

THE STATE AGRICULTURAL COLLEGE  
OF COLORADO

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The Twenty-Fifth Annual Report

OF

**The Agricultural Experiment  
Station**

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**For 1912**





# The State Board of Agriculture

THE AGRICULTURAL EXPERIMENT STATION.  
Fort Collins, Colorado.

*Term Expires*

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 }  
PRESIDENT CHARLES A. LORY } Ex-Officio

EXECUTIVE COMMITTEE IN CHARGE

A. A. EDWARDS, Chairman.

J. L. BRUSH.

E. M. AMMONS.

## Station Staff

C. P. GILLETTE, M. S.	Entomologist	.....	Director
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
E. B. HOUSE, B. S. (E. E.), M. S.		.....	Irrigation Engineer
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.		.....	Veterinary Pathologist
GEORGE P. WELDON, B. S.		.....	Assistant in Entomology
L. C. BRAGG		.....	Assistant in Entomology
R. S. HERRICK, B. S., Grand Junction		.....	Field Horticulturist
C. L. FITCH		.....	Potato Investigations
W. E. VAPLON		.....	Poultry Investigations
J. W. ADAMS, B. S., Cheyenne Wells		.....	
		.....	Agronomy Assistant, Dry Farming
G. D. WALTERS, B. S.,		.....	Assistant Irrigation Investigations
ELLWOOD D. ROOD, A. B.		.....	Assistant Chemist
W. W. ROBBINS, M. A.		.....	Assistant Botanist
PAUL S. JONES, B. S.		.....	Assistant Irrigation Investigations
<b>OFFICERS</b>			
CHARLES A. LORY, LL. D.		.....	President
C. P. GILLETTE, M. S.		.....	Director
L. M. TAYLOR		.....	Secretary
MARGARET MURRAY		.....	Executive Clerk

1.—Resigned November 1, 1912.

2.—Resigned July 31, 1912

3.—Resigned May 1, 1912.

4.—Appointed May 15, 1912.

## LETTER OF TRANSMITTAL

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*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-fifth Annual Report.

The financial statement is for the fiscal year ending June 30, 1912; the other portions being reported substantially for the calendar year, 1912.

C. P. GILLETTE,  
*Director.*

Agricultural Experiment Station,  
Fort Collins, Colorado.  
December, 1912 .

**FINANCIAL REPORT**  
of the  
**COLORADO AGRICULTURAL EXPERIMENT STATION**  
for the fiscal year ending June 30, 1912.

Dr.	RECEIPTS						Total
	Hatch Fund	Adams Fund	State Fund	Sales Fund	Special Fund		
From the Treasurer of the United States as per appropriation for the fiscal year ended June 30, 1912, under acts of Congress ap- proved March 2, 1887 (Hatch Fund) and March 16, 1906, (Ad- ams Fund) .. . . .	\$15,000.00	\$15,000.00					
Balance on hand July 1, 1911 - - - - -					\$8,120.77		
Overdraft July 1, 1911			\$10,631.77				
Other sources than the United States - - -			11,250.00	\$30.00	6,031.79		
Total receipts - - - -							\$44,800.77

Cr.	Hatch	Adams	State	Sales	Special	Total
By Salaries.....\$	9,132.70	\$11,494.12	\$ 6,513.35		\$ 8,240.08	\$27,964.25
Labor .....	344.88	226.98	2,397.98		1,065.61	4,035.45
Publications .....	2,200.72		55.25		17.82	2,273.77
Postage & Stationery	613.84	113.79	292.37		152.52	1,172.52
Freight and Express	128.38	213.83	177.49		38.99	558.69
Heat, Light, Water and power.....			.95			.95
Chemicals and labora- tory supplies ....	5.40	505.31	17.80		6.25	534.76
Seeds, plants, & sundry supplies .....	545.18	203.86	411.60		116.89	1,277.53
Fertilizers .....			26.10			26.10
Feeding stuffs .....	34.00		3,191.39		2,417.16	5,642.55
Library .....	186.45	115.75	7.01		1.00	310.21
Tools, machinery and appliances .....	81.40	154.63	318.82		598.72	1,153.57
Furniture & fixtures	335.85	172.65	85.50		19.80	613.80
Scientific apparatus and specimens ....	246.43	607.08	224.55			1,078.06
Live stock .....	5.30		21.10			26.40
Traveling expenses..	441.20	453.40	651.05		136.54	1,682.19
Contingent expenses	25.80		55.00		10.00	90.80
Buildings and land..	672.47	738.60	300.53		79.09	1,790.69
Total expenditures	\$15,000.00	\$15,000.00	\$14,747.84	\$30.00	\$5,484.47	\$50,232.36
Balance					8,668.09	8,668.09
Overdraft			14,129.61			58,930.04
			618.23		14,152.56	14,129.61
						\$44,800.77

## REPORT OF THE DIRECTOR.

*To the President:*

I am presenting herewith the annual report of the Experiment Station for the State fiscal year just closing. I am also appending the financial statement to the Governor and brief reports from those who have been in charge of the various lines of investigation and research.

I am glad to report that there have been very few important changes in the Experiment Station staff during the year, and none in the heads of Sections.

Very few new projects have been taken up; some of the old ones have been completed, and for the greater part, work will continue on the projects that were in force the past year. The lines of research that were carried upon the Government (Hatch and Adams) funds have progressed very satisfactorily, but the investigations upon State appropriations have been seriously handicapped because of inadequate and uncertain funds with which to support the work. From the date upon which the appropriations were made by the General Assembly, the State Treasurer was in serious doubt as to whether or not he would be able to pay any, or more than a very small portion, of the appropriations. These appropriations were made for the biennial period of 1911-1912, but there have been only eleven months since the first allowance of 25 % was received. Consequently we were without any money from these appropriations for the first thirteen months of the biennium, and have received only 50% to date. We could have used this money to much better advantage if we had known at the beginning of the period just what funds would be at our command and when they would be available.

It is extremely important that the Station should have its investigational work supported by some form of continuing appropriation that will extend over a period of several years. In the first place, such an appropriation would bridge the hiatus that now exists from November 30th, closing one biennial period, to the time when money is again available, which is seldom, if ever, less than six months, and sometimes a full year or more. In the second place it would permit our investigators to plan their projects along important lines of investigation with an assurance that the work could be continued for a period of years if necessary in order to reach results.

Furthermore, if we are to avail ourselves of opportunities to co-operate with the various bureaus of the Department of Agricul-

ture of the General Government, thereby doubling our funds for experimental work, we must be able to promise the continuance of our co-operation for a period of years. It is seldom that the Government Bureaus would care to undertake such work in co-operation with the Station unless they can have a reasonable assurance of its continuance for at least five years.

A mill levy for a period of four to six or more years, would be ideal for the support of this work, if it could be secured, and there would be plenty of money to take care of such a levy if a reasonable assessment of the property of the State could be secured for the purpose of taxation.

The vast extent of our territory, the great variation in soil, climate and altitude in this State, our comparatively new and un-tried condition, under which our agriculture is carried on, and the fact that the farming population is almost entirely from sections where irrigation practices are unknown, make it especially important that the work of the Experiment Station should be strongly supported. Money put into Agricultural Experiment Station and Extension Work in Colorado should not be considered a tax, but a good business investment that will bring big financial returns to all classes, whether taxpayers or not.

#### STATION REVENUES

During the last biennial period the Station has received the full Hatch and Adams appropriations from the General Government, as follows:

	1911	1912	Total.
Hatch .....	\$15,000.00	\$15,000.00	\$30,000.00
Adams .....	15,000.00	15,000.00	30,000.00
			\$60,000.00

This money comes regularly and can always be depended upon, and consequently we are able to get maximum results from its expenditure.

The Sections sharing in these funds, during the past year, were: Chemical, Bacteriological, Irrigation Engineering, Entomological, Agronomy, Horticultural and Veterinary Science. The first four mentioned are the only sections receiving money from the Adams fund. As the Adams fund cannot be used for anything but technical research, excluding all general office expenses and the expense of publishing bulletins and reports, and as the Station has had almost no money from other sources for these purposes, it has been necessary to bear these expenses very largely from the Hatch fund, which has left but a remnant of this fund for real experimental work.



Because of receiving only fifty percent of our State appropriations, we have been compelled, in nearly all cases, to spend the full amount received or more, in the prosecution of our investigations, which has left nothing for the expense of publishing information and popular bulletins and circulars. As a result, only one such bulletin—"Some Poultry Diseases," by Dr. B. F. Kaupp; one press bulletin—"Flax Growing," by Professor Keyser, and two information circulars—"Preparation of New Land for Crops," and "Flax Growing," both by Professor Keyser, have been published by the Station during the biennial period. There are several bulletin manuscripts in my hands, and many others have been offered that can soon be prepared, whenever funds for publication are available.

I believe it is the duty of the Station to get the results of its experimental work carried on from State appropriations of two years ago, into the hands of the farmers of the State at as early a date as possible. I see no way by which this can be accomplished, however, unless the College can come to the support of the Station in the matter of providing funds for publication.

In my annual report for one year ago I announced the expenditure of \$20,873.25 upon projects for which the State appropriations had been made, but for which no money had been received, the expenses of the work having been supported temporarily from other funds. During the year just closing we have expended a further sum of \$17,198.72, or \$15,571.97 more than has been received during the biennial period for the work. The statement may be given as follows:

**STATE APPROPRIATIONS FOR 1911-1912**

Appropriated for	Total Amount Appropriated	Amount Received	Amount Spent	Over- drafts
Horticultural Inv. ....	\$ 6,000.00	\$ 3,000.00	\$ 3,527.58	\$ 527.58
Plant Industry .....	5,000.00	2,500.00	3,425.60	925.60
Potato Inv. ....	5,500.00	2,750.00	4,120.85	1,370.85
Horse Inv. ....	5,000.00	2,500.00	5,000.00	2,500.00
Poultry Inv. ....	5,000.00	2,500.00	2,533.49	33.49
Animal Inv. (Including Vet.)	10,000.00	5,000.00	5,000.00	.....
Dry Farming Inv. ....	3,500.00	1,750.00	1,750.86	.86
Irr. & Drainage Inv. ....	5,000.00	2,500.00	2,500.00	.....
Total .....	\$45,000.00	\$22,500.00	\$27,858.38	\$5,358.38

*The Chemical Section* is supported in its investigations almost entirely from the Adams Fund. The investigations of the year have been rather closely confined to a study of the effects of excessive nitrates in the soil upon the development of the sugar beet. This investigation is concluded, at least for the present, and the most interesting and pertinent results reached are published in

Bulletin 183 by Dr. Headden. This bulletin indicates the methods of cropping and cultivation that should be practiced to avoid the excessive and harmful accumulation of nitrogen in the soil. To impress the importance of these methods upon the farmers, it seems important that a demonstration farm or field should be used for a period of eight or ten years. Dr. Headden offered to go to the Arkansas Valley and undertake this work if I should urge it, but as it would practically require him to leave his home and family and his laboratory for the greater part of the time during the next eight or ten years, I decided that the demonstration of the remedy should be left for others, and that he should take up another problem, which he suggested which seems to be of as much importance and one that can be carried on at or near the Experiment Station.

This new project, which will probably occupy almost the entire attention of this section for the next two or three years, is a study of the causes leading to the transformation of the hard into soft wheats when grown under our conditions. This project has been approved and work has already been started upon it.

There is an endless amount of investigational work that the Chemical Section should do if the Station had funds and men enough to do it. Our soils and ground waters are very unlike those of the older sections of the country and conclusions drawn from chemical analyses of soils and waters and agricultural crops in the eastern portion of the United States are likely to be very erroneous when applied to Colorado conditions. The chemical work cannot be further extended, however, without larger laboratories and increased equipment and funds. The Section is seriously in need of a separate building for its research work, every foot of the present building being needed for educational purposes.

The *Bacteriological* Section is also supported in its work almost entirely from the Adams Fund. The work in this Section has been rather closely co-ordinated with that of the preceding Section.

The principal line of investigation has been devoted to a study of the effects of soil bacteria upon fertility. Professor Sackett in speaking of his work says: "The investigation has included a study of over thirty soils, the majority of which were affected with niter. The results point clearly to the unusual ability of most of these soils to convert organic nitrogen into ammonia, a form of nitrogen which is readily changed to the nitrate by nitrifying bacteria. In addition to the points of scientific interest which have been brought out, the work has an immensely practical bearing on the use of nitrogenous fertilizers on Colorado soils . . . . Cottonseed meal applied to our soils is three times as efficient as it would be if used on certain Iowa lands, for example." The investigations also show that cer-

tain fertilizing materials which are valuable when applied to soils in the eastern portions of the country are of very little value when applied to the alkali soils of Colorado.

Professor Robbins has also done some important scientific work in coordination with the work of this Section in determining the microscopic forms of vegetable life living in the soils and the bearing which these living forms have upon the development of the nitrogen forming bacteria.

The Bacteriological Section has also done considerable work in cooperation with Mr. Fitch's potato investigations. In this work Professor Sackett seems to have proven that the trouble known as "leaf-roll" of the potato top, is quite distinct from the *Fusarium* disease, although it often accompanies this fungus infection. Upon this subject Professor Sackett says, "I doubt if it (*Fusarium*) plays an important part in our potato failures of the past two years. Invariably, when the leaf roll is accompanied by *Fusarium* in the vascular system, the mortality of the vines is very high, while, when the leaf roll occurs by itself, the destruction is slight."

Professor Sackett has also prepared and sent out to those requesting them, pure vinegar cultures, which may be used by anyone who can follow simple directions, to convert apple cider into strong vinegar within a few weeks.

*Irrigation Section:* There are two divisions of the work in this section; one carried on wholly by Professor E. B. House, and supported entirely by State funds; and one carried on by Mr. V. M. Cone, who is in charge of all of the co-operative work supported by funds from the Office of Irrigation Investigations and the Experiment Station. This work is, for the most part, of a true research type, and is consequently supported from the Station side principally by the Hatch and Adams funds, although the State appropriation has contributed somewhat to the work.

We are especially fortunate in being able to co-operate with the Office of Irrigation Investigations in the building of a new hydraulic laboratory, where practically every problem connected with the flow of water can be investigated. I wish to express to the members of the State Board of Agriculture, my gratitude for their hearty support and for funds which they have contributed which have enabled us to build the laboratory, which is now nearly completed. Mr. Cone, with the assistance of Mr. Robert E. Trimble and Mr. Paul S. Jones, devotes his entire time to irrigation investigations which are sanctioned by the Office of Experiment Stations in Washington.

Mr. Cone and Professor Keyser have together undertaken co-operative work with the Costilla Estate Development Company for the purpose of determining, so far as possible, the duty of water in the San Luis Valley, and also the crops best suited for that Valley. The large amount of preparatory work has been done in this investigation during the present season, and the real investigational work will be taken up next spring, and will probably require two or three years for its completion.

Mr. Cone also has in charge an investigation of the possibility of draining the land connected with the Teller Indian School at Grand Junction, and has done sufficient work upon this project to satisfy himself that the drainage of this tract of land is entirely feasible. I will refer you here to complete plans which Mr. Cone has presented with blue prints attached, for the carrying out of this drainage work.

Bulletin 182, on "Colorado Climatology" was prepared from this Section by Mr. R. E. Trimble, and distributed during the past year. Part 2, Bulletin 180, by Professor Carpenter, on "Seepage and Return Waters," has been sent out from the Station, and Part 3 of this Bulletin is nearly ready for distribution. Part 1, giving an introduction and general conclusions in regard to this work, it is expected will be ready to issue in the near future.

*Agronomy Section:* The work in this section has been rather seriously handicapped because of the fact that only fifty percent of the State funds were received, and the work is quite largely supported by State appropriations. The alfalfa investigations, carried on at Rocky Ford, have made good progress this year, and are entirely supported by Hatch money. Professor Keyser also has a very important project entitled, "Correlation Work with Grains and Grasses," which is supported on the Hatch fund. A large amount of very valuable data has been gathered during the year.

The dry farming investigations closed the first of last April on account of the funds for the support of this work being entirely exhausted. Mr. J. W. Adams, who was living in the Cheyenne Wells Dry Farming Station, has kept careful records upon his dry farming work for this year, a copy of which he has sent to my office. Mr. Adams remained upon the Station farm and carried on the experiments of the year on condition that we would spend \$175 for needed improvements upon the place. There is plenty of data on hand for the preparation of several bulletins from this Section as soon as there is money available for printing.

*Horticultural Section.* The Horticultural Section has been almost entirely without funds for experimental work during the

past year. We have been compelled to remove our field men from the Western Slope for this reason, and we shall not be able to take up the work over there again until there are funds for carrying on the work. Professor Bennett reports sufficient data upon three of his projects for the preparation of bulletins; one of these is upon the Cherry Industry, and another upon Onion Growing, both of which he is quite anxious to publish as soon as funds are available. There is a large amount of very important investigational work that should be carried on in this Section with our orchard fruits, small fruits and vegetables. It is very much to be hoped that better appropriations can be secured for the support of this work during the next biennial period.

*Entomological Section.* The principal line of work in this Section throughout the year has been that of plant louse studies. This work is supported by the Hatch and Adams funds, and devoted almost entirely to a study of life habits and host plants, and the parasitic and pernicious insects that take part in the control of the plant lice.

Considerable attention has also been given to the habits and remedies for the bean beetle, which has been so destructive to the bean crop along the eastern slope of the foothills in Colorado and New Mexico each year. The tomato psyllid, which has been very destructive to the tomato plants during the last two or three years in Colorado, has also received considerable attention, and remedies have been developed for its control.

Early last spring this Section, in connection with the office of State Entomologist, undertook an investigation of the leaf roller injuries in the orchards of the Arkansas Valley, especially in the vicinity of Canon City and Pueblo. We have been successful in finding very efficient remedies for the control of this pest. The results of this investigation were published in Circular 5 of the Office of the State Entomologist. The field work in this investigation this year, has been in charge of Mr. George P. Weldon.

Besides the circular just mentioned, the Office of State Entomologist has issued, during the past year, Circular 3 "Loss from Foul Brood and Poor Management," by Mr. Wesley Foster, Circular 4 "Suggestions for the Control of Prairie Dogs and Ground Squirrels," by Mr. W. L. Burnett; Circular 6, "Report on Rodent Investigations for 1912," by Mr. W. L. Burnett, and the report of the State Entomologist for 1911.

*Animal Husbandry.* Two projects, "Ration Experiments with Swine," and "Beef Production," were completed early in the year by this Section, and there has since been no money to take up further work. Professor Morton is adverse to starting any further ex-

periments until there is money available to carry on the work to a satisfactory conclusion. There is a great deal of demand from the stockmen of the State for information along stock feeding lines, and we hope that money may be provided to carry on this investigational work during the coming biennial period. On account of the necessity of buying animals to feed at rather high prices, experiments in this Section are necessarily rather expensive.

The Poultryman, who has carried on his work in connection with the Section of Animal Husbandry, has taken care of the poultry plant through the year, but has not undertaken any experimental work owing to the fact that the funds for the support of this work did not permit of anything more than maintaining the plant.

*Veterinary Section.* Only \$1250 have been available for investigational work in this Section during the biennial period just closing. To this sum the counties of Bent, Prowers, Otero, and Pueblo contributed \$1500 in order to have an investigation of the "Kansas horse plague," which broke out in the Arkansas valley early in the fall. A small amount of money was also allowed from the Hatch fund. Apparently Dr. Kaupp was able to discover the cause of this disease and prepare a vaccine for the protection of animals, as well as a serum for the cure of the disease. On account of our not being able to undertake this work until near the close of the outbreak, Dr. Kaupp was unable to try out his vaccine and serum on as large a number of animals as he desired. The results obtained, however, indicated that both the vaccine and serum were efficient in controlling the malady.

Bulletin 185, on "Some Poultry Diseases" written by Dr. B. F. Kaupp, was published and distributed during the past year. This Section has also prepared bulletin manuscripts upon the following subjects, "Equine Infectious Aenamia," "Equine Cerebrospinal Meningitis," "Necrotic Stomitis," and "Sugar Beet Poisoning," all of which are in my hands awaiting publication.

*Horse Investigation.* The work of this Section, for the purpose of developing a standard breed of American carriage horse, has progressed very satisfactorily during the past year. There are at the present time, over 80 animals in the stud, all of which are doing well. A small number, which do not come up to the standard, are culled out each year. The appropriation which has been made by the State for the support of this work during the past six years, has not been sufficient to bear over half of the expense. We should have an appropriation of not less than \$3,000 or \$3,500 a year in order to meet our half of the expense for carrying on the work for the horse breeding section.

*Potato Investigation.* This work has been in charge of Mr. C. L. Fitch during the past biennial period. Mr. Fitch, at the present time, is in the University of Wisconsin taking special work preparatory to continuing his studies of the potato diseases in this State, which we hope we shall be able to take up again next spring. Potato growing has been one of the most important agricultural industries in this State. Over a large section of our potato growing area, the potato crop has been greatly reduced during the past few years, by some unknown disease which has gone under the name of "potato blight," "leaf curl," and "*Fusarium*." Up to the present time it is uncertain whether or not the trouble is due primarily to some disease organism, or whether it may be due to peculiar climatic or soil conditions in the arid section. If it is due to a disease organism, it is not certain what that organism is, although it has been thoroughly demonstrated that at least two plant diseases, *Fusarium* and *Rhizoctonia*, have been more or less prevalent in their attacks on the potato plant. We hope to arrange for cooperative work in the investigation of potato troubles, with the Bureau of Plant Industry of the Department of Agriculture at Washington. The Bureau is offering to cooperate with us upon very liberal terms, but it will be necessary for us to give them a reasonable assurance that we shall be able to continue our part of the expense entailed by this investigation for a period of at least five years. For the support of this work the Station should have, at the very least, \$6,000 a year, and it is doubtful if this amount would be sufficient to properly carry the work.

### PUBLICATIONS

The following publications were issued by the Experiment Station during the the past year:

- 150—On the Measurement and Division of Water, by L. G. Carpenter.
- 182—Colorado Climatology, by Robert E. Trimble.
- 183—Deterioration of the Quality of Sugar Beets Due to Nitrates Formed in the Soil, by W. P. Headden.
- 184—(I) The Ammonifying Efficiency of Certain Colorado Soils, by W. G. Sackett.  
(II) Algae in Some Colorado Soils, by W. W. Robbins.
- 185—Some Poultry Diseases, by B. F. Kaupp.

### PRESS BULLETIN

- 55—Flax Growing, by Alvin Keyser.

## STATION NEEDS

In order to carry on the work of investigation during the next biennial period, the station needs, at the very least, the following appropriations:

Horse Breeding Experiment	-	-	-	6,000.00
Horticultural Investigations	-	-	-	12,000.00
Potato Investigations	-	-	-	12,000.00
Plant Investigations	-	-	-	10,000.00
Dry Farming Investigations	-	-	-	5,000.00
Irrigation and Drainage Investigations	-	-	-	10,000.00
Animal Husbandry (Including Veterinary Science)	-	-	-	20,000.00
Poultry Investigations	-	-	-	5,000.00
Total	-	-	-	\$80,000.00

In addition to this amount, our Station should have at least one new building for the Chemical Section and Bacteriological work, to cost not less than \$20,000.

Respectfully submitted,

C. P. GILLETTE.

Director.

## REPORT OF THE CHEMIST

*To the Director:*

I have the honor of herewith presenting the report of the Chemical Section of the Experiment Station.

In 1910 we presented two bulletins, Nos. 155 and 160 of this Station, on the occurrence of unusual quantities of nitrates in some of our soils. One of these, No. 160, was a more popular presentation of the subject, but contained the results of observations additional to those presented in No. 155. The work on this subject was continued and in June 1911 Bulletin No. 178 was published presenting the results of our work up to the winter of 1910-1911. Up to this time, the fact of the occurrence of nitrates in extraordinary and prejudicial quantities in our soils was the principal feature of our study. This fact was abundantly established for many localities in the State, for instance in the San Luis Valley, in the Grand Valley, in the Arkansas Valley and in the Poudre Valley. The most general and serious occurrences were found in the Grand and Arkansas Valleys. We had known of the occurrence of these salts in spots for several years before it became evident to us that there was any danger that their occurrence might become either abundant or gen-



eral enough to make them a seriously detrimental factor in our agriculture.

In June 1909, however, our attention was called by Mr. A. B. Hoyt of Grand Junction, to some apple trees which had died suddenly and apparently without any assignable cause. These trees were as large and healthy as any in this orchard of thirty or more acres. The trees surrounding them were at that time apparently healthy. A thorough examination of the trees and of the conditions obtaining in this orchard failed to show any cause to which their death could be attributed. The trouble spread very rapidly so that by the following October six or eight acres of the orchard were involved. From this date on many trees and even whole orchards in the Grand Valley and the Arkansas Valley have died in the same manner, often very quickly but sometimes the progress of the trouble has been slow. The results of this trouble in all cases in which it is at all severe is fatal to the apple tree and to most other trees.

The examination of the soil from the orchard to which Mr. Hoyt called our attention, was found to be rich in nitrates, that is these salts were present in the surface soil in such quantities as to suggest that they might be the cause of trouble, especially as there was no other apparent or adequate assignable cause to which the death of the trees could reasonably be attributed.

The effect of nitrates in excessive quantities upon apple trees had not, up to this time, been determined by direct experiment, so far as I can find. Direct determination of this point by the application of nitrates to healthy, growing apple trees was the only way in which to obtain sufficient and satisfactory information on this point. Such experiments were made with most positive results. The nitrate used was Chile saltpeter which produced the same kind of injuries as we find in the orchards even to killing the trees in the same manner that those in the affected orchards die. At first I thought this was probably only a temporary condition which would not become general enough to justify serious apprehensions. In this, however, I was too optimistic, for it has extended to new orchard territory each year since we definitely recognized the cause of the trouble.

The year 1909 was really not the beginning of the trouble. We had, as previously stated, known of the occurrence of these nitrates in small areas for several years previous to this date and even seen the peculiar burning of some leaves on apple trees years before, but we did not know the cause of the latter and did not associate the two. Still it was only in 1909 that we observed the first fatal effects upon apple trees which we traced to this cause.

The orchards present most conspicuously the effects of the nitrates. No one fails to notice the change when a tree in full and

healthy, perhaps excessively, green foliage, dies in mid-summer in ten days, or at most within a few weeks. The change in the leaves is especially marked for they turn brown, die and remain upon the tree. While this may be the most striking, it is by no means the only effect upon our crops. The presence of these salts up to a certain limit, varying with the crop and many other factors, is without question beneficial, but beyond this limit, or under other conditions, their presence is prejudicial.

Beginning in 1909 and extending through the years of 1910 and 1911 and into 1912, we have studied the effects of these salts, nitrates in general without distinguishing between the nitrates of calcium and magnesium or those of the alkalis, potassium and sodium, upon the sugar beet crop. The results of our work on this subject are presented in Bulletin 183 of this Station. This latter subject was studied almost exclusively in the Arkansas Valley. The beets grown in this Valley from 1893 to 1904 or 1905, were excellent in quality. From the latter date on to 1910, and we may say 1911, the quality varied exceedingly, but the average sugar content was low and the beets did not work satisfactorily. The average sugar content from 1893 to 1904, according to the best available information at hand, was not far from 17.5 percent; that for the period from 1905 to 1911 inclusive, did not exceed 14.5 percent. There were fields of excellent beets each year, but there were more fields of very poor beets. The Chemical Section of the Station set itself the task of finding out which of the many causes involved is the principal one which has brought about this great change.

The facts pertaining to the quality of the beets were of course fully known to the factory managements but they were not fully realized by the public. The causes considered as responsible for this condition were, of course, such as were known to be unfavorable to the normal development of the crop, or such as could be seen or otherwise recognized, such as seepage, alkali, insect pest, leaf-spot disease and climatic conditions. That these separately have their own individual influence upon the quality of the crop is not questioned. In regard to these individual causes we do not know as much as we might, but there is no doubt but that the general estimate in regard to some of them is far from the truth and is so general that but little importance can be attached to them. No one doubts for instance, that too much water in the land is an unfavorable agricultural condition, nor that alkali may be of such a character and so abundant as to be very bad, but the habit that is so prevalent among us of attributing almost any evil to these causes, is not justified. The same is true of climatic conditions even to a greater degree, for this includes so many factors known and

unknown, that an appeal to it is only a way of getting out of a difficulty or acknowledging our ignorance. The leaf-spot disease undoubtedly has its own specific effects upon the crop and its quality. I know of no serious attempt that has been made to determine this. In our work we have assumed that the effects of this disease is simply that of defoliation and that no enzymic or poisonous effect is produced in the beet. We do not know that this is true, on the other hand we do not know that it has even been asserted that this fungus, *Cercospora beticola*, produces any such effect upon the beet. We have taken the same general view of the effect of the attack of insects, i. e. that the damage done is essentially a mechanical one and that the changes in the composition and quality of the beet are such as would be produced by any equally extensive mechanical injury inflicted at the same period of the beet's development. We endeavored as early as 1896-1899 to determine the specific influence of alkalis upon the composition of the sugar beet, and found that they slightly increased the ash content but did not decrease the percentage of sugar.

In 1911 we investigated the effects of defoliation upon the crop and composition of the sugar beet. The results were in harmony with those found by previous investigation in so far as the investigations were parallel. The questions which we endeavored to solve were not to ascertain whether we could obtain the same results that others had obtained, but to ascertain whether the composition and quality of such beets, i. e., defoliated ones, were those of the average crop grown in the Arkansas Valley, and in this way to learn whether the leaf-spot disease could, with possible justice be assigned as the cause of the poor quality of the beets from 1905 to 1911. There were already a number of considerations which made it quite doubtful whether the leaf-spot disease was the cause of this general deterioration or not. The results of our investigation of the effects of defoliation showed that it produced very marked effects upon the crop and its composition, but that these effects are quite different from those which mark the difference between good, normally developed beets and the average crop of the Arkansas Valley. The inferior quality of the Arkansas Valley beets then could not primarily be attributed to the prevalence of this disease, leaf-spot, besides it was not sufficiently general and virulent throughout the period to be the principal cause. This does not deny that at times it may have injured in a measure both the crop and its quality, but these injurious effects were not the specific ones which constitute the general deterioration of the crop throughout this period.

Examination of the beets and by-products of the sugar factories showed the presence of nitric acid in larger amounts than are normally present. This led to the institution of experiments in co-operation with the American Beet Sugar Company on a larger scale than would have been possible for this Section of the Station to do with the resources at its command. These experiments were carried on in 1910 at Rocky Ford, Colorado. They were continued on a smaller scale at Fort Collins in 1911. The object in view was to ascertain whether the presence of nitrates in the soil in excessive quantities would produce the specific qualities in the beets which we actually found in the general crop. Our experiments established in the most satisfactory manner that such is the fact. The beets have, as a rule, been supplied with so liberal a quantity of nitrates annually that the quality has been affected thereby.

The immediate cause of production of these nitrates, for they are produced in the soil, is the *Azotobacter* flora of the soil which uses the atmospheric nitrogen in building up its own substance later to be transformed into nitric acid and nitrates. This flora like any other may vary in its luxuriance from year to year and then the amount of nitrates formed will also vary. This is probably a general condition in our alkaline soils.

We have already stated that at first we hoped that it would prove to be only a temporary condition and would correct itself, but its injurious effects have already continued through several years and while there may have been fewer instances of very intense action in 1912 than in 1909, 1910 and 1911, there were altogether too many of such and the general occurrence of the trouble was certainly more extensive than ever.

Our efforts during the season of 1912 have been directed toward finding out the variations in the quantities of nitrates occurring in certain soils both on the surface and with depth. While we have obtained some usable and fairly satisfactory results, the season's work has been greatly interfered with by rains at inopportune times and also by other things over which we have had no control.

While we believe this to be an important, even a serious factor in our agriculture, it may not be a permanent one, and if it should prove to be there will certainly be some way found to hold it in check and make it serve our interests instead of injuring them. This will mean, however, a revolution in our present agricultural practices. These questions, however, will have to be worked out in the immediate future, possibly the laboratory may help but the big burden of these improvements rests upon our field practices. This Section hopes to be able to continue the study of this problem.

In this connection it has become imperative that I should call attention to the fact that our laboratory space is already too small and our facilities need to be increased. When the present Chemical Building was planned both the College and Station work was much less than at present. The present building was planned about sixteen years ago when the total number of students handled by the Department was less than half the number to be handled at the present time. We at that time planned for a maximum of about 100 students to be accommodated in the laboratory. This year we will have 210 and possibly more. The College needs at this time all of the floor space of the present building. The Station work sixteen years ago was confined to the Hatch fund work which, so far as this Section is concerned, was on similar lines to those being prosecuted at the present time but they had not developed and the investigations were not so broad and specific nor were they presented in the detail that they have come to be under the Adams fund. The space allotted to the Station was never more than sufficient, and of late years has been too small. The Station could with profit use all of the floor space on the first floor of the building, so it is not only a question of handling 210 students in the space originally calculated to handle possibly 100 students, but at the same time to conduct the Station work in less than one-fourth of the space that we could profitably use.

The work that we have planned in connection with the further investigation of the problems detailed in this report will require much more floor space than we can possibly make available in the present building. I urgently request that every proper measure be taken to obtain a separate building for the accommodation of the Chemical Section. My idea for a building devoted wholly to the Chemical Section of the Station would be a plain one-story building with sufficient floor space for its present needs, with some allowance for future expansion and basement room for storage of stock and samples and some room for coarse sorts of work.

I am bringing this subject to your attention not as a possible future, but as an actual present need.

I append hereto the inventory of property, stock, etc., now on hand amounting to a total of \$5,589.25.

Respectfully submitted,

WM. P. HEADDEN.

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#### REPORT OF BACTERIOLOGIST.

*To the Director:*

I have the honor to submit herewith the annual report of the Bacteriological Section of the Experiment Station for the year 1912.

Under the provisions of the Adams Fund, two lines of investigation have been pursued during the year. Both of these are projects which have been continued from last year, and, in the one case, four new phases of the investigation have been taken up, two of which have been completed, and two are in progress; in the other, confirmatory evidence has been secured.

In addition to the above, this section has inaugurated a line of commercial work in the preparation and distribution of pure cultures for vinegar making. From time to time we have co-operated with the potato specialist in his study of Colorado potato troubles.

*Project I.—Bacteriological Studies in Alkali Soils.*

With the publication of our results on the Fixation of Nitrogen in Certain Colorado Soils in Bulletin 179 of this Station, the first step in this problem was completed. At this time, it is possible to report the completion of the second division of the investigation, namely the Ammonifying Efficiency of Certain Colorado Soils. The results of this work have been gratifying beyond expectation and, together with a discussion of the question, have been published as Bulletin 184.

The investigation has included a study of over thirty (30) soils, the majority of which are affected with niter. The results point clearly to the unusual ability of most of these soils to convert organic, proteid nitrogen into ammonia, a form of nitrogen which is readily changed to the nitrate by nitrifying bacteria. In addition to the points of scientific interest which have been brought out, the work has an immensely practical bearing on the use of nitrogenous fertilizers on Colorado soils. We have been able to show that certain of these become available for plant growth more quickly than others and, consequently, they are better suited to our needs. For example, in New Jersey, blood meal is four times as valuable as cottonseed meal from the standpoint of available nitrogen, but in Colorado cottonseed meal is equal, if not superior, to blood meal, undoubtedly because of the bacterial flora peculiar to our soils. Cottonseed meal applied to our soils is three times as efficient as it would be if used on certain Iowa land. Again, flaxseed meal is almost worthless with us, but when employed in New Jersey, it is as valuable as cottonseed meal in Colorado. We have been able to show that so far as available nitrogen is concerned, cottonseed meal ranks first, blood meal next, followed by alfalfa and flaxseed meal last. The rapidity with which the proteid nitrogen of the cottonseed meal and blood meal is converted into ammonia has been of great interest, since in one case 52.64 percent of the total nitrogen was changed in seven days.

The study may be summarized as follows:

The power to transform organic nitrogen into ammonia is a property common to many cultivated Colorado soils.

Soils in the incipient stage of the niter trouble appear to surpass our normal soils in ammonifying efficiency.

Compared with soils from other localities, our niter soils excel in ammonifying efficiency to a very marked degree.

Nineteen of the thirty-one soils examined have ammonified cottonseed meal more readily than the other nitrogenous materials employed; the remaining twelve have broken down the dried blood most easily; twenty-six have formed ammonia from alfalfa meal more readily than from flaxseed meal, and with five the reverse has been true.

The maximum per cent. of ammonia produced in seven days by any soil from 100 m. g. of nitrogen as cottonseed meal was 51.98 per cent; as dried blood 52.64 per cent; as alfalfa meal 34.85 per cent.; as flaxseed meal 112.15 per cent.

Returning, now, to the question of the fixation of atmospheric nitrogen by *Azotobacter*, we have given some attention to certain factors which are closely related to this branch of the main project. Among these may be mentioned the possibility of *Azotobacter* being able to fix nitrogen as nitrate; the relation of chlorides to the growth and nitrogen fixing power of *Azotobacter*; and soil algae as a possible source of energy for *Azotobacter*.

It is generally accepted by soil bacteriologists that the genus *Azotobacter* fixes atmospheric nitrogen in the form of a proteid, but because of certain facts peculiar to our niter soils there seemed to exist a possibility that the nitrogen was being fixed directly as a nitrate. Large cultures, capable of giving several grams of the dry material, were prepared from a Colorado strain of *Azotobacter* and after a sufficient growth had taken place the germ substance was removed and a chemical analysis made for nitric nitrogen. We failed to demonstrate any nitrate, however, and the experiment served only to confirm the work of others.

Chloride, as sodium chloride, which is abundant in many of our soils, were shown to be detrimental to the growth of *Azotobacter* when present in amounts greater than two per cent but they had no effect upon the nitrogen fixed so far as the formation of nitric nitrogen.

#### *Soil Algae.*

Some doubt has been expressed by investigators elsewhere in this country concerning the source of the carbohydrate from

which our *Azotobacter* flora derives its energy for nitrogen fixation. In order to answer their objections, in a measure, at least, we have undertaken a systematic study of the algae which occur in some twenty niter soils. The original cultures and routine work have been taken care of in our laboratory, but Mr. Robbins, of the Botanical Department, has given us invaluable assistance in the systematic work of describing and identifying the different species. He states that all of the twenty soils which he has examined thus far are abundantly stocked with algae, and he feels reasonably certain that in the list there are some previously undescribed forms. Up to the present time, all of those found, some twenty in number, belong to the blue greens and by far the largest percentage of species belongs to the family *Nostocaceae*. It is our purpose ultimately to combine pure cultures of these algae with pure cultures of *Azotobacter* in order to demonstrate that the demand for carbon by the *Azotobacter* cells can be satisfied by the carbohydrate manufactured by the algae. Mr. Robbins is endeavoring to obtain such pure cultures, but, owing to difficulties in the technic and the extreme slowness with which they develop on the agar, we have not been very successful. The results of the systematic study have been published as Part II of Bulletin 184, entitled, "Algae in Some Colorado Soils."

#### *Azotobacter* Pigment Studies.

Intimately associated with our high niter soils, we almost invariably find a characteristic brown stain on the irrigating furrows and ditch banks. While this phenomenon might result from several causes, our previously recorded experiments indicate that the brown pigment of *Azotobacter chroococcum* will account for the color in most cases. At this point, two possibilities arise regarding the manner of deposition of the coloring matter: Is it due to the bacterial pigment formed *in situ* by the microorganisms growing on the surface of the soil, or is this coloring matter dissolved out of the bacterial cells which occur in the surface layers, and subsequently carried to the surface in solution and there concentrated through evaporation? Unquestionably, the former takes place to a certain extent, but before any expression of the probability of the latter could be given, extensive studies on the solubility of this pigment became necessary. This work is now in progress, and while it is only partially completed, we have no hesitancy in stating from the results already at hand that this coloring matter is readily soluble in solutions of a number of our soil alkalies.



*Nitrification Studies.*

Studies dealing with the third division of the main project entitled, "The Nitrifying Efficiency of Certain Colorado Soils," are now under way. The purpose of these experiments is to determine the ability of certain soils, through the agency of microorganisms, to convert the ammoniacal nitrogen resulting from proteid decomposition (ammonification) into nitrites and nitrates. If it can be shown that the soils under examination do possess this power to any marked degree, then we shall have demonstrated beyond any shadow of doubt that our soils can transform atmospheric nitrogen into nitric nitrogen, and the mystery of the accumulation of nitrates will resolve itself into a simple question of microbial activity of a malignant type.

*Project No. 2, Raspberry Disease.*

It is with no little regret that I report the results of our spraying experiments on raspberries at Loveland as very unsatisfactory for the past season. Because of the very wet weather early in the year, it was impossible to accomplish but one spraying before picking time began. The picking season this year was prolonged almost two weeks over former years, because of the cold summer, which in turn delayed late sprayings. Although I feel reasonably certain that early sprayings alone are beneficial, I decided to try at least one late spraying, with the hope that the spread of the disease might be controlled. However, a combination of circumstances and unfavorable weather conditions, over which we had no control, threw the spraying so late in the season that I felt it would be a waste of time and material to do anything further this year.

I am glad to be able to report that the one spraying which the raspberries received has had a very marked benefit in controlling the disease, as compared with unsprayed canes in the near vicinity, and I have no hesitancy in saying that the trouble would have been controlled entirely had it been possible to have given the raspberries at least three sprayings previous to picking time.

*Miscellaneous Investigations.**Potato Disease.*

From time to time, Mr. Fitch has called upon me to assist him in the study of the *Fusarium* disease of the potato. Together we drew up the plans for the greenhouse and field experiments, the results of which I leave to him to report. Previous to starting the greenhouse work, I made a preliminary examination of a large number of apparently healthy tubers to determine whether the seed

was infected before planting. 97.29 per cent. of these gave cultures of *Fusarium*, either upon their external surfaces or cut faces. At the conclusion of the greenhouse experiments, I made some two hundred and fifty (250) *Fusarium* examinations of the potato vines in order to confirm the apparent cause of disease or health, as the case might be.

Occurring contemporaneously with the *Fusarium* trouble, we find another phenomenon which growers have come to associate with their recent potato failures. This is characterized by a curling or rolling of the leaves very similar to the rolling which accompanies the *Fusarium* wilt, except that there is no discoloration of the foliage and no plugging of the vascular system by fungus hyphae. During September last, I made some one hundred fifty (150) examinations of stems and roots from such potato plants sent me from the San Luis Valley. Microscopic examination of sections from these plants failed to show any *Fusarium* infection whatever and upon incubation in moist chambers this same material failed to give any growth of *Fusarium*. The results of this work would seem to indicate that the rolling of the leaves is a trouble quite distinct from the *Fusarium* infection and, while it may often accompany the *Fusarium* trouble, I doubt very much if it plays an important part in our potato failures of the past two years. Invariably, when this leaf-roll is accompanied by the presence of *Fusarium* in the vascular system, the mortality of the vines is very high, while when the leaf-roll occurs by itself, the destruction is slight.

#### *Disease of Sugar Beet Seedlings.*

Late this past spring at about the time sugar beet growers were actively engaged in thinning and blocking beets, a number of complaints were received from the beet growing sections of northern Colorado which stated that the beet seedlings were turning black at the root and rotting off at the ground line, a procedure technically known as "damping off." The trouble was most prevalent in the low ground and in some cases the loss was heavy. An examination of the diseased material showed the ailment to be due to an attack of *Corticium vagum*, a fungus which is a recognized agent in the damping off of sugar beet seedlings. The occurrence of this trouble on former potato land, but at the present in beets, was quite conspicuous and at the same time significant, since the same casual fungus has been partly responsible for our potato failures in past years. Crop rotation or planting on land which has not been in either beets or potatoes for the past ten years offer the only two practical solutions of the difficulty.

To the end of providing the layman with information which would lead to a more intelligent understanding of bacteriological soil problems, and which would prepare him to grasp more readily the material contained in technical articles, a popular bulletin entitled, "Some Soil Changes Produced by Micro-organisms," was prepared early in the year, but, owing to lack of funds, the publication of this treatise has been postponed indefinitely.

Our experimental work has been very greatly facilitated this year by the addition of a room for chemical determinations. While our quarters are still crowded, the temporary relief afforded by this newly acquired floor space has been greatly appreciated.

In conclusion, I wish to express to the Director my sincere appreciation of the liberal support and hearty cooperation which he has accorded me, both in my work and in providing me with equipment and with more spacious laboratory quarters.

Respectfully submitted,

WALTER G. SACKETT.

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## REPORT OF IRRIGATION ENGINEER

*To the Director—*

The following is the report concerning the experimental work done in Irrigation during the past year. This report covers everything except that which is being done in co-operation with the U. S. Government. I am not informed as to the progress of any of this work and not able therefore to report on same.

Owing to the fact that our appropriation of \$5,000.00 made by the State Legislature two years ago was not available until recently, the last irrigation season found us not prepared to do any extensive work in this line. There was about \$200.00 on hand that could be used for the work, and the summer's work was therefore limited to the careful measurement of all water applied to the College Farm.

During the past season we have measured all the water put upon any field of the Farm and have worked up the data so that we are ready to report upon the duty of water obtained by the present system of irrigation, which consists of flooding or row irrigation from laterals.

There is at the present time another quarter of the State appropriation available and it is my intention to use this money for the purpose of purchasing the necessary material to install two new systems of irrigation. One will be by the use of surface pipe carrying the water to the high places of the field through a light

fibre pipe and laid on the surface of the ground. This pipe will be in sections which join one to another so that the pipe line may be extended or turned and the water delivered in any direction. This will do away with the necessity of drowning out the low spots in the field in order to force the water over the high spots.

The remainder of the money available will be spent in the purchase of material and the installation of a sub-irrigation system by means of under ground pipes. I am negotiating now for porous pipe manufactured in Oklahoma for this purpose and said to work very well. I think probably we shall also install the ordinary glazed sewer pipe or drainage tile and compare the duty of water obtained by these two up-to-date systems with the present systems in use on the College Farm.

It will be necessary for this experiment to run several years before results can be published but when once secured, I think it will fill a long felt want.

Respectfully submitted,

E. B. HOUSE.

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## REPORT OF IRRIGATION INVESTIGATIONS.

*To the Director—*

I have the honor to present herewith the report of the co-operative Irrigation and Drainage Section of the Station.

The work is supported by four funds: Hatch, Adams, State Appropriation and Government Appropriations. The last fund, however, equals the aggregate of the first three.

The hydraulic research work has been interfered with and delayed during the past season owing to the necessity for providing adequate laboratory facilities. The experiments with the flow of water and weir construction were partially completed during the past winter, but insufficient water supply necessitated their postponement. In order that these experiments might be carried to completion, and other much needed research work in hydraulics conducted, a hydraulic laboratory is being constructed. Work on the laboratory was started in June. This consists of the supply and calibration reservoirs of reinforced concrete, with electrically operated pumps for returning the water supply, and a suitable laboratory building, all of which are located on the western portion of the College campus. This plant is so designed as to be available for the investigation of general hydraulic problems, but is especially well suited to work on measuring devices.

During the past summer Mr. Trimble and Mr. Jones have devoted a considerable portion of their time to the investigation of the coefficient of friction in empirical formula. This work called for considerable travel and resulted in a material addition to the available data on this subject.

The field work in eastern Colorado, which has been carried on by Mr. Lauck, has resulted in the development of a great deal of information on pumping possibilities in that section, especially from an auxiliary irrigation standpoint.

The investigation of irrigation conditions in the San Luis Valley by Mr. Hemphill has progressed well, but will necessitate an additional season for the completion of the work.

The cooperative experiment farms on the Costilla Estates Development Company's property near San Acacia produced but little results this season, but the work done has served to place everything in very fair shape for profitable results next season. Three 40-acre tracts of sod land were broken in the spring, but the preparation of this land for irrigation, and the breaking down of the sod for seeding purposes, consumed so much time that the seeding was done very late in the season and the early fall cut short the crops. It is fair to state, however, that material results were not expected this season.

The tank work on the water requirements of crops, and drainage requirements of crops and drainage factors, part of which is field and part laboratory work, has progressed very well. These experiments are to run through a series of years.

The general meteorological observations, which have been continued for years at Fort Collins, are very complete and are being kept up to date in every respect. Mr. Trimble has recently published the results of the meteorological observations of the past twenty-five years at Fort Collins and other portions of the State, as Experiment Station Bulletin No. 182.

Quite recently this Section has undertaken the investigation of the drainage possibilities on the Grand Junction Indian School lands for the purpose of reporting immediately upon the feasibility of draining these lands.

The orchard irrigation work at Canon City has been continued, this making the sixth year.

At the beginning of the present fiscal year the experiment farm at Eads was discontinued because of its considerable cost and adverse conditions.

The coming year offers greater possibilities for efficient and satisfactory work than heretofore because of the added equipment

and increased facilities, especially those in connection with the new hydraulic laboratory.

Respectfully submitted,  
V. M. CONE.

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## REPORT OF THE ENTOMOLOGIST.

To the Director—

I am presenting herewith my annual report of the Entomological Section for the year 1912.

The projects carried on under the different Experiment Station funds during the year are given below :

### ADAMS FUND:

*Plant Louse Investigations.* Systematic and life history studies of the Aphididæ have been continued during the past year. Because of the illness of Miss M. A. Palmer, very few drawings have been made. Mr. L. C. Bragg has devoted his time almost fully to plant louse studies during the year and has been able to accumulate a large amount of valuable data, especially in regard to life histories. The collection has also been very much enlarged in numbers of species, both American and foreign; the latter having been secured through exchange for the most part.

My announcement in last year's report, page 28, that I believed we had found the alate pre-sexual form of *Eriosoma lanigera* gathering in large numbers on elm trees in September and October, seems to have been premature, as a more thorough study has convinced me that the migrant obtained about the elm trees is *americana*, a species quite distinct from *lanigera*. The fall migrants of *lanigera* from the apple are very easily mistaken for the fall migrants of *americana* that we were taking about the elm trees and which produces the curled leaves on the elm during the summer months. A careful examination of the antennal characters alone is sufficient, also, to separate this leaf curling form from the form producing the rosette like cluster of leaves at the tip of elm twigs. These lice are also quite different in the habits of the stem-mothers. The lice that hatch in the spring from the over winter eggs of the leaf-rolling form (*americana*) migrate upon the opening buds and feed from the first upon the green leaf tissue, and as soon as possible work their way into the opening buds, whereas the form producing the rosette, locates at first at the base of a terminal bud where it feeds until the leaves curl about and enclose the louse. Shortly after this the louse sheds its skin and migrates

into the leaf cluster, where it comes to maturity and produces a large number of young that inhabit the rosette.

#### HATCH FUND:

##### *Insect Control by Egg Treatment.*

Considerable additional data upon the treatment of the eggs of the fruit-tree leaf-roller (*Archips argyrospila*) and several species of plant lice have been secured during the past year. The experiments with the leaf-roller have been published from the Office of the State Entomologist in Circular No. 5, entitled "Fruit-Tree Leaf-Roller."

##### *The Locust Borer (Cylene robiniae).*

The appearance of this insect in destructive numbers in and about Denver and the lack of knowledge as to methods of control led us to begin work, under the direction of Mr. George P. Weldon, for the purpose of determining more exactly the life habits and effective means of control for this insect in Colorado. This work was begun late in the summer and considerable data has already been secured.

##### *Syrphus Flies in Colorado.*

Mr. Weldon outlined a study of *Syrphus* Flies because of the importance of this group of insects in the control of our plant lice. In fact, this study is to be practically confined to the *Syrphidae* that feed partially or entirely upon plant lice. Considerable data has been secured and many species have been reared and determined, and we hope to continue this work for years to come.

##### *Tomato Psyllid (Paratrioza cockerelli).*

Professor S. Arthur Johnson has continued his studies upon the life history and remedies for this insect and is preparing a bulletin in which he will give the results of his investigations.

##### *Western Bean Beetle (Epilachna corrupta).*

Professor Johnson has a bulletin in preparation covering his studies into the habits and remedies for this insect.

##### *Grasshopper Investigations.*

This project has been held in abeyance the past year because of the very small number of grasshoppers that were available for the work. As these insects increase in numbers again the project will probably be resumed.

Respectfully submitted,

C. P. GILLETTE.

## REPORT OF AGRONOMIST.

*To the Director:—*

I submit herewith, my report on the experimental work of the Agronomy Section, for the fiscal year closing November 30.

I have attached herewith, the report of the Alfalfa Specialist and the report of the Superintendent of the Plains Dry Land Sub-station at Cheyenne Wells.

The work for the year has been limited almost entirely to those lines of experimentation carried on under the Hatch fund. Only one-half of the state appropriation was paid which compelled the discontinuance of all work financed by that fund.

Two lines of work were carried under the Hatch fund. First, an investigation of alfalfa in which studies are being made of the inheritance of different strains. In making these studies about 75 varieties or strains from different parts of this and other countries were obtained. These have been carried in duplicate on the Fort Collins Experimental Farm and on the Rocky Ford Experimental Farm. These variety tests are still being conducted in order that we may be able to pick out the best strains among those already existing, for our future work. These tests have resulted in the selection of two types from which to work. Using these types as a basis, we are conducting selection breeding.

Experiments are also being made to determine whether very much trouble is to be expected from natural cross fertilization. If, when a variation is found within the type, it can be fixed at once by selection, we will be able to make very rapid progress. If crosses are frequent it will be necessary to carry selections two or three generations before progress can be made. We consider this a very essential part of our work because it gives us a basis, not only for our future work, but for general alfalfa seed production in a commercial way.

We are also carrying on cultural methods; tests to determine if possible, the factors influencing seed and hay production, in order to be able to apply the best methods. The details of this work for the year are to be found in the report of the Alfalfa Specialist attached herewith.

The work on the dry land was carried until March, when the shortage of funds made it necessary for us to drop the superintendent of the Plains Dry Land Sub-station from the pay roll. The work reported from this sub-station is partly that started when funds were available and partly work which has been carried on as a general farming proposition by Mr. J. W. Adams, who is operating the Cheyenne Wells farm under lease.



The correlation studies which have been conducted have had the object in view of determining whether or not there was any relationship between measurable or visible botanical characters and the production when measured in yield or the quality of crops. These studies have been carried on with wheat, barley, brome grass and alfalfa. Definite results have been obtained in the case of alfalfa. So far, we have not obtained definite results from our studies on the grains. The data on the brome grass has not been worked up so that we cannot predict for a certainty, whether we have positive or negative results on this crop. It is hoped from these studies to determine if there are any visible or measurable characteristics which can be readily observed which will enable us to judge of the productive capacity within a variety. If there are such factors it would enable us to improve by breeding much more speedily. If no such factors can be determined, it will be necessary to conduct the breeding work under the same old laborious methods by which the best is determined by a process of elimination.

No work was conducted this year under state appropriations, although we were enabled to make a few observations on some of the high altitude work which had previously been started. Enough material has been collected and is on hand as the result of work done under the appropriation, to publish a preliminary bulletin on high altitude crop production, to publish a general bulletin on alfalfa culture and management, and to publish a special short report on tame grasses adapted to the various sections of the state. We have information enough on hand to justify the publication of information bulletin on field pea growing. Before this matter is published we should get some pictures of machines used in harvesting, threshing, and caring for the crop, for illustrations in the publication. Enough information has been collected under the Plant Industry appropriation so that if funds were available for their publication, a few special circulars or information circulars could be put out upon several crops.

Under the dry land appropriation, enough material has been collected to enable us to publish a circular bulletin on broom corn, which has been distributed. A bulletin was also published on flax growing, and as a result of work done on flax, about 16,000 acres were grown in Colorado in 1912 where, previously, there had been only a few hundred acres grown. Material has been collected also which would justify the publication of a bulletin on the culture of Mexican beans, one of the most successful of the dry land crops. We have on hand material enough to publish a number of special crop bulletins for the dry land as a result of the work done under this appropriation. This information could be worked up into bul-

letin form with a comparatively moderate amount of labor if there were funds for its publication. On some of these points it would be necessary to do a little traveling in order to get more information upon the market side and a little more general information on types of harvesting machines. Other cultural data needed is already at hand.

Respectfully submitted,

ALVIN KEYSER.

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REPORT OF ALFALFA SPECIALIST

*To the Agronomist—*

I hereby submit the following report on the alfalfa investigations under my control.

The present alfalfa project can be classed under three headings: Improvement by Seed Selection; Determining the Factors in Seed Production; and Increasing the Hay Yields by Improved Cultural Methods.

*Improvement by Seed Selection.*

For eight years we have been testing out in comparison a number of selections and varieties of alfalfa from different parts of the world. The general results of this work have shown that certain varieties have decidedly superior qualities over others. Numerous selections of the desired traits have been made from time to time, and new nursery tests have been followed up. The most valuable result so far is probably the determination of the fact of a difference in the type of the crown in the southern strains of alfalfa from the type of crown found in the northern varieties, and that there is an evident relation between this type of crown and the tendency to winterkill. A detailed report of this difference has been made in Colorado Experiment Station Bulletin No. 181, "Alfalfa—The Relation of Type to Hardiness," published since my last annual report.

In making selections to increase hay production, we have made hay tests based on the average production of a number of individual plants. We have found a great difference in this respect. For instance, the average of five of the best selection rows, was 50 percent above the average production of all the rows including the good and poor.

We have also found that heavy seed production is evidently inherent in some plants. This fact promises valuable results. We have found heavy seed production evident in some of the highest hay producing selections of the hardy types of alfalfa.

This desirable combination of favorable traits found in some of our best selections, causes us to feel that it would be well to increase as rapidly as possible, some of these strains, so that the benefits of the investigation can be available to the farmers, and at the same time continue the work of systematic selection, in order to improve and fix the desirable traits as far as possible.

#### *Determining Factors in Seed Production.*

Investigations to determine the best cultural methods for alfalfa seed production have been continued, but the results do not indicate any immediate solution of the problem, yet some progress has been made. In 1911, five acres of alfalfa were seeded in 20 inch rows for seed production, half of the field being of the Grimm variety and the other half of the Baltic strain, two of our best sorts. The field was given the same care in every way possible and was quite uniform. During the season of 1912 no irrigation was applied, yet the growth of hay was almost phenomenal, consequently the yield of seed was light, averaging only about one and a half bushels per acre. But the Baltic half of the field manifested its seed producing tendency by outyielding the Grimm's alfalfa about 20 percent, a difference which has been evident each season we have tested the two strains. The capillary action of the soil in this field, was evidently too favorable to the production of hay, to expect a good yield of seed. Yet the results proved the advantage of having the alfalfa in rows for intertillage, as weeds could be controlled. Had the field needed moisture irrigation could be applied in small amounts. The results of several years' observation along this line, seem to indicate that there are several factors that affect alfalfa seed production—the inherent tendency of the strain of seed; the control of moisture, not only the amount but also the time of application seems to be an important question. The soil and the climate is so variable that it seems probably necessary that each type of soil will have to be learned to insure a fair success with alfalfa seed.

Owing to the lack of funds, some of the cooperative work started last year could not be kept close watch of, yet the results of those who attempted to grow seed made fair success, so that there will be quite a quantity of Grimm's alfalfa seed available for the next season's seeding.

#### *Improving Hay Production by Cultural Methods*

With a view to determining the best cultural method of producing alfalfa hay, and to find the relative value of the heavy stooling types as compared with common alfalfa, two adjacent fields were seeded, one to common alfalfa, the other to Baltic alfalfa. In each

field ten different rates of seeding were used, varying from two pounds to twenty pounds per acre. Three different rates of seeding were used in seeding the rows. Plantings were made, alternating rows and thick seeding. The rowed alfalfa was irrigated in furrows to contrast the results of irrigation by flooding, the common method used on alfalfa.

Only a progress report can be made at this time. The stand of plants in all these seedings can be considered almost perfect. It is the plan to keep record of the production of each plat for a series of years. The result will doubtless be of great value, as our nursery tests would indicate that alfalfa seeded in rows and cultivated will produce much more hay than the ordinary broadcast methods that are used.

Additions of over two acres of select plants of the best types have been added to the nursery.

During the past season a new fence with new steel gates and an attractive sign has been made on the Rocky Ford Sub-station. A set of new five-ton wagon scales was installed.

Respectfully submitted,  
P. K. BLINN,

Rocky Ford, Colorado,  
November 1, 1912.

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#### REPORT OF SUPERINTENDENT OF PLAINS DRY LAND SUB-STATION

##### *To the Agronomist:*

I submit herewith my report for 1912. The season has been very trying at this station. We have had nearly the normal amount of rainfall, but much of it has come in very small showers so that it did little good.

*Oats.*—I sowed 14 acres of oats (Texas Red). They were sowed the 1st of May with a hoe drill. There were three acres on land plowed and summer tilled in 1911. The rest were sowed on ground that was cultivated in cane and milo in 1911. I got a good stand on the summer fallow, but a poor stand on other land. The yield was about one-fourth of a ton of hay per acre. The summer fallowed land produced somewhat more than the other land.

*Corn.*—I planted 15 acres of corn, mostly on summer fallowed land which did not have a good rain after it was plowed. It was planted June 1, with planter with furrow openers attached. There was not sufficient moisture for perfect germination. I got only three-fourths of a stand. It did well until late in August when it began to dry up. I put it in the silos the first day of September. Part

of it had ears on and part had none. It made an estimated yield of 4 tons of green feed per acre.

*Millet.*—Five acres of hog millet made only a quarter of a ton per acre.

*Potatoes.*—One acre of potatoes on summer fallowed land yielded 80 bushels of marketable potatoes.

*Beans.*—Half an acre of beans, mostly Mexican, were planted. They did quite well but were injured by hail. They have not been cleaned so do not know the yield.

*Garden.*—I planted half an acre to garden, which produced all the vegetables needed for the family. A half acre of Spanish peanuts were a complete failure.

The remainder of the place was planted to sorghums of various kinds. Owing to the cold, dry spring, I got a poor stand and some parts became very weedy in the rows. Early frost prevented much of it from maturing. It averaged nearly a ton per acre. Three acres on summer fallow land made a heavy yield.

The alfalfa planted in August, 1911, all winter killed. I broadcasted one acre this spring and have a good stand, but it did not make much growth.

Sowed two acres of sweet clover and got a good stand, but no crop this year.

*Trees and Shrubs.*—The fruit trees are dying out badly. The shade trees are doing well in general. The asparagus and strawberries sent here last spring were set in a favored location and have done well this season.

*Silos.*—During the season, two pit silos were made, one of them 10 feet in diameter, 25 feet in the ground and 3 feet above ground. The other is of the same dimension except it is only 20 feet in the ground. A concrete ring 1 foot deep and 10 in. wide was made at the top of the ground on each silo. The part above the ground is made of adobe 9 inches thick. The entire inner surface of the silo was plastered with cement.

*Cost of Silo.*—

Material:

17 sacks of cement for concrete rings	----\$ 8.50
21 sacks of cement for plastering	----- 10.50
Derrick and bucket for hoisting dirt	----- 10.00

Total cost of material -----\$29.00

## Labor:

Hauling sand (man and team at \$3.00)---	\$ 4.50
Excavating (at \$2.25) -----	89.20
Hauling away dirt -----	6.50
Making adobe walls -----	10.00
Putting in concrete rings -----	5.00
Plastering -----	22.00
Sheet iron box for hoisting ensilage-----	8.00

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\$174.20

*Extension to Cow Barn.*—A 16-foot extension was made to the cow barn to include the silo. The walls are of adobe and the roof of boards.

Cost of material -----	\$28.00
Labor -----	28.50

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\$56.50

*Cost of Filling Silo.*—

Labor and teams -----	\$48.45
Rent on engine and man to run it -----	21.00
Gasoline -----	5.00
Oil and incidentals -----	2.00

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\$76.45

We put 15 acres of corn and 6 acres of kafir and milo (21 acres in all) in the silos. It rounded them up full, but they settled down about five feet.

We began feeding from one of the silos October 2. There was about 8 inches of spoiled ensilage on top with 18 inches at the edges. The ensilage has kept well and the cows eat it with relish. There is no waste whatever.

*Dairy.*—I have milked 12 cows during the year and kept individual records of same. My records are at present in the hands of Mr. Barr of the U. S. Dairy Department so I can only give record of cash received, which is as follows:

Dairy products, year ending Oct. 31, 1912,	\$495.12
Six steer calves sold-----	63.00
Two cows sold -----	60.00
Seven heifer calves retained-----	120.00

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\$738.12

*Poultry.*—

Receipts from poultry and eggs-----	\$118.52
Feed consumed -----	45.50

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\$ 73.02

Net return, \$73.02.

Respectfully submitted,

J. W. ADAMS.

Colorado Dry Land Sub-Station, Cheyenne Wells, Colorado.

November 1, 1912.

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## REPORT OF HORTICULTURIST

*To the Director*—

The work along Experiment Station lines in the Horticultural Section has been seriously handicapped during the past year. Owing to lack of funds and to the great amount of work required for the College side of the office, it has not been possible to give as much time to our Experiment Station projects as we would have liked. Two of our men in the Department have been obliged to abandon their work, at least for the time being, so that altogether the work has been badly broken up.

Mr. Herrick, our Field Horticulturist for the West Slope, was shifted early in the year from the payroll of the Experiment Station in Horticulture to that of the College and, consequently, a large part of his time was required in taking care of the College interests and the extension work in that district.

The work of Mr. Fitch, the Potato Specialist, was carried on until the first of October and since he has left we are holding the work together as well as possible and keeping it in shape so that when funds are available we will be able to take up the work as nearly as possible where it was left off. To this end, seed in the various districts where it was grown this year has been saved, in the hope of continuing the work next season. A detailed report from these men has already been made direct to your office.

Mr. Smith, Assistant in Horticulture, has given by far a larger part of his time to College work. One project, however, has been carried along by him throughout the season. This project, a study of the "Cross" cabbage, is reported in detail by Mr. Smith. Originally, this project was started in the hope of eliminating the difficulty of reversion to the parent types in the Cross cabbage. This

cabbage, which was originated at Greeley, is one of the most valuable varieties used in the cabbage industry of northern Colorado, which is one of the most promising industries for this part of the State. Careful selection of seed by the growers did not seem to eliminate the difficulty and the work was taken up here in the hope of fixing a type in such a way that no further reversion would occur. So far, we have not been able to accomplish this result, but valuable data have been secured in the way of a study of the Mendelian characters that govern this variety. We have little hope of solving the original problem, but think it worth while to carry on the investigation a short time longer in order to more clearly determine the laws involved in the growing of this hybrid variety.

No new projects were started this past year. The orchard investigation project started three years ago has been carried along during the season. The attempt to get given varieties on their own roots has been at least partially successful and at present we have some very good stock of Northern Spy and other varieties growing on their own roots. These are still in the nursery row, but may be transferred to the permanent plots next spring.

The asparagus investigation project is now being carried on for the third year. We were unfortunate this year in setting our selected pistillate and staminate plants in the fall, as for some reason they did not live well through the winter and a poor stand has resulted. Comparatively little work has been necessary on this project. One difficulty has presented itself in connection with asparagus growing that will need investigation in the future, that is the prevalence of asparagus rust, which was particularly bad this season. This is a disease that is difficult to control, but we think that thorough spraying with some of the fungicides at the right time should control the disease.

The investigation of the cherry culture project has been carried on during the season and we think we have sufficient data now to produce a bulletin on this subject. This project, together with onion growing in Colorado, is the source of more questions than any other one problem that comes to our office. We hope to have the write-up of this work completed in a short time so that an information bulletin or a small monograph can be published as soon as funds are available for such work.

Onion Growing in Colorado.—This project is practically completed so that we are ready to write an information bulletin concerning the same and, like the cherry industry, we shall be ready to publish this as soon as funds are available.

The project of cauliflower and small fruit growing in high



altitudes has, because of lack of funds, been neglected this season. Some strawberry plants have been sent to high altitude districts for trial there, and we hope to use the information obtained, together with a project to be started next season, providing funds are available for such a purpose. These are problems of considerable importance, as there is a great field for the development of a small fruit and vegetable growing industry in our high altitudes.

For the same reason, the vegetable gardening investigation and demonstration was practically abandoned this last season. Some plots of onions were planted by students and were used later by the writer in getting data for a bulletin. The perennial crops, as the raspberries, currants, gooseberries and strawberries and asparagus, were kept from going back, but no additional work started. Some valuable data on strawberry growing in this district was obtained from our plots, which fruited for the first time this past season. The plots consist of eighteen standard varieties. Of these, we have found that only five or six are of real commercial value in this district. This point, however, is of comparatively little value, as the trials of different soils in other districts might have given different results.

The best varieties here as demonstrated by these trials were Glen-Mary, Marshall, Haverland and Dunlap, of late varieties and Crescent and Warfield, for early. One-half of each of these varieties was covered with straw after the ground froze last fall. We found this spring that those left uncovered did not come through in so good shape as those covered with a consequent difference in yield in favor of the covered plants. A difference in date of ripening period was also observed between the covered and uncovered plants. This is caused from the straw retarding the growth of the plants in spring by about one week. So far, no disease has developed in the strawberry plots. In some parts of the State, much damage has been done by a strawberry disease which is as yet comparatively little understood.

The investigation of cover crops for the orchard was not carried on in our orchard this year. This was due partly to a lack of funds and partly because of our inability to get sufficient water to start the cover crops at a time when it was desirable to do the work. This work has been carried on by our west slope representative with better results, as the problem is more imperative there and in most cases the orchardists have been able to obtain water so as to start their crops.

We hope before work of another season opens up that we shall have sufficient funds to employ a man in place of our Field Horticulturist, who has resigned. If we are able to do this, we

would recommend that he be located here at the College so that we shall be able to correlate our work in the Department to better advantage and take up some of the many problems that are demanding attention and, at the same time, carry on the other lines of work that are necessary in the department.

Respectfully submitted,  
E. R. BENNETT.

### CABBAGE BREEDING EXPERIMENT

*To the Horticulturist—*

This experiment is a study in the operation of Mendel's Law. The "Cross" cabbage is supposed to be an accidental cross between Flat Dutch and Winningstadt, the former a flat headed variety and the latter a pointed head. The result is a round head, or what might be called an 'intermediate hybrid;' that is, neither flatness nor pointedness is dominant.

The object in this study is to find whether or not by selection and close fertilization and round type can be fixed, or whether it will follow Mendel's Law and continue to split up or revert in each generation to the extent of about 25 per cent. flat and 25 per cent. pointed. It is one of the most desirable varieties in the cabbage growing sections on account of its vigor and yield, both of which we would expect to find pronounced in a cross. The one objection to it is that each year both flat and pointed heads are found in varying numbers, even where care is used in selecting the seed heads.

Our chief difficulty is to get pure seed, that is, self-fertilizing seed, as the cabbage objects stubbornly to self-fertilization. We have been able to secure a few such seeds by screening the heads with muslin and then not only hand pollinating but catching bees at intervals of 24 or 48 hours and putting them under the screens for a week or more during the blossoming period.

Last year a few seeds were secured from seven of the screened heads and these have been carefully guarded and planted out this year. The following table deals with the progeny of this seed:

Seed from head	No. of plants	Size of heads	Round heads	Flat heads	Pointed heads	Plants not headed
No. 1	36	Large	22	13	1	
No. 2	17	Small	14	1	1	1
No. 3.	25	Fairly large	16	6	1	2
No. 4	9	Medium	5	1	1	2
No. 5	28	Medium	19	5	1	3
No. 6	30	Small	17	0	2	1
No. 7	103	Large	60	35	3	5
	<hr/> 238		<hr/> 153	<hr/> 61	<hr/> 10	<hr/> 14

About 100 of the most typical heads of these seven lots were trenched for seed next year.

Typical heads selected last year and trenched over winter were screened and hand pollinated for pure seed this year so the work is being carried on in two groups one year or one-half generation apart.

We are finding the work quite complicated and interesting and expect to be able in a few more years to publish some interesting data, but are not able to draw any valuable conclusions yet, owing to the small number of individuals with which we are working, due to the difficulty in getting self-fertilized seed.

S. VAN SMITH.

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## REPORT OF THE POTATO SPECIALIST

*To the Director:*

The most needed work of the year for the potato industry has been to try to find the cause of the disaster to potato growing by disease previously unknown, at least in this country. In 1911, a season with an unusually warm summer, the *Fusarium* fungus was associated so universally with the sick plants that it seemed to be the cause of the trouble, and the winter of 1911-12 was spent in experiments to find the soil temperatures and percents of moistures that would cause the *Fusarium* to appear in the tubes of the vascular bundles. At considerable expense at the time when the institution had no funds appropriated for such purpose, a portion of one of the greenhouses was equipped to grow 136 hills of potatoes under known moisture conditions and controlled soil temperatures, by the use of electric heat and cold water, both electrically regulated. Important evidence was secured that the development of *Fusarium* is a matter of soil temperature and moisture.

During the season of 1912, the potato fields have been afflicted almost as universally with the "leaf-roll" symptoms of the disease as in 1911, but with the appearance of the *Fusarium* fungus in a small percentage of the plants. It is apparent that we have another manifestation or another disease than *Fusarium* and one that has not been described in this country, and there is much evidence that this new disease was the cause of *Fusarium* being so universally found in the stems in the infected fields of 1911.

Much time during the summer of 1912 was spent in the study of factors influencing soil and irrigation water temperatures in potato fields, and much has been learned to make clearer potato

growing practice and to make potato growing a little surer when we have *Fusarium* alone to deal with.

The study of the causes for good and bad tuber shape and the degeneracy of the tuber and plant and of seed stocks has gone forward. A series of tubers of the Pearl variety, selected by the potato specialist and arranged in the order of their degeneracy, were grown for him by the Minnesota and Wisconsin stations, and in New York by a prominent member of a breeder's association affiliated with Cornell University. Reports have been received from Minnesota and New York and both lots were affected by diseases (in New York by *Phytophthora infestans*) and died in the order of the degeneracy of the tuber, while in both cases only the plants from the most degenerate tubers bore seed balls.

Our experiments in the close planting of early and seed stock potatoes in our mountains and the designing of special machinery therefore have been completed, and will lead the way, we hope, to still more intensive methods in regions adapted to these crops.

We are maintaining at Carbondale small stocks of all standard varieties of potatoes, but we have not had the funds to make this of the importance which it should be as a source of pure and improved strains of seed.

Our efforts to secure an improved variety by crossing the pearl and rural have taken on a new significance and importance with the two years of potato disease and with the hope that we may secure by hybridization or seed propagation a variety that will be immune. About 1000 seedlings were raised last winter in the greenhouse and the better ones repropagated last summer at Del Norte. We have learned where and how to secure pollen and conditions for this work, and shall hope to do it on a large scale.

The studies of the history of varieties and of standard varieties have gone forward and are ready for publication when funds are available.

The reports of the leaf-roll disease, which has been serious in Germany and Austria since 1908, have been secured and a summary is ready for publication with our own studies of the *Fusarium* and our leaf-roll disease.

Respectfully submitted,

Madison, Wisconsin,  
Nov. 9, 1912.

C. L. FITCH.

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#### REPORT OF THE HORSE INVESTIGATION SECTION.

To the Director—

I respectfully request to report that the carriage horse breeding work which is being carried on in co-operation with the U. S.

Department of Agriculture, has enjoyed considerable progress during the past year. Seventeen foals were dropped during the season, including six colts and eleven fillies. A number of these foals are of exceptional merit, and if they develop properly will mature into animals of desired type.

The annual meeting of the Board of Survey resulted in the elimination of ten animals including eight yearlings, one two-year-old and one five-year-old. These animals were appraised and sold at private sale with very satisfactory results, all of them being disposed of in a very short time. The Board also authorized the Director and Expert in Charge to proceed with plans to place the young stallions throughout the state during the season of 1913. These plans have resulted in the placing of the stallion Albion at Akron, Colorado, for the season. Other stallions will be placed as satisfactory arrangements can be made for them.

The standard-bred stallion "Loyal D" has been purchased for the purpose of following Carmen in the stud and will be placed in service next year. This stallion is an exceptional individual of the breed and will undoubtedly fill a long felt want in the development of our work. Three standard bred mares, Edna Lipps, Josephine Belle and Mary Clay were purchased in Kentucky and have been delivered to the Station. With the addition of these standard bred animals to our stud, we should enhance very materially the production of animals of the desired type. The animals of questioned or unknown breeding have been almost eliminated from the Station, and the work is now on a sounder basis than ever before.

Respectfully submitted,

J. O. WILLIAMS,

Expert in Charge.

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## REPORT OF THE VETERINARIAN

*To the Director:*

The following bulletins covering the work of the fiscal year, or work started previously and completed this year, are as follows. "Diseases of Poultry", "Necrobacillosis", "Sugar Beet Poisoning", "Equine Cerebrospinal Meningitis", and "Equine Infectious Anemia". These bulletins are at this time either in press or being prepared for publication in the near future.

Animal disease investigation in this department depends largely upon special appropriations and this year our support has been meager, but we have been assisted by the counties of Bent, Prowers,

Otero and Pueblo to the extent of approximately \$1500.00, for special investigation of the so-called "Kansas Horse Plague."

### *Poultry Diseases*

Poultry raising is generally looked upon as a minor industry. After a cursory glance at the tabulated statistics of the poultry industry in Colorado and further consideration of the amount of money that is sent out of the state each year for poultry products, we are impressed with the magnitude of this industry and with the importance of safe guarding it in every possible way.

During the past two years Dr. B. F. Kaupp, Pathologist to the Experiment Station, has been actively investigating diseases of poultry. This investigation has been directed, not only to determining the cause and conditions surrounding the diseases of poultry, but a satisfactory treatment as well; directed largely to prevention of diseases. Parasites, both external and internal, have been studied and means for control will be found in the popular bulletin which is now in the hands of the publishers. Roup, cholera, blackhead disease of turkeys and white diarrhoea of chicks can be largely prevented by better sanitary conditions and the diseases in each instance controlled by certain remedial and prophylactic measures.

### *Sugar Beet Poisoning*

Losses have occurred among all classes of farm animals from pasturing in sugar beet fields after harvesting in the fall. Beet tops with a small portion of beet ends are left in the fields and after a few days of alternate freezing and thawing become poisonous, especially when eaten in large quantities. Whether the poisoning is caused from excess of sugar, from moulds or bacteria that develop under these conditions has not been determined. A bulletin has been issued merely as a note of warning to farmers and we hope to continue investigation of this condition.

### *Necrobacillosis*

Necrobacillosis, or what is commonly known as "necrotic stomatitis" in hogs, "lip and leg ulceration" of sheep and "calf diphtheria" in calves, has been studied for the last four years and a bulletin under cover with the article on sugar beet poisoning will be issued in the near future.

### *Equine Infectious Anemia*

Equine Infectious Anemia, or what is more commonly known as "Swamp Fever" is general all over the State and has caused considerable loss. This investigation has been under the direction

of Dr. B. F. Kaupp and has been confined largely to a disease in the vicinity of Colorado Springs simulating infectious anemia but which has been differentiated by inoculation experiments, and otherwise proven to be non-infectious. This disease, which is called the "No Name Disease" in that vicinity is of enough importance to warrant a thorough scientific investigation. The work thus far seems to establish the fact that it is not infectious and conditions generally point to some toxic plant on the range pasture as the probable etiologic factor.

### *Equine Cerebrospinal Meningitis*

"The Kansas Horse Plague" apparently started in western Kansas about the middle of last July and spreading in all directions, reached as far west into Colorado as Granada. A field laboratory was established at Holly, Colorado, with Dr. B. F. Kaupp in charge. Four counties along the Arkansas valley appropriated in all about \$1500.00 and the investigation went forward without interruption. It was quite definitely determined that a certain microorganism is the specific cause of the disease but no effort has as yet been made to determine the factors necessary to its transmission. History of the disease in Colorado indicates that there has been about 80 per cent mortality and that not more than 10 per cent of exposed animals are susceptible. Our field notes further show that the largest loss was in Prowers county, in all about 130 horses. A vaccine was made and tried experimentally on close to a thousand exposed horses and the disease did not develop in any vaccinated horses after the time that immunity was presumed to have been established.

This work which was of necessity done with much haste, in the hope of controlling the disease, will be checked up by careful study of pathological tissue involved and by repeating inoculation experiments.

The results obtained in this hurried investigation are, however, quite conclusive and warrant an extended research, for there is reason to believe that this disease may be an important factor in the animal industry of the western states in the future.

### *Hog Cholera*

Colorado escaped the ravages of hog cholera for many years but at last the state has become thoroughly infected. The Dorset-Niles Anti Hog Cholera Serum is the only means we have at present for controlling it aside from sanitary police measures. The serum when used alone establishes a very uncertain immunity after sixty days and the extent to which the general use of the virus (simultaneous method) has spread the disease into new territory, is prob-

lematical. The ravages of this disease have cost this country many millions of dollars and never has it been so disastrous as in the last twelve months. Present conditions portend a greater disaster to the hog industry in the future unless a cheaper and more effective means of control is forth coming.

Livestock conditions are fairly good throughout the State but there is a tremendous loss every year from preventable diseases. Animal disease investigation can not safely nor profitably be hampered for lack of funds. There must be an eternal vigilance to safe guard our animal wealth against the many diseases which constantly threaten its security.

Respectfully submitted,

GEO. H. GLOVER

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### ANIMAL HUSBANDMAN

*To the Director:*

Two projects were completed by this Department within the past fiscal year. First—Ration Experiments with swine, testing the proportion of ground alfalfa with barley to secure the best results. Second—Beef Production, a trial of the cost of producing beef steers under conditions where they are run on the range during the summer and fed during the winter. Both of these projects were a continuation of work begun during the present biennium.

No new work has been started during the present biennium because of the fact that only fifty per cent of the state appropriation was received, and the greater share of this was required for the liquidation of debts contracted for feeding experiments during the winter of 1910 and 1911 before the legislature passed the appropriation for this biennium.

I preferred to discontinue all experimental work during the present year rather than incur more debts to be paid out of future appropriations. When the new appropriation becomes available we will start new work and I hope that distinct provision will be made at such time for the return of a portion of the sales to the Animal Investigation fund so that an amount of work comparable with the appropriation may be carried on.

The following is the report of the poultry specialist:

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“Professor G. E. Morton,

Much to the regret of the Poultryman no experiments have been possible during the past year. It seems to us that the plan



submitted a year ago, of experimental flocks among the farmers would be of great value, and we hope to be permitted to put the plan into operation during the coming year.

Nine college boys took the course in poultry last year and we hope better equipment will be furnished the coming year if poultry instruction is to be given.

Respectfully Submitted,

W. E. VAPLON.

Poultryman."

With this report I submit the station inventory.

Respectfully Submitted,

G. E. MORTON

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## REPORT OF BOTANIST

*To the Director—*

I herewith submit the annual report of the section of Botany and Forestry.

On account of the increase in the number of students and of classes, together with the added responsibilities and duties which the office of State Forester has brought to this department, I have done no personal work on any Station project under the Adams Fund. Mr. Robbins has given a good deal of time in his studies of algae in some Colorado soils. The results of these studies have been published in Bulletin 184. This work is being carried on in cooperation with the Bacteriologist.

One trip of inspection has been made to Akron to look over the cooperative forest planting work there in connection with the Government Forest Service. The cooperative tree plantations with farmers over the State have not been inspected for two years. Following my last inspection, a tentative report was furnished for publication. This report, however, I believe has not yet been printed. I recommended that it be withheld until another inspection, which can possibly be made during the coming summer. This should furnish us some rather definite data as to the adaptability and growth of the black locust and hardy catalpa, the two species used in experimentation, to the varied conditions of our State.

A number of plant diseases have come to our attention during the past year which are either uncommon in the State or have never yet been reported. Some of these have been quite injurious,

however, during the past season. A very interesting *Sclerotium* disease affecting the roots of the wheat plant has been received and is being carefully studied by Mr. Robbins. So far as we have been able to determine, there is no *Sclerotium* disease of the wheat now described and this should furnish a subject for investigation. A fruit spot of the peach has been prevalent during a number of years in the peach growing regions of the western slope. The real cause of the trouble has not been definitely determined.

A *Cronartium* on the yellow currant has made its appearance. Its life history is but little understood. It appears to be the same disease which appeared in New York about seven years ago and was there recognized as the currant rust from Europe. Late blight of celery has proven quite injurious in some instances. It was first reported during the past season. An Englemann spruce disease which affects the twigs and young branches, has been sent by the City Forester of Colorado Springs, but the cause has not been determined. These are a few problems in plant pathology which need further attention and others are coming to light every season.

#### *Plant Pathological Laboratory.*

For a number of years there has been a very urgent need for a well equipped pathological and physiological laboratory for taking up the study of problems connected with the growing of fruits and field crops in this State. Up to the present time, I have personally been unable to give very much attention to the various diseases of plants which have been brought to our notice. It is believed, however, that during the coming year we should undertake to investigate the more important of these troubles, such as have been mentioned above. In order to do such work effectively, however, a laboratory should be fitted up especially for the work. There is now in the botanical laboratory pathological material, such as herbaria, mycological books, and apparatus to the value of \$1,065. Using this as a basis, it is estimated that such a laboratory could be complete and adequately furnished for an additional expenditure of \$1,355, including furniture and fixtures, providing a suitable room could be given to this work.

Mr. Robbins has already shown special aptitude in the study of some of these problems and is very desirous of entering this field of work to as great an extent as teaching duties will allow. I believe that one-fourth of his time, at least, can be devoted to work of this kind, and perhaps all of it during the summer vacation. The operation of such a laboratory I believe should be under the direction of the Botanist, as this department has done all of

the teaching of such subjects and as this is the almost universal arrangement in other institutions with which the Experiment Station is connected.

*Agricultural Survey of Colorado -*

Through funds received from the Station, Extension Department, and College, the Department has been enabled to get under way the past year a project entitled, "An Agricultural Survey of the State." The principal work involved is the collecting, recording, and interpreting of data relating to the distribution of, not only the native plant and animal life of the State, but of farm, orchard and garden crops as well. This should also be extended to include a social survey. All data as accumulated from whatever source is being recorded on filing cards and plotted outline maps of the State. The cooperation of the Departments of Zoology, Entomology, Museum, Botany and Forestry, Horticultural, Climatology, Civil and Irrigation Engineering, and Extension is sought. Although the project is barely under way, considerable data has already been secured concerning native trees, weeds, and plant diseases. Material is now in hand for the publication of a potato map of the state, data for which has been furnished by Mr. C. L. Fitch, the Potato Specialist, with the intention to publish this potato map soon. It is the aim to put out one or more of these special crop maps of the state each year. The material now on hand for this work consists of filing cards, outline maps of the state, and U. S. Geological Typographic sheets of the Colorado quadrangles.

There are frequent requests for popular information bulletins upon the following subjects:

Colorado native grasses; mushrooms, edible and poisonous; Colorado plant diseases; and Colorado weeds.

Whenever the funds of the Station will permit, it will be possible, I believe, for this Department to enter upon the preparation of manuscript for such bulletins.

Respectfully submitted,

O. B. LONGYEAR.