

**Eleventh Annual Report**  
of  
**The Agricultural Experiment Station**  
of  
**Colorado**

**For the Year 1898.**

**Home Station,  
Fort Collins, Colorado,  
December 14, 1898.**

# The Agricultural Experiment Station,

Fort Collins, Colorado.



BOARD OF CONTROL:  
The State Board of Agriculture.



## EXECUTIVE COMMITTEE IN CHARGE:

A. L. KELLOGG, *Chairman*,  
Rocky Ford,  
ALSTON ELLIS, JOHN J. RYAN,  
Fort Collins, Fort Collins,  
P. F. SHARP, B. F. ROCKAFELLOW,  
Denver, Canon City.

## STATION COUNCIL.

Alston Ellis, A. M., Ph. D., LL. D. . . . . President and Director.  
W. W. Cooke, B. S., M. A. . . . . Agriculturist.  
C. S. Crandall, M. S. . . . . Horticulturist and Botanist.  
W. P. Headden, A. M., Ph. D. . . . . Chemist.  
L. G. Carpenter, M. S. . . . . Meteorologist and Irrigation Engineer.  
C. P. Gillette, M. S. . . . . Entomologist.  
J. E. DuBois . . . . . Secretary.  
F. H. Thompson, B. S., Stenographer.

## ASSISTANTS.

F. L. Watrous . . . . . Agriculturist.  
Carl H. Potter, B. S. . . . . Horticulturist.  
Louis A. Test, B. M. E., A. C. . . . . Chemist.  
Fred Alford, B. S. . . . . Chemist.  
John E. Kiteley, B. S. . . . . Chemist.  
R. E. Trimble, B. S. . . . . Meteorologist and Irrigation Engineer.  
E. D. Ball, B. S. . . . . Entomologist.

## SUB-STATIONS.

Harvey H. Griffin, B. S. . . . . Superintendent.  
Arkansas Valley Experiment Station, Rocky Ford, Colorado.  
J. E. Payne, M. S. . . . . Superintendent.  
Rainbelt Experiment Station, Cheyenne Wells, Colorado.

# The State Experiment Station.



SECRETARY'S FINANCIAL STATEMENT OF THE EXPERIMENT  
STATION FUND FOR THE FISCAL YEAR ENDING JUNE 30,  
1898.

<i>Receipts—</i>	<i>United States.</i>	<i>College.</i>	<i>Total.</i>
United States Treasurer.....	\$15,000.00	.....	\$15,000.00
Balance June 30, 1897.....	.....	\$1,938.89	1,938.89
Farm Products.....	.....	730.69	730.69
Total .....	\$15,000.00	\$2,669.58	\$17,669.58
<i>Expenditures—</i>	<i>United States.</i>	<i>College.</i>	<i>Total.</i>
Salaries .....	\$ 9,601.82	\$ 562.43	\$10,164.25
Labor .....	2,223.28	265.92	2,489.20
Publications .....	1,206.45	285.30	1,491.75
Postage and Stationery.....	77.50	.....	77.50
Freight and Express.....	24.75	.....	24.75
Heat, Light, and Water.....	1.25	.....	1.25
Chemical Supplies.....	.....	.....	.....
Seeds, Plants, and Sundry Supplies	259.41	6.00	265.41
Fertilizers .....	104.02	2.40	106.42
Feeding Stuffs.....	76.53	358.65	435.18
Library .....	.....	.....	.....
Tools, Implements, and Machinery..	101.06	.....	101.03
Furniture and Fixtures.....	.....	.....	.....
Scientific Apparatus.....	343.41	87.66	431.07
Live-Stock .....	36.00	.....	36.00
Traveling Expenses.....	806.40	467.30	1,273.70
Contingent Expenses.....	10.00	.....	10.00
Buildings and Repairs.....	128.12	.....	128.12
Balance .....	.....	633.92	633.92
Total .....	\$15,000.00	\$2,669.58	\$17,669.58

## Letter of Transmittal.



HON. ALVA ADAMS,  
*Governor of Colorado.*

Sir—I have the honor to present herewith the Eleventh Annual Report of the Agricultural Experiment Station which, by the terms of Congressional and State legislation, is one of the departments of THE STATE AGRICULTURAL COLLEGE of Colorado.

Both College and Station are under the direct control of The State Board of Agriculture, some of whose employes give time and effort to both College and Station work.

Two sub-stations are maintained by the use of a part of the Government fund provided for in the "Hatch Act" of 1887. Such use of said fund is unauthorized by the law, but it has been thought best "to stretch the law" a little rather than wholly to abandon the work in which the people in two important districts of the State are so deeply interested. There is faint hope yet that the Legislature, realizing how vitally concerned are our farming communities in sub-station experimentation, will furnish the financial support necessary to render it permanent and of increasing utility.

Irrigation surveys in at least two important valleys of the State and wide-reaching experiments in the growing of sugar-beets, have profitably engaged the time of some of our station workers. All scheduled lines of ex-

perimental work have been followed out with painstaking effort put forth systematically.

Forming interesting and valuable parts of the matter herein presented for your consideration, are the reports of the different members of the Station Council and those of the Superintendents of the Rainbelt Station, at Cheyenne Wells, and the Arkansas Valley Station, at Rocky Ford.

Respectfully submitted,

ALSTON ELLIS,

Director of the Agricultural Experiment Station of  
Colorado.

Fort Collins, Colorado, December 14, 1898.

## Report of the Director.



*To the Executive Committee of The State Board of Agriculture:*

Gentlemen—Station work has been more successfully prosecuted within the last year than ever before. It is very fortunate for us that changes in the Board of Control and the station working force are not frequent. There has not been a change in the *personnel* of the Station Council for a number of years. Even the labor force has a permanency that adds greatly to the efficiency of the service by which planned work is carried into execution.

A sum in excess of eleven hundred million dollars is expended annually for the support of experiment stations in the United States. About one-fourth of this sum comes from state appropriations; the rest is provided for by drafts upon the Treasury of the Government under the terms of the "Hatch Act" of 1887. It is a significant fact that Colorado has never appropriated any money for experiment station support. The substation at Cheyenne Wells was put in operation by the economic use of a state appropriation of \$2,500, but the support of that station, for the four years of its existence, has been at no cost to the State.

Drafts upon the experiment station fund have been made in strict compliance with the letter and spirit of the law. No part of college support is secured at the expense of this fund. All ordinary farm operations, as well as many of a wholly experimental nature, are car-

ried on at college expense. The salaries of employes whose service is in any way connected with both College and Station are so adjusted as financially to strengthen the latter at the expense of the former.

Our principal lines of station work, pursued without material deviation ever since that work was entered upon, are as follows: Chemistry, field experiments, meteorology, botany, horticulture, entomology, and irrigation. About two years ago, garden experiments were discontinued. I hope to see provision made for some garden work in future schedules. \*

There is a growing demand that our experimentation in the interest of dairying be made more far-reaching. Dairymen have just reason to ask that their interests be not overlooked in the station work paid for out of the government fund. The act creating that fund contains provisions in which experimental work closely connected with the dairy interests of the country is plainly suggested. Original researches on the physiology of animals, the diseases to which they are subject and remedies therefor, are provided for. The experimental work outlined in the "Hatch Act" includes consideration of "the composition and digestibility of the different kinds of food for domestic animals" and "the scientific and economic questions involved in the production of butter and cheese." We have not the *best* conditions for carrying out the investigations referred to in the language quoted. Our present facilities for prosecuting these investigations could be added to at no great expense; and that course is suggested by the rapidly increasing interests that would be favorably affected by its adoption. Some qualified to make suggestion assert that if the conduct of a station be put on a *business basis*, the dairy can be made efficient as an experimental agent and partially self-sustaining at the same time. The dairy interests of Colorado are now large and annually growing in importance. The alfalfa districts of the State, as they may be termed, are peculiarly fitted for the profitable handling of dairy herds. The products of such herds will

find a constantly increasing market-area when their excellent character is more widely advertised. An editorial writer in a recent issue of "The Western Creamery," published in San Francisco, expresses the opinion that "an era of great faith in dairying" is at hand. His description of some conditions favorable to the dairy industry in California might be applied with equal force to those now existing in many parts of Colorado. In referring to the superior dairy products coming from the alfalfa districts of California, he says:—

"Until 1897 it was commonly believed that alfalfa would not make good butter, but when ten California tubs of butter were sent to the National exhibit at Owatonna and alfalfa secured the highest score of the lot, it dawned upon our people that they might be mistaken. When again, at Topeka, the alfalfa butter secured the highest score of the four tubs sent from California, an impression was made upon the trade and, with the intrinsic merit of such goods to sustain the reputation there gained, alfalfa butter has since stood in the first place in our markets."

The recent action of the Executive Committee in authorizing the feeding of a small "bunch" of yearling calves, at the sub-station at Rocky Ford, is in line with the thought that prompts me to say what I have said on dairying.

Within the last two years appropriations amounting to \$1,350 have been made for the prosecution of irrigation surveys in the San Luis and Arkansas valleys. Measurements of the Arkansas river are now in progress. Prof. L. G. Carpenter, Irrigation Engineer, has direction of the work.

Experiments in the growing of sugar-beets have been made in various parts of the State. The plans for this work were perfected by Prof. W. W. Cooke, head of the Agricultural Section, and the Station Chemist, Dr. William P. Headden. All this work was but the continuation of effort begun nearly a dozen years ago. The results, as they are seen at present, may be thus summarized. Under average conditions, from 14 to 16 tons



of sugar-beets can be raised on one acre of land; their sugar content will be from 12 1/2 to 13 per cent.; and their purity will be represented by a per cent. ranging from 75 to 78.

These wide-reaching experiments have entailed upon at least two of our station workers a vast amount of labor and have been prosecuted at no slight expense to the experiment station fund. They were undertaken to show the adaptability of our soil for growing sugar-beets in amount and quality to justify capitalists in building beet-sugar factories in Colorado. The results already secured make it clear that all phases of the sugar-beet industry can be made profitable when labor and capital unite for their development. In view of what has already been accomplished—the facts now pretty definitely established—it may well be considered whether further experimental work, along the lines so well wrought out heretofore, shall be undertaken by the Station in the near future.

The work of the Entomological Section, directed by Prof. C. P. Gillette, has been, principally, an investigation of the value of different methods of destroying the codling moth, an examination of grasshopper depredations in certain localities, and a continuation of apiary investigations. The continuation of a systematic test of varieties of orchard and small fruits, has engaged a large part of the time, available for station work, of Prof. C. S. Crandall, Station Horticulturist.

We are frequently called upon for statements showing in what manner our station investigations have proved of practical benefit to the farmers of the State. Station work in Colorado has been systematically carried on ever since the "Hatch Act" made an experiment station a college department. Even before the provisions of that act were made operative, much experimental work had been intelligently planned and successfully executed. To meet with question regarding the value of the work done in the past, and that planned for the future, is to be expected. A reference to our numerous bul-

letin publications furnishes strong testimony of the far-reaching efficacy of what has been already accomplished by the well-directed efforts of our station workers.

Not long since I received a letter containing a number of inquiries regarding the *practical* results secured by our station workers in the carrying out of their investigations and researches. Some of these queries are worthy of more than a passing notice and, for that reason, are herewith given:—

1. What are the special lines of work which the Colorado station is trying to follow, and what has been the success of the work?

2. What special discoveries, if any, of scientific or practical value have been made by workers of the station?

3. Has the station discovered, or been active in introducing any system, method, process, remedy, variety, or other principle which has been of marked value?

4. Has any publication of the station been of special importance or excited special criticism?

It would require much space and no little thought to give full and satisfactory replies to such inquiries as these. They are not made by an *outsider*, but by one closely and practically identified with station work. They are suggestive of some things that the station employé should keep steadily in mind in the prosecution of his work.

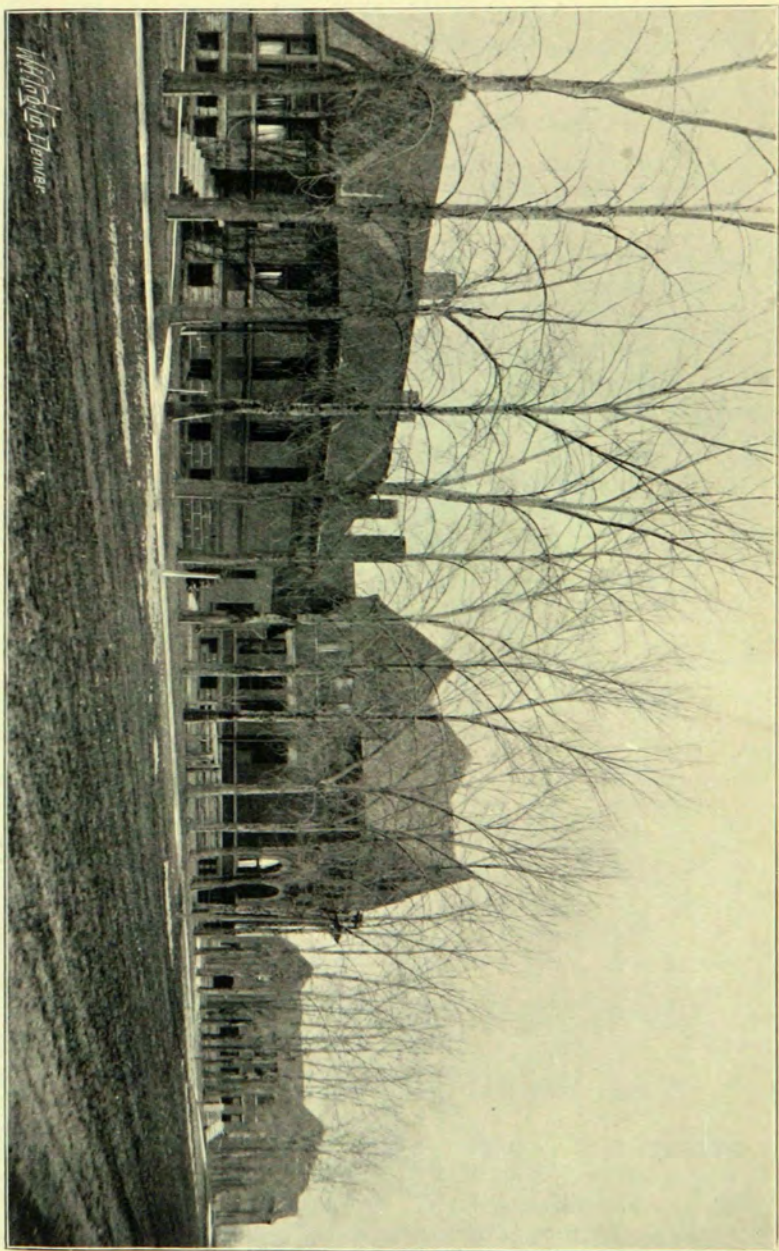
Our station work, in its plan and execution, has met with the *general* approval of the authorities at Washington. In some not essential particulars that work has been criticised, perhaps justly. In so far as criticism is based upon observations made in one hasty station visit, by an official, there is ground for questioning its justness and value. Things are not the same at all times, and broad generalizations are not warranted by one hasty and, necessarily, superficial examination.

In a letter to me, under date of September 27, 1898, Dr. True, of the Government Office of Experiment Stations, writes as follows:—

"In looking over the accounts of the work of your station, during the past year, which have been received here, including the report of Dr. Allen on his visit to the station at Fort Collins and the sub-station at Rocky Ford last spring, I am impressed with the increasing value and importance of the work which your station is doing. I am particularly glad to see that not only the irrigation engineer is making successful studies of the irrigation problems, but that other officers are also beginning studies having vital relation to the successful development of farming in Colorado under irrigation. As you know, I spent some time last summer in the irrigated region west of the Mississippi and I am more than ever convinced that your station, with others, has a great opportunity for work of a high scientific and practical value by devoting itself to studies of problems directly connected with irrigation farming. There is work here for the chemist, botanist, horticulturist, agriculturist, and experts in a number of other different lines as well as for the irrigation engineer. I hope it may be possible for your station to develop this work more largely in the future and that Congress will put this Department in a position to give you financial assistance. Arrangements have already been made to utilize the investigations of your irrigation engineer in connection with the work on irrigation which the Department is attempting this year. It will be our policy to cooperate most largely with those stations which are doing the most to help themselves in this line of work."

The same official, in his annual report for the year ended June 30, 1897, speaks of our station work in the language herewith quoted:—

"The work of the Colorado station is being strengthened and developed along lines of great usefulness to a wide region of the West. The importance and value of thorough experimental inquiries in behalf of agriculture is being more fully appreciated by the managers of the station and by the agricultural public of the State. When once the station is relieved of the expensive and wasteful burden imposed by the sub-stations, it will undoubtedly be able to do still better service through cooperative and other enterprises affecting the vital interests of the agriculture of the entire State."



SOME COLLEGE BUILDINGS—NORTH FRONT, LAUREL STREET.

**STATION EMPLOYEES, 1898-1899.**

HEREWITH ARE GIVEN THE NAMES OF ALL PERSONS REGULARLY CONNECTED WITH STATION WORK, THE POSITIONS FILLED, AND THE SALARIES RECEIVED.

<i>Home Station—</i>	Annual Salaries from
Names and Positions.	Station Fund.
Alston Ellis, Director.....	\$ 900.00
W. W. Cooke, Agriculturist.....	500.00
C. S. Crandall, Horticulturist.....	500.00
Wm. P. Headden, Chemist.....	500.00
C. P. Gillette, Entomologist.....	500.00
L. G. Carpenter, Meteorologist and Irrigation Engineer .....	500.00
J. E. DuBois, Secretary Executive Committee and Station Council.....	500.00

**ASSISTANTS.**

Frank L. Watrous, Agriculture.....	\$1,000.00
Carl H. Potter, Horticulture.....	700.00
Louis A. Test, Chemistry.....	900.00
Elmer D. Ball, Entomology.....	900.00
Robert E. Trimble, Meteorology.....	900.00
Fred Alford, Chemistry.....	540.00
John E. Kiteley, Chemistry.....	540.00

*Sub-Station Superintendents—*

Harvey H. Griffin, Rocky Ford.....	\$ 900.00	
J. E. Payne, Cheyenne Wells.....	800.00	\$11,080.00

The yearly expense for labor is about \$2,500.00.

**OUTLINES OF STATION WORK FOR 1898.**

At a meeting of the Station Council, held January 25, the schedules of station work for the year were presented, revised, and adopted. These schedules were subsequently—January 28—adopted at a regular monthly meeting of the Executive Committee. The outlines of

experimental work for the different sections of the Home Station and for the sub-stations, located at Rocky Ford and Cheyenne Wells, are herewith given:—

AGRICULTURAL SECTION.

*Spring Lambs:*—

A continuation of the third year of the experiment, selling both the lambs and the ewes, closing up the experiment and making a bulletin report to be accompanied by notes on the raising of lambs on alfalfa and pasture, for which purpose twelve ewes were purchased last fall.

*Ensilage:*—

A continuation of the fourth year of the experiment, closing up the tests to be made with reference to sheep, cattle, and dairy cows, and making bulletin report of the whole subject as related to Colorado conditions.

*Sugar Beets:*—

The work in this connection to be done in coöperation with the Chemical Section, tests of seed grown in the United States as compared with that grown in Europe, tests of the effect of alkali, early and late thinning, early and late planting, medium and late irrigation, manured and unmanured land, and alfalfa sod; all these tests to be made at Fort Collins and Rocky Ford, and part of them at fourteen other places distributed in the valleys of the Platte, Arkausas, Grand, Gunnison, and on the Divide and in the San Luis Valley.

*Bromus Inermis:*—

Tests for hay, pasture, and seed, with and without irrigation, especially with reference to fall seeding.

*Alfalfa:*—

The continuation of the tests of top dressing, with duplicate tests of plowing-in stable manure; duplication of the tests of the past season on the losses of alfalfa in the stack and in the mow, and on the effect of different

times of cutting alfalfa; a test of a new variety of alfalfa as compared with the common variety, to be made at Fort Collins and Rocky Ford, and if possible, at several other places.

*Corn:*—

A continuation of the second year of a three years' test on the value of seed from different climates.

*Winter Wheat:*—

A test of its use as fall pasture for sheep when sown after barley.

*Gypsum:*—

A test as a top dressing on alfalfa, as plowed in for cereals and corn, and as an addition to stable manure, in our third year of the test for the reclamation of "poverty weed" land.

*Digestion Experiments:*—

In connection with the Chemical Section, it is especially desired to make some digestion experiments with sheep with reference to Dr. Headden's new method for determining the feeding value of fodders by chemical analysis. The animals necessary for the experiments are already on hand. It will probably take about \$75.00 to buy the necessary apparatus for performing the experiments and for fixing up the stalls to make them suitable for carrying on these lines of experimentation.

SECTION OF BOTANY AND HORTICULTURE.

I. The study of the Flora of the State, special attention being given to:

1. The weeds of the farm and garden.
2. Grasses, native and introduced.
3. The various species and varieties of the genera *Oxytropis* and *Astragalus*.

II. The further introduction to the garden of such wild fruits as can be obtained.

III. Nursery test of orchard fruits with a view to the study of the adaptability of varieties to this climate.

IV. Tests of varieties of small fruits.

V. Coöperative work with the Division of Forestry of the United States Department of Agriculture.

#### SECTION OF METEOROLOGY AND IRRIGATION ENGINEERING.

I. Meteorology—To continue observations as hitherto. This includes observation and record of the data bearing on agricultural meteorology; average maximum and minimum temperatures; range; solar radiation; terrestrial radiation; rainfall and humidity observations; barometer, wind, amount, direction, etc.; and amount and intensity of sunshine. This also includes observations by various voluntary observers and at the sub-stations. To make these of most value, the stations should be visited to examine the exposure of the meteorological instruments.

II. Evaporation determinations—The continuation of that from waters, and study of evaporation from soils and vegetation.

III. Soil moisture.

\*IV. Soil temperatures.

V. Continuation of examination of irrigation questions of the State—The subirrigation question of the San Luis Valley was not completed last year. The correspondence now in progress may enable its completion without taking it up as a topic for the summer. I think it is desirable to enter upon a study of the questions of the Arkansas Valley.

VI. Seepage measurements in the State—On the Arkansas and on some other streams.

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\*Note—In some lines there is enough accumulation of data to make it possible to obtain useful results from their careful study. As time permits, it is intended to take up some of these questions.



ENTOMOLOGICAL SECTION.

I. Collecting and rearing insects for the purpose of determining food-habits and life-histories.

II. Experiments for the destruction of insect eggs.

III. The beginning of work looking to an Orthopterological survey of the State.

IV. Testing insecticides.

V. Experiments to determine the value of the bandage system of combatting the Codling Moth.

VI. Experiments for the destruction of miscellaneous insect pests.

VII. Experiments in the Apiary:

1. To determine the value of sugar for winter stores.
2. Testing apiary appliances.
3. Making a collection and list of honey-producing and pollen-producing plants with notes as to their probable value.
4. Experiments to determine the nature of and remedy for the disease known as "Bee Paralysis."

CHEMICAL SECTION.

I. Continuation of the soil study already begun, including a study of the effect of cropping alkali soil to sugar beets, as outlined last year.

II. Coöperation with the Farm Department in the study of the sugar beet problems in Colorado, including the subjects of the influence of the seed upon the date of maturing, effect of manuring, etc.

III. Animal digestion experiments in coöperation with the Farm Department—a continuation of the study

presented in Bulletin No. 39. This will entail an expenditure of about \$75.00 by the Department of Chemistry.

Note—The miscellaneous work is not considered in this schedule. This character of work has increased very greatly during the past year.

#### ARKANSAS VALLEY EXPERIMENT SUB-STATION.

Rocky Ford, Colorado.

#### CEREALS:—

1. Wheat—A comparative test of varieties begun last season. A half acre plat each to Turkey, Clawson, Red Russian, and one-tenth acre to Canadian Velvet Chaff. One-tenth acre each of six varieties of Russian wheat furnished by the Department of Agriculture, Washington, D. C.

2. Rye—Four acres of Mammoth Spring rye; more clearly, Polish wheat.

3. Corn—(a) Test on culture. Cultivation *versus* irrigation, and how much and when best to apply each. This is the second year of a continuous test begun last season, with a slight change in the original plans, so that those portions of the field which are to receive only one or two irrigations shall not be given any water until the corn shows signs of decided need of moisture.

(b) Corn on alfalfa sod. To show how long the effects of alfalfa will last. This will be the third year of the test. The variety, Golden Beauty, will be used on a plat of four acres.

#### GRASSES:—

1. The establishing of test grass plats and plats of different kinds of forage crops, with tests of annual forage crops, to take the place of those drowned out the past season; the different grasses, cereals, and forage crops to be sown in single or double rows. The entire area to be limited to one-fourth of an acre.

2. Alfalfa—A test to discover if anything can be gained by planting alfalfa, in such shape as to give light

cultivation and subirrigation, where intended to produce seed; the tests to be made on an area not exceeding one-fourth of an acre.

GARDEN DIVISION.

VEGETABLES:—

A test of varieties with notes on irrigation and cultivation; to be restricted to what is needed for immediate use on the farm and for exhibition purposes.

1. Celery—To experiment with varieties and methods of growing and bleaching, on an area of two square rods.

2. Potatoes—One-half acre devoted to experiments on two varieties on the different methods of planting, culture, and irrigation.

3. Sugar Beets—One-eighth of an acre grown as a duplicate test of the experiments made at the Home Station at Fort Collins.

HORTICULTURAL DIVISION.

OLD ORCHARD:—

Observations on the amount and date of first bloom of varieties, and of the setting of fruit, and of yields. Observations of the blight and its effects on different kinds of apples and pears. The replanting of places where trees have been killed out by blight.

NEW ORCHARD:—

The vacancies in the orchard set out in 1896, caused by the dying of the trees, are to be replaced by new trees of the same varieties, but the live trees to remain in their present places. A few conifers from the Department of Agriculture, at Washington, are to be set in connection with the deciduous trees, as far as it can be done without materially increasing the labor of cultivation. The remaining 4 1-2 acres of the original ten acres set apart for the orchard, are to be set out to new varieties as far as means at hand, at this time, for this purpose, will permit.

## FORESTRY AND ORNAMENTAL TREES:—

The planting of elms along one side of the lane which runs through the Station, and the planting of elm, catalpa, locust, ash, and other ornamental and nut trees around the 80 acres devoted to experimental work as far as means may be on hand for this purpose.

## ENTOMOLOGICAL DIVISION.

Observations on injurious insects in connection with the Entomological Department of the Home Station. Spraying and other remedies on orchard and garden crops when affected with insects. Special observations and notes on the strawberry leaf-roller.

## METEOROLOGICAL DIVISION.

A continuation of the meteorological records that have usually been kept at the Station.

## FERTILIZERS.

Experiments with decomposed gypsum as a top dressing on three acres of land which received too much water last season. This land has been covered lately with manure, and the intention is to apply the gypsum at the rate of 500 pounds per acre in strips with alternate spaces left with nothing but the stable manure.

The remainder of the station land, not included in the leased land, to be used in growing such general farm crops as, in the judgment of the Superintendent, will be of most value.

## RAINBELT EXPERIMENT SUB-STATION.

Cheyenne Wells, Colorado.

## CAMPBELL PROCESS TEST.

## I. Spring of 1898—

- (a) Potatoes,.....1.2 acre.
- (b) Spring wheat,.....1 acre.
- (c) Spring rye,.....1 acre.

- (d) Oats,.....1 acre.
- (e) Barley,.....1 acre.
- (f) Corn,.....4 acres.
- (g) Sorghum.....1 1-2 acres.
- Total.....10 acres.

In each case the land is to include the part that is under the Campbell method and the check plats under ordinary cultivation; i. e., the ten acres to be about three quarters Campbell and one quarter common culture.

II. Autumn of 1898—Fall wheat, two acres selected varieties, one-half the land to be by Campbell method and the other half a check by common method.

Variety tests of grasses, cereals, and forage crops to be reduced to double rows and included in the ten acres of the Campbell test.

III. Vegetable tests to be made on a small scale and not included in the ten acres, but as far as possible made by the Campbell methods.

IV. The remainder of the farm to be devoted to forage grains, such as California barley, millet, and bromus inermis, with at least three acres devoted to a test of decomposed gypsum, at the rate of 500 and 1,000 pounds per acre.

V. Scientific work—

- (a) Test effect of wind-break on soil moisture at different distances from the wind-break.
- (b) Test rate of evaporation from four types of soil found here.
- (c) Test evaporation from water surface in shade and sun.
- (d) Continued examination of the soil of the Station which was begun in 1896.
- (e) Test effect of the Campbell method on soil moisture.
- (f) Observations on meteorology to be continued.

## STATION PUBLICATIONS.

Within the year covered by this report, nine bulletins have been issued. The total number of bulletins is now forty-nine. A list of these publications is here-with given:—

<i>No.</i>	<i>Subjects.</i>	<i>Authors.</i>
1.	Reports of Experiments in Irrigation and Meteorology.....	Elwood Mead
2.	Report of Experiments with Grains, Grasses, and Vegetables on the College Farm .....	A. E. Blount
3.	Concerning the Duties of the Secretary of The State Board of Agriculture, and Distribution of Seeds.....	Frank J. Annis
4.	Report of Experiments with Potatoes and Tobacco.....	James Cassidy
5.	Experiments in the Apiary.....	C. M. Brose
6.	Notes on Insects and Insecticides.....	James Cassidy
7.	Potatoes and Sugar Beets.....	{ .....James Cassidy .....David O'Brine
8.	Alfalfa: Its Growth, Composition, and Digestibility.....	{ .....David O'Brine .....James Cassidy
9.	Soils and Alkali.....	David O'Brine
10.	Tobacco .....	{ .....David O'Brine .....James Cassidy
11.	Sugar Beets.....	{ .....C. L. Ingersoll .....David O'Brine
12.	Some Colorado Grasses and Their Chemical Analysis.....	{ .....James Cassidy .....David O'Brine
13.	On the Measurement and Division of Water .....	L. G. Carpenter
14.	Progress Bulletin on Sugar Beets.....	David O'Brine
15.	The Codling Moth and the Grape-Vine Leaf-Hopper .....	C. P. Gillette

<i>No.</i>	<i>Subjects.</i>	<i>Authors.</i>	
16.	The Artesian Wells of Colorado and Their Relation to Irrigation.....	L. G. Carpenter	
17.	A Preliminary Report on the Fruit Interests of the State.....	C. S. Crandall	
18.	Index Bulletin.....	W. J. Quick	
	Special Bulletin "A" Concerning Subjects Investigated by the Experiment Station .....		
19.	Observations upon Injurious Insects, Season of 1891.....	C. P. Gillette	
20.	{ I. The Best Milk Tester for the Practical Use of the Farmer and Dairyman..... }	..... W. J. Quick	
			{ II. The Influence of Food upon the Pure Fat Present in Milk..... }
21.	{ I. Sugar Beets..... }	..... F. L. Watrous	
			{ II. Irish Potatoes..... }
			{ III. Fruit Raising..... }
22.	A Preliminary Report on the Duty of Water .....	L. G. Carpenter	
23.	Colorado Weeds.....	C. S. Crandall	
24.	A Few Common Insect Pests.....	C. P. Gillette	
25.	Progress Bulletin on the Loco and Larkspur .....	David O'Brine	
26.	{ Garden Notes for 1893..... }	{ Marion J. Huffington } { ..... C. S. Crandall }	
			{ Farm Notes for 1893..... }
		{ Seeding, Tillage, and Irrigation..... }	Fred. Huntley
27.	The Measurement and Division of Water. (Third Edition, Revised, of Bulletin No. 13).....	L. G. Carpenter	
28.	The Russian Thistle.....	C. S. Crandall	
29.	Strawberries and Grapes: Notes on Varieties .....	Marion J. Huffington	

<i>No.</i>	<i>Subjects.</i>	<i>Authors.</i>
30.	I. Farm Notes for 1894.....	{ .....W. W. Cooke
	II. Notes on Tomatoes.....	{ .....Frank L. Watrous
31.	Hemiptera of Colorado. (Technical Series, No. 1).....	{ .....C. P. Gillette .....Carl F. Baker
32.	Sheep Feeding in Colorado.....	W. W. Cooke
33.	Seepage or Return Waters from Irrigation .....	L. G. Carpenter
34.	Cattle Feeding in Colorado.....	W. W. Cooke
35.	Alfalfa .....	Wm. P. Headden
36.	Sugar Beets .....	{ .....W. W. Cooke
		{ .....Wm. P. Headden
37.	The Birds of Colorado. (Technical Series, No. 2).....	W. W. Cooke
38.	I. Sheep Scab.....	{ .....C. P. Gillette
	II. A Few Insect Enemies of the Orchard .....	
39.	A Study of Alfalfa and Some other Hays .....	Wm. P. Headden
40.	Barley .....	W. W. Cooke
41.	Blight and Other Plant Diseases.....	C. S. Crandall
42.	Sugar Beets in Colorado in 1897.....	{ .....W. W. Cooke
		{ .....Wm. P. Headden
43.	I. Colorado Lepidoptera.....	{ .....C. P. Gillette
	II. A Few New Species of Deltocephalus and Athysanus from Colorado .....	
	III. A List of Original Types, etc., in Collection. (Technical Series, No. 3).....	
44.	Further Notes on the Birds of Colorado. (Technical Series, No. 4).....	W. W. Cooke
45.	The Loss of Water from Reservoirs by Seepage and Evaporation.....	L. G. Carpenter
46.	A Soil Study, Part I. The Crop Grown: Sugar Beets.....	Wm. P. Headden



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47. Colorado's Worst Insect Pests and their Remedies .....C. P. Gillette
48. Losses from Canals from Filtration or Seepage .....L. G. Carpenter
49. Meteorology of 1897, with Illustrations ..... { .....L. G. Carpenter  
 .....R. E. Trimble

The cost of the station publications issued since the last report is herewith given. The number of copies of each and the pages of matter therein contained are likewise shown.

I.	1,500 copies Tenth Annual Report, 110 pages, with cover.....		\$ 119.84
II.	6,000 copies Bulletin No. 41, 22 pages....		77.44
III.	7,000 copies Bulletin No. 42, 64 pages....		286.39
IV.	2,000 copies bulletin No. 43, (Technical Series, No. 3,) 32 pages.....	\$ 92.50	
	Electrotypes .....	2.30	94.80
V.	2,000 copies Bulletin No. 44, (Technical Series, No. 4,) 32 pages.....		66.00
VI.	6,000 copies Bulletin No. 45, 32 pages....	\$132.00	
	Electrotype .....	1.00	133.00
VII.	6,000 copies Bulletin No. 46, 64 pages....		255.00
VIII.	6,000 copies Bulletin No. 47, 65 pages....	\$227.50	
	Six (6) pages half-tone work.....	36.00	
	Six (6) pages half-tone cuts.....	21.80	
	Electrotypes .....	15.64	300.94
IX.	6,000 copies Bulletin No. 48, 36 pages....		161.25
X.	6,000 copies Bulletin No. 49, 72 pages....	\$252.00	
	Thirty-five (35) pages tables, \$2 per page, extra.....	70.00	
	Two (2) pages brevier, extra.....	1.70	
	Electrotypes .....	3.30	327.00
	Total .....		\$1,821.66

**THE SUB-STATIONS.**

The condition of sub-station management is that which existed at the time of the last report. The future of these auxiliaries of the Home Station is as unsettled now as it ever was. A modest state appropriation for their maintenance would insure their permanency and usefulness. As long as the burden of their support falls upon the Government fund the question of their continuance is one of anxiety and uncertainty.

In speaking of station work in Colorado, Dr. True, in his annual report, from which quotation has already been made, says:—

“The sub-stations at Cheyenne Wells and Rocky Ford have been continued, but under unsatisfactory conditions. The work at Cheyenne Wells, considered as a temporary enterprise to determine the agricultural possibilities of the locality, may prove of some value, but no good reason has been assigned for a permanent sub-station there. The sub-station at Rocky Ford has suffered the usual vicissitudes attending the prosecution of station work under ill-trained superintendents, and is clearly an expensive venture without important results.”

In Dr. True's letter, before referred to, is found the following language:—

“Dr. Allen's inspection of the sub-station at Rocky Ford did not satisfy us that it had been properly managed. While there are good features about the work in progress there, there have been so many changes in the management and the records have been kept in such an incomplete and unintelligible form that it seems to us that the money spent there has been very largely wasted. I hope no effort will be spared to secure state aid to put these sub-stations on a substantial basis and permit the entire withdrawal of the Hatch fund from them. Otherwise I think definite steps should be taken to abandon them. This has been done in nearly all the states where sub-stations existed at the expense of the Hatch fund.”

Dr. True's strictures upon the station work at the existing sub-stations, and his suggestions as to their fut-

ure disposition, are, in the main, warranted; but no one with only the knowledge of the conditions under which our sub-station work is conducted secured by hurried visits, few and far between, can be in a position to speak with high authority on the subjects of sub-station efficiency and sub-station continuance.

*The Arkansas Valley Experiment Station*—Conditions have not been favorable for securing desirable results. Three different persons have been in charge of the work of the station within a year.

W. Frank Crowley was, June 29, 1897, appointed Superintendent of the station and at once entered upon the duties of the position. His work was satisfactory and gave promise of good results. On February 10, 1898, the following communication, from Mr. Crowley, was received by the Executive Committee:—

“Honorable Sirs:—I have to-day telegraphed you my resignation as Superintendent of the Arkansas Valley Station and I further write to explain my action.”

“I have resigned the position in order to establish an experimental fruit farm near Holly, Colorado. I consider that I can do more good for the horticultural interests of the Arkansas Valley by this move. I shall be glad to cooperate with the State Experiment Station in every way possible.”

“The move will also, I think, better my condition financially and otherwise. I desire to move as soon as possible and shall be glad to have you put a man in this place by the first of March, or sooner. I shall endeavor to make the proposed improvements which I have begun on the station property before leaving.”

“Thanking your Honorable Body for past consideration, I remain,

Yours truly,  
W. FRANK CROWLEY.”

The resignation was duly accepted, and an election to fill the vacancy thus created resulted in the unanimous choice of Harvey H. Griffin, at an annual salary of \$900. Mr. Griffin graduated from The State Agricultural College of Colorado in 1888. From that time until now, he has been actively engaged in station work. He assumed charge of the sub-station at Rocky Ford, March 1, 1898, and at once began intelligently and vigorously

the carrying out of the season's work as scheduled prior to his appointment. His first year's work promised well, but in the very midst of the growing season came a destructive hailstorm that made havoc of many of the experiments from which such desirable outcome was confidently expected. I am confident that, under usual conditions, the future work of the station will meet the reasonable expectations of the public.

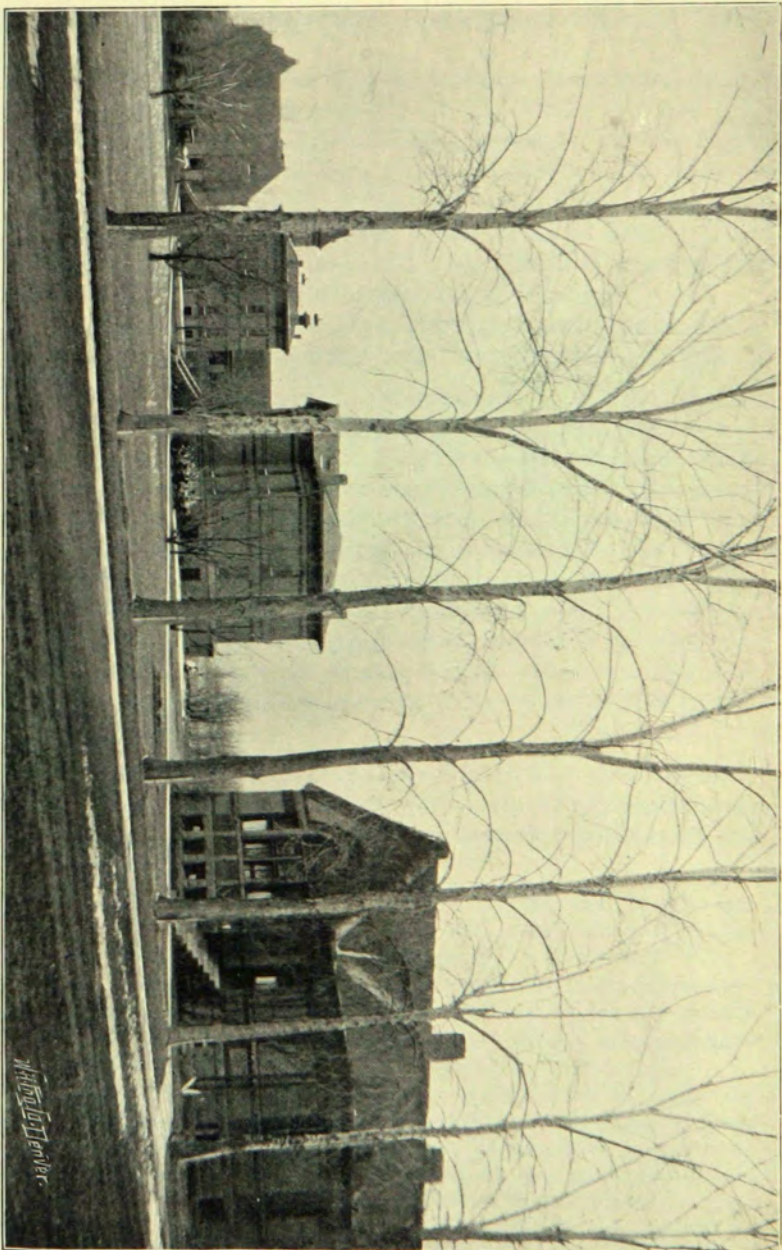
A part of the land belonging to the station has been leased, as the total acreage was not needed for the proper carrying on of the scheduled station work. At a meeting of the Executive Committee, held August 30, 1898, Chairman Kellogg was authorized to re-lease the land, unused by the station, to Francis Harson.

For the year, closed June 30, 1898, the expenditures were as follows:—

Superintendent's salary.....	\$333.33
Labor .....	976.96
Other expenses.....	387.28
	_____
Total .....	\$2,197.57

Farm sales, for the same year, amounted to \$519.69.

*Divide Station*—This station has not been operated as an experimental farm since March 31, 1896, since which time it has been leased to W. A. Diebold, of Table Rock, who has proved a prompt-paying tenant. The station land, forty acres, is rented for \$40 per annum, the tenant making repairs and improvements at his own charge. The station house is in bad condition but the barn and sheds are in good repair. The cottonwood trees have maintained their reputation for hardiness but the apple and cherry trees have died. A seventeen-acre tract of land, sown to wheat April 8-11, yielded 18 bushels to the acre. A six-acre barley field gave a yield of over 11 bushels per acre, from seed sown May 24. The potato crop, from a four-acre field planted May 18-23, proved of little worth, the yield not exceeding 1,000 pounds per acre.



SOME COLLEGE BUILDINGS—EAST FRONT, COLLEGE AVENUE.

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*The San Luis Valley Sub-Station*—The station land, 180 acres, had been leased to J. H. Stone who has furnished some statements of crop production. Thirty-eight acres, of the east 80-acre tract, produced 1,405 bushels of oats of good quality. The rest of said tract gave two tons of field peas per acre. Nine acres of alfalfa land produced 18 tons of hay. The west 80-acre tract, sown to wheat, gave a yield of 30 bushels per acre.

Rent receipts from this sub-station amount to \$161; the year's expense—water rent—is reported to be \$25.

*The Delta County Sub-Station*—A sub-station in Delta county was authorized by act of the Legislature approved April 4, 1887. No steps looking to the establishment of a station were taken until about two years ago when a 40-acre tract of land, eligibly located and well adapted to fruit culture, was donated to the college authorities, having ultimate control of station work, by Delta county. Then effort was made, without avail, to secure a legislative appropriation to enable the Governing Board to open the station for the prosecution of that experimental work of greatest value to the people of the Western Slope.

The following action relating to the land donated by Delta county for the establishment of an experiment station was taken by the Executive Committee at its April meeting, 1898:—

“Whereas, The State Legislature has entirely failed to aid The State Board of Agriculture in the maintenance of experiment stations located in different parts of the State; and

“Whereas, It is in direct violation of the spirit of the law, as construed by the Department at Washington, for any portion of the money derived from the so-called *Hatch Act* to be expended upon outlying sub-stations; therefore,

“Resolved, That the Secretary be instructed to notify the County Commissioners of Delta county that, for reasons above given, The State Board of Agriculture is unable to comply with the (at least implied) contract to keep up an experiment station in Delta county and that it is the sense of the Executive Committee of The State Board of Agriculture that all holdings of said

Board, derived from said Delta county for the purpose of establishing an experiment station, be deeded back to the proper authorities of said county, if their wish is to receive the property."

At the semi-annual meeting of The State Board of Agriculture, held June 1, 1898, the following action was taken:—

"Resolved, That the President and Secretary of The State Board of Agriculture be and they are hereby authorized to execute a deed to the County Commissioners of Delta county, Colorado, for the south-east quarter of the south-west quarter of section thirty-five, township fourteen, south of range ninety-five west of the sixth principal meridian, being the forty acres of land deeded by said county to The State Board of Agriculture for an experiment station, together with a transfer of the water stock thereto belonging."

The deed authorized in the resolution has been drawn, properly acknowledged, and forwarded to Delta county. Thus eleven years of ineffectual effort to make provision for experimental work in fruit growing in Western Colorado have come to a close.

*The Rainbelt Sub-Station*—This station, established at Cheyenne Wells nearly five years ago, has had an uneventful history. The advisability of opening a station in the "arid region" is a question about which "much might be said on both sides." The so-called rainbelt district of Colorado is of considerable extent and contains soil of acknowledged fertility. Stockmen have used the most accessible and promising portions of it as grazing fields for their herds but, until recently, no efforts worthy of consideration have been made to test the adaptability of the plains of Eastern Colorado for the homes of an agricultural people. The prime object of the work in Cheyenne county is to settle, as far as intelligent, scientific investigation can give answer, the questions of most importance to the people of a semi-arid region. If any considerable portion of lands now regarded as well-nigh valueless can be shown to be fit

for the homes of an industrious, frugal people, a result worth the cost of station maintenance for many years will be reached.

After the gubernatorial veto, two years ago, of a bill making provision for the support of this station by money taken from the general revenue for college support, the following action was taken by The State Board of Agriculture, at a special meeting held April 20, 1897:—

“Ordered, by The State Board of Agriculture of Colorado, That the sum of two thousand five hundred dollars (\$2,500) be and is hereby appropriated out of any available college revenue for the support and maintenance of the agricultural experiment station located at Cheyenne Wells, Colorado: said appropriation being for a period of two years.”

“The purpose of this action is to set at rest, definitely, the statements that have been made by certain parties that the Board contemplated the abandonment of said station at Cheyenne Wells, or would, in the case of its continuance, fail to give it such financial support as would secure the best results from it.”

“The Executive Committee is hereby directed to make such drafts upon the appropriation herein specifically set apart for the support of said station as in its judgment may be necessary for the full realization of the purport and intent of the order above given.”

There is yet a balance of appropriation, in the station treasury, for the support of this sub-station, amounting to \$481.33. With this sum must be met all expenses connected with the sub-station maintenance up to March 1, 1899.

The station expense for the fiscal year, ended June 30, 1898, may be summarized as follows:—

Superintendent's salary.....	\$800.00
Labor .....	146.40
Equipment and incidentals.....	437.56
Total .....	\$1,383.96

The sale receipts are insignificant, being only \$10.



At a recent meeting of your Committee, Messrs. P. F. Sharp and B. F. Rockafellow, a sub-committee, who had visited the sub-station at Cheyenne Wells, and investigated its workings and possibilities, made report as follows:—

“The location being on the Great Plains, about 175 miles east from Colorado Springs, where the buffalo and grama grasses are abundant, owing to the lack of water and all growth except native grasses, indicating its being heretofore the summer range of the buffalo and the possibility of its being made the limitless range for domestic animals and, if certain conditions are complied with, the homes of a large population engaged chiefly in such pursuits as permanent as agriculture or mining, we deemed it our duty to cast about to see if our experimental work is on the lines of providing a possible success.”

“It has been shown to our minds that if the Government and the possessor of the land-grant, the joint owners of the country, can join, with the railroad as a base line, in sinking bore-hole wells on the line between belts of stock range extending back for miles, that water, without which the country can not be made habitable the year round, can be secured, as is done here, at a depth of 300 feet and in sufficient quantities for domestic and stock purposes—then, as proving what kind of development is possible to make the home of the future possessors of this vast region habitable, we consider the location of this experiment station wisely chosen.”

“We found, by low-trained living apple and cherry trees, five years set and of healthy though slow growth through monthly stirring of the surface by the cultivator, by a moderate growth of alfalfa yielding the second year about one ton per acre, *Bromus inermis* or Russian grass, sorghum, corn, peas, broom corn, Kaffir corn, large sweet-potatoes, small but exceedingly rich Irish potatoes and melons, and gooseberry bushes in bearing, that there is sufficient moisture to promote slow growth and small yield where the conditions are made and kept as favorable as possible. Thus, it is possible, in this otherwise treeless belt, to make living possible, less monotonous, and more enjoyable.”

“The station having been established only a few years, and consequently its work but fairly commenced, we believe in its continuance and recommend certain expenditures now necessary.”

“We deem the location of the station, partly at the foot of slopes and thus taking the wash from the higher lands in time

of storms, as demonstrating the advantage of such locations where any sort of cultivation is aimed at."

"The soil of this region being rich, experiments have been made with grasses from Asiatic and other arid countries with the hope to find some forage plant that will produce larger yields than our native grasses, without success so far, except on the short-time test of Russian grass of which a good stand has been secured. This grass will be anxiously watched to note the outlook after the winter has passed. As this forage plant has a large blue-grass blade and has so soon shown its kindly adaptation to this climate, we are hopeful that the cost of this station to the Government has, in its growth, already been returned manifold, but if not, some other plant filling the requirements will yet be found by the persistent, able efforts of our painstaking Superintendent, J. E. Payne, whose studious, industrious, and faithful service we most earnestly commend."

"Successful experiments in the use of gypsum as a moisture retainer, as well as a stimulating fertilizer for making the properties of the soil active, have been made, showing in one instance 60% advantage."

"The machinery and appliances for testing the *Campbell Theory* are on the ground and their use, part of the season, has proved very satisfactory. They will be given thorough use the coming season."

#### CONCLUSION.

Our station workers, particularly those of the Home Station, have rendered much and acceptable service as lecturers before farmers' institutes, horticultural conventions, and other bodies whose aims and purposes intersect the industrial life of the people.

The station work prosecuted outside of Larimer county, in which the Home Station is located, has cost the experiment station fund not less than \$6,000 within the year. The station publications, sent into nearly every post-office district of the State as well as to other states and foreign countries, made drafts, upon the same fund, amounting to a sum but little less than \$2,000. All station work is designed to promote the agricultural interests of the whole State, whether it is done at the Home Station, the sub-stations, or elsewhere.

Herewith are presented the reports of members of the Station Council, in the order in which they reached my office; also the reports of Superintendents of the substations.

An early planning of station effort to be put forth the coming year is recommended.

Respectfully submitted,

ALSTON ELLIS,

*Director.*

Fort Collins, Colorado, December 14, 1898.

## Report of the Section of Botany and Horticulture.



*To the Executive Committee of The State Board of Agriculture:*

Gentlemen—I have the honor to submit the following report on the work of the Section of Botany and Horticulture for the year 1898.

In 1894 the Department commenced a systematic test of varieties of orchard and small fruits. The horticultural work of this season has been mainly a continuation of this test. Some additions to the lists of varieties previously reported have been made. Much of the effort of the Department has been required in the care of trees and plants set in previous years, and in the maintenance of records that, when compiled on the completion of the test, may show the complete history of each particular variety.

In the spring of 1896 a new apple orchard was planted with trees from the station nursery. The area planted was about five acres, requiring 480 trees which represented 140 varieties. The land lies high, the soil is good, and the subsoil of such nature that water is not retained, but quickly seeps to the lower land adjoining. It is dependent for water upon the No. 2 ditch, and for the three seasons since the first planting the supply has been wholly inadequate for the successful starting of young trees.

The record for 1896 shows that planting began as soon as water was available, April 24, but the next day

the water was turned out of the ditch and the remaining trees were watered, in part from a hydrant and in part by water hauled in barrels. The further record of irrigation for the season is as follows. May 1 and 2 a small stream was obtained and run on about half the orchard; May 13 to 15 a run was secured, and again June 22 to 25. No water was available during the balance of the season. Under these conditions the summer loss was considerable, and the living trees entered the winter in very poor condition. The winter of 1896-'97 was a very open one; much of the time there was no frost in the ground and evaporation was continuous, proving destructive to the trees. The planting in 1897 was practically a resetting of the whole orchard, the number of trees required to fill vacancies being 315. Two additional rows were added, making the total number of trees planted 344. The planting was done May 6 to 8 and water was at hand until the work was completed. From this time until the 14th of June no water was available; then we had it for two days, and again June 28 and 29, and this was the last obtainable during the season. The loss during the summer and winter of 1897-'98 amounted to 115 trees or about 22%, being nearly evenly distributed between the trees planted in 1896 and those planted in 1897. Vacancies were again filled this last spring, the work of planting being commenced on May 9 (as soon as the ground was in fit condition after the storm of April 30 to May 5, during which 3 inches of rain fell) and was finished on May 11. Between planting and the end of the season, water was available for but two days, May 23 and 24. On October 12 water again came in the ditch and continued for five days. During this time it was run on the orchard night and day, and the ground thoroughly soaked.

A count of the orchard made last month shows 46 existing vacancies, 33 of these are among trees set last spring, 9 among trees set in 1897, and 4 among trees planted in 1896. It is proposed again to fill these places next spring. As the orchard now stands it contains 461

trees representing 145 varieties, but many of these trees show very low vitality and have made very little growth.

In any assemblage of a large number of varieties it is to be expected that some, perhaps a considerable portion, will prove failures, but under the conditions as above outlined the trial of these varieties can hardly be regarded as fair, and we are not warranted in condemning them. During the past season we have made a special effort in the direction of cultivation, keeping the surface soil continually loose. This has undoubtedly aided in preventing evaporation, but it did not supply the deficiency which was apparent in the appearance of the trees.

The experience of the three seasons has forced the conviction that unless an adequate water supply can, in some way be secured, further attempt to establish the orchard will be effort thrown away. I have, therefore, presented the facts in some detail and would respectfully ask your consideration of the matter.

The plum orchard is under the same conditions regarding water supply as the apple orchard, but the trees have in the main made a reasonable growth, and such losses as have occurred are among varieties that have proved too tender to withstand the cold of winter. The effect of short water supply has, however, been apparent among the varieties now fruiting. It was most noticeable in 1897 when the crop borne was heavy, but even this season when the trees bore only a light crop, the fruit was below normal in size.

This orchard as now platted has places for 601 trees. There are 58 vacancies, to be filled next spring, and 543 living trees representing 153 varieties. These varieties are distributed among the different classes of plums as follows—

Prunus Americana.....	71
Wild Goose group.....	24
Prunus domestica.....	30
Japanese group.....	17

Chicasaw group.....	6
Beach plum.....	1
Hybrids, unclassified.....	4

It is evident from our work thus far with plums that the native American varieties are the ones to be relied upon for this region. A few of the Wild Goose group like Miner and Prairie Flower are hardy and do well, and it is probable that a few of the domestica plums, and possibly some of the Japanese varieties may after further trial prove valuable additions, but the greater number of these last mentioned groups and all of the Chicasaw group, so far as we have tried them, are practically worthless for this part of the State, because they do not survive the winters.

Last spring, studies on the blossoming periods, on self-fertility, and on crossing were outlined and carried out. The results are of some value although seriously interfered with by the cold storm which prevailed from April 30 to May 5. Early varieties began opening flowers on April 27 and many varieties were sufficiently advanced to be badly injured by the prolonged cold, and the snow which held to the branches for several days. Domestica varieties received the greatest injury; on some the fruit buds being all killed, even though still dormant. All varieties were in some degree injured and the light crop can be directly attributed to this cause. The work with plums has been made the subject of a bulletin which is now ready to be submitted.

The test of varieties of strawberries and bush fruits has been carried on as in years previous, and the records accumulated are sufficient to warrant a report on the varieties under trial. This matter is now being arranged for publication.

The coöperative experiment with the division of Forestry of the U. S. Department of Agriculture to test the relative hardiness of forest-tree seedlings as grown from seeds produced in different sections of the country has been continued this season. As started in

1897 there were provided 88 packages of seeds representing 11 species from 22 states and Canada. The addition made last spring consisted of 52 packages representing 9 species from 14 states. The range of climate now represented is sufficiently extended to make the test an interesting one. Under instructions from the Forestry Division the seedlings of 1897 were transplanted in May to allow them room for development. The records thus far made, while not regarded as conclusive, show some interesting results that point strongly to the conclusion that in the matter of hardiness the seedlings from northern seed have a decided advantage over those from southern seed. It is the expressed intention of the Forestry Division to continue this experiment until the results justify a positive conclusion.

The addition of five acres to the forestry plantation planned for last spring was deferred owing, as I am advised, to lack of funds. For the same reason the help necessary to keep the plats free from weeds, and in good growing condition could not be employed. No work has been done since July, and the plats have presented an untidy appearance. There being no water available for irrigating, the growth made during the season was small. Under these circumstances the advancement of the plantation has been unsatisfactory and much less encouraging than for the year 1897. The seedlings received last spring were as follows: Maple 5,000, Austrian pine 12,000, Scotch pine 12,000, Bull pine 9,000. Most of these were used to plant between the other trees and to fill vacancies; the balance being planted in nursery rows. Thus far the attempt to grow pines and spruces has been a practical failure, but it is hoped that when the nurse trees attain greater size, affording protection from the sun, these trees will succeed better. I have as yet received no information as to the work contemplated for next year.

In pursuance of the work on a flora of the State and for the purpose of adding to our collection of plants for exchange, several short trips were made during the sea-



son. In May one week was spent in an examination of the spring flora of the Western Slope; collections being made at Palisades, Grand Junction, and Cimarron. During the latter part of June and early July two weeks were spent in the southern portion of the state, and collections made at Antonito, Durango, Silverton, Mancos, and Rico. This was followed late in July by a wagon trip into the mountains west of Fort Collins, and in August one day was spent on Gray's Peak. At all places visited, and when traveling between points, lists of plants seen were made, thus adding largely to our records regarding the distribution of native and introduced plants.

Particular attention was given to the grasses and forage plants found at each place visited, and lists of weeds were also made.

The number of species now available in quantity for exchange exceeds 700 and it is hoped that the herbarium can be largely increased through exchanges to be made. The importance of a larger and more representative collection of North American plants is each year becoming more apparent. The greater the number of species in the collection, the more will it facilitate the work of determining the plants sent to us, and this feature of the department work is increasing each year. Since January first we have named 448 plants which have come to us from various parts of the State, and one collection of about 100 species is waiting attention as soon as time can be spared from other work. Many of the plants sent here are acceptable additions to the herbarium, and coming as they often do from regions not yet visited by the writer they add to our records of distribution.

The number of specimens added to the herbarium by exchange during the year is about 2,000. Several offers of exchange for the coming year have been made, some of which it is hoped we may be able to accept, but the available time for work of this character is so limited that but few exchanges can be undertaken.

The Department has prepared one bulletin during the year, No. 41, "Blight and Other Plant Diseases." The blight of apple and pear trees has, in its spread westward, reached the orchards of Delta and Mesa counties and many inquiries regarding it have been received during the summer.

Colorado orchards have in past years been free from fungus diseases, but the diseases which have given the eastern growers trouble are gradually coming in, and there is a rapidly growing interest in them among the fruit growers. Besides the blight, which is caused by a bacterium, several parasitic fungi have been sent to us from different parts of the State with reports of more or less serious injury. Four of these had been previously reported from other counties; three had not before been reported in the State. The Leaf Spot of blackberries and raspberries (*Septoria rubi*) has come from three counties and is said to be doing much damage. The Orange Rust of blackberries (*Cæoma nitens*) and the Leaf Blight of the strawberry (*Sphærella fragariæ*) are reported from several localities. The Powdery Mildew of the cherry (*Podosphæra oxyacanthæ*) is reported from the Arkansas valley, and from the same region four growers of cantaloupes have sent a blight disease which is said to be doing much injury, and which proves to be caused by a species recently described by Messrs. Ellis and Everhart as *Macrosporium cucumerinum*. The Anthracnose of the raspberry, and the Apple Scab are also reported, but have as yet done no very serious injury. These fungus diseases are sure to become very important factors in the business of fruit growing, and as the applications for information increase it will be necessary to make the investigation of these diseases and their remedies a more important feature of the department work.

Respectfully submitted,

C. S. CRANDALL,  
*Botanist and Horticulturist.*

Fort Collins, Colorado, December 14, 1898.



## Report of the Agricultural Section.



*To the Executive Committee of The State Board of Agriculture:*

Gentlemen—I have the honor to submit the following report of the work of the Agricultural Section for the year 1898.

The larger part of the time and energies of the Section has been devoted to the investigation of the growth of sugar-beets in Colorado. In connection with the Denver Chamber of Commerce the work has been extended to include all those parts of the State that seem at all adapted to this crop. A large part of the seed was obtained from the United States Department of Agriculture, but some from the Oxnard Sugar Company of Grand Island, Nebraska, through the efforts of the officials of the Union Pacific, Denver and Gulf Railroad, and some from the sugar factory at Rome, N. Y., through the efforts of Mr. M. B. Colt, of Alamosa. When near the end of the season all these sources had become exhausted, the Denver Chamber of Commerce purchased in open market enough seed to supply the remainder of the demands. In all a little over four thousand pounds of seed were distributed to two thousand three hundred persons.

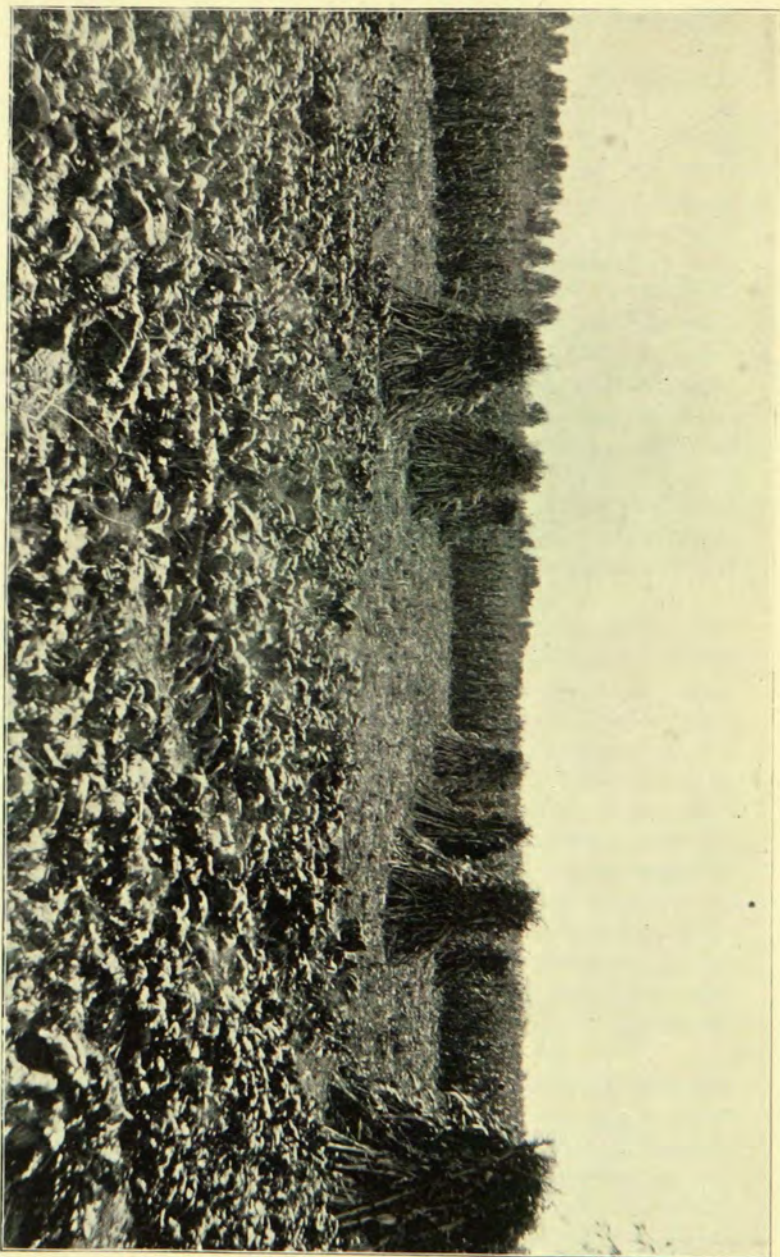
The Denver Chamber of Commerce in connection with the County Commissioners, or the local organizations, offered prizes aggregating nearly two thousand dollars to those who raised the best crops of sugar-beets. These competitions were confined to the irrigated

parts of the State. Seed was distributed, however, to many persons outside of the counties where the prizes were offered. About forty persons agreed to carry on some special tests for this Section, and extended tests were conducted on the sub-station at Rocky Ford and on the college farm. Thus the work of the season has been carried out in four distinct lines.

1. General tests were made on the growth of beets in the unirrigated parts of the State and in some of the counties having irrigation but not enough interest in the matter to offer prizes for large crops. From this source were received ninety-one samples of beets, most of them accompanied by full notes on the planting and cultivation of the crops and by less satisfactory notes on the harvesting and yield.

2. Records were received from nine counties in competition for the prizes. It was recognized last spring that the time had come when there should be a well organized effort to get the most exact information possible on the adaptation of the sugar-beet to Colorado soil and climate. Nearly all the estimates of previous beet crops in Colorado have been based on the yield from a hundred square feet of ground. It was recognized by all that this was too small a plat for commercial estimates. It had been adopted because the beet growers disliked to spend the large amount of time and trouble necessary to make exact experiments on a large scale. It was seen that some substantial inducement must be offered before it could be expected that better results would be obtained than those of former years. It was with this idea in view that the prizes were offered and the results have confirmed the judgment and justified the large expenditure of time, labor, and money. Seventy-two persons competed for the prizes and their records form such a valuable mass of material that they are included in this report.

3. The work of testing foreign grown seed as compared with that grown in the United States was undertaken. Two of the best German varieties, one of the



EXPERIMENT STATION—FIELD CORN, SUGAR BEETS IN FOREGROUND.

French, and one of the Austrian were compared with one lot of seed grown in Utah and one grown in New Mexico. These were distributed to about forty persons in all the principal agricultural sections of the State and some of the most interesting and valuable results have been obtained. The superiority of the Utah grown seed was very marked over the seed from which it originated, so much so that arrangements have been made to grow seed next year on the college farm and at various places throughout the State from some of the beets that made exceptionally good returns the past season.

4. The work at Rocky Ford and the college farm was principally along the lines of different times of planting, distances of thinning, times of thinning, and date of irrigation. About two hundred samples of beets were analyzed from these two sources but the results have not yet been carefully enough studied to know what they indicate.

In connection with the shipment of eight car-loads of beets from Loveland and Fort Collins to Grand Island, Nebraska, many samples were taken to ascertain tare in trimming, shrinkage in shipping, and yields from large areas under ordinary farm management.

It will thus be seen that the work has been conducted on a larger scale than ever before attempted. Some idea of the labor involved can be gotten from the fact that my letterbook shows one thousand six hundred and sixty-six letters written during the first eleven months of this year in addition to several thousand mimeograph circulars. To do this in addition to my other work would have been an impossibility and extra clerical assistance was granted through the five summer months.

The records sent in competition for the prizes present the largest amount of the most reliable reports that have ever been collected concerning Colorado sugar-beets. They made such a remarkable showing for the State that they are included in this report. They are based on the yields of one-sixteenth of an acre.

Early in the summer a circular was sent to each one asking for information concerning the planting and cultivation of the crop. Later circulars were sent out giving a statement of the prizes that had been offered and the rules that would govern the harvesting of the crops, the taking and the analyzing of the samples.

The samples for analysis were all sent to the Colorado Agricultural College at Fort Collins and were analyzed by the chemist of the College and his assistants. Through the courtesy of the United States Department of Agriculture, the College was granted the franking privilege so that more than 3,000 pounds of beet samples were sent through the mail free of postage.

The accompanying tables give the results of the season's work. A few words of explanation seem necessary. It was desired that the crops be harvested and samples taken as far as possible at about the same time, between October 15 and November 1. In the case of Logan county the crops were harvested the last week in September so that they could be exhibited at the county fair. The crops were not then ripe and the results are much poorer both in quantity and quality than would have been obtained had the beets remained in the ground a month longer. At my request two of these fields were but partly harvested and the rest of the beets were dug the latter part of October when the beets in the other counties were being harvested. In each case the beets tested in sugar more than 3 per cent. higher than during September. The figures for Mesa county are not yet complete and it is not deemed advisable to hold this report until the returns are all in.

It was desired that the contest be put as nearly as possible on a commercial basis; i. e., the prizes be awarded to the crops in the order of their real value for sugar-making purposes. It was necessary then to take into account three things, the weight of the crop, the amount of sugar in the crop, and the amount of sugar that could be gotten out in the factory. These items are given in the accompanying tables. The column



headed "Gross weight of trimmed beets per acre" gives the weight of the beets in the same condition as they would ordinarily be brought to a factory; i. e., the tops cut off but no attempt made to remove the dirt that naturally sticks to the beet. At a factory, a sample of the beets, usually about half a bushel, is taken and cleaned and the calculation made as to how much dirt there is in the whole load. The column headed "Per cent. of sugar in the beet" represents the character of the beet at the time it was analyzed. On the average this was about three days after harvesting. During this time, of course, the beets had been drying out, which would tend to raise the per cent. of sugar in the sample. The first two columns therefore represent the gross weight of beets and dirt together and the analysis of a partly dried sample, in both cases making the crops apparently better than they were. To offset this, the column headed "Pure sugar per acre" is obtained by multiplying the other two together and deducting one-fifth for tare and drying out. It is probable that this is a larger shrinkage than would have been made had these crops been sent to a sugar factory, but it was deemed best to make sufficient reduction so there could be no possible appearance of an attempt to exaggerate Colorado's sugar-beet crop. The figures, even after the 20 per cent. reduction, show magnificent crops and still more so that we can look at them as a slight underestimate.

The column headed "Coefficient of purity" is the measure of the factory value of the sugar that is in the beet. If a beet tests "80 per cent. purity," it means that for every 80 per cent. of pure sugar that the beet contains it also contains 20 per cent. of impurities that are not sugar. These impurities prevent the factory from saving all the pure sugar and the greater the amount of impurity, the greater the amount of pure sugar that will be lost in the process of manufacture. The "pure sugar per acre" multiplied by the "coefficient of purity" will give the "available sugar per acre," or the approximate amount of sugar that would have been produced

from the crops in an ordinary factory. It is considered that this measures the true sugar value of the crop and it is on the figures of this column that the order of excellence of the various crops is based.

In the table of averages by counties another column is introduced headed "Factory value per acre." This is intended to represent the amount that would be paid for the crop at a factory under present prices. It is obtained by deducting 10 per cent. tare from the gross weight of the crop and multiplying the remainder by the price paid by factories during 1898, where the price is varied according to the quality of the beets. The prices used are: Three dollars and seventy-five cents per ton for beets testing from 12.00 per cent. to 14.40 per cent. sugar and of less than 78 per cent. purity; \$4 per ton for the same per cent. of sugar and more than 78 per cent. purity; \$4.25 per ton for tests from 14.50 to 15.40 per cent. sugar; \$4.50 per ton for tests from 15.50 to 16.40 per cent. sugar; \$4.75 per ton for tests of 16.50 or higher per cent. sugar.

SUGAR-BEET CULTURE.

CONEJOS COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
Charles Milne, La Jara	Nov. 7	28.16	17.65	79.8	7,952	6,436
W. M. Martin, Alamosa	Oct. 29	24.57	16.96	86.8	6,684	5,802
W. A. Braiden, La Jara	Oct. 10	20.95	11.45	72.2	3,673	2,803
G. W. Shaw, Alamosa	Oct. 22	12.29	15.30	86.6	3,068	2,605
D. E. Newcomb, La Jara	Oct. 12	12.80	15.65	80.1	3,205	2,563
S. J. Parish, Alamosa	Oct. 16	12.06	16.64	80.5	3,174	2,554
W. G. Bradshaw, Alamosa	Oct. 21	12.40	15.77	80.0	3,129	2,499
A. McKinnon, Alamosa	Oct. 18	7.26	12.54	83.8	1,457	1,213
Peter Legard, Alamosa	Oct. 20		15.58			
Average	Oct. 21	16.20	15.26	81.2	3,955	3,221

## SUGAR-BEET CULTURE—Continued.

## DELTA COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
G. H. Hammond, Hotchkiss.....	Oct. 22.....	38.51	17.34	77.4	10,962	8,485
Martin Cade, Delta.....	Oct. 17.....	20.57	15.91	89.5	5,236	4,686
G. W. Umbrell, Delta.....	Oct. 31.....	21.78	14.68	80.9	5,116	4,139
I. S. Hewitt, Delta.....	Oct. 19.....	19.96	12.87	71.0	4,118	2,924
J. M. Trew, Delta.....	Oct. 19.....	10.87	13.40	76.5	2,331	1,783
Charles A. Barnes, Delta.....	Oct. 28.....	.....	15.44	83.9	.....	.....
Average.....	Oct. 23.....	22.54	14.74	80.0	5,301	4,241

SUGAR-BEET CULTURE—Continued.

FREMONT COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
B. F. Rockafellow, Canon City.....	Oct. 21 .....	30.05	18.05	86.8	8,678	7,533
William Curtis, Canon City.....	Oct. 29.....	29.18	16.63	86.9	7,766	6,748
L. K. Mortimer, Canon City.....	Nov. 2.....	26.35	17.96	83.5	7,589	6,337
Charles Kaess, Cotopaxi.....	Oct. 24.....	29.40	16.63	79.6	7,822	6,226
G. E. Murray, Howard.....	Oct. 15.....	29.80	15.33	84.3	7,310	6,162
W. A. Dumm, Canon City .....	Oct. 28.....	21.33	18.95	82.0	6,160	5,051
J. M. Murray, Howard.....	Oct. 15.....	29.52	13.63	79.4	6,444	5,117
John Ripley, Canon City.....	Oct. 27.....	21.90	16.96	86.3	5,942	4,772
H. T. Gravestock, Canon City.....	Oct. 20.....	14.50	16.48	90.7	3,831	3,475
E. S. Armstrong, Hillside.....	Oct. 12.....	16.13	15.68	77.0	4,046	3,116
C. H. Gravestock, Canon City.....	Oct. 28.....	8.45	19.00	84.8	2,569	2,178
E. V. Kimmel, Canon City.....	Oct. 20.....	.....	18.05	93.5	.....	.....
Average.....	Oct. 23.....	23.36	16.87	84.1	6,226	5,236

## SUGAR-BEET CULTURE—Continued.

## GARFIELD COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
C. H. Harris, Catherin.....	Oct. 29.....	37.98	17.20	80.1	10,458	8,397
D. G. Edgerton, Carbondale.....	Oct. 18.....	14.91	17.34	91.8	4,113	3,776
Jesse Kerlee, Parachute.....	Oct. 19.....	10.77	15.68	88.0	2,702	2,378
Charles H. Miller, Antlers.....	Oct. 17.....	12.17	14.25	79.4	2,774	2,203
Average.....	Oct. 21.....	18.96	16.12	84.8	4,901	4,155

SUGAR-BEET CULTURE—Continued.

LARIMER COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
J. M. Naylor, Loveland	Oct. 23	36.26	16.53	79.3	9,590	7,589
I. W. Clapper, Loveland	Nov. 1	31.60	18.53	80.4	9,369	7,533
C. C. Smith, Loveland	Oct. 27	33.01	14.73	79.0	7,781	6,147
F. G. Bartholf, Loveland	Oct. 31	28.72	15.68	85.3	7,205	6,142
Alfred Wild, Loveland	Oct. 27	31.50	15.25	80.7	7,606	6,138
Alvin Shields, Loveland	Oct. 29	27.47	17.43	79.7	7,490	5,970
Harvey Skiuner, Loveland	Oct. 27	24.60	17.38	85.3	6,896	5,882
R. O. Joslyn, Loveland	Oct. 27	14.10	18.05	84.8	4,072	3,453
R. S. Cox, Loveland	Oct. 27	21.95	13.40	75.7	4,513	3,416
P. C. Benson, Loveland	Oct. 31	10.72	19.05	86.0	3,267	2,810
N. R. Faulkner, Loveland	Oct. 22	19.35	12.07	74.0	3,456	2,765
Average	Oct. 28	25.32	15.69	80.9	6,356	5,091

## SUGAR-BEET CULTURE—Continued.

## LOGAN COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar, Per Acre, Pounds	Available Sugar, Per Acre, Pounds
Fred Bernhard, Sterling.....	Sept. 26.....	34.15	13.40	72.7	7,322	5,323
W. C. Propst, Merino*.....	Sept. 25.....	24.50	14.72	76.2	5,771	4,397
A. F. Krause, Sterling*.....	Sept. 27.....	21.50	14.50	84.7	4,988	4,175
J. H. King, Sterling.....	Sept. 27.....	18.10	13.30	79.1	3,852	3,047
C. D. Brownell, Iliff.....	Sept. 26.....	14.60	14.72	80.0	3,438	2,750
C. M. C. Woolman, Sterling*.....	Sept. 27.....	12.50	14.30	72.4	2,860	2,071
C. E. Harter, Sterling.....	Sept. 27.....	9.50	15.33	78.8	2,331	1,837
T. A. Whiteley, Sterling.....	Sept. 26.....	7.65	14.15	71.6	1,730	1,239
James Weir, Sterling.....	Sept. 26.....	.....	14.49	78.2	.....	.....
M. V. Propst, Sterling.....	Sept. 26.....	.....	14.25	78.8	.....	.....
John Landrum, Sterling.....	Oct. 1.....	.....	14.10	79.2	.....	.....
R. C. Perkins, Sterling.....	Sept. 27.....	.....	13.30	79.1	.....	.....
H. C. Hatch, Sterling.....	Sept. 26.....	.....	12.63	73.3	.....	.....
Average.....	Sept. 27.....	17.8	14.09	77.3	4,013	3,102

\*The crop from 100 square feet of ground is used in making these estimates of yield per acre. The rest of the yields are based on one-sixteenth of an acre.



## SUGAR-BEET CULTURE—Continued.

## OTERO COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
J. W. Ruble, Rocky Ford	Oct. 25	31.40	18.19	86.2	9,138	7,877
J. P. Pollock, La Junta	Nov. 7	33.52	18.01	77.7	9,652	7,550
B. F. Wyckoff, Rocky Ford	Oct. 25	23.21	14.16	78.3	5,259	4,108
Albert Conner, Rocky Ford	Oct. 27	27.70	10.83	72.8	4,800	3,494
C. S. McKinley, Fowler	Oct. 20	13.27	16.06	84.7	3,411	2,889
Fred Janrow, Fowler	Oct. 29	18.17	13.30	73.6	3,906	2,875
Richard Mason, Higbee	Oct. 20	10.70	15.20	78.3	2,603	2,048
C. S. Heath, La Junta	Oct. 26	-----	15.39	76.8	-----	-----
Average	Oct. 26	22.59	15.14	79.8	5,474	4,379

## SUGAR-BEET CULTURE—Continued.

## WELD COUNTY.

Name and Place	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds
Leonard Burch, New Windsor	Oct. 25	17.17	17.10	83.5	4,699	3,924
Newton Clegg, Greeley	Oct. 25	12.20	16.25	78.1	3,172	2,477
Martin Nelson, Greeley	Oct. 18	12.58	15.68	74.2	3,154	2,340
Fritz Niemeyer, Evans	Oct. 26	.....	14.54	82.4	.....	.....
Average.....	Oct. 23	13.95	15.89	79.8	3,562	2,850

SUGAR-BEET CULTURE—Concluded.

AVERAGE RESULTS BY COUNTIES.

County	Date of Harvesting Crop	Gross Weight of Trimmed Beets Per Acre, Tons	Per Cent. of Sugar in the Beets	Coefficient of Purity, Per Cent.	Pure Sugar Per Acre, Pounds	Available Sugar Per Acre, Pounds	Factory Value, Per Acre
Conchos	Oct. 21	16.20	15.26	81.2	3,955	3,221	\$ 62.02
Della	Oct. 23	22.54	14.74	80.0	5,301	4,241	86.23
Fremont	Oct. 23	23.36	16.87	84.1	6,226	5,236	99.75
Garfield	Oct. 21	18.96	16.12	84.8	4,901	4,155	76.98
Larimer	Oct. 28	25.32	15.52	80.2	6,278	5,023	102.56
Logan	Sept. 27	17.80	14.09	77.3	4,013	3,102	64.00
Otero	Sept. 26	22.59	15.14	79.8	5,474	4,374	86.40
Weld	Sept. 23	13.98	15.89	79.8	3,562	2,850	56.70
Grand average	Oct. 20	20.05	15.43	80.8	4,955	3,995	\$ 76.67

In considering the foregoing tables one is struck at once with the high average excellence of the sugar-beets of Colorado as regards both quantity and quality. In the districts of the United States where beets are raised for factories, 12 per cent. of sugar and 78 per cent. purity are considered standards and that one who has raised ten to thirteen tons of beets per acre has done well. A fair estimate of the cost of raising sugar beets is \$30 per acre, while the above table gives \$76.67 as the average factory value for the whole state. The difference of \$46.67 profit per acre will compare well with any other kind of farming practiced in Colorado, not even excepting the famed cantaloupes of the Arkansas valley, the orchards of the Western slope, or the lambs of the northern feeding districts.

Among the other subjects considered by this Section, during the year, may be mentioned the feeding of sheep and lambs on alfalfa. An experiment along this line was conducted on the college farm and data were secured on the subject from nearly every person in the Arkansas Valley that had tested this method of feeding. The results will be ready for issuing as a bulletin early this winter.

We completed our tests of raising early lambs and the final report will be made in connection with the above bulletin.

The second year's test of our 'three years' test of corn grown from seed from different altitudes and latitudes was somewhat injured by the early frost the first week in September, but it served to emphasize the differences of the plats in their time of ripening.

We are now engaged in our final tests of feeding ensilage and sugar-beets to cows and sheep.

The bulletins issued by this Section during the year have been one, in connection with the Chemical Section, on "Sugar Beets in Colorado in 1897" and a technical bulletin entitled "Further Notes on Colorado Birds." The collection of data on the above subject was kept in

mind during the past season in connection with the trips made over the State on the sugar-beet work and almost as many additional notes collected as were given in the above-mentioned bulletin.

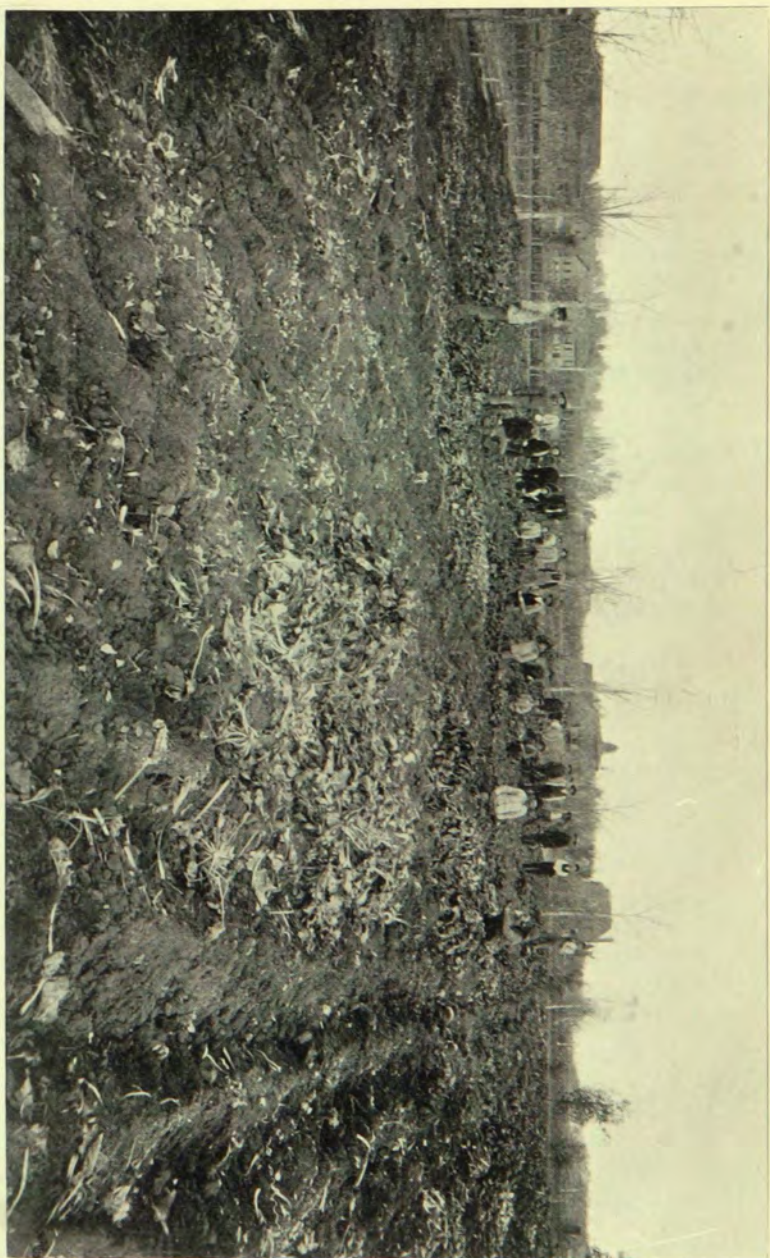
Respectfully submitted,

W. W. COOKE,  
*Agriculturist.*

Fort Collins, Colorado, November 30, 1898.



EXPERIMENT STATION—STEAR BEETS, SOME COLLEGE BUILDINGS IN THE BACKGROUND.



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## Report of the Entomological Section.



*To the Executive Committee of The State Board of Agriculture:*

Gentlemen—I have the honor to submit herewith the annual report of the Entomological Section of the Agricultural Experiment Station for the year 1898.

While this is hardly the place for a detailed account of experimental work, I presume it will not be out of place for me to call attention to the more important results that have been reached.

### **EXPERIMENTS WITH THE CODLING MOTH** (*Carpocapsa pomonella*).

The experiments with this insect were chiefly for the purpose of determining the comparative values of different methods of combatting the pest, to determine the number of broods in the vicinity of Fort Collins, and to compare the results of early with late spraying.

The three remedies compared were, gathering the fallen apples daily to destroy them, catching the larvae under bandages put around the trunks of the trees, and spraying twice with Paris green. To test the first remedy, the fallen apples were gathered each morning and examined for worms throughout the season. In this manner 16% of all worms infesting the fruit of Duchess trees and 3½% of the worms infesting the fruit of Ben Davis trees were taken. By the bandage system 17% of the worms were taken on all trees up to the time of gathering the fruit.



By twice spraying with Paris green and estimating the benefits by the effect upon the first brood only, it was found that 83% were destroyed upon Ben Davis trees. The Ben Davis trees were sprayed when the calyx cups were still wide open. This work was compared with the result on a Duchess tree where the calyx cups had closed before the first spraying. The saving in the latter case was only 25.4%.

The experiments also show quite conclusively that there are but two broods of the codling moth a year in northern Colorado.

#### ORTHOPTEROLOGICAL SURVEY.

Good progress has been made in a study of the Orthoptera (grasshoppers, locusts, crickets, etc.) of the State. Quite extensive collecting has been done in the vicinity of Fort Collins, both inside and outside the foothills. Mr. Ball spent two weeks in the southeastern portion of the State collecting and studying these insects, and the writer made one trip to Delta and Grand Junction and another to Marshall Pass, Salida, Palmer Lake, and Boulder for the same purpose. Not less than two thousand specimens have been added to the station collection during this work and the number of Colorado species in the collection has been very largely increased. It will probably require two or three summers yet to bring this work to a fair stage of completion.

In the fruit-growing districts on the west side of the Range I found the differential locust (*Melonoplus differentialis*) the chief depredator this summer, though the two-lined locust (*Melonoplus bivittatus*), the red-legged locust (*Melonoplus femur-rubrum*), and a green locust (*Schistocerca emarginata*) were doing decided injury in many places. On this side of the Range the two-lined locust has been by far the most injurious species. Next in importance has been the red-legged locust. These two species are the only ones that we have found doing very serious harm to cultivated crops on this side of the foothills.

**EXPERIMENTS WITH SHEEP SCAB.**

Possibly the most important result reached in studying this disease the past year has been the determination of the life history of the mite. Seventy-five eggs were taken from the back of an infested sheep and put, in about equal numbers, upon the skin of the backs of two lambs that were free from the disease. The mites began hatching the 1st day and continued until the end of the 4th day; on the 9th day the earliest hatched individuals were mature and were seen in copula; and on the 11th day eggs began to be deposited. This would indicate that, to cure scab, the second dipping should not be sooner than five days after the first nor should it be postponed longer than ten days. Otherwise there will probably be some eggs upon the sheep, unhatched when the second dipping is made.

The experiment also shows the time required for the full round of development from egg to egg again is fourteen or fifteen days, as the oldest mites in the experiment came from eggs that were ready to hatch when first transferred and hence must have been about four days old when the observations began. The transfer of the eggs was made by the writer and the observations upon the sheep were made by Mr. E. D. Ball.

**TESTING INSECTICIDES.**

“Woodbury’s Summer Spray” and “Woodbury’s Kerosene Emulsion” were tested to determine their value for the destruction of insects, the samples being sent gratis by the manufacturers. The emulsion was of good quality, diluted readily, did not separate badly, and was used with satisfactory results upon plants for the destruction of plant lice. The “Summer Spray” which the manufacturers recommend for the destruction of “all insect pests” and which they guarantee to give better results than can be obtained from arsenical solutions, proved to be perfectly harmless to those insects to which it was applied. It was tested upon plant lice,

cherry slugs, and three species of cabbage-feeding caterpillars; namely, *Pieris rapæ*, *Plusia brassicæ*, and *Mamestra picta*, without any apparent discomfort to the insects. The manufacturers say of this spray that it "is absolutely non-poisonous" which probably accounts for its failure to harm the insects that ate it.

#### EXPERIMENTS IN THE APIARY.

The experiments in the apiary this year were chiefly with different kinds of foundation, including the artificial drawn foundation manufactured by The A. I. Root Company, of Medina, Ohio, with plane sections and with fence separators.

One question that has long been a matter of dispute among beekeepers seems to have been settled beyond farther question and that is in regard to bees removing wax or foundation from one place and using it in another. The experiments proved beyond question that this is done. When the bees were given heavy foundation to build comb upon, it was always thinned but the amount of thinning varied rather widely. In some cases nearly half the weight was thinned away. Where the artificial drawn comb was used it had the septum, which is thinner than in natural comb, thickened by the bees, but the thickening was in spots and not evenly spread over the surface. It was also observed that the bees accepted the artificial drawn comb more readily than they did the ordinary foundation. They also built it rather more firmly to the sides and bottom of the section leaving fewer holes as passage ways.

The plane sections and fence separators gave excellent results. When filled with honey, the sections were particularly handsome in appearance and well filled out about the margins though the average weight was a little below the average in the old-style section which is notched above and below for a bee-space.

**INSTITUTE WORK.**

I have, during the past year, attended and delivered addresses at two meetings of the State Bee-keepers' Association, at the annual meeting of the State Board of Horticulture, and at two institutes, one held at Delta and one at Grand Junction.

**INSECT COLLECTION.**

Without making an actual count, it will be safe to say that more than 10,000 pinned insects have been added to the insect collection during the year, and far the greater part through the efforts of my assistant, Mr. E. D. Ball. These insects are chiefly in the orders *Hemiptera* and *Orthoptera*.

**BULLETINS.**

Two bulletins, Nos. 43 and 47, comprising 100 pages, have been issued from this Section during the past year.

Very respectfully submitted,

C. P. GILLETTE,

*Entomologist.*

Fort Collins, Colorado, December 8, 1898.



## Report of the Chemical Section.



*To the Executive Committee of The State Board of Agriculture:*

Gentlemen—The work of this Section has been continued in the lines indicated in my former reports. The Station Laboratory was moved into the new building in June last. The station work was, of course, interfered with to some extent by the moving from one building to the other and the accompanying delays subsequent to such changes.

The work on the bulletin entitled "A Soil Study," of which Part I. has already been published, has advanced at a fairly satisfactory rate considering the interruptions to which it has been subjected. The field work, in this connection, has been prosecuted this year, as it was last, on the plat of ground set aside for this purpose. Last year sugar-beets constituted the crop chosen for the experiment. The cultivation of the crop has again been carried on by this Section. The chief object has been the study of the effects of manuring with good, well-rotted sheep manure as compared with no manure or dressing of any kind, and with a dressing of straw, cut the length of about one inch. The study of the water level and the chemical composition of the ground water has been continued up to the time of harvesting the crop. The results of the study of the composition of the ground water, the composition of the soil, and the effects of the manuring upon the crop and soil will be recorded in a bulletin entitled "A Soil Study," Part II. This bulletin

will conclude the work of the Section on this subject. The time through which the study will have extended is shorter than desirable from many points of consideration, but I will have attained my object in undertaking the study, and as other work is waiting to be undertaken, it seems advisable to conclude this, or at least to record the work already accomplished and leave the further study of it till another time.

During the year, coöperative work on the general culture of sugar-beets has been carried on jointly with the Agricultural Section. Much of this work is the enlargement of the work recorded in Bulletin No. 46.

I have undertaken, in coöperation with the Botanical Section, to study the composition of the grasses of the State. The volume of my work will probably force me to confine this to a smaller number of species than may be desirable. But as this is a study which I have long considered as one which it is very desirable to make, I shall endeavor to give it as much time as can possibly be commanded for this purpose. A bulletin has already appeared on this subject, but new and fuller analyses seem desirable, therefore, I have most willingly consented to undertake the work, especially as I believe that the subject of our native forage plants is as worthy of our study as our cultivated crops.

A considerable amount of work on the artesian waters of the San Luis Valley has already been completed and should, I think, be published as an independent bulletin as soon as the remaining work can be completed.

The new Station Laboratory has proven to be very convenient and well adapted to the purposes for which it was intended. A definite measure of the volume of work accomplished by the Section may be conveyed by the fact that the number of determinations made between December 1, 1897 and December 1, 1898, amounts to thirty-nine hundred, which is to be considered in connection with the outdoor work done by my force and the delays caused by our moving from the old building into the new one.

I would not commend any increase in the working force at the present time, but I earnestly urge that it be maintained at its present number and that the salaries of the junior assistants be increased to at least six hundred dollars per annum, which is only a fair compensation for their services.

Respectfully submitted,

WM. P. HEADDEN,

*Chemist.*

Fort Collins, Colorado, December 9, 1898.





## Report of the Section of Meteorology and Irrigation Engineering.



*To the Executive Committee of The State Board of Agriculture:*

Gentlemen—The scope of the work of this Section is too well known to need recapitulation. Nevertheless its work touches that of the College in the corresponding Department under my charge in so many ways that the work of one can scarcely be mentioned without consideration of the work of the other and their mutual relations. During the year the work of this Section has been carried forward as close as possible to the general plan, and as much accomplished as the time and means at my disposal would permit. From some of the work conclusions of immediate value may be drawn during its progress, as is the case with determination of the seepage gains and losses from streams and canals; while much more requires investigations extending over several years and much labor in working out the results to obtain the most valuable results.

In a general way, it may be said that about 450 linear miles of streams have been measured during the year to determine the gains or losses from seepage, and about 100 linear miles of canals and ditches measured to investigate further the amount of losses from canals and ditches. The ordinary records in meteorology, in stream flow, in evaporation have been maintained in the vicinity of Fort Collins. Records from a number

of voluntary observers and the sub-stations have been regularly received and reduced. Most of these are near the water shed of the Cache a la Poudre river, but others have become necessary by the other investigations in progress. A study of the sub-surface waters in their relation to the surface applications by irrigation has been begun. A series of observations to determine the amount of water used in irrigation and to study the methods of irrigation has been commenced in other parts of the State. It has long been evident that the observations and measurements on the use of water in the Poudre valley needed to be checked by measurements under other conditions and in other parts of the State. The lateness of the season before this latter work could be undertaken give the results for only a part of this year, but forms a point of departure for the work of the coming year which by being begun earlier can be organized on a more extensive scale without material increase in cost.

In the prosecution of this work there has been some 3,000 miles driven by horse; some six or eight thousand miles of railroad travel, and several hundred miles by bicycle. No attempt has been made to keep account of these distances, but this estimate is believed to be below rather than above the sum total traveled by myself and assistants.

Three bulletins have been prepared during the year and seen through the press. The charts, diagrams and maps needed for the study of the data relating to a number of other topics are prepared, and many of those needed for use in future bulletins, several of which are quite advanced in their essential preparation. The amount of material now on hand furnishes the foundation for a good many. Ten years of continuous service was closed during the summer. There are thus ten years of observation carried on under the same plan and with the same purpose in view. In a number of cases the accumulation of at least ten years data has seemed desira-

ble before attempting to seriously discuss the observations and their lessons. The termination of this period now renders it possible to enter upon the reduction and discussion of certain of these lines with available opportunity.

Several years ago I took occasion to visit the irrigated regions of France, Italy and Algeria, to observe their conditions and learn what lessons drawn from their long experience would be applicable to our conditions. It was evident then, and the several years that have since elapsed have strengthened the conclusion, that in many ways our development under irrigation conditions is parallel to theirs, but that our experience is developing within a shorter period. I have gradually collected nearly all the works which would aid in the study of their irrigation, and have constantly planned to utilize the results of that visit before again passing over their ground to study some phases not sufficiently studied when there before. I am more than ever convinced of the desirability of studying their experience and rendering it available to save some of the mistakes which are constantly being made. The experience of the older countries long might have prevented the commission.

The correspondence of the year has increased considerably. The letter copying books show that the letters sent out have required about 1,200 letter pages. The inquiries received cover several phases of the irrigation question, and have been received from many states and many foreign countries. One day's mail this fall brought letters from Alberta and the N. W. Territories of Canada; from Scotland; France; and the province of Oudh, India. The correspondence received during the year includes Ontario, New Brunswick, Nova Scotia; England, Holland, Germany; Mexico and Peru; Algeria, Italy; Western Australia; Victoria; New South Wales, New Zealand, and Russia in addition.

**METEOROLOGY.**

The meteorological observations have been maintained with no material change. The intent has been to record the elements important in Agricultural Meteorology. These include rainfall, moisture, humidity, temperature, cloudiness, evaporation, wind, air pressure, soil temperature, etc. Such observations need to be maintained for a series of years before the averages are of any great value in determining the normals for the climate.

To determine our rainfall normal at this place, we now have twenty years' observations for most months. The normal thus obtained for the whole year is 13.26 inches. Treating the observations by the method of least squares, it is found that it is an even chance that in a longer series of years, the normal is .62 greater or less than this. It is thus probable that with a longer series of observations the annual will not be found to be lower than 13.24, or more than 14.24 inches. For single years it is an even chance that the total will be as low as 11.64 or as great as 16.08 inches.

In a number of special lines, some attempt has been made looking forward to special study for separate application as to soil temperatures, evaporation, etc. The character of the observations themselves has been shown in the annual reports hitherto given up to 1891, after which date, according to the request of the Director as stated in the report for 1893, they were omitted.

**SUNSHINE.**

In the Agricultural applications of Meteorology, as well as from its climatic and sanitary aspects, the amount and intensity of the sunshine, is one of the most important of the elements to measure. The energy which exhibits itself in the growth of plants, is derived principally from the heat received from the sun and is converted into the forms of plant growth. The relation is obscure,

but there is no question but that there is such a relation, and the only way to find it is to make attempts with that purpose in view. Records of the sunshine have been maintained during the past nine years, but available time has not permitted the measurements of the sheets, except those of a few years. There is now enough data on hand to warrant a more careful study. During the past summer some progress was made in measuring and reducing these measurements with the intention of bringing the ten years' observations, with the several years' records at the sub-station, into form for publication in a bulletin on "Sunshine in Colorado." The records are not completed, and probably a couple of months of continuous work will be required to complete the measurements, and at present without additional help, this cannot be done.

Observations along the same line to determine the intensity of sunshine have been carried on for some years. Additional observations to determine the intensity at high elevations were made at altitudes of 9,000 feet and over 14,000 feet during the summer, but were incomplete, from the disabling of one set of actinometers, and from taking but a short "vacation," in which such observations could be made. We now have sufficient data to make an instructive bulletin and probably to clear the ground for more systematic work along the related lines.

#### SOIL MOISTURE.

Early in the year, an instrument of the Whitney pattern, to determine the temperature and amount of moisture in the soil was ordered, and the instrument was received in the summer. The instrument is intended to determine the temperature by the change in electrical resistance with the change in temperature, the material used being a solution of salt. The amount of moisture is also determined by its effect upon the electrical resistance, the less the moisture the greater being the re-

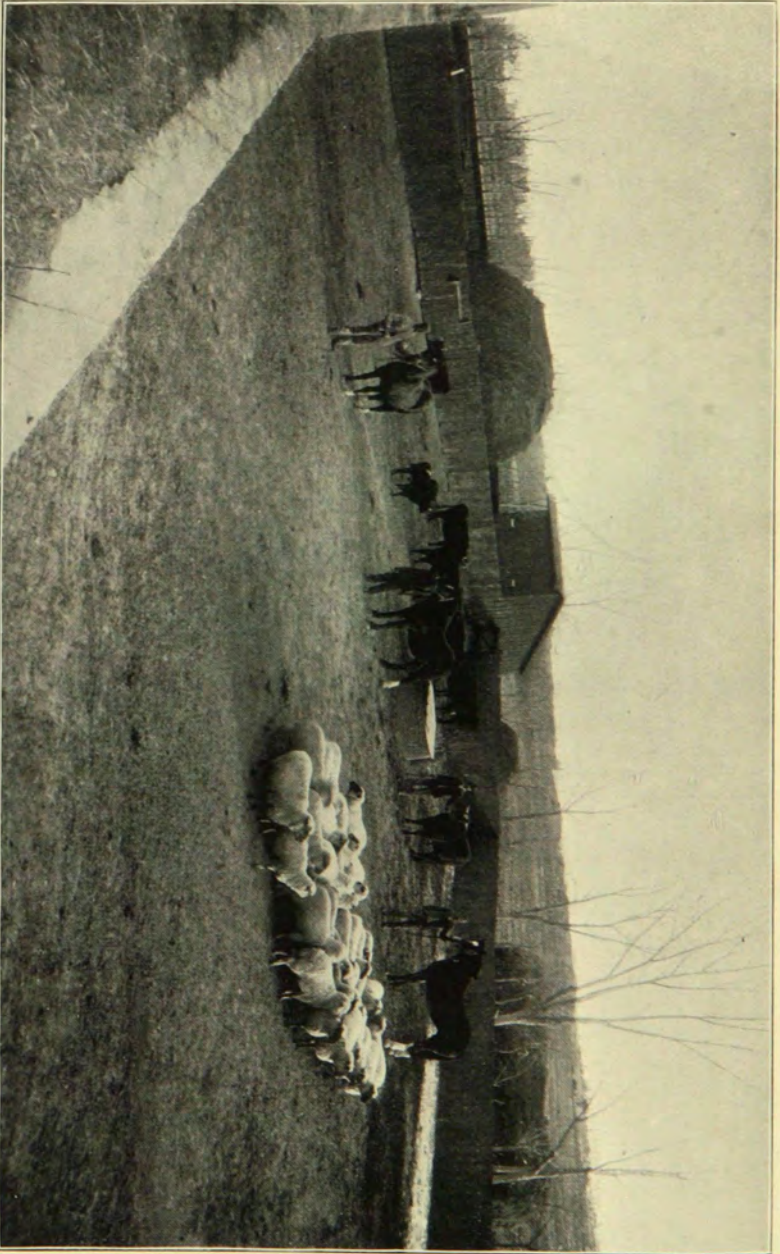
sistance. An alternating electric current is used and the resistance found by the use of a rheostat.

Before placing the instruments in the soil, it seemed desirable to thoroughly test the tabulated temperature corrections, and determine the accuracy of the apparatus. The resistance of these temperature cells ranges from 1,400 to 2,000 ohms, at 60°, and the change for one degree of temperature is from 5 to 20 ohms per degree, within the range of our temperature changes. As this is a variation which can be determined by ordinary means of measurement, it was at first hoped that these instruments would furnish the means for much more sensitive determinations of soil temperatures than the thermometers hitherto in use, and when once provided with a rheostat box, the expense of additional tubes would be nominal. The accuracy has not, however, been as great as hoped for.

Probably three weeks were taken in these tests by Mr. Stannard. The results were disappointing so far as leading to any very accurate results. Single readings varied at times over two degrees from the correct temperature.

#### WATER SUPPLY.

Continued record and study has been made on the Poudre river, the stream nearest to our door and which is typical of the streams which supply nearly all of the water for irrigation in Colorado. Its study has thus been of more than local application. We now have fifteen years of continuous record, for most of the time made with the self registering instrument, and thus have not only a longer but a more complete record than any other stream in the West. Additional attention has been given during part of the time to the questions pertaining to the watershed, and rain-gages have been put in the hands of observers who would furnish observations on rainfall. It has been difficult to find people who lived where such observations were desirable, and to find those who would be interested in tak-



EXPERIMENT STATION—SOME ANIMALS TO BE SEEN ON COLLEGE FARM.



ing them. But the data thus obtained is of value not only for this stream, but as an indication of the fluctuations in the other streams in the State. The general conditions which cause high or low water are more than local, so that it is often the case that the various streams reach high water on the same day.

The sheets on the instruments have been changed weekly, requiring a visit to our rating station, which is about fourteen miles from the College. The results of these weekly records have been furnished in manuscript or mimeograph copies to the papers in northern Colorado, and for a portion of the year, through the courtesy of the Fort Collins Courier, printed slips have been sent to other papers. The reports have been furnished to the papers in northern Colorado and to a number of ditch companies or those specially interested in the distribution of water. Altogether 28 of such weekly reports have been issued. These have been printed widely in the local papers and in the Denver dailies, and occasionally in papers as far south as Pueblo. The weekly distribution of the report has thus sometimes reached as high as 150,000 copies. These reports were begun some five or six years ago as a matter of accommodation to the local irrigation interests. As the printed slips have been furnished gratuitously, I could not urge the printing office to lay aside profitable work to print them. In consequence the reports have sometimes not been distributed until too late in the week to reach some journals before their day of publication, and therefore have not been as useful as they would otherwise have been.

There is no good reason why these slips should not be printed as special bulletins of the Experiment Station, and thus distributed under the Station frank. By so doing a small sum that is now expended for postage can be paid to the printing office, and we can consistently expect that the printing will be done promptly. Thus without greater expense than at present they may be made more useful, and the distribution can also be made more

widely than at the present, when from 40 to 80 copies are distributed weekly.

A portion of the last weekly bulletin of the year of more than ephemeral value is herewith given.

"The year 1898 has been exceptionally low in its water supply. The small amount of snowfall in the mountains last winter gave indication of this and the little which fell early in the winter gave reason to expect that the late water would be unusually low, unless maintained by storms. These were the general features of the year, and while the rains of May were abundant the dry ground absorbed a large proportion of the rainfall, and a relatively small amount reached the river. Fortunately, storms have helped out the year to some extent on the Poudre, but not so much as on the Arkansas; nevertheless the stream has been abnormally low.

Since the early settlement the areas of forest have become much less from fires, and by denudation for mining and railroad purposes. The amount used for domestic purposes is of small importance, except as careless and irresponsible cutting gives conditions favoring the start and spread of the devastating forest fires. From the standpoint of the water supply on which our agriculture depends, the protection of the forests becomes of vital importance. The protecting influence of the forests on the snow cover is of the greatest importance. The letting in of the sun and wind melts and evaporates the snow without sensible formation of water, dries the springs and lessens the amount of water available for use. It is safe to say that with the former forest cover, even with the small snowfall and little rainfall of the past year, the low stage of the river would not have fallen to 34 feet as it did this year. It would have been several times more, for the innumerable small springs would have continued their supply. If the forest cover continues to be removed, autumns of low water like the present will cease to be exceptional, but become the rule, the river will be lower than it has been this year, and may become as dry as some of its tributaries.

During the current year, starting with an average of 184 second feet for the week ending April 26, the river rapidly rose after the middle of May. The highest of the year was the week of June 21, which averaged 1543 feet. Then the river rapidly dropped, the next week to 1200 feet, and the week following to 744 feet. By August 1, there was only 220 feet. Early in September there was only 100 feet, and by October 1 it had reached the unprecedented low stage of 34 cubic feet per second. After a couple of weeks the early snows in the mountains had the effect of raising the river.

In comparing with previous years it is instructive to compare with the high water and with the average for the whole season.

Taking the record by years, the closing dates of the weeks of high water and the average for the week have been given as below. The dates of high water are the resultant of the amount of snow, the periods of warm weather, and the effects of rains, and no attempt to distinguish the causes is made.

Year.	Week Ending.	Average for Week.
1884.....	June 14.....	5071
—.....	June 28.....	5075
1885.....	June 7.....	3330
1886.....	May 31.....	2439
—.....	June 14.....	2120
1887.....	June 7.....	2400
1888.....	June 14.....	1240
1889.....	June 7.....	1545
1890.....	May 31.....	1592
1891.....	June 14.....	2692
1892.....	June 28.....	2057
1893.....	June 14.....	2445
1894.....	June 7.....	3196
1895.....	June 14.....	2914
1896.....	May 31.....	1736
1897.....	June 14.....	2220
1898.....	June 21.....	1543

The average for the 27 weeks of 1898, from April 26 to November 1, has been 451 cubic feet per second, an amount less than for any other year of which we have record except 1888, when the average fell to 400 cubic feet per second. After the middle of July the river fell lower than in 1888, the higher average being due to the higher water in May and June.

For the period of 27 weeks the record in the different years has been as follows:

Year.	April 26 to Nov. 1.
1884 .....	1761
1885 .....	1196
1886 .....	747
1887 .....	720
1888 .....	400
1889 .....	482
1890 .....	567
1891 .....	671
1892....(May 17 to September 6, only).....	753
1893....(May 10 to September 6, only).....	815
1894 .....	804
1895 .....	914
1896 .....	520
1897 .....	793
1898 .....	451

The year 1898 has thus averaged but little over one-fourth of the amount received in 1884 for the corresponding time and if deduction be made of the water received from other watersheds it would be less than one-fourth.

The river water of 1898, during this 27 weeks, if applied to the whole of the irrigated area of the valley, which may be called 130,000 acres, would cover it to a depth of about 16 inches. The rainfall during the same time has been about 8 inches, or the total moisture has amounted to about 24 inches, which would be increased by the amount stored in the various reservoirs during the winter and spring."

It has been increasingly evident that in the study of many of the questions of irrigation, a simultaneous study of the water conditions below the surface of the soil, and of the quantities and times of application of water at the surface is needed. It was mentioned in the last report that continuous records had been maintained for several years of the height of the ground water in a disused well, and records on small holes of a moderate depth near by. During the present season, a similar trial has been made on a larger scale, a series of wells extending to the foot hills four miles away, being taken. Wells already sunk were used. Their elevations were obtained by running a line of levels connecting them. The distance from the surface of the water was determined weekly. The uppermost well was above irrigation ditches. The trial was tentative to find out the character of the questions involved and to determine what might be expected to be settled by such an inquiry, if carried out more fully. Enough is found to show that valuable information can be obtained by extending such an inquiry over a more extended area and made more complete, according to the topography, examining at the same time the canals and the irrigation records of the tracts. Such a record is very desirable in connection with the duty of water in irrigation and before the last word is said on the subject, such an investigation will be necessary.

The following table shows the weekly changes in level in the water surface. Some of the more marked changes of level are due to the irrigation of lands near the well.

Poore's well is above all irrigation, and as shown in the notes the water table is a considerable distance from the surface of the ground.

## MEASUREMENTS OF WATER SURFACE.

(IN FACT.)

Date.	Miller's.	Parsons.	Harris.	Zenner.	An- drews.	Ward's.	Poore's.
April 13.....							
April 19.....	0	.....	-.30	.....	+ .47	+1.63	+ .03
April 26.....	+ .02	-.14	-.10	+3.13	+ .48	-.15	+ .00
May 6.....	+ .56	-.11	+1.23	+3.67	+ .58	-.65	-.22
May 13.....	+ .60	-.05	-.13	+ .43	+6.10	+ .34	-.04
May 20.....	+ .39	+ .09	+ .80	+ .41	-5.46	+ .59	+ .09
May 27.....	+ .45	+ .13	+ .57	-.26	+ .18	+ .49	-.04
June 3.....	+ .25	+ .24	+ .45	-.67	-.04	+ .35	-.01
June 10.....	+ .28	+1.38	+ .30	+ .25	-.32	+1.27	-.04
June 16.....	+ .12	+ .48	+ .15	-.86	-.07	+ .54	-.10
June 24.....	+2.47	+1.24	+ .50	+ .03	-.23	-.27	+ .08
June 30.....	+ .21	+ .50	+ .56	-.40	+1.17	+ .48	-.00
July 7.....	-.70	+ .18	+ .78	-.31	-0.62	+ .54	-.08
July 14.....	-.05	+ .26	+ .56	-.30	+ .79	-.48	-.00
July 22.....	-.78	+ .37	+ .88	-.34	-.61	-1.16	+ .03
July 28.....	-.61	0	+ .41	-.25	-.59	-.39	-.01
August 4.....	-.50	-.01	+ .07	-.22	-.59	-.09	+ .05
August 13.....	+ .55	-.07	+ .57	+ .75	-.28	-.28	+ .09
August 18.....	-1.33	-.13	+ .02	+ .15	-.58	-.15	-.27
August 26.....	-.43	-.37	-.04	-.07	-.35	-.45	0
September 2..	-.04	-.35	-.34	+ .03	-.35	-.03	+ .06
September 17..	-.70	-.69	-.73	+ .04	-.68	-.90	-.03
September 24..	-.30	-.26	-.51	-.15	-.01	-.43	+ .01
October 4.....	-.35	-.38	-.68	+ .30	-.05	-.65	-.01
October 11.....	-.15	-.08	-.41	-.08	-.59	-.07	-.01
October 18.....	+ .66	-.25	-.35	-.17	-.32	-.19	+ .07
October 25.....	+ .65	-.24	-.39	-.23	+ .04		-.13
November 1..	-.05	-.10	-.30	-.06	-.03		+ .07
November 11..	-.27	-.22	-.50	+ .43	+ .40		+ .01
November 18..	-.18	-.15	-.31	+ .20	+ .13		-.02
November 25..	-.14	-.14	-.47	+ .09	+ .10		+ .01

Miller's well, observations generally taken 8-9 a. m. Distance to water from point 2 in. above ground at first observation, 11.81; at last observation, 11.18.

Parsons's well, observations generally taken 8-9 a. m. Distance to water from point 3 ft. above ground at first observation, 20.96; at last observation, 19.83.

Harris's well, observations generally taken 8-9 a. m. Distance to water from point 3 ft. 6 in. above ground at first observation, 23.85; at last observation, 21.56.

Zenner's well, observations generally taken 8:15-9:15 a. m. Distance to water from point 3 $\frac{3}{4}$  ft. above ground at first observation, 11.96; at last observation, 6.42.

Andrew's well, observations generally taken 8:30-9:30 a. m. Distance to water from point 3 in. above ground at first observation, 20.11; at last observation, 21.44.

Ward's well, observations generally taken 8:40-9:40 a. m. Distance to water at first observation, 4.58; at last observation, 4.69. Measured from point about 6 feet below general surface level.

Poore's well, observations generally taken 9-10 a. m. Distance to water from point 3 in. above ground at first observation, 29.93; at last observation, 30.34.

#### DUTY OF WATER.

Observations have been continued looking toward the further determination of the amount of water used in irrigation. These have included the continuance of the observations on a farm of 160 acres under the direction of J. H. McClelland of Fort Collins, devoted to mixed crops and on a native meadow belonging to Capt. W. M. Post of Fort Collins, both of which have been used for this purpose for the past eight years. Owing to change of management, other farms in the vicinity of the Agricultural College used in previous years were not used for this purpose this season. Three of the instruments which have been used to record the amount of water were transferred to the Arkansas valley. We were then fortunate in obtaining the aid of some of the most successful and widely known horticulturists in the valley. Measurements were maintained at Cañon City on one of the largest orchards of that region, belonging to Hon. B. F. Rockafellow, also on a part of the Frederica mesa under the Bessemer ditch near Pueblo; at Rocky Ford on a portion of the fruit farm belonging to Hon. J. H. Crowley, on a portion of the sub-station farm of the Experiment Station under the superintend-

ence of H. H. Griffin; and at Holly on the newly established fruit farm of W. F. Crowley.

The valley at Cañon City is at the base of the mountains, and is widely known for its fruit interests. The orchard of Mr. Rockafellow is one of the oldest and finest of that region. It is devoted to apples, cherries, grapes, etc., principally, and has been in bearing for several years, its commercial success being well known. The water used on 41 acres was measured. A flume was put in place and a recording instrument, being attended by Philip Sheridan, who had immediate oversight of the place and attended to its irrigation. The soil is heavy. Across the river on the south side the soil is of quite a different character, being much lighter. It was hoped to conduct similar measurements under those conditions at the same time, but the lateness in organizing the work precluded an attempt this year. Arrangements are made for next year, however, whereby it is expected to have the use of the fruit lands on that side in comparison.

In addition, the Fruitland Ditch Co. at Cañon City were kind enough to supply full information of the amount used by them day by day throughout the year, and also for the previous years since their pumping plant—said to be the largest west of the Missouri river—has been in operation.

The fruit farm of J. H. Crowley at Rocky Ford is well known. A portion of mature trees, including apple, plum, cherry, peach, is situated close to one canal, not convenient for measurements. A part, about 23 acres above the canal mentioned but below another canal, was more conveniently located for such purpose. This portion, planted to fruit for a few years, was kindly furnished by Mr. Crowley.

This orchard gave one of the clearest instances of the effect of cultivation in conserving moisture as shown by its effect on the growth of the trees that I have seen.

The Experiment Station farm or as much as could be supplied through one measuring box was used, and the record kept by Mr. Griffin.



On the Frederica mesa a tract of 219 acres was kindly placed at our disposal by the kindness of Mr. C. K. McHarg. A box was put in place by Mr. Hawley and the measurements made by Mr. Petrie.

Mr. W. F. Crowley, the superintendent of the Arkansas Valley sub-station in 1897 and formerly well known as a young horticulturist of great activity and promise, started an orchard on the plains north of Holly and under the Amity Canal early in the Spring. I had happened to see the tract of land as it lay in unbroken prairie but a short time before. It is generally believed that the need of land for water becomes less after a few years. This was an excellent opportunity to observe the change, if any from the first use of water. Mr. Crowley took a keen interest in the attempt, putting in the box and caring for the instrument. Mr. Crowley is a skillful irrigator and the results of the measurements will be of great interest. As there had been no previous irrigation given in the immediate vicinity, it affords a model case of original irrigation. The only draw-back is that it is over 300 miles from the Home station, and the opportunities for examination are not so frequent as desirable.

A survey and topographical map has been made of each of the tracts thus used during the past year, and will form the basis of the more detailed measurements for the next year, which is hoped to begin earlier in the year, in order to include all of the irrigation season.

None of the measuring weirs or instruments could be put in place as early the past season as desired, as the question whether funds could be used for the purpose was not decided until July.

By that time the most important irrigations of the season were over, and the results that we obtained are only for a portion of the year. They however will show the amount of water used in these special irrigations and give means of estimating the amount used for the whole season. They will insure that tracts with boxes in place will be ready for next season's operation. These meas-

urements need to be carried on more extensively and are very desirable to extend.

In addition to the tracts above mentioned, the information from other sources, as from ditch companies that maintain a system of measurement will materially increase the amount of data available.

At this date the observations resulting are not reduced and the results of the determination cannot be given. We have now some six years' continuous observations since the Bulletin 22 on "The duty of Water" was published in 1892, enough to warrant another and more extensive investigation of the data at hand.

#### SEEPAGE MEASUREMENTS.

We have made in round numbers some 1,200 linear miles of river measurement to determine the loss or gain from seepage since bulletin No. 33 was published on this subject in 1896. These measurements have included three on the Poudre, one on the Platte in connection with the State Engineer's office, two on the Arkansas from the mountains to the State line, three on the Rio Grande in Colorado, two on the Big Thompson and the Little Thompson, and one on the St. Vrain.

The first measurements on the Big Thompson and on the Arkansas were made in 1897, on the St. Vrain, in 1898. We have found from experience that the first year's measurement is usually defective, the first trip being required to learn the location of the headgates, the roads or paths to get to them, the location of the wastegates, and in general obtaining the detailed local knowledge necessary to prevent oversight of important points, or in order to select the most desirable points for gaging, accessibility and topographical features being considered. The Water Commissioner usually possesses this detailed knowledge in his district. Still we have often had occasion to visit ditches which the Commissioner had never seen, the ditch perhaps having an early appropriation and thus requiring no regulation

from the Commissioner. We have sometimes found disturbances brought in from wastegates which had been overlooked by not learning that there were several sets. The measurements after the first year have usually been free from such errors.

At the time of writing the last annual report late in November, 1897, the measurements were reported in progress on the Arkansas river. The river at that time contained considerable water and was at times difficult, if not dangerous to wade. The water was sometimes breast deep. The temperature was low, and before the 200 miles were completed the water was at freezing temperatures and running slush ice. At one place the observer lost his footing and was entirely submerged.

The work was simultaneously carried on in two field parties. I was able to do but little myself, the first attempt in October having been stopped by a heavy storm. The measurement of 1898 was more satisfactory, both because of the detailed knowledge gained in 1897, and because the river being lower the gagings were more easily made by wading.

From Cañon City to Pueblo, a distance of 40 miles, for a large part of the way the river is in a chasm with no wagon road convenient to the river. The measurement was made by covering the distance on bicycles along the railroad grade. Below Pueblo horses were used and the assistance of Water Commissioners Reece and Cressey and of the Fort Lyons, Lamar and Amity Canal companies through P. J. Preston, A. E. Bent and W. M. Wiley, is gratefully acknowledged.

I was able to pass personally over the ground in detail for most of the distance from Cañon City to the State line. I gave more particular attention to the conditions affecting seepage, and to a study of the geological stratigraphy as it bears on seepage, and find a close relation between the rock strata and the gain and losses from the river.

Wherever the drainage of an important watershed discharged into the main river, it was desired to take a

measurement both above and below to obtain a measurement of the water entering the stream in the sands, if any such existed.

Before starting the measurement, the names and the location of the headgates were determined as far as possible, and from general knowledge of the country and from the topographical maps, which though often seriously incorrect, were found useful. The points of gaging were selected. Blue prints were made showing the available information, and typewritten sheets of instruction of which the following is an example, were given to the observers.

The points selected for gaging stations were chosen from their accessibility, from their being critical points in the topography, or at some place where the information was desirable, as at the head of important ditches.

#### INSTRUCTIONS IN SEEPAGE MEASUREMENTS, DISTRICT 14.

Water District No. 14, Carlile Springs to Nepesta. River gaging No. 4. At Carlile Springs, on west side of Pueblo County.

No. 5. Head of Bessemer ditch, distance 9 miles.

No. 6. At Rock Cañon, distance 4 miles.

No. 7. Above Pueblo, about opposite or a little below the Insane Asylum, distance 5 miles.

Gage Fountain creek at its mouth.

No. 8. Below the Fountain, and below Pueblo. This should be about a mile below the Fountain, or if the roads are more convenient, about two miles. According to the map the road seems to reach the river on the north side about two miles below the mouth.

Gage the St. Charles near its mouth.

The St. Charles needs to be gaged above the Bessemer ditch; this can probably be done by L. G. C.

No. 9. Gage the river below the St. Charles, distance 6 miles. This can be at the road crossing about a mile below the St. Charles.

No. 10. Above the Huerfano, above the plain formed by the river. Gage the Huerfano, or see the amount of water it contains. It will probably be dry.

No. 11. Gage below the Huerfano. A favorable place about a mile below, near the head of Bob Creek Canal, or, better, a little lower yet.

No. 12. The river at Nepesta at or above the rail-road bridge.

No. 13. Head of the Otero Canal. Measure all streams going in, and all canals taking water out.

MEMORANDUM OF DITCHES, IN ORDER, ALONG THE RIVER.

No. of Section.	Range of Township.	Name of Ditch.	Side of River.
1	68	Hobscn .....	North
16	67	Fields .....	North
15		Ritchie .....	South
23		Brooks .....	South
33	66	Bessemer .....	South
36		Hampbell .....	South
31	65	West Pueblo.....	North
27		Morey .....	North
27		Haden .....	North
34		Riverview .....	South
34	65	Pueblo Water Cos.....	South
4	64	Barnum .....	South
18	64	The Arkansas.....	North
16		I. N. Sater.....	South
32		The Booth.....	North
35		Warrant, Barnes & Baxter.....	North
32	63	Excelsior .....	North
6	62	Ballow Hill.....	North
8		Collier .....	South
10		Colo. Canal (Bob Creek).....	North
1		Arkansas Valley.....	North
17	61	Rocky Ford High Line.....	South

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No. of Section.	Name of Township.	Name of Ditch.	Side of River.
16		Allen .....	South
31	60	Enterprise .....	North
31		Oxford Farmers.....	South

## SEEPAGE GAINS AND LOSSES, ARKANSAS RIVER.

The following summary shows the seepage gains and losses that were found on the Arkansas river in 1897 and 1898, the measurements being given in cubic feet per second.

Place.	Dist. Miles.	Area of Tribut'y Water-shed Sq. Miles	1897.		1898.	
			Gain. Sec.	Loss Ft.	Gain. Sec.	Loss Ft.
Canon City to Bessemer ditch.....	33	1,481	54.40	....	55.17	....
Bessemer to Pueblo.....	10	255	....	42.18	....	15.96
Pueblo to Orchard Grove.....	8	1,101	....	9.40	19.41	....
Orchard Grove to Boone.....	16	1,335	103.47*	....	20.30	....
Boone to Nepesta.....	10	2,235	40.44	....	....	17.65
Nepesta to Otero Canal.....	8	182	....	5.78	....	11.00
Otero Canal to Apishapa Creek.....	7	57	16.90	....	18.15	....
Apishapa Creek to Rocky Ford.....	16½	1,667	30.55	....	31.21	....
Rocky Ford to Fort Lyon Canal.....	9	749	35.59	....	22.39	....
Fort Lyon Canal to La Junta.....	3	88	13.04	....	8.20	....
La Junta to Jones Ditch.....	11	115	10.85	....	14.76	....
Jones Ditch to Las Animas.....	9	193	28.51	....	20.08	....
Las Animas to Old Fort Lyon.....	6	3,509	38.14	....	13.26	....
Old Fort Lyon to Caddoa.....	11	660	3.63	....	....	0.16
Caddoa to Amity Canal.....	10	445	....	....	....	6.64
Amity to Lamar.....	11	256	....	....	6.68	....
Lamar to Holly.....	30	461	13.21	....	14.20	....
Holly to Coolidge, Kansas.....	7	1,171	....	....	....	....
Total .....	215	15,960	387.43	57.36	243.81	51.41
			57.36		51.41	
			330.07*		192.40	

\*Evident error.

\* Assuming the result of 1898 from Orchard Grove to Boone as correct, the gain would be 250 ft.

The river as it crosses Colorado, passes through several basins caused by the folding of the rocks. The larger one has its western rim at Rock Cañon, a few miles west of Pueblo, and the eastern rim near Old Fort Lyon, about 15 miles east. The rocks also dip to the north away from the river. The significance of this latter condition, is, that so far as the water penetrates these rocks it does not return to the river, but is lost to the agriculture of the valley. If the water thus taken up is considerable, it means a serious loss to the valley.

Practically the measures seem to indicate that at the places of cutting through the sandstones above Pueblo and from Old Fort Lyon to the Amity Canal, there is a loss, while in between there is a gain with few exceptions.

My studies on this point this year have not been extensive or detailed enough to warrant any conclusive statement further than to say, that the facts so far found seem to indicate that this loss is not so serious as has been feared. The conditions of the north side of the river especially under the larger canals, like the Colorado, the Holbrook, the Fort Lyons and the Amity, need to be examined more in detail for evidence bearing on this subject.

On the Platte the understanding with the State Engineer was that his office would make the measurement in 1897, and he was preparing to make it in 1898. We coöperated in the measurement in 1896. I wish to make a further examination of this valley giving more special attention to the conditions relating to seepage, before publishing the results made since those detailed in Bulletin 33. The conclusions there given have been strengthened by the subsequent development.

#### SEEPAGE MEASUREMENTS ON THE BIG THOMPSON.

The measurement for seepage on the Big Thompson and Little Thompson were referred to in the last annual report. The measurement in 1898 was postponed beyond

the time desired, because the water was being changed from one ditch to another giving daily a new condition of the river outflow. Until the conditions became more stable it seemed useless to make the measure. The valley is one of the oldest in the state. Some water from this stream irrigates area which is tributary to the Poudre river and a little land tributary to the Little Thompson is irrigated by water from the St. Vrain.

The following is a summary of the results of the two years.

	1897.	1898.	Distance. Miles.
Handy to the Home Supply Canal.....	0	....	1.0
Home Supply to the Barnes Ditch.....	15.78	8.13	5.7
Barnes Ditch to the Loveland & Greeley.....	4.62	3.52	3.1
Loveland & Greeley to the Big Thompson Ditch..	12.38	13.31	10.5
Big Thompson Ditch to the Hill & Brush.....	4.52	6.62	5.3
Hill & Brush to the Big Thompson & Platte.....	12.42	9.59	10.6
Big Thompson & Platte to the Evanstown Ditch..	14.36	11.59	11
Total .....	64.08	52.74	47

#### ON THE LITTLE THOMPSON.

	1897.	1898.
From Eagle Ditch to Dry Creek.....	1.35	3.16
Dry Creek to Rockwell Ditch....	2.77	1.52
Rockwell to Miner Ditch.....	2.43	1.32
Miner Ditch to Mouth.....	4.08	2.59
Total .....	10.63	8.59
Total for both Big and Little Thompson....	74.71	61.63

It is noticed that the increase in 1898 is less than in 1897, probably due to the smaller water supply in the past year. The measurements are given in cubic feet per second.



## ON THE ST. VRAIN.

The St. Vrain creek rises in the high mass of mountains from the south slope of Longs Peak southward to the headwaters of Boulder creek, and waters one of the most fertile of the tributary valleys of the Platte.

The following were the gains found in the measurement made Oct. 26-28, 1898 by Mr. Trimble with the aid of Mr. L. H. Dickson of Longmont, Water Commissioner of Water District No. 5.

	Distance, miles.	Gain, sec. ft.
From Lyons to the Oligarchy Ditch.....	3.7	2.63
From the Oligarchy to the Niwot ditch.....	2.7	3.24
From the Niwot to the Boulder-Weld Co. line.....	6.7	7.59
Co. line to Boulder creek.....	2.2	5.34
Boulder creek to Fleming place.....	5.8	4.21
Fleming place to Platte river.....	7.0	2.98
Total .....	28	25.79

This does not include the seepage return entering Left Hand creek, a tributary of the St. Vrain and which is supplied with water by ditches from the St. Vrain principally, nor seepage entering Boulder creek. Both of these streams need to be measured to include the return waters from their water sheds.

The amount of land irrigated from the St. Vrain is approximately 89,000 acres according to the report of Water Commissioner Dickson.

## THE RIO GRANDE RIVER IN COLORADO.

A measurement to determine seepage on the Rio Grande was made in 1897, this being the third year of measurement and the results are satisfactory. The measurement of this year again shows that the losses from the river in the upper part equal or exceed the subsequent gains of the remainder of the river in Colorado. I have attempted to get information bearing on the con-

ditions south of the San Luis valley which should confirm or disprove the hypothesis I had formed to explain the excessive loss, indicated by the loss from the river and by the disappearance of the numerous side streams. In 1896, I crossed the valley at the lower end and in 1897 took a hurried trip as far as Santa Fe, New Mexico, and crossed the valley in the vicinity of Espanola. Now it seems desirable to pass lengthwise of the valley from San Luis to Taos. The country is very sparsely settled and is mostly a barren country. By correspondence, I have been able so far to obtain little definite information which would serve to narrow the search for indications thought to be there.

In the measurement of the Rio Grande in 1898, it is noticed that the river begins to gain, or perhaps it would be better to say ceases to lose, at a point higher up than was noticed in 1896. Whether this is the effect of some fluctuation in the river or is an actual fact, is an important question. If the latter, it is significant in interpreting the greater amount of water taken by the valley. As this was not noticed in comparing the observations of 1896 and 1897, it emphasizes the need of caution in drawing conclusions before sufficient data is accumulated. Desire is sometimes expressed for results to be published before sufficient data is at hand, but it may be said that unless there are enough and long enough continued observations to make the conclusions more than probable, publication is apt to be more harmful than beneficial.

Gain in 1898.

From gaging station to Del Norte.....	-51.69
Del Norte to Prairie Canal.....	+ 2.11
Prairie to Monte Vista bridge.....	+ 6.26
Monte Vista to Kenilworth ditch.....	+ 8.82
Kenilworth to Hickory Jackson ditch.....	+18.10
H. Jackson to Alamosa.....	+ 2.78
Alamosa to Conejos river.....	+ 1.57
Conejos to Lava canon.....	- .92
	<hr/>
Total loss.....	13.17

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The measurement in 1898 was made from Aug. 19 to 25 by Mr. J. D. Stannard aided by Water Commissioner M. D. Blakey of Monte Vista. The last measurement was below the Mexican village of Los Sauces where the river enters a cañon.

CACHE LA POUFRE RIVER.

	1896.	1897.	1898.
	November.	October.	August.
Weir to Fort Collins Water Works.....	- 2.92	+ 1.39	- 7.76
La Porte to Larimer and Weld Canal.....	?	} 16.61	+ 0.41
Water Works to La Port.....			+ 8.75
Larimer and Weld Canal to No. 2 Reservoir			
Supply .....	- 5.68	- 3.96	+ 3.37
To Strauss Bridge.....	-22.87	- 2.90	+14.84
Strauss Bridge to No. 2 Canal.....	+16.41	+10.42	+ 1.23
No. 2 Canal to Eaton Ditch.....	+10.42	+13.36	+ 8.34
Eaton Ditch to Greeley No. 3 Canal.....	+ 5.77	+35.72	+15.44
No. 3 to Greeley Mill Power Canal.....	+16.64	?	+21.16
Mill Power Canal to Camp Bros. Ditch.....	+25.52	+26.57	+25.98
Camp Ditch to Mouth.....	+21.98	+23.58	33.37
Total .....			135.18

In 1898 measurement made Aug. 9-12 by R. E. Trimble and Prof. G. L. Swendsen Aug. 9-10, and the remainder by R. E. Trimble and J. C. Mulder.

In 1897, the measurements were made Oct. 7-14, by R. E. Trimble and R. Q. Tenney.

In 1896, the measurements were made Nov. 11-14 by R. E. Trimble and R. W. Hawley. Water was being changed from power to canal purposes and from night to day, causing fluctuation in the river and throwing doubt on one of the upper sections.

LOSSES FROM DITCHES AND CANALS.

Bulletin 48, issued in July, on "The Losses from Ditches," was intended to call attention to a source of loss whose extent had been little realized by the agricul-

tural community, to arouse attention to its importance, and to point out some practicable methods of lessening it. The importance of this source of loss is evident when we consider that from one-fourth to two-thirds of the water resources of every ditch is wasted without beneficial use. In one ditch measured this summer, which pumps water over 100 feet high, one-fourth of all the water is lost in the first half mile of ditch. It therefore takes one-fourth of all their coal to supply the waste in this extent of ditch. In another case the loss has amounted to 18 to 20 feet in depth at places.

As opportunity served during the year, additional measures of this type have been made, mostly on ditches in the Arkansas valley. This included a number of ditches around Cañon City and the determination of the losses on the whole length of the Bessemer ditch. As it will be some time before the subject is taken up in the form of a bulletin, some of the measurements are here given.

#### ORIGIN OF SEEPAGE WATER.

In the case of the Bessemer ditch, which extends some ten miles above Pueblo to about twenty miles below, the conditions are unique and are such as to enable a determination to be made of the amount of water entering the river from seepage from the canal and the land which it waters. In almost every case in the state it is difficult to determine the origin of the return water because several ditches are found one above the other, and the source of the seepage that is found thus becomes doubtful. Even in those cases where there is but one ditch, it is not at all sure that all of the water entering the river comes from this ditch, or that all of the water coming from the ditch is collected in a given stretch in the river. In the case of the Bessemer ditch, however, the mesa over which it extends is underlaid with a stratum of shale rock which slopes towards the river and forms a shelf along the bluffs of the river for the whole length of

LOSSES FROM DITCHES AND CANALS.

MEASUREMENTS IN 1898.

DATE AND HOUR	NAME OF CANAL	Temp. of Water	Amount of Water, Sec.-feet	Amount Withdrawn, Sec.-feet	Surface Width in Feet	Assumed Average Width in Feet	Depth in Feet		Average Velocity, Ft. per sec.	Distance from Previous Measurement, Miles	LOSS OR GAIN		Observer	REMARKS
							Average	Greatest			Second Feet	Depth over Canal, Feet in 24 hrs.		
July 20-10:40-11:20 a. m.	Greeley No. 3	72.5°	11.94		13.8		0.44	0.60	1.88				T.	
July 20-12 m	Greeley No. 3	74.5°	10.26	0	14.4		0.83	1.01	0.81	760 ft.	-1.68	-14.2	T.	Same place as measured in 1897.
Aug. 13-8:45 a. m.	Greeley No. 3	68°	7.06		13.6		0.32	0.45	1.63				T.	
Aug. 13	Greeley No. 3	68°	6.73	0	13.2		0.58	0.68	0.89	760 ft.	-0.33	-2.8	T.	Same place.
Aug. 10-2 p. m.	Hottell's Mill Race	81°	2		4.3		0.28	0.40	1.70				T.	
Aug. 10	Hottell's Mill Race	87°	1.19	0	8		0.70	0.70	0.20	4 m.	-0.81		T.	
Oct. 5-11 a. m.	Bessemer D, 34+37	56°	64.74		26		1.56	1.85	1.53				H.	At scouring gate.
Oct. 5-2:30 p. m.	Bessemer D, 372+90	55°	50.40	11.12	16		2.28	2.35	1.38	6.40	-3.22	-0.46	H.	At rating flume.
Oct. 5-5 p. m.	Bessemer D, 692+10	51.5°	43.98	2.23	15.5		1.63	2.30	1.64	6.05	-4.19	-0.73	H.	Flume No. 16.
Aug. 10-9:40 a. m.	Bessemer D, 692+10		59.61		16		2.87	3.30	1.30				H.	
Aug. 10-3 p. m.	Bessemer D, 1039+0	73.5°	32.12	15.62	17		0.95	1.55	2.00	6.57	-11.85	-1.82	H.	Lower end Siphon under the St. Charles.
Aug. 10-5:30 p. m.	Bessemer D, 1411+0		30.60	5.89	15		0.98	1.60	2.08	7.05	+4.37	+0.64	H.	Road crossing 3 miles southeast of Artmann.
Aug. 11-5:20 p. m.	Bessemer D, 1879+0		10.01	17.07	9.7		0.75	1.35	1.03	8.85	-3.59	-0.79	H.	Below headgate McHarg lateral.
Aug. 23-4:09 p. m.	Bessemer D, 1879+0	72°	7.11		6.2		1.20	1.60	0.95				H.	
Aug. 23-5:45 p. m.	Bessemer D, 2780+0	67°	4.21	2.04	6		0.87	1.35	0.77	5.70	-0.81	-0.38	H.	End of ditch.
Aug. 6-10 a. m.	Bessemer D, 34+37		62.56		19		1.60	1.72	1.80				H.	
Aug. 6	Bessemer D, 372+90		50.03	6.36	16		2.49	2.50	1.30	6.40	-6.17	-0.88	H.	
Aug. 6-6:20 p. m.	Bessemer D, 525+10		49.39	2.75	18		1.57	2.70	1.75	2.89	+2.21	+0.74	H.	Van Buren Street bridge, Pueblo.
Sept. 9	Bessemer D, 372+90	55°	53.21		16		2.42	2.50	1.40				H.	At rating flume.
Sept. 9-3:30 p. m.	Bessemer D, 550+0		52.14	0.31	14.5		2.01	2.80	1.66	3.35	-0.76	-0.25	H.	At street railway bridge, Pueblo.
July 9-3 p. m.	McHarg Lateral		20.51		10		1.54	2	1.29				H.	At headgate.
July 9-4 p. m.	McHarg Lateral		19.75		11	10	0.77	0.90	2.09	Estimated 2,000 ft.	-0.76	-3.30	H.	At first divisor.
July 23	McHarg Lateral		19.99		9.6		1.52	2	1.25				H.	Same as above.
July 23	McHarg Lateral		21.40		11		0.77	0.90	2.26	Estimated 2,000 ft.	+1.41	+6	H.	
Aug. 11	McHarg Lateral		5.70		5.7		0.63	1	1.53				H.	Same as above.
Aug. 11	McHarg Lateral		5.09		5.2		0.53	0.70	1.80	Estimated 2,000 ft.	-0.61	-4.88	H.	
Aug. 24-8 a. m.	McHarg Lateral	68°	4.73		5.4		0.61	1.55	1.40				H.	
Aug. 24	McHarg Lateral			4.80						1.9 m.	+0.07	+0.19	H.	For seepage on Frederica Mesa.
Aug. 10-11:30 a. m.	Hartig Lateral		1.16		2.1		0.50	0.80	1.12				H.	
Aug. 10	Hartig Lateral		0.90		1.8		0.62	1.10	0.76	1 3/4 m.	-0.26	-1.24	H.	
Aug. 5-5 p. m.	McGrew Lateral		1.28		1.2		0.22	0.22	4.83				H.	
Aug. 5-5:20 p. m.	McGrew Lateral		0.94		3.0		0.43	0.55	0.72	2 m.	-0.34	-0.93	H.	
Aug. 26-6:45 a. m.	Canon City Ditch	54°	31.97		10.2		1.12	1.50	2.57				H.	Near headgate in caou.
Aug. 26	Canon City Ditch		31.44	1.10	12.4		18.6	2.30	1.31	1.59 m.	+0.57	+0.49	H.	At Second Street bridge, crosses Sand Creek, in section.
Aug. 26-11:30 a. m.	Canon City Ditch	69°	25.23	6.95	8.8		1.55	1.65	1.85	2.15 m.	+0.74	+0.58	H.	At first flume E. of Canon City. Under Fruitland ditch.
Aug. 26-2 p. m.	Canon City Ditch	78.5°	0.70	20.69	3.0		0.23	0.35	0.94	3	-3.84	-3.54	H.	Waste at Four Mile or Oil Creek.
Aug. 26-5 p. m.	Mill Ditch	71.5°	24.20		7.0		1.42	1.60	2.30				H.	Opposite old smelter, Canon City.
Aug. 26-2:30 p. m.	Mill Ditch	72°	9.95	{ 14.31 } { -4.95 }	5.5		0.52	0.55	3.40		-4.89		H.	Flume over Four Mile Creek.
Aug. 30-1:50 p. m.	Deweese and Dye Ditch	81°	11.11		4.5		1.23	1.35	1.96				H.	At rating flume, near headgate.
Aug. 30-3 p. m.	D. and D. Ditch Sta. 158+40	80.5°	9.42	0.92	6.0		1.11	1.40	1.37	3	-0.67	-0.61	H.	Below Cemetery.
Aug. 30	Deweese and Dye Ditch		2.95	5.89	2.3		0.25	0.25	5.19	3.52	-0.58	-0.54	H.	On line 1/2 mile E. of W. side of Sec. 2.
Aug. 27-9:45 a. m.	South Canon Ditch		33.80		13		1.80	2.25	1.38				H.	At bridge at Hot Springs Hotel.
Aug. 27-12:35 p. m.	South Canon Ditch		21.44	8.81	10		1.57	1.90	1.32	2.20 m.	-3.55	-2.22	H.	At bridge above pumping plant.
Aug. 27-1:15 p. m.	Fruitland Ditch	73.5°	13.37		6.5		1.24	1.50	1.42				H.	Below reservoir connection with ditch.
Aug. 27	Fruitland Ditch		9.36	{ +1.00 } { -2.24 }	6.0		1.06	1.50	1.33	0.50	-4.01	-20.56	H.	At point of leaving shale hills.
Aug. 27-3 p. m.	Fruitland Ditch		8.53	{ +1.27 } { -8.74 }	3.75		1	1	2.27	1.09	+0.41	+1.27	H.	At 2d flume along line, over small creek.
Aug. 27-3:45 p. m.	Fruitland Ditch					2.25				1.32	-1.06	-4.42	H.	At Cone avenue.
July 30-3:15 p. m.	Catholic Ditch	79.5°	5.30		3.8		0.58	0.80	2.20				H.	Near headgate on Amity ditch.
July 30	Catholic Ditch		4.96		6.3		0.48	0.70	1.56	1 m.	-0.34	-1.11	H.	At first road south.
July 30	Catholic Ditch	78.5°	4.65		5.6		0.49	0.75	1.57	2.4 m.	-0.31	-0.36	H.	At second road crossing.
Aug. 1-10 a. m.	Las Animas Ditch	65.5°	17.15		4.9		1.72	2.90	1.87				H.	
Aug. 1-11:45 a. m.	Las Animas Ditch		16.96	1.48	6.0		1.57	2.10	1.70	1 1/2 m.	+1.29	+2.37	H.	North of Las Animas pump house. Passes under Jones ditch.
Aug. 1-12:30 p. m.	Las Animas Ditch		15.72		3.5		2.31	2.55	1.97	1 1/2 m.	-1.24	-2.73	H.	Road crossing east of Las Animas.
Aug. 23-11 a. m.	Excelsior Ditch	72°	5.77		11		0.80	1.15	0.62				H.	Below waste gates.
Aug. 23-1:20 p. m.	Excelsior Ditch	75°	4.81	6.81	9.6		0.56	0.90	0.70		+5.85		H.	At west side of orchard.
Aug. 23-3:10 p. m.	Excelsior Ditch	76.5°	0.41	4.40	2.5		0.23	0.40	0.62		+0.16		H.	At road crossing north from Chico bridge.

\* Water flowing into the canal is preceded by the + sign.

the ditch. It thus forces all the seepage to the surface, renders it evident, causes it to collect in streams at the edge of the bluffs and thus permits it to be measured. The opportunity was too exceptional to omit taking advantage of it, and in 1897 the measurement was made by Mr. Trimble from Pueblo to Grant Arroyo, and in the fall of 1898 by Mr. Hawley for the whole distance. It was necessary to walk most of the distance. Without entering into detailed statement of the measurements, it is sufficient to say that about one-half of the amount of water entering the river is derived from the losses from the ditch itself, the other half being supplied by the water which is applied to the farms by the farmers. When the whole conditions are taken into account and the flow throughout the year is considered, it is possible that the amount coming from the ditch will not be as large a proportion of the whole year's inflow, as during the irrigation season.

The general result is borne out by the measurement made in the valley around Cañon City. In this case the losses from the various ditches were measured and the gain of the corresponding stretch of the main river. The gain in the river was found to be about twice the loss in the ditches. This measurement is not so conclusive as in the case of the Bessemer ditch, because of the uncertainties in the measurement of the river and from several other conditions.

Some systematic attempt was made during the year to obtain photographs showing the methods of irrigation with view to use in connection with studies that have been more or less systematically made for a number of seasons. We have found in the past that when postponed until the latter part of the summer, as the demands of field work at the earlier part of the season has usually required, the growth of plants and weeds have prevented obtaining successful photographs. It is both hard to find the conditions which shall clearly show the points desired, to find the application of water and to find the state of vegetation such as to exhibit the meth-

ods desired. In the several days' trip made for this special purpose, a few, but only a few, successful photographs were obtained.

#### ACKNOWLEDGMENTS.

The work of the Section could not have been as successful without the conscientious work of those connected with the department: Mr. R. E. Trimble, assistant in the Experiment Station, on whom has devolved the details of the local observations at Fort Collins, and much of the reduction; Mr. J. D. Stannard, assistant in the College, who has helped with some charts and with the seepage measurements in the San Luis valley; R. W. Hawley, who aided in the field in the Arkansas valley from July to December; J. C. Mulder, principally in office draughting during the summer vacation; W. R. Headden, in office work for a couple of months during the summer, and Miss Ella Goldsborough, for typewriting services during the rest of the year.

We are indebted to many throughout the State for material services, rendered at considerable expense of time and expense to forward the investigations in progress. Among these are Henry Earle, manager of the Fruitland Ditch, who has materially helped with obtaining valuable information and freely placed the records of his company at my service; Dr. J. L. Prentiss, also of Cañon City, proprietor of the Hot Springs Hotel, who has taken daily samples of water for the determination of sediment; Philip Sheridan, in charge of the irrigation of the orchard of Hon. B. F. Rockafellow at Cañon City, who has taken care of the instrument and record intended to record the water used in irrigation; Hon. B. F. Rockafellow, for the use of his orchard as a field for observation. At Pueblo Mr. C. K. McHarg, manager of the Bessemer ditch, and Hon. J. S. Greene, ex-State Engineer, took active interest in the measurements and investigations and were instrumental in having land placed at our disposal, as well as aiding with the Bessemer

ditch; Water Commissioner Reece, who has not only aided with records, but assisted for several days in the seepage determinations along the river; Mr. Bentley, superintendent of the Bessemer ditch, also gave material aid, as did Messrs. Taylor and Keasby, of Vinland, in the arrangements for determining the duty of water. At Boone, Messrs. Philip and ——— Burton, Deputy Water Commissioner, aided in the stretch of the river to Nepesta. At Manzanola, Mr. M. D. Lyle, superintendent of the Fowler ditch; in water district 17, S. W. Cressey, Water Commissioner for that district, actively aided in person and with vehicle in the measurements; Hon. J. H. Crowley, in the use of his orchard and in many other ways; Mr. Harvey Griffin, superintendent of the Arkansas Sub-Experiment Station; and the Hon. A. L. Kellogg, President of the State Board of Agriculture, whose intelligent interest helped in rendering the work possible.

At Las Animas Mr. P. J. Preston, superintendent of the Fort Lyon Canal system, one of the longest in the United States, and Mr. C. W. Beach, an engineer for the same company, both graduates of the Agricultural College, took active interest in the work, expended time, furnished transportation, and Mr. Preston was instrumental in putting the facilities of the canal at our disposal. Hon. A. E. Bent and Thos. Berry, of Lamar, president of the Lamar Canals, and engineer in charge of the Amity Canal, E. C. Hawkins, chief engineer of the latter system, also aided by helping in the seepage measurements, in the sediment observations, in attempting to determine the losses from a long stretch of canal and in many other ways. Likewise Hon. W. M. Wiley, of Holly, the general manager of the Amity and other canal systems, placed every facility at our disposal, arranged in many ways to facilitate the work and to render it possible. W. F. Crowley, of Holly, placed his fruit farm at our service, constructed weirs and maintained the observations on the water used. W. F. Montgomery, connected with The Great Plains Storage Company, also aided, as did numerous others connected with the company.



Mr. H. O. Brown, a graduate of the College living at Salida, took an interest in the sediment observations and began their collecting.

In the San Luis Valley, M. D. Blakey, of Monte Vista, Water Commissioner of district No. 20, helped in the seepage measurements on the Rio Grande. A number of others helped in various ways, as M. B. Colt, at Alamosa; W. R. Hapney, of Alamosa, with information concerning artesian wells, and observations on their pressures.

Hon. L. H. Dickson, of Longmont, Water Commissioner of district No. 5, aided for several days in the measurement of the seepage on St. Vrain creek.

J. H. McClelland and W. M. Post permitted their farms to continue to be used as a field of experiment, and Mr. McClelland actively aided in the collection of the data desired.

Mrs. F. W. Sherwood, of Glen Eyre; Geo. Barnes, of Pinkhaptton; Carlyle Lamb, of Estes Park; P. H. Boothroyd, of Arkins; C. B. Andrews, of Home P. O. and Fort Collins, all aided materially as volunteer observers, as did John Deaver, of Home P. O.

Mr. Enos A. Mills, of Estes Park, took a special trip to the top of Long's Peak, at an elevation of nearly 14,300 feet, in order to make simultaneous actinometric observations in connection with myself, who took observations at 9,000 feet.

Also to Messrs. Frank Trumbull and Henry Michelsen, of the Union Pacific, Denver and Gulf railway, and to Messrs. Paul Morton, vice president, and J. E. Frost, land commissioner of the Atchison, Topeka and Santa Fe railway, for important courtesies, without which the work of the summer could not have been carried on.

Our thanks are due to all of these, besides many others who have aided in a lesser degree. The assistance has been freely rendered, and has served to stretch the possibilities of the funds placed at our disposal.

Nor should many of the press of the State be omitted from the list. Their support has materially aided

the work. I would especially mention the Fort Collins Courier for its gratuitous publication of the weekly river bulletins, and the furnishing enough slips to send to the ditch men and papers of Northern Colorado.

Thanking the Committee for their active support, this report is respectfully submitted.

L. G. CARPENTER.

*Meteorologist and Irrigation Engineer.*

December 14, 1898.



## Report of the Rainbelt Experiment Station.



*To the Executive Committee of The State Board of Agriculture:*

Gentlemen—I herewith present the Fifth Annual Report of the Rainbelt Experiment Station.

The season of 1898 was the shortest in the history of the Station. Snow fell May 1st, accompanied by a severe storm which did considerable damage to young cattle on the range. Then a severe snowstorm occurred September 10th.

Planting was delayed on account of the ground being too wet to work during the first ten days of May. The season continued to be favorable for crops until towards the last of July, when dry weather at critical periods cut down the yields of many very promising crops.

The following table shows the precipitation at this Station from the time record-keeping began until the present:—

	1894.	1895.	1896.	1897.	1898.	Means.
January .....	.67	.45	.26	.03	.03	.35
February .....	.27	Tr.	.10	.00	.00	.09
March .....	.16	.71	1.58	.61	.61	.77
April .....	1.67	3.41	1.20	2.20	2.20	2.12
May .....	1.46	2.28	1.44	5.54	5.54	2.68
June .....	.48	2.69	3.03	2.22	3.95	2.47
July .....	1.99	6.38	2.27	4.19	2.09	3.38

	1894.	1895.	1896.	1897.	1898.	Means.
August .....	1.03	1.22	3.07	3.24	1.33	1.98
September .....	.14	Tr.	.84	.92	2.00	.78
October .....	.14	.21	.78	2.73	....	.96
November .....	.00	.30	.00	.10	...	.10
December .....	.55	.42	.60	.20	...	.44

The crops were planted according to the schedule. All crops on the special schedule were cultivated carefully as in past years, but the south half of the cultivated land was planted to sorghum and millet and allowed to produce what it would without further attention. Light crops of fodder were cut from the south half of the field; but that which received special care yielded fair crops or forage.

The small grain was all cut when in the dough stage, except small plats which were left to mature seed for the purpose of estimating the yields. According to the schedule, all small grain was to be planted by the "Campbell Method," so all planting was delayed until after the sub-surface packer arrived, April 25th.

#### HORTICULTURE.

All forest trees have made a good growth this year. The wind-break around the orchard, composed of ash, black locust, and Russian mulberry, now affords considerable protection. In the spring of 1897, seeds of black locust, black cherry, red mulberry, Russian mulberry, and box-elder were planted. None germinated last season except the black locust, and the seedlings from these are now five feet high. The box-elder and black cherry seeds came up this season, and the seedlings are about a foot high.

All fruit trees have grown well. None has died since the last report.

The standard cherry trees bore some fruit this year. The Rocky Mountain cherry trees were loaded, as usual, with fruit, which, for all ordinary purposes, is worth-

less. The plum trees bore a small quantity of fine fruit. The gooseberry bushes bore a heavy crop of extra fine fruit. Two Missouri Pippin apple trees blossomed, but dropped their fruit before it matured.

Two dozen seedling peach trees have been grown this year from pits planted here. They appear to be quite healthy.

#### THE GARDEN.

Good yields of various garden crops were produced. Salzer's tree bean yielded especially well. It seems to be the bean to plant here instead of the Navy bean, which does poorly in this region.

The melons, squashes, cucumbers, and pumpkins were planted just before a heavy rain. The rain packed the ground so hard that but few of the plants came up, and these did not grow well. A few melons of good quality were produced.

Fifteen varieties of sweet corn were planted May 18th. From these, roasting ears were used from July 26th until September 25th. The best varieties this year proved to be Maule's First of All, Black Mexican, Early Bonanza, Nonesuch, New Champion, Country Gentleman, and Egyptian. These came into roasting ear in the order named. All these varieties produce ears which are long enough so that a worm can live happily and eat all he needs, while there will still be a good-sized roasting ear left for the table.

Queen's Golden and White Pearl pop corn made good crops.

Parsley, anise, sage, and upland cress were added to the list of garden crops which do well in this region.

Irish potatoes were a poor crop here this year. The earliest varieties got a good start before the beetles attacked them, and made a fair crop. The Early Six-weeks, Early Ohio, and Early Montana made the best yields. The late varieties were so damaged by the beetles that we may call them total failures. The vines

were kept covered liberally with Paris green from the time the beetles began to come until late in the season. But as soon as one horde of beetles would eat and die, another moved in to commit suicide in the same way, until the vines were completely defoliated and some of the stems eaten into the ground.

I furnished a small quantity of seed potatoes to a neighboring ranchman. His were early sorts, and were planted the first week in June. He reports a yield of 60 bushels per acre.

#### FIELD CROPS.

*California Barley*—Two acres were sown broadcast upon corn stubble, April 30th, and disced in. All except a small plat was cut for hay. The test plat showed a yield of 18 bushels per acre.

*Bromus inermis*—Two acres were sown to bromus inermis, April 30th, on deep-plowed ground, a part of which was packed with a Campbell sub-surface packer. A good stand was obtained. Some on high land died during a dry time in the summer, but there is still enough left to make a fair test of the value of the plant for hay.

*Alfalfa*—One-half acre of alfalfa was sown in May 1897. This was cut in June of this year, making a yield of a ton per acre. It did not grow high enough to cut again during the season.

*Other Forage Plants*—Eight varieties of non-saccharine sorghum, four varieties of cow peas, one of Canada field peas, and one of Idaho peas were planted on ground plowed eight inches deep and packed. All these were carefully cultivated.

The following table shows the yields:—

Kaffir corn No. 39, 12 bushels seed per acre.

Brown Duhra, 20 bushels seed per acre.

Jerusalem corn, 15 bushels seed per acre.

Red Kaffir corn, 5,320 pounds of fodder.

White Kaffir corn, 6,720 pounds of fodder.

Black-hulled White Kaffir corn, 6,565 pounds of fodder.

Black Rice corn, 4,970 pounds of fodder.

Yellow Milo-maize, 5,110 pounds of fodder.

Kansas Orange sorghum, 8,400 pounds of fodder.

Early Amber sorghum, 6,192 pounds of fodder.

Black-eyed cow peas, 6 bushels of seed.

Black cow peas, 1.5 bushels of seed.

Whip-poor-will cow peas, only a few pods matured.

Clay cow peas, only a few pods matured.

Idaho peas, 11 bushels of seed.

Canada field peas, 8.5 bushels of seed.

Red Kaffir corn, White Kaffir corn, and Kansas Orange sorghum failed to mature seed. Yellow Milo-maize, Black Rice corn, and Early Amber cane produced some mature seed.

#### THE USE OF GYPSUM.

A plat extending across a patch of land which had never yet produced a crop on account of some unknown qualities it possessed, was treated with gypsum at the rate of one thousand pounds per acre. This plat and another adjoining one were planted to Early Amber cane the same day. The cane was planted in rows with a planter drill. Both plats were cultivated alike. The crops growing on the two were cut the same day. After curing, it was found that the treated plat yielded 2,880 pounds of fodder per acre, while the untreated yielded but 1,620 pounds of fodder per acre, making a difference of 1,260 pounds of fodder per acre which seems to be due to the use of gypsum. In harvesting the crop, the barren spot could hardly be noticed on the treated plat.

#### MIXING CORN.

In this region, where hot winds are likely to blow at critical times, the corn crop is frequently an entire failure on account of a day of hot winds. The hot winds,



coming when the tassels are in blossom, kill all the pollen and thus leave the seeds unfertilized. If only one variety of corn is planted in a field and all is in tassel when a hot wind blows one afternoon, it will produce but a few ears. But, if a number of varieties which blossom a few days apart are planted, some tassels will escape the hot wind and live to fertilize many ears, thereby increasing the yield considerably. With this in mind, we made three mixtures for planting this year. The seed was chosen from the crop grown here in 1897. Six varieties of white dent were mixed for white dent. Eight varieties of yellow dent, and twelve varieties of flint were mixed to plant for flint corn. These mixtures were planted in separate plats. Each was thinned to two stalks in a hill, and all suckers were pulled off. After it tasseled, all stalks which had no ears started were de-tasseled so that no barren stalk could reproduce its kind. The corn grew well, but as no hot winds occurred during the blossoming period, we can not say that any gain resulted from the mixing of varieties. We shall choose the best matured ears from the strongest stalks for next year's seed, and hope to get a number of cross-bred ears for future use.

We have found that varieties of corn do better here after they are acclimated. So, we hope to produce a few "natives" by the process above described. It is a haphazard way of crossing, but is just what any farmer can do for himself and what most farmers have done either accidentally or purposely. We believe that the idea should be more used in this region, where our climatic conditions make it necessary.

#### VARIETIES OF CORN.

Twenty-two varieties of corn were planted. The following table gives the yields of the different varieties:—

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Variety.	Kind.	Bushels per acre.
1 Mercer .....	Flint	14.0
2 Houghton's Silver White.....	Flint	13.1
3 Sanford's Early.....	Flint	14.6
4 Waushakum (yel.).....	Flint	8.6
5 King Philip.....	Flint	13.4
6 Squaw .....	Flint	12.3
7 N. D. Flint.....	Flint	13.0
8 S. D. Flint.....	Flint	8.6
9 Golden Row (yel.).....	Dent	15.4
10 Angel of Midnight.....	Flint	8.6
11 New Leaming (yel.).....	Dent	10.8
12 Star Leaming (yel.).....	Dent	11.7
13 Parson's White.....	White flint	16.0
14 Murdoch's 90-day (yel.).....	Dent	10.0
15 Early Yellow Rose (yel.).....	Dent	8.6
16 Dakota Dent (yel.).....	Dent	10.8
17 Queen of the Field.....	Yellow dent	12.3
18 Queen of the North.....	Yellow dent	13.1
19 Early Huron.....	Yellow dent	4.5
20 Canadian Yellow.....	Yellow dent	9.6
21 White Cap Yellow Dent.....	White dent	12.6
22 Swadley White.....	White dent	13.1

According to the experience of this Station, and also of the settlers here, the most reliable varieties of corn for this region are those which mature in from 90 to 100 days from planting.

**THE CAMPBELL METHOD OF SOIL CULTURE.**

What is commonly called "The Campbell Method of Soil Culture" has been so extensively advertised, and so much has been claimed for it, that it was thought best to give it a careful trial at this Station.

Mr. B. A. McAllaster, of the Land Department of the Union Pacific System, kindly loaned us tools for this purpose.

The ground for small grain was plowed and packed April 25th to 27th, and the grain was drilled immediately with a press drill across packed and unpacked ground. A part of the grain was cultivated after rains with a Campbell Jr. cultivator. All except enough to test the yield was cut for hay. The following table shows the results given in bushels per acre:—

	Packed.		Unpacked.	
	Culti- vated.	Uncul- tivated	Culti- vated	Unculti- vated.
Wheat, Blount's No. 16.....	3.50	3.75	4.75	4.50
Oats, Black Russian.....	18.00	23.00	30.00	27.00
Rye, Giant Spring.....	5.25	5.00	5.15	4.10
Barley, Beardless.....	22.6	20.60	25.70	14.60

*Early Amber Cane*—One and one-half acres were planted to Early Amber cane May 25th. All the land was plowed eight inches deep and three-fourths of it was packed. The seed was planted with a planter drill. The cane was all carefully cultivated until August.

The cane on the packed ground yielded 6,444 pounds of dry fodder per acre, while that on the unpacked ground yielded 5,940 pounds per acre, a difference of 504 pounds for packing.

#### CORN.

Four acres were planted May 21st to corn. The same method was used in preparing the corn land as in the case of the sorghum plats. The corn was planted in check rows, by hand, three grains in a hill. The seed was Yellow Dent, White Dent, and Flint, grown at this Station in 1897. It was chosen from the best of six varieties grown. All was carefully cultivated after each rain and more frequently when conditions seemed to require it. The suckers were pulled off, and all weak stalks were removed after they had shown their form. It was also thinned to two stalks in each hill. The following table shows the results:—

Variety.	Packed. Bu. per acre.	Unpacked. Bu. per acre.	Differences. Bu. per acre.
White Dent.....	10.5	10.9	.4 Loss
Yellow Dent.....	13.4	8.7	4.7 Gain
Flint .....	14.3	12.6	1.7 Gain

*Potatoes*—One-fourth of an acre was planted to Carman No. 3 potatoes, May 13th. One-half the ground was packed and one-half left unpacked. The potato beetles committed such depredations in this section of the field that only a few tubers were produced.

#### REMARKS.

1. All ground in this test was plowed eight inches deep.

2. All ground not packed was thoroughly harrowed as soon as it was plowed.

3. All crops in this test which are usually cultivated were cultivated alike on both packed and unpacked land.

4. The moisture in the soil was tested a few times during the season by sampling with soil sampling tubes to a depth of one foot, and to the depth of six feet with a sampling auger. It was found that immediately after a rain, the upper foot of the unpacked plats contained more moisture than the upper foot of the packed plats. Later, the reverse was the case. Also, the moisture falling upon the unpacked plats sank deeper into the ground than that falling upon the packed plats. Later in the season, after several rains had fallen and all plats had been cultivated several times, the differences were not so noticeable.

We give no figures here because we had not the time to make as many moisture determinations as we wished, but could go over the ground only in a general way. It is possible that with more work in this line, we should be forced to draw different conclusions.

**STUDY OF EVAPORATION.**

Tools for use in these experiments were ordered April 15th, but many delays caused by non-arrival of essential tools and inability to get help when needed, prevented work in this line before July 1st.

We had planned to determine the amount of water used by a crop of corn in this region, but it was considered too late to give this matter a fair test by the time the necessary tools were at hand, so evaporation from water and soil surfaces was tested during the remainder of the season.

**EVAPORATION FROM WATER SURFACE.**

Two galvanized iron cans eighteen inches in diameter and fifty-two inches deep were set close together in the ground so that the tops of the cans were on a level with the surface. These were filled with water. During July, the evaporation was 11.38 inches. Both were exposed equally to the action of the sun and wind during this time. August 1st, one was screened from the direct rays of the sun and the other was left uncovered. From August 1st until September 24th, the one in the shade lost 14.75 inches while the one in the uncovered can lost 18.43 inches.

The can which was uncovered was left until October 3d, when it was found that it had lost 35.31 inches during the time from July 1st until October 3d, or 95 days.

**EVAPORATION FROM DIFFERENT TYPES OF SOIL.**

In this test four types of soil were used. No. 1 is a soil very common here on level upland. It is of a mulatto color, containing a small per cent. of clay, considerable sand, and enough lime to cement it so that it is quite hard when in its natural condition.

No. 2 is a type found on a hilltop. It is a very fine black soil upon which very little vegetation has grown since the Station has been in operation.

No. 3 is a rich clayey soil of a dark color, upon which all crops grow well whenever the location is such that the crops are supplied with water in moderate quantities. The best crops grown on the farm grow upon this type of soil.

No. 4 is a fine light-colored soil commonly called "gopher clay." Where it crops out, it supports quite a scanty vegetation, as a rule. It occurs in many places as a subsoil.

One can, eighteen inches in diameter and fifty-two inches deep, was used for each kind of soil. The cans were filled as the soils occur in nature. Subsoils occupied the lower parts of the cans, but the upper eight inches were filled with the types to be tested. All cans were placed side by side in a trench so that their tops were on a level with the surface of the ground. They were weighed at the beginning of the experiment and at intervals through the summer. Water was added from time to time to all the cans at the same time. The water was introduced through a piece of gas pipe which extended two and one-half feet below the surface. In this way water equal to three inches of rainfall was added to each can of soil, besides the natural rainfall. Nothing was allowed to grow on any of the soils. After standing 85 days, the amount of loss was estimated. It was found that type No. 1 had lost water at the rate of 1,038 tons per acre; type No. 2 at the rate of 527 tons per acre; type No. 3 at the rate of 435 tons per acre; and type No. 4 at the rate of 600 tons per acre. None of this soil was cultivated. Four other cans just like the ones described were filled with subsoil and soil of type No. 1. In two of these, millet was planted, while two of them were left bare. After 85 days it was found that the average loss from the bare soils was 905 tons per acre, while the average loss of the two upon which millet was growing was 1,056 tons per acre. The millet grew to be only four to six inches high before it formed heads. Three inches of water besides the rainfall was added to each of these cans also.

Another test of evaporation from soil surface was in connection with a wind-break test. Twenty galvanized iron buckets, each eleven and one-half inches in diameter, were all filled to the same level with the same kind of soil and sunk into the ground so that their tops were on a level with the surface. Ten of them were in buffalo grass sod and ten in a millet field. Their positions represented a sufficient variety of exposure and protection to make a fair test, and to consider that they would represent average conditions on the farm for that type of soil. Type No. 1 of the soil was used, as representing the widest area of any of the soil types found here.

The buckets were left in position sixty days. Water was added to each bucket occasionally by means of glass tubes which reached nearly to the bottom of the buckets. In sixty days, beginning July 13th and ending September 13th, the average loss of water per acre from the soil in the buckets was 705 tons. Nothing was allowed to grow in the soil in the buckets. The soil was left un-stirred.

#### INFLUENCE OF A WIND-BREAK UPON EVAPORATION FROM SOIL SURFACE.

In 1896, twelve rods of sod wall were built east and west across a field of buffalo grass which sloped to the south. In 1897, this wall was extended eight rods by building a tight board fence. All the wall and fence was made four feet high. Buckets were placed in the ground on each side of the wall. All the buckets were filled alike with the same type of soil. On the north side, the buckets were placed at one, three, five, seven, and ten rods distance from the wall. On the south side, they were placed one, three, five, seven, and eight rods distant. The table below shows the results of evaporation from the pairs of buckets during 62 days, from July 14th to September 14th.

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	Evaporation— tons per acre.
North side of Wall, in sod.	
Buckets one rod from wall.....	.677
Buckets three rods from wall.....	.633
Buckets five rods from wall.....	.700
Buckets seven rods from wall.....	.703
Buckets ten rods from wall.....	.712
South of wall in millet field.	
Buckets one rod from wall.....	.647
Buckets three rods from wall.....	.686
Buckets five rods from wall.....	.738
Buckets seven rods from wall.....	.764
Buckets eight rods from wall.....	.761

Some negative results are apparent here, but the general results show that the wind-break did save moisture. We do not feel able to explain the differences which appear. As an experiment to test the influence of wind-breaks upon evaporation, we consider it very unsatisfactory, but for testing evaporation from soil surface, it shows some interesting figures. The location of the buckets was such that their weights could be but little, if any, affected by the blowing of dust which had been considered as the greatest source of probable errors in this test.

ADDITIONS TO TOOLS AND APPARATUS.

A Campbell sub-surface packer and a Campbell Jr. cultivator were furnished the Station by the Union Pacific System for use as long as ten acres of the station land are devoted to testing the "Campbell Method of Soil Culture."

Ten galvanized iron cylinders, 18 inches in diameter and 52 inches deep, for use in testing evaporation and also in testing the amount of water used by plants, three dozen galvanized iron buckets for general use in soil work, one evaporating oven, four dozen evaporating



dishes, twenty feet of special copper tubing, thirty-five soil-sampling tubes, and one special weighmaster's beam have been added to the apparatus for the study of soils and other problems.

#### CONCLUSIONS.

The Station has been in operation five seasons, and during that time no grain crop has been produced which would pay if the producer had to depend upon the sale of it for his living. Fair crops of fodder have been raised each year since the first, when the seed was planted on sod. That year was an extremely dry year, but enough fodder was raised then to feed the station stock until the next season's crop was ready for use.

No fair test of fall grain has yet been made. Fall grain was sown but one year on the Station soil. Some good crops of fall wheat have been raised in this county.

The cost of producing fodder is the most important question to be considered in this region. It is believed, from our experience here, that fodder can be produced, on a large scale, at a cost of not to exceed two dollars per ton. The figures below show the estimated cost per acre of growing fodder.

Preparation of ground and planting.....	\$1.00
Seed .....	.10
Cultivating three times.....	1.20
Cutting and putting in shock.....	1.00
	<hr/>
Total .....	\$3.30

The yield of the Kaffir corns and of Early Amber cane is usually between one and one-half and five tons per acre. If improved harvesting machinery be used, we believe that the cost of putting fodder in the shock would be still less than the above estimate, which is based upon the use of sled cutters in harvesting the fodder.

**ACKNOWLEDGMENTS.**

Members of The State Board of Agriculture have greatly assisted me by their sympathy with my efforts to make the most of conditions here. I have also been helped very much by suggestions from members of your Committee.

Respectfully submitted,

J. E. PAYNE,

*Superintendent.*

Cheyenne Wells, Colorado, October 15, 1898.



## Report of the Arkansas Valley Experiment Station.



*To the Executive Committee of The State Board of Agriculture:*

Gentlemen—Herewith is presented the Eleventh Annual Report of the Arkansas Valley Experiment Station.

My connection with this Station dates from March 1, 1898, at which time the schedule of the season's work had been adopted: hence the most of my duties have been to carry out the line of work laid down therein, as far as conditions would permit.

The present year has been an unfortunate one for the agricultural interests of a large portion of the Valley, including the Station.

On the 6th day of June, a severe hailstorm devastated this section, and for the time being thrifty crops were transformed to a bare waste.

Nor was the destruction of the crops the only severe feature of the storm affecting subsequent agricultural operations, as is evidenced by the poor mechanical condition of the soil induced by the severe flooding.

For nearly eight hours most of the station land was under water to a depth of about eight inches, the effect being thoroughly to compact what was previously a loose, mellow soil, which conditions could not be overcome by surface cultivation.

The season, in general, has been characterized by an excess of rain and by moist conditions, causing heavy

dews. An unusual amount of fungous diseases has been prevalent.

During the storm referred to, 2.08 inches of rain and hail fell in two and one-half hours.

Subsequent to this, and of results almost as disastrous as the previous one (except no hail), was the storm of July 8th, when 1.5 inches of rain fell in a few hours; sufficient again to place the station land under a considerable depth of water.

An excess of water is very detrimental to the soils of this Valley, especially so if allowed to stand. Better results would often be obtained by more cultivation and less irrigation.

#### AGRICULTURAL DIVISION.

*Wheat*—The wheats grown for a comparative test were destroyed by the hail of June 6th, at which time they were well headed.

The last week of September 1898, twenty-one varieties, including some Russian wheats, were sown on 2.8 acres of land.

March 17th, 350 pounds of Polish wheat, or Mammoth rye, were sown on 3.7 acres of land. This seed came up nicely without irrigation, and the crop was looking well at the time of the hail, just as the heads were forming.

All the main stalks were destroyed; the tillers afterwards grew and produced 35 bushels of grain.

We consider this grain a valuable one that promises to enter largely into feeding rations. It produces well with but little water, and is especially valuable for lands under canals with scant water supply.

*Corn*—Test on culture; cultivation *versus* irrigation. The schedule called for nine acres to be laid off into plots of one acre each and treated as given in Table I.

TABLE I.

No. of plot	No. of cultivations.	No. of irrigations.
1	3	3
2	3	2
3	3	1
4	2	3
5	2	2
6	2	1
7	1	3
8	1	2
9	1	1

Table II. gives the dates of cultivation and irrigation, together with the yield.

TABLE II.

No. of plot.	Yield in pounds.	Dates of cultivation.	Dates of irrigation.
1	1,775	July 6 and 12, Aug. 4	July 22, Aug. 8 and 23
2	2,010	July 6 and 13, Aug. 4	July 22, Aug. 9
3	2,005	July 6 and 13, Aug. 4	July 30
4	2,120	July 7 and 12	July 23, Aug. 8 and 23
5	2,115	July 7 and 13	July 23, Aug. 9
6	1,695	July 7 and 13	July 30
7	2,395	July 12	July 27, Aug. 8 and 24
8	2,215	July 12	July 27, Aug. 9
9	1,685	July 12	July 29

This land was planted to Golden Beauty corn on May 14th, and at the time of the hail was up, in good stand, about four inches high. The storm reduced the stand considerably by covering some hills with mud.

The whole crop had received the same attention up to July 6th; viz., one cultivation with shovel plow to kill small weeds, and after the hail the use of an Acme plow to stir the soil. Some hogs running at large de-

voured a considerable quantity of corn on Plat 1, and for this reason this plat must be eliminated in drawing any conclusions.

The fertility of this soil was not uniform, as we afterwards learned; cattle having been fed upon plats 7 and 8 the previous winter.

In general it may be said, that corn should seldom be irrigated until near the time of tasseling; after which one more irrigation will be sufficient to produce the crop.

*Corn on alfalfa sod*—This is the third year corn has been grown continuously on this land (4 acres) for the purpose of testing how long the fertility of alfalfa will remain.

One and one-half acres near by were planted at the same time as a check upon this work. The first mentioned produced 8,470 pounds of ear corn, equivalent to 30.2 bushels per acre, of 70 pounds each.

The latter portion produced 3,535 pounds of ear corn, or 33.6 bushels per acre.

The appearance of the corn during growth showed very plainly that the fertility from the alfalfa had been exhausted. The unhealthy, yellow appearance showed that the supply of nitrogen was not sufficient for a maximum crop. On the check portion (a soil naturally much weaker), the growth was rank and of a dark healthy green.

*Grasses and Forage crops*—Under this head, as outlined in the schedule, the following were sown:—

Turkestan alfalfa, Italian Rye grass, Brome grass (*Bromus inermis*), Tall Meadow Oat grass, Kentucky Blue grass, Sheeps' Fescue, Meadow Fescue, Idaho coffee pea, Mummy field pea, Southern cow pea, Soja bean, Rape, and Hairy Vetch.

The alfalfa and brome were sown April 14th and a good stand secured, but the hail beat them to the ground so severely that the weeds took the start and choked them out.

The alfalfa was sown September 9th, and promises to do well.

The rye grass and fescues are also a failure, due to hail and weeds.

The meadow grass was not sown until June 23th, and promises to be of value.

Some are growing the Kentucky blue grass for pasture. It can not be utilized for this purpose except where water is abundant. We are of the opinion that fall is the preferable time to sow this grass, as the weeds do not then become so troublesome.

The Idaho and field peas were severely injured by the hail. Of the former, we threshed 300 pounds, or nearly 14 bushels per acre. It is probable that under normal conditions 30 bushels per acre can be grown.

Early field peas might be grown to a profit. As a food for young hogs during the summer months, when growth and not fat is desired, they are excellent.

The hail required us to replant the cow pea and soja bean. The former ripened but few seeds; only the earliest varieties will be productive here. We think it a plant of much value, both for its grain and as a fertilizer for small tracts.

*The Hairy Vetch*—This we wish to test both for its value as a forage plant and green fertilizer. Two sowings were made, May 23d and again in July. Early sowing of this plant is not desirable as but little growth is made during the hot weather. Further time is necessary to determine its value.

*Essex Rape*—An early planting was destroyed by the flea beetle.

A second planting, August 3d, made a growth of 12 to 16 inches, but we do not consider it a desirable plant here.

Since the Station has been in operation, tests have been made of most of the more common grass and forage plants. But three were growing when I assumed charge, *Bromus inermis*, orchard grass, and red clover. A test of the first for the past six years has not established it as a pasture grass for this section. It commences to grow quite early in March but in summer does but little, again



making some growth in the fall. We think in sections of greater rainfall and lower mean temperature it would prove valuable. However, to test it still further, a fall sowing has been made and is doing well.

From our present knowledge we consider orchard grass the best one for pasture purposes. It thrives either alone or in connection with alfalfa. At the time of the hail it stood from  $2\frac{1}{2}$  to 3 feet high. It resists drouth well, and for pasture or to improve the quality of alfalfa it can be advantageously used.

#### GARDEN.

*Celery*—Three varieties of celery were grown, White Plume, Golden Self Blanching, and Boston Market.

This plant requires a moist, cool, loamy soil made very rich by heavy manuring.

Our trials have shown the following particulars must be observed:—

Run off quite deep furrows east and west and place the plant on the south side of them to insure partial shade. None but the strongest plants should be used, as the smallest will not survive the heat.

For a time, after transplanting, almost constant irrigation must be given. Of the two early varieties we much prefer the White Plume for its richer and better flavor.

The only method of blanching used was with earth. More extended notes are reserved for the future.

*Potatoes*—Our trials comprised five varieties, Burbank, Barclay's Prolific, Rose Seedling, Prolific Rose, and Mammoth Pearl.

On a half acre plat, May 2d, twelve rows, each 100 feet long, were planted to the Rose Seedling variety to compare the time of planting with that of a later date. May 25th, the remainder of the half acre was planted to the above varieties; twenty rows being of the Rose Seedling.

To five rows of this variety wood ashes were applied in the furrow. A top dressing of 150 pounds of gypsum was applied to six rows June 28th.

The following table gives the area and yield of the different varieties; no mention being made of those too small for seed purposes.

Variety.	No. of rows each 100 feet.	Total yield in pounds.	Yield per acre in bushels. Estimated.
Rose Seedling.....	9	116	31.1
Burbank .....	7	400	138.0
Barclay's Prolific.....	7	275	94.8
Mammoth Pearl.....	8	300	90.5
Rose Prolific.....	8	315	95.0

From the five rows treated with ash we secured 40 pounds, from those treated with gypsum 90 pounds, and from the twelve rows planted May 2d, 98 pounds. Our experience, as well as the tests of former years, has shown that the early plantings are not successful nor are early maturing varieties as productive as the late maturing ones; that to insure success late blooming varieties and late planting are essential.

As a further test six rows each (100 feet long), were planted of the Burbank and Rose Seedling varieties and covered with straw to a depth of eight inches.

The former yielded 182 pounds and the latter 72 pounds. There is no advantage in this method; the potato requiring cultivation to secure best returns.

A difference in the mechanical condition of the soil was noticeable where gypsum had been applied; its tendency being to make it more mellow and friable.

The soil and climate here do not favor the potato, but we see no reason why by judicious planting and irrigation the farmer should not supply his own needs.

Of the varieties tested we much prefer the Mammoth Pearl on account of its smooth growth and uniform size.

*Sugar-beets*—One-half acre of beets was grown, under instructions from the Agricultural Section of the

College, to derive information in regard to the following:—

- (a) The best time to plant.
- (b) The proper depth to plant.
- (c) The quality of water required.
- (d) Irrigation *versus* natural moisture for the germination of the seed.

Four plantings were made, April 18th, May 2d, May 16th, and June 1st.

The plants from all sowings (except June 1st), were up at the time of the hail and were greatly injured by it. The rainfall this year has been sufficient to grow good beets. From a plat planted to the Vilmorin variety, and irrigated four times, 1,300 pounds were harvested; from the same amount of land without irrigation, 1,315 pounds; and from the plat receiving one irrigation, 1,365 pounds. Our work shows that 18 inches between the rows is not sufficient where irrigation is employed; that two feet is close enough, and where the product is designed for stock use a still wider distance is preferable.

The half acre produced a total yield of 7 tons and 855 pounds.

As the work with the sugar-beet will probably appear in bulletin form, further details will not be entered into in this report.

#### HORTICULTURAL DIVISION.

*Orchards*—Twenty-nine varieties of apples, in the old orchard, put forth bloom from the 24th to the 30th of April.

The hail destroyed all of the first set except those of the Ben Davis variety, which were afterwards used in taking notes upon the codling moth. But two varieties of pears remain in the orchard (Keiffer and Longworth), which blighted in the bloom.

The work with the blight has comprised; first, spraying with the Woodbury Blight Cure and with the Bordeaux mixture; second, to determine to what extent the

blight may be carried to healthy trees in the operation of pruning and to note the efficacy of a germicide upon the implements employed.

In the spraying experiments, trees were left in such localities as carefully to check our work, and the results of this year show that no benefit is derived from either of the mixtures used.

The directions for applying the former, together with the Woodbury wash, were strictly adhered to, and had the farmers of this vicinity been content to allow the Station to test it before they purchased, hundreds of dollars might have been saved to them this year.

All vacancies in the young orchard were filled with the same varieties as formerly set, as far as they could be obtained.

Nearly all these trees had commenced a good growth when the hail of June 6th stripped them of their bark from the ground to the top of the tree.

The stone fruits repair the damage done by such storms much more rapidly than do apples or pears.

There are in this orchard at present 119 trees, comprising apple, peach, plum, cherry, quince, apricot, and nut that appear to have survived the storm sufficiently to remain.

Of the elm trees set along 80 rods bordering the avenue, all but one are living.

#### INSECTS AND FUNGOUS DISEASES

Experiments to ascertain the per cent. of wormy to non-wormy apples were conducted upon eleven Ben Davis apple trees.

The same trees were also used to determine the number of worms going down the tree compared to those going up.

The results of the work have been reported to Professor Gillette, and further investigations along this line are contemplated.

The Striped Cucumber beetle, which is very destructive to the cantaloupe plant, first appeared (in increased numbers) during the last week of May. Experiments as to the best means to combat this insect were conducted but were not completed owing to the destruction of the plants by the hail.

The remedies used were Paris green, tobacco water, kerosene emulsion sprays, and dusting with a mixture of lime and Paris green.

The emulsion is the only effective remedy of those above mentioned. Dusting the plants with lime and Paris green answers for a short time, but the beetles may soon return.

Notes were taken upon the Strawberry Leaf-roller, and upon an adjoining patch we are studying the efficacy of burning the vines in the fall to rid them of this insect.

The 8-Spotted Forester, which eats the leaves of the grape in May, is successfully combatted with a Paris green spray (10 oz. to 10 gallons of water).

A poison spray is effective for the Yellow-Necked caterpillar, which destroys the foliage of the apple.

Cottonwood-leaf beetles appeared in abundance upon the trees belonging to the poplar family. A poison spray may be used to combat them.

The Melon louse appeared upon the cantaloupe vines in a few localities. It is important that this insect should be at once exterminated to avert serious injury to an important industry. Some information to this end was given our farmers by means of the local press.

A fungous disease affecting the cantaloupe has proven quite serious in a few localities.

In conjunction with Professor Crandall, we are investigating the subject, and experiments to control it may be entered into another year.

The bean blight has proven quite serious and suggests future study.

Mildew was more troublesome than usual on account of an unusually moist season.

**METEOROLOGY.**

Records of temperature, hygrometer, precipitation, wind, clouds, and sunshine have been kept and reports sent monthly to the Department of the College and to the Weather Bureau in Denver.

**FERTILIZERS.**

Decomposed gypsum and wood ashes constitute the fertilizers employed for experimental purposes.

Upon 124 square rods of land, that had previously received so much water as to destroy its productiveness, gypsum was applied to alternate plats. This land had been plowed in the fall and coarse manure spread upon it during the winter. In the spring the soil appeared quite mellow and apparently the freezing and thawing had put it in proper condition for crops. It was again plowed this spring and corn and beans (which are widely different in character) selected as the crops to be grown upon it.

Upon one-half (43 square rods) the area planted to beans, 375 pounds of gypsum were applied as a top dressing. The blight seriously affected them and a yield of 156 pounds was secured from the plat receiving gypsum, while that receiving no application returned 150 pounds. Three plantings were required to secure a stand of corn upon this soil; there seemed to be some condition not favoring germination. The stand that was secured was late, making an excellent growth of stalk but not thoroughly maturing the grain.

From 18.7 square rods receiving gypsum 276 pounds of ear corn was obtained; from the same area, but no application, 178 pounds were taken. Brome grass was not benefited by an application of gypsum. We also applied it to trees, but time is needed to determine results. Our work with gypsum this year was not intended to be more than preliminary.

While we do not look for any *decided* benefits from its application to soils similar to those of the Station, yet there is much land in this Valley that would be greatly benefited by its use, as we know from former trials with it under similar conditions.

#### FEEDING EXPERIMENTS.

An important line of work was inaugurated this fall when fifteen calves were purchased for experimental feeding.

#### ALFALFA.

About three acres of land was seeded to alfalfa, September 9th, and at the present writing it is looking well. About 30 tons of alfalfa hay, which will be used for feeding purposes, have been put up.

#### CONCLUSION.

Many items of importance accumulate, in the course of experimental work, that can not be enumerated in a report like this, but may prove to be of much value in the work of the future.

Respectfully submitted,

H. H. GRIFFIN,  
*Superintendent.*

Rocky Ford, Colorado, November 30, 1898.

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