

THE STATE AGRICULTURAL COLLEGE
OF COLORADO

THE TWENTY-FOURTH ANNUAL REPORT

OF

**The Agricultural Experiment
Station**

For 1911



The State Board of Agriculture

THE AGRICULTURAL EXPERIMENT STATION.
Fort Collins, Colorado.

	TERM EXPIRES
HON. B. F. ROCKAFELLOW,* Canon City.....	1911
HON. E. H. GRUBB,* Carbondale.....	1911
HON. R. W. CORWIN, Pueblo.....	1913
HON. A. A. EDWARDS, President, Fort Collins....	1913
HON. F. E. BROOKS, Colorado Springs.....	1915
HON. J. L. BRUSH, Greeley.....	1915
HON. J. C. BELL, Montrose.....	1917
HON. E. M. AMMONS, Littleton.....	1917
HON. T. J. EHRHART,** Centerville.....	1919
HON. CHAS. PEARSON,** Durango.....	1919
GOVERNOR JOHN F. SHAFROTH	} Ex-Officio
PRESIDENT CHARLES A. LORY	

EXECUTIVE COMMITTEE IN CHARGE.

A. A. EDWARDS, Chairman.

J. L. BRUSH.

E. M. AMMONS.

*Term expired April 12, 1911.

**Term began April 12, 1911.

Station Staff

C. P. GILLETTE, M. S., Director.....	Entomologist
¹ L. G. CARPENTER, M. S.....	Irrigation Engineer
W. P. HEADDEN, A. M., Ph. D.....	Chemist
G. H. GLOVER, M. S., D. V. M.....	Veterinarian
W. G. SACKETT, B. S.....	Bacteriologist
ALVIN KEYSER, A. M.....	Agronomist
J. O. WILLIAMS, B. S. A., U. S. Expert-in-charge.....	Horse Breeding
E. R. BENNETT, B. S.....	Horticulturist
B. O. LONGYEAR, B. S.....	Botanist
G. E. MORTON, M. L., B. S. A.....	Animal Husbandman
² E. B. HOUSE, B. S. (E. E.), M. S.....	Irrigation Engineer
³ V. M. CONE, B. S.....	Irrigation Investigations
R. E. TRIMBLE, B. S.....	Assistant Irrigation Investigations
P. K. BLINN, B. S., Rocky Ford.....	Alfalfa Investigations
EARL DOUGLASS, M. S.....	Assistant Chemist
S. ARTHUR JOHNSON, M. S.....	Assistant Entomologist
B. F. KAUPP, M. S., D. V. S.....	Pathologist
MIRIAM A. PALMER, M. A.....	Delineator
⁴ L. C. BRAGG.....	Assistant in Entomology
GEORGE P. WELDON, B. S., Grand Junction.....	Field Entomologist
R. S. HERRICK, B. S., Grand Junction.....	Field Horticulturist
C. L. FITCH.....	Potato Investigations
W. E. VAPLON.....	Poultry Investigations
⁵ J. E. PAYNE, M. S.....	Field Agent, Plains
J. W. ADAMS, B. S., Cheyenne Wells.....	
.....	Agronomy Assistant, Dry Farming
⁶ D. H. MATHIAS, B. S.....	Assistant Irrigation Investigations
⁷ J. C. SUMMERS, B. S.....	Assistant Chemist
⁸ G. D. WALTERS, B. S.....	Assistant Irrigation Investigations
⁹ ELLWOOD D. ROOD, A. B.....	Assistant Chemist

¹To January 1, 1911.

²From January 1, 1911.

³Appointed April 1, 1911.

⁴To November 1, 1911.

⁵Resigned June 1, 1911.

⁶Resigned May 1, 1911.

⁷Appointed May 1, 1911.

⁸Appointed September 1, 1911.

LETTER OF TRANSMITTAL.

To His Excellency, John F. Shafroth, Governor of Colorado:

In accordance with the conditions of the Act of Congress which requires a full and detailed report of the operations of the Experiment Station, I have the honor to present herewith the twenty-fourth annual report.

The financial statement is for the fiscal year ending June 30; the other portions being reported substantially for the current year.

C. P. GILLETTE,

Director.

Agricultural Experiment Station,
Fort Collins, Colorado,
December, 1911.

FINANCIAL REPORT OF THE COLORADO AGRICULTURAL
EXPERIMENT STATION FOR THE FISCAL YEAR
ENDING JUNE 30, 1911.

Dr.	RECEIPTS.				
	Hatch Fund	Adams Fund	State Fund	Special Fund	Totals
From the Treasurer of the United States as per appropriation for the fiscal year ended June 30, 1911, under acts of Congress approved March 2, 1887. (Hatch fund) and March 16, 1906. (Adams fund)....	\$14,755.58	\$13,882.71			
Balance on hand July 1, 1910...	244.42	1,117.29	\$21,294.81	\$10,632.47	
Other sources than the U. S....				12,497.14	
Total receipts					\$74,424.42
	DISBURSEMENTS.				
	Hatch Fund	Adams Fund	State Fund	Special Fund	Totals
By Salaries	\$ 7,654.93	\$10,491.34	\$12,230.13	\$ 1,013.41	\$31,389.81
Labor	1,124.95	597.45	3,496.22	2,162.54	7,381.16
Publications	3,098.38		2,789.47	1,056.12	6,952.87
Postage and Stationery.....	523.85	133.45	632.31	141.71	1,431.32
Freight and Express.....	85.41	243.50	2,455.34	445.89	3,230.14
Heat, Light and Water.....			8.60	1.90	10.50
Chemical Supplies		1,210.02		22.15	1,232.17
Seeds, Plants and Sundry Supplies..	356.16	243.74	1,443.41	303.20	2,346.51
Fertilizers					
Feeding Stuffs			2,218.38	6,541.03	8,759.41
Library	214.74	103.49	7.50	5.00	330.73
Tools, Implements and Machinery..	50.23	224.70	\$34.99	200.75	1,310.67
Furniture and Fixtures.....	692.70	38.00	1,205.43	13.25	1,949.38
Scientific Apparatus	366.55	951.13		88.95	1,406.63
Live Stock			192.13	2,309.40	2,501.53
Traveling Expenses	684.62	566.75	1,573.50	191.00	3,015.87
Contingent Expenses	25.00		1,033.78	27.00	1,085.78
Building and Repairs	122.58	196.43	1,796.39	485.54	2,600.94
Total Expenditures.....	\$15,000.00	\$15,000.00	\$31,926.58	\$15,008.84	\$76,935.42
Balance				8,120.77	8,120.77
Overdraft			10,631.77		85,056.19
					10,631.77
			\$21,294.81	\$23,129.61	\$74,424.42

REPORT OF THE DIRECTOR.

To the President:

I have the honor to present the following report upon the work of the Experiment Station for the State fiscal year of 1910 and 1911.

The personnel of the Station has undergone slight change, and the general plan of organization remains the same as a year ago.

THE WORK OF THE SECTIONS.

Appended hereto are the reports of the heads of the various sections. I will refer you to these for full statements as to the projects under which we are working, and somewhat detailed statements as to the progress of the work. It will be noticed that the projects are drawn along lines that are of special importance to the agricultural interests of the State. In fact, the State is so large and the interests so varied that we are only able to take up a small proportion of the important problems that force themselves upon the attention of the Station, with the funds at its command.

The Chemical Section has done all its work during the past year upon Adams fund projects, and chiefly upon a further study of the effects of the nitrate deposits in the soils of the State upon the development of certain crops. A partial report upon this work was made by Dr. Headden in two papers which he read at the Columbus meeting of the Society for the Promotion of Agricultural Science, this month.

The opinion continues to be more or less prevalent that the Experiment Station will analyze soils, water, beets and other objects for the people of the State free. The Station has neither funds nor men available for this work. If done at all, it would have to be by the College, or upon special funds provided by State appropriations.

The Bacteriological Section has been supported entirely by the Adams fund. The work has been largely in co-operation with the Chemical Section, taking up the biological side of the nitre trouble in our soils. Bulletin 179 is an outgrowth of this work. Bulletin 177, giving the results of a study of Holdover Blight, was also published from this Section during the year. The demands upon this Section are so numerous that we should give additional help and larger quarters as soon as we are able to do so.

Irrigation and Drainage Section. This Section was re-organized last spring with Professor E. B. House as its head, and with Mr. V. M. Cone as Irrigation Specialist in full charge of the co-operative work entered into by this Station and Irrigation Investigations of the Office of Experiment Stations. The Station is very fortunate in being able to arrange for this co-operative work, for it greatly increases the scope of the work that can be carried on, and also the funds available for experimental work in this line.

Under Mr. Cone's direction we are also co-operating with the Costilla Estates Development Company for the purpose of carrying on rather extensive field experiments in the San Luis Valley to determine the duty of water, efficiency of underflow for irrigation, suitable crops, methods of cultivation, etc., for that district. The plans and agreements for conducting this work have been completed, but active work will not be begun until early next spring.

Agronomy Section. The work in this Section is supported by the Hatch fund and two State appropriations, and includes both general farming and dry farming problems. A large proportion of the experimental work is along the line of the development of better grains and forage crops for Colorado. Sufficient progress has been made in these lines to thoroughly justify the expenditures to date. Two very distinct types of alfalfa have been secured, one adapted to the warmer countries, and the other adapted especially to resist cold and the injuries sustained by severe pasturage.

Mr. P. K. Blinn, situated at Rocky Ford, has special charge of the alfalfa work, and Mr. J. W. Adams, at Cheyenne Wells, has direct supervision of the dry land experiments that have been carried on in that locality; Professor Keyser having general charge of the entire work of the Section.

There is no Section of the Experiment Station that is more continually in demand for information by letters and through farmers' meetings and upon special trains than the Section of Agronomy. Its work touches the interests of every farmer in the State, whether he grows grain, alfalfa, sugar beets, fruit or live stock. The work has been very much hampered this year because of lack of funds to carry it on properly.

Entomological Section has been carrying on experiment station work on Adams and Hatch funds only. One new project, Grasshopper Investigations, has been in the hands of Professor Johnson. Mr. L. C. Bragg, who devoted

most of his time to Plant Louse Investigations, resigned September 30, and his place has not been filled.

Animal Husbandry Section. This section has drawn funds from the special State appropriations only. Feeding experiments have been carried on with cattle, sheep and swine for the purpose of determining relative values of important feed-stuffs in this State. Because of our failure to get any of the State appropriation to carry on this work to the present time, we are only able to undertake rather limited calf and pig feeding experiments the present fall and winter.

The Poultry Plant is organized as a division of the Animal Husbandry Section and is in charge of the Station Poultryman, Mr. W. E. Vaplon. On account of the small appropriation for this work and the constant demand for Mr. Vaplon at meetings of poultrymen and farmers in the State, it has been impossible to keep up detailed experimental work. A model poultry plant, at which the leading poultry types for egg and meat production are kept, is maintained.

Horticultural Section. Except for two rather inexpensive projects, the work of this Section is supported by State appropriations. Professor Bennett is considerably crippled in his efforts to carry on experimental work at the home Station from the fact that a considerable portion of this appropriation is expended on the Western Slope in the support of two field men, Mr. George P. Weldon and Mr. R. S. Herrick, who devote their time chiefly to extension work, one in entomology and one in general horticulture. An important line of work in this Section is the discovery of varieties of fruits that can be successfully grown in our high altitudes.

Potato Investigations form an important part of the work of this Section, the work being in the immediate charge of Mr. C. L. Fitch, our Potato Specialist. On a further page is given a rather full outline of the work that has been under way during the summer, along with some conclusions that Mr. Fitch has drawn. While the money appropriated for this work is practically exhausted, and it looked for a time as though we should have to discontinue the work, we are greatly pleased to learn that the farmers and business organizations of the State are making an effort to raise the money needed to continue the work for another year, and it seems probable that they will succeed. The serious potato crop failure this year, due to the prevalence of a

fungus (*Fusarium*) disease, makes it imperative that we continue our potato investigations in the hope that we may find some means to avert such losses in the future.

The Veterinary Section. There have been no funds available for Experiment Station work in this Section so far this fiscal year, and it was not thought best to start any new projects until money should be available from the appropriations made by the Eighteenth General Assembly. It is hoped that there will be some funds available for the Veterinary Section during the fiscal year of 1911-1912, as there are several important lines of work that should be taken up if possible.

The Botanical Section. This Section has had only one project in the Experiment Station work during the past year, and that was the "Black-root of the Strawberry." This project has been supported by the Adams fund and has called for very little expense.

Horse Breeding Section. While the horse breeding experiment has made very satisfactory progress the past year, it is apparent that the appropriation made by the last General Assembly for the continuation of the work is quite inadequate to meet the Station's half of the expenses for the two years, even if the entire appropriation should become available, which does not seem very probable. As the experimental animals increase in number from year to year the expenses of their keep and training must also become greater, so that it will be necessary hereafter to secure larger appropriations for the experiment if the work is to be continued at this Station.

We get the full appropriation of \$15,000 on both the Adams and Hatch funds this year. The calls for money for experimental work were so many and urgent that these funds were allotted to the various budgets with but a small reserve for contingencies. These funds are in good condition, a smaller part having been spent than the proportion of the year that has passed.

The State special appropriations that are being administered through the Station are those made for,

Horse Breeding Experiment.....	\$ 5,000.00
Fruit Investigations	6,000.00
Potato Investigations	5,500.00
Plant Industry	5,000.00
Dry Farming	3,500.00
Irrigation and Drainage Investigations.....	5,000.00
Animal Husbandry (including Veterinary).....	7,500.00
Poultry	5,000.00
Total	<u>\$42,500.00</u>

While no money has been available from the State treasury, up to the present time, with which to pay the expenses incident to carrying on any of the above lines of work, the money has been advanced from other College and Station funds in order to continue the work that was already under way from appropriations of the Seventeenth General Assembly. This was necessary both for the sake of efficiency and for the economic use of the funds. Otherwise we should have had to discharge men and stop the work that was in progress, and plan later to fill their places with whoever could be found to take up the work. By doing this we would have all lines of work to reorganize with the serious losses due to lack of continuity and a change of management. Such a course would also necessitate spending the whole appropriation in each case in one year instead of two, which would cause a serious disadvantage in securing the best results.

If not more than 50 per cent of the appropriations are to become available, as we have been led to expect, we shall have to stop work on most of these appropriations at the close of the present fiscal year, unless funds are supplied from other sources to continue the work.

The amounts loaned to these funds and spent to November 30, are as follows:

Animal Husbandry	\$2,672.21
Fruit Investigations	2,926.70
Plant Industry	3,040.35
Potato Investigations	3,297.50
Poultry Investigations	1,692.38
Horse Investigations — \$3,570.53 less \$557.84	
(H. Sp.)	3,012.69
Dry Farming	824.70
Irrigation and Drainage.....	394.03

It appears that the only reason why the State institutions do not get their appropriations is that the assessors in the various counties will not assess property as required by law. Instead of assessing at actual value as the law requires, property is assessed at about one-fifth actual value, and as a result the State gets only one-fifth of the valuation that it should have to assess for State purposes. A strong united effort should be made at the next General Assembly to pass a law that will bring about a reasonable assessment of the taxable property of the State. If County Commissioners could be limited to a ten mill assessment for county expenses, the situation would be relieved at once.

PUBLICATIONS.

On account of the entire absence of State funds during the year there have been no information bulletins printed, though several have been offered. The Hatch fund publications of the fiscal year have been:

Bulletin 177—Hold-Over Blight, by W. G. Sackett.

Bulletin 178—The Fixation of Nitrogen in Some Colorado Soils, by Wm. P. Headden.

Bulletin 179—A Bacteriological Study of the Fixation of Nitrogen in Some Colorado Soils, by W. G. Sackett.

Bulletin 180—Seepage or Return Waters From Irrigation, by L. G. Carpenter.

Bulletin 181—Alfalfa, by P. K. Blinn.

Following are the reports of the heads of the Sections in the Experiment Station.

Respectfully submitted,

C. P. GILLETTE,

Director.

REPORT OF THE CHEMICAL SECTION.

To the Director:

I herewith present my annual report of the Chemical Section of the Station.

This Section has no projects that are paid for by the Hatch fund, and those on the Adams fund remain unchanged except that the nitre project has been divided into two parts, i. e., (a) Occurrence and Formation of Nitrates in the Soil; (b) A Study of the Effects of Nitrates on Sugar Beets. The second division of this subject has for its object to ascertain whether the continued, abundant development of nitrates in the soil during the season may not be the actual cause for the quality of the beets produced in large sections which are lower in percentage of sugar than they ought to be, and which produce unduly large percentages of molasses.

Bulletin 178, presenting the results of our work under division (a) of this subject, has been distributed since my last semi-annual report. The questions pertaining to this phase of the subject are by no means wholly solved. While the facts pertaining to the occurrence of this class of salts in very unusual quantities in our soils have been conclusively shown, there remain questions pertaining to the distribution of the nitrates over the surface of larger areas and also in depth. Further, the variation in the quantity of nitrates from time to time within a given area needs to be studied in greater detail. I had hoped to do some work on these lines during the past season, but I was deterred from doing so by a number of things, some of them entirely beyond my control—such as excessively heavy rains. It seems needless to state, as you personally know, that all of the principal localities where we are studying these occurrences are from 250 to 450 miles from Fort Collins, and the close observation desirable and even necessary to obtain a satisfactory record of the changes and the rate at which they take place is so good as impossible. The question of entrusting this work to others has been considered, and in a measure tried. Without disparagement to anyone I am fully persuaded that it is unsafe and ill-advised to entrust any portion of the work, especially of observation, to anyone. It is true that the amount of work is already large for our present force to handle, especially the amount that falls upon me personally, still I believe that we will accomplish

the best results by persisting in doing this work ourselves, undertaking only so much at one time as we can get done in a good, and to us at least, satisfactory fashion.

In regard to division (b) of this subject, we have the work of 1910 well advanced and I am now preparing a bulletin which will present, possibly, a complete statement of the results up to the autumn of 1911. The results which we have obtained seem to me to be of considerable interest and are rich in suggestions of further work in the same direction with other crops.

The other Adams projects stand just as they did at the time of my last report. Our whole energies have been directed to the questions already mentioned. I have not been able to do any work on the other problems. I hope and believe that the Station authorities, both in Washington and in Colorado, will agree with me that while the other projects are interesting and important, they do not rank as high in importance as the nitre question, which is an outgrowth of our "Study of Colorado Alkalies," under which name this work was pursued for several years.

The subjects which have been held in abeyance are:

The Effect of Arsenic on Orchard Trees.
Rio Grande Valley Waters in Relation to Their Alkalies.
Composition, Heat Values and Digestibility of Hays.

As already stated, I have done nothing with these subjects within the past six months, and I am convinced that we shall be fully occupied with the beets and nitre the rest of this year at least.

In the form of a suggestion, I have one which is of considerable importance; it relates to the space required for our Station work. The College classes have increased in size and number until they are actually crowded for room and space which we have heretofore used for Station work is no longer available. In addition to this, the space allotted to some of our special Station work has never been too large and is now too small. The volume of our Station work has very greatly increased within the last few years, so that it is at least four-fold what it was when the present Chemical building was planned; and in the meantime the College work has certainly more than doubled. The result is that both the Station and College are badly in need of room. It is my opinion that we ought to take steps immediately looking toward the relief of this position. As to which department should give way there is in my mind no question, for the College can most advantageously use the whole of this building. The modifications which would be necessary

to adapt it wholly to College purposes would be few and not expensive. In regard to the Chemical Section of the Station, I believe that it should be housed in a one-story building with sufficient floor space to accommodate the variety of work which it will be likely to have to do, together with basement for storerooms and some classes of work. I have stated the College side of this question in my report to Dr. Lory, and I say therein that my statements are not anticipatory, but simply descriptive of the conditions now existing.

As already stated, I believe that we shall obtain our best results by simply maintaining our present force and holding it to the prosecution of the problems on hand which are quite sufficient to keep it fully engaged all of the time. We do, however, need more space.

Respectfully submitted,

WM. P. HEADDEN.

REPORT OF THE BACTERIOLOGICAL SECTION.

To the Director:

I have the honor to submit herewith the annual report of the Bacteriological Section of the Experiment Station for the year 1911.

Under the provisions of the Adams fund, four lines of investigation have been carried on during the year thus far. Two of these have been completed; the third is being continued; and a new phase of one that has been finished is being taken up; one new project has been initiated.

In addition to the work above mentioned, I have been called upon from time to time to investigate minor problems, for which no definite projects have been prepared. A further discussion of this part of my work follows:

Project 1. Bacteriological Studies of Alkali Soils. At this time I am able to report the completion of one phase of this project, namely, the studies which have been directed toward the fixation of atmospheric nitrogen in certain Colorado soils. The results of this work, covering some eighteen months of laboratory experiments, have been prepared for publication and have been published as Bulletin 179 of this Station. This investigation has shown us that nitrogen fixing bacteria are abundant in many of our soils, that they are unquestionably responsible for the high nitrogen content, and that at least forty different soils from widely separated parts of the State possess nitrogen fixing powers. While our early studies seemed to indicate the occurrence of a number of different species of *Azotobacter*, our later work has shown that in all probability *Azotobacter chroococcum*, in its various forms, is the only species of the genus which we have met with thus far. Our experiments have demonstrated, conclusively, that the brown color associated with the nitre trouble is due in a large part, to a bacterial pigment made by the nitrogen fixing germs, which pigment appears to be soluble in the alkaline soil waters and in solution is capable of staining the soil. We have been able to show, further, that the nitrates in the soil stimulate the bacteria to the production of this brown pigment, and that none of the other ordinary forms of nitrogen found in soils are capable of exciting this function. Given, the germ in the soil and the nitrate in the soil, the production of the brown pigment is a natural sequence. Again, given the germ in the soil with a proper soil environment, the increase in nitrogen follows inevitably.

Stated briefly, this study of the occurrence of *Azotobacter* in certain Colorado soils leads us to the following conclusions:

The power to fix atmospheric nitrogen is a property common to many cultivated Colorado soils.

This power is not confined to nitrogen fixation in solutions, but is manifested in soils as well.

“The rate of fixation of nitrogen obtained is sufficient to account for the nitrates found in the soil, provided it is nitrified. The rate of nitrification obtained is sufficient to account for the formation of the nitrates found, in most cases if not all of them.”

Excessive nitrates either destroy or greatly attenuate the nitrogen fixing flora of a soil.

A limited amount of soil nitrate does not seriously affect the nitrogen fixing power of a soil.

Azotobacter chroococcum appears to be the dominant nitrogen fixing organism in the soils studied. The dark brown color of the nitre soils is due, in a large part, to the pigment produced by *Azotobacter chroococcum*.

Given a source of energy, the nitrate is the limiting factor in the production of the brown color.

In the presence of nitrates, *Azotobacter chroococcum* develops a chocolate brown to black pigment; nitrites, in certain amounts, produce similar results, but to a less degree; nitrogen as ammonium chloride, ammonium sulphate, asparagin, and peptone has no effect upon this function.

The highly colored extracts obtained from certain nitre soils suggest that the pigment of *Azotobacter chroococcum* may be soluble in the alkaline soil waters.

Excessive soil moisture, by interfering with the growth of *Azotobacter chroococcum*, prevents the formation of the brown color on the soil, and makes the fixation of atmospheric nitrogen impossible.

Excessive irrigation, too diligent cultivation, and the alkaline reaction of our soils appear to favor unduly the growth of *Azotobacter*.

Supplementary to our studies on the fixation of atmospheric nitrogen in soils, Mr. Robbins, of the Department of Botany, has very kindly consented to look into the algal flora of these same soils as a possible source of carbon for *Azotobacter*. His work will be directed toward determining the kinds and numbers of algae which make our soils their natural habitat.

Having demonstrated beyond all doubt the presence of a nitrogen fixing flora in many of our Colorado soils, and

having shown further that these organisms do bring about an increase in the nitrogen content of these soils, I have turned my attention to the ammonifying and nitrifying efficiency of these same soils. My purpose in doing this has been to show experimentally the power of these soils through their microbial activities to change the proteid nitrogen accumulated by *Azotobacter* forms into ammonia, nitrites and nitrates. For this phase of the investigation, I am employing proteid nitrogen in the form of peptone, cottonseed meal, linseed meal, alfalfa meal, and blood meal. Some twenty-five different soils are being studied and their ammonifying and nitrifying efficiencies are being determined with reference to the above-mentioned nitrogenous compounds. This work is in progress at the present time, but it is too early to report results.

Project II. Hold-over Blight in the Pear. This investigation was completed with the collection of material made April 14, 1911. The period of study was extended over two years and the results of the work have been published as Bulletin 177, of this Station. Briefly stated, we have reached the following conclusions:

The prevalence of hold-over blight has been greatly underestimated, and under Colorado conditions at least 20 per cent of the hold-over cankers on the small limbs and twigs contain virulent blight germs at the time of blossoming.

Project III. Raspberry Yellows. From an economic standpoint, the results of my spraying experiments at Loveland last year were most gratifying. The benefit derived from this treatment was plainly visible early in the season. The canes which were sprayed developed many more fruit shoots on their lower portions than the unsprayed ones. This, of course, meant a much larger increase in the amount of fruit to be harvested.

It was my purpose to continue the spraying experiments this season on the experimental raspberries at Loveland, but instead of the early application of Bordeaux mixture, as carried out last year, I had intended to spray immediately after the picking season had closed. If it could be shown that late spraying was just as efficient, there were several reasons which made it more desirable than early treatment.

However, at about the time the last berries were being gathered, the characteristic brown blotches, indicative of the cane blight, made their appearance, and I saw at once that late spraying would be impractical with the disease as far advanced as it was; consequently, no treatment was

given this season. From this, it is clear that if we are to expect any benefit from spraying at all, it must be begun early in the spring when the canes are not to exceed eight inches high and kept up at intervals of two weeks until the picking season begins.

A number of growers at Loveland observed the results of my spraying experiments last year and were so favorably impressed with the control secured that they expect to spray their entire patches next spring. A number of the men are going to set new plantations and will endeavor to keep them free from the cane blight by early spraying. I hope to continue my experiments next season in order to determine the latest date on which efficient spraying can be begun, as well as the minimum number of applications necessary to control the disease. Our work at Loveland has further demonstrated the absolute necessity of covering canes with soil during the winter, since those which were left uncovered perished, as well as a large per cent of those which were covered with straw and then with soil. This year the growers took up their canes earlier than usual, with the result that not much growth took place before they were uncovered and, consequently, what growth they secured had an opportunity to become well hardened. In previous years, when the canes were left uncovered until late in the season, considerable weak, succulent growth took place underground, which when exposed to the air, turned black and died, thereby causing the loss of many fruiting shoots. From the results which I have seen this season, I am impressed more than ever with the importance of taking up the canes early.

Another factor which has certainly had its detrimental influence on the raspberries at Loveland has been the injury to the young canes by the late frosts, which has resulted in the development of small, forked canes. Weather conditions this year have been excellent for the growth of new canes and the growers seem very hopeful over the prospects of large canes for the next season.

In noting the deterioration of the raspberry industry at Loveland, we must not lose sight of the fact that many of the plantations have been set for ten to fifteen years, and, while the young canes appear very vigorous early in the season, these do not make the fruiting canes which the younger plants in newer patches develop. The crowns of the old plants are greatly spread through age, and, to all appearances, the nutrition of the cane suffers because of some peculiar physiological relation existing between the

old root system and the spreading crown. I mention this because I believe the age of the plantations is another factor which should be considered in the failure to secure the previous yields of red raspberries.

Project IV. Grasshopper Disease. For a number of years past, an epidemic has been prevalent among the grasshoppers of Colorado, which has appeared sporadically with more or less varying degrees of virulence. The extreme severity of the attack at times has suggested to us the possibility of utilizing the causal organism for the destruction of the grasshoppers. Although the disease was prevalent this past season, it was not so widespread as to cause unusual comment. My purpose in undertaking this line of work is to make a rather careful study of the life history of the organism, a fungus, which is responsible for the disease in order to determine if possible whether there is not some period or stage in the growth of the parasite which is extremely pathogenic for the grasshopper. Experiments carried on in co-operation with the division of Entomology, have demonstrated that the grasshopper is not susceptible to the organism when brought in contact with the ordinary form of the fungus, such as is obtained from the bodies of dead grasshoppers. In these experiments to which I refer, the grasshoppers were literally fed with the fungus, and the pure culture was spread upon their bodies. More than this, grasshoppers free from the disease were placed in breeding cages with sick grasshoppers and grasshoppers dead of the disease, but in spite of these numerous attempts to infect them, all remained healthy. In the light of these results, it seemed clear to me that it was useless to attempt to propagate the disease and spread it among the grasshoppers by the use of the fungus in its ordinary vegetative condition, such as is secured from dead grasshoppers. Pure cultures of the supposed causal fungus have been isolated, and an attempt is now being made to produce on culture media some unusual form of the fungus with which we hope to infect grasshoppers next season. Unfortunately, this project was taken up so late this year that it was impossible to secure living grasshoppers for inoculation experiments with our modified fungus.

During the coming months it is my purpose to continue the cultural study of the parasite, directing especial attention toward any unusual stages in the life history which may occur.

In addition to the above work covered by the Adams fund, at the request of Professor Bennett, of the Horticul-

tural Department, I have spent considerable time in working out a method by which low grade vinegar containing less than 1 per cent of acetic acid could be worked over into good vinegar which would fulfill the legal requirements, namely, 4 per cent acetic acid. I am glad to say that I have been able to accomplish this by introducing a pure culture of a desirable yeast along with a pure culture of the acetic acid germ, and by adding to the low grade vinegar 2 per cent of cane sugar. In this way it has been possible, by maintaining the proper temperatures, to stimulate a further fermentation of the low grade vinegar so that I have secured in less than two months a product containing 5.7 per cent of acid.

At the request of Professor Fitch and the Director, I have devoted a small part of my time to a study of the potato wilt so prevalent in the State this season. Diseased potato vines have been examined from the San Luis Valley, the Arkansas Valley, and the Fort Collins and Greeley districts. Without exception, I have found the trouble to be due to a species of fungus known as *Fusarium oxysporum*. This is nothing new to the literature on potato disease, since it has been extremely severe in other sections of the United States at other times and for some reason which is just now not clear to us, it has become very severe in Colorado this season. In addition to this trouble, many vines are also attacked by *Rhizoctonia*, the cause of big vines and little potatoes.

Respectfully submitted,
WALTER G. SACKETT.

REPORT OF THE IRRIGATION ENGINEER.

To the Director:

I present herewith a report of the work done by this Section of the Station during the past year.

The teaching in this Department is very heavy and keeps Professor Parshall and myself busy with class work during nine months of the year, hence the State Board of Agriculture appointed Mr. V. M. Cone to take charge of research work in Irrigation and drainage investigation. He devotes his entire time to the experimental side of the work, and has under him two assistants, Mr. Robert E. Trimble and Mr. G. D. Walters.

Mr. Cone came to us April 1st, and has been working ever since along experimental irrigation lines. He has under way a number of projects which should be of interest and value to the irrigators of the State. He will make a separate report to you on the progress of this work.

On June 21 we met, by appointment in Denver, Mr. Samuel Fortier and Dr. A. C. True, of the United States Department of Agriculture, and contracts were drawn up for co-operative work along irrigation lines. This is the first time work of this kind has been attempted in Colorado and we expect much from it.

Considerable work was planned for the summer by Professor Parshall and myself to be done on the funds from the appropriation made by the last Legislature, but as these funds have not been available, most of this work had to be postponed. We did, however, build weirs and install measuring devices in the different ditches on the College farm, and the season's run of water was measured for most of the fields. Computations on this work are proceeding at the present time. From these results we shall get the duty of water for the different crops grown on this land.

It was also necessary to have an accurate map of the entire farm. This work was placed in the hands of Professor Parshall, and he and his helpers did as much of it as finances would permit. The survey was practically completed for the farm and campus. The ditches and fields were all located and areas obtained; also the buildings, drains and pipe lines were all carefully located and a topographical map prepared. This map will be kept up to date, and will

be of great value in the future for the installation of new and up to date systems of irrigation. The map is now ready for tracing and we shall complete it as soon as finances will permit.

Respectfully submitted,
E. B. HOUSE.

REPORT OF THE IRRIGATION AND DRAINAGE SECTION.

To the Director:

This report is a statement of the co-operative projects planned and under way in the Irrigation and Drainage Section of the Station.

The Meteorological work is virtually the only work now in progress that was being carried on when I became connected with the Station in April. Much additional equipment has been added to the Section, most of which has been satisfactorily installed.

It is the intention of Mr. Trimble to write a report giving the results of the Meteorological observations at the Station for the past 25 years, and it is expected that these data will be of sufficient value to issue in bulletin form. In connection with this report, to overcome a portion of the customary dryness of statistics, an experiment is being started, the equipment having been secured and installed, with the expectation of securing some definite data for the establishment of the law governing evaporation losses from water surfaces. It is expected that this experiment will be completed by the end of the present calendar year, and that the Meteorological report will be prepared before the opening of the field work next season.

At the beginning of the present Government fiscal year, July 1, irrigation work that had been conducted by the Agricultural Experiment Station of Colorado, and by Irrigation Investigations of the Office of Experiment Stations, United States Department of Agriculture, was consolidated under a co-operative agreement according to which reports of all results obtained from experimental, research or field investigations will be available both to the Government and to the Station. The expense of such work is covered by a fund of \$11,600 per annum, one-half of which is furnished by each party to the contract.

Planning the work, organizing a working force, and putting the plans into operation, consumed time, and it is for this reason largely that practically no tangible results have been secured to report upon.

Of the work now under way the project known as "Drainage Requirements of Crops and Drainage Factors," supported largely by the Adams fund, is probably the most extensive. Two double sets of concrete tanks, each double set containing ten separate compartments, have been in-

stalled in the experimental plot on the College farm. Here it is planned to experiment with the effect of various water levels upon plant growth, both annual and perennial crops being used. The compartments vary from two to six feet in depth, and all are provided with a system of water supply and drainage. The soil excavated from one set of tanks has been replaced, while a different type of soil was secured about four miles southeast of Fort Collins for filling the second set. It is the intention to determine, if possible, the effect of various ground water levels upon plant growth with various soils.

Double-jacketed percolation tanks have been installed in the Station research laboratory in the basement of the Civil and Irrigation building, and the above-mentioned soils have been placed in these tanks, which are now in operation. In this connection it is also intended to observe the effect of temperature upon the rate of percolation of water through soils. As a part of this project the extent of the capillary action in many types of Colorado soils is being investigated in the laboratory.

An equipment has been installed with the hope of securing some data which will lead to a means of checking, if not curing, the nitre trouble which is so serious on the Western Slope in this State. Infected soil has been secured from near Grand Junction for this experiment, which is a co-operative one, between the Chemical, Bacteriological and Irrigation Sections of the Station.

A series of eight double-jacketed soil tanks for the determination of the actual water requirement of crops has been in operation throughout the summer in the experimental plot. Owing to the late planting of the alfalfa results are not as complete as desired, but this shortcoming was fully anticipated.

Equipment consisting of weir boxes and flumes with various appurtenances, has been installed in the hydraulic laboratory for determining additional laws concerning the flow of water, with special reference to flow through orifices. A small portion of the actual experiment has been made, and it is the plan to complete this work during the present winter.

Arrangements have been made for the field investigations next season on the Coefficient of Friction in the Empirical Formula. This is also research work under the Adams fund.

Projects covering pump irrigation, weir construction and concrete structures have been planned, but little actual

work has been done on them because of the necessity for installing other apparatus and securing other data before the winter season commenced. These projects, however, will be carried on next summer as a part of the general field work, though now they form a part of the co-operation.

There are three original Government projects: Irrigation in the San Luis Valley; the Eads Demonstration Farm; and Duty of Water in Orchards at Canon City. They have been carried on as before. The purpose of the San Luis Valley work is to secure data for a general report on that Valley preparatory to taking up specific problems. In connection with this project an agreement has just been reached with the Costilla Estates Development Company for the installation of three 40-acre experimental and demonstration farms on the Costilla Estates. Two of these farms will be irrigated by pumping plants, while the third will be under an existing gravity ditch. It is expected that everything will be in readiness for complete cropping next spring. The Costilla Estates Development Company has agreed to furnish the land, necessary labor, and in fact stand practically all expenses of the work, other than the salary and traveling expenses of the Agronomist and Irrigation Specialist of the Station, who will have direct control of the experiments. This co-operation is planned for at least two years, and as the entire conduct of the experiments is to be controlled by the Station, the probability is that results will be obtained. The irrigation field man in the San Luis Valley can visit the Costilla work whenever necessary without any considerable loss of time or additional expense.

For the past five years duty of water experiments have been made in an apple orchard at Canon City by Mr. R. G. Hemphill, but this work has been interfered with by poor crops for three seasons. This season, however, conditions were such that some very good data have been secured. The experiment has consisted in irrigating with and without cover crops and with various quantities of water applied at various intervals of time. The primary object, of course, has been to devise means of securing maximum results with a minimum quantity of water. Whether or not this work will be continued another year has not been decided.

A 40-acre farm at Eads, which is being operated by Mr. W. H. Lauck, has for its object the comparison between dry farming and irrigation, the use of small supplies of pumped water as a supplement to dry farming, and the proper handling of the soil to prevent the damaging effects of high winds. The Eads farm has met with some reverses, due to

a reduction in the water supply caused by perforations in the well casing becoming clogged. This has led to a change in the original plans, as there was not sufficient water to properly irrigate all the crops. Although the results at Eads have not been all that were anticipated, still the work has not been a failure from an experimental standpoint, and has served as a good demonstration of the value of a small water supply in connection with dry farming.

Mr. Lauck has now in course of preparation, a report on the results obtained during the past five years, and this should be received within the next three months. In addition to conducting the work at Eads, Mr. Lauck devotes a considerable portion of his time during the winter months to Farmers' Institute and Demonstration Train work for the Station and College.

As stated at the beginning of this report, most of the work is in the future tense, and some of the projects will continue for a number of years before final results are obtained. However, there is much work that should be completed ere another annual report is called for, and tangible results should take the place of project plans.

Respectfully submitted,

V. M. CONE.

Fort Collins, Colorado,
November 1, 1911.

REPORT OF ENTOMOLOGICAL SECTION.

To the Director:

I have the honor to present herewith the annual report of the Entomological Section of the Experiment Station for the year 1911.

The work has been carried on under the Adams, Hatch and State funds, the projects being as follows:

Adams Fund:

Plant louse investigations.

Hatch Fund:

Coddling-moth investigations;
Grasshopper investigations;
Experimental orchard.

State Fund:

Horticultural investigations (insects).

Plant Louse Investigations:

The work on this project has continued about as in previous years, special stress being put upon working out the life histories and host plants of Colorado species. In this work, Mr. L. C. Bragg has devoted much of his time to observations in the field and the gathering together of a large number of specimens in all stages of development and mounting specimens for study in balsam and in alcohol. Miss M. A. Palmer has given her time largely to the making of accurately drawn and colored figures of the species collected and to the rearing of the natural enemies of the lice. The writer, besides directing the work, has made many field notes and observations, collected and mounted many species, made many descriptions of new or undescribed forms, and taken care of the systematic side of the work.

The plant louse collection contains over three thousand (3,000) balsam mounts and about two thousand (2,000) vials of alcoholic material, representing the Aphididae of the State.

Among the most interesting observations that we have made in this work are the finding of the winged pre-sexual forms of *Eriosoma lanigera* in great abundance about the crowns of elm trees during the fall, September and October, depositing the sexual forms; and a similar habit of the winged pre-sexual form of *Pemphigus betae* upon cottonwood trees. These observations are in confirmation of similar ob-

servations made one, two, and three years ago. These observations have been made about Fort Collins, in the Arkansas Valley and in the Grand Valley in the vicinity of Grand Junction, so I cannot doubt that the woolly aphid of the elm has the elm as an alternate host, and the root-lice of the beet has the cottonwood tree for its alternate host.

Several papers resulting from these studies have been published during the year. One of these, a most important technical paper, "Some Notes on Heredity in the Coccinellid Genus *Adalia*," by Miss M. A. Palmer, was published in "Annals of the Entomological Society of America" for September, page 283; and the writer has published one paper* in the "Journal of Economic Entomology," and one** in "Entomological News."

Codling-Moth Investigations:

This project has been held in abeyance on the Hatch Fund, but considerable attention has been given to life habits and remedies of this insect by Mr. George P. Weldon, under the support of the State appropriation for horticultural investigations.

Grasshopper Investigations:

This project has been in charge of Professor S. Arthur Johnson the past year, and the work has been supported partly by the Hatch fund and partly by State appropriation for the control of insects and other pests. In this work, Professor Johnson has given much attention to a more thorough knowledge of the life habits of the more injurious locusts, and as much, or more, to the work of testing out different methods of control.

Grub Injury to Plants:

Several complaints have been brought to my attention during the latter part of the summer of a Scarabid that has been attacking the roots of garden truck, especially carrots and turnips, in Eastern Colorado. While at Cheyenne Wells on August 20, my attention was brought to the injury of this insect, by Mr. Adams, who is in charge of the Station dry farm at that place. The injuries to the garden stuff there were confined to carrots, and it was impossible to find a specimen of red root, *Amarantus* sp. that did not have about its roots from one or two to a dozen of the adults

*August, 1911; "Plant Louse Notes, Family Aphididae."

**December, 1911; "A New Genus and Four New Species of Aphididae."

of *Ligyrus gibbosus*; and several complaints have been sent in from other parts on the plains region east of the foothills.

Fruit Tree Leaf-Roller (*Cacoccia argyrospila*):

This leaf-roller, which did so much damage to fruit trees in Eastern Colorado a few years ago, has attracted but very little attention for a number of seasons, but was very bad again this year at several points in the Arkansas Valley from Canon City to Rocky Ford. There were many complaints that the ordinary spray mixtures as used for the Codling-moth were not sufficient to control this pest, but very good success was attained where arsenate of lead in the proportion of five or six pounds to 100 gallons of water was used two or three times, at intervals of only about one week. The insect has deposited large numbers of eggs in the orchards where it appeared last spring and may be expected to do considerable damage next year.

San Jose Scale:

This insect has been found in a few instances only during the past year. Very careful and thorough investigations to determine its presence have resulted in locating not to exceed 25 trees that were infested by it the past summer and fall. While it may be impossible to ever completely exterminate the scale in Colorado, we are succeeding in keeping it thoroughly in check.

The Grasshoppers:

The ordinary destructive grasshoppers that do so much injury to alfalfa and grain fields hatched in rather unusual numbers the past spring in the northern part of the State, but for some reason the numbers have grown rapidly less throughout the season and comparatively few have deposited their eggs this fall, so it seems probable that we shall have a year of comparative freedom from this insect, at least in Northern Colorado, during 1912.

The New Corn Root-Worm (*Diabrotica virgifera Lec*).

This little insect, closely resembling the striped cucumber beetle, has been a rather serious pest on several occasions that have come under my observation, attacking corn roots and crowns. The remedy lies in avoiding the planting of corn after corn where the insect has been present the previous year.

An illustrated paper giving the results of our observations upon this insect has been prepared for the April meet-

ing of the Pacific Slope Association of Economic Entomologists and will probably be published in the Journal of Economic Entomology during 1912.

A New Fruit Tree Pest (*Cleonus canescens* Lec).

This insect has been reported to me on several occasions as seriously injuring the foliage of young peach, apple and pear trees on the western slope of the Rocky Mountains in Colorado and Utah. Those who have reported the pest to me are O. B. Whipple, George P. Weldon and E. P. Taylor, while field agents of the Experiment Station located in Western Colorado.

A fuller account of this pest with illustrations accompanied the paper on the "corn root-worm" mentioned above.

EXPERIMENTAL ORCHARD.

The experimental orchard has received no special attention this year further than what was necessary to trim the trees and cultivate and irrigate the orchard to keep it in a good growing condition.

The Personnel of the Section remains about the same as last year. Mr. L. C. Bragg closed his work with the Department on the first of November.

The report of the Field Entomologist, George P. Weldon, follows.

Very respectfully submitted,

C. P. GILLETTE.

REPORT OF FIELD ENTOMOLOGIST.

To C. P. Gillette, Entomologist, the Director of the Experiment Station:

The shortage in funds for the State Fruit Investigations made it necessary that this work cease on July 1, consequently this report covers a period of only nine months, during which time the work done may be classified under the following heads: Institute, Experimental, Inspection, Bulletins, Demonstration, and General Investigations.

About three weeks were spent in institute and demonstration train work. I took part in meetings at the following places: Grand Junction, Fruita, Delta, Rifle and Canon City and went with the demonstration train and looked after the exhibit from the Department of Zoology and Entomology, on the trip over the Rio Grande and Union Pacific systems. This journey made it possible to meet the orchardists of many sections and talk over their various problems with them.

The experiments of the past season consisted in one at Rifle, to test the effect of different sprays on green peach-aphis and peach twig-borer when applied for both at the same time; also one to determine the value of fall sprays for these pests. Another was conducted at Grand Junction for the purpose of testing the relative merits of arsenite of zinc and arsenate of lead as codling-moth sprays.

The experiment at Rifle gave some good data on the control of peach twig-borer. Both fall and spring applications of Rex lime and sulphur while trees were dormant controlled this pest perfectly. The crotches of unsprayed trees contained multitudes of living larvae when examined after the spring sprays had been applied, while those sprayed with lime and sulphur contained just as many larvae but all dead. Tobacco preparations, Black-leaf and Black-leaf 40, were used in this experiment, also, but were of little use in controlling this pest.

The data gathered from this experiment relative to the control of green peach-aphis was not such that many conclusions could be drawn. It seemed evident, however, that little good could be accomplished with a fall spray in controlling this pest, unless applied very late, after the eggs had all been deposited. Spraying was done last season in November and there seemed no doubt but that many of the egg-laying forms of this louse were deposited on the trees after this time, the spray being too early for them.

Arsenite of zinc gave very promising results in controlling the codling-moth. In some cases it seemed to do better work than arsenate of lead. Some burning of fruit and foliage from both arsenate of lead and arsenite of zinc was noted.

Inspection of orchards to determine what pests are present, and the necessity of spraying for certain of them, always requires a lot of the field workers' time. The first three months of the year, much of this kind of work was done. In the peach growing section adjacent to Palisade and Clifton, the orchardists were in doubt as to whether or not it was necessary for them to make a spring application of lime and sulphur to their peach trees, for the control of green peach aphid and twig-borer. Very careful inspection was made in a great many orchards of this section, and in most cases scarcely any aphid eggs could be found, where the year previous they were abundant. The twig-borer hibernaculæ were also found to be very scarce; consequently the growers were told that the lime-sulphur spray would not be of great importance last spring. As the season advanced, it was evident that no mistake had been made and that the conclusions as a result of this inspection work were, in the main, correct. Many of the orchardists were saved the expense of a spray which otherwise would probably have been applied at a loss.

One bulletin, No. 169, on "Some Insect Pests and Mites of the Peach in Colorado," was issued last November. This bulletin gave life history notes, methods of control and data gathered from previous experiments for the control of most of the peach insect pests which occur in the State. The plant lice attacking this tree were treated in the bulletin by Gillette and Weldon.

Most of the work with codling-moth the past season was more of a demonstrative than experimental nature. Four orchards were chosen early in the season, and the work of spraying in them was given personal supervision until it was necessary to leave the Grand Valley, about August 1. These orchards were located at Palisade, Clifton, Grand Junction and Fruita. The season proved rather an unfavorable one for such work. In three out of four orchards the crop was very light, which with an abundance of codling-moth, always means that an extra effort has to be put forth to control them. Fairly good success was had, however, in each case, and possibly a new idea of thoroughness in spraying was given to some of those in whose orchards the work was done.

General investigations were carried on in connection with other insects besides those already mentioned, such as San Jose scale, Howard scale, Putnam scale, Woolly aphid, Green apple aphid, and the various species of mites which are closely allied to the insects, as well as a number of pests of only minor importance.

It was interesting to note the past season the almost total absence of the tiny egg parasite of the codling-moth, viz.: *Trichogramma pretiosa*, where the year before it was so plentiful that probably at least 90 per cent of the codling-moth eggs were killed by it, during the months of August and September.

The scarcity of San Jose scale on the western slope is very encouraging, and speaks well for the spraying done by those orchardists who have had this pest to fight. But for the fact that very careful and thorough spraying has been done wherever this insect has made its appearance, it would now, in all probability, generally be distributed through the orchards of that section. As it is, there is little live scale to be found anywhere.

Respectfully submitted,
GEORGE P. WELDON.

REPORT OF THE BOTANIST.

To the Director:

During the past year the following matters in Station work have received the attention of the Botanist:

Adams Fund. Black Root of Strawberry. But little has been added to our knowledge of this trouble since my last report was made. The need of continuous and undivided time to be put on this subject has been the chief obstacle in the way of progress. Observations along the line of winter injury to the strawberry, at one other Experiment Station, indicate that this is a common cause of root injury such as that found in this State and which has been considered one of the chief causes of the trouble here.

Special Fund. The lack of such funds has prevented the continuance of work with the co-operative tree planters of the State. One trip in this connection, however, was made to Akron last spring to inspect the tree-planting there on the Government Experimental farm in co-operation with the U. S. Forest Service. As the complete handling of this matter does not fall to this Station until next year, a report on the trees that should be replanted was made to the U. S. District Forester at Denver, who promised to attend to the replacing of dead trees.

During the winter, some work was done on the Jonathan spot and Storage Scald of Apple in conjunction with the storage experiments of the Jonathan apple by Mr. R. S. Herrick. The results were furnished for publication in a bulletin to be published by Mr. Herrick on the storage of this variety.

Some studies of the sugar beet, as grown on "nitre" charged soils, were also undertaken for Dr. Headden. A large series of specimens were preserved for future study as time should permit. Some specimens were obtained from Michigan for comparison with those grown in our State. Mr. W. W. Robbins, the new instructor in Botany, is now studying these and other recently gathered samples in a comparative way. Thus far, his observations agree closely with those of investigators who have studied abnormally developed beets, poor in sugar content, as grown in Germany.

Mr. Robbins is also undertaking the study of the algal flora of nitre-charged soils in co-operation with the Bacteriologist. This problem is, in brief, as follows:

In connection with the nitrogen fixation problem, it is claimed that there is not sufficient carbon in our soils to fur-

nish energy for the high degree of fixation which takes place. At the request of Professor Sackett, a study of soil algae will be made. Algae may be regarded as a possible source of carbon. Each soil specimen will be filtered; the suspension will be used to inoculate pure quartz sand, upon which the algae will be grown. The problem is to ascertain whether or not algae in our soils may be, and to what extent if any, a source of carbon supply.

In this connection, I wish to state Mr. Robbins is proving to be not only an efficient instructor, but is showing much ability as an investigator. I desire, therefore, to recommend that he be placed on the Station staff during the coming year, as I am confident that he will be a valuable man for certain lines of work which this department desires to carry on.

Respectfully submitted,

B. O. LONGYEAR.

REPORT OF THE AGRONOMIST.

To the Director:

I respectfully submit herewith my annual report of the work of the Agronomy Section of the Experiment Station.

The experimental work has been included and carried on under three different funds: the Hatch fund, and State appropriations for Agronomy and Dry Farming work.

Under the Hatch fund we have been carrying two lines of work. One of these we have called "Correlation." This is essentially a study of the characters of plants to see if there is any relation between their habits of growth and the adaptability of those crops to a specific purpose. As an illustration, we are studying the head growth and length of head and size of head to see if there is any relation between these characters and the yield of wheat. We are making a similar study of barley and oats and alfalfa as well as the grasses. We are making a similar study to see if there is any relation between the type of growth of the plant and its adaptability to different altitudes. For instance, we have found that a certain type of cereal seems to do better in the lower altitudes, while certain others prefer the higher altitudes. For instance, the Swedish Select oats is one of our very best varieties for the high altitudes, where the nights are cool and the season relatively short. On the other hand, the Texas Red and the Kherson can be grown successfully in those regions where the temperature rises quite high during the day and in localities where the Swedish Select will not thrive at all. We are making a careful study between the characters of these plants to see if there is any relation between their habits of growth and their adaptability to the different situations. If we can discover such a relation between them it will enable us to quickly select or eliminate varieties for planting either in the higher altitudes or on the dry plains.

The work in alfalfa is being carried on at the Experiment Station at Fort Collins, upon the Sub-station at Rocky Ford and at various places in the State. We are doing two main things in alfalfa growing. First, we are trying out all the varieties of alfalfa that we can get from all possible sources to see which types are best adapted to our conditions. We are already able from our work to classify all the varieties that we have tested, which means something over seventy, into two general types which we may call the Northern type and the Southern type.

The Northern type has certain characteristics which enable it to resist cold and which make it hardier through our dry winters and springs. The Southern type is quick growing and has some value, but cannot be grown successfully in many localities in the State.

The work in determining these two types has been valuable in that it has shown a definite correlation between type or character and hardiness. The Northern type of alfalfa puts out root-stalks or shoots below the surface of the ground. These shoots are therefore protected by a layer of soil varying in depth from one inch to over six inches. It is this characteristic of putting out shoots protected by the soil, that enables it to withstand the cold and the severe cold and dry conditions of the spring. This characteristic also enables the plant to withstand pasturage to a greater extent.

The Southern type of alfalfa put its shoots out at the surface, or above the surface of the ground. They are, therefore, unprotected. The result is that the Southern type cannot withstand the cold nor the tramping in pasturing which the Northern type will endure with no apparent injury.

In addition to working out these factors, we are conducting very careful breeding experiments in order to get the best seed yield and the best hay yield of each of the types which we are working with. We are spending most of our efforts on the Northern type because the most of our territory is subject to dry or very cold winters. We have found from our experiments that there is as much variation in the production and in the transmission of characters between individual plants in any type as there is between different types. We are making use of this to select plants which are most favorable for our purposes and are planting these in increase plats so as to increase the amount of seed which we can get from the very best selections.

Under the Agronomy appropriation given by the State, we have been conducting experiments in breeding improved varieties of grains and in testing varieties from as many sources as possible in order to obtain the best sorts for our conditions. In this work we have found as the result of our experiments a few definite things. We have found that the early maturing types of winter wheat are best adapted to most of our conditions and will give the largest returns. Of these varieties, the Turkey types have been superior in all of our experiments. The Turkey types include a number of varieties; the Kharkov, Turkey Red, Crimean, Malakoff and some half dozen other varieties which are more or less synonyms of those already given. Of these we have found the

Kharkov to be the best under our conditions. Next to this we would place the Turkey Red, the Crimean and the Malakoff in the order given.

We have been attempting in this work to breed earlier varieties, that is varieties that matured in a shorter growing period. We are working along two lines to secure this object. First, we are making selections in the field of plants which mature earlier than the general run of the field. Second, we are making crosses. We have one cross in our nursery now which matured from seven to ten days earlier than our earliest Kharkov when planted at the same time. If this should prove stable and yield as well in the field tests as it has yielded in the nursery tests, it will be of very great value to the irrigated and dry farm sections of the Great Plains portion of our State, since it will in maturing ten days earlier, escape a great deal of possible injury from hail storms, drouth, insect depredations and other troubles which afflict wheat crops.

We are doing similar variety testing work with oats, barley, rye, winter emmer, sugar beets, millets and a few miscellaneous crops to determine their usefulness and adaptability to different sections. This work has resulted in showing us that the Kherson oats, the Sixty-day oats and the Texas Red oats are the best adapted to our dry land regions; that the Great Dakota, the Colorado 37, the Swedish Select and the Kherson oats are best adapted to our irrigated regions; that two varieties of rye are better than all other tried, viz., the 20th Century and the Dwarf; that California Feed barley is our heaviest yielding feed grain; that Hanna barley and types of barley similar to the Oderbrucker are best adapted for brewing purposes and in addition make good yields for feed grain.

We are carrying on extensive experiments with high altitude crops in order to find as many as possible adapted to the higher altitudes of our State. We have been experimenting in Middle Park, in Grand County, in Routt County, in Moffat County, in South Park and in the San Luis Valley. We have been keeping track of co-operative work in North Park and in the extreme southwestern part of the State, but as yet we have not been able to visit these points to see the actual results.

We have been able to grow Kherson oats, Colorado 37 and Swedish Select oats, California Feed barley, bald barley, Turkey Red winter wheat, timothy, alsike clover, alfalfa, rutabagas, Yellow Aberdeen turnips, stock beets and field peas at altitudes as high as 8,000 feet, in Middle Park and

at similar altitudes in Routt County and Moffat County. Kherson oats, California Feed barley, bald barley and Turkey Red winter wheat are so far the only grains that have been uniformly successful in the North Park region, although the grasses and such crops as potatoes and a great deal of garden truck have been successful there also. We have been able to mature Kherson oats, Blue barley, Turkey Red winter wheat and such crops as potatoes and a great many of the garden crops at an altitude of 8,600 feet near Fraser. Field peas were also successfully grown at this altitude. We are gradually increasing the number of crops that can be grown at any given altitude and we are finding out what characters of the cereal crops and various other crops render them adaptable to such high altitudes. It is interesting to note that the Kherson oat, which is the best of our dry land oats, is also the best of our extremely high altitude oats. At a moderately high altitude, say six to seven thousand feet, in localities like Grand County and Middle Park, Swedish Select oats will out-yield the Kherson; but at 8,000 to 8,600 feet the Kherson is much better than the Swedish Select. This is no doubt due to the fact that the Kherson will fully mature in a much shorter growing period.

Until the first of July we had a field man in our dry land work who carried on co-operative experiments in various parts of the Plains region with farmers, and who traveled over that region from place to place and advised the farmers of the different communities how best to carry on their work. We were obliged to dispense with the services of a Field Man after July 1, owing to the failure to get our appropriation. Our dry land work since that time has consisted mainly of the work which is being carried on at Cheyenne Wells at the Dry Land Sub-station. Upon this Sub-station we are testing varieties of corn, the grain sorghums such as milo, white hulled kafir, black hulled kafir and a number of others of the non-saccharine sorghums. We are also experimenting with the white amber and the early amber sorghums. All of these are more or less successful. The milo and black hulled kafir have been most promising for grain production. The kafir and sorghums have been most promising for forage production. Stock melons, Mexican beans, the Black Eye cow peas, certain varieties of muskmelons and certain varieties of potatoes have done well upon this station. The potatoes which have done well have all been early maturing types, that is, those that mature in a short season. In addition to these we have tried out a number of varieties of millets. Of the millets, the Proso seems

best adapted because it grows to its full development in a short, quick growing season. The Siberian and German millets have also done well.

We have been able to grow such fruits as plums and cherries and some apples successfully on this Sub-station.

We are co-operating to a limited extent with the Bureau of Plant Industry. This Bureau has a sub-station at Akron which adjoins our forestry plantation. Through a co-operative arrangement, the Bureau of Plant Industry has worked a portion of the land in the forestry tract, which enables us to try a number of crops in this way. The grain sorghums, the sunflowers of the tame variety, the millets, Turkey Red wheat and Durum spring wheat have made something of a crop even in the dry years such as that of 1911.

I am appending herewith the reports of Mr. P. K. Blinn, Alfalfa Specialist, Department of Agronomy, Rocky Ford, Colorado, and Mr. J. W. Adams, Superintendent of the Dry Land Sub-station, Cheyenne Wells, Colorado.

ALVIN KEYSER.

REPORT OF ALFALFA SPECIALIST.

I hereby submit the following report on the Alfalfa Project under my control.

The improvement of alfalfa by seed breeding in our nursery work has made splendid progress during the past season. The present nursery of over eighty nursery rows was increased by the addition of sixteen new numbers from the Bureau of Plant Industry, thirteen from Mr. A. C. Dillman of South Dakota, twenty from Prof. F. A. Spragg of the Michigan Experiment Station and about ten new selections that I made here in the old nursery and on the trip to Minnesota last fall. With one or two exceptions these new seedings made a splendid stand.

The nursery as it now stands is composed principally of the more hardy strains of alfalfa, most of the non-hardy strains having been omitted in the last two years' seedings. The Nursery probably contains the best known strains of alfalfa of today.

Notes and records have been made on the relative value of the different rows in the nursery; frost resistance, disease resistance, hay and seed production are points that have been carefully studied. Nearly seven hundred individual plants have been selected and saved for seed from the most promising nursery rows. After the results of the present winter are shown, the selection of the best of these selected lots of seed will be made for future increase work, for it is now very evident that there are some of the nursery rows that are easily fifty per cent better in yield of hay and seed than even the average of the whole nursery. Now, that a comparative test of the best strains has been carried on for a number of years, it seems advisable to make plans to increase a few of the best, most distinct types and have them tested in a few of the distinct sectional areas of the State, to try and determine which are best adapted to the conditions that exist in the different sections.

The co-operative work with farmers to introduce the Grimm's alfalfa into this State and to establish a more available supply of the seed, had the dual object of also trying to determine the best cultural methods, and the best districts in which to encourage alfalfa seed growing. The results have not been so gratifying as we hoped on account of the exceedingly dry climatic conditions that have prevailed the past season; also the attacks of grasshoppers and the injury from severe hail storms have caused some failures.

One hundred pounds of seed was used in small lots, in sending to farmers who made application and were willing to make reports, from different sections of the State, where it was not very possible to make personal visits. The reports of these tests are not fully in from which to make a correlated report at this time.

Four hundred pounds of seed was used to make larger field tests, principally in the Arkansas Valley under my supervision. The objects were to furnish practical field tests, to try out seed production in cultivated rows, and to furnish sufficient seed to make it profitable to thrash and thus make available a supply of the hardy strain within reach of the farmers in the vicinity where it is grown.

A complete report of just the condition of all the Grimm's alfalfa seedings in the State cannot be made at the present time, but the following is a general statement of the results from the seed furnished by the Experiment Station for field tests:

Lamar, Colo., on farm of Mr. A. B. Nowels	6	acres, fair stand.
Las Animas, Colo., on farm of Mr. W. H. Wadhams	12	acres, fair stand.
Rocky Ford, Colo., on farm of Mr. C. J. Cover	8	acres, good stand.
Rocky Ford, Colo., on farm of Mr. J. B. Ryan	3	acres, good stand.
Rocky Ford, Colo., on farm of Mr. C. V. Ryan	2½	acres, good stand.
Rocky Ford, Colo., on farm of Clark Kitchen	2	acres, failure.
Rocky Ford, Colo., on farm of Mr. J. W. Edgar	8	acres, failure.
Rocky Ford, Colo., on farm of Mr. D. D. Wiley	10	acres, failure.
Rocky Ford, Colo., on farm of Mr. P. K. Blinn	3	acres, good stand.
Rocky Ford, Colo., on farm of Experiment Station	5	acres, good stand.
Sugar City, Colo., on farm of National Sugar Co.	2	acres, good stand.
Sugar City, Colo., on farm of Prof. Mitchell	4	acres, good stand.
Manzanola, Colo., on farm of Mr. B. F. Powell	4	acres, failure.
Eads, Colo., on farm of Mr. Ben Hickman	10	acres, failure.
Eads, Colo., on farm of U. S. Experiment Station	1½	acres, failure.
Cheyenne Wells, Colo., on farm of Experiment Station	5	acres, good stand.
Eastonville, Colo., on farm of Keen Bros.	10	acres, good stand.
Eastonville, Colo., on farm of Kimzey Land Co.	5	acres, good stand.
Olathe, Colo., on farm of Mr. J. W. Strieby	5	acres, good stand.
La Junta, Colo., on farm of Mr. D. A. Boles	6	acres, not seeded yet.
Total	112	acres.

The above makes a total of 112 acres, 52½ with good stand, 18 with fair stand, 6 acres not seeded and 35½ a failure from lack of rain or a run of water for irrigation at the right time.

The investigation to determine the best cultural methods for seed production has not been fruitful of any very decided results. A plat of alfalfa in rows which had not been irrigated during the year 1910 was uniform in every way. Moisture was applied in varying amounts to five different sections of the plat. One section had no water applied; on one section the water was run in every other row just ten minutes; on another twenty minutes, and another forty minutes, and on another the water soaked two hours. In the spring the whole plat started growth uniformly and made so heavy a growth of hay that seed did not set well. A test of the soil revealed the fact that moisture was rising by capillary action more than ten feet, and yet there seemed to be no difference in hay growth in the different sections of the plats.

In the Nursery, and also in another portion of the field of alfalfa in rows, there were dry soil spots that were caused by gravel in one case and a hard-pan in the other. In both places the alfalfa dried up for lack of moisture. We anticipated that we would find a good yield of seed in a zone around these drying spots where the plants would get the proper amount of moisture, but such was not the case. It seems as if the problem of alfalfa seed setting is not dependent on just the amount of moisture, but rather the amount of moisture at certain times. In one case a little water ran over a portion of one of the dry spots just as the plants were beginning to suffer for moisture. They came into full bloom just as far as this water ran and seed set extra well.

It is the plan to follow up a line of observations that will eventually determine, if possible, the conditions best suited to alfalfa seed yields.

Notes on the general alfalfa problems with photographs have been taken, looking forward to the publication of a comprehensive bulletin on the subject of alfalfa culture in Colorado.

Respectfully submitted,
PHILO K. BLINN.

REPORT OF SUPERINTENDENT OF CHEYENNE WELLS DRY LAND SUB-STATION.

It has been the purpose this season to continue the work of 1910 as a demonstration of general farming combined with dairying and poultry raising, including some strictly experimental work, and comparative tests of some of the grain and forage sorghums. The orchard and trees have received careful cultivation.

ORCHARD AND TREES.

The apple trees have suffered from drouth this season notwithstanding the fact that they have been carefully cultivated and kept free from weeds. The rainfall has been much below normal and most of the rain received has been in showers of less than one-half inch, so it has been impossible to get the moisture to a depth to be conserved, and as 1910 was also a dry season there was not a large surplus of moisture in the soil. The trees also suffered from the attacks of leaf-rollers and other insects.

The shade trees, honey locust, ash, elm and black locust have done well, making considerable growth in spite of the adverse conditions. We picked forty quarts of cherries, but no apples.

GARDEN.

We planted two gardens, one-fourth acre each. The first was planted on ground which had been summer tilled in 1910. This was on high ground where it could not receive run-off water. The soil was moist to a depth of twenty inches at seeding time. In this garden we planted watermelons, cantaloupes, garden beans, navy beans, Mexican beans, cow peas, beets, parsnips, sweet potatoes, Virginia peanuts and radishes. All of these made a fair return for labor except parsnips, which failed to germinate, and radishes, which were destroyed by flea beetles. With a normal rainfall this garden would have been very profitable. As it was, we sold \$10.00 worth of produce over and above that required for family use.

The second garden was planted on ground that was farmed in 1910, but which is overflowed by water from the prairie above in case of a dashing rain. There was practically no available moisture in this soil at planting time. This was planted to peas, beans, cucumbers, potatoes, turnips, radishes, lettuce, onion sets, cabbage plants and tomato plants. About two quarts of water were put under each

cabbage and tomato plant at time of setting. The tomatoes survived the drouth until we had a rain that overflowed the patch; then they came out and made enough fruit for our own use and some to preserve. All other truck planted in this patch was a complete failure except a row of garden beans that were planted late. These came on after the July rain and made good returns.

POTATOES.

We planted about $1\frac{1}{2}$ acres of potatoes of six different varieties, as follows: Early Ohio, Irish cobbler, Carmon No. 1, rose seedling, peachblow and pearls. These were planted at different dates as follows: April 14, April 29 and June 2. They were also planted, some on summer fallow, some on fall plowing and some on spring plowing. They were given a careful cultivation, but none of them produced marketable potatoes except a few small patches that received run-off water from the adjacent prairie. The vines looked well and made a good growth, but the potatoes barely set except as above stated. It is not possible to make a comparison of varieties except that the Irish cobbler and the peachblow came nearer producing a crop than the other varieties.

MEXICAN BEANS.

We planted one-half acre of Mexican beans on fall plowed land. They only produced $1\frac{1}{2}$ bushels of beans.

FIELD CROPS—OATS.

On April 14 we sowed $3\frac{1}{4}$ acres of oats bought in open market, varieties not known. Also $\frac{1}{2}$ acre of Swedish Select oats and $\frac{3}{4}$ of an acre of Kherson oats. These were seeded with a hoe-drill on ground that had raised kafir and milo in 1910, except $\frac{1}{2}$ acre through the middle which was in beans in 1910.

The ground, except one acre, was old ground that had been farmed for years. One acre was new ground broken for the first time in 1910. The ground was all double disked and floated before seeding. They were harrowed once after coming up. They came up evenly and started off well, but the drouth checked this growth so that the Russian thistles came on and finally choked the oats out. It is significant that while none of the oats made a crop, those on the new ground gave up first, and the old ground on which kafir and milo were raised in 1910 died next, while those on the bean ground survived much longer than either of the others.

WINTER WHEAT.

The first week in August, 1910, we planted and packed the ground from which spring grain had been cut. The

ground was very dry when we began plowing. When we were half done we had an inch of rain. On August 30 I seeded four acres of this ground to Kharkov wheat. That portion on the ground plowed previous to the rain came up well, while that plowed after the rain came very poorly. Some light rains later sprouted it, but part of it died. The winter and spring continued dry and no crop was produced. About the middle of June we double disked, harrowed and seeded to Herse grass and millet. (See Millet.)

MILLET.

June 19 we seeded two and one-third acres of Hungarian millet and two and two-thirds acres of hog millet on a portion of the ground previously seeded to winter wheat and including one and one-half acres of ground that had the same treatment except it had not been seeded to wheat, but had been kept free from vegetation. We used a hoe drill for seeding. That portion on the fall plowing which had not been seeded to wheat come up good and grew well for a while, but was finally overtaken by drouth. The Hungarian millet made about one-third ton per acre, while the hog millet made one-fourth ton per acre. On the ground that had been seeded to wheat the stand was poor and uneven, and was not worth cutting except in a low portion of the field. The Hungarian millet withstood the drouth a few days longer than the hog millet.

CORN.

May 31 we planted about four acres of White Australian corn on ground that had been in millet in 1910. The ground was plowed deep in 1910, and as there was very little rain that season the ground was very mellow in the spring of 1911. This ground was double disked, harrowed, floated and planted with corn planters with furrow openers attached.

This corn received three harrowings and three cultivations. It came up well and grew well until near the tassel, when it began to burn. Only small patches produced corn. We cut it with a corn binder. I have not stacked it yet, but I estimate that it will make three-fourths of a ton per acre of very fine fodder. At the same time we planted four rows across a strip of summer fallowed ground and gave same care as above. Hot winds caught the tassel so we got no corn, but the fodder was considerably heavier than that not summer fallowed.

SORGHUMS.

In order to get at the comparative value of the different grain and forage sorghums we planted on as nearly uniform ground as was obtainable, twelve rows, sixty rods long,

each of the following varieties: Dwarf, White Kafir, Black hulled white Kafir, Sudan Dura, White Amber cane, Orange cane, Early amber cane and four rows of broom corn.

These were planted on ground that was broken for the first time in 1910 and planted to milo and kafir. In March, 1911, we double disked and plowed it about two inches deeper than it was broken in 1910. It was very dry when plowed. It was harrowed immediately after the plow by using an extra horse to drag a section of harrow. On May 17, the ground was disked to kill weeds and then floated by placing a 2x4 through the front of harrow and driving diagonally across the field. June 1 and 2 the seed was planted with corn planter, using the furrow openers. Two and one-half to four pounds of seed were used per acre according to the size of the seed. There was not sufficient moisture to germinate the seed at once, but on June 17 we had one inch of rain. This brought it all up except the Dwarf White Kafir, which had rotted. This seed had been treated with formaldehyde and had not been properly dried, but had been allowed to remain in a damp sack for a few days. On June 22 this was replanted with seed not treated. It germinated immediately and made a good stand. These crops were harrowed twice and cultivated three times. All grew well and bid fair to make good until the latter part of July when spots began to show the need of rain. These spots grew larger until they consumed more than half of the field. Those dry areas were not evenly distributed over the different varieties so that the comparative value of the different crops is hard to get at. The crop was mostly cut with the corn binder and has not been stacked or thrashed. It will be necessary to feed these crops out and note how the stock relish them before reporting upon their comparative value as feed. The Dwarf Kafir is undoubtedly the best combination of grain and fodder. The milo is probably the best to raise if grain alone is wanted, and the Orange cane yields the largest amount of good forage.

The White Dura and the brown Kowliang made a small yield of seed and comparatively large yield of almost worthless fodder. The Sudan Dura is a little more promising, but doubt if it ever is equal to the milo. The White Amber cane did well and if stock relish it, it will be a valuable combination of grain and forage crop as its seed does not possess the objectionable tannin that the black ambers possess.

In addition to the above, we planted five and one-half acres of standard milo and 5 and three-quarters acres of Orange cane on the same kind of ground and gave same

treatment as above except that it was not plowed before planting. The seed germinated at once on this ground, but did not make any growth until the rain on the 17th, which germinated the seed on the plowed ground. The crops on the plowed ground made better growth after coming up, but did not mature so early. This milo has been stacked. One load was weighed and the yield estimated at one and one-third tons per acre. The cane is not sufficiently dry to stack; we think it will yield one and two-thirds tons per acre.

The accompanying plat will give an idea of the extent of the part that burned out. The areas marked "D" are the portions that did not head out.

POP CORN.

We planted eight rows of pop corn on same ground as varieties of sorghums and gave same treatment; portions of it did well and others burned out. Gathered about three bushels of pop corn badly worm eaten.

RENTED GROUND.

In addition to the above field crops we rented from Mr. Trimble 30 acres of land adjoining the farm. This ground was in wheat in 1910 and had received no attention from the time the wheat was out until May, 1911, when we rented it. We harrowed off the weeds, double disked and harrowed again.

May 16 we began listing this to corn and kafir. There was no moisture below the lister slice so that the seed did not germinate until we had a shower. This was not enough to last long so that the kafir and part of the corn died out and was replanted to kafir with corn planter. This did well for a time, but was finally overtaken by drouth, so that the corn only made fodder and only part of the kafir was worth cutting, but it makes good winter pasture.

STRICTLY EXPERIMENTAL WORK.

During the season of 1910 about three acres of ground was summer fallowed and carefully tilled. The first of September we drilled about two acres to Kharkov wheat. It came up and stooled out and covered the ground nicely before winter. The winter was open and dry. The rabbits and birds worked hard on it all winter and killed some of it. It started off well in the spring, but it was so dry that there was no green grass for the rabbits so they kept it mowed down until the Russian thistles finally got the best of it. On April 14 we drilled in another portion of this summer fallowed ground one-eighth acre each of Kherson oats, Swedish Select oats, California barley, Kubanka wheat and some

white wheat from Wray, Colorado. These patches were green when all the country around was dry and brown, but the rabbits like oats also, so there was no chance to see what it might have made had the rabbits left it alone. This proves that it is not practical to raise small plots of grain here unless they be fenced rabbit proof.

ALFALFA.

In August, 1910, we broke 12 acres of low land which is subject to overflow, but which has not been overflowed in the past two years.

In the spring of 1911 this was thoroughly cut up with disk and in June it was plowed 8 or 9 inches deep and packed and harrowed several times. In August we seeded five acres of this to alfalfa. It was seeded with an attachment which we made for the corn planter. Four acres were seeded 40 inches apart and one acre 20 inches apart. We used 14 pounds of seed on the five acres. This was more than was needed. It came up and has roots over a foot deep. The rabbits have kept it eaten close to the ground, but it has stooled well. After frost the rabbits began digging it out, so we took a cultivator and covered it with earth. They have not bothered it since.

SUMMER FALLOW.

In addition to the ground prepared for alfalfa we summer tilled and plowed about 21 acres in different fields. It has been so dry that there is not a large accumulation of moisture. The ground is moist, not wet, to a depth of two to three feet. All stubble ground except millet has been plowed but has no accumulation of moisture.

THE DAIRY.

We have continued to keep individual records on the bunch of cows we reported on last year. We purchased a registered Holstein bull which we have used on the grade cows the past season. We also purchased one Holstein cow and one Holstein heifer calf last November. The cow came in fresh in December, 1910, and careful record has been kept. The Holstein cow has not given better results than the average of the grades this season. We have cared for the herd much in the same way as the average homesteader does, that is, they have been allowed to get a large part of their feed on the prairie. This has been supplemented with kafir, milo and corn fodder. Practically no grain was fed during the year. The grass was very late starting in the spring owing to the drouth. We ran out of feed before the grass was good and as feed was prohibitive in price and butter

fat very low, the cows were allowed to rustle, and as a result they fell off very badly just when they should have been doing their best. They did not regain when grass came, which was not until July. We had intended to furnish a herd summary as obtained from the use of scales and Babcock test, but we find that Mr. Maris of the Dairy Division has part of our records. We will furnish this later if desired.

We have kept a ledger account with the herd. We have milked 10 cows, but the record of feed consumed is for the entire herd, which consists of 10 cows, 3 heifers and 1 bull, 14 head in all.

The cost of feed, dip, etc.....	\$122.43	
Receipts from sale of products.....		\$235.03
Sale of seven calves.....		70.00
Two heifer calves retained, valued at.....		30.00
		<hr/>
		\$335.03
	Less	122.43
		<hr/>
		\$212.60

Considering the extremely low price of butter fat the past season and the extremely poor pasture, it will be seen that under average conditions the dairy business will yield a good profit even under these shiftless methods. While by the use of good dairy cows and a silo to utilize the feed to the best advantage, the dairy will doubtless yield a handsome profit.

POULTRY.

November, 1910, we had 80 hens and pullets and 4 cocks.

Total amount of feed, lice killer, etc., not counting waste products.....	\$21.39	
Total poultry products sold and used.....		\$100.03
Increase in value of flock.....		20.00
		<hr/>
		\$120.03
	Less	21.39
		<hr/>
	Net	\$ 98.64

RECOMMENDATIONS.

I believe this station should be made strictly a demonstration farm. It should be run just as nearly as possible as we should advise the settler to operate his farm. This will include general farming, care of trees, the family garden, dairying and poultry raising.

In order to do this certain additional equipment is necessary, namely:

- 1.—A spraying outfit suitable for spraying orchard.
- 2.—A silo and machinery for filling same.
- 3.—Manure spreader.

Careful records should be kept of the cost of production of all products of the farm, and samples of crops should be kept as an educational feature. In order to accomplish the first it is absolutely necessary that we have wagon scales. And for the second we must have a mouse proof room. This is also needed for storing seed. With this equipment the farm should be made self-supporting with the exception of salary of the superintendent.

In addition to this demonstration farm it would be desirable to carry on some experiments by way of testing out some promising crops that have not been tested in this locality, and also testing the value of different dry land crops as silage. This would call for an extra silo, but an extra silo would be desirable any way to furnish reserve feed for off seasons.

At present there are 75 acres under cultivation in addition to orchard and trees. I recommend that 30 or 40 acres more be broken and planted to crops. This would necessitate the renting of pasture land, but it would be better to rent pasture than farm land. In that way we could plan a series of rotations, including summer fallow that will retain the fertility of the land and get maximum crops. During the winter season the superintendent should be used in institute and other educational work.

Respectfully submitted,

J. W. ADAMS.

REPORT OF HORTICULTURIST.

To the Director:

I have the honor to submit the following statement of the work of the Horticultural Section for the year ending November 1, 1911.

The work connected with the various projects on potatoes has been carried on almost entirely by Mr. C. L. Fitch, Potato Specialist, whose report is given separately. The work connected with the orchard investigation on the west slope has been looked after by Mr. R. S. Herrick, in co-operation with this office. This report is also given separately. The rest of the work of this section has been under the direct supervision of the writer and has been carried on by Mr. S. V. Smith, Mr. Erdman and myself.

The projects that have been approved and carried on for the past year are as follows:

1. Orchard investigation;
2. Asparagus investigation;
3. Cherry investigation;
4. The onion industry;
5. Cover crops for orchards;
6. Cauliflower and small fruit investigation in high altitudes;
7. Vegetable garden investigation and demonstration;
8. Cabbage investigation.

The cover crop and the cherry investigations have been carried on here and also in co-operation with R. S. Herrick on the west slope. The vegetable garden investigation, cabbage investigation and cauliflower and small fruit investigation in high altitudes are being carried on here by the writer and Mr. Smith, jointly.

Owing to a lack of funds, very little traveling has been done this year in connection with these various investigations. One trip was made to Canon City for the purpose of studying some orchard problems; one trip was made to the Arkansas Valley to investigate some difficulties with cherries in that district; and one trip was made to Durango to investigate some orchard difficulties causing the dying of fruit trees. One trip was made to Grand Junction early in the spring of 1911 for the purpose of starting some co-operative work in gardening in that district. This work has not been continued for the reason previously mentioned.

In the way of orchard investigations, the apple, cherry and plum orchards set in the spring of 1911 have been cared for, and dead trees replaced. Two additional rows of apple trees were set on the east side of these plots. New stock for

use in this investigation has been grown in the garden plots. This has consisted of about one hundred piece root grafts made at the College last winter; one hundred Northern Spy piece root grafts which were purchased from the Colorado Nursery Company for experimental purposes; and one hundred or more yearling trees grown last year in the nursery row, transplanted this spring and cut back to the surface of the ground. This experiment has had for its object the securing of the best stock for setting in the orchard.

So far, the whole-root grafts made a year ago are by far the best stock. Some valuable data has been secured in the way of obtaining Northern Spy stock on its own roots. The piece-root grafts secured from the Colorado Nursery Company were set in a trench about six inches beneath the surface of the ground. As these grafts grew, the soil was filled in around the new growth in the hope that the new growth would send out roots sufficiently to support the young tree. At this time these stocks have not been taken up so as to know what percentage of the stock has made roots above the graft.

Other piece-root grafts that have been taken up have shown as high as forty per cent of the trees that have taken root above the graft, so that we have considerable hope of securing a number of varieties on their own roots. These trees will be eventually set in a permanent orchard where their development may be observed.

One-half the permanent orchard has been kept in clean cultivation during the season of 1911. The other half was plowed in the spring and seeded to cover crops and has not been cultivated since. None of the cover crops made a favorable growth, but the weeds, particularly the red root pig weeds, have covered the ground so as to make a fair coat of vegetation. Owing to a lack of water, the trees in this part of the orchard have not made as good growth as those in the cultivated area. Irrigation water was applied to the orchard twice, only, during the early part of the season.

During the winter of 1910 a large part of the trees in the young orchard were banked up with soil, to prevent their whipping and loosening during the winter. We believe this is a desirable practice for trees, for at least the first year after setting in the open ground. Recently, some veneer wood tree protectors have been purchased, which will be used for wrapping a part of the young trees in this orchard. Nearly all cherry trees have made exceptionally good growth the past season. The apples, which came through the season of 1910 in good shape, have made a satisfactory

growth. The stock purchased last spring to reset was very poor and has not made a satisfactory growth during the season of 1911. The plum stock used in this orchard was not especially good and considerable loss has been sustained from young trees dying.

Many important problems are continually coming up in connection with the development of young orchards, and it is hoped to get some valuable data from these plots.

Asparagus Investigations. The asparagus investigation, started in 1910, has been continued during the past season. The seed sown in the spring of 1910 made remarkably good plants for 1911 setting. Three permanent rows of these plants were set on the west side of the plots north of the potato storage house. These rows were set six feet apart, the plants eighteen inches apart in the rows. One row was put in in three plots, the first plot being set six inches beneath the surface; the next, nine inches; and the third, twelve inches beneath the surface of the ground, and as the plants came up, soil was filled in around them. Between these permanent rows, more rows were put in to be grown during the season of 1911 from which to select plants for another experiment. All of these plants have grown well during the season and those in the temporary rows have been marked so that we can determine the plants that produce seed. These are to be taken up this fall and reset, separating the seed producing from the staminate plants.

Another small plot was sown with asparagus in the spring of 1911, which has made good plants for next season's work, providing we need plants for this purpose.

Considerable asparagus rust has developed in the two-year-old plots, and this will mean some work the coming year in an effort to control this disease, which is probably the most serious obstacle to successful asparagus culture in this State.

Cherry Investigation. Data has been accumulated during the season for a bulletin on this subject. Comparatively little time has been devoted to this subject, as a large part of it should have been put in, in distant districts of the State, and money has not been available for this purpose. We think, however, that as soon as funds are available we will be able to issue a bulletin on the cherry industry of the State that will be of considerable value to the growers.

Cover Crops for Orchards. The cover crop investigation has been carried on this year in a similar manner to that of 1910. These plots of red clover, alsike, crimson clover,

soy beans, Canada peas and winter vetch were sown in both the old and the young orchards on the west place. Lack of water and dry season together prevented the securing of good stand of most of these crops. It was hoped to not only sow these plots early in the season, but to also sow plots of them during July to secure a crop to leave on the ground during winter. Lack of moisture made this impossible, however, so that the late sowing was not made.

None of the early sowed crops made a satisfactory stand in these experiments, but observations in commercial orchards have shown that in most cases a stand of any of these cover crops can easily be obtained. It is doubtful if the late sowing of cover crops is practical in Colorado orchards, excepting where an abundant supply of irrigation water is available.

From observations in the field we have come to the conclusion that the common red clover is one of the most desirable species for cover crops in the mature orchard. It is hoped to carry on this work another season, providing the season is favorable for getting a start.

Cauliflower Investigation. Cauliflower plants were raised by the College, both for setting in the gardens and for sending to the high altitudes. One difficulty has presented itself in the growing of late cauliflower in this way, in that plants grown for use at Fort Collins are too late to come to maturity in the shorter season of the high altitudes. This year plants were put in a little earlier to obviate this difficulty, with the result that those planted at Fort Collins came to maturity during the warm weather in fall, so that we were unable to store the crop for winter use. At Del Norte the plants were seasonable, and produced a good crop. So far as we have learned, those at Parshall were rather late to reach full maturity.

It would undoubtedly be better to have these plants grown in hot beds or cold frames in the locality where they are to be set, as long distance shipping of plants greatly reduces their vitality.

Some observations made in the high altitudes in regard to small fruit growing have shown that there are great possibilities for the development of this industry and further investigation should be taken up as soon as funds are available for that purpose. The strawberry, at Steamboat Springs, has made a remarkable success during the past season, but comparatively little is known there of the various problems that confront the grower. We have now in our plots at the

College garden, eighteen standard varieties of strawberries, from which we hope to send plants to some of the high altitude districts to co-operate with them in working out some of these problems.

Vegetable Gardening. The vegetable garden investigation has been carried on largely by S. V. Smith. All the solanum family of vegetables have been practically a failure in our experiments this year. Potatoes failed to make any tubers at all, and tomatoes, though they had an extra good chance to make a crop, were an absolute failure. In fact, the plants made almost no development after being set in the field in May. Egg plants were in more or less the same condition and made only a poor development. This failure is undoubtedly due to the same trouble that caused the loss of the potato crop over a large part of the State, that of *Fusarium*, as the symptoms were practically the same with all those species.

Practically all other vegetables in the garden made a satisfactory growth. The Cross cabbage, put in for market purposes, made practically eighteen tons per acre. One other variety, the Danish round-head, while no exact figures could be obtained as to weights, made considerably more than this, probably not far from twenty-five tons per acre.

Data has not yet been secured on yields of celery, onions, etc.

No serious insect pests or diseases have caused trouble in the gardens this past season. The grasshoppers were somewhat numerous in the early part of the season, but were very scarce from the first of August on. In fact, nearly all of them had disappeared before the end of the season. The cabbage worm started to do some damage, but was controlled by the use of slaked lime and Paris green dusted on the plants.

Small plots of all the different vegetables that are adapted to this climate were planted in this garden. A few of the standard varieties of small fruits were also started the past season. We believe this garden work is valuable both from the standpoint of a demonstration and as a means of obtaining material for experimenting with the various troubles that arise in the gardening business.

In the past, comparatively little attention has been given the small fruit and trucking possibilities in Colorado. We believe there are great possibilities for developing these lines of industry in Colorado and think that this garden

work should be continued. The cabbage investigation has been carried on by Mr. S. V. Smith, who will report further in regard to it.

The Onion Industry. Some data has been obtained during the season with the end in view of writing up the onion industry in Colorado. Plots of onions were planted in the College garden and data obtained from the commercial fields of the State. This has not been carried so far as we had hoped, owing to inability to get to the onion growing districts of the State this season. There is a great demand for literature along this line, and we hope to be able to publish a bulletin on onion growing in the near future.

On the whole we feel fairly well satisfied with the horticultural investigations for the year. In order to do the best work for these investigations, a continuous period of time should be given to the work. We have not found this possible to do, as the administrative work of the Department and College work have demanded a certain amount of time at all seasons.

The Frost Problem. One of the most important problems that is now before the fruit growers of the State is that of the prevention of loss from spring frosts. Several bulletins have been issued by different stations giving the temperatures at which buds, blossoms, or young fruits are injured by low temperatures. We believe that some work should be done in this State to determine the conditions under which frost is most likely to prove disastrous. We also believe that no place in the country offers such an opportunity for this investigation, as several different altitudes of the Colorado fruit districts give us an abundant opportunity for comparative observations in the way of temperature conditions previous to frosts.

Following are the reports of Field Horticulturist R. S. Herrick; of Mr. S. V. Smith, who has charge of the cabbage breeding experiment, and of the Potato Specialist C. L. Fitch.

Respectfully submitted,

E. R. BENNETT.

REPORT OF FIELD HORTICULTURIST.

The following is the annual report for the year ending November 1, 1911, for work done in State Fruit Investigations.

The following approved projects have been worked upon:

1. Shade Crops for Old Apple and Peach Orchards.
2. The Season of Bloom of Apple Trees.
3. The Control of the Fruit Spot of the Peach.
4. The Thinning of the Jonathan.
5. The Cold Storage of Jonathan Apples.
6. The Growing of Sweet Cherries in Colorado.

Shade Crops for Old Apple and Peach Orchards. Shade crops for old apple orchards is a continuation of the work which was started in the spring of 1910. From the middle to the latter part of June, 1911, the following crops were sown in Mr. Wm. Duling's apple orchard at Delta, Colo.: Crimson clover, 10 pounds on one-half acre; alsike clover, 4 pounds on one-half acre; green Canada field peas, 30 pounds on one-half acre; spring vetch (*Vicia sativa*), 30 pounds on one-half acre; Grimm alfalfa, 5 pounds on one-half acre. The alsike clover and Grimm alfalfa were showing a fine stand this fall while the others were very poor. All of these crops were sown rather late for the purpose of seeing how late they could be sown and still obtain a good stand. It was found that the earlier the annuals could be sown the better would be the stand. It was also found by this experiment and by investigation that, as a rule, red clover does better if sown early. Good stands of alfalfa have been noticed when sown as late as the first of September.

The covers, which include the *Trifolium pratense*, *T. medium* *Melilotus* or sweet clover, and the common alfalfa, will be plowed under this fall. These crops were sown early in the spring of 1910 and were all cut for hay this summer. All except the sweet clover grew up again and made a great mat of green material for green manure. The mammoth red clover made the best mat of any, and so far, all things considered, seems to be one of the best for shade crop purposes in an old apple orchard.

As was stated in last year's report, the fall rye sowed in the Excelsior peach orchard at Paonia, Colo., did the best of the crops sown in the latter part of July, 1910, and which consisted of red clover, crimson clover, fall rye and field

peas. This spring (1911) the rye was the only one that showed a good stand. There was, however, some red clover, sown by Mr. Frank Van Deren, manager of the Excelsior orchard, in 1910, which this spring was showing in good proportion as good a stand and growth as the rye. Both of these had to be plowed or disced under in June, 1911, as the peach trees were turning yellow, which was due, very likely, to too much water.

It seems at the present time that one of the best methods in handling a shade crop for an old peach orchard would be the method used by Mr. Frank Van Deren on six acres of his orchard, and is as follows: Sow field peas very early in the spring, and about the first of July when they are about ready to go to seed, plow them under with a disc. Clean cultivate for two or three weeks, and then sow beardless barley and plow this under in the fall of the same year.

Shade crops for the control of the nitre trouble which we have in some of our soils, is another phase of this project which it is hoped can be carried on with this work another year.

A great many orchard calls have been made where the orchardists have either sowed a shade crop of some kind or expects to do so in the near future, and many inquiries have been made by them as to the best crop to grow. So far as results have been obtained from experiments and investigations made, it would seem that either the common red clover or the mammoth red clover were about the best to use for a shade crop in an old apple orchard.

The Season of Bloom of Apple Trees. This project, which is a continuation of last year's work, was divided into three parts, viz.: first, to determine what varieties bloomed near enough together to insure cross pollination. Second, to tell how long the calyx of each variety remains open. This part of the experiment was done to tell how much time one has to do the first spraying for the codling-moth. Third, to determine what varieties are self fertile and which are self sterile. Seven hundred bags and tags were placed on eight of the leading commercial varieties of apples before the blossoms opened. This part of the experiment was ended by the freeze during the middle of May.

APPLE BLOOMING SEASON FOR 1911.

	Commencing to bloom	Full bloom	End of bloom	Calyx open*
Willow	April 25	May 2	May 7	9 days
Arkansas	April 24-26	May 3	May 5-6	10 days
Gano	April 24	May 1	May 7	8 days
Winesap	April 27	May 3	May 8	8 days
Grimes	April 26	May 2	May 7	8 days
Jonathan	April 25	May 3	May 8	8 days
Rome	April 27	May 5	May 12	7 days
Ralls	May 4	May 7	May 11	7 days

*The number of days that the calyx remained open, in this experiment, are not very accurate on account of the frost killing much of the fruit.

Control of the Peach Fruit Spot. The peach fruit spot (*Coryneum beyerenkii*) was first reported in Colorado in 1908. From this time it has been on the increase in certain localities, especially during rather wet seasons, such as the summer of 1909 and 1911, until the majority of the peaches in those localities were greatly damaged. This year the peach spot was first noticed about the first of August. Its appearance on the fruit will vary somewhat with the season. It first appears on the fruit as a dark brownish black speck, about the size of a pin head. In a few weeks it grows to one-eighth to one-quarter of an inch in diameter, and is generally roundish in shape. It then has a very dark, almost black, center, around which is a dark brown ring and the outer margin of the spot is reddish in color.

The upper portion of the peach, as it grows on the tree, seems to be affected more than the lower portion. This shows that very likely the spores winter over on the branches from which they are blown to the peaches below, or to those growing near. The trouble was found to be always worse in closely set orchards which allowed plenty of shade and thus more moist conditions.

During the latter part of October, 1910, a block of peach trees in Mr. Henry Teachout's orchard at Eckert, was sprayed to determine the value of fall spraying for the control of Peach Fruit Spot. The following fungicides were used: Rex lime-sulphur, 1 to 10; home made lime-sulphur, 20-15-50, and Bordeaux, 4-5-40. On August 31, 1911, the peaches on several trees were counted, and it was found that where the lime-sulphur or Bordeaux were used there were about 10 per cent of the peaches affected with the spot, but on the check trees about 50 per cent were affected.

Results from this experiment and careful investigations are summed up in the following conclusions regarding the control of the Peach Fruit Spot:

1. Spraying in the fall after the leaves have fallen (this generally can be done the latter part of October or the fore part of November) with home made lime-sulphur (20-15-50), or a good grade of commercial lime-sulphur (B. 33, 1 to 10), or Bordeaux (4-5-40), all things considered, either the home made lime-sulphur or the commercial lime-sulphur are preferred over the Bordeaux.

2. The affected peach trees should be heavily pruned during late winter to allow the sun to penetrate to the branches during the summer. If the trees are set so close as to crowd each other, it would be well to cut out every other one in the rows.

The Thinning of the Jonathan. This project, which was started during the early summer of 1910, had to be discontinued this year on account of the May frost killing all of the fruit in the orchard in which the experiment was running. However, at blooming time there could not be seen much difference in the amount of bloom between the thinned and unthinned trees. This experiment should be run several years to determine in the aggregate the value of thinning the Jonathan.

The Cold Storage of Jonathan Apples. This experiment was carried on in Denver during the winter of 1910-11. and has been written up in bulletin form and is now ready for publication. The following conclusions are obtained from the experiment:

1. Where the Jonathan apple is to be placed in cold storage it is advisable to use only extra fancy apples unless there is a scarcity of apples, and then it might pay to use some extra choice.

2. The earlier picking can be done after the apples have attained good color and reached a certain point of maturity.

3. The more carefully apples are handled in picking and packing the less will they be susceptible to any of the troubles that they are liable to in storage.

4. The earlier they can be placed in cold storage after they are picked and packed, the less liable they are to storage scald.

5. Apples are less liable to communicate the different rot fungi to one another when they are wrapped.

6. When taken out of cold storage they will keep much longer if the temperature is raised gradually.

The Growing of Sweet Cherries in Colorado. Considerable investigational work has been done on this project dur-

ing the past summer in the Paonia and Cedaredge districts in Delta County, but on account of lack of time very little was done in the Palisade District where many sweet cherries are grown.

One of the chief requirements for the successful growing of sweet cherries is that of temperature. Sweet cherry fruit buds will not, as a rule, stand a temperature below 5 to 10 degrees F. below zero in the dormant stage. When the weather is warm, during February and March, the buds commence to swell and in that case they will not stand zero weather. Sweet cherries bloom very early and are often caught by spring frosts. They seem to grow well on a variety of soils, but the lighter soils seem to be preferred over heavier ones. The sweet cherry grower has to be very careful with the irrigating of them, as they will not stand much water. Some of the leading varieties grown on the Western Slope are Black Republican, Bing, Napolian and Windsor.

Demonstration Work in Orchard Management. Many orchard calls have been made to help the different orchardists in the problems confronting them. One of these was peach mildew which in places became rather destructive. In one orchard the trouble was checked, but not entirely controlled, by the use of 1 to 50 commercial lime-sulphur with six pounds of lime added.

A fall spraying experiment will be started in November, 1911, and should be continued next year to find out when and what to use for the control of peach mildew.

During last winter papers were read at the following Farmers' Institutes: Delta, Grand Junction and Fruita. Six lectures were given on Practical Pomology before the Delta High School.

Several days were spent on the College Demonstration train.

During September the fruit exhibits were judged at Hotchkiss, Delta, Montrose and Grand Junction fairs.

During the year the following articles were written for College "News Notes": Winter Injury of Fruit Trees by Sun Scald, Preparing for Spring Orchard Work, Thinning Apples, The Apple Grower, The Score Card and the Judge, Selecting Apples for Show Purposes, Fall Plowing the Orchard, and The Control of Peach Fruit Spot by Fall Spraying.

Respectfully submitted,

R. S. HERRICK.

CABBAGE BREEDING EXPERIMENT.

Prof. E. R. Bennett:

In this experiment, the object is to fix the type in the cross between the Wunningstadt, a pointed headed variety, and the Flat Dutch, a flat headed variety.

The work this season consisted in setting out four feet apart each way, the heads saved from last year for seed, and also in screening some of the best heads in an effort to obtain some self fertilized or pure seed.

In order to carry on the pollenization, bees were caught and put under the screens, but even then very little seed was obtained from these heads. It is probable that if the bees had been put in every day or two, better results might have been obtained. Hand pollenation, however, seems to be the only way to be sure of getting seed in any considerable amount. Seed pods were produced in abundance, but were nearly all empty; and even those few containing seed had usually not more than one or two seeds and these were rather small, poorly developed seeds, in most cases. Those heads not screened produced a good crop of seed, which was saved and will be first class seed for planting next year. It is the intention to plant this pure seed in the greenhouse this winter and transplant the heads to the garden next spring and secure seed next fall, thereby saving a year's time, as with the method of growing in the garden entirely, two years are required to produce seed from seed.

This experiment involves the application of Mendel's Law and should be carried on for two or three years, until the "Cross" type can be well fixed.

Respectfully submitted,

S. V. SMITH.

REPORT OF THE POTATO SPECIALIST.

To the Director:

The one great fact of the year in the potato industry of Colorado has been the loss of at least four-fifths of the crop by *Fusarium* disease. It seems clearly proven that we are liable at long intervals to a combination of unfavorable conditions, and we may again meet such disaster, unless we can learn just what induces the disease and how to counteract the inducing factors. These studies have been the chief work of the potato specialist for the months past and will be for the next winter and summer, at least.

Since the disease came on in July and August, almost my entire time has been given to examining all possible fields in every important potato region and in gathering, by the help of leading growers, significant instances of crop failures and successes in the same neighborhood, and in trying to read from the mass of evidence and from several days' study at the weather bureau in Denver, some common cause or causes of the disease. The fungus is pretty well understood in a laboratory way, except its winter stage, and was well written up by Rolfs and Paddock about ten years ago.

It appears from my studies that either excessive heat in the soil about the stem and upper roots, or excessive moisture, or particularly both conditions either together or in succession, will always and everywhere in Colorado bring on *Fusarium*.

During the coming winter these field conclusions should be submitted to test in the greenhouse under conditions of known temperature and percentage of moisture, and tests should be made of the seed from diseased fields, because other seed will be high in price and hard to get. If, as I believe, this diseased seed is good, it will be of great use to know it. It seems to me that the condition is one of absolutely universal infection requiring only the needed degrees of warmth or moisture or both to give the fungus the advantage over the potato plant, and without those degrees of soil heat and moisture the plant will not be much restricted by *fusarium*.

Next summer should be given largely to the study in the field of soil temperatures and moistures, to learning the temperature of irrigation water as it is used, from ditches, reservoirs, and pumps; the effect upon soil temperature of

irrigation before planting; the effect of shade and of close planting upon temperature; the effect of slope and of quick or slow irrigation, and of double and single side irrigation upon soakage and temperature and disease.

I have hopes that we shall yet be able to know for any field at what temperature of soil we may irrigate, and I believe that it will yet be considered a practical matter for growers to use soil thermometers. I believe it will be possible to insure half a crop in seasons like 1911.

We are working upon many other problems, all of importance but which we may only enumerate here: the matter of getting a good stand from Stove Prairie Seed; why potatoes run out and what makes good shape and bad; studies of root systems and the underlying reasons for yield and for the potato plant being limited to certain soils; the varieties of the United States, their history, origin and identification; the attempt to secure a better variety for Colorado by crossing the Pearl and the Rural; an attempt to maintain and supply small quantities of pure seed stocks; and the study of yields in early potatoes.

We believe that the production of early potatoes in our mountains is to be one of the big facts in the industry, and that this affords at present, next to disease study, the greatest field of usefulness that we have. We have done a great deal of experimentation along this line, and feel sure of our facts. Manufacturers of potato machinery are helping us to design and build the special cultivators, planters and diggers that will be required, for fullest success and permanent profitableness from this industry.

During the past summer the potato specialist visited, at his own expense, leading potato growing regions, growers and breeders from Wisconsin to Maine. Also he has spent \$80 in lantern slides and equipment for presenting to growers the general and local facts of potato disease and the interesting and useful lessons to be gathered from other potato regions.

Five thousand dollars per year is needed for the work in order to cover the expense of constant travel to all potato sections; of office, stenographers and administration; of publication and mailing of bulletins as fast as useful facts become available; and of experimental work and equipment. At a time of great need our work has been made uncertain, unsatisfactory and seriously crippled, because of lack of funds. Growers and regions have complained be-

cause I have been unable to meet them more frequently, but under the conditions the best possible has been done, with an eye to the interests of all the potato regions of the state.

Respectfully submitted,

C. L. FITCH.

HORSE BREEDING INVESTIGATION.

To the Director:

I beg to submit my annual report of the work in Horse Breeding Investigation, which is being conducted in co-operation with the United States Department of Agriculture.

ANIMALS IN EXPERIMENT.

There are at the present time eighty-six (86) animals in the stud, consisting of the following:

1	aged stallion
21	aged mares
1	five-year-old stallion
5	five-year-old mares
1	four-year-old stallion
5	four-year-old mares
3	three-year-old stallions
4	three-year-old mares
4	two-year-old stallions
4	two-year-old mares
12	yearling colts
6	yearling fillies
14	weanling colts
5	weanling fillies

—
86—Total in the stud.

ADDITIONS TO THE STUD.

There has been but one addition to the stud during the past year, the only purchase being that of the mare Lavendar Lady. This mare has been a consistent winner in the American Carriage Classes during the past two years, and has also won several championships. Negotiations for several other mares are at present under way, and additional purchases may be made in the near future.

SALE OF SURPLUS STOCK.

The annual meeting of the Board of Survey has not been held as yet this year, so that the recommendations for the elimination of surplus stock have not been made. A number of recommendations will be made this year as the Station is slightly overstocked at present.

It is the policy of the Station to retain only those individuals which give promise of developing into high class specimens, so the selection this year will undoubtedly be closer than that of previous years.

PROGRESS OF WORK.

During the past year this Section has added to its staff an expert trainer, who began his work August 1. The work of the trainer has resulted in bringing out the good qualities of the young animals, and incidentally the inferior

ones if they possess any. The expert handling of these young animals aids materially in determining their value for harness purposes. If the young colts do not respond to careful handling, and do not show improvement in the various qualifications of a harness horse, they are not considered valuable for further use in the experiment and are recommended for disposal.

The past season has been the most successful of any since the experiment was established. Nineteen foals were dropped and raised without a single loss. The foals are quite uniform in size and quality and several exceptional individuals are to be found among them.

NEEDS OF THE DEPARTMENT.

The needs of the Department are as follows:

1. More barn space.
2. Heating plant.
3. Equipment for developing young animals in harness.
4. Stallion paddocks and sheds.
5. Training pavilion.

Barn Space. The present space in the barn is becoming entirely inadequate for our needs. The floor space for the storage of vehicles should be considerably enlarged with additional space included for harness rooms. The space now devoted to storage of harness and vehicles is cramped with our present equipment, and if the present policy of developing a show stable is carried out the space will be entirely inadequate in the near future. With additions being constantly made to our training school, the demand for box stalls and floor space will be enhanced. Plans should be formulated for bringing our barns and equipment up to the demand that will be made upon them in the future.

Equipment. The time is approaching when it will be necessary for the Station to exhibit some of the animals developed at the Station. The nucleus of a splendid stable is now being formed and fitted with this end in view. In order to fit out and train a stable of harness horses properly, equipment is an absolute necessity. Such equipment should include vehicles, harness, clothing and other appointments. We have an efficient trainer who is obtaining splendid results with the young animals, but to bring the horses to their highest point of efficiency as show animals additional equipment is necessary.

Heating Plant. One of the immediate and greatest needs of the horse barn is a heating system of some sort. It is practically impossible to keep the horses in show con-

dition without artificial heat. Besides the need of heat for maintaining the horses in proper condition, the stable is extremely uncomfortable for workmen at various times during the winter. The installation of a heating plant of some sort should be planned at once. I have made inquiries about the cost of hot water and steam systems for the present radiation necessary and find that the former would cost approximately \$450 and the latter \$375, completely installed.

Stallion Paddocks. Permanent stallion paddocks should be built which will permit of turning stallions out for self exercise, thereby lessening the danger of developing unsoundness resulting from exercising our service stallions on the public roads. Plans are being formulated for such paddocks, which can be built as necessity demands without great expense.

Training Pavilion. The work of developing harness horses to the highest degree of perfection demands systematic and consistent schooling. When we depend upon our public roads for such training, the work is necessarily inconsistent owing to fluctuating weather conditions. As our training school grows, the demand for a training pavilion will become greater and eventually it will become imperative that one be built. With the present inadequate equipment the need is not urgent.

I urge your careful consideration of the various recommendations made in this report with a view of having them installed as our circumstances permit.

Respectfully submitted,

J. O. WILLIAMS,
Junior Animal Husbandman.

ANIMAL HUSBANDRY SECTION.

To the Director:

I hereby submit the following annual report. During the winter of 1910 and 1911 experiments were carried on as follows:

Ration Experiments with Steers.

- Lot 10—Alfalfa hay ground, corn, molasses.
- Lot 11—Alfalfa hay cut, corn, molasses.
- Lot 12—Alfalfa hay whole, California feed barley, molasses.
- Lot 13—Alfalfa hay whole, corn, molasses.

Ration Experiments with Lambs.

- Lot 1—Alfalfa hay whole, Four-Rowed barley.
- Lot 3—Alfalfa hay whole, corn.
- Lot 4—Alfalfa hay whole, California feed barley.
- Lot 5—Alfalfa hay ground, corn.
- Lot 6—Alfalfa hay cut, corn.

Ration Experiments with Swine.

- Lot 1—Corn one part, wheat shorts one part.
- Lot 2—Barley two parts, ground alfalfa one part.
- Lot 3—Barley four parts, ground alfalfa one part.
- Lot 4—Barley six parts, ground alfalfa one part.

It was expected that these experiments would be written up ready for publication this summer, but because of the fact that Mr. Dvorachek left about the first of July and a man was not secured to fill his place until just before the beginning of the school year, there was not time to get the data in shape.

The following experiment was carried on but not completed:

BEEF PRODUCTION ON THE RANGE.

This experiment was started in the spring of 1910 by the purchase of cows heavy with calf. The cows were turned upon the college range and in the fall the cows and calves were brought in for winter feeding. The cows were finished off for market the same winter and the calves were fed hay and a small quantity of grain which carried them through the first winter. In the spring of 1911 they were again turned upon the college range pasture and this fall were brought in for fattening. They are now upon feed and will be finished for market probably about April 1, 1912. The object of this experiment is to arrive at the cost of producing 1,100-pound steers for the market as yearlings under modified range conditions.

During the present winter of 1911 and 1912 the following work is under way: The continuation of the experiment just outlined; and ration experiments with swine. These are as follows:

Lot 1—Corn and shorts, equal parts.

Lot 2—Barley four parts, ground alfalfa one part.

Lot 3—Barley five parts, ground alfalfa one part.

Lot 4—Barley six parts, ground alfalfa one part.

The report of the Poultryman follows.

Respectfully submitted,

G. E. MORTON.

REPORT OF THE POULTRYMAN.

We have not been able to carry on any projects during the past year nor will we be able to do so until we can leave the work in competent hands when away from home.

The Station Pathologist has been working with us on poultry diseases and has sufficient material in hand for a bulletin. We had hoped to carry out the plan of establishing model poultry farms of about one hundred fowls each, in a number of communities in the State, to determine the cost of egg production under different conditions and methods of feeding. We also wished to work out better methods of marketing. Lack of funds has prevented our working out this plan.

Rather than increase the size of our flocks under the present conditions, we believe it would be better to devote all the time we have to making the surroundings as attractive as possible about the poultry plant, keeping only one breeding pen of each of the varieties we now have, and adding to these varieties two or three other popular ones for the instruction of students and visitors.

The poultry yards should and can be as attractive as any part of the college campus, and we would recommend that means be provided for such work as soon as poultry funds become available.

We believe the extension work along poultry lines has been of some value. We have induced one creamery to handle eggs and the results have been very satisfactory to all concerned. After further trial we would like to bring the results to the attention of other creameries.

Respectfully submitted,

W. E. VAPLON.

REPORT OF THE VETERINARIAN.

To the Director:

There is much important work to be done for the livestock interests of the State, along veterinary lines. We deem it of as much importance as any other and could we be allowed an annual budget on either the Hatch or Adams funds, even though it were small, we could proceed regularly with our work and accomplish much.

HOG CHOLERA.

Hog cholera is more general over the State and seemingly more virulent than it has ever been in the past. The only thing that will control it is the hog cholera serum perfected by the United States Department of Agriculture. Most of the States, where this disease exists, are manufacturing it for the farmers of their own states, and as the disease is a serious menace to the hog industry of the State, it would seem that we should now consider ways and means of protecting this important industry, by establishing a serum plant. This would require about \$5,000 but would be self-supporting after being once established.

NECROBACILLOSIS.

This disease appeared two years ago in the form of "sore mouth disease" of calves and pigs, and in the latter killed about 20 per cent of pigs in the State, under six months of age. Last winter it appeared only in sporadic outbreaks, but this fall has again become general.

The same disease in sheep, known as "lip and leg ulceration," endangered the sheep feeding industry for two years, but seems now to be under control. We have done considerable work in this investigation among sheep and hogs and have much valuable data on hand, but our work has necessarily come to a standstill because of lack of funds. We have plans laid for a thorough research with the object of determining a practical means of control, and possible eradication, by means of preventive inoculation.

ELK RIVER DISEASE.

This is a disease peculiar to the Elk River country and has caused the loss of many hundreds of horses each year. We would like to carry on original research work with the hope of reaching a possible solution and practical means of control.

"NO NAME" DISEASE.

Over a large area, of which Colorado Springs is the center, there is an annual loss of many valuable horses from an unknown disease, in which the mortality is 100 per cent. We have been repeatedly called upon for help in this connection, but so far have been able to render very little assistance.

INFECTIOUS ANEMIA.

This disease has been on the increase for the last 20 or more years, and is threatening the horse industry of the arid states. Several of the State Experiment Stations have appropriated money for special investigation of this disease. We have done some work in an effort to determine the etiologic factor, but thus far the cause remains unknown, and until this is determined, we can not expect that much will be accomplished in its control.

SUGAR BEET POISONING.

We are still working on this problem and hope soon to issue a bulletin (practical) warning farmers against injudicious feeding of sugar beet tops.

RABIES.

Rabies has been very common in Eastern Colorado and there has been some loss of livestock. Several persons have been bitten by rabid dogs and obliged to leave the State for treatment. This disease has not been so prevalent in the last six months.

POULTRY DISEASES.

Diseases of poultry have been studied and enough valuable data accumulated for a 30-page bulletin. Among other things, it has been determined that there are two forms of white diarrhea in young chicks, one due to a germ, *Bacterium Pullorum*, and the other is caused by a single celled animal organism, called *Coccidium Tenellum*.

Blackhead is causing much loss among turkeys and we have found a means of control in both these diseases, reducing the loss from 80 per cent to 20 per cent in ordinary outbreaks.

Respectfully,

GEO. H. GLOVER.