THE STATE AGRICULTURAL COLLEGE
OF COLORADO

# The Thirty-Third Annual Report

OF

# The Agricultural Experiment Station

1920

# The Colorado Agricultural College

## FORT COLLINS, COLORADO

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B. O. LONGYEAR, B.S. ..... Assistant in Forestry
I. E. NEWSOM, B.S., D.V.S. ..... Veterinary Pathologist
RALPH L. CROSMAN ..... Editor
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N. E. GOLDTHWAITE, Ph. D. ..... Home Economics
R. E. TRIMBLE, B.S. ..... Assistant in Irrigation Investigations
W. F. ALLEWELT, B.S. .....
.....In Co-operation with Office of Markets, Marketing Investigations
EARL DOUGLASS, M. S. ..... Assistant in Chemistry
P. K. BLINN, B.S., Rocky Ford ..... Alfalfa Investigations
MIRIAM A. PALMER, M.A. ..... Delineator
J. W. ADAMS, B.S., Cheyenne Wells ..... Assistant in Agronomy, Dry Farming
RALPH L. PARSHALL, B.S., U.S. Irrigation Engineer ..... Irrigation Investigations
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J. H. NEWTON, B. S. ..... Assistant in Entomology
JOHN L. HOERNER, B. S. ..... Assistant in Entomology
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O. V. ADAMS, B.S. ..... Testing Engineer
G. A. CUMINGS, B. S. ..... Assistant in Mechanical Engineering

## LETTER OF TRANSMITTAL

*To His Excellency, Oliver H. Shoup, Governor of Colorado*:

In accordance with the law of Congress, I have the honor to transmit to you herewith the Thirty-Third Annual Report of the Colorado Agricultural Experiment Station.

The financial statement is for the government fiscal year ending June 30, 1920. The other portions are reported substantially for the state fiscal year of December 1, 1919, to November 30, 1920.

C. P. GILLETTE,
Director.

Agricultural Experiment Station,
Fort Collins, Colorado,
December, 1920.

## FINANCIAL REPORT OF THE COLORADO AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING JUNE 30, 1920

| DR. | Hatch Fund | Adams Fund | State Mill Levy Fund | Sales Fund | Special Fund | Pure Seed Fund App'n | Horse Cash Fund | Total Fund |
|---|---|---|---|---|---|---|---|---|
| Balance on hand July 1, 1919 | ..... | ..... | $18,609.95 | $267.32 | $16,822.53 | $5,978.16 | $1,743.60 | $ 43,421.56 |
| From the Treasurer of the United States as per appropriation for the fiscal year ended June 30, 1920, 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 U. S. | ..... | ..... | 61,892.24 | ..... | 28,539.15 | ..... | 1,009.07 | 91,440.46 |
| Total receipts | | | | | | | | $164,862.02 |
| **CR.** | | | | | | | | |
| To Salaries | 12,073.62 | 12,304.84 | 26,309.40 | ..... | 1,907.48 | 1,894.13 | ..... | 54,489.47 |
| Labor | 1,009.95 | 628.37 | 3,408.99 | ..... | 672.41 | 578.69 | 511.62 | 6,810.03 |
| Publications | 84.50 | ..... | 1,297.94 | ..... | 81.73 | 207.29 | ..... | 1,671.46 |
| Postage and stationery | 62.76 | 56.72 | 671.72 | 31.16 | 113.77 | 252.95 | 24.48 | 1,213.56 |
| Freight and express | 31.79 | 5.35 | 354.54 | ..... | 78.60 | 24.71 | 5.60 | 500.59 |
| Heat, Light, Water and Power | ..... | ..... | 4.40 | ..... | ..... | ..... | ..... | 4.40 |
| Chemicals and laboratory supplies | 91.08 | 185.80 | 257.91 | 7.07 | 17,266.34 | 26.15 | ..... | 17,834.35 |
| Seeds, plants and sundry supplies | 171.54 | 98.64 | 837.48 | 17.05 | 1,499.09 | 110.57 | 222.46 | 2,956.83 |
| Fertilizers | ..... | 11.69 | 1.08 | ..... | ..... | ..... | ..... | 12.77 |
| Feeding stuffs | 184.90 | 7.30 | 2,342.04 | ..... | 1,631.14 | ..... | 1,388.01 | 5,553.39 |
| Library | 53.01 | ..... | 52.84 | ..... | 511.50 | 12.19 | 9.50 | 639.04 |
| Tools, machinery and appliances | 11.71 | 740.00 | 317.32 | 1.70 | 1,295.30 | 3.00 | 33.00 | 2,402.03 |
| Furniture and fixtures | 407.80 | 5.55 | 387.24 | ..... | 39.10 | 16.00 | 16.50 | 872.19 |
| Scientific apparatus and specimens | 154.37 | 420.19 | 323.42 | ..... | ..... | 40.00 | ..... | 937.98 |
| Live stock | 95.50 | ..... | 6,610.92 | ..... | 28.90 | ..... | ..... | 6,735.32 |
| Traveling Expenses | 541.47 | 225.00 | 1,844.60 | 54.50 | 1,285.65 | 94.20 | 291.92 | 4,337.34 |
| Contingent Expenses | 26.00 | ..... | 36.75 | ..... | 125.00 | ..... | ..... | 187.75 |
| Buildings and land | ..... | 310.55 | 1,304.23 | ..... | 6,317.15 | 87.93 | ..... | 8,019.86 |
| Total expenditures | $15,000.00 | $15,000.00 | $46,362.82 | $111.48 | $32,853.16 | $3,347.81 | $2,503.09 | $115,178.36 |
| Balance on hand June 30, 1920 | ..... | ..... | 34,139.37 | 155.84 | 12,508.52 | 2,630.35 | 249.58 | 49,683.66 |
| Grand total | $15,000.00 | $15,000.00 | $80,502.19 | $267.32 | $45,361.68 | $5,978.16 | $2,752.67 | $164,862.02 |

# *REPORT OF THE DIRECTOR*

*To the President*:

I am presenting herewith the Thirty-third Annual Report of the Colorado Agricultural Experiment Station for the State fiscal year closing November 30, 1920. The financial statement is for the Federal fiscal year of 1919-20. The sections, or divisions of the work at the time of this writing, number fourteen aside from the station editor. The reports of section heads are given below. The number of projects in force during the year is 60.

The number of workers giving full time to the Experiment Station projects at the close of the year is eighteen; those giving part time number twenty-six.

The progress of the investigational work during the year has been seriously handicapped through the resignation of several station workers who were carrying important lines of research. We have been fortunate, however, in finding competent persons to take their places so that none of the projects have been discontinued because of loss of men. Such changes, however, always result in slowing up the work and delaying its completion.

Because of a small increase in the Station Mill Levy, a balance carried over from last year and a rather large sales fund, it has been possible to somewhat increase the number employed in research work, in spite of the fact that most of the salaries were increased 30% in April. The Station has also increased the number of its employees that give full time to the work. It is my hope that we may continue to advance in this direction. The *esprit de corps* among the workers is also good; in several instances there being two or more sections co-operating in carrying on projects.

The work in the Agronomy Section has been greatly benefitted by the action of the State Board of Agriculture in turning over to it the entire east farm with its farm buildings, conditioned upon the Experiment Station's building the military barns. The assignment of the large mountain pasture to the Animal Husbandry Section has enabled it to broaden its work in an important way and take on a co-operative project, having for its object to determine the best method of handling large areas of native pasture lands in the State for the maintenance of livestock.

The Station has materially increased its budget to the Animal Husbandry Section enabling it to take on more extensive experiments to determine the value of home-grown stock feeds. The Station has employed two additional analysts of experience, Mr. C. E.

Vail and Mr. J. W. Tobiska, to strengthen the work in the Chemical Section, and one full-time man, Mr. W. F. Allewelt, has been employed to further the work in Market Investigations.

There have been some changes in the work at the sub-stations. At Akron, a Summer Fallow and Sheep Pasture experiment is being carried on in charge of the Animal Husbandry Section. At Rocky Ford, the testing of varieties of corn and the growing of some other crops, in a small way, has been added to the work with alfalfa. At Cheyenne Wells, it was necessary for Mr. Adams to purchase a tract of unimproved land to enable him to continue with his dairy herd. At Fort Lewis, the investigational work has been better cared for than for some years past, and I heartily recommend the plan of having a competent man at that station who can give full time to the experimental work.

There are strong calls for additional funds to carry on needed lines of investigational work in many of the sections, but I see little prospect of extending the investigational work in the near future unless provision is made at the coming meeting of the Legislature for an increase in funds for the Experiment Station.

For information concerning the publications of the year, see the report of the Editor which is appended hereto. There are six bulletin manuscripts, including an index bulletin, in the hands of the Station Editor or the printers at the present time.

**PROJECTS IN FORCE DURING THE YEAR**

**Agronomy Section**

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

Correlation of Characters in Grain. Hatch Fund.

Alfalfa Breeding. Hatch Fund.

Methods of Selection Breeding. State Fund.

High Altitude Crops. State Fund.

Seed Crop Improvement. State Fund.

Rotation of Crops for Colorado. State Fund.

Plains Crops and Management. State Fund.

Methods of Handling Hay. (In co-operation with Engineering Section, Mechanical Division).

**Animal Husbandry Section**

Supervision of Dairy Cow Records. State Fund.

Acre Value of Pasture for Dairy Cows. State Fund.

Ration Experiments with Steers. State Fund.

Sunflower Silage for Dairy Cows. State Fund.

Rations for Fattening Lambs. State Fund.

Range Improvement. State Fund.

Winter Maintenance of Breeding Ewes. State Fund.

**Bacteriological Section**

Bacteriological Studies of Alkali Soils in Relation to Nitrogen Fixation. Adams Fund.

Nitrogen Fixation as a Function of Associative Action. Adams Fund.

Active Principle of Whorled Milkweed. Adams Fund.

Natural Innoculation of Colorado Soils with Legume Bacteria. Hatch and State Funds.

A Bacterial Disease of the Wragg Cherry. Hatch and State Funds.

Miscellaneous Vinegar Studies. Hatch and State Funds.

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

**Botany Section**

Microscopy of Stock Poisoning Plants. Hatch Fund.

Hard Seed of Alfalfa. State Fund.

Colorado Forage Grasses. State Fund.

Fungous Disease Survey. State Fund.

Fungous Diseases of the Sunflower. Hatch Fund.

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

**Chemical Section**

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

**Entomological Section**

Plant Louse Investigations. Adams Fund.

Ants of Colorado in Their Relation to Plant Lice. Hatch and State Funds.

Life Habits of the Syrphus Flies. Hatch Fund.

Control of Insects by Egg Treatment. Hatch and State Funds.

Codling Moth Studies. Hatch and State Funds.

Grasshopper Control. State Fund.

General Insect Investigations. State Fund.

**Forestry Section**

Studies in the Decay of Wood. Hatch Fund.

**Home Economics Section**

Cooking Quality of Colorado Potatoes. State Fund.

**Horticultural Section**

Hardy Stock for Apples. Hatch and State Funds.

Potato Investigations. Hatch and State Funds.

Fruits and Vegetables for High Altitudes. State Fund.

Hardy Tree Fruits for High Altitudes. State Fund.

Seed Potato Growing in High Altitudes. State Fund.

Effect of Diseased and Ill-shapen Seed Potatoes on Succeeding Crop. Hatch and State Funds.

Fruit Surveys. State Fund.

Tomato Variety Tests. State Fund.

**Irrigation Investigations Section**

Evaporation Experiment. Hatch Fund.

Meteorology. Hatch and State Funds.

Current Meters. Adams Fund.

The Venturi Flume. Adams Fund.

South Platte Investigations. Seepage and Return Waters. State Fund.

**Marketing Section**

Survey of Marketing Practices.

**Pathology Section**

Necrotic Stomatitis. State and Hatch Funds.

Contagious Abortion. State and Hatch Funds.

Chicken Diseases. State Fund.

Sheep Losses in Feed Lots. Hatch Fund.

**Veterinary Section**

Animal Diseases. State Fund.

Whorled Milkweed. State Fund.

**ENGINEERING DIVISION**

**Civil Engineering Section**

Road Materials of Colorado. State Fund.

**Mechanical Engineering Section**

Coefficient of Heat Transmission in Commercial Wall Boards. State Fund.

Methods of Handling Hay. (In co-operation with Agronomy Section). State Fund.

Respectfully submitted,

C. P. GILLETTE,

Director.

## REPORT OF THE EDITOR OF PUBLICATIONS

*To the Director*:

I have the honor to submit herewith a report of the activities of my office for the year ending November 30, 1920.

We have paid more attention during the past year to publicity for the purpose of getting facts about the Station and its work before the people of the State. In this we have used the newspapers, circulars direct by mail, and motion pictures. This type of publicity is, in my opinion, highly desirable and indeed very much needed. Heretofore, the custom has been to confine all publicity from the Experiment Station strictly to the dissemination of information and sufficient attention has not been paid to keeping the people of the State informed regarding their Experiment Station and the service it is rendering them. This publicity work should be greatly expanded and I would like to see it organized on a definite project basis.

### NEWSPAPER PUBLICITY

A full-page story was used in a special edition of the Colorado Manufacturer and Consumer, the story being well illustrated and telling of the work of the Experiment Station.

A similar story with illustrations was used in the Industrial edition of the Pueblo Chieftain.

A story regarding the steer-feeding experiment was written for the Denver Post.

Through this office a story about the steer-feeding experiment written by Mr. Maynard was supplied the Denver Record Stockman.

### GENERAL PUBLICITY

A four page circular profusely illustrated and done in two colors was designed and printed to advertise Cattle-feeders' Day, when the cattle-feeders of the State were invited to visit the steer-feeding experiment and hear the results of the work.

### MOTION PICTURES

A motion picture, "Colorado Experiment Station Tests Colorado Live-stock Feeds" was made and has been exhibited a number

of times. This picture is 850 feet long and tells the complete story of the steer-feeding experiment from the time the steers arrive at the feeding yards until they reach the Denver Union Stock-Yards and are sold, including all the various operations such as cutting into bunches of ten each, weighing, numbering, and feeding the various rations. This picture was shown continuously at the National Western Stock Show at Denver in January of this year, at a meeting of live stock breeders at Fort Morgan, at a meeting of Pomona Grange near Golden, at a meeting of the county agricultural agents and at various other places.

## PUBLICATIONS

Eight bulletins have been published by the Experiment Station, one by the Seed Laboratory, and two reports have been published, one for the Station and one for the Seed Laboratory.

The eight bulletins published by the Experiment Station totaled 297 pages, with a combined edition of 25,500. The Seed Laboratory bulletin was of 16 pages. Following is a complete list of Station publications:

| Bulletin No. | Title and Author | No. Pages | Number Published |
|---|---|---|---|
| 251 | "Identification and Control of Colorado Weed Seed" By W. W. Robbins and Breeze Boyack | 126 | 5,000 |
| 253 | "Irrigation Water as a Factor in the Dissemination of Weed Seeds" By G. E. Egginton and W. W. Robbins | 25 | 3,000 |
| 254 | "Orchard Survey of Fremont County" By E. P. Sandsten and C. M. Tompkins | 28 | 3,000 |
| 255 | "Whorled Milkweed", (The Worst Stock-Poisoning Plant in Colorado) By W. L. May | 39 | 3,500 |
| 256 | "Horticulture at High Altitudes" By R. A. McGinty | 19 | 3,000 |
| 257 | "Factors that Affect Alfalfa Seed Yields" By P. K. Blinn | 32 | 6,000 |
| 264 | "Perennial Peppergrass" By A. K. Peitersen and R. T. Burdick | 10 | 4,000 |
| | **TECHNICAL BULLETINS** | | |
| 252 | "Honey as a Carrier of Intestinal Diseases" By Walter G. Sackett | 18 | 2,000 |

**SEED LABORATORY BULLETINS**

| | | |
|---|---|---|
| "The Colorado Pure Seed Law" By W. W. Robbins | 16 | |

**REPORTS**

| | | |
|---|---|---|
| "Thirty-Second Annual Report of the Agricultural Experiment Station" By C. P. Gillette | 37 | 1,500 |
| "Third Annual Report of the Colorado Seed Laboratory" By W. W. Robbins and G. E. Egginton | 28 | |

**SPECIAL**

| | | |
|---|---|---|
| List of Bulletins | 4 | 10,000 |

All of these bulletins contained much valuable information and those classified as "popular" were, for the greater part, so written and illustrated as to be of real and immediate value to the farmer and layman. Their contents are quite clearly indicated by their titles.

Six bulletins are in the process of publication. Two of these will be popular bulletins and the other four technical. The popular bulletins are, "Potato Investigations", by Dr. Chas. Clark, and "Sod Diseases of Chickens", by Dr. I. E. Newsom and W. H. Feldman. The remaining bulletins are, "Fixation of Nitrogen in the Wellington District", by Dr. W. P. Headden, "Colorado Plant Diseases", by Julian G. Leach, "Colorado Weed Seeds" by Geo E. Egginton, and an index of Experiment Station publications by Miss Arlene Dilts. All these bulletins are in the hands of the printer, are already in type and practically ready for publication with the exception of Dr. Headden's bulletin which recently came back to this office after a revision, and for printing of which new bids will be secured.

Respectfully submitted,
RALPH L. CROSMAN,
Editor of Publications.

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**AGRICULTURAL DIVISION**

## REPORT OF THE AGRONOMIST

*To the Director*:

The year just closed has been one of readjustment of affairs in the Agronomy Section. Mr. Breeze Boyack left us the first of April, after having been in the work for six years. To replace Mr.

Boyack, Mr. David W. Robertson was employed. Mr. Robertson came to us from the University of Minnesota, having received his Master's degree there. Mr. Robertson, of course, came to us without any experience under our conditions and he has to learn the lines of work under way, learn our field conditions and many other things necessary to be picked up before he is familiar with cropping and soil situations. He is taking hold rapidly. No matter if he proves to be as able as Mr. Boyack, it will take him at least three years to get as fully in touch with the work. It is quite probable that some of the incompleted lines of work which Mr. Boyack was carrying will be lost because of this change. We have been in correspondence with Mr. Boyack. He has agreed to come back for a period during the winter to attempt to get into manuscript form so that we can publish (if the material justifies it) much of his back work.

During the season, the so-called East Farm has been turned over entirely to the Agronomy Section. The transfer, however, was not made until rather late this fall, owing to the fact that the new Military barns on the west campus were not completed in time for an early transfer. This change will make it possible for us to house individual plant selections under shed. The past few years we have had to stretch a wire in the field and shock these selections against the wire, attempting to protect the bundles as much as possible by covering with canvas. There has always been some destruction and loss by winds, storms, mice and birds where so handled. By stretching suitable wires in the sheds, these bundles can be hung so as to permit thoro drying, they will be protected from the weather, they will be protected from rodents and they can easily be screened off from birds, either by wrapping of heads or by screening the openings in the building. This is an improvement which we have needed for a long time. This method effects still another economy, in that during stormy weather, threshing of the small bundles can commence when outside work can not go on at all.

We have pulled out most of the cross fences in the old corrals and all of them in the old paddocks. We have started to build and have partially completed a new fence on the west line and on the south line, covering the ground formerly occupied by the horse-breeding pastures. There is still some further fencing to be done.

We have started repairs and alterations on the barn, which will be converted into a seed storage building. Concrete floors have been put in the east box stalls and also in the two wing buildings at the south. These will be lined with quarter-inch mesh wire screen, in order to make them mouse- and other vermin-proof.

When so fixed, grain can be stored in these places in bags. If we wish to construct tight bins, the lumber can be simply put over the screen. The fund allowed for such repairs will not be large enough to do all. We will be able, by taking a little out of our regular budget, to supplement the repair fund to put the buildings in shape so that we can store grains with safety. But the necessary repairs will not be completed. These changes and alterations will very materially improve our equipment and make it possible for us to handle the increase seeds and purified plants, which we have not been able to handle in the past. Some of our new creations will soon be ready, thru increase, to commence preliminary distribution, a type of work which has been almost prohibited by our grain storage facilities in the past.

We have many further improvements which are needed, such as the installation of an elevator, the installation of further bins, and numerous other minor repairs of this general nature, which will put the buildings in shape and make them usable for the new purposes.

I think it will be desirable to plan improvements in the irrigation system, especially for the lawns, so that we can irrigate the lawns from the ditch instead of having to use the more expensive city water. The nice lawns which always surrounded these buildings should always be maintained because this spot is more or less of a show spot.

The work of the year has been carried on under three general funds—the Adams Fund, Hatch Fund and Station Tax. Some few items, I believe, have been contributed by the Station Special.

The Adams Fund work was entirely carried on at the Fort Collins plant. The project under the Adams Fund was entitled "Critical Periods for Water in Plant Development." We are using wheat this year. Fifty plots, each 1-500 of an acre in size, were used. These plats were laid out in series and covered with canvas covers to prevent the natural precipitation from reaching the plats. Each plat was then watered under a pre-determined schedule, applying the water at different periods in the growth of the crop. The exact results are not reported here, but will be reported in a separate, individual report.

Under the Hatch Fund the Correlation work, which has been going for several years, was continued. We hope to close out some features of this work during this winter when Mr. Boyack is here by preparing those features for publication. The Alfalfa project under the Hatch Fund was carried by Mr. Blinn at Rocky Ford. The alfalfa project was aimed primarily for the last few years to find some of the underlying reasons why alfalfa does not seed well

in the Rocky Ford district. We have been able to breed up improved strains of alfalfa, but we have run into the difficulty that no alfalfa would seem to produce a good yield of seed. We have tried about all of the methods that we could think of of water control, both in the field and in specially designed concrete tanks. While we get some influence in such water control, the amount of water is evidently not the only factor involved. We put some plants under glass the past year to see if heat were a contributing factor. The results obtained were not at all conclusive. I rather imagine that before we get thru we will have to make a serious soil study, using distilled water or rain water as a source of irrigation supply. We have been a little reluctant to attack some of these phases of the problem because of the high initial expenditures that would have to be made and because of the difficulty of getting nitrate-free water. We would have to put up a still and distill water or we would have to put up suitable metal tanks to collect rain and snow water during the rainy seasons or else use city water from the Rocky Ford city supply, which is brot down from Fountain. The city water, however, carries considerable mineral matter. This would introduce a disturbing factor. It is a factor that would be exactly the same for all plats receiving the same amount of water. Practically all of the soils and even the irrigation water in the Rocky Ford and other Arkansas Valley districts carry more nitrate than is absolutely essential for the best production of crops. It is quite possible that our problem of alfalfa seed production is one of too vigorous vegetative growth, due to high nitrate content. But we cannot be sure of this until we eliminate the different variables by experimentation.

Under the Station Tax Fund, we have been carrying the Pure Seed project. The work on this project for the year consisted of some increase work, a great deal of selection work, and some purification work. With this project it has been necessary to start cleaning up certain land where pure seeds could be put without danger of mixing from volunteer material, and also to get seeds under control. Our corn end of this project has been under way and we had tests out, not only on the Station farm, but in over eight different counties where such corn could be kept under observation. The season of 1920 was an unusually good one to check on adapted corn varieties. August was cool and moist. Corn stood still in its development and, as a consequence, all of the corn which was anything like late maturing got caught more or less by the frost. Some pure grains were put out for local test in two or three localities.

The Farm Management work or cost surveys were not vigorously pushed during the season. Mr. Burdick felt that he was

not well acquainted with the territory and the work which had been done, so he proceeded first to make a study of all previous records gathered, and second ,to go into the field and get in touch with the territory and some of the men from whose farms the records came. I think this work was essential because it will put us in the way of going forward with our cost studies more vigorously because of this part of the orientation.

The work at Cheyenne Wells has gone forward under the regular plan. The sale of land which we had previously leased adjoining the Cheyenne Wells farm has made it necessary to search vigorously and to plan seriously on how we are going to continue the management of this situation. Mr. Adams has this fall succeeded in leasing a quarter section in striking distance of his tract. Owing to the amendment campaign and to rather heavy duties here on the campus, I have not been able to visit the Cheyenne Wells station this fall in order to crystalize our plans for that work. I have held up repairs which were authorized until we could get these plans crystallized and approved.

The work at Fort Lewis was again started by the appointment of Mr. L. R. Quinlan to carry the joint Agronomy and Horticulture work at Fort Lewis. While I believe the work has been better carried than ever before, we have run into the annual difficulties of the attempt on the part of the Fort Lewis management to pull Mr. Quinlan off of necessary work and put him onto service work, a system which cannot be done and have research work accomplished. We must bring still further pressure to bear to correct this situation. We realize perfectly that part of the situation is due to the difficulty of getting labor and very meager funds at Fort Lewis. But, nevertheless, a condition exists which must be corrected before we can get investigational work going vigorously in that high altitude locality.

Like the Experiment Stations all over the country, we have suffered from a loss of personel. We are in hopes that settled conditions have arrived which will enable us to go ahead continuously on a policy. With these settled conditions of employment and a little better financing we should be able to go forward and develop more strongly than ever our agronomic work. We have been partially held back from certain factors of the work by lack of sufficient land to permit cleaning up of certain rotations. This has been remedied. We have been obliged to postpone certain work because of a lack of suitable storage place for seeds and other requisites. Some time in the future we must look forward to the establishment of greenhouses to enable us to carry forward certain features of the

work in the winter as well as in the summer. In certain of our breeding work, the use of greenhouses would split in half the time at present resuired because we could make the first crosses in the greenhouses and grow two crops in a year where only one may be grown outside. Thus we could take the stuff outside as soon as there were seed enough to start a test. There are many problems which we encounter along soil lines which we cannot solve without some equipment and without further laboratory equipment which some such equipment and without further laboratory equipment which we must plan to add as funds permit in the future.

Respectfully submitted,
ALVIN KEZER,
Chief Agronomist.

## REPORT OF THE ANIMAL HUSBANDMAN

*To the Director*:

The last year's work in Animal Investigations has been chiefly the carrying on of several lines of work planned to cover a series of years. The results on these have accumulated to the point where we can now publish.

Some new work has also been started, and these new projects, we hope, will run for a number of years. These new experiments are, the Range Improvement Investigation, Relation of Sheep to Dry Farming Conditions, Sunflower Silage for Dairy Cows, and Winter Maintenance of Breeding Ewes.

It will be two or three years before we shall have material for publication on these, except in the form of progress reports.

Following is a detailed statement of the status of the various investigations prepared by Mr. E. J. Maynard, Associate in Animal Investigations:

### FEEDING BEET BY-PRODUCTS TO STEERS

A three year series of cattle feeding tests, dealing with different methods of handling beet tops and rations containing the different beet sugar by-products and corn silage, cake and alfalfa will be terminated this winter and a bulletin will be published covering the work done. This will make two "beef-making" bulletins covering two "three-year" series of work carried on here at the Station that can be put out this coming spring to be available for Colorado cattle feeders next fall.

Preliminary results already completed have seemed to indicate that when weather conditions are favorable, pasturing beet tops in the field will prove the most economical method of feeding them to cattle.

For the man who has no wet pulp or corn silage available, the beet top silage should prove economical. Fed in a limited quantity (20 pounds per day per 1000 pound animal) it will furnish the necessary succulent feed throughout the feeding period.

The advisibility of siloing tops will depend largely on labor and teams available during the beet hauling period. Silage should be made within a week or ten days from the time the beets are topped. Under favorable weather conditions, however, pasturing the tops has proved most economical.

Beet top silage assures a succulent feed from the tops regardless of weather conditions. A bad year may cause such costly gains on steers that the feeder might better sacrifice the tops than attempt to pasture them. At the same time, steers apparently do so much better on pastured tops that one could afford to take a total loss on tops once in three or four years under the pasturing plan if it is not feasible for him to insure the crop by siloing.

Data from the steer feeding tests include information concerning the feeding value of wet beet pulp, dried molasses beet pulp, beet molasses, ground barley, ground corn, cottonseed cake, beet-top silage, pastured beet tops, dried beet tops, corn silage and alfalfa hay.

### BEET SUGAR BY-PRODUCTS FOR LAMBS

Owing to the large number of lambs fattened off yearly in Northern Colorado, and the numreous calls for information regarding different rations, it was thought advisable to test out the value of beet molasses, dried molasses beet pulp and wet pulp in the lamb fattening ration, and also to determine the comparative value of corn, oats and barley fed with these by-products.

The following test is at present in progress:

#### RATIONS BEING FED

1. Corn and alfalfa.
2. Corn, molasses, alfalfa.
3. Barley molasses, alfalfa.
4. Oats, molasses, alfalfa.
5. Dried molasses beet pulp, alfalfa.
6. Dried molasses beet pulp ½, corn ½, alfalfa.

7. Dried molasses beet pulp ⅓, corn ⅔, alfalfa.
8. Corn, wet beet pulp, alfalfa.

**RELATION OF SHEEP TO DRY FARMING CONDITIONS**

The animal investigation section of the State Experiment Station co-operating with the government field station at Akron, Colorado, is trying to determine the value of sheep on the average dry land farm. An experiment which has just been started at the Akron field station has been planned with the idea of showing the benefits that can be secured by carrying a breeding flock of sheep along with the general dry farming scheme from year to year.

It is believed that the sheep will tend toward a cleaner cultivation of the land by eating the weeds and that the different fields included in a rotation will, at different times during the year, furnish stubble and fodder that will tend to keep the maintenance cost of the flock at a minimum. In the case of fallowed land, it is believed that, at least, one cultivation can be saved where sheep are allowed to keep the land free from weeds. At the same time data are being secured on the carrying capacity of the native sod and botanical observations on the flora are being taken to secure complete information regarding grazing problems.

The test has been planned to include three lots of ten ewes each.

These three groups are being run respectively on three ten-acre plats. The first plat consists of native sod alone which is used as a check to show the carrying capacity of typical grazing land. The second and third plats represent miniature dry land farms each having eight acres under cultivation and two acres in native pasture.

The land under cultivation in these two plats comprises two standard dry land rotations. In one plat the rotation will be corn, barley, summer fallow and winter wheat. In the other plat the rotation will consist of corn, barley, winter rye (pastured in spring and then turned under), and winter wheat.

The sheep secured for this test are 2-year-old grade Rambouillet ewes. They produced this year a 90 per cent lamb crop, and consequently there are nine lambs included with each lot. The lambs will be pastured along with the ewes until fall, each year, at which time several of the best ewe lambs will be saved with the idea of gradually replacing the flock and making it a permanent one. The remaining lambs will be sold each fall.

As will be noted, the experiment this year has been planned for all three lots on the basis of one sheep per acre. This experiment should furnish some valuable facts for dry land farmers. It is planned to issue a report this winter covering the first summer's work.

### ACRE VALUE OF PASTURE FOR DAIRY COWS

An area of two acres planted to a pasture grass mixture has been tested out by comparing the pasture to a ration of alfalfa hay and corn silage as fed to dairy cows. The test this last year was not representative inasmuch as only one irrigation was secured. The pasture dried up the middle of July.

It produced considerable forage again during the early fall.

Results so far secured have seemed to indicate that irrigated pasture should carry one and one half to two cows per acre throughout the summer.

### SUNFLOWER SILAGE FOR DAIRY COWS

Sunflower silage was fed along with a grain mixture and alfalfa in comparison with corn silage, a grain mixture and alfalfa. It was found that the sunflower silage was not as palatable as corn silage and that in some instances the cows would not clean it up. In practically every case the cows eat less sunflower silage than they will take of corn silage.

The milk and butter fat production was not as high with the sunflower silage, (butterfat 86%, milk 91%), but taking into consideration the fact that the sunflowers yielded more than twice the tonnage per acre, the test seemed to show sunflower silage in a favorable light. More data will be secured on this experiment during the present year, and conclusions should not be drawn on the limited experience now at hand.

### RANGE IMPROVEMENT

Practically 540 acres of low range and foot hill pasture land have been turned over to the Animal Investigation Section. In cooperation with the Forest Service and the Botany Department plans have been made to test out different systems of Range Management with a view toward ascertaining the most practical methods for Colorado stockmen to follow in building up their range lands. The land was allowed to reseed this fall and was late fall pastured by 60 head of long yearling steers. It is planned to put cattle on the land next spring after dividing the range into three areas.

I. Check - Range land pastured from early spring to late fall continuously.

II. Deferred grazing System.

III. Rotational Grazing System.

**WINTER MAINTENANCE OF BREEDING EWES**

The ewes comprising the college purebred flock have been divided into two lots, and are being carried on maintenance rations during the winter as follows:

I. Alfalfa.

II. Alfalfa and corn silage.

They are being kept at an even weight throughout the winter. In the spring data will be kept on the birth weight and condition of their lambs.

Last spring a Cattle Feeders' Day was held at the College at which time results of the current test were given out. The following program was planned:

Assembly at Stock Judging Pavilion

Address of Welcome ..... Dr. Chas. A. Lory
President of College

Visit to the Experimental Pens

The Object ..... Geo. E. Morton
Head of Animal Husbandry Department

The Results ..... E. J. Maynard
Animal Investigations

The Commission Man's Point of View ..... Clyde B. Stevens
Clay, Robinson & Co.

The Packer's Point of View ..... H. F. Blayney
The Coffin Packing Co.

Lunch at College Dining Hall

Assembly at Civil Building

The Feeder and the Experiment Station..... C. P. Gillette
Director of Experiment Station

Feeding Beet By-Products for Profit..... Hans Mendelson
Agriculturalist Great Western Sugar Co.

The Meat Situation ..... J. Wallwork
Head Cattle Buyer, Armour & Co.

Future Outlook for the Cattle Feeder in Colorado.....
..... E. M. Ammons
Former Governor of Colorado

Owing to severe weather conditions the attendance was very poor, although the program was good.

It is planned this coming spring to hold a Livestock Feeders' Day at the finish of the cattle feeding experiment, possibly in April. At this time results secured during the year can be given out if advisable. In fact this Feeders' Day will be made an annual affair and a sort of clearing house for information of value to livestock feeders secured during the year.

An exhibit covering some phase of the work carried on was put up in connection with the College exhibits at the National Western Stock Show last year, and it is planned to include a similar exhibit this year.

Respectfully yours,

GEO. E. MORTON,

Chief.

## REPORT OF THE BACTERIOLOGIST

*To the Director*:

I have the honor to submit herewith the annual report of the work of the Bacteriological Section of the Experiment Station for the year 1920.

Five lines of investigation connected with definite projects have been undertaken during the past year. Three of these have been classified as Adams and two as Hatch. In addition to these we have carried miscellaneous vinegar studies and conducted numerous examinations of diseased plants, soils, farm waters, etc.

### ADAMS FUND PROJECTS

**Bacteriological Studies of Alkali Soils.**

The presence of small quantities of nitrates on the country rock has suggested that these salts might owe their origin to bacterial action. The fixation of atmospheric nitrogen being the first step in this process, we have made a study of these bacteria, from the Book Cliff and Mesa Verde sandstones, capable of growing on a nitrogen low agar, and have determined their ability to fix atmospheric nitrogen both in pure cultures and when associated with one another. The results indicate that such microorganisms are present, and that although the amount of nitrogen fixed is small, the fixation is consistent. Associative action appears to play no important role in this process. Rock lichens have been shown to be capable of satisfying all carbon requirements. Fourteen pure cultures and their combinations have been examined in this investigation.

**Heat resisting bacteria in flesh and canned vegetables and their relation to spoilage.**

This project was not begun until near the close of the fiscal year, and but little progress was made except to visit a number of the canneries of the state, become acquainted with their spoilage problems, and obtain material for subsequent examinations.

**Food poisoning in sheep and cattle.**

*Asclepias galiodes* or whorled milkweed, a poisonous plant responsible for the death of many sheep, cattle and horses in Colorado, has been shown to contain a glucoside. Just previous to blossoming time, this active principal is most abundant in the leaves and little if any is present in the stems. In addition to the glucoside, we find various resins, some of which may be poisonous. The purification of the active constituent has been extremely difficult and nothing in the nature of a pure product has been obtained as yet.

## HATCH FUND PROJECTS

**The natural inoculation of Colorado soil with legume bacteria.**

The increased demand for information regarding the advisability of pure culture inoculation of legumes together with the somewhat extravagant claims by certain commercial firms for their products in connection with legumes in Colorado, has made necessary a rather extensive examination of soils with a view to ascertaining the extent of natural inoculation, both in virgin and cultivated tracts. Representative samples from both dry and irrigated sections have been planted with numerous different legumes, and after six weeks the plants have been examined for nodules. Thus far we have completed our test of forty-five soils and have several parts of the state yet to sample. While it is impossible to generalize the results, we may say tentatively, that they indicate a rather general and natural inoculation for alfalfa, sweet clover, and vetch; and the need of inoculation for peas and beans. Artificial inoculation of alsike and red and white clover would doubtless prove beneficial.

**Bacterial Disease of the Wragg Cherry.**

Additional inoculation experiments and cultural studies of the causal organism have constituted the work in this project. Further spraying experiments are being planned for the coimng year.

**Vinegar Studies:**

Relatively recently there has appeared a popular fad of making vinegar from molasses, sugar, and water with the use of "vinegar bees." So much of the resulting product has been of inferior

quality and the spoilage from its use has been so great, that it was deemed worthwhile to study the possibility of making vinegar from the above ingredients. Our results indicate that good vinegar from "vinegar bees" is very uncertain; whereas the use of pure cultures produces a very satisfactory molasses vinegar in from six to eight weeks.

Another phase of this question to which we have given some attention is the possibility of utilizing waste cantaloupes from the seed producing sections of the state for vinegar. The results of our experiments have shown that the fresh cantaloupe juice does not contain sufficient fermentable sugar to produce the alcohol necessary to make marketable vinegar. It is entirely possible, however, that this juice could be concentrated to a point where the sugar content would satisfy the requirements of a vinegar stock.

Respectfully submitted,
WALTER G. SACKETT,
Bacteriologist.

## REPORT OF THE BOTANIST

*To the Director*:

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

The investigation work of this section has been somewhat handicapped by the changes in the personnel and the subsequent readjustments necessarily following such changes. All present staff members have taken up their respective positions here sometime during the past fiscal year, each worker following his (or her) predecessor after an interim of from one to four months. The writer took up his duties as botanist January 1, 1920, following Dr. W. W. Robbins' resignation in October, 1919. Mr. C. D. Learn of the Oklahoma Agricultural College and Experiment Station, fills the position made vacant by Mr. J. G. Leach, who resigned July 1, 1920. Mr. E. C. McCarty has taken up some investigational work in grazing following Mr. W. L. May, who resigned to take up some work in the office of the State Entomologist. Miss Anna M. Lute of the Federal Seed Laboratory, Washington, D. C., fills the position of Seed Analyst and is continuing the Hard Seed investigational work begun as a Station project by Mr. C. E. Egginton.

It has been our aim to discontinue such projects as seemed best in view of the changes in the staff. Bulletins covering the

work of these projects so far have been published or are being submitted for publication. The projects that have been actively taken up are as follows:

1. Microscopy of Stock-poisoning Plants (Hatch) (Peitersen)
2. Fungus Disease Investigation (State) (Peitersen, Leach)
3. Hard Seed of Alfalfa (State) (Peitersen, Lute)
4. A Fungus Disease of the Sunflower (Hatch) (Learn)
5. Range Improvement Project (State) (Peitersen, McCarty)

The following Station bulletins have been published:

Bul. No. 253.—Irrigation Water as a Factor in the Dissemination of Weed Seeds. By G. E. Egginton and W. W. Robbins.

Bul. No. 255.—Whorled Milkweed. By William May.

Bul. No. 259.—Colorado Plant Diseases. By J. G. Leach. (Now in press.)

Bul. No. 260.—Colorado Weed Seeds. By G. E. Egginton. (Now in press.)

Bul. No. 264.—Perennial Peppergrass. By A. K. Peitersen and R. T. Burdick.

Respectfully submitted,
A. K. PEITERSEN,
Botanist.

## REPORT OF THE CHEMIST

*To the Director*:

No change has been made in the general project on which we are engaged, except to direct our activities during the past season principally to the study of the variation in the nitric nitrogen in the soil in which we have grown potatoes to study the effects of nitric nitrogen upon the growth and characteristics of this plant. We are now engaged in analyzing samples of the potatoes produced, with and without the application of nitrates. Owing to a hail storm, that seriously injured the plants, the season's work will have to be repeated, but it is advisable for us to investigate the extreme members of our series to see what we effected under the conditions that we had this season. Of course, we may find it necessary to reject these results, but we can do no less than carry the extreme members of the series through, for it may be that these results may prove of value to us in future work, or may be of value

by themselves in several ways. The storm that injured the vines and potato crop will have no other effect upon our work than to reduce the number of series that we shall carry through. The potatoes and their ashes will be examined just as though no storm had occurred to interfere with the experiments.

We have been unable to do any work in the Arkansas Valley on the Cherry-tree trouble for two reasons; first, we have been engaged with our full force on the Potato work and, second, we lost our trees last winter. I have some young ones growing, but they are not nearly large enough yet to experiment with.

The niter conditions in the San Luis Valley really need our attention, for great changes have taken place, I might say, throughout the Valley, since we have done any actual work there. The changes are very much for the better. It is a matter of regret to me that I was not in this field to observe these from time to time. The improvement is great and very general. The one cause to which this improvement is apparently to be attributed is the drainage. Whether this is the real cause, or only apparently so, is, to my mind, a matter worthy of study, and it is unfortunate that we have no continuous observations on these changes and their causes. Drainage has been introduced on a large scale in some sections since we did our last work in the Valley and the changes for the better have occurred in the meantime. It is natural that the two should be associated in the minds of all as cause and effect. I am not satisfied that this is directly the case; for, in the meantime, the farmers have largely changed their system of irrigating, and there are other points which have no place in this report.

We have done some work on our niter project in the Wellington section. We have incorporated the results in a bulletin on this section, that has gone to press.

In regard to the occurrence of nitrates on rocks, we have gathered some data during the season, but our work can only be partial owing to the fact that the further study of the bacteriology involved was not deemed advisable. Further, we have not been able to see our way clear to gathering samples from the interior of the various rock formations. Sandstones seem to be the best suited for our purposes, but there is no longer any quarrying done that I know of that is available for us, and I have not been in the field that I might find opportunities for gathering such. I would like very much to bring this branch of my work to an end at the earliest possible date, but there is much work that should be done.

I have no suggestions to make in regard to new projects. We

have more now than we can simultaneously prosecute, but usually they fit into different seasons of the year.

There have been some changes in the organization of the section.

Respectfully submitted,

WM. P. HEADDEN,
Chemist.

## REPORT OF THE ENTOMOLOGIST

*To the Director*:

All the projects assigned to the Entomology Section have received some attention during the year, and no new projects have been added.

Mr. George M. List, Chief Deputy State Entomologist, has given considerable time, principally as Chief Deputy, but partly as an assistant in the Experiment Station, to the Codling Moth, the Fruit-tree Leaf-roller and the Alfalfa Weevil investigations. Mr. J. H. Newton, chiefly as Deputy State Entomologist, but receiving part pay from Experiment Station funds, has given his time to Alfalfa Weevil investigations and Codling Moth life history and control work in Delta County. Prof. C. R. Jones has full charge of the projects dealing with Syrphus Flies, Ants in their Relation to Plant Lice, and Grasshopper Control. Miss M. A. Palmer has given most of her station time to drawings to illustrate papers being prepared on the Syrphus Flies and the Plant Lice and to life histories of the aphides. Mr. J. L. Hoerner has been in charge of the insectary work and has acted as a general assistant in the entomological work. Mr. L. C. Bragg, who was giving most of his time to Plant Louse Investigations, found it necessary to withdraw from the station work early in the summer because of failing health, and no one has been employed to take his place.

A brief mention of the work done on each of the projects might be of interest.

*Plant Louse Investigations.* Considerable work has been done on life-histories and food-plants and numerous technical drawings, and progress on the preparation of a paper for publication has been made, and many specimens have been added to the already large collection of species.

*Ants of Colorado in their Relation to the Plant Lice.* A large collection of material for study has been made upon which some systematic work has been done.

*Life Habits of the Syrphus Flies.* Some additional data have been collected but most time has been given to the preparation of a paper giving the known Colorado species with our present knowledge as to habits. Prof. Jones has this paper nearly ready for publication. It will be accompanied by colored plates of the more common species and many detail drawings made by Miss M. A. Palmer.

*Control of Insects by Egg-Treatment.* Considerable additional information has been accumulated on the effects of insecticides upon the hatching of insect eggs by the writer, with the assistance of Mr. Hoerner.

*Codling Moth Studies.* A large amount of data has been collected on the life history of this insect at Paonia, Delta County, by Mr. J. H. Newton, and by Mr. Wm. P. Yetter, Deputy State Entomologist, at Canon City. Mr. Newton also carried on very carefully conducted spraying experiments to determine their value for the control of this insect, with good resluts. Mr. Newton and Mr. Yetter will spend much of their winter tabulating and correlating the data in hand.

*Grasshopper Control.* The only work done upon this project during the year has been in response to calls for assistance in grasshopper control and in writing letters of information. The work is in direct charge of Prof. Jones.

*General Insect Investigations.* This project is continued from year to year to enable us to carry on timely investigations or collect data upon any insect outbreak that may occur from time to time and that can not be anticipated with any certainty. A few notes upon the more important will appear in my Annual Report as State Entomologist. Prominent among these are the Melon Louse, *Aphis gossypii;* the Harlequin Cabbage Bug, *Murgantea histrionica;* two of the web-worms, *Loxostege sticticalis* and *L. commixtalis;* the Fruit-tree Leaf-Roller, *Archips argyrospila;* the Spotted Bean Beetle, *Epilachna corrupta,* and the Alfalfa Weevil, *Phytonomus posticus.*

Considerable work has also been done, chiefly by Mr. John L. Hoerner, in collecting data on insects coming to light and recording the numbers of each sex appearing each night thruout the summer. We have found these data of much importance in their bearing upon the number of generations and the dates when egg-laying is at its height.

On account of the extremely heavy losses to the apple crop during the past two or three years in the Grand Valley, we are planning to concentrate our efforts in co-operation with the grow-

ers, to bring this insect under more satisfactory control thru the formation of pest districts under the Pest Inspection Act.

Respectfully submitted,

C. P. GILLETTE, Entomologist.

## REPORT OF THE FORESTER

*To the Director*:

I herewith submit the annual report of the Section of Forestry for the past year.

The only project now in force is the one which has been carried on for the past four years, dealing with the measurement of decay in timber. All of the original species under investigation were finished with last year. Since then a set of Redwood specimens from the Pacific Coast has been under observation. After a period of more than a year and a half, the specimens show very little indications of decay. It appears at present that the claims made for this species as a timber of great durability in contact with the soil are fully justified.

Within the past year a set of specimens of *Populus acuminata* has been put under test conditions to determine what effect the seasoning of this wood has upon its durability as compared with green or unseasoned wood. It is too early at present to offer any definite results upon this phase of the work. Another set of test specimens to show what difference, if any, in rate of decay may be caused by planting the wood with bottom end up or top end up in relation to the way it grew in the tree.

A preliminary report of the work done is now under way.

Respectfully Submitted,

By B. O. LONGYEAR,

Assoc. Prof. of Forestry.

## REPORT OF HOME ECONOMICS SECTION

*To the Director*:

In October 1919 work on the cooking quality of Colorado Potatoes was begun.

Potatoes of four types (Pearl, Brown Beauty, Rural, Burbank) were obtained from the San Luis Valley. Each hill was handled, kept and examined individually. Potatoes of the above types, ex-

cept Brown Beauty, but including four others (King, Triumph, Ohio, Downing) were obtained from the Greeley district. Owing to the lateness of the season we were obliged to get these Greeley potatoes from the ware-houses; of each type, three different sizes were selected.

During the academic year, 1919-'20, extensive chemical analyses covering the water content of all the above types of potatoes were carried out, likewise the total nitrogen content of the San Luis potatoes was determined.

Owing to the poor condition of the Greeley potatoes it seemed likely that more comparable results would be secured could potatoes taken directly from the hills be obtained.

Several series of cooking experiments involving comparative tests of palatability, relative economy, and waste of the different types of potatoes from these two localities were carried out. As indicated above, it was felt that the poor condition of the Greeley potatoes rendered the results unfair to that region.

For this year's work, twelve hills each of Pearls, Rurals, Brown Beauties, Burbanks, each hill being handled separately, have been obtained from the San Luis Valley and from the Greeley district; also Burbanks from Carbondale; Burbanks, Red McClures, Ohios, Cobbler, Triumphs and Pearls from the Arkansas Divide. It is expected to get samples of the last three types from Greeley, for comparison. It is planned to make extensive determinations of moisture, carbohydrates, nitrogen, and ash on the above material. Comparative cooking tests will also be carried out.

Respectfully Submitted,

N. E. GOLDTHWAITE.

## REPORT OF THE HORTICULTURIST

*To the Director*:

The following is a brief report on the experimental work carried on in the Horticultural Section during the past year:

The work at Fort Lewis on small fruits and potatoes is in progress but we have not yet received any definite report as to the yield of potatoes from Mr. Quinlan. His report merely states that the potatoes were harvested and separated according to the classes and varieties. Apparently the crop was below normal.

The work on potatoes in the state may be divided into two general lines; first, the project to determine the influence of poor seed, other than culls, on the yield, as compared with selected seed.

During the two years that this work has been in progress, it appears that poor seed, such as that showing roughness, gnarliness, and ill-shaped tubers, is producing a normal crop under normal conditions, and that, in one or two cases, the yield from such tubers has exceeded the yield from selected tubers. This is especially true when an equal number of hills have been compared. Where there has been a difference in favor of the good seed on a given acreage, the higher yield of the good seed, has in most cases, been due to the better stand and to more vigorous plants because of larger seed pieces, giving the young plants a better opportunity in establishing themselves before the development of the root system.

We want to continue this work for another year or two before publishing. It is rather a difficult matter, and whether we shall publish the direct results of our work so far, will depend upon circumstances, because the growers are apt to be misled by the results, especially when we are endeavoring to encourage them to use better seed.

The other line of work has to do with certification, or the importance of good seed potatoes. In this line we have made considerable progress, and the growers are greatly encouraged in the work because of the relatively high prices obtained for the certified seed. We want to continue this work, possibly under slightly modified regulations. We hope to finally select the better growers in a given community, so as to build up a community industry. The scattered growers, especially of small acreage, cannot hope to develop this particular work. It must come thru community efforts and by the better growers. About 200 applied for inspection, 60 certificates were given.

This year, the second year of variety tests with tomatoes has been completed. We had certain factors such as disease, and unfavorable weather which seriously affected the plants so far as yield is concerned, though the figures obtained will be used in a comparative way, thus minimizing the bad season. The work has progressed far enough to warrant us in eliminating two-thirds of the former varieties under trial and concentrating on the few remaining ones. This will be undertaken next year, and we hope to close the work with the end of next season and make the report.

On the apple project I can only report progress. If we are fortunate enough to get through the winter without serious damage, the orchard will be in fairly good shape. We came through last winter better than we had expected.

The pear project must be closed and failure written over the project so far as positive results go, but success in showing that pears cannot be grown commercially in this section of the state.

The fruit survey work has been completed, and we are now at work compiling and editing the results. It will be brought forward in one complete bulletin and report by mid-winter. We, in addition, still have to publish the survey work of the eastern section and of Montrose County, but we hope to finish all of these surveys in time for the Legislature. In connection with this project which was undertaken jointly by the Station and the State Horticulturist, the work on the keeping qualities of apples in cold storage at different seasons of ripeness or maturity, is in its second year of progress. We hope to close this up by January or February and publish results.

We are endeavoring to work out a better method of determining the ripeness of fruit, especially apples, for picking, as at present there is no standard except the individual judgment of the grower or the buyer, and this is not always reliable.

Since the last annual report, one bulletin on an Orchard Survey of Fremont County has been published, and Professor McGinty's bulletin on Horticulture in High Altitudes. We hope to be able to get out several publications during the winter.

Respectfully submitted,

E. P. SANDSTEN,

Horticulturist.

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## REPORT OF THE IRRIGATION INVESTIGATIONS ENGINEER

*To the Director*:

The fiscal year just closed has brought forth a number of interesting things in connection with our several projects under investigation. The nature of most problems that are worthy of consideration is such that, after following along a definite line, one is soon confronted with several other subsidiary conditions that threaten to be of major importance. It appears that in these secondary problems lies much of the interest of the investigation. This fact seems to be particularly borne out in the results of the work for the past year.

During this fiscal year we have made progress on three of our main projects, and have virtually concluded the field work on the South Platte River investigation. The study of the Venturi flume, an Adams project, has been partially completed and a report submitted, with the intention of publishing the results of our investigation. This bulletin is to be issued as a Station publication. Since

completing the investigation along the line of the original idea underlying the project, we have made further study concerning the behavior of flow under various conditions for the purpose of establishing a type of flume which would be more desirable than our present accepted design. This secondary study of the Venturi flume was conducted at our field laboratory on the Cache la Poudre River near Bellvue. This field laboratory is located at the head of the Jackson ditch and consists of a flume ten feet wide, five feet deep and sixty feet long, with a level concrete floor. This structure is so designed that various experimental devices may be installed and tested, and was built to provide means of extending our investigation of conditions which were beyond the limits of our hydraulic laboratory. Ample regulation of flow of water is provided and under the present arrangement this flume has a capacity of thirty second-feet discharge. This structure was primarily designed to complete the investigation of the rectangular type of flume, but other uses are intended to be made of this laboratory.

The report just completed on the Venturi flume is the second issued on this subject. The first bulletin was preliminary in its nature and was confined to experiments conducted at the hydraulic laboratory. The continual request for information applicable to large-size flumes, led to a series of tests conducted at the Cornell Hydraulic Laboratory on the rectangular type of flume where quantities of 400 second-feet were successfully measured through these experimental structures. Our second report includes these Cornell data, together with all our data collected at the hydraulic and field laboratories on the rectangular and V-notch flumes. Very extensive and elaborate experiments should be undertaken in calibrating the trapezoidal type of Venturi flume, which possesses many desirable features for the measurement of large flows. This phase of the because of the investigation cannot be successfully undertaken here inadequate water supply. It is recommended that, if such studies be made, calibrations be extended to at least 1000 second-feet discharge. There is in demand information for the installation and operation of these larger flumes, and our present range of knowledge of this type of measuring device is rather limited and should be extended.

The first study of the Venturi flume principle made evident the necessity of some form of recording instrument that would indicate the rate or quantity of water passing through the structure. Several attempts were made to produce a successful design, but not until this past year was it possible to produce a working model of such an instrument. A Venturi flume register was completed early last summer and put under test at the hydraulic laboratory.

where satisfactory results were obtained. At present this instrument is installed in the field under practical conditions and its operation is very gratifying. Application is being made for a public patent covering the principle and design of this type of recording instrument.

The Evaporation Project has been taken up along a different line of attack. Our previous experiments did not appear to possess sufficient uniformity or continuity to follow the variations of the water losses with any degree of certainty. Formerly our observations were made at twelve hour periods, this long interval of time being necessary to produce sufficient change to make possible the measurement of loss. The variation of the influencing factors during the periods of observation gave very discordant results. To improve upon these conditions, there was installed, at the hydraulic laboratory, apparatus capable of measuring extremely small differences of the elevation of the free water surface. It is possible with this new apparatus to follow quite accurately the hourly change in the losses, and for conditions of maximum loss the rate can be followed for five minute intervals. The major portion of our observations was extended over 24-hour periods. A very interesting relation has resulted from our studies as to the diurnal losses. For still air conditions in the laboratory, it is found that the rate of evaporation increases from a minimum in the early afternoon to a maximum in the early morning hours. Under normal conditions during August, September and October, we have found that the maximum rate of loss is from 300 to 400 per cent of the minimum. High-grade mercurial thermometers were used in observing the temperature, these instruments being standardized by comparison with the calibrated thermometer or standard, whose rating has been established by the U. S. Bureau of Standards. To determine the humidity of the air, one of the evaporation factors, we have provided an Assmann psychrometer. The calibration of this type of psychrometer is now under way at the hydraulic laboratory. It is hoped that with the improved apparatus now being used in connection with the evaporation problem, it will be possible to definitely state the law or the fundamental principle underlying this phenomenon.

The project on the study of return waters to the South Platte River from Kersey to Julesburg, Colo., has been actively pursued since the beginning of the work, May, 1919. The field work on this project was discontinued during the first part of November, 1920. On the stretch of river from Kersey to Julesburg, approximately 150 miles, there were installed 64 water stage registers, of which seven were operating on river stations and the remainder

on canals, ditches and seepage streams. This co-operative investigation was given permission to use three other registers that were installed on the Prewitt reservoir system. A new type Stevens register was loaned the investigation for test purposes, with the understanding that we would submit to the makers a report giving our criticism and recommendation as to the practicability of this instrument. The various interested parties concerned in this co-operative investigation contributed instruments as follows: State Engineer's office, 2; Colorado Experiment Station, 25; Prewitt Reservoir Company, 3; Leupold & Voelpel, Portland, Oregon, 1, and the U. S. Dept. of Agriculture, 33. The dismantling of the field equipment was completed on the 12th of November and all registers returned to the hydraulic laboratory, with the exception of the two State instruments on the river stations at Kersey and Balzac and the Prewitt instruments. To carry on this investigation, two field offices were established, one at Fort Morgan and the other at Sterling. The river was divided in two sections, Kersey to Balzac and Balzac to Julesburg, and the field operations were carried on from these two offices. All travel in the field was performed by Ford automobile, three machines being used the greater part of the time, these machines being the property of the Station.

Under agreement, a deputy water commissioner was maintained at Fort Morgan, Water District No. 1, and at Sterling, Water District No. 64, these deputies acting as our assistants in carrying on the field work. The salary of these men was paid from county funds. Considerable difficulty has been experienced in maintaining the personnel on this project. Two different deputies have served in District No. 64 and three in District No. 1, during the existence of the field work. Mr. Hemphill, who was assigned to the Fort Morgan office to look after the field work in both districts. resigned the first of July from the Colorado work to take charge of the irrigation investigations in the state of Texas. This continual interruption and change of assistants was not conducive to the best interests of the investigation, but the work has progressed without delay and our records have been maintained according to schedule. Mr. Hemphill's leaving was very severely felt, and required the major portion of my time to direct the work on the river during the remaining part of the irrigation season.

The primary purpose of this investigation was to study the extent of the return waters to the river channel, and, secondarily, to establish a system of measurements and dstribution which may be maintained on a permanent basis. The success of our endeav-

ors cannot now be affirmed, but many encouraging and complimentary statements have come which, in general, might indicate that our work was not in vain. The continuation of our system of measurements and records is much sought after on the part of the irrigation officials, and interested parties in these two water districts covered by our recent investigation. It is expected that our office will be called upon to assist in getting established this continuation of our work on a permanent basis. This work will be absolutely independent of this office and will depend wholly upon the efforts and support given by local interests. However, it is expected that assistance will be given by the State Engineer's office in maintaining an experienced hydrographer in both districts 1 and 64.

The work in Meteorology is continued without interruption, and consists merely of collecting meteorological data and computing the general averages. During the past couple of years this office has been submitting to the local newspapers our daily observations, together with direct comparisons of unusual conditions, and it is believed that this information is read with considerable interest.

The current meter project has received very little consideration this past year; however, some work has been done. It is intended that the data secured in connection with the South Platte investigation might be used in part to substantiate our results obtained in the field study of current meters. In designing the field laboratory at Bellvue, it was intended to use the equipment to further the current meter studies. To arrange the conditions to be suitable for current meter work will require alterations and possibly some additional construction, and to do this work will require but little outlay of funds. The unexpected changes in the personnel of our crops of workers has made it necessary to continue with such projects as required immediate attention. Plans were made early last season to continue with the current meter work, but it was later found impossible to follow our schedule.

The government budget for support of our co-operative work was very materially reduced this year, which precluded the possibility of getting additional experienced assistants capable of undertaking the various phases of our approved projects. Our present corps of workers in this section is hardly adequate to carry the work in an efficient manner, and to expand in other projects not yet outlined. If funds were available, several new lines of activity could be profitably started. More problems could be undertaken at the hydraulic laboratory, but due to the lack of assistance and necessary funds, we are finding that it is only possible to continue

with certain projects. It is to be regretted that federal appropriations for the past fiscal year were reduced, and in this respect it is to be hoped that the allotment for the coming year might be sufficient to provide means for carrying on this important cooperative work in a more vigorous manner.

Our office, in addition to regular work on assigned projects, has advanced assistance to various interests about the State. Recently I assisted with the compilation of assessment schedules for two organized drainage districts near Lamar, Colorado. Two reports were submitted to the State Board of Agriculture on the present irrigation system of the college farm and campus, and proposed improvements necessary to efficiently handle their water supply. Requests have reached the office for assistance that could not be met, due to immediate work which required our constant attention.

New lines of work are being planned and these new projects will be outlined in proper form and submitted to you for your approval.

Respectfully submitted,
RALPH L. PARSHALL,
Irrigation Engineer.

## REPORT OF THE VETERINARY PATHOLOGIST

*To the Director*:

As in previous years, most of the time of the workers in the pathological section has been given to the sheep project.

An experiment arranged for the purpose of determining the advisability of vaccinating sheep at the time they come in to the lots and involving some thirteen thousand animals, was conducted during the earlier part of the year with results which showed that the owner of the sheep would have lost money had he paid the regular price for vaccine. However, it should be said in justice to the work that the losses were comparatively light in all of the bands where this work was carried out, and we are not, therefore, in a position to say what would have happened had the disease really broken out in epidemic form.

Pen work on the value of vaccination, controlled both by serum tests and inoculation cultures has been continued.

A larger number of colon bacilli are being isolated from the organs of sheep dying in the lots than was formerly the case. Some of these colon bacilli are not only virulent for rabbits but also for

sheep, which offers sufficient indication to us that a more thorough study should be made of them, as it is possible that they are factors in some of our losses.

We have seen two rather serious outbreaks of *Ictero hematuria;* one in ewes where there was a loss of one hundred and thirty head out of seven hundred, and another in wethers, showing a loss of seventy head out of four hundred. The disease has also been reported to us from the vicinity of Kremmling. Our work so far has not revealed the presence of either *Piroplasma ovis,* which is supposed to cause this disease, nor any tick which has been said to carry it. In fact, in four outbreaks which we have studied, our findings have been entirely negative. Consequently, we are loth to believe that the disease is either due to the same organism or carried by the same tick which has been reported in Roumania and Italy.

We are finding also a number of cases of suppurative meningitis, but have not yet done sufficient work on it to offer an opinion as to the cause.

Owing to the lack of funds and lack of time, we have not given as much time to the San Luis Valley work as it deserves; although we understand that the losses there have been rather heavy this fall. This problem still remains somewhat of an enigma and will probably require investigation on a much larger scale than any which we have attempted as yet.

During the year, we submitted a bulletin on the "Sod Disease of Chickens".

The epidemic of forage poisoning in horses, which caused such serious losses during 1919, did not recur in 1920, and consequently no work has been done on this project.

We are continuing to examine all blood samples sent us, for contagious abortion, but little outside of routine work has been accomplished. We had hoped to get a range herd put under our supervision for some experimental work on this disease, but have so far been unsuccessful.

We have examined 221 specimens sent in by farmers, veterinarians and physicians and have returned diagnosis on most of them. This service appears to be increasing, but is probably advisable, not only from the standpoint of helpfulness to the livestock industry but also to keep us in touch with the disease conditions in the State.

During the summer, Dr. Feldman spent six weeks at the University of Michigan summer school, taking special work in Pathology.

Our new quarters in the barracks are much more commodious than in the old buildings and allow the station work to be almost entirely separate from the educational department.

Respectfully submitted,

I. E. NEWSOM.

## REPORT OF THE VETERINARIAN

*To the Director*:

Most of the investigational work in veterinary lines is under the direction of the Pathologist, Dr. I. E. Newsom.

At the present time there are no diseases among livestock that approach the proportions of an epizootic or pestilence. The State is freer from hog cholera just now than it has been for several years. At this writing it is reported only from Walsenburg. Pure hog cholera has lost its significance largely as a menace to the hog industry thru the perfecting and standardizing of anti-hog cholera serum. What now passes current as hog cholera is usually mixed infection and this has greatly complicated both the diagnosis and treatment. At the present time much confusion exists respecting hog cholera and its many complications.

*Hemorrhagic septicemia* is causing some loss in the feed lots. In cattle this disease appears sporadically in all parts of the State but the losses have not been as heavy as in sheep. The value of *hemorrhagic septicemia* bacterin is questionable. We are working with this disease as a special project and much first hand information has been obtained, which will be published in bulletin form later.

Blackleg is still causing some loss among calves. This loss is entirely unnecessary, since it may be absolutely prevented by use of blackleg aggressins.

Anthrax appears every summer in the southeastern portion of the State and causes considerable loss. Vaccination, while not as successful as with blackleg, is nevertheless the main reliance in its control. With the proper disposal of anthrax and blackleg carcasses these disease would soon disappear.

Contagious abortion is widespread and disastrous. At present our only means of control is in herd management. The value of contagious abortion bacterins is questionable.

A bill will be presented to the legislature this winter providing for cooperation with the Federal Government in the control of tuberculosis. Most of the states have already accepted the gen-

erous terms provided in this act and the work of tuberculosis control is under way. That the disease can be controlled seems to have been demonstrated but success will depend upon cooperation of all of the states, covering a period of a series of years. The indemnity provided, and the benefits to be derived from having an accredited herd, are the inducements that should especially appeal to stockmen.

Poisonous plants have been studied throughout the year with special attention given to the whorled milkweed. As a poisonous plant, its economic importance is second only to the loco weeds and larkspur, and its extermination equally as difficult. The whorled milkweed areas have been mapped, an effort made to educate the stockmen to identify the plant and otherwise avoid its disasterous effects.

New and preplexing problems are constantly arising in animal pathology, and demanding investigation. Two or three projects are the most that should be under consideration at one time, and they usually require several years. The amount of progress made is somewhat problematical, but the sum total of all efforts in research, marks some advance from year to year.

There is need of special work on poultry diseases, which have been sadly neglected. Among other disease conditions which have an economic as well as scientific interest at this time the following may be mentioned: paralysis of hogs, a fatal edema among horses near Sterling, forage poisoning and its relation to botulism and a summer disease of cattle characterized by paralysis of the organs of prehension.

Respectfully submitted,
GEO. H. GLOVER.

## ENGINEERING DIVISION
LD. CRAIN, Chairman

*To the Director*:

I am transmitting herewith the report of the Civil and Irrigation Engineering Section covering the activities of that department in the road materials laboratory. I am also transmittnig the report from the Mechanical Engineering Section. These two reports indicate the activity of the Engineering Division for the past fiscal year.

Respectfully submitted,
LD. CRAIN,
Vice Director.

## REPORT OF THE CIVIL AND IRRIGATION ENGINEER

*To the Director*:

The report of the Civil and Irrigation Engineering Section for experimental work in the Road Materials Laboratory for the year ending December 1, 1920, is as follows:

Two survey trips were made for the purpose of locating road surfacing materials; one to counties lying in the northeastern part of the state, and the other to western slope counties. On these trips investigation was made relative to county organization for construction and maintenance. The general conditions in the different counties, as regards co-operation between the county executive officers and the county engineers, were also investigated. With the exception of Mesa County on the western slope, the eastern slope counties visited were, as a rule, found to possess much better working organizations.

The materials used in the construction of concrete highways near Boulder, Longmont, Loveland and Fort Collins were tested in the laboratory and reports on this work submitted to Mr. W. R. Douglas, Field Engineer in charge of construction for the State Highway Department.

An investigation of possible sources of supply of crushed rock for concrete aggregate in northern Colorado to supplement the supply of the river gravel is in progress. The known sources of supply of the latter are limited and the quantity is not entirely satisfactory, due to the presence of dirt and disintegrated granite. In my judgment, if the State Highway Department were able to furnish aggregate for concrete highway construction to the contractor for a definite sum, f. o. b. cars, a saving would result, due to the elimination of the uncertainty which now faces the contractor, as regards his material. It is planned to have the results of the investigation available for use when the construction program of 1921 is considered. This investigation, of course, cannot cover the entire range of deposits of road materials in northern Colorado, but merely those accessible to existing lines of railroad in the region mentioned.

Tests of brick for use in man-hole construction, and tar for use in contraction joints of concrete pavement were made for the City of Fort Collins.

An investigation has been outlined, and the necessary specimens are now being prepared to determine the action of beet pulp upon concrete. This work will be completed about January 1, 1921.

Additional equipment, consisting of necessary apparatus for testing bituminous materials, has been installed. An order has been placed with Riehcl Brothers Testing Machine Company of Philadelphia for a 150,000 lb Universal Testing Machine, motor driven, and equipped with a 16 ft. table for transverse test. This machine has not been received at this time, but will aid materially in the work contemplated for the coming year.

Plans for a conference of County Engineers and Road Supervisors have been submitted to these officials thruout the state, and replies so far received indicate that the plan is being favorably received. It is planned to hold this conference in Fort Collins, January 20 and 21.

A measure has been prepared for introduction into the coming Legislature asking financial aid for the use of the Experiment Station in making a survey of the road materials of the State. This appropriation is designed to cover the biennial period of 1921-1922. If it receives favorable action, this work should be started early next spring, with two field parties working at points where construction is to be carried on next year. The Good Roads Association of Colorado, at a meeting held in Colorado Springs during the past summer, passed a resolution setting forth the necessity of a survey of this nature. This plan should be submitted to the State Highway Department in the near future for its approval.

Respectfully submitted,

O. V. ADAMS,
Testing Engineer.

Approved:
E. B. House,
Head of Section.

## REPORT OF THE MECHANICAL ENGINEER

*To the Director*:

I am submitting the report of the Section of Mechanical Engineering of the Experiment Station for the State fiscal year just closing. The Section has had two projects under day during this period. The project on Methods of Handling Hay, carried on by Mr. Cumings, occupied all of the summer up to the time that his service with the station ended and his work with the college began. The result of his investigations rather conclusively proved that there is no saving, financially, by the employment of movable hay stack covers. The average loss in uncovered stacks would not

pay for the first cost of the covering, and he therefore recommends that temporary coverings be not employed if financial gain is the main object. His investigation in the problem of stacking is incomplete. This portion of the work will be taken up when he returns to the station in April.

The project on Co-efficient of Heat Transmission in commercial wall boards was carried out by the members of the senior class last spring. I think it will be necessary to run some more of the tests, in order to check the results obtained. This work will be done in the spring semester when I have a class in laboratory work.

The Department finds very little time to devote to Experiment Station work, aside from the half time given by Mr. Cummings. The importance of the work would seem to demand at least one man, employed for full time, to carry on investigational work and, while I am not asking for that at the present time, I think next year we ought to definitely face the matter and place a man in the Department on full time to carry on experimental engineering project.

Respectfully submitted,

LD. CRAIN,

Mechanical Engineer.