THE STATE AGRICULTURAL COLLEGE
OF COLORADO

The Thirty-Sixth Annual Report

OF

The Colorado Agricultural Experiment Station

FOR THE YEAR 1923

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OF COLORADO

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The Colorado Agricultural College

FORT COLLINS, COLORADO

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* On leave

LETTER OF TRANSMITTAL

To His Excellency, William E. Sweet, Governor of Colorado:

In accordance with the law of Congress establishing Agricultural Experiment Stations, I have the honor to transmit to you, herewith, the Thirty-sixth Annual Report of the Colorado Agricultural Experiment Station for the government fiscal year, July 1, 1922, to June 30, 1923.

The report covers a full financial statement of all receipts and disbursements, and brief summaries or outlines of the work done by those in charge of the different sections or departments of the Experiment Station.

C. P. GILLETTE,
Director

Agricultural Experiment Station
Fort Collins, Colorado.
December 1, 1923

FINANCIAL REPORT OF THE COLORADO AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING JUNE 30, 1923

	Hatch Fund	Adams Fund	State Mill Levy Fund	Special Fund	Pure Seed Fund App'n.	Total Funds
DR.						
Balance July 1, 1922	.....	.....	$ 6,505.24	$ 6,373.56	$ 2,643.34	$ 15,222.14
From the Treasurer of the United States as per appropriation for the fiscal year ending June 30, 1923, under acts of Congress approved March 2, 1887 (Hatch Fund), and March 16, 1906, (Adams Fund)	$15,000.00	$15,000.00				30,000.00
Other sources than the United States			104,964.85	20,407.94	12,000.00	137,372.19
Total Receipts	$15,000.00	$15,000.00	$111,470.09	$26,781.50	$14.643.34	$182,894.93
CR.						
To salary	12.112.46	13,232.96	54,469.46	.....	3,896.54	83,711.42
Labor	401.28	62.35	9,193.93	693.50	626.83	10.977.89
Publications	190.75	.....	1,871.69	1.56	32.40	2,096.40
Postage and stationery	29.26	2.95	1,424.35	129.70	370.92	1,957.18
Freight and express	13.55	18.33	949.29	29.69	10.22	1,021.08
Heat, light, water and power	.....	.....	93.58	29.70	.....	123.28
Chemicals and laboratory supplies	87.81	703.18	882.05	7,767.49	2.60	9,443.13
Seeds, plants, and sundry supplies	275.25	53.28	1,406.42	783.18	142.11	2,660.24
Fertilizers	.....	.....	50.95	.....	.....	50.95
Feeding stuffs	254.93	83.27	6,487.41	1,620.56	.....	8,396.17
Library	71.35	8.00	517.22	13.50	6.00	616.07
Tools, machinery and appliances	.....	.....	1,597.77	.....	1.60	1,599.37
Furniture and fixtures	53.50	8.50	983.74	4,611.96	284.46	5,942.16
Scientific apparatus and specimens	825.82	631.38	3,879.32	1.50	28.00	4.916.02
Livestock	28.00	.....	7,210.69	.....	.....	7,238.69
Traveling expenses	451.33	195.80	4,400.29	649.89	757.88	6,455.19
Contingent expenses	.....	.....	977.00	194.75	.....	1,171.75
Buildings and lands	704.71	.....	4,386.78	461.13	13.60	5,566.22
Total expenditures	$15,000.00	$15,000.00	$100,781.94	$16,988.11	$ 6,173.16	$153,943.21
Balance on hand, June 30, 1923	.....	.....	10,688.15	9,793.39	8,470.18	28,951.72
Grand total	$15,000.00	$15,000.00	$111,470.09	$26,781.50	$14,643.34	$182,894.93

REPORT OF THE DIRECTOR

To the President:

Following is a brief report covering the work of the Colorado Agricultural Experiment Station during the Government fiscal year, July 1, 1922 to June 30, 1923:

The financial statement prepared by the College Accountant is confined strictly to the Government fiscal year, and gives a true record of balances and all money received and disbursed during the period covered. The reports from the various sections having been prepared for the most part during the month of November, include, in some instances, work done at a later date than June 30th.

Results of investigational work carried on in the field are often affected by weather conditions. In some instances, unfavorable weather has interfered with Station work the past year, but, on the whole, the investigational work has seemed to the writer to progress as well as in average years. There are phases of the work deserving special attention, but rather than give what might seem to be undue prominence to any of these, I will allow each report to speak for the work of its respective department.

There are frequent calls on the part of the workers for additional funds to permit them to put on new investigations or enlarge the scope of those already being pursued. While in nearly all cases these requests are reasonable and should be granted if possible, the funds of the Station are definitely limited and it has been our policy to urge the completion of work on present projects before taking up new ones, and to intensify the work on a few of Colorado's most important problems rather than try to cover a larger number of problems and be compelled to touch them too lightly to reach dependable results.

A few additional projects have been approved during the past year in excess of the number that have been completed or put in abeyance. These occur almost exclusively in the new section of Agricultural Economics and in Animal Husbandry. In the former section, the added work and expense was made possible because of the provision made by the 24th General Assembly for the support of a department of Agricultural Economics in the College, because we were able to co-operate with the U. S. Department of Agriculture in carrying on our investigations, and because the Station funds were somewhat relieved by not having to pay heavy fire losses the past year. The investigations were made necessary by the strong demands of the farmers for help in this line and the evident great necessity for it.

The additional problems in the Animal Husbandry section were put on without additional expense except that incurred in taking over the project on Lamb Losses in Feedlots formerly carried by the Pathology Section. This was done because Dr. Newsom, of the Pathology Section, had come quite definitely to the conclusion that the particular

lamb losses that were being investigated were due to feeding problems and not to specific diseases.

The number employed in investigational work remains practically the same as last year, there being 16 regular employees devoting their time exclusively to Station work and 28 dividing their time between Station and College duties.

It is a pleasure to report that there have been but three resignations from the Station staff during the year, none of them heads of sections, and three new employees have taken their places.

The total Station budget approved for the fiscal year 1921-22 was $137,075. of which $5,000 was to cover fire losses, $3,630 for the purchase of water rights, $3,035 for publications, leaving $125,410 for the actual investigational work.

The 24th General Assembly made a special appropriation of four thousand dollars ($4,000) for the better equipment of the Cheyenne Wells branch station. and a special appropriation of ten thousand dollars ($10,000) to be met by a like appropriation by the Commissioners of Weld County, for the purchase of land and equipment for the Greeley Potato Station which is conducted by the Bureau of Plant Industry of the U. S. Department of Agriculture in co-operation with the Colorado Experiment Station. These funds, however, will not be spent until the coming fiscal year.

The loss of the old chemistry building and contents by fire on the night of December 22, 1921, was a serious setback to the investigation of that section, as it was not until February, 1923, when the new quarters were fully equipped for the resumption of the work. However, in the reconstructed building the space and facilities for chemical investigations have been greatly improved so that the section is now much better equipped than ever before for its work.

The investigations of the Chemistry Section are still confined chiefly to soil problems of the State as related to the formation and accumulation of harmful quantities of nitrates due to the action of soil bacteria (*Azotobacter sp.*). The extreme importance of the nitre problem to Colorado and other portions of the arid West was first discovered and made known by Dr. Wm. P. Headden, and later studied by the Chemistry Section in co-operation with Dr. Sackett of the Bacteriology Section. During the past two years the sections of Agronomy and Irrigation Investigations have been included in the co-operative work of investigating soil trouble in the Arkansas Valley, where we have also had the splendid co-operation of the American Beet Sugar Company, in an attempt to determine what can be done to correct the evil. I am glad to report that very encouraging results have been secured, the work will be continued, and all data secured to date are in harmony with the early conclusions of Dr. Headden, supported by Dr. Sackett, that the source of the excessive nitrates is in the action of *Azotobacter sp.* in the soil, and that, in all probability, it can only be

corrected economically by such agricultural practice as will make conditions unfavorable for the development of these organisms.

Following is a list of the sections, along with the projects carried by each during the past year:

AGRICULTURAL DIVISION

Agronomy Section

Relation of Soil Moisture, Structural Development and Acre Yields in Small Grains. Adams and State Funds.

Correlation of Characters in Grain. Hatch and State Funds.

Methods of Selection Breeding. State Funds.

High-Altitude Crops. State Funds.

Plains Crops and Management. State funds and special appropriations.

Arkansas Valley Nitrate Control. (In co-operation with Bacteriology and Irrigation Investigations).

Animal Investigations Section

Acre Value of Pasture for Dairy Cows. State Mill Levy.

Ration Experiments with Steers. State Mill Levy.

Rations for Fattening Lambs. State Mill Levy.

Range Improvement. State Mill Levy.

Winter Maintenance of Breeding Ewes. State Mill Levy.

Summer-Fallow Experiment at Akron, Colorado. State Mill Levy.

Supervision in Dairy-Cow Records. State Mill Levy.

Bacteriology Section

Heat-Resisting Bacteria in Fresh and Canned Vegetables. Adams Fund.

Value of Certain Carbon Compounds as a Source of Energy for Azotobacter. Adams Fund.

Active Principle of Whorled Milkweed. Adams Fund.

Arkansas Valley Nitre Investigation. State Mill Levy.

A Bacterial Disease of the Wragg Cherry. Hatch Fund.

Botany Section

Hard Seed of Alfalfa. State Mill Levy.

Range Improvement. (Co-operation with Animal Investigations). State Mill Levy.

Plant-Disease Survey. State Mill Levy.

Biologic Specialization of Parasitic Fungi in Relation to Disease Resistance. Adams Fund.

Chemistry Section

Nitre in Colorado Soils, its Occurrence, Formation and Effects upon Vegetation. Adams Fund.

(a) Relation of Nitrates to Potato Diseases in the Greeley District, Colorado.

Entomology Section

Plant-Louse Investigations. Adams Fund.

Ants of Colorado in their Relation to Plant Lice. Hatch and State Mill Levy.

Codling-Moth Control. Hatch and State Mill Levy.

Grasshopper Control. State Mill Levy.

General Insect Investigations. State Mill Levy.

Economics and Sociology

Marketing Investigations, in co-operation with the Colorado division of Markets, State House, Denver, Colo. State Mill Levy.

Settlers' Progress Study, in co-operation with the Division of Land Economics and the Office of Farm Management and Farm Economics, U. S. Dept. of Agriculture. State Mill Levy.

Cost of producing Beef Cattle on the Range, in co-operation with Cost of Production and Farm Management Division, U. S. Dept. of Agriculture. State Mill Levy.

Farm Organization and Costs on Farms in the Greeley Area, in co-operation with Division of Farm Management and Farm Economics, U. S. Dept. of Agriculture. State Mill Levy.

Rural Life Studies. Three sub-projects have been taken up under this general heading. One was carried in co-operation with the Rural Life Section of the Bureau of Agr. Economics, U. S. Dept. of Agriculture. State Mill Levy.

Forestry Section

Studies in the Decay of Wood. Hatch Fund.

Home Economics Section

Cooking Quality of Colorado Potatoes. State Mill Levy.

A Study of the Bread-Making Qualities of Colorado Flours. State Mill Levy.

Horticulture Section

Potato Investigations. Hatch and State Mill Levy.

Seed-Potato Growing in High Altitudes. State Mill Levy.

Hardy Tree-Fruits for High Altitudes. State Mill Levy.

Tomato Variety Tests. State Mill Levy.

Head Lettuce in High Altitudes. State Mill Levy.

Irrigation Investigations Section

Evaporation Experiment. Hatch Fund.
Meteorology. State Mill Levy.
Measurement of Water as Applied to Irrigation. Hatch Fund.
Arkansas Valley Nitre Investigations. State Mill Levy.

Pathology Section

Contagious Abortion. State Mill Levy and Hatch Funds.
Sheep Losses in Feedlots. Hatch Fund.

Veterinary Section

Animal Diseases. State Mill levy.

ENGINEERING DIVISION

Civil Engineering Section

Road Materials of Colorado. State Mill Levy.

Mechanical Engineering Section

Methods of Handling Hay in Colorado. State Mill Levy.
Heat Transmission of Commercial Wall Board. State Mill Levy.
Treatment of Alkali and other Waters for Domestic Use. State Mill Levy.
Testing of Lubricating Oils. State Mill Levy.

Following are brief reports upon the work of the year from the heads of sections.

Respectfully submitted,
C. P. GILLETTE, Director

REPORT OF THE AGRONOMY SECTION

To the Director:

The work of the Agronomy Section for the fiscal year ending June 30, 1923 is appended below. The following projects have been active:

Relation of Soil Moisture. Structural Development and Acre Yields in Small Grains. Adams Fund and State Funds.
Correlation of Characters in Grain. Hatch Fund and State Funds.
Method of Selection Breeding. State Funds.
High-Altitude Crops. State Funds.

Plains Crops and Management. State Funds and Special Appropriations.

Arkansas Valley Nitrate Control. State Funds.. (In co-operation with Bacteriology and Irrigation Investigations.)

The above projects have been approved for work during the fiscal year. July 1, 1923 to June 30, 1924.

Relation of Soil Moisture, Structural Development and Acre Yields in Small Grains:

The use of Marquis spring wheat was continued under this project, which for shortness we have called "Critical Periods" in our work. Specific and annual results have been reported to you from time to time. This work has now gone far enough so that we feel that a preliminary report can be worked out for publication. We would recommend the publication of a progress bulletin and perhaps also of the submission of a manuscript to the Research Journal for publication.

This year we had an unusual opportunity for testing the effectiveness of our methods of protection against undesired water. As you know the plats are covered in times of threatening rain with canvas covers with drains at the side to remove any precipitation. On Thursday, July 26, we had a rainfall of 2.13 inches, according to the rain guage located within a few feet of the plats. This rainfall came within twenty minutes. Our system of covering and water removal was sufficient to absolutely protect the plats even with this unprecedented precipitation. We can, therefore, say with assurance that our plans for protection against undesired or accidental moisture are quite successful. We continued the trial of potometers to check against field plats. So far the field plats have been very much more successful.

Correlation of Characters in Grain:

No new plantings were made for the study of correlation of characters in 1923, but we had on hand in our field laboratory several thousand plants grown in previous years for study. We hope to gather material enough to close this project either this year or in 1924, at least in its present form. There are features of the work which have arisen because of the project that are worth further investigation. For that reason it may be desired to continue the project for sometime after the main line of work has been written up and filed.

Alfalfa Breeding:

We are doing very little work in alfalfa breeding at the present time, only enough to hold a few of the seed stocks with which we have sometimes worked in the past. The larger attention which we have been obliged to give to the Arkansas Valley nitre problem has necessitated a reduction of our alfalfa-breeding work to the minimum. We are

more or less convinced that the nitrate problem is associated with the problem of low seed production, which we have faced in our alfalfa-breeding work in the past. We can breed new and desirable varieties of alfalfa. Formerly we could produce seed in abundance but in many of the old seed producing regions it is now so extremely uncertain whether or not seed will be produced, that we are obliged before proceeding vigorously with this project to find reasons for low seed production where seed production was formerly good.

High-Altitude Crops:

Work on the high-altitude-crop project has been largely confined to Fort Lewis. We have had some work going in other sections of the State. The main body of our work, however, has been at Fort Lewis. During the past year our Fort Lewis high-altitude work has been in direct charge of Mr. Harrison D. Horton. Mr. Horton has given very satisfactory attention to the work. At present our high-altitude work is limited to a study of adapted types of crops. We feel that this preliminary work must be done first. It is of very great importance to settlers in high-altitude regions. Besides this immediate use, the determination of adapted types is extremely useful for crop-improvement work to be taken more seriously later on.

Mr. Horton is now at work on his annual report for the 1923 summer season, which will be filed with you when completed. We enlarged the work somewhat this year by adding forage and pasture crops to the investigation.

Seed-Crop Improvement Work:

1. We are doing pure line breeding in the attempt to isolate valuable pure line strains from our best adapted standard sorts.
2. We are importing and testing varieties of grain and forage crops with the view to determining the best of these in their adaptability to our conditions.
3. We are purifying existing good varieties or strains which have become mixed thru some accident or otherwise in order that the pure strains may be again put into production without mixtures.
4. We are attempting to produce absolutely new things by making cross fertilizations between existing types. The parents in each case are chosen because of some desirable quality contained in each of two different parents but not in any one strain. We believe that we can be of best service in producing new strains, in determining the valuable sorts and then as quickly as possible getting those strains to the hands of growers. We consider it a duty, however, to first determine the value of those strains before we put them out.

In order to get a new variety or a new strain generally adopted it is necessary to produce large quantities of seed. This can best be done by getting the new strain into the hands of farmers, who have

capabilities as seed growers. If we put all of our available land into a strain to increase it, it would only supply a relatively small number. By getting good things into the hands of farmer growers, good things can be spread with great rapidity because the acreage devoted to such good strains can be increased far beyond the capacities of our plant.

We are now putting on the market Colsess, a very promising new barley of hybrid origin. Colsess is the result of the development of one strain from a cross between Coast, commonly called California Feed, and a strain of Success locally known as Beardless. We have six year's tests of this variety at Fort Collins and four year's test at Fort Lewis. At Fort Lewis as the average of the four year's test, Colsess stands first from point of yield. At Fort Collins it stands second in yield among all barleys. We have sent samples to adjoining states for test at their Experiment Stations with good reports in every instance. The report we get everywhere is that Colsess is the highest yielding beardless or hooded-type barley tested. We expect to use extra effort to get this barley propagated and grown in the higher altitudes. Its beardless character together with high yield makes it especially desirable for high-altitude barley production. It can be grown for thrashed grain. It can be used in pea-barley mixtures. It may be pastured with perfect safety as there are no beards. It may be cut for barley hay. It may be pastured off with livestock without danger of sore mouth. which is one of the troubles quite prevalent with such varieties of bearded barley as Coast, which has a very heavily barbed beard.

Plains Crops and Management:

The legislature of 1923 appropriated a small sum for use in our experimental work at Cheyenne Wells. This appropriation fund augmented by our regular Cheyenne Wells support for investigation of crops adapted to our plains, is being utilized at Cheyenne Wells. We are increasing our building plant somewhat at the Cheyenne Wells farm.

Crop production on the plains is an up-and-down affair, good one year and poor the next. For some years we have been working on the idea of producing and storing a reserve feed supply. This program we are helping forward by putting down four additional silos, by increasing shed storage room to take care of some other feeds. A successful and permanent agriculture on the plains must be a mixed type of farming; first, because the surest crops are feed crops, which must be utilized by livestock; second, because a variety of crops must be grown so that if one fails something may be obtained from the others. We have been working steadfastly on this fundamental idea for a number of years and have made considerable progress. We enlarged the work at Cheyenne Wells this year by a comprehensive set of small forage plats. We will continue these forage plats in pasture mixtures as a part of the future program.

I may say that our plains soy-bean tests conducted at Cheyenne Wells and at Akron are giving promise of an additional leguminous

crop to help out the feed situation. It looks as if we could produce yields as high as is possible with pinto beans. The soy bean, owing to its high oil content as well as its high protein content, is valuable for feed and if it can be produced in quantity will have a definite market as a cash crop.

We are continuing the studies of pasture-cropping legumes and their management.

We are not able to take up all of the problems that should be investigated. During the year we have made partial arrangements with the Office of Dry Land Agriculture and the Cereal Office of the Bureau of Plant Industry, looking forward to co-operation at Akron with those offices in the future. Co-operative arrangements have not been completed but preliminary negotiations have been carried out. We have a quarter section of land at Akron adjoining the Government 60 acres. Furnishing this land for the use of the Government and conferring frequently with the Government workers enables us to obtain a large amount of information on methods of dryland agriculture for northeastern Colorado.

Our Cheyenne Wells plant needs further enlargement and support to settle the dryland problems for central eastern Colorado. Sometime it will be necessary to do more experimental work in the extreme southeastern portion of our plains. Just what the farm unit should be for the average plains farmstead is not yet determined. We should have a larger body of land upon which this might be worked out as a practical problem. Preferably this should be done at Cheyenne Wells.

Arkansas Valley Nitrate Control:

Since making the last report definite arrangements for continuous chemical checks have been made. Mr. Justus C. Ward was placed upon an annual salary basis to give a continuous picture of the chemical changes in the soil. In 1922 samplings were taken to a depth of 4 inches only. The samplings were made every two weeks, beginning in the fall of 1922 and continued in our 1923 and 1924 plans. Once every month samplings are taken by four-inch cores to a depth of 6 feet, in order to get a picture of nitrate changes and movement in the soil itself.

In last year's annual report, mention was made of the fact that it would be desirable to follow the percentages of some other constituents than nitrates. Beginning with the fall of 1922 studies were made on the chlorine or chloride contents of every sample analyzed for nitrates. Mr. Ward made a study of the agreement or disagreement of chlorine and nitrate contents in 1,982 samples studied. If in a specific sample of soil the chlorine content rose with the nitrate content or fell with the nitrate content, that is if it changed up or down in the same direction with the nitrates it was placed in the class as agreeing in fluctuation with the nitrates. If on the other hand the chlorine content varied in a different direction than the nitrate it was placed in a class as dis-

agreeing. It made no difference what the order of agreement or disagreement was if the variation was with the nitrate it was marked as agreeing and if it was contrary it was marked as disagreeing. Arranged in this way a thousasd samples showed an agreement in the rise or fall of chlorine and the nitrate content and a disagreement in 982 cases. In other words there was no relation between nitrate and chlorine concentrations. One thousand to 982 is about as near a 50-50 arrangement as could be made with that number of variants. Such a distribution indicates that there is no relationship between the movement of the two.

In attacking our problem the three co-operating sections—Agronomy, Bacteriology and Irrigation Investigations—have had the use of 40 acres of the Station farm and have actually used about 50 acres of one of the sugar company farms at Rocky Ford. The plans on the sugar company farm are primarily to show the possibilities of control and what controls are possible with nitrates with special reference to the sugar-beet crop.

On the Experiment Station farm we have attempted more to get at fundamental plans of control with the expectation that we would work out a definite system of relationship later. This plan is being adhered to. Arrangements have already been made for the continuance of the Sugar Company's co-operation, because it furnishes a valuable additional set of data in the attempt to solve the problem. In addition to agricultural methods which we are stressing most strongly thru green manures, rotations and crop and soil management, we are also trying the effect of certain chemical corrective measures. Some of these chemical measures have given considerable flattering promise.

General Comment:

The Agronomy staff for the year has consisted of Alvin Kezer, Agronomist; D. W. Robertson, Associate; G. Warren Deming, Assistant at the Fort Collins plant; P. K. Blinn and Justus C. Ward at the Arkansas Valley plant; Harrison D. Horton at the Fort Lewis plant and J. W. Adams at the Cheyenne Wells plant. Mr. Joseph F. Brandon and F. A. Coffman of the U. S. Department of Agriculture have rendered very valuable assistance thru the turning over of results that they have obtained at the Akron plant. We can strongly recommend the consummation of definite co-operation.

It seems advisable for the coming fiscal year to enlarge the plans in the Arkansas Valley to include jointly with the Bacteriology Section a spray program as a part of the protection of crops against virulent plant-disease infections.

Respectfully submitted,

ALVIN KEZER,
Agronomist

REPORT OF THE ANIMAL HUSBANDMAN

To the Director:

Following is a list of projects that have been carried on in our section during the present fiscal year:

Acre Value of Pasture for Dairy Cows—E. J. Maynard in Charge
Ration Experiments with Steers—E. J. Maynard and G. E. Morton
Rations for Fattening Lambs—E. J. Maynard in Charge
Range Improvement—E. J. Maynard in Charge
Winter Maintenance of Breeding Ewes—Chas. I. Bray in Charge; L. K. Crowe for current year.
Summer-Fallow Experiment at Akron, Colorado—E. J. Maynard in charge
Supervision in Dairy-Cow Records—Chas. N. Shepardson in Charge.

Following is a list of projects planned for the coming fiscal year, all of which are on the State Mill Levy Fund:

Acre Value of Pasture for Dairy Cows—G. E. Morton and B. W. Fairbanks
Ration Experiment with Steers—E. J. Maynard and G. E. Morton
Rations for Fattening Lambs—E. J. Maynard in Charge
Range Management—E. J. Maynard and G. E. Morton
Winter Maintenance of Breeding Ewes—Chas. I. Bray in Charge
Summer-Fallow Experiment at Akron, Colorado—E. J. Maynard in Charge
Supervision of Dairy-Cow Records—Chas. N. Shepardson in charge; L. K. Crowe for current year
Sunflower Silage for Dairy Cows—B. W. Fairbanks in Charge
Death Losses Among Lambs in Feedlots in the San Luis Valley—E. J. Maynard in Charge
Investigations into Methods of Financing the Cattle Industry—Chas. I. Bray in Charge
Incubation Experiments with Poultry—O. C. Ufford in Charge
Value of Mineral in Mixed Rations for Swine and Cattle—Chas. I. Bray in Charge

The ration experiments with steers were run in series of three years, and we are getting useful results with regard to Sugar Beet Tops, Corn Silage and Sunflower Silage in fattening rations.

The most important result with sheep has been in finding the feeding value, in rations, of beet molasses. We are now investigating the value of the method of feeding called "lambing off" corn.

We are now holding Cattle Feeders' and Lamb Feeders' Days just before the stock is sent to market, and this is causing a rapid spread of knowledge of the results secured.

I believe the chief problem this section has to face is that of providing for the future of the poultry experimental work. The prob-

lems are great enough and the industry sufficiently important to demand attention at our hands.

Respectfully submitted,
GEORGE E. MORTON.

REPORT OF BACTERIOLOGIST

To the Director:

I have the honor to submit herewith the annual report of the Bacteriology Section of the Experiment Station for the fiscal year ending June 30, 1923.

Our studies covering this period have been, for the most part, continuations of the projects of the previous year; however as our work has progressed it has been found necessary to modify the line of procedure as originally planned in two instances. Three of the projects have been supprted by the Adams fund, one by the Hatch, and one by the State funds..

We have continued to furnish vinegar cultures to the farmers and commercial vinegar plants all over the United States, and judging from the reports and orders received from former customers, they are giving excellent results.

In addition to our research work, an appreciable amount of time has been consumed in the examination of the numerous samples of water, soils and diseased plants, which are referred to this laboratory by correspondents.

Adams Fund Projects

1. *Azotobacter*

Energy Studies:

Further studies have been conducted upon the part which green manures may play in retarding or stimulating the fixation of atmospheric nitrogen in soil by *Azotobacter*. We have endeavored to find out whether the decay of the green crops would produce sufficient acid to exercise any injurious action upon the nitrogen-fixing bacteria as measured by a lag in the normal increase of total nitrogen; second, whether the crop residues would ultimately act as an additional source of energy for the *Azotobacter* and stimulate their growth to a point where there would be a measureable increase in total nitrogen. Corn, barley, oats, millet, Sudan grass, and rye served as green crops, and in addition to these sulfur was employed as a possible source of acid. Soil from both the Crowley and Rocky Ford districts was used in the experiment.

2. Spoilage in Canned Vegetables:

Because of the difficulty we have experienced in securing home-packed vegetables for our investigation, we have had to confine our work mostly to commercially canned products. The list includes beans, peas, corn, mixed pickles, pears, raspberries, logan berries, minced meat, salmon and corned beef. From the commercially canned goods we have been unable to find any micro-organisms whatever, which led us to believe that either the micro-organisms had died out or there was no spoilage. As a matter of fact, none of the commercial pack exhibited either abnormal appearance or odor, and it is altogether possible that the store keeper's judgment on the "spoiled" goods was based upon insufficient evidence.

Because of the increasing number of cases of botulism poisoning traceable to home-canned vegetables, we have given some attention to the occurrence of *B. botulinus* in soil as a possible source of the contamination.

3. Milkweed Poisoning:

The material which was collected for our work on the active principle of *Asclepias galioides* during the summer of 1922 was so low in potency that no satisfactory extract could be prepared unless very large quantities of the weed were used, and this was found to be impracticable. As had been noted before, the potency of the plant appears to diminish as the blossoming time approaches, and the season of 1922 being unusually dry, the plants came into flower nearly a month earlier than normal. Inasmuch as we had not anticipated this early maturity of the crop until it was too late to obtain other material, we found ourselves without a suitable supply for further investigations.

HATCH FUND PROJECT

1. Bacterial Disease of the Wragg Cherry:

The disease was present in the Crowley district to a somewhat greater degree than in 1922. It was also observed at Rocky Ford, but the damage to the crop was practically negligible.

We have again isolated the same bacillus from diseased cherries as in former years, and have made inoculation on both leaves and fruit. Negative results were secured on the leaves with nine different cultures, but spots suggestive of the disease were produced on the cherries themselves with several of the cultures.

STATE FUNDS

1. Arkansas Valley Niter Investigation:

The Rocky Ford laboratory, which was opened in the spring of 1922 for the purpose of following systematically the development of

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Respectfully submitted,
GEORGE E. MORTON.

REPORT OF BACTERIOLOGIST

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Our studies covering this period have been, for the most part, continuations of the projects of the previous year; however as our work has progressed it has been found necessary to modify the line of procedure as originally planned in two instances. Three of the projects have been supprted by the Adams fund, one by the Hatch, and one by the State funds..

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STATE FUNDS

1. Arkansas Valley Niter Investigation:

The Rocky Ford laboratory, which was opened in the spring of 1922 for the purpose of following systematically the development of

soil nitrates in that section of the State, has yielded results far beyond our expectations.

The weather conditions in 1922 and 1923 were so different from the standpoint of precipitation that comparisons of the analytical results of our soil analyses for the two years is futile; however, we have had a most excellent opportunity of observing the relation of extreme moisture conditions to nitrate development and accumulation.

The necessity for continuing the sampling thruout the year became apparent early last fall after harvest, and accordingly arrangements were made to retain Mr. Ward as chemist on a twelve months basis. Subsequent work has demonstrated the wisdom of this change in our original plan, which contemplated operating the laboratory only until late fall.

The need for analysing a larger number of surface samples, as well as samples taken to a depth of six feet, was felt last year and this spring we added the necessary equipment to the laboratory to handle the extra work. In consideration of the soil analyses which we are making for the American Beet Sugar Company in connection with our co-operative plots on the Company farm, the Company has given us part time of one assistant to help Mr. Ward with routine operations in the laboratory.

The results of our first year's work upon the project have indicated rather clearly which crops can be grown to advantage upon high niter soils, both for the good of the soil and the crop; they have suggested a feasible rotation for the utilization of the nitrates and the control of their formation; they have shown certain crops, previously considered desirable for the control of nitrate accumulation, to be unsuitable for this purpose; finally, they have given additional support to the biological explanation of nitrate accumulation by showing the absence of any relation between soil nitrates and chlorides.

A brief report by Mr. Ward follows:

To the Director:

The work of the Colorado Experiment Station Laboratory at Rocky Ford during the fiscal year has been continued under the joint supervision of the Agronomy and Bacteriological Sections of the Experiment Station, and has been confined to the problems related to Arkansas Valley Nitre Control.

Investigations have been conducted on the Station Farm at Rocky Ford, and on fifty acres belonging to the American Beet Sugar Company at that place. Nitric nitrogen variations in the surface four inches of the soil on all the plots of both farms were noted at two-week intervals thruout the year. Sub-soil nitrates were examined to a depth of six feet on selected plots of each farm each month.

Results of the study this year have corroborated previous findings, in that seasonal averages show similar tendencies; namely, the nitro-nitrogen values of those plots planted to cultivated crops are again consistently higher than those of fields growing small grains, clover, or alfalfa. This correlation is the more valuable because of the strikingly different moisture conditions of the two seasons.

Plans for the coming season contemplate an extension of the investigations to again include privately owned farms in the vicinity of Rocky Ford.

where lack of time this year made it necessary to discontinue work started in 1922.

In addition to the nitric-nitrogen determinations made during the past year, the amount of chlorine present in each soil was found also. This work is to be continued and extended as time permits.

Respectfully submitted,

JUSTUS C. WARD,
Chemist, Rocky Ford Sub-Station.

This report would be incomplete without a word of appreciation for the additional laboratory space on the third floor of our building. These two rooms will be used for our soil and hydrogen-ion determination investigations. Eventually I hope to fit up one of these for a biochemical laboratory.

To the director I wish to express my appreciation for the generous and sympathetic support he has given our work, and to Miss Brown and Mr. Ward like appreciation for their faithful and efficient service.

Respectfully submitted,

WALTER G. SACKETT,
Bacteriologist

List of Projects for Fiscal Year 1922-1923.

1. The value of certain carbon compounds as a source of energy for *Azotobacter*. Adams Fund.
2. Heat resisting bacteria of fresh and canned vegetables, and their relation to spoilage. Adams fund.
3. Food poisoning in sheep and cattle. A study of the active principle of whorled milkweed *(Asclepias galioides)*. Adams fund.
4. A bacterial disease of the Wragg cherry. Hatch Fund.
5. Soil nitrates in the Arkansas Valley. State Fund.

List of Projects for Fiscal Year 1923-1924.

1. The value of certain carbon compounds as a source of energy for *Azotobacter*. Hydrogen-ion concentration studies. Adams fund.
2. Heat-resisting bacteria of fresh and canned vegetables, and their relation to spoilage. Occurrence of *B. Botulinus* in soil. Adams fund.
3. Food poisoning in sheep and cattle. A study of the active principle of whorled milkweed *(Asclepias galioides)*. Adams
4. The natural inoculation of Colorado soils with legume bacteria. Hatch fund.
5. A bacterial disease of the Wragg cherry. Hatch fund.
6. Soil nitrates in the Arkansas Valley. State Fund.

REPORT OF THE BOTANY SECTION

To the Director:

I beg to submit the following brief report of the work of the Botany Section for the past fiscal year:

The Range-Improvement work has been carried along the lines previously outlined. Emphasis has been placed on the study of clipped quadrats this year. Two new series of quadrats have been added with the view of a more intensive study of yield factors. While these series are expected to yield data especially applicable to Wheat grass and Buffalo grass, the general results will be applicable to the other species occurring on the range.

In the investigation of the native rubber-producing plants in Colorado, special attention has been given to *Hymenoxys floribunda* which is very abundant on the Western Slope and which is considered by some as being of some commercial value. Histological analyses have been made to determine the distribution of rubber within the plant. Chemical analyses of the primary and multicipital roots have also been made.

A preliminary report of the work done on the project of Hard Seed in Alfalfa is being prepared for publication.

The work carried on with the different varieties of beans both here and at Rocky Ford for the past three years under the project Biologic Specialization of Parasitic Fungi has been discontinued and the data is being prepared for publication.

The Plant-Disease-Survey work shows a very great prevalence of cereal diseases in the State this year. The rusts, smuts and *Helminthosporium* diseases caused considerable loss to the grain growers of the State. Epidemology studies of the black stem-rust and investigational work on the wintering over of the red-rust spore of this fungus has been carried on during the past season.

Some preliminary work has been started on the *Coryneum* Blight of the peach and apricot. Celery Yellows and the Powdery Mildew of the apple are becoming more and more prevalent and some investigational work ought to be done on these diseases. There is an urgent need for a Station plant Pathologist who could devote his entire time to this work.

The analysis and inspectional work of the Seed Laboratory has been carried on this year in a very satisfactory way and has received the hearty support of both farmers and seedsmen throughout the State.

Respectfully submitted,

A. K. PEITERSEN,

Botanist

REPORT OF THE CHEMISTRY SECTION

To the Director:

The period covered by this report has been an unfortunate one for the Chemistry section. On the night of December 21-22, 1921, our building was burned out. A temporary roofing was erected and the Chemistry Section proceeded to carry on its work in the improvised laboratory from the spring until about the middle of September, 1922. Of course, all of the arrangements were temporary and crowded, but this was not our greatest inconvenience. The dirt, consequent upon the fire, was very annoying indeed. The delays in obtaining supplies after ordering, were very vexatious indeed. The greatest inconvenience, however, arose from the fact that the notebook that contained the key data to a large portion of the work for 1921 had been destroyed. We had samples of the potatoes of the 1921 crop in cold storage and the work on the tubers could, in a manner, be reported, but the samples of the tops were gone except the dried ones intended for ash determinations. The ashes had to be prepared in these temporary quarters with much danger of contamination by the dust and dirt then prevalent in the building.

The work on the tubers was repeated on the cold storage samples, but it was not very satisfactory. By the middle of June the work of the 1922 season had to be commenced, and that on the 1921 crop was not yet finished. This crowded us very badly. In the meantime, rebuilding operations had begun and the dirt consequent to the tearing out of old walls and the cleaning of brick was very annoying. We had to abandon all work by the middle of September. This permitted us to get the bulk of the work on the green crop and that on the soil done, as well as these circumstances permitted, but we were not able to do anything with the tubers and the dried samples at that time.

Building operations were delayed for good reasons, so that we did not get into the building until February, 1923.

After we got into the building, we had to clean up as best we could, get our supplies in order and take an inventory. This consumed several weeks for the entire force. We found that we had many things to replace and new things to buy. We could not get all of the back work off our hands before the season's work of 1923 had to be begun.

At the end of the period covered by this report, some of the work of 1921 and much of that of 1922 remained incomplete. It may serve to convey to you an idea of the volume of work done by this section to state that for the past five months we have averaged 1040 determinations per month.

In this connection, it is due to my assistants to state that they did not ask for their annual vacation until the work on the 1923 crop was so well advanced that it could be interrupted without detriment.

The section has presented one bulletin entitled "A Peculiar Soil Condition in the San Luis Valley." Besides this, two articles * were prepared for scientific journals which should be credited to this period although one of them did not appear until September, 1923.

We continued our work on the potato crop of the Greeley Station throughout the period in such measure as the circumstances already stated permitted. It is evident from statements made that it will take us a long time to complete the work accumulated. It would be unwise, in my opinion, to leave this work undone. It is necessary to finish the project up to this date, and, however unsatisfactory the results may be, it would be well to complete the work as best we can and file our record for the crops grown.

You ask in your letter for a list of projects upon which we would like to work during the present fiscal year. I have already pointed out the fact that we are so far behind in work partially done that it will be a long while before we have finished it. It will probably be well into May, possibly June, before we can catch up.

You probably do not wish me to discuss the situation at Greeley. Our work there is not co-operative; it is associated with the pathological work of Dr. MacMillan but is really independent. I do not myself think it altogether proper for me, at this juncture, to express my views on the question. Of course, we can continue or quit, there is no co-operative obligation. The uncertainty in regard to how things may develop in this connection leaves me, much to my regret, in a quandary as to what I wish to do. I have no special recommendations to offer.

I wish to officially acknowledge the patience and consideration the section has received during the trying period of homelessness and uncertainty which, unfortunately, still cripples us in some measure.

Respectfully submitted,
WM. P. HEADDEN,
Chemist

REPORT OF ECONOMICS AND SOCIOLOGY SECTION

To the Director:

Five projects received active consideration during the year:

1. Marketing Investigations; in co-operation with the Colorado Division of Markets, State House, Denver, Colo.

2. Settlers' Progress Study; in co-operation with the Division of Land Economics and the Office of Farm Management and Farm Economics, U. S. Department of Agriculture.

3. Cost of Producing Beef Cattle on the Range; in co-operation with Cost of Production. and Farm Management Division, U. S Department of Agriculture.

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* Deportment of Calcites toward Radium Radiations—American Journal of Science, Vol. VI, September, 1923
The relation of Composition, Color and Radiation to Luminescence in Calcites. Proceedings of the Colorado Scientific Society, Vol. XI, pp. 399-434, 1923

4. Farm Accounting and Farm Organization; in co-operation with Division of Farm Management and Farm Economics, U. S. Department of Agriculture.

5. Rural Life Studies. Three sub-projects have been taken up under this general heading. One of these was carried in co-operation with the Rural Life section of the Bureau of Agricultural Economics, U. S. Department of Agriculture, Washington, D. C.

It is our plan to continue work with the five major projects listed above during the year 1923-24. A study of the methods of organization, management and results secured through the operation of Colorado co-operative associations is also contemplated. The field of co-operative endeavor is comparatively new in this State. The best interests of these co-operative associations will be served if they can be provided with constructive suggestions with respect to factors that make for success in their business enterprises. In order to know something about what is taking place in our Colorado co-operative associations, active field studies should be initiated and continued through a period of two, three or more years.

Report of Progress on Project No. 1

During the past year information has been assembled regarding some of the more important methods and practices that are employed by Colorado growers in the marketing of fruits and vegetables. This work is being supplemented during the current year with a study of car rejections and the causes for these rejections. It is our plan to combine data collected last year along with the information which will be made available this year and these two phases of our marketing investigations will be presented in a special report.

During the month of August, 1922, approximately 100 farms in the San Luis Valley were visited and information was obtained concerning the methods employed in marketing potatoes in the valley. A brief summary of the results of this investigation were made in a preliminary report.

Report of Progress on Project No. 2

The Settlers' Progress Study which was conducted in co-operation with the Division of Land Economics and the Office of Farm Management and Farm Economics, U. S. Department of Agriculture, was organized and field work was begun in June, 1923. The field work for this project included a study of the farm business for the year 1922. Approximately 80 records were secured in the vicinity of Hugo, in Lincoln County, and essentially the same number was obtained in the vicinity of Akron, Washington County. Along with the farm-business-analyses data, suggestions were obtained from these farm operators with reference to the date of settlement and the approximate amount of money and equipment required to begin work in these areas. The records in question have not been worked over sufficiently to enable us to present a detailed report at this time.

Report of Progress on Project No. 3

During the present year some 45 or 50 cost records have been secured from men who are producing beef cattle on the range. It is expected that a preliminary statement will be made available shortly. This will indicate the cost of producing calves under Colorado conditions during the year 1922. A preliminary report on "The Cost and Methods in Carrying Cattle on the National Forest Ranges of Colorado in 1922" has been prepared.

Report of Progress on Project No. 4

Detailed farm accounting records have been kept on some 28 farms in the Greeley area during the past year. These records include complete information with respect to the hours of labor required in handling each farm enterprise; also a complete history of crop production on these farms together with systematic records in regard to current expenses, crop sales and livestock-feeding operations. This investigation will be continued for a sufficient length of time to provide reliable suggestions with reference to changes or modifications in farm organization with the object of securing maximum profits.

Report of Progress on Project No. 5

During the year over 1000 families in a typical small town within a prosperous agricultural district were visited in order to discover how many of these families had lived in the country; where they had lived; why they removed to town; whether they have been satisfied with the change; what they consider the advantages of the city and the country and if they had their lives to live over again would they have moved as shown by this investigation.

During the summer, approximately 100 successful farm families, representing the different farming conditions of the State, were interviewed with the object of finding out just how they have succeeded. Special questions were asked concerning the family; the education of the children, the schools and churches in the district; the economic condition of the farmer and his family; recreation, and their attitude toward the work of operating a farm. The material collected in these two surveys is being tabulated and a detailed report will be made available later.

A special report on Potato Marketing in the San Luis Valley was prepared by Professor R. T. Burdick of this department.

Respectfully submitted,

L. A. MOORHOUSE,

Agricultural Economist

REPORT OF ENTOMOLOGY SECTION

To the Director:

The following is a brief report of the work of the Entomology Section during the fiscal year closing June 30, 1923:

There has been no change in either personnel or projects in this section during the year.

The entomological work from my office as State Entomologist is very closely associated with the investigational work. In fact, some of the men are paid in part from Experiment Station funds, and in part from State Entomologist funds. The life-history and control work with the codling moth and the alfalfa weevil on the Western Slope have continued during the year, but the results of this investigation are published from time to time in State Entomologist circulars.

Following are brief notes on the several projects carried in this section:

Plant-Louse Investigations:

Miss Palmer and the writer have completed a technical paper giving the life habits and descriptions of several new species of Aphids *(Lachninae)* attacking conifers in Colorado. The paper is very fully illustrated and has been accepted for publication in Annals of the Entomological Society of America. This paper more than doubles the number of known species of plant lice attacking the conifers of this State.

Ants of Colorado in their Relation to Plant Lice:

This project is being carried by Professor C. R. Jones, who has made progress in the work during the year, chiefly in adding to the number of species taken in the State and notes concerning their habits as related to the plant lice.

Codling-Moth Studies:

Our studies on the life history and methods of control for this pest to our apple industry have been continued at Grand Junction and in Delta County during the year. We have been especially interested in results obtained in an effort to trap these moths by means of attractive liquids placed in jars in the apple trees. The experiments along this line are to be continued thru another year.

Grasshopper Control:

Mr. C. L. Corkins has continued his experimental work with poisoned baits for the control of grasshoppers, special attention having been given to a very serious outbreak of the Mormon Cricket* in southern Moffat and northern Rio Blanco counties the past spring. While this work was planned and directed from the office of the State Entomologist, I am glad to mention in this connection the great service of Governor Sweet in raising a good contribution in Denver which, with a $2,000 contribution from the Southwestern Division of the American Red Cross, enabled us to put on an effective campaign for the control of the pests in the section where the new settlers would have been unable to raise funds to protect their crops.

* *Anabrus simplex*

General Insect Investigations:

The Potato Flea-beetle *(Epitrix cucumeris)* has been quite destructive again to the potatoes in the Greeley section, and Mr. J. L. Hoerner has been giving considerable of his time to a study of the life habits of this insect, with the hopes of being able to work out better methods of control. Mr. Hoerner has also given some attention to a study of the habits of the false wireworms *(Eleodes sp.)* in the eastern portion of the State, and has made observations upon the extent of the injuries that are being done by them, especially to fall grains, hoping to do some control work later.

The so-called "Alfalfa Eel-worm" has appeared in Fremont County near Canon City, and a single alfalfa crown affected with this same eel-worm was sent to the Station from Walsenburg. This promises to be a rather serious pest to alfalfa and the Station will doubtless be compelled to give some attention to its control in the near future.

Brief mention of a number of injurious insects will be found in the Report of the State Entomologist for the year 1923.

Respectfully submitted,

C. P. GILLETTE,

Entomologist

REPORT OF THE FORESTRY SECTION

To the Director:

Attempts were made toward the close of the last semester of the present year to finish the report upon the project now in force, that of Studies in Timber Decay. It was found impossible, however, due to the summer-camp work in forestry which soon followed commencement. The accumulated data call for intensive work in order to put out the type of report which seems most effective.

A further increase in our teaching schedule under the new four-year course, together with the working up of new courses, will prevent my finishing this report during the present year. It is felt that if any outside work is done it should be in preparing a revision of the State Forestry Publication No. 1, The Evergreens of Colorado. The first edition of this publication is entirely out of print while calls for it are continually increasing. The public schools of the State, especially, are asking for it and its extensive use in this way is regarded as a valuable means of increasing popular forestry knowledge in our State.

Respectfully submitted,

B. O. LONGYEAR

Associate Forester

REPORT OF THE HOME ECONOMICS SECTION

To the Director:

During the year 1922-'23 research was continued on The Cooking Quality of Colorado Potatoes. We obtained potatoes as follows:

a. From the Greeley district: Pearls, of 2-, 4-, 7-, and 11- irrigations; Rurals of 8-, 10-, and 11- irrigations.
b. From Carbondale: Burbanks and Cobblers.
c. From the San Luis Valley: Burbanks

On a certain number of individual tubers of each one of these groups of potatoes, the same rigorous quantitative determinations of moisture, starch, nitrogen and ash, were made as in preceding years. The results of this continued research are now being compiled into a bulletin which it is hoped will be issued this year, 1923-'24.

Research was begun on the Bread-Making Qualities of Colorado Flours. Satisfactory progress was made on this project, which it is hoped to complete during the present academic year, when it is planned to issue a housekeeper's bulletin dealing with the Principles of Bread-Making.

As in other years, the permanent equipment of this section has been added to, always looking towards the ideal of a very completely fitted-up, research, food laboratory.

Attention is respectfully called to the last paragraph of last year's report, in which the needs of excellent library facilities for the research investigator were pointed out.

Respectfully submitted,
N. E. GOLDTHWAITE,
Home Economics Investigations

REPORT OF THE HORTICULTURE SECTION

To the Director:

The following is a brief report on the status of the experimental work carried on by the Horticulture section. The following projects are now in force and will be discussed under project titles:

Head Lettuce:

This work has been in progress for two years at Buena Vista. The object of this work was to aid the farmers in overcoming some of the difficulties that the growers encountered in growing the crop. The newness of the industry made it necessary not only to work on varieties and strains of lettuce best adapted to the mountain conditions of the State, but also to work on problems relating to soil fertility, crop rotation, cultural methods and diseases.

The problem of seed, as to variety and strain, has been quite definitely settled.

The problem of soil fertility is a difficult one in the mountain sections. The limited area of land available for this crop makes it difficult to persuade the grower that one should not grow lettuce successively on the same land year after year. Then, too, the soil types are such as to require considerable vegetable matter to keep up the soil conditions, as well as that of fertility. Stable manures are not available in sufficient quantities and it will be necessary to grow and plow under green crops.

The problem of correct cultivation is fairly well established among the better growers, tho considerable difficulty along this line is met with among beginners and among growers who have had little experience and have little knowledge of the effect of cultivation upon the growth of the plant.

In the matter of the plant diseases, considerable difficulty has been encountered, especially with the disease known as tip burn. This problem has been studied in the field and arrangements have been made and are now in progress to study the disease in the greenhouse and in the laboratory, and establish some correlation between the disease and certain constituents in the plant itself. The solution to this problem seems to point to the selection of the resistant strains. This belief is strengthened by the fact that a considerable percentage of the plants in the field are free from the disease. It then resolves itself into a question of selection, which will be carried on for a considerable time to establish disease-resistant strains in seed.

There are also some questions in regard to the proper time of planting the crop. From our work during the last two years, it is evident that Colorado lettuce will reach the highest quality and commercial value during the months of September and October. This means that the planting should be done, starting with the first week in May and continue for two weeks. This will bring the crop on the market during September and October, when there is the greatest demand, and the best prices are obtained.

From our two years of experience in the field we are convinced that head lettuce can be grown successfully in practically all of our mountain sections, at an elevation running from 7500 up to 8000 feet, and even up to 9500 feet.

Like every new industry, it has to pass thru the stage of elimination and thru a state of speculation. While there is a considerable profit in the growing of head lettuce under proper soil, climatic and cultural conditions, there is also considerable to be learned in regard to questions of cultivation, irrigation and planting time, and those who look upon the business in a speculative way are sure to lose money. During the past season the growers have been, on the whole, successful. With a slightly smaller acreage than last year, the shipment or the production has been about three times as great.

In connection with this work, the department is severely handicapped by the lack of experimental land to carry on the work. It is almost impossible to control the various factors in production in doing the

experimental work on land which is rented from some farmer, and there is no security in the matter of continuing the work on the same land for more than one season.

This handicap is more severe when it comes to the exacting requirements of this particular crop.

Tomatoes:

This work was started with the idea in mind to aid in the development of the tomato-canning industry in the State, particularly in the Arkansas Valley. Experiments have shown that the seed or the offspring from the first cross are usually superior in productivity, if not in quality, over their parents. To test out this belief and to inaugurate improved cultural methods, a tract of three acres was leased at Manzanola and the work placed in charge of one of the senior students. Unfortunately, the first planting was entirely destroyed by a heavy hail storm, and a later planting was partially destroyed by flood and what was left perished during a subsequent hail storm, so that no results could be obtained from the work.

High-Altitude Orchard and Small Fruits at Fort Lewis:

Like many of our projects at Fort Lewis, this project has suffered considerably from causes over which we have had no control. The orchard was practically destroyed by mice during the winter of 1922-23 but was, of course, replanted in the spring of 1923. Precautions have now been taken to guard against this trouble in the future; every tree has a wire-netting protector.

The small-fruits work has been, on the whole, successful. Practically every kind of small fruit that can be grown in the North Temperate zone seems to flourish in the altitude of Fort Lewis. The heavy winter snowfalls are rather beneficial to small-fruit plantings, as they afford an excellent winter cover for the planting. The summers are cool, which tends to develop large fruit and fruit of high quality. The small-fruit plantings will be further extended next spring, and with the data we have accumulated a small bulletin on small fruits in high altitudes should be published after a year or two more of work.

Potatoes:

The potato work has, on the whole, been unsatisfactory, insofar as the work on the experimental side is concerned. We are up against the same proposition as we are in the case of head lettuce. Renting or leasing land from a farmer and being dependent upon him for the use of tools and power as well as water for irrigation, makes it almost impossible to carry on experimental work of any value, as the work cannot be performed at the exact time when it should be done.

The problem of disease with which we are now working is an exceedingly complex one, and in order to do effective work, we should have a considerable acreage to permit us to carry on selection of disease-

resistant strains, as we believe that is the only method by which we can hope to cope with the potato diseases in the State. We must also be able to contol the matter of rotation and other features connected with the growing of the crop.

The past year has been one of the most disastrous ones, so far as potato diseases are concerned, that we have experienced in Colorado. Undoubtedly, the climatic conditions during the year were more or less favorable to diseases. Yet, on the whole, we must ascribe the prevalence of diseases to the continued use of poor and diseased seed. The question of seed selection is perhaps the greatest question before our potato growers today. How to carry it across or how to sell this idea to the farmer is difficult to decide, as one cannot get the hearing or the attention of the farmer, unless he is absolutely down and out.

Considerable work has been done in the matter of seed selection and the elimination of diseases, and we have some pure strains, but not having the facility to expand we can go no further with this work. The main attention has been centered on the growing of certified seed, and in this connection we are meeting with considerable encouragement from good growers in every part of the State. The number now growing certified seed is, to be sure, somewhat small in comparison with the production of potatoes. Yet we have laid a foundation for this work and it looks promising for the future. Our ideas in regard to the growing of certified seed have undergone some changes during the last two years. We have come to the conclusion that the growing of certified seed is a business for the specialist, the high type of potato grower, and not a business for the average man. We rather look for a reduction in the number of growers of certified seed and to an increase in acreage of those who are most fitted and able to grow the seed. To keep it on that high plane, it will require the high-class grower to enter this line of production.

Vegetables in College Garden:

The vegetable work at the College has been centered on the growing of celery, which is one of the important vegetables grown commercially in the State.

Professor McGinty, who has general charge over vegetable production, is trying out a new strain of lettuce and different cultural methods, and the results are very promising.

A new line of work in the College garden will be that of breeding disease-resistant strains of squash. The ravages from disease on squash have been heavy during the last few years and Professor McGinty is arranging to carry on work in breeding and selecting disease-resistant strains.

Considerable work has been done with the Denia onion, which we have now grown for a period of six years. Two objects are in view: First, the development of a strain of seed that will mature the onions from the seed in the field; second, the development of a type to elimi-

nate scullions and undesirable types of plants in the field of the set onions.

The possibilities of onion culture are not realized in the State. From our experimental plots we have produced as high as 1200 bushels of salable onions to the acre.

Grapes and Variety Test of Fruit Trees on College Farm at Austin:

There is nothing of interest to relate about this work. Extensive plantings were made of many varieties of tree fruits and of grapes last spring. It will be several years before any definite results can be obtained.

Cold Storage:

This project was started four years ago in connection with the horticultural work, and we have the data now from three years of work. It has been written up and is ready for publication, either as an Experiment Station bulletin or as a part of the State Horticulturist's report. I will talk to the director in the near future as to the publication of this project.

Landscape Gardening:

This project is of a more general nature as we are not in a position to carry on experimental work or work of the type that is usually considered experimental. Yet, there is a distinct field for work caused by the demand for definite information on certain shrubs and trees that are adapted to Colorado conditions; also general information upon the principles of planting and arrangement of the materials into a landscape.

Professor Lowry has accumulated the material for this bulletin and the manuscript is now being prepared and the publication should be printed for distribution by spring.

This concludes in a brief and general way the report of the activities of this section. I wish to make some remarks in regard to the features of the work that we are now undertaking, particularly the work with potatoes and vegetables in high altitudes.

The fruit industry in the State is now well provided for. We have acquired a College experimental fruit farm where problems relating to the industry can be studied to the best advantage. In the case of potatoes and vegetables we are at a loss. The home station is so unfortunately located that the work that can be done is only applicable to general vegetable growing in Northern Colorado. The ground cannot be utilized for the potatoes nor for the vegetables that may be grown in the high altitudes. We are very anxious to place this line on a permanent basis, and the only way that this can be done is to acquire the ownership of land in the mountain section where potatoes and vegetables can be grown, with adequate acreage. This work could yield satisfactory results and we would have a permanent place and would not be continually interfered with by the owner of the land. We wish it were pos-

sible that some money could be set aside for the purchase of such a farm. It need not be expensive. The upkeep as well as all running expenses could be borne by the proceeds from sales, as is the case with our College orchards. It would be, to be sure, the first outlay in the way of the purchase of the land and equipment that would have to be figured as a permanent investment, but I cannot see but what the investment is entirely justified; in fact, I believe that the institution would be greatly benefitted by such an investment, not only from the results obtained from the work but from the support that the College would obtain from all the mountain counties of the State.

Respectfully submitted,

E. P. SANDSTEN,

Horticulturist

REPORT OF IRRIGATION AND DRAINAGE INVESTIGATIONS SECTION

To the Director:

During the past fiscal year, ending June 30, 1923, the work of this section has been confined to the following projects:

Only one Adams Fund project has been under consideration, that of the Venturi Flume. The application of the hydraulic-jump, as developed in a new device, has proved a wonderful improvement in the principle of the Venturi Flume. This improvement was commenced at the close of this fiscal year.

Under the Hatch fund two principal projects have been carried, namely, the Evaporation experiment, and the Measurement of Water as applied in irrigation. The Evaporation studies have been carried in two parts. The observations within the laboratory have been made either under still-air conditions, or under wind conditions of known velocity. The outside condition is under full exposure where the rate of evaporation is carefully determined. The rate of evaporation within and without the laboratory shows very similar characteristics, but the peak or maximum rate does not occur at the same time of day. Within the laboratory, this maximum occurs during the early morning hours, while, outside, the maximum occurs during the afternoon or early evening. The effect of wind is very marked upon the rate of evaporation, observations having been made where the wind velocity has a range from 1.8 to about 11.5 miles per hour. As a usual thing, the data are taken in a series of hourly observations covering a period of approximately 30 hours at intervals of ten days or two weeks. Up to the close of this fiscal year there have been 1328 hourly observations taken within the laboratory, and 258 outside since June, 1920.

At the Bellvue laboratory a series of observations was made on the Herschel Hollow-Crest Weir for the purpose of determining its practic-

ability as an irrigation device. This structure consists of a hollow crest (tubular) set in a horizontal position, where the floor of the approach section rises at a slope of 2:1 to the crest level and then is depressed at this same slope beyond the crest. The sides of the structure are parallel and vertical. Two pressure heads were observed; one at a point upstream from the crest and the other at the crest, the latter being a negative value. One striking feature of this device is the fact that the discharge is directly proportional to the difference in value of these two heads. Various settings concerning contractions were investigated. It was found that by eliminating the sloping upper bottom contraction and flaring the sides of the approach section, but still confining the stream downstream from the crest by parallel vertical sides,, the device then possessed certain characteristics which were of practical importance. This modified design now eliminates the hollow crest.

A series of calibrations was made using this modified design, but instead of permitting the water to fall indefinitely down the 2:1 slope from the crest, a reverse slope of 6:1 was installed, which led the discharging current upward to an elevation one-half foot below the crest elevation at a point five feet down stream from the crest. Such a device possessed the remarkable characteristic of withstanding a submergence of practically 75 percent before the free flow condition is materially affected.

Because of the extreme low-water conditions of the river during the late summer and fall, work at the Bellvue laboratory was discontinued early in September. This new device was then installed at the Fort Collins laboratory, where 1, 1½, 2 and 3-foot widths of structure were calibrated, but with discharges limited to about 16 second feet, the capacity of the laboratory. The results obtained at the Fort Collins laboratory show very consistent relations thruout the range of discharge investigated. For free-flow discharge, with a minimum head of 0.3 foot and maximum head of 1.4 feet on the 1, 1½ and 2-foot flumes, and 1.0 foot on the 3-foot flume with discharges from 0.5 second-foot to 16 second-feet, the mean computed deviation from the curve was 0.8 percent. The free flow discharge formula is

$$Q = (4.66W - 0.23)\ H^{1.65}$$

where Q is second-feet, W width of flume and H the upper head in feet.

The Bellvue laboratory was originally built in the fall of 1919, when a flume 10 feet wide and 60 feet long was constructed of framed timber with a concrete floor. The season of 1922 found this flume in bad condition, and because of the economic importance of this field laboratory, as well as with the sincere and cordial co-operation of the Jackson Ditch Company, it was decided to replace the wooden structure with substantial concrete construction. The building of the two walls forming the flume and the laying of another floor cost $500. The small office building and protecting stone wall cost about $400. These improvements have been decidedly worth while and have now made possible the investigation of irrigation structures of practical size. The

maximum discharge available at this laboratory is about 100 second-feet, some six times the capacity of the Fort Collins laboratory, and the size of the flume, which is 14 feet wide and 5½ feet deep, is sufficient to accommodate test structures of actual dimension such as would be found in practical application. This Bellvue laboratory has made possible the further investigation of the new-type flume, as previously mentioned, to a width of 10 feet and a discharge of about 60 second-feet. The development of this new type of measuring device is an important step in the advancement of the science of measuring flowing water, both for power and irrigation purposes, and it is felt that the facilities provided at Bellvue, which permit the study of this new device under practical sizes, have amply repaid the time and expense incurred in establishing this important feature of our experimental work.

Under State funds the projects in Meteorology and the Arkansas Valley investigations have been carried during the past fiscal year. The work in Meteorology has been a continuation of that in past years, consisting in the observation of meteorological conditions twice daily, the posting of weather bulletins each day, and the publishing in local papers of the weather report. Sufficient data are now avaliable for the publication of a revised edition of Colorado Climatology, which will be brought out during the fiscal year of 1924.

The Arkansas Valley Investigation has been actively pursued during the year. The general outline followed is similar to that of last year. The several farms selected for special study in the Duty of Water have all been maintained except one at Fowler. Because of difficulty with the measurement of water on this farm, it was thought advisable to abandon it and we were successful in substituting another in the same vicinity. Due to the variation in the soil type of the valley, a series of observations has been made to determine the water-holding capacity of the soil, these soil investigations having been made at Fowler, Rocky Ford, Las Animas, Wiley and Lamar. A basin 12 feet square was constructed and a known quantity of water applied to this area. Soil samples were taken previous to the test for the purpose of determining the percentage of moisture at 1-foot intervals to a depth of 6 feet. After the application of the water, other samples were taken at various intervals to obtain the rate of percolation downward thru the soil column and ultimately to determine what portion of the water applied in irrigation was lost beyond the root zone, and also to ascertain the economic application as well as the interval between irrigations.

The results obtained during the season of 1922 on the experimental plots of the farm of the American Beet Sugar Company did not show any marked effect of the amount of water applied in irrigation to the yield in crop. In general, the more water applied the greater the tonnage of sugar beets; the percent of sugar reached a maximum at about 1-acre-foot per acre application; but no direct relation appears between amount of irrigation and purity. The yield of sugar in pounds per acre was greatest for an application of 3 acre-feet per acre. For the eight-

een 1-acre plots under study, the yield in sugar per acre was directly proportional to the niter content of the soil.

The special farms in the valley under observation concerning Duty of Water show a rather wide variation, ranging from a duty of 0.77 acre-foot to 2.34 acre-feet, with an average duty on the several farms, for all crops, of 1.50 acre-feet per acre.

Attention has been given to general work thruout the State pertaining to special assignments, such as assistance in the organization of drainage districts, and advice and assistance to farmers in their measurements-of-water problems, as well as the investigation of conditions having to do with general irrigation conditions of the State.

Respectfully submitted,

RALPH PARSHALL,
Senior Irrigation Engineer

REPORT OF THE VETERINARY SECTION

To the Director:

Most of the work in Animal-Disease investigation is carried on in the Pathology Section. In the Veterinary Section there is but one general project, Animal Diseases.

During the present year there has been no disease among animals in Colorado which has assumed anything like epizootic proportions, save, possibly, hog cholera. This disease comes in cyles, and as was expected there has been more cholera than for several years.

The State is well organized to control contagious diseases. The office of State Veterinarian in Denver has regulatory supervision in such cases. We have benefitted by Federal co-operation in the control of mange and scab for several years. Furthermore, a veterinarian under the auspices of the Bureau of Animal Industry, has been placed in Colorado, with the title of Hog Cholera Specialist, who has been given a wide range of service in the control of all infectious and contagious diseases. Lastly, the veterinarians of the department co-operate to the fullest extent, but more especially along the line of investigations under approved projects.

There have been no changes in the staff of the Veterinary Section during the last year and no important addition has been made to the equipment.

Respectfully submitted,

GEO. H. GLOVER,
Veterinarian

REPORT OF THE ENGINEERING DIVISION

To the Director:

I am transmitting herewith the reports of the Civil Engineering and of the Mechanical Engineering Sections of the Experiment Station.

The Civil Engineering Section has been devoting practically all of its time to carrying out the co-operative agreement between the Station and the State Highway Department, and much valuable information is being gathered concerning the road materials of Colorado.

The Mechanical Engineering Section has completed two projects and is now at work on two others.

Respectfully submitted,
LD CRAIN,
Vice-Director

REPORT OF THE MECHANICAL ENGINEERING SECTION

To the Chairman, Engineering Division:

The projects upon which the Mechanical Engineering Section has been engaged during the last Federal fiscal year are: (1) Methods of Handling Hay in Colorado; (2) Heat Transmission of Commercial Wall Board; (3) Treatment of Alkali and Other Waters for Domestic Use; (4) Testing of Lubricating Oils.

The investigational work on the projects, Methods of Handling Hay in Colorado, and Heat Transmission of Commercial Wall Board, was completed during the fiscal year 1921-22, but the publication of a popular bulletin on each of the above mentioned projects was done during the past fiscal year. Neither of the two remaining projects have been completed. The investigational work has been done by the writer who is spending full time in this section.

The greater part of the present fiscal year will be given to the completion of the projects—Treatment of Alkali and Other Waters for Domestic Use, and Testing of Lubricating Oils. We would like to prosecute work during the present fiscal year on "A Comparison of Domestic Heating Plants," if proper arrangements can be made. This work will be under my immediate supervision.

Respectfully submitted,
G. A. CUMMINGS,
Investigator

REPORT OF THE CIVIL ENGINEERING SECTION

To the Chairman, Engineering Division:

The experimental work in this section is carried on by Mr. O. V. Adams.

Mr. Adams is doing experimental work upon Road Materials of Colorado in conjunction with the State Highway Department of Colorado. A preliminary report on this work was issued in April of this year, entitled "Report of Road Materials Project, Part I." Mr. Adams is temporarily on leave, his place being taken by Mr. Donald L. Jones.

The report of the work in the Road Materials Laboratory is fully covered by the men in charge. A brief report by Mr. Jones follows:

"To E. B. House, Civil Engineer:

"In this section the only project carried during the year has been that on Road Materials of the State.

"The co-operative agreement between the State Highway Department and this section, made in 1921, has, by mutual understanding, remained in force. The organization has consisted of a field party of two men; the foreman being furnished by the State Highway Department, and the assistant by this section. The work in the laboratory has been carried on with the aid of an assistant on part time, and with student labor.

"During the period covered by this report, the laboratory has tested materials from 241 pits which were located by the field party. A total of 302 samples have been tested up to this time since December 1, 1922. Since September 15, the field party has consisted of but one man, the assistant being taken off at that time.

"A progress report of the work done in this section was published, April, 1923, and contains the reports of all samples up to December 1, 1922.

"The investigation to determine the effect of beet pulp upon mortar and concrete has been completed insofar as the storing period is concerned, and the testing completed. The data on this investigation have not, as yet, been compiled."

Respectfully submitted,

E. B. HOUSE,
Civil Engineer.

REPORT OF THE EDITOR OF PUBLICATIONS

To the Director:

I am submitting herewith a brief report of the work done by this office for the Colorado Experiment Station for the fiscal year 1922-23.

In addition to the regular run of bulletins, considerable publicity has been secured through the newspapers and magazines of the State during the past year.

Following is a complete list of the Station publications passing through this office:

Three more bulletin manuscripts are now in the hands of the printer and should be ready for distribution within a very short time.

Bulletin No.	Title and Author	Pages	Edition
278	Degeneration in Colorado Potatoes, E. P. Sandsten and C. Milton Tompkins	15	3000
279	Return of Seepage Water to the Lower South Platte River, Ralph L. Parshall	72	2500
280	Sodium Arsenite as a Killing Agent in Grasshopper Baits, C. L. Corkins	15	3000
281	Methods of Handling Hay in Colorado, G. A. Cumings	39	4000
282	Heat Transmission of Commercial Wallboard, G. A. Cummings	8	2000
283	Head Lettuce in Colorado, R. A. McGinty	26	4000
284	Report of Road Materials Project, Part I., O. V. Adams	46	1500
285	Control of the Whorled Milkweed in Colorado, W. L. May	24	3000
286	A Peculiar Soil Condition in the San Luis Valley, Wm. P. Headden	15	1500
	Report		
	Thirty-Fifth Annual Report	30	1500
	Total	290	26000

Respectfully submitted,

I. G. KINGHORN,
Editor of Publications

ANNUAL REPORT OF THE VETERINARY PATHOLOGY SECTION

To the Director:

PROJECTS IN FORCE:

I. Sheep Losses in the Feedlots.
II. Contagious Abortion.
III. General.

Projects in Abeyance:

Forage Poisoning in Horses.

I. SHEEP LOSSES:

Work on this project during the last feeding season was largely concerned with excessive losses associated with a heavy grain feeding. Lambs that were being fattened for market, on receiving 1 to 1½ lbs. corn, died in considerable numbers, in many cases without particular preliminary symptoms. Where symptoms were observed, scouring was noticed and a cerebral disturbance which was evidenced by throwing the head back toward the shoulders. In many bands 2 to 4 percent were lost from this trouble. It appeared that the lambs which were most vigorous and in the best condition of flesh were those most likely to be attacked. A large number of animal inoculations failed to reveal any organism which could be held responsible for the trouble. Neither aerobic nor anaerobic cultures gave any indications of the cause. In all cases observed by us where the grain was removed for as much as three days, the lambs stopped dying immediately. However, when the same lot was again brot up to 1 or 1½ lbs. corn per day the disease, in many instances, manifested itself again and with considerable loss. It seemed difficult to feed a sufficient ration to fatten the lambs and at the same time not cause death. It seemed, from this, reasonable to assume that the malady was in some way associated with the high feeding of corn, although we were not able to demonstrate any particularly poisonous principles in this concentrate. Further work is being continued on this trouble as it seems to be of the same nature as that which has been observed in the San Luis Valley for many years.

San Luis Valley:

During the year we finished the second feeding experiment in the San Luis Valley with results which seemed to point in the same direction as our previous findings:—that the real problem was to work out a satisfactory method of feeding peas. Since it seemed to be a question of proper variety of ration, we felt that the Animal Husbandry Section was better able to handle the matter than we, and as a consequence, have turned the project over to that section retaining interest in it only in an advisory and co-operative capacity. There is reason to hope that peas can be used for food for lambs if fed in proper mixture with other foods.

Hemmorrhagic Septicemia:

Only a few outbreaks of this disease have been observed during the year, so that little further information has been obtained. A paper appeared by the writer in the Journal of the A. V. M. A. entitled, "An Outbreak of Hemorrhagic Septicemia in Sheep," Vol. 62, Page 759. In this outbreak we were able to show that the organism was present in 32 out of 34 animals examined.

The work on determination of strains of the organism causing Hemorrhagic Septicemia in sheep has been continued but is not yet ready for publication.

Ictero Hematuria:

Ticks were obtained from sheep in the region of Craig, Colo., where *Ictero Hematuria* is known to exist and brought to Fort Collins where they were placed on experimental animals. While they fastened onto the animals for a time nothing has developed which would indicate that the disease was thereby transmitted. This disease still remains an enigma.

II. CONTAGIOUS ABORTION

Our work to determine the value of the live organism vaccine in beef animals has been continued, but, owing to some failure on the part of co-operating parties, we have been unable to obtain as much information as we would have desired. However the work is being pushed as rapidly as possible, and is being closely checked by agglutination tests, so that it is hoped information may be added over a series of years which will prove of value.

FORAGE POISONING

The work on this project has been held in abeyance for the reason that no field cases have developed..

In view of the fact that the teaching in the department has required more attention it seemed to be desirable to transfer Dr. Feldman to teaching work for most of his time, expecting him to give only his summer to the investigational side. This made is necessary to employ someone who could take some of the routine work off of Dr. Cross. Accordingly, Miss Beulah Malone has been employed for this purpose. She is giving half time to investigational work and half to the instructional side. Dr. Cross continues to carry the larger proportion of the investigational work and is becoming more and more efficient.

Respectfully submitted,

I. E. NEWSOM, Pathologist