place of Origin.	When Originated.	STATE DISTRICT.		
Atlantic	Bisexual	N. J.	......	Northern	Southern	Western
Belmont	"	Mass.	1880	"	"	....
Bidwell	"	Mich.	1872	....	"	....
Bubach	Pistillate	Illinois	1885	Northern	"	....
Captain Jack	Bisexual	Mo.	1874	"	"	....
Champion	Pistillate	Penn.	1872	"	....	....
Charles Downing	Bisexual	Ky.	1860	"	....	....
Cloud	Pistillate	La.	1887	"	....	....
Cornelia	Bisexual	Ohio	1882	"	Southern	....
Cowing	"	Ind.	......	"	....	....
Crawford	"	Ohio.	1887	"	....	....
Crescent	Pistillate	Conn.	1870	"	Southern	Western
Cumberland	Bisexual	Penn.	1874	"	"	....
Gandy	"	N. J.	1885	"	....	....
Gold	Pistillate	Conn.	1884	"	....	....
Haverland	"	Ohio	1884	"	....	....

STRAWBERRIES—Continued.

VARIETY.	Sex.	Place of Origin.	When Originated.	STATE DISTRICT.		
Henderson	Bisexual	N. J.	1880	Northern	Southern	....
Jersey Queen........	Pistillate	"	......	"	"	Western
Jessie	Bisexual	Wis.	1885	"	....	....
Jewell	Pistillate	Conn.	1882	"	....	....
Jucunda.............	Bisexual	Belg.	1855	"	Southern	Western
Lady Rusk	Pistillate	Illinois	1887	"	....	....
Lida.................	"	N. J.	1883	"	Southern	....
Manchester..........	"	"	1876	"	"	....
May King	Bisexual	"	......	"	"	....
Miner	"	"	......	....	"	....
Parker Earle	"	Texas	1886	Northern	....	....
Parry................	"	N. J.	1880	"	Southern	....
Sharpless............	"	Penn.	1874	"	"	Western
Warfield.............	Pistillate	Illinois	1883	"	....	....
Wilson	Bisexual	N. Y.	1860	"	Southern	Western

THE

State Agricultural College

The Agricultural Experiment Station.

INDEX BULLETIN, No. 18.

Indexing First Seventeen Bulletins of the Station, for

VOLUME I.

Fort Collins, Colorado.

DECEMBER, 1891.

Bulletins are free to all residents of the State interested in Agriculture in any of its branches, and to others as far as the edition will permit. Address the EXPERIMENT STATION,
Fort Collins, Colorado.

PREFATORY NOTE.

In presenting this Index Bulletin, the following is offered in explanation. The object is to index, for the first volume of the Agricultural Experiment Station, all Bulletins issued to date, numbering with this, eighteen, and closing with the year 1891.

The titles of Bulletins are printed in small capital letters. The bulletin numbers are printed in black type, smaller than the ordinary type, in which page numbers are set. In repeating words from topics above, dashes are employed as ditto marks.

Second editions of Bulletins No. 8, on Alfalfa, and No. 13, on The Measurement and Division of Water, have been issued. An asterisk before the bulletin number designates all references to these editions.

Walter J. Quick

Director.

INDEX.

Vol. I. Bulletins 1-17.

—— THE ——

State Agricultural College

The Agricultural Experiment Station.

BULLETIN NO. 19.

OBSERVATIONS UPON

INJURIOUS INSECTS,

SEASON OF 1891.

Approved by the Station Council, Alston Ellis, President.

FORT COLLINS, COLORADO.

MAY, 1892.

The State Experiment Station.

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OBSERVATIONS

UPON

INJURIOUS INSECTS

SEASON OF 1891.

By C. P. GILLETTE.

THE FRUIT-TREE LEAF-ROLLER.

(*Cacœcia argyrospila*, Walk*.)

IMPORTANT REFERENCES AND SYNONYMS.

1869.—Robinson, C. T. *Tortrix furrana*. Described as new species.

1870.—Packard, A. S. *Tortrix V-signatana*. Mass. Agr'l. Rep. Described.

1885.—Packard, A. S. *Cacœcia argyrospila* Walk. Rep. Com. of Agr. p. 329.

1890.—Riley & Howard. *Cacœcia argyrospila* Walk. Insect Life v. 3, p. 19.

1890.—Packard, A. S. *Cacœcia argyrospila* Walk. 5th Rep. Ent. Com. p. 192.

Soon after arriving at Fort Collins in January of last year, I noticed upon the trunks, branches and small twigs of apple and other fruit trees, little grayish egg-patches (Fig. 1, a) of some small moth.

*Determined for me by Mr. L. O. Howard, Washington, D. C., and by Dr. C. H Fernald, Amherst, Mass.

From these eggs myriads of minute larvæ (worms) hatched in time to begin feeding upon the very young leaves and, in case of the cherry trees that started late last spring, they ate into and destroyed

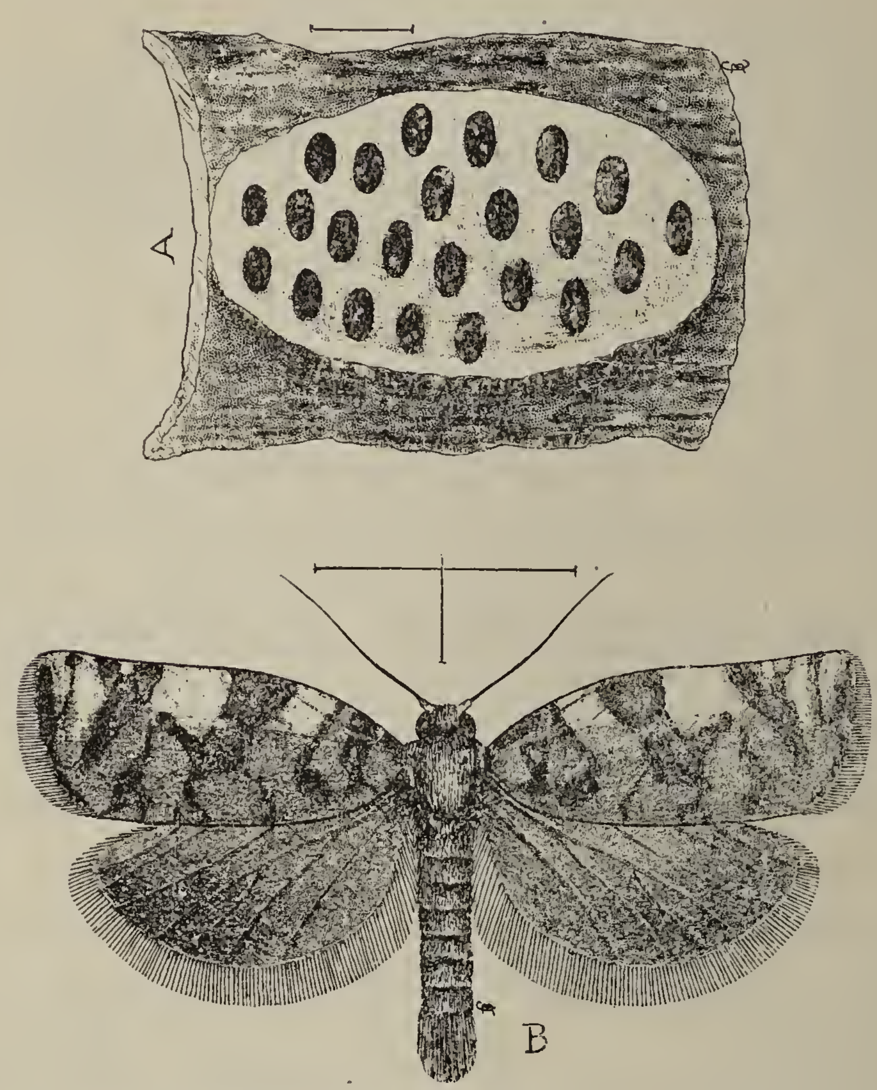

Fig. 1.—The Fruit-tree Leaf-roller, *Cacœcia argyrospila* Walk.: A, egg-patch from which the larvæ have escaped; B, moth(original.)

a large portion of the buds. Figure 2 is from a photograph of a cherry tree that was thus attacked, the few uninjured buds alone having put forth leaves. Later in the season new buds were formed and the trees put on full foliage, but bore no fruit.

Aside from the apple trees and the cherry trees, this insect attacked the plum and honey locust, and the rose, currant, raspberry and gooseberry bushes and a species of *Circocarpa* growing on the foot hills in great abundance and known as "Deer-Bush."

Aside from the peculiar appearance of the cherry trees, the first thing to attract popular attention, on account of the attacks of this insect, was the rolling and fastening together of the leaves

Fig. 2.—A cherry tree that had its buds nearly all destroyed by the Fruit-tree Leaf-roller. From a photograph (original).

as shown in Fig. 3. This is done by means of silken threads which the larvæ spin. These rolls or clusters of leaves form excellent hiding places for the larvæ which only leave them long enough to feed, and then quickly retreat out of the sight of their many enemies. In fact, they usually feed upon the edges of the leaves that form their hiding places, so as to expose their bodies as little as possible.

Fig. 3.—A, twig of an apple tree showing the work of the Leaf-rollers; b, small apples gnawed by the Leaf-rollers (original).

If a tree supplies food enough for the larvæ that are feeding upon it, they will pass the pupa state in the rolls of the leaves. The pupa in a few days wriggles itself partly out of the leaf fold, the pupa case splits on the back and the moth (Fig. 1, b) escapes. The developement of this insect was closely watched last summer, and on June 17, I noted the fact that the larvæ were fast changing to chrysalids. On June 24 the first moths appeared in the breeding cages and on the evening of June 29 a number of the moths flew to light in my office for the first time, and on July 6 the moths were swarming in the trees in the evening for the purpose of egg-laying. The eggs deposited at this time are still (April 28) unhatched, so there can be but one brood of this insect in a year in Colorado.

The moth measures about four-fifths of an inch from tip to tip of the wings when spread and the length of the body is about two-fifths of an inch. The predominant color of the fore wings is rust brown and the markings are very light yellow, almost white. When the wings are spread, the most conspicuous markings are a rather large rust-red area at the base of the wing, a similarly colored broad band extending from near the middle of the anterior margin back and outward to or beyond the middle of the wing, and a spot near the outer margin of the wing. Either side of the band on the costal margin is a rectangular or triangular light area, the outer one being fully as broad as the rust colored band but the inner one narrower. The posterior wings are of an uniform smoky or slate color. It should be said, however, that the markings vary a good deal in different specimens.

The larva, when fully grown, measures a little over three-fourths of an inch in length, is greenish in color, with the thoracic, legs and cervical shield black or blackish. The head and cervical shield are often lighter after the last moult.

Packard speaks of this insect as probably being double brooded, the first brood of larvæ appearing in June and the second in August and September. He also thinks that the pupæ of the second brood hibernate and that the moths appear early in the spring and lay the eggs for the first brood of larvæ. Such is not the habit of the species here, although it may be farther south.

This insect is one of very wide distribution. Robinson's descriptions were made from specimens taken in Maine, where it is said to be common, and it has been reported as far south as Georgia and Texas and west to California. Aside from the food-plants above mentioned it has been reported as feeding upon oak, hickory, horse-chestnut, soft maple, elm and wild cherry. I have also found it occasionally feeding on box-elder.

This insect was exceedingly abundant in many places in Colorado last summer and did a large amount of injury, especially to fruit trees and rose bushes which, in many cases, were entirely defoliated in the latter part of June. Figure 4 is from a photograph taken in a young apple orchard in Greeley, Colo., last summer, where not a green leaf was left on any of the trees. The trees with leaves showing in the picture are elm trees in the street, which were not attacked.

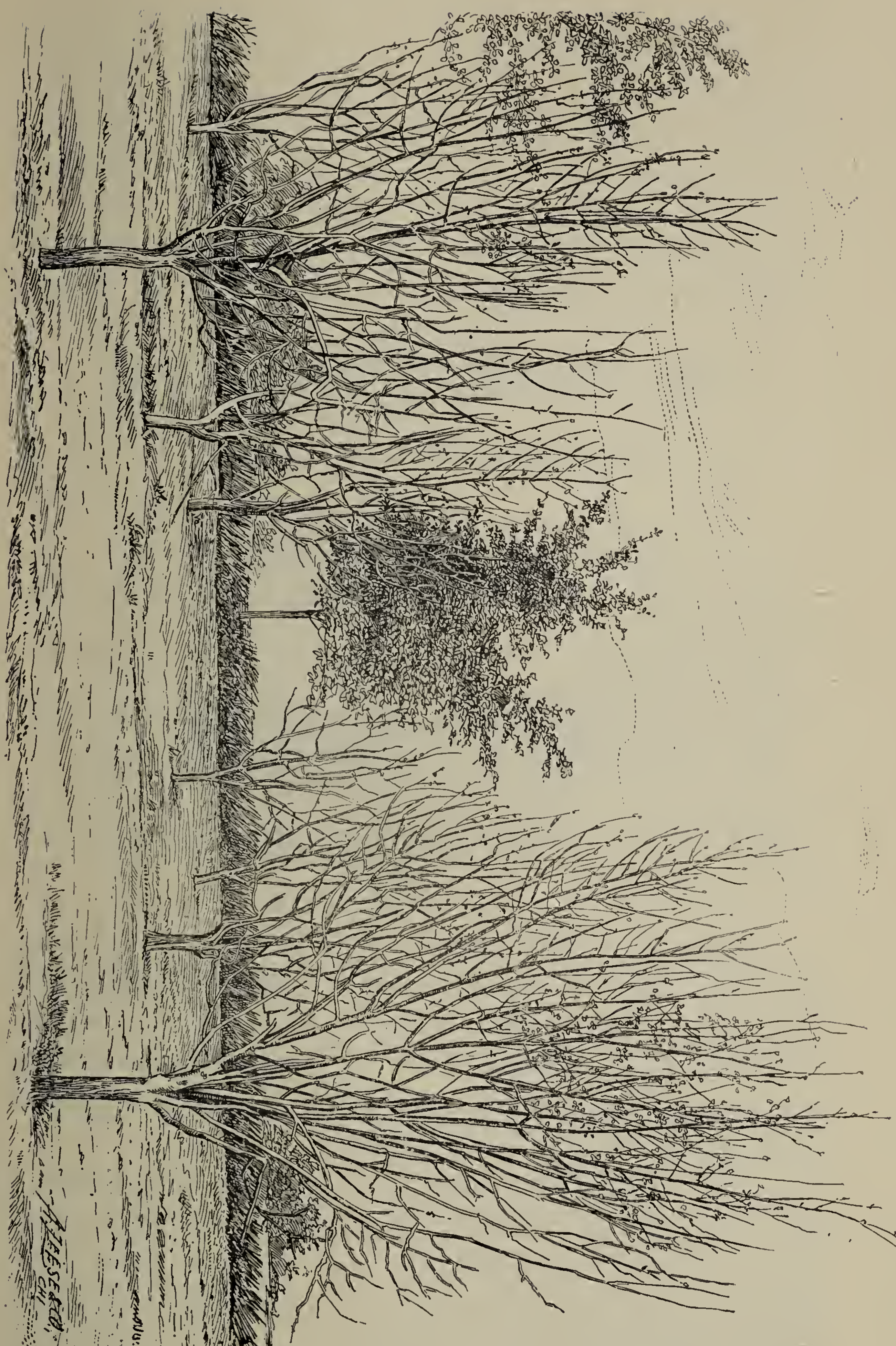

Fig. 4.—View in an apple orchard at Greeley, Colo., showing how completely the trees were stripped by the Leaf-roller. Drawn and engraved from photograph (original).

THE BOX-ELDER LEAF-ROLLER.

(*Cacœcia semiferana* Walk.*)

IMPORTANT REFERENCES AND SYNONYMS.

1863.—Walker. *Lophoderus(?) semiferanus* n. sp. Cat. Lep. Het. xxviii. p. 336.

1869.—Robinson, C. T. *Tortrix flaccidana.* n. sp. Trans. Am. Ent. Soc., Vol. 2, p. 277.

1875.—Zeller. *Tortrix (Loxotænea) flaccidana,* n, sp. Beitr. p. 13.

1879.—Lord Wals'm. *Cacœcia semiferana.* Ill. p. 7. pl. 62.

1890.—Packard, A. S. *Cacœcia semiferana.* 5th Rep. U. S. Ent. Com. p. 314

1890.—Gillette, C. P. *Cacœcia semiferana.* Can. Ent. vol. xxiv, p. 36.

Miss Murtfeldt reports this insect as attacking oak and hickory in Missouri. I have called it the Box-elder Leaf-roller because of its occurring on this tree in such numbers in Colorado, and I have not seen it on any other. Oak and hickory, however, do not occur in this vicinity.

The moth resembles very much the preceding species, but is larger and lighter in color. (Fig. 5, C.) Those obtained last year measure from four-fifths of an inch to an inch in the expanse of their wings when spread. The markings are distributed

*Determined for me by Dr. C. H. Fernald.

much as in the fruit-tree species, but the rust color is never so bright, and in some specimens there are no visible markings, the entire upper surface of the moth being of a light straw color. The larvæ (Fig. 5, A) also differ from those of the preceding species by being a trifle larger, much lighter colored, having hardly a tinge of green, and having

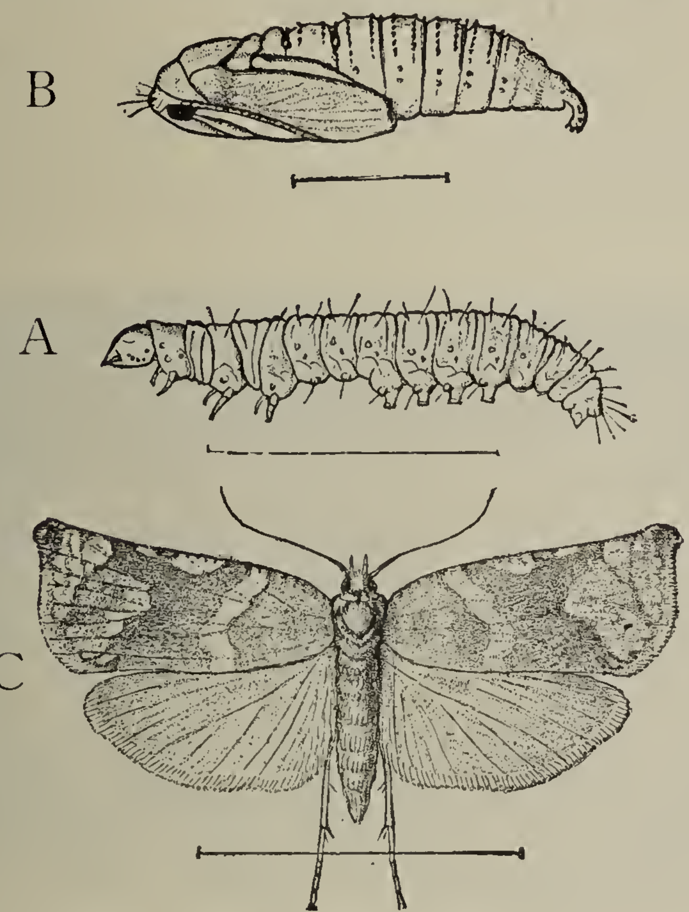

Fig. 5.—The Box elder Leaf-roller, *Cacœcia semiferana* (Walker): A, larva; B, pupa; C, moth. (After Riley).

no black markings except the minute eye-spots and the tips of the mandibles.

The habits of the larvæ in attacking the box-elder are similar to those of the former species on its food plants. The moths are about ten days later in appearing. They began hatching in the breeding cages July 5.

This species is also single brooded. The eggs are deposited on the trunks and large limbs of the trees, and never upon the small, smooth twigs. The female has a very peculiar method of protecting her eggs. They are first deposited in a compact cluster and then covered with a gluey substance that is very impervious to water. After this is done, it seems that the moth must lay her abdomen at full length in this sticky covering and leave it there until the glue has sufficiently hardened to hold fast the scales when the insect withdraws its abdomen. Figure 6 represents one of these shingled egg-clusters after the abdomen has been removed. The breaks in the lines of scales mark the joints of the abdomen. The eggs are in-

Fig. 6.—An egg-patch of the Box-elder Leaf-roller, *Cacœcia semiferana*, covered with scales from the abdomen of the moth(original).

variably covered in this manner and so imitate little, light colored spots of the bark that they are not easily seen.

I have examined trees in the vicinity of Greeley and also in the vicinity of Fort Collins the past winter and find that the eggs of the two leaf-rollers are very abundant upon fruit and box-elder trees, so it is fair to expect that the larvæ will be as numerous this year as last and do as much harm unless something is done to destroy them.

Two parasites, *Liophron* (?) s. p. and *Meteorus indagator*, Riley, were reared from the Leaf-rollers. The former was quite abundant and it is to be hoped will increase in numbers sufficiently to keep these insects in check.

REMEDIES.

Both of the leaf-rollers above mentioned can be very easily destroyed in the larval state by thoroughly spraying the trees with London purple or Paris green in water in the proportion of one pound of the poison to 160 to 200 gallons of water. The application should be made as soon as the leaves show any signs of rolling, or as soon as the presence of the larvæ is known. If the first application is not sufficient, another should be made about a week or ten days later, and should not be stronger than one pound of poison to 200 gallons of water. By adding enough freshly slaked lime to make the water quite milky, the injury that the arsenites often do to foliage may be avoided. If apple trees are sprayed for the Codling Moth the application will also destroy the Leaf-rollers.

While at Greeley last summer, I met one man, Mr. Eli Hall, who had sprayed his box-elder trees with Paris green and their foliage was perfect, while adjoining trees against his neighbor's lot were completely stripped of their leaves. Figure 7 shows one of the treated trees at the left of the picture and one of the untreated trees at the right. The illustration is from a photograph taken at the time. Any farther argument in favor of spraying seems unnecessary.

Fig. 7.—At the right a Box-elder tree not treated and entirely stripped by the Leaf-rollers; at the left an adjacent tree that was treated with Paris green and the foliage saved. From photograph (original).

Where shade trees in town are being attacked it would seem best for the town authorities to take the matter in charge and appoint some capable person to spray all of the trees in the place. Otherwise there will be a great many who cannot be induced to spray their trees and the pest will be continued from year to year.

While speaking of the remedies for the Leaf-rollers, I should do wrong not to mention the valuable services of the toads.

One of the most interesting sights that came under my observation in Greeley last summer was the large number of well-fed toads that hopped lazily about on the walks under the trees from morning until night, watching for Leaf-rollers that were dropping on every side. The rollers were usually snapped in by the toads even before they could reach the ground. As many as fifty of these toads were counted under a single tree, and it was not uncommon for people to take the middle of the street to avoid the toads along the walks. Toads seldom do harm and feed almost entirely upon insects and should be carefully protected, as they are decidedly beneficial.

THE GRAPE-VINE LEAF-HOPPER.

Typhlocyba vitifex (?) Fitch.

This insect was mentioned in Bulletin 15 of this station where it was given the name *Typhlocyba vitis*, which is the hopper that attacks the vine in the eastern states. A careful examination of the insect showed it not to be the eastern species, and specimens sent to Prof. Osborn of Ames, Iowa, and to Mr. Van Duzee of Buffalo, N. Y., have been determined for me as *T. vitifex*. The form which occurs here, however, differs from the typical *vitifex* by having a large black spot on either side of the scutellum at the base, by having the red line on the middle of the thorax usually not forked in front and by not having the red on the head in two lines but in a large blotch more or less spotted with whitish.

The illustration, Fig. 8, was made from a specimen that most nearly approaches a typical *vitifex* in coloration, It seems that the Colorado form is a very distinctly marked variety and for it I suggest the name *Coloradoensis*. The two spots on the scutellum, which are perfectly constant, will alone separate it from the eastern form.

REMEDIES.

The experiments of last season fully convince me that this pest can readily be kept in check by the use of kerosene emulsion, but to destroy

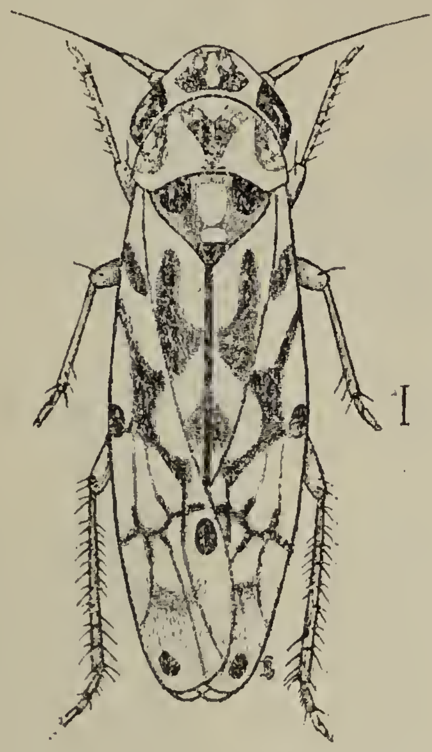

Fig. 8.—The Western Grape-vine Leaf-hopper, *Typhlocyba vitifex* Fitch, var. *coloradoensis* Gill. (Original).

the mature hoppers, it should be made not weaker than one-fifteenth kerosene, and then it will not be wholly effectual if used in the middle of the day. The application should be made as early in the morning as one can see to work and before the sun is up to raise the temperature enough to make the hoppers active. Then, by throwing the spray upon the vines with a good deal of force, the hoppers can nearly all be knocked to the ground and destroyed. For further remedies see Bulletin 15 of this station.

THE GOOSEBERRY FRUIT-FLY.

(*Trypeta canadensis* Loew.*)

When the first green gooseberries were picked from our garden last summer, it was noticed that many of them had been stung by some insect. On visiting the bushes it was found that fully one-half of the berries had been stung and were turning red upon one side and falling. The punctures appeared as if they had been made by thrusting a sharp needle obliquely through the skin of the fruit. If the fruit was freshly stung, this puncture was all there was to be seen, but the fruit soon turned red about the stung spots and in a few days fell to the ground. By raising the skin at the puncture a little white egg or minute maggot could be easily found.

The gooseberry bushes under observation lost fully 75 per cent of their fruit from this cause, and the currants suffered a good deal. By a little careful watching among the bushes I succeeded in finding the insect that was the cause of the mischief and had the pleasure of seeing the eggs deposited. The parent insect is a two-winged fly

*Determined for me by Mr. L. O. Howard, Div. of Entomology, Washington, D. C.

(Fig. 9) about as large as a common house fly, but of a yellowish brown color, and has smoky patches on its wings. The ovipositor is very sharp at the

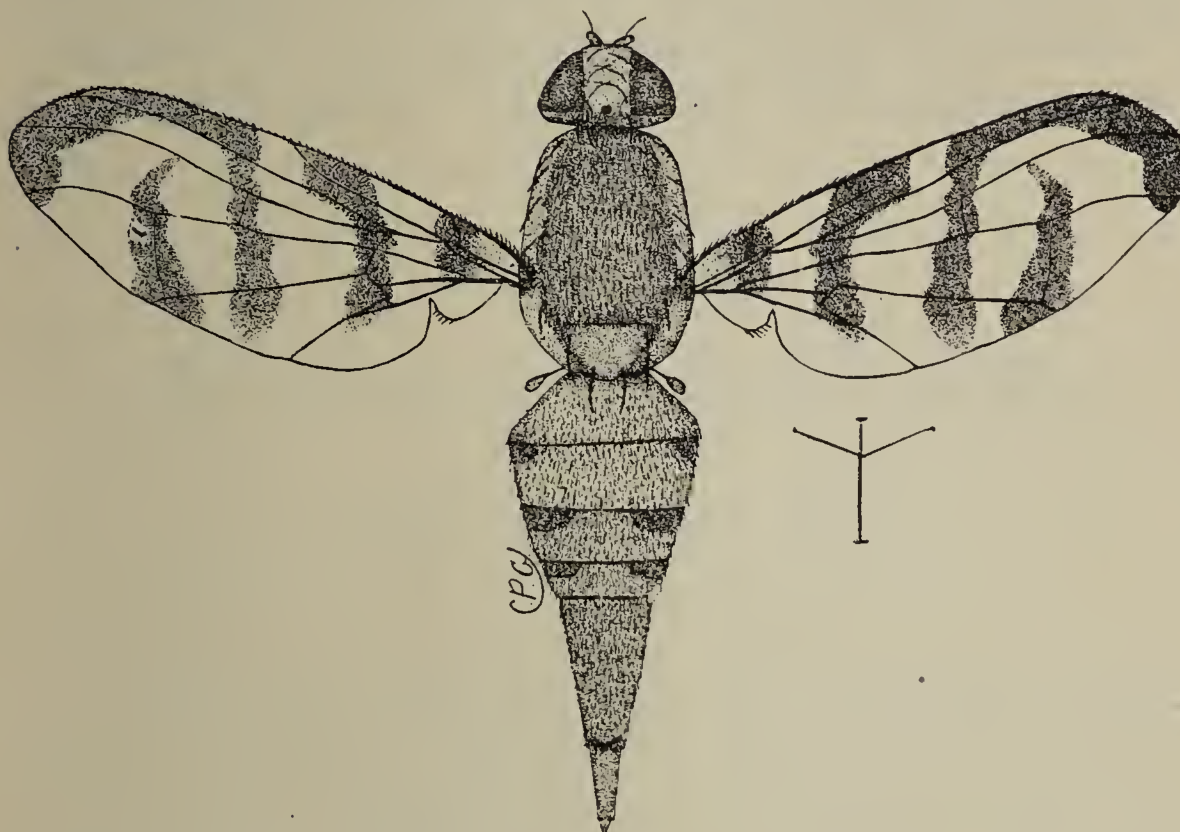

Fig. 9.—The Gooseberry Fruit-fly, *Trypeta canadensis* Loew (original).

tip so that the fly is able to puncture the tough, smooth skin of the fruit and place the egg in the juicy pulp beneath.

The berries lie upon the ground for a number of days after falling before the maggots escape from them. So there is, at least, one method of combating this insect, and that is to carefully gather and destroy all infested fallen berries, before the maggots leave them to enter the ground for the purpose of undergoing their transformations.

No flies were reared last season from infested berries that were kept in breeding cages and none of the flies were seen late in the season, so there is but one brood of this insect in a year.*

*The flies are now (May 1) appearing in the cages where infested berries were placed last June.

This fly has never been considered a serious pest in the eastern states but it is certainly one of the worst enemies to the growing of gooseberries and currents in Colorado and its numbers are not liable to grow less until the gathering and destroying of infested fruit is faithfully attended to.

THE IMPORTED CURRANT BORER.

(*Sesia tipuliformis* Linn.)

This insect was imported from Europe and has spread rapidly to nearly all parts of this country where the common red and white currants are grown.

I have never before seen this insect as abundant as it was in the vicinity of Fort Collins last summer. The mature insect is a peculiar clear-winged moth much resembling a wasp in general appearance. The moths were very abundant about the bushes in the middle of the days from the 12th of June to the 5th of July, during which time the eggs were deposited. The moths are very quick flyers but are quite easily caught, especially towards the cool of the day, as they rest on the leaves. The body of the insect is about one-half of an inch in length and the wings span about three-fourths of an inch from tip to tip. The body is black with a steel-blue lustre and with a large tuft of long scales at the tip of the abdomen. Three narrow, bright-yellow bands cross the abdomen above, and a similar band surrounds the neck and broadens out on the ventral surface. The wings are clear at their bases but are scaled along their anterior and outer margins, and have a black patch of scales about two-thirds of the distance from the base to the tip. The posterior wings have scales along their outer and posterior margins only. The female moths lay little, brown, almost globular, eggs, one in a place, on the stems of the bushes. From these eggs the little larvæ hatch and eat their way to the pith of the stem, up and down which they burrow until fully grown, which is early in May. The larva when about fully grown eats a hole out to the surface of the stem, through which the moth may afterwards escape. The winter is spent in the stems in the larval state. During the following May the larvæ change to pupæ in the stems and from these pupæ the moths begin to appear about the 10th of June.

REMEDIES.

The best remedy for this insect is to cut out all infected stems early in the spring and burn them. The bored stems can usually be detected by the little holes that the larvæ have eaten to the surface for the escape of the moths.

When the moths are abundant about the bushes a great many of them can be taken in nets and destroyed, and much of the egg-laying prevented.

THE WESTERN CURRANT AND GOOSE-BERRY SPAN-WORM.

(*Thamnonoma 4-linearia* Pack., *and T. flavicaria* Pack.)

On the first of June, last year, Mr. Brose, foreman of the Horticultural Department, called my attention to the condition of the gooseberry bushes, some of which were entirely stripped of their leaves by a worm that was then leaving them and going in search of other food. These worms when fully grown were an inch in length, were light-colored, covered with small black spots, and traveled by looping their bodies, and are one of the so-called "measuring worms." Their appearance was so like the old currant span-worm that I did not think of their being anything else until specimens of the moths sent to Mr. G. D. Hulst, Brooklyn, N. Y., were determined for me as *Thamnonoma 4-linearia* (Fig 10, a, b, c. d., and *T. flavicaria* (Fig. 10, e, f, g.) A large number of these moths were reared in our breeding cages and the two species appeared in about equal adundance.

On June 25 the moths were noticed flying among the currant and gooseberry bushes where they continued plentiful for two or three weeks. It was during this period that the eggs were laid, and after this neither moths nor worms were seen. So these insects are also single brooded

The ground color of the moth is light yellow, and the markings are dark brown. The markings vary greatly in different individuals as shown in the accompanying drawings.

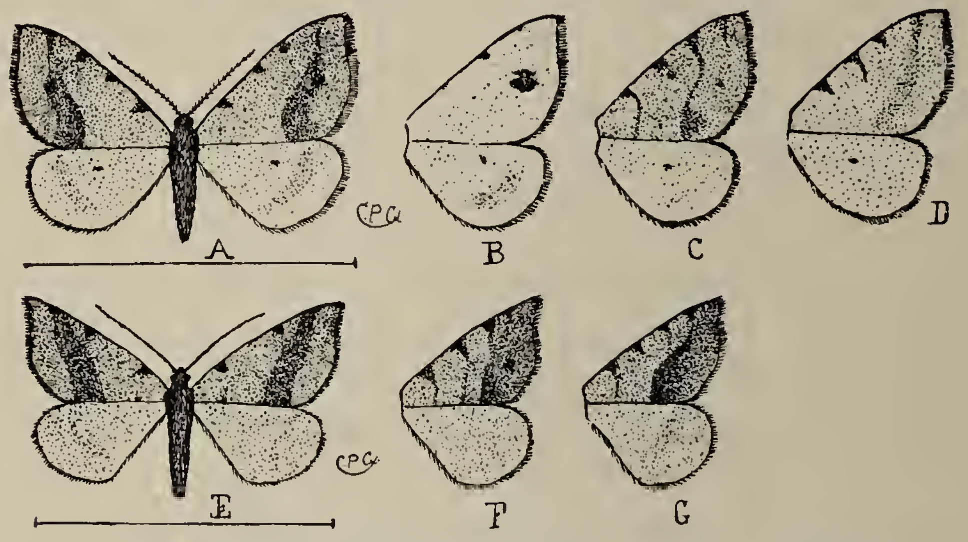

Fig. 10.—Moths of the Western Currant and Gooseberry Spanworms, showing variations in the wing markings. A, B, C, D, *Thamnonoma flavicaria* Pack.; E. F. G, *Thamnonoma quadrilinearia* Pack. (original).

REMEDIES.

Kerosene emulsion and insect powder (Buhach) were very effectual in ridding the bushes of these worms. Paris green or London purple might also be used before the fruit has set, but would hardly be safe after that. The insect powder may be applied in water in the proportion of a tablespoonful to a gallon, or it may be dusted lightly over the bushes from a cheese-cloth sack.

THE SPOTTED BEAN-BEETLE

(*Epilachna corrupta* Muls.*)

IMPORTANT REFERENCES.

1883.—Riley, C. V. Rural New Yorker, p. 42.
1883.—Riley, C. V. American Naturalist, p. 198.
1883.—Riley, C. V. Prairie Farmer, p. 87.
1889.—Riley and Howard, Insect Life, pp. 114, 377.
1890.—J. F. Wielandy, Insect Life, pp. 121, 419.

This beetle out-does all other insect pests that the bean crop has to contend with in the West. It is to the bean what the old "Colorado Potato Beetle" used to be to the potato crop in destructiveness, and it is much more difficult to manage from our present knowledge as to the remedies to be applied.

The beetle (Fig. 11 a) is oval in outline, nearly one-third of an inch in length by one-fifth of an inch in breadth, of a light yellow to a yellowish brown color and has eight small black spots on each wing cover. The mature larva is about the same in length as the beetle, is of light yel-

*Determined for me by Mr. L. O. Howard, Div. of Entomology, Washington, D. C.

low color and is covered with stout branched spines that are black at their tips. One of these larvæ is shown enlarged at Fig. 11 c, and at Fig. 12 is represented one of the spines much magnified. The larva when fully grown fastens the posterior end of its body to the under side of a leaf and then in a few days sheds its outer skin containing the spines and changes to the pupa state (Fig. 11, b). From these pupæ the beetles appear a few days later. They live over winter and appear about as soon as the beans are up in the garden or field and begin to feed upon the leaves, on the under side of which they deposit their yellowish brown eggs in large clusters, after the manner of the "Colorado Potato Beetle." The spiny little larvæ that hatch from these eggs remain on the under side of the leaves which they skeletonize in feeding. The beetles eat through the veins of the leaves and do not skeletonize them. They also eat into and destroy the green pods as shown at Fig. 11 d.

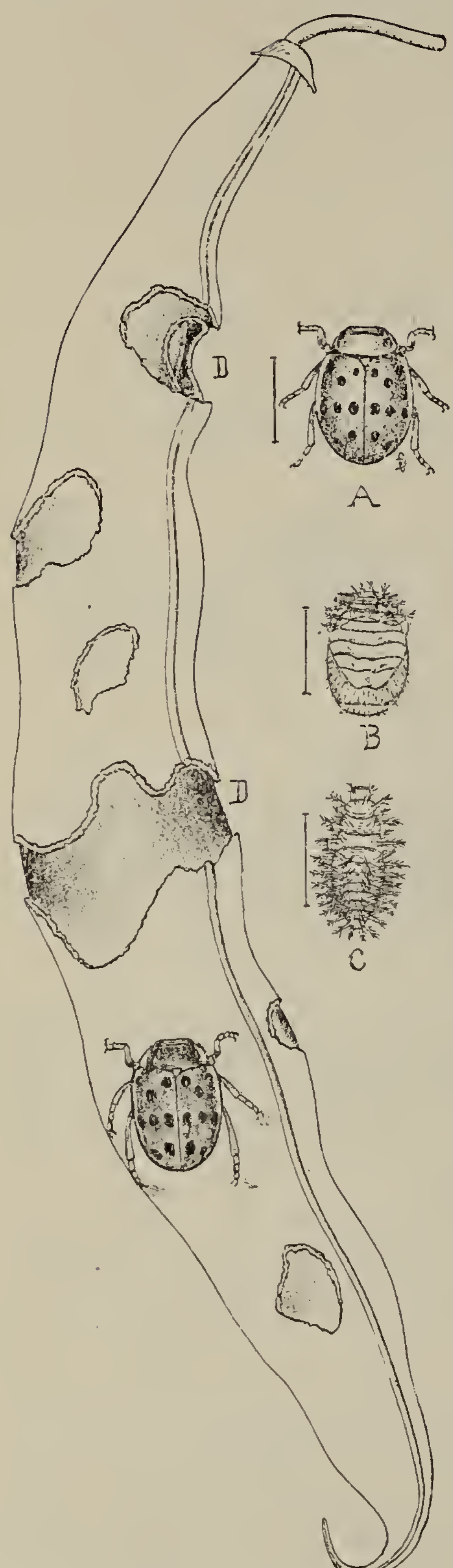

Fig. 11—The Western Bean-beetle, *Epilachna corrupta* Muls. A, mature beetle; B, pupa; C, larva; D, bean pod, showing injuries (original).

There is only one brood of this insect in a season.

REMEDIES.

Last summer was my first acquaintance with this pest and the application that I fully expected would keep it in check did not prove altogether satisfactory. In gardens, much can be done by gathering the eggs before the larvæ hatch. If London purple or Paris green are used dry, one part should be put with not less than 100 parts of the dilutant, and I would recommend slaked lime as being the best for this. The application should be made very light or the poison will kill the leaves of the plants. If these poisons are used in water, there should not be more than one ounce of the poison to twelve gallons of water, and slaked lime should be added to the mixture to prevent the

Fig. 12.—One of the branched spines from the larva of the Bean-beetle, greatly enlarged.

burning of the leaves. It is probable that kerosene emulsion or insect powder thrown on the larvæ from the under side of the leaves would be useful, but these insecticides have not been tried as yet.

I hope to be able to recommend some thoroughly efficient remedy for this pest another year.

This insect, in the beetle state, has a method of protection that is worthy of mention in this connection. If a beetle is disturbed it will draw up its legs and from each knee joint there will be exuded a small drop of a yellow liquid that has a very strong, disagreeable odor which, I have no doubt, gives the insect perfect immunity from the attacks of birds.

THE SQUASH ROOT-MAGGOT.

(*Cyrtonema stabulans* (?) Fabr.*)

As early planted squashes were just beginning to send out vines last summer, it was noticed that many plants suddenly wilted and died. The ground in each case was wet with the juices that had escaped from the injured roots and crown of the plant. I was told that the death of the plants was due to the punctures of the squash bug (*Anasa tristis*) which was very abundant about the plants. I found, however, on examination, that the stems of the plants below the surface were completely honeycombed by a white maggot, the young of some two-winged fly. In the earth about the stems, eggs, maggots and pupæ of the fly were found as late as July 13 and from maggots and pupæ gathered at that time flies began to appear during the last day of July.

The eggs are pure white in color, about one twentieth of an inch in length and, as seen under a microscope, are ribbed longitudinally except along one side, which is smooth. A single egg is so small

*Determined for me by S. W. Williston, Lawrence, Kan. as Cyrtonema sp. and probably stabulans.

as to hardly be seen with the unaided eye but the eggs are usually deposited in clusters between the earth and the stem of the plant. They are usually removed with the earth as it is taken from about the plant and then appear as little white mouldy spots.

REMEDIES.

When this insect was first discovered last summer it was too late to do much with remedies but the remedies that are used against the cabbage and radish maggots should be equally as effectual in destroying this insect. First, I would recommend removing the dirt from about the stem of the plants every two or three days during the egg-laying season and replacing this dirt by fresh soil. Dilute kerosene emulsion, strong tobacco tea or a decoction of insect powder put about the stems of the plants every three or four days would undoubtedly do much to destroy the eggs and young maggots.

THE PEA-WEEVIL. (*Bruchus pisi* Linn.)

I have never before seen this insect so enormously abundant as it was in this vicinity last summer. From the examination of peas in gardens and in the stores in Fort Collins, it was evident that those who ate of this favorite vegetable here last summer must have devoured more maggots of the pea weevil than peas. It was not uncommon to find pods with thirty or forty eggs of the weevil upon them and by the time that the peas were fully grown nearly every seed would be infested.

The eggs are yellowish brown in color, rather elongate, somewhat curved and very small, though they can be plainly seen scattered over the green pods. The little grubs, on hatching from the eggs, burrow through the pods and can often be seen as minute yellow objects crawling over the peas before entering them. In eating their way into the peas they leave small holes appearing as the punctures of a fine needle. Very soon after one enters a pea there appears a dark green blotch about the punctute that is very noticeable.

"Buggy" peas can easily be detected, either by the eggs upon the outside of the pods or by the themselves. By rejecting all such peas that are offered in the markets the growers will soon learn to take the proper precautions to raise peas free from the weevils.

REMEDIES.

This insect was first brought among us in "buggy" peas shipped from the East for seed and the pest can never be subdued so long as such seed is used. If seed peas are found to have the weevil in them, one of the following things should be done: The peas, weevils and all may be destroyed by burning or feeding to some animal that will eat them. If the peas are to be saved, they may be kept in a paper sack for a year before planting, at the end of which time all of the weevils will come out of the peas and die. Or, the peas may be put in a jar, a little chloroform, ether or carbon bisulphide poured in, and the jar tightly sealed for twenty-four hours. This will kill the insects but will not injure the peas for seed. It is also claimed by those who have tried it that the weevils can all be drowned by immersing the seed for a few hours in water before planting.

Seed men kill the weevils by putting the seed in a tight bin and pouring in a quantity of carbon bisulphide and closing the bin very tightly for a number of days. First-class seed men are very careful not to send out seeds with weevil in them.

Taking care not to plant peas with the weevil in them will only serve to keep the pest away when it is not already in our fields and gardens. In order to rid ourselves of this pest now, great care will have to be taken to see that none of the beetles that are in the peas in the fall shall live over till punctured and blotched appearance of the peas planting time the following spring. The vines in the garden should all be pulled and burned as soon as the peas are too large for table use. As soon as peas are harvested from the field, hogs or sheep should be turned in to pick up all scattered seed, and the harvested crop should be so managed as to secure the destruction of all the weevils that are taken with it if possible.

We found that we could use the peas from our garden last summer by picking them quite green and then looking them over and throwing out all infested ones before cooking.

The illustrations in Figs, 1, 6, 8, 11 and 12 of this bulletin were drawn by Mr. C. F. Baker, assistant entomologist of the station, and Fig. 3 by Miss C. M. Southworth. Fig. 5 is from the Fifth Rep. of the U. S. Entomological Commission and was obtained through the kindness of Dr. C. V. Riley.

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State Agricultural College

The Agricultural Experiment Station.

BULLETIN No. 20.

I. The Best Milk Tester for the Practical Use of the Farmer and Dairyman.

II. The Influence of Food Upon the Pure Fat Present in Milk.

Approved by the Station Council.
ALSTON ELLIS, President.

FORT COLLINS, COLORADO.

AUGUST, 1892.

The Agricultural Experiment Station,

FORT COLLINS, COLORADO.

I.

The Best Milk Tester for the Practical Use of the Farmer and Dairyman.

WALTER J. QUICK.

That time is the present when intelligent farmers and dairymen, like other business men, have discovered the noteworthy fact, that those who make the greatest success, do so by means of that enterprise which introduces or adopts and manipulates into practical utility the most approved methods. Being ever ready for the many and rapid modifications of this advanced age, enables one to place the balance on the right side, perpetuate his business and crown it a success. Those men who lead are ever on the alert for the new, at the same time, the tried and the best, and do not wait until every one has acquired it and reaped the benefit accruing from its adoption. Just now, during the rapid progress of the present century, a simple and practical method for the reliable valuation of milk should be in general use.

Numerous methods have been introduced, and are being employed for ascertaining the amount of butter fat in milk. The poorest is better than none. Churning each cows milk separate will detect unprofitable animals. It is certainly quite as important for the dairyman to know what quality of milk he buys, as for the owners of a beet sugar factory, or a smelter, to ascertain by analysis or assay the quality of the product they purchase. The farmer, too, wants to know the quality of the milk he sells, that he may receive the proper recompense, and not too little, while perhaps his neighbor for poorer milk receives too much. Both the farmer and the dairyman, by the employment of a milk tester, find the cows it is the part of wisdom to retain, and as readily those which, reducing the profits of the better animals, should be speedily discarded.

The farmer with but a few cows is now ready for such a machine or apparatus, provided it is not too expensive, and he can successfully manipulate it. Does such a method for testing cows exist?

COMPARING METHODS.

As we have said, there are a number of methods that are well known, accurate and approved, but the question arises, Which is the most practical for the farmer and the dairyman?

It is our purpose, then, to compare three methods for determining the fat present in milk, viz., Babcock's, Cochran's, and Shorts', observing the economy of handling the different apparatus, the rapidity of work, simplicity of structure, accuracy, and the cost of the outfit. To do this, we have made from 16 to 32 fat determinations with each apparatus; from each, whole, skim milk and cream, always drawing from the same general sample and source. Our conclusions are summarized below:

Economy of Handling.—Regardless of time, we find the Babcock tester to be much more cheaply manipulated, from the fact that but one reagent is required, commercial sulphuric acid, or oil of vitriol, having a specific gravity of 1.82, or about 90 per cent. pure acid. In addition to this, hot water is always required. The cost is about one-fifth cent per test when the sulphuric acid can be secured wholesale. With each of the other methods the same required for the Babcock is necessary, and, in addition, for the Cochran examination acetic acid of a specific gravity difficult to procure, and ether, which is highly explosive and must be handled with care. For the Shorts method, besides that necessary for the Babcock, caustic soda, caustic potash and acetic acid must be used.

The apparatus of the last-mentioned is not more breakable than the Babcock, but that of the Cochran is much more delicate, the most careful manipulators often breaking testing flasks.

Rapidity.—With Shorts' method, about five hours are necessary for the analyzing of one set of twelve flasks. This condemns it for the farmer's use.

The Cochran requires, for heating water, transferring from bottles to fat indicators, cleansing, etc., from three-quarters to an hour for a set of nine samples.

With the Babcock, and without assistance, I analyzed ten samples in thirty-nine minutes, being about four minutes to the sample, and, with assistance, in thirty-three minutes, cleansing the entire apparatus in the time. Alone I tested two samples in duplicate in eighteen minutes, and thirty samples—three sets—in one hour and twenty-two minutes, only cleansing such of the apparatus as was necessary between sets. It is claimed that analyzing can be done in half the time with the new Curtis' Babcock tester.

Simplicity of Structure.—All are simple enough, so that the ordinary farmer will experience very little difficulty in handling them. He may break more, perhaps, than the trained chemist. The glassware of the Cochran is the most complicated and easily broken. There is very little, if any, difference in the other two methods in this respect. The Babcock is a centrifugal machine, and requires no heating, and less hot water than either of the others.

Accuracy.—The accuracy of the Babcock was tested by the gravimetric method—it is true by samples taken from ten to twelve hours apart, but under the most favorable conditions of the milk possible, with that consideration. The variations below, though small, would not likely be as much if the samples where taken at the same time.

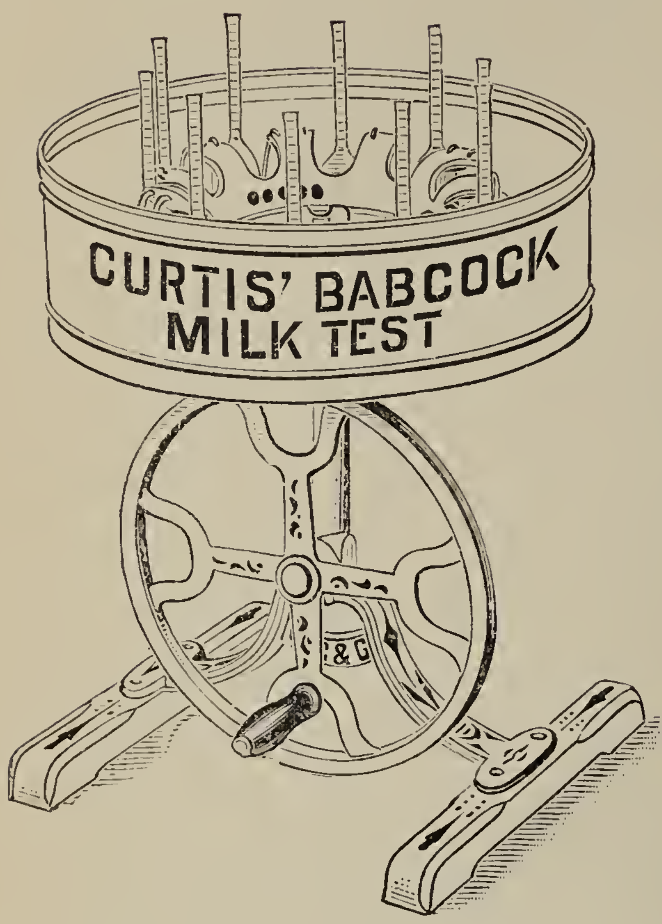
Source of Sample.	Averages of	Per Cent. Butter Fat.		
		Gravimetric.	Babcock.	Difference.
Shorthorn cow........	7 samples in Feb.	4.14	3.86	.28
Shorthorn cow........	7 samples in Feb.	3.98	3.28	.70
Jersey cow............	7 samples in Feb.	3.07	2.94	.13
Jersey cow............	7 samples in Feb.	4.00	4.04	—.04
Shorthorn cow........	8 samples in March.	4.01	3.83	.18
Shorthorn cow........	8 samples in March.	3.60	3.30	.30
Jersey cow............	8 samples in March.	3.10	2.82	.28
Jersey cow............	8 samples in March.	4.05	4.17	—.12

Accuracy depends mainly on the careful sampling of the milk, using reagents of the proper strength, and in following directions closely. It is seldom, if ever, that the graduated scales on the test bottles are wrong. By several trials with all in duplicate an error can easily be discovered.

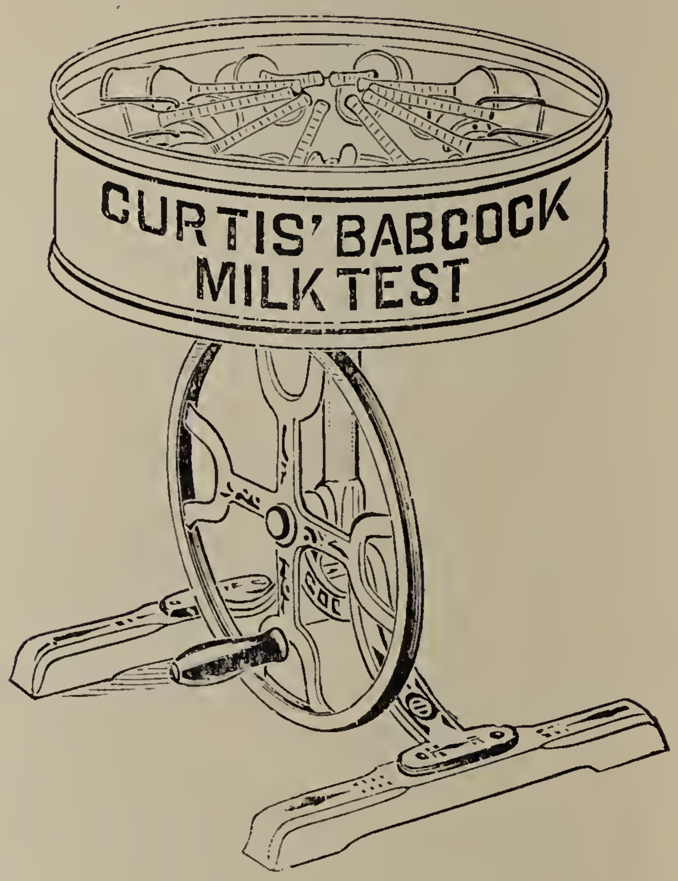
After testing the Babcock with the gravimetric, we then tested the Cochran, Shorts and Babcock together, with the following results, which can be said to be very little better for one than another :

SOURCE OF MILK.	Per Cent. of Fat.		
	Babcock.	Cochran.	Shorts.
Whole milk, Bonnie Louan, Shorthorn, ...averages,	4.56	4.32	4.22
" " Orchard Lark, " .... "	2.65	2.76	2.86
" " Lizzie Lesley, " .... "	3.80	3.80	3.74
" " Kirk. Duchess 29 " .... "	2.70	2.93	2.95
Separated milk, from Shorthorn cow,................	1.80	1.81	1.83
" " " " "	1.70	1.65	1.83
" " " " "	1.80	1.78	1.83
" " " " "	1.60	1.38	2.01
Milk, separated very close, from College herd,.......	.20	.15	Trace.
" " " " " " "	.15+	.15 —	Trace.
" " " " " " "	.10 —	.10 —	Trace.
" " " " " " "	.10+	.10+	Trace.
Cream, separated, from College herd,................	14.35	14.06	13.86
" " " " "	19.70	19.68	19.23

Cost of Outfit.—The Babcock method for the use of the ordinary farmer or small dairyman, or creamery, is manufactured in very convenient size, with ten test bottles, at a cost of $15.00. It is also made larger for testing more samples simultaneously. It is not patented, and can this year be procured of almost any dairy supply house. We believe it to be the best milk tester on the market for practical use. On the following page we give a cut of the Babcock apparatus, as improved recently by Mr. Curtis:

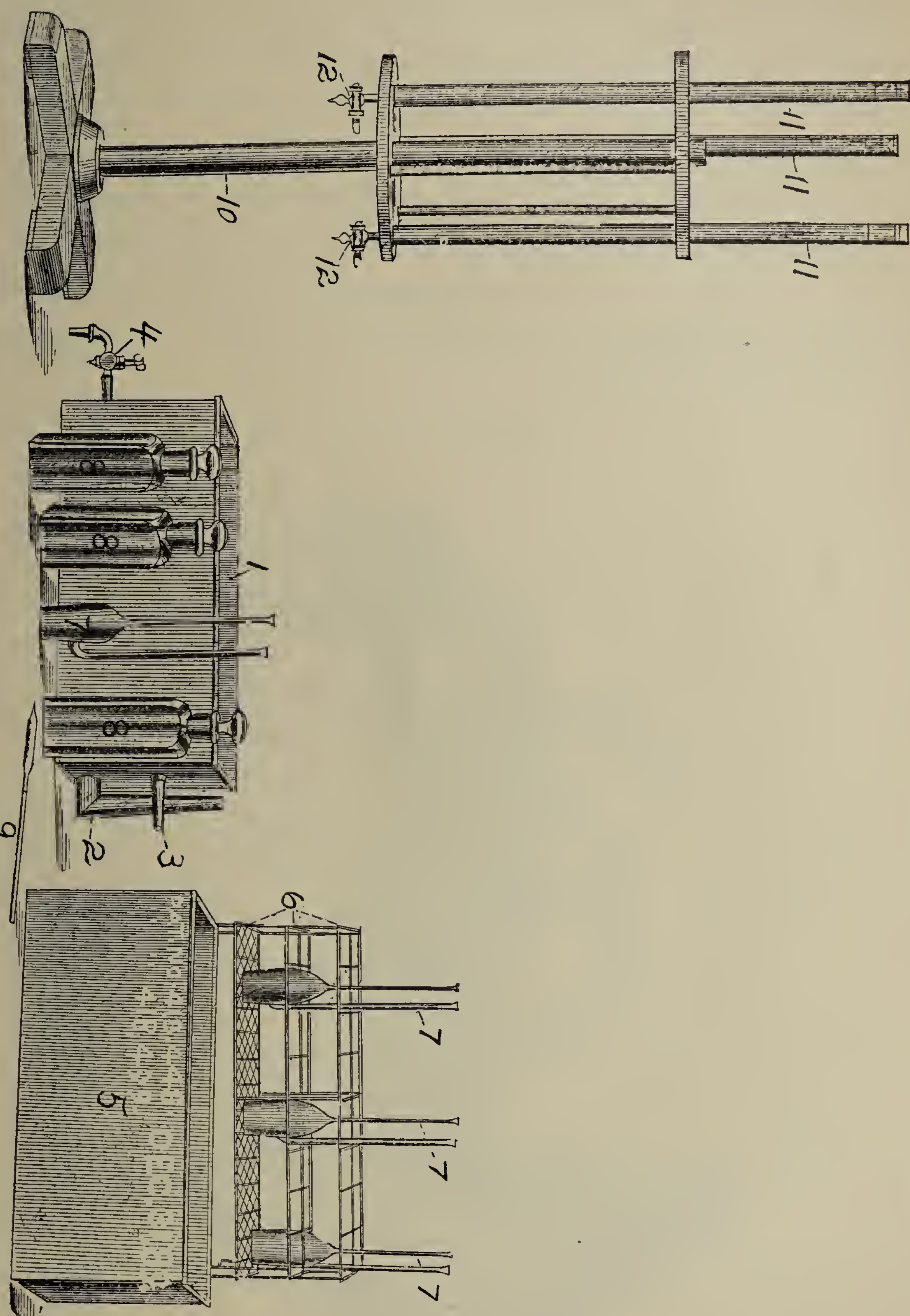


Stationary.



In Motion.

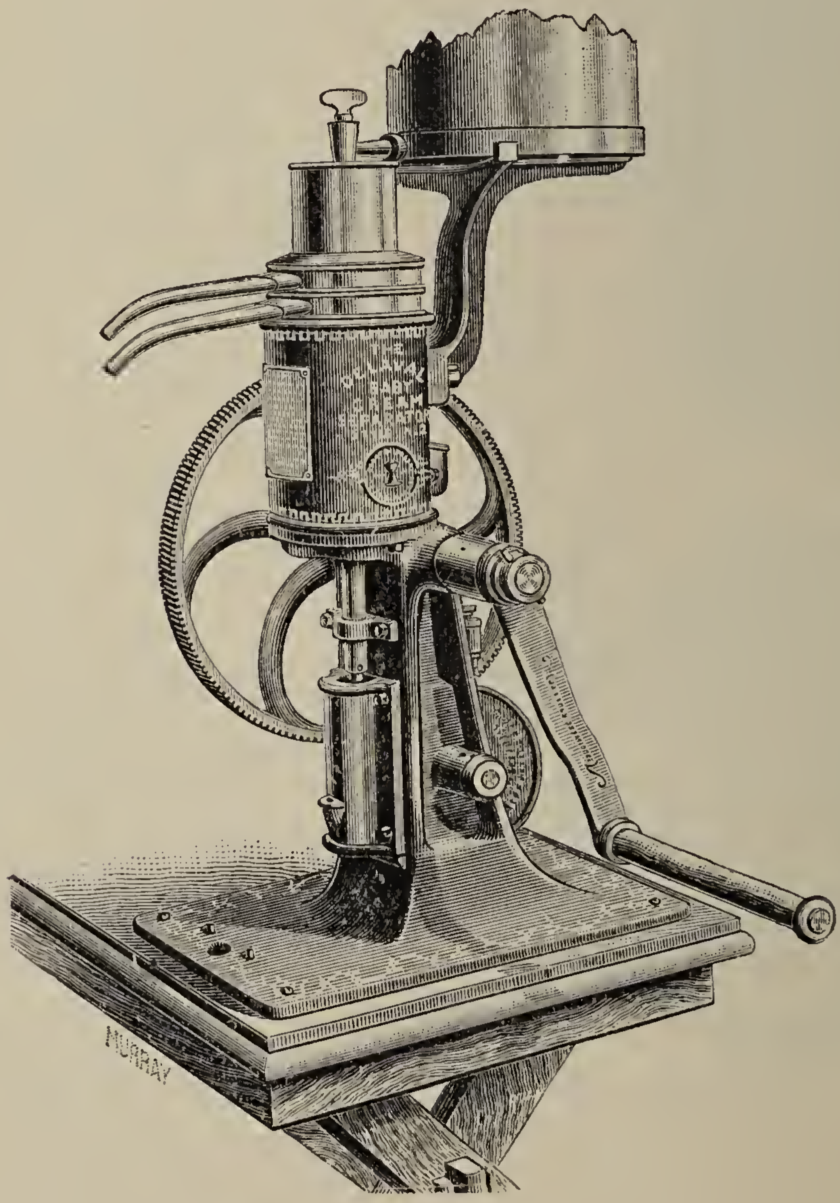
The Cochran and Shorts apparatus can be procured at any dairy headquarters at prices not varying much from those at which the Babcock is sold. Though requiring more care in manipulation, we consider the Cochran method the second best for determining fat, because of greater speed, together with the accuracy. It can be procured at $10.00, for a four-bottle test. We herewith give a cut representing this apparatus:



THE COCHRAN MILK TEST.

THE DE LAVAL SEPARATOR.

The skim milk for the foregoing analyses was separated from the cream by means of the De Laval "Baby" Cream Separator, which, from this experience, and other trials made and observed with this machine, and from observations at the trials of other separators, we believe to be the best on the market. Farmers who have enough cows to justify the expenditure, and dairymen who make sweet cream butter, and all who patronize creameries, can illy afford to be without this valuable separator. We append a cut of the machine:



II.

The Influence of Food Upon the Pure Fat Present in Milk.

WALTER J. QUICK.

It is quite generally understood that the quantity of food consumed influences the yield of milk. There is not very much conclusive and authentic evidence regarding the *quality* of food as materially modifying the richness of the milk. It will be acknowledged that certain foods and grasses influence the color of butter. Numerous experiments exhibit results to prove that an increase of the same ration will increase a cow's milk yield, but *not* the quality of that yield. By a few it is believed that the quality of milk can be changed very perceptibly by changing rations. Not enough has been accomplished to settle the question conclusively. Eminent men remain on both sides, many among the most prominent stoutly maintaining that the quality of the milk depends solely, or almost so, on the individual animal, some being producers of rich milk, and others of the poorer article.

It was not with the belief that we, by this experiment, would settle this mooted question, that we undertook it. If we can throw some light upon the subject, or inspire investigation among those interested in Colorado, we will be satisfied.

Much has been said, and many the belief expressed, by men of the West, where such abundant oat crops are always produced, that "oat chop" fed with alfalfa is better than wheat bran for producing rich milk. This question has been the source of much argument at farmers' institutes, and various meetings of dairymen and farmers. The statement has been made, and not successfully contradicted, that with oats worth $1.00 per hundred ($20.00 per ton), and wheat bran at $15.00 per ton, the oats, ground, and alfalfa hay is worth enough more as a dairy feed and butter producer to justify its use. This question we have been asked to test in connection with this experiment.

This feeding experiment was determined upon early in February, 1892. It was desirable to have cows representing at least two breeds. The College being in possession of a fine herd of Shorthorns, two cows were selected from it suitable for the trial. The loan of two Jerseys was secured, through the kindness of Mr. John Nelson, a Jersey breeder near Fort Collins. The feeding commenced February 18, Mr. A. Campbell, the College herdsman, in charge, and Mr. F. A. Huntley, Assistant Agriculturist, helping with the milk analyses.

With the above objects in view, the four cows were placed upon a ration of 2 pounds of oat chop—that is, ground or rolled oats—and the first crop of lucerne, or better known as alfalfa hay. They were given the ration morning, noon and evening; more hay was fed than they would eat, the residue always being weighed, and deducted from the original weight of the feed. Every forenoon, between 10 and 11 o'clock, each cow was weighed. They were given exercise in a lot, but not allowed access to anything they might eat, and were given all the water they desired.

At the close of the first feeding period, clear wheat bran was substituted for oat chop; this was, as stated, *clear bran*, specially ordered for this experiment, containing no shorts. All may not know that the so-called bran received from the mills contains all the shorts produced, run together from the mill into the bran bin. This is what the farmer gets when he buys bran. The clear bran costs us at Fort Collins $14.00 per ton; oats was worth $20.00.

From daily analyses and close observation, we ascertain it to be a fact that a longer time is necessary for securing an even yield of butter fat from some cows than others. While with some the per cent. may be influenced by a change in the ration in forty-eight hours, and such cows become regular in that length of time, with others we find the per cent. influenced, for better or worse, according to the quality of the ration, and grow regular in sixty-four to seventy-two hours, and still others (exceptions), requiring even more time. As should be expected, this is governed to a great extent by the appetite of the cow. Those animals that might be termed good feeders, and that will eat one ration with about the same relish as another, exhibit in the quality of the milk the results of a change in feed sooner, and in every case under our observation, a steadier flow, with more uniform per cent. of butter fat. Naturally, then, we would expect, and do find, that the shy or dainty feeder shows a greater variation in both quantity and quality.

We have consulted men of experience in the feeding of dairy stock, and several eminent experimenters located in other stations, and we are informed that while a longer period is usually taken for each ration, yet with care it is not absolutely necessary. The results of these experiments give indorsement to these statements, and while we would not recommend less than ten days for a feeding period, we believe that quite sufficient.

Having found, then, that the fluctuations in the per cent. of butter fat are reduced to a minimum in most cases after a change in a ration has been instituted seventy-two hours, we add twenty-four hours for safety, and include in our averages only analyses after ninety-six hours, or after twelve feeds have been consumed by the cows, except in starting the experiments. As some cows were moved, they were given from twenty-four to forty-eight hours still more, to become familiar with their new surroundings and feed before the analyses of their milk were taken into the averages. Analyses, however, were made from which to observe changes. Occasionally one has been thrown out, when by accident or other cause it is known to be wrong.

METHOD OF ANALYSIS EMPLOYED.

The most careful records of milk yield, feed, water, and animal weight, have been kept throughout the experiment, and the milk of each cow has been tested daily for its fat per cent. by the Babcock method. This tester was adopted, as we consider it the most accurate and speedy, and less subject to errors.

The analyses with the Babcock tester were nearly all duplicated by the Station Chemist with the gravimetric method. The difference in the results of these two methods is greater than was expected, but can be accounted for in the fact that the samples for the gravimetric examination of each day's milking (combined morning and evening) were drawn off the morning after, while those for the Babcock were pipetted from the combined milk as soon as the evening's milking was over, and were placed in the test bottles ready for analysis.

The variation being so great, not only in comparison with the Babcock, but frequently as compared with the same cow's milk the day before, by the same method, caused us to investigate. With the Babcock we found the duplicate samples in the evening run very close, never varying over .4 of 1 per cent., while those taken the next morning varied from $\frac{1}{2}$ to 2 per cent. The explanation is that the cream rises, sometimes dries on top, and frequently is sour, when it is impossible to mix and secure a fair sample. At times, without the knowledge of the operator, his pipette will draw in a clot of cream, while again from the same vessel its mouth is surrounded by the poorest of milk, containing almost no butter fat. We find, from repeated analyses with the Babcock, that after sampling, the milk may stand in the test bottles until it is sour and coagulated, without the results being changed.

From a study of the tabulation we learn that the quality of milk was quite perceptibly influenced by the change of food given these cows. It will be also observed that in every case by the Babcock analysis, the wheat bran produced the best results, and that the gravimetric analysis exhibited two cases as good or better, with the other two but slightly lower. It must be remembered that in the two cases which showed a lower per cent. when the cows were on bran, the samples were from the two longest in milk; and, further, that if there is any advantage from this fact, it was given the oat chop ration, which was fed first. Three of the cows lost in yield of milk, which might be due to some extent to the same cause, but more likely to natural fluctuations or the condition of the weather at that time. This is the more likely, since there is sufficient evidence extant, that bran causes a better flow of milk than oats. While they gained in weight on the oat chop, each lost a few pounds on the bran ration. The difference in either case could have been caused by the difference in water drank, at a single time. With these suggestions, we leave the conclusions to be drawn by the reader, asking his attention to the almost constant difference existing in the values of the foods in question, and that in this experiment clear bran was employed, instead of the usual mixed mill feed.

1st period, ration oat chop and alfalfa; 2d period, bran and alfalfa.

Period.	NAME.	BREED.	Age.	Calved.	Hay Eaten.	Per Ct. Fat. Bab.	Grav.	Weight of Animal. Begin.	Close.	Gain or Loss.
1	Bonnie Louan	..Shorthorn .	7	April, 1891	24.8	3.81	4.08	1315	1320	5
2	" "	"	....	....	25.0	3.95	4.10	1320	1315	—5
1	Orchard Lark.........	"	3½	Oct., 1891	28.3	3.43	3.75	1230	1270	40
2	" "	"	....	. ...	26.8	3.50	3.62	1270	1264	—6
1	Matilda................	... Jersey ...	4	Dec., 1891	23.0	2.55	3.00	910	955	45
2	"	"	....	....	23.1	2.95	3.00	955	942	—13
1	Pride of the Rockies..	"	4	Sept., 1891	22.5	4.00	3.93	865	895	30
2	" " "	"	....	....	20.1	4.26	4.28	895	880	15

FEEDING EXPERIMENT CONTINUED.

Apparently, we secured a glimpse into the darkness with the oat and bran feeding. Our idea in this experimenting in the same line was, if possible, to learn more of the influence of different foods upon the butter fat.

Cows.—More cows were added. We employed in this work the same Shorthorns, secured from Messrs. Cornforth & Styles, of Loveland, two pure-bred Holsteins, retained one of the Jerseys and exchanged the other for an older cow; each breed was then represented by an aged and a young animal. These six cows received the same treatment and quarters as had the four, and were under the charge of the same herdsman until April 1, when he was succeeded by Mr. B. Roseberry, who gave them the same careful attention to the close of the experiment.

Feeds Selected.—A change was deemed advisable in feeding stuffs. Very dissimilar foods were selected, believing that it is better to compare two or three such than to try more, for the reason that it is difficult and requires most careful attention to details, to be certain from one trial as to the results of even two different rations. The selections consisted of linseed oil meal, corn meal, and wheat bran, with the first cutting of alfalfa and bright oat straw. Each kind of concentrated food was fed alone with one kind of rough stuff, except when the ration was changed to oil meal, at which time some bran had to be added as an appetizer. It is seldom that more than 4 pounds of oil meal can be fed a cow daily without salivating her, but we succeeded in feeding in this case 4.5 pounds, with alfalfa, without bad results. Since the question of the amount of food fed is conceded not to be of special importance as bearing upon or influencing the composition of the milk, the animals were given all they would consume without impairing their appetites. They were watched most carefully, fed according to their demands, and record kept.

FEEDING PERIODS.

The length of a period determined upon was ten days.

1. The six animals were fed alfalfa and bran for ten days, for the purpose of testing the milk, and making comparison on the same ration as a basis.

2. Beginning with the eleventh day, we fed one lot of three cows (one of each breed) with oil meal and alfalfa, and the other three with wheat bran and alfalfa.

3. Straw was substituted for alfalfa for ten days, other feed continued the same.

4. The conditions of the two lots of cows were reversed, giving the first lot wheat bran, and the second oil meal.

5. All were feed wheat bran and alfalfa.

6. The first lot of three cows were now changed to Indian corn meal, and the second to wheat bran, all receiving alfalfa.

7. Reversed the conditions of the two lots of cows.

8. All fed corn meal and alfalfa.

The object in the last three periods, and others similar, is the noting of variations in the quality of the milk, and to see if they correspond to the variation and quality of the foods employed.

During all of this work we took samples of each cow's milk, combining that of morning and evening, and analyzed them, as in the case of the four cows, by the Babcock method. Gravimetric analyses were frequently made by the Station Chemist, which do not correspond as well as we would wish with the other method employed, for the reasons heretofore stated. A careful record of the food eaten and water drank has been kept, and the cattle weighed daily between 10 and 11 o'clock. A great deal of attention and labor is connected with such an experiment. Analyses to the number of 706 have been made, recorded and averaged for this bulletin. It is believed that the experiment is not wholly without merit, and that the tables on the following pages are that interesting and comprehensive as to enable the reader, by careful study, to deduce from them information of much value.

No. 1.—Bonnie Louan, Shorthorn, age 7 yrs; last calf April, 1891.

FEEDING PERIOD.	Food Consumed. Daily Average, lbs. Feed.	Hay or Straw.	Water.	Milk Yield, Daily Average. lbs.	ozs.	Per Ct. Fat. Babcock.	Gravimetric.	Weight of Animal. Beginning	Closing.	Gain or Loss.
1. Wheat bran and lucerne......	6	23.3	107.1	13	1	3.84	4.16	1232	1344	112
2. Linseed oil meal, some bran and lucerne	Bran, 1.9 O. Meal 1.8	22.8	106.3	12	5	4.53	4.16	1344	1342	—2
3. Lin. oil meal and oat straw..	4.3	7	60.7	9	7	5.22	5.15	1342	1312	—30
4. Wheat bran and oat straw....	6	14.6	75.8	10	3	3.99	3.77	1312	1304	—8
5. Wheat bran and lucerne......	8.7	20.1	105.9	12	12	3.90	3.50	1304	1342	38
6. Indian corn meal and lucerne	6.4	20.8	95.2	13	4	3.92	3.48	1342	1326	—16
7. Wheat bran and lucerne......	10.5	19.7	119.7	14	6	3.67	3.75	1326	1338	12
8. Indian corn meal and lucerne	9	20.4	107.3	13	12	3.38	3.55	1328	1356	18

No. 2—Orchard Lark, B. 2d, Shorthorn, age 3½ years; last calf, October, 1891.

FEEDING PERIOD.	Feed.	Hay or Straw.	Water.	lbs.	ozs.	Babcock.	Gravimetric.	Beginning	Closing.	Gain or Loss.
1. Wheat bran and lucerne......	6	24.1	123.6	13	13	3.45	3.81	1180	1285	105
2. Wheat bran and lucerne......	6	24.2	126.4	13	4	3.18	3.22	1285	1294	9
3. Wheat bran and oat straw....	6	12.5	79.9	10	10	3.68	4.53	1294	1270	—24
4. Lin. oil meal and oat straw..	4.3	17.4	84.6	10	9	3.97	3.72	1270	1210	—60
5. Wheat bran and lucerne......	8.7	22	120.2	12	5	3.66	3.73	1210	1234	24
6. Wheat bran and lucerne......	10.5	24.5	122.7	13	1	3.52	3.54	1234	1298	64
7. Indian corn meal and lucerne	7.3	26.1	133	12	10	3.22	3.35	1298	1296	—2
8. Indian corn meal and lucerne	9	26.7	127.5	12	13	3.38	2.95	1296	1322	26

No. 3—May Lincoln, Holstein, age 8 yrs; last calf, October, 1891.

FEEDING PERIOD.	Feed.	Hay or Straw.	Water.	lbs.	ozs.	Babcock.	Gravimetric.	Beginning	Closing.	Gain or Loss.
1. Wheat bran and lucerne......	6	22.3	110	21	12	3.14	3.35	1005	1115	110
2. Linseed oil meal, some bran and lucerne..............	O. Meal 2.1 Bran 1.2	24.8	118.2	20	10	3.42	3.12	1115	1132	17
3. Lin. oil meal and oat straw...	4.4	8.3	67.5	15	9	3.38	3.53	1132	1070	—62
4. Wheat bran and oat straw....	6	12.8	73.1	14	0	2.74	3.23	1070	1076	6
5. Wheat bran and lucerne......	8.7	18.4	106.3	16	6	2.78	2.95	1076	1128	52
6. Indian corn meal and lucerne	6.4	21.3	97.5	18	1	2.53	2.82	1128	1132	4
7. Wheat bran and lucerne......	10.5	20.8	129.6	18	8	2 60	3.10	1132	1138	6

No. 4—Queen Sontag, Holstein, age 4 years; last calf, July, 1891.

FEEDING PERIOD.	Food Consumed. Daily Average, lbs. Feed.	Hay or Straw.	Water.	Milk Yield. Daily Average. lbs.	ozs.	Per Ct. Fat. Babcock.	Gravimetric.	Weight of Animal. Beginning.	Closing.	Gain or Loss.
1. Wheat bran and lucerne......	6	27.9	129	21	1	3.34	3.50	1002	1145	143
2. Wheat bran and lucerne......	6	29.3	139.7	21	7	3.42	3.44	1145	1170	25
3. Wheat bran and oat straw....	6	12	84.7	15	6	3.53	3.93	1170	1164	—6
4. Lin. oil meal and oat straw ..	4	19.1	104.7	10	12	3.73	4.18	1164	1160	—4
5. Wheat bran and lucerne......	8.7	23.4	150	12	2	3.20	3.27	1160	1178	18
6. Wheat bran and lucerne......	10.3	27.1	160	16	3	3.18	3.40	1178	1214	36
7. Indian corn meal and lucerne	7.3	29.2	138.7	18	4	3.02	3.50	1214	1206	—8

No. 5—Lalite, Jersey, age 9 years; last calf, January, 1892.

FEEDING PERIOD.	Feed.	Hay or Straw.	Water.	lbs.	ozs.	Babcock.	Gravimetric.	Beginning.	Closing.	Gain or Loss.
1. Wheat bran and lucerne......	6	21.1	99.3	21	8	4.00	4.73	750	857	107
2. Linseed oil meal, some bran and lucerne	Bran 1.4 Oil m. 2.1	20.8	94.2	20	4	4.62	4.86	857	848	—9
3. Lin. oil meal and oat straw..	4.4	7.1	52.1	15	3	5.12	5.20	848	800	—48
4. Wheat bran and oat straw....	6	11.3	62.6	14	9	4.47	5.20	800	792	—8
5. Wheat bran and lucerne......	8.1	14.1	76.4	15	10	4.38	4.83	792	848	50
6. Indian corn meal and lucerne	6.4	19.6	75.6	17	15	4.27	4.36	848	826	—22
7. Wheat bran and lucerne......	10.5	15.4	102.3	18	5	4.42	4.85	826	830	4
8. Indian corn meal and lucerne	9	18.6	84.7	19	15	4.32	4.20	830	838	8

No. 6—Pride of the Rockies, Jersey, age 4 years; last calf, September, 1891.

FEEDING PERIOD.	Feed.	Hay or Straw.	Water.	lbs.	ozs.	Babcock.	Gravimetric.	Beginning.	Closing.	Gain or Loss.
1. Wheat bran and lucerne.....	6	20.8	98.6	14	13	4.14	4.43	815	899	84
2. Wheat bran and lucerne......	6	20.1	96.6	15	1	4.45	4.86	899	892	—7
3. Wheat bran and oat straw....	6	8.6	62.7	13	2	4.68	4.80	892	886	—6
4. Lin. oil meal and oat straw..	3.9	14.6	81.9	12	11	4.70	4.90	886	862	—24
5. Wheat bran and lucerne......	8.7	19.4	92	13	13	4.46	4.43	862	910	48
6. Wheat bran and lucerne......	10.5	16.5	94.6	15	1	4.40	4.78	910	888	—22
7. Indian corn meal and lucerne	7.3	16.5	85.8	15	5	4.03	3.85	888	886	—2
8. Indian corn meal and lucerne	9	17.2	87.3	15	14	4.02	3.60	886	898	12