THE STATE AGRICULTURAL COLLEGE
OF COLORADO

The Thirty-Fourth Annual Report

OF

The Agricultural Experiment Station

1921

The Colorado Agricultural College

FORT COLLINS, COLORADO

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EARL DOUGLASS, M.S.	Assistant in Chemistry
P. K. BLINN, B.S., Rocky Ford	Alfalfa Investigations
MIRIAM A. PALMER, M.A.	Delineator
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RALPH L. PARSHALL, B.S., U. S. Irrigation Engineer	Irrigation Investigations
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LETTER OF TRANSMITTAL

To His Excellency, Oliver H. Shoup, 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-fourth Annual Report of the Colorado Agricultural Experiment Station for the government fiscal year, July 1, 1920, to June 30, 1921.

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, 1921.

FINANCIAL REPORT OF THE COLORADO AGRICULTURAL EXPERIMENT STATION FOR THE FISCAL YEAR ENDING JUNE 30, 1921

	Hatch Fund	Adams Fund	State Mill Levy Fund	Sales Fund	Special Fund	Pure Seed Fund App'n	Horse Cash Fund	Total Fund
DR.								
Balance on hand July 1, 1920	.....	.....	$ 34,139.37	$155.84	$12,508.52	$ 2,630.35	$249.58	$ 49,683.66
From the Treasurer of the United States as per appropriation for the fiscal year ending June 30, 1921, under acts of Congress approved March 2, 1887, (Hatch Fund) and March 16, 1906, (Adams Fund)	$15,000.00	$15,000.00						
Other Sources than United States			57,800.66	.....	17,528.67	12,000.00	.....	87,329.33
Total Receipts	$15,000.00	$15,000.00	$ 91,940.03	$155.84	$30,037.19	$14,630.35	$249.58	$137,012.99
CR.								
To Salaries	$10,996.83	$12,812.75	$ 42,621.55	.....	$ 5,731.42	$ 3,290.79	.....	$ 75,453.34
Labor	1,272.68	421.30	10,422.22	8.00	313.94	802.09	12.50	13,253.73
Publications	695.35	.....	4,353.93	.....	48.96	350.27	.....	5,448.51
Postage and Stationery	302.40	31.72	1,372.30	.....	62.19	150.55	.....	1,920.16
Freight and Express	5.40	1.75	554.74	.....	558.79	30.88	.....	1,151.56
Heat, Light, Water and Power	.....	.....	63.91	.....	4.60	.....	.....	68.51
Chemicals and laboratory supplies	94.70	533.85	2,109.73	.....	6,428.82	.....	.....	9,167.10
Seeds, plants and sundry supplies	178.45	86.48	3,038.25	.....	644.99	259.07	.....	4,207.24
Fertilizers	.....	.....	1.03	.....	.....	.....	.....	1.03
Feeding stuffs	212.98	24.00	5,647.60	.....	1,036.53	.....	.....	6,921.11
Library	44.83	11.36	109.48	16.70	20.91	13.50	195.00	411.78
Tools, machinery and appliances	46.50	49.85	4,826.76	5.50	.....	76.30	.....	5,004.91
Furniture and Fixtures	63.40	16.20	131.55	.....	16.67	95.95	.....	323.77
Scientific apparatus and specimens	232.55	299.53	1,736.35	.....	395.38	328.15	.....	2,991.96
Live stock	189.60	10.50	10,447.40	.....	.....	.....	.....	10,647.50
Traveling expenses	293.83	344.30	4,705.64	110.64	270.71	500.62	42.08	6,267.82
Contingent expenses	.....	.....	17.20	15.00	1,008.52	10.00	.....	1,050.72
Buildings and land	370.50	356.41	9,503.10	.....	3,005.10	8.82	.....	13,243.93
Total expenditures	$15,000.00	$15,000.00	$101,664.74	$155.84	$19,547.53	$ 5,916.99	$249.58	$127,534.68
Balance on hand June 30, 1921	.....	.....	9,724.71*	.....	10,489.66	8,713.36	.....	9,478.31
Grand total	$15,000.00	$15,000.00	$ 91,940.03	$155.84	$30,037.19	$14,630.35	$249.58	$137,012.99

(*Overdraft)

REPORT OF THE DIRECTOR

To the President:

Following is my report as Director of the Experiment Station for the federal fiscal year, 1920-1921. It includes a full statement of all moneys received and expended on federal and state funds, and brief statements from heads of sections concerning investigational work.

There are, at present, fifteen sections or departments of the work, and there have been sixty-one active projects receiving more or less attention during the year. There are also, at the present time, sixteen regular employees giving full time to Station work and thirty others giving part time.

The Twenty-third General Assembly of the State of Colorado increased the levy for the support of the Experiment Station .025 of a mill, which will increase the funds for investigational work by about $40,000 a year. The total of mill levy for the support of Station work is now .0675 of a mill, which will provide an annual revenue of approximately $100,000 in addition to the $30,000 received from federal funds. However, the Station actually received somewhat over $4,000 less from the State levy during the year just closing than it did during the previous fiscal year.

In order to improve the Station's water rights and make certain an abundant supply at all times for irrigation purposes, we have spent more than $13,000 during the year for the home farm. In addition to this, an artesian well was put down at the Cheyenne Wells station, where we were wholly dependent upon the city water suppy that had become wholly inadequate. I am glad to report that a good flow of water was obtained.

A few departments of the Station work, especially the Chemical, Bacteriological and Botanical, are greatly in need of additional laboratory and office room and equipment, which it is hoped may be provided in the near future through the erection of new buildings.

There are urgent calls for additional help and permission to put on additional projects, all of which are important, but it seems to me that there can be little, if any, extension of the work of the Experiment Station for a year or more on account of the probable reduction in the State's valuation for taxation and the necessity that we shall have of putting more money into the improvement of our water rights for irrigation purposes.

The Agronomy, Bacteriology and Irrigation Investigations Sections have co-operated with one another and with the American Beet Sugar Company of Rocky Ford for the purpose of carrying investigations that might cast more light upon the reasons for the adverse soil and cultural conditions that have brought about a

serious reduction in tonnage and sugar content of beets grown in the lower Arkansas Valley in Colorado. The investigations this year started out very auspiciously, but were brought to a sudden close by the Pueblo flood early in June. We plan to continue this project the coming year.

I might call attention to some of the rather outstanding results coming from the investigations of the year, but prefer not to seem to minimize the work of any section by calling special attention to what has been accomplished in any of the projects.

An additional analyst was employed for the Chemical Section in order to take care of service work that might be asked for, either by other sections of the Station or by outside parties, but, as an actual-cost charge is being made for all work of this character, the calls for chemical service have been very few so that Mr. Tobiska has given a large proportion of his time to the investigations being carried on by the Chemical Section.

A good number of bulletin manuscripts have been received from the workers during the year, ten of which have been published and others are in the hands of the Director or the Station Editor. One or two are being held back because of their large size, the high cost of printing and the small balance in our funds. For a full statement concerning publications, see report of the Station Editor at the close of this report.

I am giving below a complete list of projects that have been in force in the Station during the year.

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.
Plains Crops and Management. State Funds.
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 Cattle. State Fund.
Rations for Fattening Lambs. State Fund.
Range Improvement. State Fund.

Winter Maintenance of Breeding Ewes. State Fund.

Summer-Fallow Experiment at Akron, Colo. State Fund.

Maintenance of a Purebred-Beef Breeding-Herd at Fort Lewis, Colo. State Fund.

Bacteriology Section

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

Active Principle of Whorled Milkweed. Adams Fund.

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

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

Miscellaneous Vinegar Studies. Hatch and State Funds.

Steckling Rot of Sugar Beets. State Fund.

Rocky Ford Sugar-Beet Investigation. State Fund.

Mustard Poisoning. State Fund.

Corn Root-Rot. State Fund.

Botany Section

Microscopy of Stock-Poisoning Plants. Hatch Fund.

Hard Seed of Alfalfa. State Fund.

Fungous Diseases of the Sunflower. Hatch Fund.

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

Range Improvement. (In co-operation with Animal Husbandry Section.)

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 Funds.

Life Habits of the Syrphus Flies. Hatch Fund.

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.

Horticulture Section

Hardy Stock for Apples. Hatch and State Funds.
Potato Investigations. Hatch and State Funds.
Seed-Potato Growing in High Altitudes. State Fund.
Hardy Tree-Fruits for High Altitudes. State Fund.
Effect of Diseased and Ill-shaped Seed Potatoes on Succeeding Crop. Hatch and State Funds.
Tomato Variety-Tests. State Fund.

Irrigation Investigation Section

Current Meters Adams Fund.
The Venturi Flume. Adams Fund.
Evaporation Experiment. Hatch Fund.
Meterology. Hatch and State Funds.
South Platte Investigations: Seepage and Return Waters. State Fund.
Measurement of Water as applied to Irrigation. Hatch Fund.

Marketing Section

Survey of Marketing Practices. State Fund.

Pathology Section

Contagious Abortion. State and Hatch Funds.
Chicken Diseases. State Fund.
Sheep Losses in Feed Lots. Hatch Fund.
Forage Poisoning. (Co-operative work with Botany Section.) State Fund.

Veterinary Section

Animal Diseases. 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 AGRONOMY SECTION

To the Director:

The work of the Agronomy Section has been carried on under Adams, Hatch, and Station Tax funds. For two or three items we have used Station Special, making four funds contributing to the support of the Section to a greater or less degree. Perhaps a good way to report the work of the Agronomy Section would be to do so by funds.

ADAMS FUND

Under the Adams Fund, the Agronomy Section has carried one project designated for brevity, "Critical Periods". This project is essentially a study of the physiologic periods in the development of crops at which water is most necessary for the development of the plant. Stated in slightly different words, these physiologic periods are the critical periods in the water requirements for the growth and development of the crop. We, of course, hope to measure these periods in crop produced. For this year's work, Marquis spring wheat was used as the grain, as was the case in 1920. Fifty-five plats, each 1-500 of an acre, were laid out.

Canvas covers were provided which could be rolled up in the alley-way between the ends of the plats during pleasant weather and could be stretched over the plats during stormy or threatened stormy weather, so as to prevent any moisture preciptation reaching the plats, this precaution being necessary in order to keep absolute control of the amount of water supplied and the time such water was supplied. In one week in the spring of 1921 we had a precipitation of considerably over four inches, nearly three inches of it in one rain. Of course, during such a time we are watching the plats with extreme care. The covering gave perfect protection thru this, the biggest storm with which we had to contend, showing the efficacy of our precautions in protecting the water supply. The amount of moisture in the soil at the beginning, at various periods in the growth of the crop, and at the conclusion of the growing season was determined by sampling and actual moisture determinations. Records were also kept of the total rainfall during the season by instruments set up adjoining the plats. Temperature and sunshine records are being kept in addition. We expect to add to the list, instruments for determining sunshine intensity so as to be able to compare somewhat the conditions of one season with those of another.

All of the plats were harvested by hand, cutting the grain one inch from the ground with shears, taking the greatest precautions to get the exact crop grown. Both grain and straw weights were taken. The seed is being saved for any other analytical de-

terminations we choose to make. Every period-treatment was replicated at least five times, and most of the period-treatments were replicated ten times in the experiments.

As a check upon the field plat work, six potometers were obtained, each potometer being five feet in depth by one foot in diameter. The potometers were made on the double wall plan, that is, one can being made to fit inside the other with a half-inch space all around between. The outside can was made of galvanized iron, all seams soldered. The inside can was made of plain black iron, all seams soldered, the inside treated with melted coal tar or pitch. Black iron was used for the inside can because there was a tendency for plant poisoning from the galvanized can to take place, which tendency was observed in previous potometer experiments. Only one set of six potometers were used in this preliminary work, in order to determine whether or not the potometers are comparable or can be used to check against field plat experiments. If comparable results may be obtained by protecting the potometers, the controls are a little more absolute. In previous potometer experiments in comparison with the field plats, where galvanized iron cans were used in the potometers, such fluctuating results were obtained that no consistent results ensued. In the potometers, soil temperatures were taken by means of soil thermostats, temperatures being taken in the potometers and in the surrounding soil at distances of at least ten feet from the potometers themselves. Samples were taken from potometers one and six in the series for special moisture determinations.

We are not yet ready to announce results on this line of work, altho we have the results in tabular form. We deem it wise to have further replications of season as well as of plat until the number of replications is sufficient to remove all doubt as to the tendency of results in our work.

HATCH FUND

Under the Hatch Fund, we are carrying two major lines of effort--the Correlation project and the Alfalfa project—and some Hatch funds were put into grain-breeding work at Fort Lewis. The amount, however, at Fort Lewis, was very small.

The Correlation experiment has been running for some years. The work is not yet completed and should not be. As side issues from the Correlation experiment, we have obtained many valuable station results and some new plant creations that promise very good returns. These are rather indirect by-products which may prove more valuable in the way of positive results than the main project itself. Crosses have been made from time to time, a part of the progeny of which has been carefully studied to determine if correlations in the cross progeny preserve the same order as those obtaining in either of the parents.

From these crosses Mendelian results of some importance have been obtained and, likewise, worthy creations, some of which are almost ready for public distribution. Among these creations are two or three wheats which, if their milling quality shows well enough in one or two years' tests, will be ready to increase and put out in the hands of practical growers. We have a barley, which we call Colsess, a cross between Coast and Success. This new barley is a beardless or hooded type. It has a stiffer straw than the Success type. In this new barley we have obtained freedom from beards, a relatively high yield, and a relatively stiff straw—all very desirable factors.

Our high altitudes have needed a feed barley which could be grown under conditions which would give a good yield of grain or which could be used if desired for hay purposes, either alone or planted with peas. The barbed-bearded types are not adapted for this type of growing, because the barbed-bearded types of barley do not fit into a stock-feeding program, as the beards are very likely to cause sore mouth and some considerable stock loss. A beardless type, however, can be fed with perfect success. This new Colsess barley looks as if it would fill the place. In our own home Station tests, Colsess has been one of the highest yielders, ranking among the first ten of our barley of any type whatever. At Fort Lewis, Colsess topped the list and ranked first in 1921, giving an added indication of its value as a high-altitude barley. This point is mentioned because it shows some of the value of the side lines from the Correlation project, which are of real, substantial merit. Of course, these productions are being developed under the Pure Seed project, carried on by State funds, but the crosses were made and the segregations were made originally for the data which were to be obtained for the Correlation studies.

Directly we have learned a great deal about methods of work from the Correlation study. Frankly, however, we are coming pretty well to believe that, as a basis for future selection, the value of correlation studies is mostly negative. We are making a rather complete study of the effect of method of planting upon correlations. We are giving some study to nearly 70 varieties of crops. We are planting some of the grain in plats as nearly under field conditions, as to spacing and methods of growth, as possible. We are sowing in rows, with different spaces between the rows and different spacing in the row, in order to see if growth factors and spacing have a real bearing upon the correlation data which we may obtain.

The Alfalfa project, as mentioned before, is being carried on under Mr. Blinn at Rocky Ford. In the Alfalfa project we have got to that point where we feel that we must learn the reasons underlying the production of alfalfa seed or the lack of production

of alfalfa seed. We have found that we can determine the best adapted types by a careful test of native and imported types.

We have found that we can make substantial improvement in any type by cross-breeding and selection. But this work has been more or less "hung up", due to the fact that we are unable to get consistent seed production with yields sufficiently large to justify a farmer in growing seed.

In 1920 we tried out schemes to increase the temperature, so as to make different temperature ranges, as we felt that temperature does have something to do with the production of seed.

We have also laid out in 1921 a series of small plats, upon which we are applying a complete set of fertilizers, singly and in combination. In this set we are using sulfur, phosphorus, potassium, nitrogen and lime, these elements being carried in different compounds and applied singly and in the various possible combinations. Our work on this line has not progressed far enough to warrant any conclusions. We expect to continue these treatments over a short period of years for further study.

STATION TAX FUND

Under the Station Tax Fund we are carrying the general work and general plant improvement at Fort Collins, at Cheyenne Wells and at Fort Lewis, and are assisting in the work at the Rocky Ford farm, besides some special work which has been under way this year in the Arkansas Valley.

The work at the Fort Collins plant has been grouped largely under the general heading of Pure Seed, which covers the work we are doing in plant improvement, increase and distribution.

Under this project we are making crosses, selections and increases with corn, wheat, oats, rye, barley and with some minor crosses in a small way. Our work with corn includes variety testing, methods of breeding and selection work for further work, as well as our part of the work being carried on under the corn root-rot experiment. With the corn we are carrying, in addition, date-of-planting studies. The corn root-rot has been quite troublesome in the East and Middle West.

We were very much perturbed in the spring of 1921 when samples of corn put in the Seed Laboratory for germination were reported to contain different high percentages of root rot. If root rot were actually present, it meant a serious difficulty in our Colorado corn problem. Accordingly, we immediately took steps to co-operate with the Seed Laboratory and with Dr. Sackett to attempt to find out, first, if we really had corn root-rot and, second, what we could do in the way of control, either by seed treatment, rotations, or plant selection and selection of resistant sorts. With one season's work only we have a great deal of data, but

no conclusions, except possibly the conclusion that much of the trouble reported by the Seed Laboratory as root rot was probably something else and not true root-rot at all.

In our wheat-breeding work, fifty wheat crosses were made, twenty barley crosses, and a very great number of selections. About thirty varieties of wheat were under comparative field tests. Besides our own selections, nearly twenty varieties of barley and about the same number of oats were also under test. I am making no attempt to give you, in this report, the details of the selections, variety names, selection numbers, etc., which we have used in these selections and variety tests. These are on file and can be obtained if more detailed information is desired.

Additional work which we should take up at the Fort Collins plant includes the attack, or the commencing of the attack on certain soil problems peculiarly in our field. But these problems would require the organization and equipment of a laboratory, which does not seem financially feasible or wise, at least until new financing comes in. As a part of that future work, however, and as a very great aid in our breeding work, we should have a series of green-houses. Many of our cross fertilizations could be made in the greenhouse and the first generation of plants be grown in the greenhouse, getting two generations in a single year, where only one can be obtained outdoors.

It looks as if by crossing some of the spring wheats, for instance, with some of the winter wheats that it would be possible to combine some of the good qualities of each in a new sort. Crosses of this kind should be made at first in the greenhouse and the first progeny should be grown in the greenhouse. For instance, let us suppose a case. We will have to suppose a case because, for this particular factor, we do not know the genetic inheritance factors involved. But, suppose that winter resistance to cold were a recessive character and susceptibility or a lack of resistance were a dominant character. In such a cross, if this genetic condition existed, the first generation plants would be more susceptible to winter-killing than either of the parents and, if planted outdoors, would probably all be killed. It would not then be possible to get a second generation of the group of plants. If, however, the F^1 and F^2 generations were grown in the greenhouse, at least until enough seed for test could be taken outdoors, this point could be determined without losing all of the seed and the valuable recessive character (if such it were) could be perpetuated. This is only one instance of many where greenhouse facilities would be invaluable.

In our Critical Period work, before the project is finally completed, we shall need greenhouse control—a control which will

enable us, under suitable conditions of apparatus, to vary one factor at a time and keep the other factors uniform thruout the period of plant development, and thus determine the variation of that one factor.

At Cheyenne Wells the regular work which has been going has been carried out for the season. Owing to the fact that the Cheyenne Wells city-water supply became insufficient for the needs of the city, we were obliged to have our contract with the city abrogated, under which for the past 20 years the city has furnished water to the Cheyenne Wells farm. Accordingly, we were obliged to put down a well and to erect a storage tank to safeguard our own water supply. This has been done. The details of the operations have been given in various monthly reports during the year. We are still operating the pump and plant with a temporary arrangement, using a small gasoline engine. It will be necessary to make permanent arrangements as soon as we are able. Some further repair work in addition to that performed this season is also necessary upon the farm and plant.

In the dry-land region sooner or later we shall be obliged to take up definite experimental work on suitable, summer pasture-crops or annual pasture-crops and their management. The range is being restricted more and more from year to year, so that in many communities there is no longer native range for summer pastures. This makes it necessary either to change systems of farming radically or to find annual pasture-crops which can be grown on cultivated lands and get the necessary pasture thru these annual crops. I think the pressure of needs will force us to a study of this problem in the very near future. We have been anticipating such a study for some years. The Extension Agronomist, in many neighborhoods, has had a group of farmers planting different annual pasture-crops for demonstrations. These demonstrations will go on and will give us a considerable amount of information. But they do not constitute carefully checked experiments such as must be performed for the benefit of the plains agriculture.

At Fort Lewis, Mr. L. R. Quinlan has a dual role, looking after both the agronomic and horticultural work. The work has been carried in a better way at Fort Lewis this year than ever before. Detailed, monthly reports have been submitted from month to month and are now in your hands. Mr. Quinlan has not completed the detailed annual report, but is working upon the same now, copies of which will be filed with you when done. The work at Fort Lewis is primarily work of high-altitude agriculture and consists of variety testing, looking forward to more detailed plant-improvement by breeding later on. Mr. Quinlan is making a special study of pea varieties and their adaptability to that region.

General studies are being carried on in testing the adaptability of winter and spring wheats, the adaptability of barley varieties, and varieties of corn, sunflowers, and grass pasture and meadow mixtures. A grass garden was started this year at Fort Lewis for the first time.

In the Arkansas Valley, a condition has been growing gradually, the cause of which is not definitely known, but the results of which are a lowered tonnage-production of beets, together with diminished sugar-content. Since this condition is common pretty much the full length of the Valley, the Experiment Station, thru the Irrigation Investigations, the Bacteriologist and the Agronomist, attempted a series of experiments, starting in the spring of 1921. Something like 200 acres of experimental work was laid out at various points along the Valley. But, owing to flood conditions, many of these experiments were completely destroyed, making it necessary to really stop work in the region for the season, except to rearrange plans for the carrying on of work in 1922.

I am not at all satisfied with the method which we have employed to carry on this work. I believe that we shall have to have a man on the ground who is competent to carry on the various parts of the experimental work, who will actually look after the experiment and the data, if we are to be of real use in solving the Valley problems. It would seem that the needs of the Valley are important enough to warrant such studies because if the problem cannot be solved the entire agriculture of the Valley will have to undergo a change and it is not certain that that change would be a better agriculture than that now existing. The needs and wealth of the Valley fully justify more careful investigation.

Respectfully submitted,

ALVIN KEZER,
Agronomist.

REPORT OF THE ANIMAL HUSBANDMAN

To the Director:

I am submitting the following as the annual report of the Animal Investigations Section of the Experiment Station:

***Range Management:**

During the summer grazing season, May 3d to October 24th, range steers were carried on typical, low, foothill range to determine its grazing value under different systems of management. This was the first test on an experiment which is planned to determine whether or not, under proper treatment, the range can be

built up from year to year in place of being depleted as under present general practices. Gains secured were good in all lots. Where forage plants were protected during early growth and where rotation was practiced, the increase in plants maturing seed was noticeable.

***Steer Feeding:**

Feeding trials have been carried on with the principal sugar-beet by-products and other cattle feeds available in Colorado to determine their comparative value, and the most economical combinations in using them.

***Irrigated Pastures for Dairy Cows:**

A pasture-grass mixture designed for Colorado conditions is being tested and compared with dry lot-feeting of silage and alfalfa during the summer grazing-season.

***Sunflower Silage for Dairy Cattle:**

Tests are being carried on to determine the value of sunflower silage as compared to corn silage as a succulent feed for dairy cows.

The first test, made one year ago, showed favorable results for the sunflower silage, due to the large tonnage secured per acre, however, sunflowers at the Station this year developed a blight which cut their tonnage to 15.37 per acre, (nearly one-half the tonnage secured in previous tests), while the added cost of ensiling makes them more expensive than corn in the silo.

***Lamb Feeding:**

Sugar-beet by-products in conjunction with Colorado-grown grains, and alfalfa were fed to ordinary range lambs. Results tended to show that wet beet-pulp and dried-molasses beet-pulp, when combined with the carbohydrate grains, were exceptionally valuable in fattening the lambs. This project is inactive this year.

***Summer-Fallow Experiment, Akron, Colorado:**

This experiment was planned to determine the place of sheep on the ordinary, Eastern-Colorado, dry-land, grain-farm.

Two years' results under favorable and unfavorable conditions seem to show that sheep are valuable in keeping down weed-growth, and that, with the ordinary dry-land rotation of crops, they can be maintained largely on waste roughages. Lambs produced on these tests have averaged over sixty pounds per head on October 20th.

Fenced fields, required by a system of this sort, should soon be paid for by the wool and lambs produced.

***Winter Maintenance of Breeding Ewes:**

Corn silage, sunflower silage and beet-top silage are being used with alfalfa hay in maintenance rations for pregnant ewes. Alfalfa hay alone is being compared with these combinations.

Maintenance Rations for Beef Cattle:

This project is to study the value of roughages for carrying cattle through the winter. It is, at present, inactive.

***Maintenance of a Purebred-Beef Breeding-Herd, Ft. Lewis, Colo.:**

A study is being made of the care and management of a breeding herd situated at an altitude of 8,000 feet. Data on the cost of calves at weaning time will be secured.

The projects which are already started, or upon which we would like to do work, are starred. One of these, the lamb-feeding project, is expensive, and in view of the condition of finances we know that we cannot carry it on.

Respectfully submitted,
GEO. E. MORTON.

REPORT OF 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 1920-21.

During the year, the greater part of our time has been devoted to four projects, three of these being classified as Adams and one as Hatch. In addition to these, we have given some attention to minor investigations in a consulting and co-operating capacity. The number of routine laboratory examinations, called for by correspondence, has increased considerably, the field covered including well-waters, stock-waters, soils, diseased plants, poisonous plants, spoiled meats and vegetables, and vinegar analyses.

ADAMS FUND PROJECTS

Energy Studies:

Sulfur and green manures have been studied in connection with soils of high, nitrogen-fixing, and nitrifying capacities as a possible means of controlling the formation of excessive nitrates in soils.

Milkweed Poisoning:

Further studies of the active principle of the whorled milkweed ***(Asclepias galioides)*** have been carried on; considerable

progress has been made with the identification and purification of the poison, the lethal dose of our most recent preparation being .28 g. for an 1100 g. guinea pig.

Spoilage in Canned Vegetables:

The cause of spoilage in vegetables canned both by the cold-pack method, and by the process employed in commercial canneries has been studied. Corn, peas and hominy have been examined. Three spore-forming bacteria have been isolated from the corn and peas canned by the cold-pack method, and two different spore-forming anaerobes from the peas and hominy obtained from canneries.

HATCH FUND PROJECT

Natural Inoculation of Colorado Soils with Legume Bacteria:

Up to the present time, 64 samples of soil have been examined. These represent the districts around Sterling, Fort Morgan, Brighton, Hugo, Flagler, Cheyenne Wells, Grand Junction, Palisade, Paonia, Delta, Montrose and Ouray.

It is impossible to generalize our observations on these soils for some show a need of inoculation for all the legumes, while others possess a natural inoculation for certain species. Without exception, all need the inoculation for peas and wax beans; many have a natural inoculation for alfalfa and sweet clover; most would be benefited by cultures for red clover, white clover, alsike clover, navy beans and vetch.

MISCELLANEOUS INVESTIGATIONS

At the request of the Great Western Sugar Company and in co-operation with Mr. Asa Maxon of that company, I made an extensive study of the rotting of steckling beets in the silos of northern and eastern Colorado. In addition to the recognized Phoma rot, there was found a soft, viscid, slimy condition which had all the characteristics of a bacterial rot. Several different bacteria were isolated from affected beets, and when these were reinoculated into beets of low sugar-content, they produced a soft rot, but when introduced into mature beets containing relatively high sugar, little or no effect was produced. These results agree with actual field experience, and it appears that a combination of low sugar or immature beets together with high temperatures in the silos aggravated the bacterial attack.

Vinegar Studies:

Miss Brown has been working on a method for making vinegar from sorghum molasses and sugar by the use of pure cultures to supplant the less-reliable "vinegar bees". She has succeeded in producing a very good vinegar experimentally, but

there remain a few points to be worked out yet before we can give the method to the public.

Rocky Ford Sugar-Beet Investigation:

In co-operation with the Agronomy and Irrigation Sections, and in conjunction with the American Beet Sugar Company, extensive field experiments were started at Rocky Ford, Las Animas and Lamar, for the purpose of trying out certain chemical, tillage and irrigation treatments as corrective agents to the unfavorable soil-conditions which exist in the Arkansas Valley. The work was well under way and the various crops were growing nicely when the high waters of the Pueblo flood washed out practically everything. Obviously the experiment had to be discontinued, but a new tract of land on higher ground has been selected near Rocky Ford, where the investigation will be continued in 1922.

Mustard Poisoning:

A species of wild mustard (***Thelepodium elegans*** Jones) wild reported by stockmen on the western slope, as the cause of poisoning in their livestock. This plant was fed to laboratory animals in a fresh condition as their exclusive diet, but we have been unable to discover any harmful effect.

Corn Root-Rot:

In co-operation with the Agronomy Section, we have begun a study of the occurrence of corn root-rot in Colorado seed corn. Thus far, our work has been directed at establishing or repudiating, as the case may be, the validity of the method recommended by certain laboratories, and in general use in seed-testing laboratories, for determining the presence of this disease in seed corn in connection with routine germination tests.

The results of our work suggest that the method in its present form is not sufficiently reliable to warrant its general adoption by the layman. Four different laboratories, testing the sample of corn, reported respectively 90%, 65%, 0% and 0% root rot.

PROJECTS FOR 1921-1922

1. Milkweed Poisoning.
2. Spoilage in Canned Vegetables.
3. Energy Studies.
4. Bacterial Disease of Wragg Cherries.
5. Corn Root-Rot.
6. Arkansas Valley Sugar Beets.

Our very great need for more laboratory floor space is too obvious to need any elaborate exposition. As the field of our work enlarges, we find it increasingly more difficult to do satisfactory work in our present quarters. We have no suitable room for mak-

ing our chemical determinations, and the fumes from our laboratory are a constant annoyance to the other departments housed in the same building. We have no suitable room for experimental animals, the present basement quarters being dark, damp, cold and unhealthful; no constant temperature room for cultures and incubators; no library space; inadequate, greenhouse facilities; no satisfactory provision for storage of stock soils, chemicals and glassware; no laboratory for sanitary water-analysis; no suitable dark room and photographic room; no office space for either my assistant or myself. A conservative estimate of the floor space we should have to be properly housed is approximately 70x140 feet. I sincerely hope that the building committee will give our needs most serious consideration in the near future when new buildings are being planned.

I am indebted to Miss Mildred Brown and Miss Elsa B. Eisendrath for much of the routine work of the laboratory, whose faithful and efficient services I take pleasure in acknowledging. Miss Eisendrath found it necessary to sever her connection with the Experiment Station, May 31st, and was succeeded by Miss Brown.

Very respectfully submitted,

WALTER G. SACKETT,

Bacteriologist.

REPORT OF THE BOTANIST

To the Director:

Permit me to submit the following brief report on the investigational work of the Botany Section for the fiscal year ending November 30, 1921.

The five projects which were taken up by the present staff last year have been continued without much change.

Additional material has been collected in the work on the Microscopy of Poisonous Plants and a large percentage of this material has already been worked over.

In the Fungous Disease Investigation, several plant diseases have been studied, both as to causal organism and as to distribution within the State. Notably among these are the stinking smut of wheat, blight of the pear and an unidentified disease of celery.

Field data on hard seeds of alfalfa which was grown at Fort Collins and Rocky Ford have been checked with laboratory germination tests.

The work on the Fungous Disease of the Sunflower has been somewhat handicapped by a lack of material for study since the

disease was not nearly as prevalent this year as it has been in previous years. Some difficulties have also been encountered in the inoculation of healthy plants with the isolated organism.

The results obtained in the Range Improvement Project is very gratifying. During the summer months, quite complete data were obtained as to meteorological factors influencing forage growth, life histories of the principle forage grasses and the forage value of certain grasses. If the work started this year is to be carried to completion, more time will have to be devoted to it next year.

Besides carrying on the usual, routine work of the Seed Laboratory, two problems have been under investigation:

First, we made a comparison of the estimated percentage of germination by appearance of seed corn with laboratory and field test of the safe. This work shows definitely that no person can estimate correctly by the appearance of the ear and kernel the percentage of viability.

Second, we have investigated the causes of delayed germination in wheat grown in certain sections of the state.

Respectfully submitted,

A. K. PEITERSEN,
Botanist.

REPORT OF THE CHEMIST

To the Director:

The work of the Chemical Section has progressed satisfactorily during the past year. We have addressed ourselves to two phases of our niter projects: The Occurrence of Nitrates on Rocks, and the Effect of Excessive Nitrates on Potato Production. The latter part of the winter and during a portion of the spring of 1921 we did some work on the former, but during the summer and later, up to the present time, we have addressed ourselves to the potato problem.

The project on The Occurrence of Nitrates on Rocks, proves to be of such breadth that I can scarcely hope to prosecute it as it should be prosecuted. It, furthermore, is evidently of very wide interest involving many questions that are only remotely related to agriculture. The direct connection with this subject is the fact that the soils and rocks are intimately related, and the processes going on in the one are similar to those taking place in the other.

Up to the present time I have found no reason for changing my views in any respects in regard to the question of the origin and occurrence of nitrates in the soil as given in our Station bulletins.

The potato problem proves to be an evasive one; at least we meet with some difficulties. One portion of the problem, the chemistry of the soil and crop, seems to be solvable with results quite similar to those obtained with beets and wheat, to-wit: That the composition of the tubers is modified by the application of nitrate, but the pathological features of the work up to the present time have not appeared favorable. Complications have arisen in this work that render it advisable to continue it on a larger scale and more thoroughly than we have done.

The question arose last year: What influence has the soil atmosphere? We have instituted a series of carbonic acid determinations which we have carried on throughout the summer and are still continuing. This question leads into a very unsatisfactory domain. The question has been studied for some years by others with some results. I am not sanguine about the value of our work, but it is different from other investigations on this subject in plan and thoroughness. I have taken counsel with others and it seems to be the opinion that it is a subject worth prosecuting. I see only one thing in it, i. e., a measure of the biological activities of the soil, which, of course, are intimately related to growth of cultivated plants. This subject would, if properly prosecuted, take the time of one man for seven or eight months for two or more years. At Cornell they prosecuted a similar study for four years.

Our other projects have had to remain quiescent, partly because we have been engaged on the questions named and partly because of certain disappointments.

We do not wish to take up any new projects.

Yours very truly,

WM. P. HEADDEN,
Chemist.

REPORT OF THE ENTOMOLOGIST

To the Director:

I am presenting herewith the report of work carried on in the Entomology Section of the Experiment Station during the past year.

Several of the men working in this section are paid in part by the Experiment Station and in part by the office of the State Entomologist, as the State Entomologist is permitted to carry on investigational work to determine means of control for the pests with which he has to do.

There has been no change in the personnel of this section of the Experiment Station during the year, except that Mr. C. L. Cor-

kins, Deputy State Entomologist, has given a small portion of his time to the insect control work.

I am mentioning briefly the work carried in the various projects assigned to this section as follows:

Plant-Louse Investigations:

Miss M. A. Palmer and the writer have given considerable attention during the year to the work of completing plant-louse life-histories and determining the food plants of a number of the species occuring in this state. Apparently, a few undescribed species have also been taken, and two manuscripts are in preparation which we hope to publish in the near future.

Ants of Colorado in Their Relation to the Plant Lice:

This project is in direct charge of Professor C. R. Jones. Some additional data on this project have been collected durng the year, but the work in this particular line has not been specially pushed.

Life Habits of the Syrphus Flies:

This project is also in charge of Professor Jones and has been given considerable attention. In fact, a manuscript is now in the hands of the Station Editor for publication, giving rather a complete list of the species occurring in the State, with much data concerning food habits, and with quite full descriptions of all the species. We are hoping that the Station will be able to publish this paper in the near future.

Control of Insects by Egg-Treatment:

This is a project upon which we have been accumulating data for several years. During the past spring and early summer Mr. John Hoerner has done some work to determine the effect of insecticides upon the eggs of the codling moth and Mexican bean-beetle. Aside from this, very little work has been done upon this project during the year.

Codling-Moth Studies:

More work has been done upon this project than upon any other during the year. The direction of this work has been under Mr. Geo M. List, and at Paonia, Colorado, Mr. J. H. Newton has been in immediate charge of the collection of data on codling-moth life-history and methods of control for Delta County. At Canon City, Mr. Yetter and Mr. McIntyre have been in charge of the gathering of codling-moth life-history data. After the first of May, the work for the control of the codling-moth in the Grand Valley was in charge of Mr. William Yetter, a Deputy State Entomologist, the purpose of the work in that section being to bring about uniform methods of control thruout the district. A bulletin manuscript, giving the results of our investigations into codling-moth

life-history and method of control in Delta and Fremont counties has been completed and placed in the hands of the Director of the Experiment Station for publication.

Grasshopper Control:

While the grasshoppers have been rather abundant in many of the agricultural sections of the State during the year, we have had but few calls for help in the control of these pests. However, Professor Jones has made two or three trips to aid the farmers in the use of poisoned bran-mash, which, in every case, was very successful in killing the hoppers.

General Insect Investigations:

Several insect pests have been given attention during the year. Those of most importance have been: (1) The Mexican Bean-Beetle, ***Epilachna corrupta,*** with the work in charge of Mr. George M. List and Mr. John Hoerner. Mr. List has prepared a bulletin manuscript covering this work, which is now ready for publication; (2) Life history and control methods for the Beet Web-Worm, ***Loxostege sticticalis,*** and the Alfalfa Web-Worm, ***Loxostege commixtalis;*** and (3) The Fruit-Tree Leaf-Roller, ***Archips argyrospila,*** which is still doing serious injury to the fruit crops in the vicinity of Canon City, this work also being in charge of Mr. List. Mr. Hoerner has also given much time to the collection of insects at lantern traps for the purpose of determining the dates when the more important insects occurring in northern Colorado make their appearance, and the number of broods in each case.

During the spring, Mr. Corkins also gave considerable attention to the cut-worm injuries that were very prevalent in northern Colorado. According to his estimates, several thousand acres of grain were so badly injured, especially by the pale western cut-worm, ***Porosogrotis orthogonia,*** that it was necessary to reseed or put in another crop.

Many brief notes upon the insect pests of the year may be found in my report as State Entomologist for 1920-21, Circular 34, Report of the State Entomologist of Colorado.

Respectfully submitted,

C. P. GILLETTE.

REPORT OF THE FORESTER

To the Director:

The annual report of the Section of Forestry for the past year is herewith submitted:

One project only has been in force during the year. This project, which has now covered a period of over four years, is con-

cerned with an investigation of the relative durability of our more important species of timbers measured by an original method of greater accuracy than those commonly employed. By this method, sets of wood specimens of the same size and shape are subjected to the same conditions of temperature and moisture and the rate of decay is determined at regular intervals by drying and weighing the samples. Loss of weight in the samples as compared with their original weight has been taken to represent the stage of decay in each case. This is based upon the established fact that the decay of woody tissue, due to the activities of certain fungi, leads to the breaking down of the carbohydrates, of which wood is almost wholly composed, and the liberation of water and carbon dioxide.

While the original set of specimens, including 18 species of woods, has been used up, another set, the redwood of California, is now under test together with specimens of native cottonwoods. The latter species is being used to test the effects of preliminary seasoning upon the rate of decay as compared with unseasoned wood. Another set of specimens is being studied with reference to the possible effects upon the rate of decay due to placing the top ends down as compared with planting them with the butt ends down. Some interesting results of the two tests last mentioned are being secured.

A full report of the experiments thus far completed together with those under way is in preparation but cannot be finished before the end of another six months. It is realized that this project has progressed more slowly than was at first expected. However, the great durability which some species of woods exhibit requires a long period of time to show the effects of such a test. At present the writer is carrying a heavier teaching schedule than for a number of years past and but little time has been found to devote to closing up the project and organizing the accumulated data into a complete report. It is expected that some help in making graphic diagrams for the report will be secured from one of our forestry seniors in connection with his seminar period and at the same time give him a complete review of the investigations.

In view of the increasing weight of teaching which the work of the department now demands, it seems unwise for me to inaugurate a new project during the coming year.

Respectfully submitted,

B. O. LONGYEAR,
Forestry Investigations.

REPORT OF HOME ECONOMICS SECTION

To the Director:

Continuing the research of the preceding year, twelve hills each of Pearl, Rural, Brown Beauty and Burbank potatoes were grown, especially for this work, in the Greeley and San Luis Valley districts. In addition, Cobblers, Ohios, Peach Blows and Triumphs were obtained from Greeley and from the Arkansas Divide, while Burbanks were also obtained from Carbondale.

All these types were carefully compared:

(a) in regard to cooking qualities by boiling, steaming, and baking;

(b) in regard to per cent of moisture, starch, nitrogen and ash.

To reach the average analytical results obtained, the individual analyses of several hundred samples were involved. From the results obtained, it seemed wise to make, during the current year, similar comparisons of the immature and the mature potatoes of the above-mentioned types, the immature tubers being dug some weeks in advance of the mature ones taken later from the same fields. To this end, potatoes have been secured from the Greeley and San Luis Valley districts; Burbanks from several different growers in the Carbondale district also, several types have been secured from the dry-land sections of the State.

One senior student was taken into the laboratory during the spring of 1921; she was given a short problem concerning the comparative results obtained in boiling the different types of potatoes grown in the different localities.

Since this research was begun in the fall of 1919, the equipment of the Home Economics Research Laboratory has been replaced, and added to, as circumstances required. It is hoped that this policy may be continued till a very complete equipment for a research food-laboratory results. To this end the library facilities in the way of complete sets of research periodicals should be constantly and rapidly increased. It is the hope of the Department of Home Economics that as graduate work may be developed, the Home Economics Section of the Station may afford an opportunity for the carrying on of research problems which may later constitute part of the graduate requirement for advanced degrees.

Respectfully submitted,

N. E. GOLDTHWAITE.

REPORT OF THE HORTICULTURIST

To the Director:

I beg to submit the following report on the work in progress in the Horticultural Section during the past season.

In making this report, I beg to say that some of the projects naturally require a series of years to obtain results that can be embodied in a report. Projects of this nature are: The Growing of Hardy Apples for Northern Colorado, the Growing of Tree Fruits and Small Fruits in High Altitudes.

These projects have been carried forward during the past year. It is of interest to note that the project on growing hardy apples for northern Colorado has shown some results during the past year. Our experience during previous years has been rather disappointing, due mainly to the exceptionally cold spells that we have had during the month of November. The trees at this time have not been sufficiently hardy and, as a result, have suffered greatly. Last winter was very favorable, and there was practically no winter killing. Replanting in the orchards has been very extensive during the last five or six years, though some varieties, like the McIntosh, Gano and Jonathan, have stood the hard winters remarkably well. The orchard is now in fairly good condition.

The project on Growing Vegetables in High Altitudes has been concluded and a bulletin was written and no further reports will be made on this project.

The project on Seed Potatoes in High Altitudes is still in progress. The experience we have had in keeping the seed over from year to year at Fort Lewis has delayed the work to quite an extent, but with a man permanently on the job, and with increasing facilities for storing and handling seed potatoes, this project should be concluded in a year or two. The results thus far obtained warrant the efforts.

The project on Fruit Growing in High Altitudes, as mentioned before, will require a series of years to draw any conclusions. The results thus far indicate that the better varieties of the native or Americana plums can be grown successfully. The trees stood the winters well. Some of the hardy varieties of apples obtained from Minnesota seem to stand the climate, but it is too early to say what varieties we can recommend for permanent planting for this section.

All our work at Fort Lewis, as you know, has been greatly handicapped, and especially has the orchard suffered from lack of proper protection during the winter. Mice and rabbits have done considerable damage, necessitating the replanting of a large share of the trees each year. With a good fence around the orchard, this should be entirely eliminated in the future. So far as the project

is concerned, it is doubtful if the growing of apples will ever be a success, at least commercially, as the crop is apt to be killed by late spring frosts. However, the work should be continued since the fruit trees, especially the crab apples, can be grown, not only for the fruit they produce occasionally, but for shade trees.

POTATO GROWING PROJECT

The Potato Growing project may be divided into several projects, but for convenience, is grouped under one. The main work this year has been carried on at Eagle, Colorado, to which place we transferred the work last spring. Previously we have been doing all this work in the San Luis Valley, but our experience in handling the work on farms operated by the farmers, was such that we could not control the conditions, or obtain data that was reliable.

We have carried on the work to determine whether the yield and quality of the crop was dependent entirely on the quality of seed used. It is of special interest to report that the seed, so long as it is not diseased, is not as great a factor in production as the average farmer and experimenter believes. So long as the seed is vigorous and the conditions under which the seed is to be planted are normal, good results will be obtained. We have found little or no difficulty in yield from gnarly and poor looking seed. In fact we have followed the method of selecting the worst tubers from the field planted the year before, and selecting the best tubers from previous years. This work has now been going on for three years, and in almost every case we have found that, if the stand is equal, that is, if every piece of seed grows, that the results are almost identical. There is considerable difference if the seed is weak, either from disease or from improper cultural methods, but where the seed is free from disease the shape of the tubers has nothing, or practically nothing, to do with the subsequent yield.

This result is extremely interesting, but it is contrary to the doctrine that we and others have been preaching, and I do not believe that it would be a good policy, for the present at least, to publish the results until we have verified the results obtained, and also studied out the factors which are responsible for decreased yield apart from the decrease due to specific diseases.

TOMATO PROJECT

This project has now been in force for three years, and we are not satisfied with the data, or rather we feel that the data is yet incomplete and that another year should be devoted to this project before it is published. This year's trial, which was more extensive than any we have conducted, shows most conclusively that the season was unfavorable to the crop and the fruit did not ripen in sufficient quantities to justify us in drawing final conclusions.

FRUIT SURVEYS

The fruit-survey work has been completed. Every fruit-growing county in the State has been surveyed and cards catalogued. We have now a complete record of the fruit-growing industry in the State and this will be of great value in dealing with the problems that the future grower encounters.

The project on apple storage is in manuscript form and will be published as a bulletin and also be made a part of the report of the State Horticulturist.

PUBLICATIONS

There have been no publications issued during the year from the department. We now have in the hands of the editor, two bulletins, and two more are ready to be handed over. In addition we also have a bulletin on the storage of fruits. It is necessary to reprint the bulletin on small fruits and on vegetable gardening; also, possibly, one on the growing of head lettuce.

Respectfully submitted,

E. P. SANDSTEN,
Horticulturist.

REPORT OF THE IRRIGATION INVESTIGATIONS ENGINEER

To the Director:

During the past fiscal year, ending November 30, 1921, the following projects have been under consideration and attention also given to subsidiary subjects.

The study of Current Meters, an Adams project, has been under consideration since 1914, but, during this time, the work has not been continuous. However, during the past season, a strenuous effort has been made to complete the field work which should permit conclusion of this study and the preparation of the final report within the near future.

The original conception of this study was the investigation of various types of instruments and, from the results of the study, to propose a design which would incorporate the desirable features of the instruments tested,—this new design to be practical and such as to produce an improvement over the present standard instruments now in use. The investigation at first was confined to the rating of various types of instruments, both on the tangent and circular rating-stations, and, from the behavior of the meters, to seek out the desirable features as a basis for the development of the new design. Laboratory facilities were adequate for this phase of the study, but the practical application was not possible until the building of the Bellvue laboratory, which permitted testing

the meters against a known discharge of the stream. This second part of the investigation was completed the past season.

The project on Evaporation from a Free Water Surface is approved as a Hatch project. This project has been under consideration for a number of years and the first efforts at its solution were of little effect because of inadequate apparatus. Improved equipment has permitted much more refined measurements, and also the scheme of the series of observations has brought to light the possibility of following very closely the trend of the evaporation losses as affected by the variation of the various influencing factors.

The most important improvement made in the apparatus was the introduction of the optical evaporimeter, which has permitted the measurement of the depression of the water surface, due to evaporation. in units of 0.000018 of an inch. Temperatures and vapor pressures were determined very accurately, as shown by the existing relation to the evaporation losses.

Studies made during the season of 1920, under still-air conditions, show that the maximum loss occurred during the early morning hours and was a minimum in the early afternoon, and that this maximum was 300 to 400 per cent of the minimum. Further observations the past season, under like conditions, seem to verify the results previously obtained. The ultimate purpose of this investigation is to establish the fundamental law of evaporation from a free water-surface and to introduce into this law such factors as apply to evaporation losses that occur in irrigation practice.

The Hatch project on the Measurement of Water as Applied to Irrigation has just been approved this fiscal year, and some progress has been made. This project included several parts, and of these two have been completed, with the exception of preparing the report covering the work done. The finished work consisted of a study of water-stage-recording instruments and a series of observations on a short-box measuring flume. The recording instruments were of various types, some of antiquated design and others of the latest standard make, while in the collection were instruments of original design, built at the laboratory. These recorders were tested and observed at the laboratory and later installed at the Bellvue laboratory under practical field conditions. A number of the instruments were kindly loaned to us by the makers.

The calibration of the short-box measuring flume is now being completed at the hydraulic laboratory here on the campus. This flume is of short length where the stream passes over a partition board not unlike a weir, and where the end contractions are completely suppressed. The calibrations cover widths of box up to

four feet with varying bottom contractions, and to a capacity of about ten second-feet.

The project on Meteorology has been carried on without interruption during the past year. It is believed that the daily weather reports from this office, which appear in the local papers, are much appreciated by the public. This project is supported by State funds.

The South Platte project, relative to the study of the return flow of seepage to this river, was a co-operative proposition in which the State Engineer of Colorado and the several counties of water districts, Nos. 1 and 64, joined with the Station and the Division of Agricultural Engineering, Bureau of Public Roads, U. S. Dept. of Agriculture. The project covering this work was approved early in 1919, and the field work concluded November, 1920. A full report covering this investigation has been prepared, discussing in more or less detail the following: The South Platte River, organization and equipment, underground water, return flow, seepage losses from canals, daily fluctuations, canals and irrigation systems of the valley, crops and irrigation, distribution of water and recommendations, together with the summary. Included in this report may be found various tables and appropriate diagrams and illustrations having to do with this interesting study.

Considerable interest has been shown the past few years on the part of the farmers in organizing drainage districts in various parts of Colorado and particularly in the Arkansas Valley. During the past year I have assisted in the organization of six of these districts, all located in the Arkansas Valley. In the lower portion of the valley, near Lamar, I have been particularly interested in the equalization of the assessment schedules of the districts, and, of the several appraised during the past three years, only one has resulted in a controversy. Requets have come from the San Luis Valley for assistance in the organization of drainage districts there. The reclamation of damaged lands by means of drainage systems through organized effort under the drainage district law has proved to be a usccess as well as of practical importance in various localities of the State.

The growing of sugar beets profitably in the Arkansas Valley is now presenting a problem which is of a serious nature. Statistics bear out the fact that for the past few years the margin of profit, both for the farmer and the manufacturer, if profit there be, is confined within narrow limits and, during the past year, some attention has been given to this problem under a co-operative plan with the American Beet Sugar Company at Rocky Ford. A series of experimental plots was laid out and planted to various crops which were to receive various treatments as to culture and irrigation. The unprecedented flood that swept through the valley the

forepart of last June so obliterated our plots that further progress with the sugar-beet investigation would have been impracticable and it was, therefore, abandoned. The unfortunate loss of the effort put forth last season is emphasized by the importance of the problem and the acuteness of the situation.

Following out somewhat the plan of organization and line of work for the South Platte seepage investigation, a similar project was started on the Arkansas River between Canon City and the Kansas state line near Holly. This work, like the South Platte project, was undertaken as a co-operative investigation in which the State Engineer of Colorado, director of the work, the Colorado Agricultural Experiment Station, the Arkansas Valley Ditch Association and the various counties of the valley districts were interested. This work was started last April and was progressing satisfactorily until the occurrence of the flood in June, when the damage resulting was so great that this project was also abandoned. The loss of equipment along the river was not great. However, there were approximately five recording instruments of some twenty-five loaned by the U. S. Dept. of Agriculture, that were washed away and never recovered. The wrecking of irrigation structures and damage to ditches and canals so interrupted the irrigation operation of the valley that to continue with the work would have been of little value; and further, the additional expense to the several counties for roads and bridges, as well as to the various canal companies for new improvements, demanded the strictest economy, which, in turn, had its effect on the elimination of this seepage investigation.

A very important improvement has been provided in the equipment of this section of the Station at the Bellvue laboratory in the construction of a standard ten-foot rectangular weir, having a capacity in flow of 100 second-feet of water. The hydraulic laboratory on the campus has a limited capacity of about 17 second-feet, and the new weir at Bellvue has permitted greatly extending the range of the investigation of research problems not possible at the Station laboratory at Fort Collins. This new equipment at Bellvue consists of a reinforced concrete structure 24 feet long, 14 feet wide and 7½ feet deep, with a 4-inch concrete floor, and 6-inch walls. The weir notch is placed in the end wall and so designed as to be adjustable in height. The crest and sides of this weir are of 3-inch angle iron, carefully dressed and set to proper grade and dimensions, which permits quite accurate determination of the discharge. The original measuring flume at the Bellvue laboratory was 10 feet wide, but the construction of the new weir necessitated the widening of the flume to 14 feet to agree with the new concrete structure.

The laboratory on the campus has been painted, and minor

repairs made, putting things in good condition. However, it was recently discovered that the 16-inch metal discharge-pipe from the large pump to the upper reservoir is quite badly deteriorated and in all probability will have to be replaced the coming season.

At present there is being built at the hydraulic laboratory a small model which will illustrate the principle of the measurement of water over a weir through a Venturi flume and by the ordinary rating flume. This model is about 10 feet long, 3 feet wide and 3 feet high. The model devices are placed in a wooden flume, where this flume is mounted over a metal supply tank, and by suitable connections, water is pumped from the supply tank to the flume above and after passing over and through the miniature structure is again returned to the metal tank. Various instruments are installed to illustrate their application and practicability as connected with irrigation practice.

At this time it is expected that both the hydraulic laboratories will be necessary to continue the work during the present federal fiscal year, ending June 30, 1922. At the Bellvue laboratory will be undertaken further studies of the Venturi flume, confined largely to the trapezoidal section and possibly some preliminary work will first be necessary to determine the proper ratios of dimensions of the proposed flume. This project is classed as Adams work.

The project on the Measurement of Water as Applied to Irrigation is, in part, completed, but it is now planned to continue with this study, possibly at the laboratory here. This project is drawn as Hatch and is also supported by State funds.

It will be necessary to continue with the evaporation studies, but the plan of extending this work will be based upon the results obtained the past two seasons; however, it is now expected that sufficient data of fundamental charcater have been obtained to permit extending the observations under field or exposed conditions. The apparatus will be installed at or near the hydraulic laboratory where certain necessary facilities are available, and an attempt made to correlate the non-exposed still-air data to the fully exposed condition in order to fix the constants of the law of evaporation. Very gratifying results have so far been obtained, and with the improved apparatus now used it seems possible to arrive at definite conclusions. The evaporation project is classed as Hatch work.

Due to necessary equipment now available, it would be possible with very little actual outlay of funds to collect certain reservoir data in the vicinity of Fort Collins which would be of interest and value to irrigation practice. An outline covering this work has not yet been prepared but I will present this matter to you in regular form in the near future.

At this time I have no suggestions or criticisms to make other than that during the past year it has been necessary to be away from my regular work more or less of the time, which has interfered somewhat with scheduled project work. It may not be out of place to mention here that plans are being prepared for further improvements at the Bellvue laboratory, whereby much better control may be had, and also to so regulate the flow that the deposit of sand and silt in the new weir box may be reduced to a minimum. The plan of these improvements will be fully discussed with you in detail before seriously considering this work.

Respectfully submitted,

RALPH L. PARSHALL,
Senior Irrigation Engineer.

REPORT OF MARKETING INVESTIGATIONS

To the Director:

On October 1, 1920, the undersigned was employed as Research Agent in Marketing on a co-operative basis between the Colorado Agricultural Experiment Station and the U. S. Bureau of Markets, headquarters being made at Denver, Colo. During October and November the work done consisted merely of routine work in the Denver office of the Bureau of Markets. Early in December, a definite project on potato marketing investigations was outlined and work commenced in Greeley. This work was continued until the termination of the co-operative agreement with the U. S. Bureau of Markets on June 30th, when the Research Agent in Marketing resigned to accept the position of Director of the Colorado Division of Marketing. The work followed included an exhaustive investigation of all phases of the marketing of potatoes in the State of Colorado, together with a study of potato-marketing data and information for the entire United States, as collected by the U. S. Bureau of Markets and Crop Estimates, and by various State officials, railroads and others.

A great deal of work was done on the preparation of a bulletin to be issued co-operatively by the Colorado Agricultural Experiment Station and the U. S. Bureau of Markets, entitled—"Marketing Colorado Potatoes". This bulletin was almost completed when the work was discontinued, July 1. Since that time, the pressure of work of the Division of Marketing has made it impossible to spend any further time on this bulletin and it was decided advisable to hold it over for another year and incorporate the marketing data for another season before publishing this work. It is proposed to complete this bulletin for publication during July or August of 1922

On July 9, Mr. E. F. McKune was employed as Supervising Inspector for the Colorado Division of Marketing and Investigator in Marketing for the Colorado Agricultural Experiment Station on a co-operative basis, and on September 7 Mr. James R. Duncan was employed under the same agreement. In the establishment of standard grades for vegetables and apples, Mr. McKune and Mr. Duncan have done a large amount of investigative work and have had a splendid opportunity to observe in the producing sections, the methods and processes of marketing the fruit and vegetable products of the State. Thru the inspection organization of the Colorado Division of Marketing, a large amount of valuable information relative to fruit and vegetable products of the State, has been collected and is available for publication on a co-operative basis by the Colorado Agricultural Experiment Station and the Division of Marketing.

It is proposed during the latter part of the shipping season, when the field work will be relatively light, to prepare such information for publication. It is expected to carry on this work in co-operation with Professor L. A. Moorhouse, of the Department of Economics and Sociology. The work of the two men employed under this co-operative agreement has been absolutely essential for the successful conduct of the work of the Division of Marketing and it is believed that the investigational results shown will well repay the expenditure of funds provided for this purpose by the Agricultural Experiment Station.

Respectfully submitted,
WM. F. ALLEWELT, Director,
Division of Marketing.

REPORT OF THE PATHOLOGIST

To the Director:

PROJECTS IN FORCE

Sheep Losses in the Feed Lots.
- a. ***Hemorrhagic Septicemia***
- b. ***Ictero Hematuria***
- c. Losses on peas

Contagious Abortion
Sod Disease of Chickens
Forage Poisoning

Sheep Losses:

Hemorrhagic Septicemia. This disease has seemingly not been so prevalent in the feed lots during the past year as formerly, as a smaller proportion of the deaths investigated show the pres-

ence of the causal organism of this disease. Most of our work has been given toward the experimental determination of the value of vaccination, the preliminary report of which was presented to the American Veterinary Medical Association at its Denver meeting.

The results, so far, seem to indicate that a live organism gives greater immunity in sheep than does one killed by heat or antiseptics. The work on this line is being continued.

Ictero Hematuria. No outbreaks of this disease have been seen during the time covered by this report, but some ticks were gathered by Dr. Feldman in a district where the disease formerly existed, and placed on some presumably susceptible sheep at the Station. Negative results were obtained.

Losses on Peas:

We have been fortunate enough to get sufficient funds set aside to start a rather extensive feeding experiment at Center, with a view to determining the cause of the losses in pea-fed lambs in the San Luis Valley.

The experiment is under the direct supervision of Dr. Cross, who is spending some months there. While it is now under way, the progress has not been sufficient on which to make a report. It is possible that several years will be required for the solution of this very baffling problem.

Contagious Abortion:

We have had a herd of purebred range animals placed under our charge, and have run agglutination tests on the entire lot of approximately one hundred animals. We have vaccinated two-thirds of the reacting animals, leaving one-third as controls. Since approximately 30 per cent of the cows in this herd had aborted, this experiment should be of some value to us.

We are just now perfecting plans to carry on some vaccination experiments in a large dairy herd near Colorado Springs.

Sod Diseases of Chickens:

No work has been done on this disease during the past year, but our bulletin, No. 262, appeared during the time under consideration

Forage Poisoning:

There has been no epidemic of forage poisoning, but individual cases have been seen, and the forage examined particularly for ***Bacillus botulinus.*** Up to the present time, our results have been negative as far as the finding of this organism is concerned.

Two hundred specimens for diagnosis have been examined in the laboratory and reports made to the senders.

Respectfully submitted,

I. E. NEWSOM,
Pathologist.

REPORT OF THE VETERINARIAN

To the Director:

The approved project that has received attention this year is the one on Animal Diseases under the State fund.

The State has been remarkably free from pestilential diseases during the past year. Hog cholera is rather more prevalent than it was a year ago, but is well under control. An enzooty near Littleton caused a loss of fifteen out of eighteen horses on one farm. Considerable field and laboratory work has been done on this disease, hoping to determine the cause and an appropriate treatment, but at this time no definite conclusions have been reached. It is a chronic disease and thus far all animals that have become affected have died, regardless of treatment. A loss of cattle west of Denver seemed to have been caused by eating poisoned bran that had been scattered in the pastures for the purpose of killing grasshoppers. The bran had been spread by means of an end-board grain seeder and clumps of bran as large as hickory nuts were found behind the spreader. The fact that cattle were seen hunting for these chunks of bran, and further, that the symptoms were typical of arsenical poisoning made the evidence quite conclusive.

There have been many reports of cases, especially in horses and cattle, ascribed to forage poisoning. The contention is now made that forage poisoning, corn-stalk disease, the Kansas horse plague, and certain other diseases, are in reality botulism, which simulates poisoning in the human from sausage, ripe olives, canned goods, etc. The botulinus antitoxin appears to be fairly successful, both in treating and preventing this condition in the human, and much is hoped for its use in the lower animals.

A law was enacted by the last legislature providing for co-operation with the federal government in the control of tuberculosis. Unfortunately, the appropriation was small and placed in the fourth class, so that the work can barely be started during the present biennium. Tuberculosis is becoming more common in poultry, and this phase of the work should not be neglected. That the disease in larger animals at least can be controlled seems to have been demonstrated, but success will depend upon co-operation of all the states covering a period of a series of years. All of the

states, save three or four, are now actively engaged in tuberculosis control. The work is popular with the livestock interests and the benefits to be derived from having an accredited free herd, along with the indemnity provided, has resulted in the accumulation of many advance applications.

There have been no changes in the staff of the veterinary section during the last year. A new Station laboratory has been provided in connection with the Veterinary Division, which is now located in one of the barracks. No important addition has been made to the equipment.

There is need of special investigation of poultry diseases, which have been sadly neglected. Among other diseases which have an economic as well as scientific interest at this time, the following are conspicuous: Paralysis of hogs, pulmonary edema of horses, scrub-oak poisoning, and a summer disease of cattle characterized by paralysis of the organs of prehension.

GEO. H. GLOVER,
Veterinarian.

REPORT OF ENGINEERING DIVISION

To the Director:

I am transmitting herewith the reports from the Civil Engineering and Mechanical Engineering Departments of the Engineering Division of the Experiment Station.

Both departments have been busy during the year upon the projects under investigation. It is to be hoped that next year the Department of Electrical Engineering will commence investigative work in the Experiment Station.

Respectfully submitted,
LD CRAIN,
Chairman of Division and Vice-Director.

REPORT OF CIVIL ENGINEER

To the Chairman, Engineering Division:

Following is the report of the Civil Engineering Section for the year December 1, 1920, to December 1, 1921:

One project is being carried by this section, namely, Road Materials. During the past year, co-operative work with the State Highway Department has been done. Under this agreement one field party has been out all summer. Surveys of road materials have been made on the Denver-Greeley, Denver-Fort Collins, Greeley-Fort Collins, Denver-Pueblo and Pueblo-Lamar roads; also,

work has been done near Sterling, Fort Morgan, Boulder and Morrison.

Samples of this material have been sent to our laboratory and tested. A copy of all reports has been sent to the State Highway Department

Testing materials for concrete construction has been, by far, the most important phase of the work. Some surfacing materials have been tested. This part of the work will surely increase in importance.

Definite arrangements have not been made for 1922, but it is desirable that the work be carried on along the same line as was followed in 1921, but with an increased force.

More work has been done for cities and private companies this year than any previous year. The largest investigations of this nature were those for the Denver Tramway Company and the City of Trinidad.

The new testing machine has greatly broadened the scope of work which we are able to do. In fact, the work mentioned in this report could not have been done without it.

E. B. HOUSE,
Civil Engineer.

REPORT OF MECHANICAL ENGINEER

To the Chairman, Engineering Division:

The Section has had two projects under investigation during the past year. They are as follows: Methods of Stacking Hay and Covering Stacks, and, secondly, Heat Transmission through the Commercial Wall-Boards. The first project has been completed and a full report made; the second project is not completed but is still under investigation.

The projcet upon which work will be done for the present fiscal year will be that of Heat Transmission through Wall-Boards. Because the investigator in this department is on for only half-time, the work does not progress as rapidly as it should. The investigator should be on for full time in order to accomplish the best results. I would, therefore, earnestly request that, beginning the next fiscal year, this Department be allowed one man for full time for experimental work.

LD CRAIN
Mechanical Engineer.

REPORT OF THE EDITOR OF PUBLICATIONS

To the Director:

I am submitting herewith a report of the work done by this office for the Experiment Station during the year ending November 30, 1921.

The policy of more direct publicity for the Experiment Station and its work, which was started last year, was given even more attention the past year. In addition to several special stories for individual publications of the State, numerous articles regarding bulletins published by the Station as well as timely stories by Station employees, were published in "News Notes", the weekly clip sheet of the Extension Service. They were used extensively by the newspapers and that this method of publicity has been very beneficial is shown by the large number of requests for bulletins which have been received by the executive clerk from people who are not on the regular mailing list. Several requests have come from without the State, chiefly due, I believe, to the fact that News Notes clippings have been used in out-of-state publications.

Perhaps one piece of publicity which will benefit the Station more than any other one agency, not only at the present time but in the future, is the motion picture entitled "One Hop Ahead of the Hopper," which Mr. Crosman made during the "grasshopper fight" in the southern part of the State last June. It consists of 2,700 feet of film and the story of the discovery, ravages of, and campaign to exterminate the grasshoppers, is presented in very attractive, narrative form. It was shown at the Highlands Fair in Pueblo County in September, then sent to Washington, D. C., upon request of the U. S. Department of Agriculture officials there. Mr. Reuben Brigham, specialist in Visual Instruction, made the following remarks after seeing the picture:

"We have had an opportunity to show the film on the control and extermination of grasshoppers which you shipped to us recently at our request, to representatives of the Department. I think this film is without question the best one of its kind that I have seen put out by a State Agricultural College. I think those present followed the story shown with much interest and felt that Colorado was fortunate to be able to put in permanent film form such a striking piece of extension work."

One request for the film was also received from a county agent in Montana and I am now corresponding with him regarding dates to be reserved.

It should be stated that this film was made in co-operation with the office of State Entomologist.

Another piece of publicity for the Station which Mr. Crosman assisted was Brief Number Three of the series which he prepared

for the members of the Twenty-third General Assembly. It consisted of 19 pages, profusely illustrated with photos, graphs, maps and comparative diagrams, so that the whole story was told visually. A large part of the success in securing the increase in financial support for the Experiment Station, amounting to approximately $38,500 annually, must of necessity be credited to this Brief and to the personal efforts of Mr. Crosman during the sessions of the last General Assembly.

NEWSPAPER PUBLICITY

Approximately one-half of a full-page story for a special edition of the Colorado Manufacturer and Consumer, was devoted to the Experiment Station and its work. It was well illustrated and told of several of the Station's contributions to the agricultural progress and achievements of the State and nation.

A similar story but with different illustrations was used in the Historical, Development and Harvest Edition of The Weld County News.

The greater portion of a special story for the Harvest Edition of The Fort Collins Express and Courier was devoted to the Experiment Station and several of the illustrations used in the legislative brief were also used in this story.

Two special stories, one for The Rocky Mountain News, and one for The Denver Post, contained a general discussion of the Experiment Station and its work along with discussions of Resident Instruction and the Extension Service.

At the time of the Feeders' Day program, in April, several stories were furnished Denver and other State papers regarding the findings of the feeding experiments.

General Publicity

The program for Feeders' Day was designed and prepared by this office. It was a six-page folder and 2,000 copies were printed.

Publications

Ten bulletins and one report have been published by the Experiment Station during the past year. One bulletin, Number 202, was reprinted. It consisted of 36 pages, and carried an edition of 2,500 copies.

The ten new bulletins and one report published by the Station totaled 484 pages, with a combined edition of 32,500. That gives a total of 1,377,000 bulletin pages printed by the Station during the year. Following is a complete list of Station publications for the past fiscal year:

Number.	Title and Author.	Pages.	Edition.
258	"Fixation of Nitrogen in Colorado Soils" By W. P. Headden	48	3,000
259	"Colorado Plant Diseases" By Julian G. Leach	96	2,500
260	"Colorado Weed Seeds" By Geo. E. Egginton	92	3,000
261	"Report of Potato Investigations at Greeley Station" By Chas. F. Clark	34	5,000
262	"Sod Diseases of Chickens" By I. E. Newson and W. H. Feldman	12	3,000
263	"Index to Bulletins 1-249" By Arlene Dilts	69	3,000
265	"Venturi Flume" By Ralph L. Parshall and Carl Rowher	28	2,500
266	"Beet By-Products for Fattening Lambs" By E. J. Maynard	12	4,000
267	"Titanium, Barium, Strontium and Lithium in Certain Plants" By Wm. P. Headden	20	1,500
268	"Codling Moth Control in Certain Sections of Colorado" By Geo. M. List and J. H. Newton	31	3,000
	REPORTS		
	"Thirty-third Annual Report of the Agricultural Experiment Station" By C. P. Gillette	42	1,500
	Total	484	32,500

Each popular bulletin was well illustrated, and one, "Colorado Plant Diseases," contained three, full-page colored plates to illustrate portions of the text.

Two bulletins are now in the process of publication and the manuscript of one other is in my hands and will be sent to the printer as soon as I am authorized to do so by the Director. Copy

for two Orchard Survey reports has been received but is now in the hands of the Director.

The two bulletins now being published are: "The Mexican Bean-Beetle," by Geo. M. List and "Sheep Losses in Colorado Feed Lots" by Geo. H. Glover and I. E. Newsom. The manuscript which is ready for publication is entitled "A Contribution to the Knowledge of the Syrphidae," by Chas. R. Jones.

Respectfully submitted,

I. G. KINGHORN,
Editor of Publications.