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THE STATE AGRICULTURAL COLLEGE
OF COLORADO

THE FORTY-FIFTH
ANNUAL REPORT

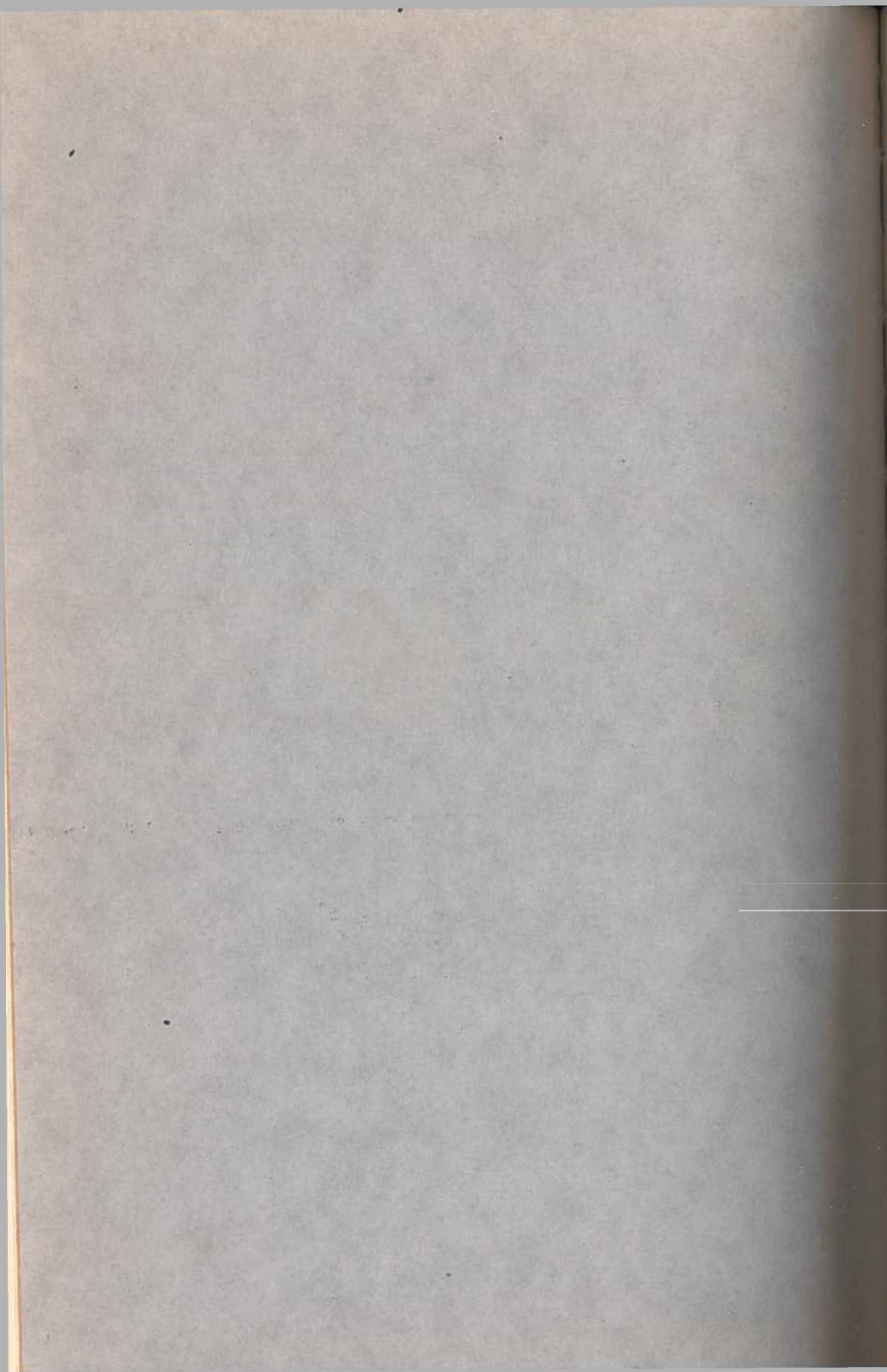
—OF—

The Colorado Agricultural
Experiment Station



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FOR THE FISCAL YEAR 1931-32



THE STATE AGRICULTURAL COLLEGE
OF COLORADO

THE FORTY-FIFTH
ANNUAL REPORT

—OF—

The Colorado Agricultural
Experiment Station



FOR THE FISCAL YEAR 1931-32

The Colorado Agricultural College

FORT COLLINS, COLORADO

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FINANCIAL REPORT OF THE EXPERIMENT STATION

For the Year Ending June 30, 1932

DR.	Hatch Fund	Adams Fund	Purnell Fund	State Mill Levy Fund	Special Fund	Pure Seed Irrig. Fund	Cash Fund	Total Funds
Balance July 1, 1931.....				\$ 4,784.27	\$ 4,947.05		\$1,311.64	\$ 11,042.96
From the Treasurer of the United States as per appropriations for the fiscal year ending June 30, 1932, under acts of Congress approved March 2, 1887 (Hatch Fund), March 16, 1906, (Adams Fund), and February 24, 1925, (Purnell Fund).	\$15,000.00	\$15,000.00	\$60,000.00					90,000.00
Other sources than the United States.....				99,385.58	34,268.60	\$16,000.00	3,015.00	152,669.18
	\$15,000.00	\$15,000.00	\$60,000.00	\$104,169.85	\$39,215.65	\$16,000.00	\$4,326.64	\$253,712.14
CR.								
To Salaries.....	15,000.00	15,000.00	52,357.73	27,433.87	21,589.51	4,655.76	2,139.25	138,176.12
Labor				19,708.88	3,086.52	2,613.97	779.25	26,188.62
Stationery and office supplies.....			212.00	1,657.10	206.27	133.93	58.30	2,267.60
Scientific supplies, consumable.....			732.71	1,564.12	5,912.20	7.90	6.99	8,223.92
Feeding stuffs.....			991.88	6,064.76	324.27			7,380.91
Sundry supplies.....			210.49	1,481.47	2,667.11	17.44	34.30	4,410.81
Fertilizers				16.89				16.89
Communication service.....			77.01	896.35	139.96	103.40	9.04	1,225.76
Travel expense....			2,266.13	7,537.07	1,096.92	413.14	591.54	11,904.80
Transportation of things.....			373.95	2,637.33	606.84		3.10	3,621.22
Publications			1,099.93	2,483.32	388.19		166.57	4,138.01
Heat, light, water, power.....			6.48	2,561.40	995.86		33.00	3,596.74
Furniture, furnishings and fixtures.....			128.60	944.78	72.07	21.04		1,166.49
Library			5.75	554.56	185.08	11.80	0.75	757.94
Scientific equipment.....			501.94	3,242.21	474.09	5.87	17.55	4,241.66
Livestock			177.85	1,283.82	680.50			2,142.17
Tools, machinery and appliances.....			230.65	1,475.25	323.27	0.75	285.99	2,315.91
Buildings and land.....			557.14	2,423.68	692.57		116.98	3,790.37
Contingent expenses.....			69.76	338.69	510.00	15.00		933.45
	\$15,000.00	\$15,000.00	\$60,000.00	\$ 84,305.55	\$39,951.23	\$ 8,000.00	\$4,242.61	\$226,499.39
Balance on hand June 30, 1932.....				19,864.30	(735.58)*	8,000.00	84.03	27,212.75
Grand Total.....	\$15,000.00	\$15,000.00	\$60,000.00	\$104,169.85	\$39,215.65	\$16,000.00	\$4,326.64	\$253,712.14

(*) Overdraft

LETTER OF TRANSMITTAL

To His Excellency, William H. Adams, Governor of Colorado:

In accordance with the law of Congress establishing Agricultural Experiment Stations, I have the honor to transmit to you the Forty-Fifth Annual Report of the Colorado Agricultural Experiment Station for the federal and state fiscal years, July 1, 1931, to June 30, 1932.

The report contains a full financial statement of all receipts and disbursements, and brief summaries of the work done by those in charge of the different sections of the Experiment Station, as well as a list of projects upon which work was carried during the year.

C. P. GILLETTE, Director.

Agricultural Experiment Station,
Fort Collins, Colorado.
July 1, 1932.

REPORT OF THE DIRECTOR

To the President:

I have the honor to present herewith the 45th Annual Report of the Colorado Agricultural Experiment Station for the fiscal year 1931-32. It contains a financial statement covering the receipts and expenditures of the year, a list of the projects upon which the investigational work has been done, brief reports upon the progress of the work in the different sections, a report from the editor giving a list of the bulletins of the year, and a picture of Dr. Wm. P. Headden, deceased, with a brief biography and a list of some of his more important writings.

It is my conviction that the results of the investigations of the year compare favorably with the accomplishments of former years, and that a careful consideration of them will convince any fair-minded person that the results secured will return to the farming communities of the state many times the cost of carrying on the work of the Experiment Station. It would be easy to prove that the Experiment Station has been an important asset to the agricultural interests of Colorado from its start in 1888 to the present time.

Because of the financial stress which the country is experiencing and which must find its relief very largely in the improvement of conditions on the farms of the country, there has been a special effort during the year to push these investigations that promise to give most immediate and practical economic results, and also to publish information bulletins upon subjects that are of immediate practical value to the farmers and stockmen of the state.

For detailed information concerning the station work, I will ask you to consult the accompanying reports of the section heads, as it would not be right for me to call attention to important results obtained in a few sections and ignore the others. To call special attention to all would be impossible in a brief report such as this.

The total station income for the year was considerably below that of the years immediately preceding, and since the reduction was wholly from state resources, it has been necessary to throw a larger proportion of the expenditure upon federal funds, which are less flexible and more given to long-time investigations and of a highly technical nature for the determination of fundamental principles. While such investigations, in the long run, are most valuable and bring greatest

returns to agriculture, they do not lend themselves readily to the urgent call for immediate results that farmers now desire. This condition has been compensated for, in part, by the increase in the number of brief practical bulletins from both the Experiment Station and the Extension Service, and by the issuing of short articles to the press of the state thru News Notes.

The Rocky Ford field station, which for many years has been in charge of the Agronomy Section, and operated chiefly for the improvement of field crops, was, on March 1, turned over to the Horticultural Section of the station and is now being operated especially for the solution of problems of special interest to growers of fruits and vegetables. The budget for the Horticultural Section was increased to take care of the additional expense in taking on this extra work, and making repairs in the farmhouse which will be occupied by the person in local charge of the station.

The Agronomy Section will transfer its investigations more largely to the home station, the Akron station, and the soil problems on the Western Slope in the state.

Below is a classified list of the projects upon which work has been done during the year.

AGRICULTURAL DIVISION

Agronomy Section

- Relation of Soil Moisture, Structural Development and Acre Yields in Small Grains. Adams and State funds.
- High-Altitude Crops. State funds.
- Plains Crops and Management. State funds.
- Crop Improvement. State funds.
- Improved Seed. State funds.
- The Control of Excessive Soil Nitrates in the Arkansas Valley. Purnell and State funds. (In cooperation with Bacteriology).
- Studies in the Control of Bacterial Wilt and Winter Killing. Purnell and State funds. (Cooperative with Bacteriology).
- Genetic Studies and Linkage Relationships in Barley. Purnell and State funds.
- A Comparative Study of the Soil Plaque (Winogradsky), Neubauer and Hoffer Methods of Determining Soil Fertility Requirements. Purnell fund. (Cooperative with Bacteriology).

Animal Investigations Section

- A, Comparison of Protein Supplements in Beet By-Products Rations for Fattening Calves. Purnell fund.
- Ground Flaxseed as a Nitrogenous Supplement in Lamb-Fattening Rations. Purnell fund.
- Creep Feeding. State funds.
- Range and Pasture Improvement. State funds. (Cooperative with Botany.)
- Utilization of Dryland Feeds. State funds.
- Yearling Heifers. State funds.
- Winter Maintenance of Ewes at Akron Station. State funds.

Bacteriology Section

- Heat-Resisting Bacteria of Fresh and Canned Vegetables, and their Relation to Spoilage. Adams fund.
- Value of Certain Carbon Compounds as Sources of Energy for Azotobacter. Adams fund.
- The Control of Excessive Soil Nitrates in the Arkansas Valley. Purnell fund. (Cooperative with Agronomy).
- Studies in Control of Bacterial Wilt and Winter Killing. Purnell and State funds. (Cooperative with Agronomy).
- A Comparative Study of the Soil-Plaque (Winogradsky), Neubauer and Hoffer Methods of Determining Soil Fertility Requirements. Purnell fund. (Cooperative with Agronomy).
- The Psyllid Yellows of Potatoes. Purnell and State funds.

Botany Section

- Range and Pasture Improvement. Purnell and State funds. (Cooperative with Animal Investigations).
- Cereal and Field-Crop Disease Studies. Hatch and State funds.
- Truck-Crop Disease Studies. Hatch and State funds.
- Weed Control. Purnell and State funds.
- Diseases of Greenhouse Plants. State funds.

Chemistry Section

- Deterioration of Hays Resulting from Rain. Adams, Hatch, Purnell and State funds.

Entomology Section

- Plant-Louse Investigations. Adams fund.
- Ants in Relation to Plant Lice. Hatch and State funds.
- The Syrphidae of Colorado in their Relation to Plant-Louse Control. Purnell and State funds.
- Codling-Moth Studies. Hatch and State funds.

- Codling-Moth Control by Means of an Egg Parasite. Purnell and State funds.
- Grasshopper Control. State funds.
- Potato Flea-Beetle. Hatch and State funds.
- General Insect Investigations. State funds.
- Rodent Life Habits. State funds.
- Colorado Insect Fauna. State funds.
- Resistance of Bees to American Foulbrood. State funds.
- Range Insects. State funds.
- The Onion Thrip. State funds.
- The Relation of the Potato Psyllid, *Paratrioza Cockerelli* (Sulc.) to the Potato Disease Known as "Psyllid Yellows." Purnell fund.

Economics and Sociology Section

- An Economic Study of the Peach Industry in Colorado. Purnell fund. (In cooperation with U. S. Dept. of Agriculture.)
- An Economic Study of Farm Organization and Management in the Greeley Area in Northeastern Colorado. Purnell fund.
- A Study of Costs and Methods of Producing Cattle and Sheep on the Range in Colorado. Purnell fund. (In cooperation with U. S. Dept. of Agriculture.)
- Rural Social Agencies in Colorado; Classification and Evaluation. Purnell fund. (In cooperation with U. S. Dept. of Agriculture.)
- A Study of Taxation in Colorado. Purnell fund. (In cooperation with U. S. Dept. of Agriculture.)
- A Study of the Methods of Storage and Marketing Practices which obtain in the Arkansas Valley in Handling Onions on Farms. State funds. (In cooperation with the Colorado Division of Markets.)
- An Economic Study of the Apple Industry in Colorado. Purnell fund. (In cooperation with U. S. Dept. of Agriculture.)
- An Economic Study of Land Utilization in Northwestern Colorado. Purnell fund. (In cooperation with U. S. Dept. of Agriculture.)
- A Study of the Major Types of Cooperative Organizations of Associations in Colorado. Purnell fund. (In cooperation with U. S. Dept. of Agriculture.)

Home Economics Section

- The Baking of Flour Mixtures at High Altitudes. Part II. Purnell fund.

Horticultural Section

- Potato-Variety Testing and Improvement by Selection. Hatch and State funds.
- Raspberry Culture in Colorado. Purnell and State funds.
- Pod-Pea Variety and Selection. State funds.
- Spanish Onion Breeding Work. Purnell and State funds.
- Development of a Tipburn-Resistant Variety of Head Lettuce. Purnell fund.
- Garden Pod Bean Project. State funds.
- High-Altitude Vegetable Production. State funds.
- Orchard Management including Cover Crops. State funds.
- Onion Storage. State funds.
- Grapes and Strawberries. State funds.
- Potato Breeding. State funds.

Irrigation Investigations Section

- Measurement of Water. Hatch and State funds.
- Evaporation from Moist Soils. Hatch and State funds.
- Meteorology. State funds.
- Pumping for Irrigation and Drainage. State funds.

Pathology Section

- Sheep Losses in Feedlots. Hatch fund.
- Contagious Abortion. Hatch and State funds.
- Coccidiosis in Cattle. Purnell fund.
- Death Losses in Lambs on Heavy Grain Feed. Purnell and State funds.
- General Disease Investigations. State funds.

Veterinary Section

- Animal Diseases. State funds.

ENGINEERING DIVISION

Civil Engineering Section

- Oil-Gravelled Roads. State funds.

Mechanical Engineering Section

- A Study of Hair Cracks in Concrete. State funds.
- Poultry Housing and Equipment. State funds.
- College Heating System. State funds.
- Sugar-Beet Machinery. State funds. (In Cooperation with Bureau of Agricultural Engineering, U. S. Dept. of Agriculture.)

Following are the reports of section heads, the editor, and the vice-director.

Respectfully submitted,
C. P. GILLETTE, Director.

AGRICULTURAL DIVISION
REPORT OF THE AGRONOMIST

To the Director:

I am submitting my annual report of the activities of the Agronomy Section of the Experiment Station for the budget year 1931-32.

The staff for the year has consisted of:

Alvin Kezer—Chief.

D. W. Robertson—Associate.

Robert Gardner—Associate.

Wayne Austin—Assistant.

R. D. Hockensmith—part-time Associate.

W. H. Leonard—part-time Assistant.

Dwight Koonce—Assistant.

Mr. Hockensmith and Mr. Leonard are regular teachers but have specific problems in the experiment station work in the Agronomy Section.

During the year, in fact, since the first of January, the Rocky Ford farm has been turned over from Agronomy to Horticulture. The problems upon which Agronomy and Bacteriology were working on the Rocky Ford farm were problems of nitrate control. The Agronomy Section was working in addition on clover experiments, including varieties, disease resistance, irrigation methods and seed production.

All of the work under way could well be transferred to the Fort Collins plant with the exception of the rotations. In the control-of-nitrate problem, we were carrying two rotations—one of 5 years in which clover constituted the legume and one of 8 years in which alfalfa constituted the legume. The land at the start of the rotations was as uniform when measured by crops produced as one could expect to find. At the end of 1931, however, the lands in the same crops on the 8-year rotation were yielding about one-third more than the lands in the same crop on the 5-year rotation. These are interesting problems and should be carried further. The very great demand in the Arkansas Valley for work on vegetable and truck crops made it seem desirable to meet this need by transferring the farm from these soil and agronomic crop experiments to a study of horticultural crops—vegetables, small fruits and others.

The soil-nitrate control problem which was carried at Rocky Ford has been thru certain phases. The first phase was to obtain the laws governing the production of nitrates in the soil. Brief-

ly, this phase of the study showed that nitrate production was relatively low in the cool portions of the year and relatively high in the warm portions of the year when water is supplied by irrigation.

As a part of this study, the effect of crop cover was investigated. These studies showed that the crop growing on the land had a very great influence on the amount of nitrate produced. All crops which were tilled during their growth gave a very much higher soil-nitrate content than crops which were untilled during their growth. The time of greatest production was the same under each type of crop. But, the amount produced was very much higher under crops tilled during their growing period.

With the solution of this phase of the problem, work was directed to finding the best crop sequence for nitrate control. In the light of information obtained in the first study, rotations were laid out—one of 5 years, using clover as the legume and one of 8 years, using alfalfa as the legume. The 5-year rotation was completed for one round, but, the 8-year rotation still had 2 years to run to make one complete sequence. Even so, yields of crops which were the same on both parcels of land at the beginning of the experiment had risen on the 8-year rotation so that they were at least one-third larger than the same crops on the 5-year rotation. Crops on the 5-year rotation were apparently increasing in yield but increases were much greater on the longer rotation.

Carried along with these studies was a series of experiments on the effect of organic material of different nitrogen content on nitrate production. Organic materials were added which carried different percentages of nitrogen—straw and cornstalks very low in nitrogen, alfalfa and dried blood very high in nitrogen. These were applied at definite rates, putting on the same number of pounds of nitrogen per acre. They were plowed under and carried as a fallow. Nitrates were determined weekly. It soon developed that the application of organic materials low in nitrogen temporarily reduced the nitrate content of the soil. This was explained on the basis of biological action. Nitrogen is required in the metabolism of the decay organisms. The straw and cornstalks were very low in nitrogen. In order to reach a maximum decay rate, the decay organism took nitrogen in the form of nitrates from the soil surrounding the organic materials. In the case of alfalfa and dried blood, there was more nitrogen than was required by the decay organisms and consequently, the nitrate content of the soil dropped slightly for

a short time and then rose to a higher point than unmanured soil.

Nitrates are a necessary plant food. But, when in excessive quantities, they become plant poisons. In the case of sugar beets, nitrates high in the soil late in the season reduce the sugar content, decrease the purity and delay maturity of the crop. The same thing is true of potatoes. Accordingly, a high nitrate content late in the season is quite injurious with sugar beets, potatoes and some other crops. In the case of celery, however, which is grown primarily for the vegetative portion and where a crisp, tender vegetative flesh is desirable, relatively high nitrates late in the development of the crop help the quality of the crop and increase the tonnage.

Some crops are considerably more sensitive to the presence of nitrates than others. While sugar beets are damaged in quality, they will endure rather high nitrate contents. Melons are damaged in quality. The flesh is more bitter, the sugar content is lower and ripening is uneven and later. Cherries are killed with relatively low nitrate concentrations.

With this body of facts in mind, the present stage of our problem is to find if it is possible to control the period of the nitrate peak in the soil, because such control is highly essential on lands devoted to sugar beets or potatoes and several other crops. With sugar beets and potatoes, it is desirable to have the nitrate peak in the early stages of the crops and low in the latest stages.

Along with these studies we have made intensive studies of the movement of nitrates in the soil. The nitrates are formed at or near the surface. On fallow land, there is a movement downward of these nitrates into the soil and that movement may proceed to several feet. We know that it may proceed as much as 9 feet. The crop to plant on the land to reduce this subsoil nitration is a part of the study. This project is authorized under the Purnell Act.

The Critical-Periods project authorized under the Adams Act is designed to discover the critical period for the need of water in the growth of crops. In ordinary everyday language, that means the best time to irrigate. Two publications have already been put out on this project— one on the Critical Periods and one on the Residual Effect. This study shows that there are critical periods for the need of water at germination, the stooling or tillering, the jointing, the heading, blossoming and filling. If there is enough water to keep the plant growing,

with wheat the most critical period is the one between heading and filling which includes the blossoming. A limited irrigation given at this time will produce the greatest results of any one irrigation. Irrigations given late in the filling period do little more than delay maturity and make a little plumper berry. The tillering and heading periods, if there is water enough to keep the crop alive, seem to be the most important. This is of considerable importance in the irrigation of small grains, if the water supply is limited.

Very soon after this experiment was started, it was noticed that if a crop of wheat were put on the land, the following year that soil behaved quite differently under the different treatments. The early irrigations produced a crop of wheat but the wheat dried the ground out thoroly early in the season and left it dry. The late irrigations produced much better crops the following year. In other words, where the soil was dried out early in the season and kept dry during the late summer and fall, it produced a smaller crop than where the soil was moist during the late summer and fall. This residual effect or retardation due to the different seasons of irrigation, could be measured when the water applications the second year varied from a minimum of 5 to a maximum of 23 inches. With the heavier applications of moisture, the retarded yield nearly disappeared but it was still measurable. This lead us to recommend, in certain sections, fall irrigation where it had not been a practice before, in order to wet up the soil in the late summer and fall. In one neighborhood, this practice increased the yields of potatoes and sugar beets quite materially. In the case of sugar beets, the yield was increased as much as 6 tons per acre on certain farms.

In this project, we have studied also the effect of using water at different temperatures. On this, we have found very little effect. We have studied the development of the root systems. Our present study is to try to discover, if possible, the reason for the reduced yield where the soil is dry late in the summer. We are studying this problem from the biological or stoppage-of-decay angle, from a physical chemical or electrolysis angle and from the available-fertility angle. The problem is to get fundamental principles so that they can be applied to the growing of the crop anywhere.

The two fundamental principles involved so far are the most critical period of the crop for water and the residual effect or the necessity or desirability of fall irrigation in special cases. Where there is plenty of water, frequent irrigations up until

the time of filling will give the best yields in small grains. Where there is limited irrigation water available, an irrigation between tillering and heading or at heading will give the greatest yield and the best quality of crop. Early irrigations increase the straw yield. Later irrigations increase the grain yield.

On the Linkage-Study project, carried with Purnell authorization, Dr. Robertson is making a study of inheritance in barley. Barley has 14 chromosomes; 7 in the haploid condition. This would indicate the possibility of 7 linkage groups of inheritance factors. Dr. Robertson has established 6 linkage groups in the present studies. The primary object of this experiment is to get a complete knowledge of barley inheritance to be used in the practical speeding up of breeding new sorts of barley. Incidentally, as a second phase of the project, many economic forms may appear and some already have appeared.

The improvement of Colorado agronomic crops has been studied under the Crop-Improvement project. Under this project, we take care of tests of varieties of cereals, pastures, meadow, forage and other crops and do general breeding and improvement. Under this project, we have created Colorado No. 37 oats, Colsess barley, have established Trebi barley, Minnesota No. 13 corn, Colorado No. 13 corn and in connection with the dryland projects, carried at Akron, have bred up or established Bruncker oats—the best dryland oat in any of the dryland station tests—Club Mariout barley, Flynn barley and improved Smyrna, all of which have added to the certainty of barley yields on the plains. Club Mariout, in the dry year of 1931 in Weld County, gave yields of 15 to 18 bushels per acre on the dryland where Trebi only yielded 4 bushels or less. Under this project, Grimm alfalfa, Baltic and strains of these varieties were brought in. Our red-clover experimental work and an extended set of experiments on pasture crops were carried out.

A manuscript is in press on the pasture work at the present time. The publication under this project, in cooperation with the Akron work, tells of the progress with hog millet. In recent times, wheat, barley and oats bulletins, under this project and our High-Altitude project at Fort Lewis, in cooperation with the Akron projects, have been published.

The most abundantly grown oats, wheat and barley have been originated or been brought into Colorado under this project. Grimm and Baltic alfalfa were brought in under this project. The best-yielding corn and the best dryland barley and oats were originated jointly under this and the Akron work. In our

studies with clover, under this project, we established originally the fact that the honey bees could pollinate red clover. The details of how they accomplished this pollination have since been worked out by the Entomology Section. Under the red-clover work, we are experimenting with disease-resistant sorts. For six generations, we have sent seed back to eastern sections to see if seed grown in this section would retain anthracnose resistance when grown in Colorado. So far, it has proved to work. We have shown, by experiments in cooperation with Wisconsin, Minnesota and Michigan, that Colorado-grown red-clover seed is as hardy as any other source of seed in those northern states. This piece of work caused the states in question to accept Colorado red-clover seed.

The project on the control of alfalfa wilt has been carried jointly with the Bacteriology Section. The Bacteriology Section has established the causative organism. It now remains for the Agronomy Section to find or breed up an alfalfa which will be resistant to the disease. In the past, we had already experimented with something over 225 strains of alfalfa seed and had found that seed from southern sources is not adapted to our agriculture. At the present time, we have a few plantings of southern seed but are confining most of our attention to varieties that are hardy and which we hope may be resistant to the disease. We are trying seeds from Siberia, Russian Turkestan, Northern Hindustan, Grimm from various sources, Canadian Variegated, Provence from France and other strains that give promise of having some degree of resistance. We are planting these strains on infected land on our station and on selected farms in Weld and Boulder Counties besides a few other selected farms in the state.

It takes from 2 to 3 years for the disease to kill out a field of susceptible alfalfa. It can readily be seen that because of this time element, it takes a considerable length of time to find out if a strain of alfalfa is both hardy and resistant. We could speed up considerably this phase of the problem if we had a suitable greenhouse with cold equipment attached. Such a greenhouse could be used for a number of other problems but it would be justified on this project. Alfalfa is the most valuable crop produced in Colorado. To solve the control of the wilt disease and restore high yields to farmers would be of very great financial assistance to the state at large. We believe that the problem is solvable but we could solve it more quickly with suitable greenhouses with suitable conditioned-air compartments

and facilities for refrigeration so as to produce artificial cold under control. Sometimes we have to wait for several years in order to have a winter that will test out the hardiness. In a greenhouse, we could make a complete set of trials in a few months and thus speed up the project and get economic result returns in a very much shorter period of time. This project is authorized under the Purnell Act.

Another project carried jointly by the Agronomy and Bacteriology Sections is the methods of determining fertility. One publication has been prepared and is now in press on this project on the early phases of the work. We have tried out laboratory methods which might be called biological methods for determining in the laboratory the fertilizer needs of land in the field. The three methods studied are reported in the publication just mentioned and are the Bacterial-Plaque or Winogradsky Method, the Neubauer Method and the Hoffer Method. The Hoffer method does not apply to our conditions but the Neubauer and Bacterial-Plaque methods both gave results in accordance with field tests. Along with these laboratory tests, we have run tests under controlled conditions in the field. The field results have been predicted almost exactly by the laboratory tests. We have had the opportunity of studying tests made by the Great Western Sugar Company on fields where the results from actual fertilizer practices could be obtained. On upwards of 7,000 fields, the Bacterial-Plaque test correctly predicted the fertilizer needs of the soil in approximately 93 percent of the cases and about 83 percent of the cases gave profitable returns for fertilizer applications. This work is in press and will soon be forthcoming.

In addition to these studies, the Agronomy Section is making an intensive study of possible chemical means of predicting fertilizer needs which might be used to supplement the somewhat slower biological methods.

Recently, we have undertaken soil work in the Colorado River Valley on the Western Slope in Mesa, Delta and Montrose Counties. The problems there are to correct difficulties. There are spots in fields which prevent full utilization of the fields. Some fields have gone out of production. One of our problems is to find out how to bring these fields back into production or find if it is economically feasible. Another problem is one of fertility and general land handling. A third problem is the problem of chlorosis. The fourth problem that moves on the horizon is potash needs of Western Slope soils. There are many

Western Slope soils where phosphate needs are now apparent. There are at least two problems justifying Adams or Purnell authorization out of this larger problem. These will be presented for consideration in the near future.

For several years, we have carried on variety tests of different crops in various parts of the state trying to get climatic and soil regions for each set of tests. By cooperative arrangements with the Seed Registration Service, this work is better cared for in 1932 than heretofore. But, already this work has given results enough to show or indicate the best varieties for the several sections. The work is valuable from several standpoints. First—if carefully conducted, a few years' tests will show the best varieties for each section; second—it will obviate the necessity of establishing separate experimental stations in those sections; and third—it allows us to serve each neighborhood in a much better way because we are able to recommend the best adapted varieties for each section.

At Akron, the experiment station owns one-half section of land and the government 66 acres. One quarter section is devoted almost entirely to agronomic experiments. We are studying in these experiments the rate and date for planting various crops, including the small grains and corn as well as forage crops. We are studying tillage methods to discover the best methods of handling and preparing land for dryland crops to get the most return. We are studying varieties of cereals, corn and forage crops. This work has already resulted in the production of Bruncker oats, the establishment of the value of Club Mariout barley, the establishment of the value of hog millet, much toward the establishment of the value of sudan grass and its use as a pasture and feed crop.

Our work on the improved-seed project and the cooperative work at Akron have brought out a method of control for the wheat foot rot. The method is entirely one of the date of planting. The early planted wheat suffers damage much worse than the late planted.

At Fort Lewis, we are working with high-altitude crops and methods of handling. These include forages, cereals, pasture and meadow crops. Much new work is being done with peas and pea varieties. It looks as if the work already done would lead to almost complete change in the pea varieties grown in the large field-pea sections. Certain of the new pea varieties almost double the yields of the standard sorts formerly grown. We tried also to develop a source of seed for southern markets

for certain varieties of peas which they desire to grow. A test of some of these varieties during the winter of 1931-1932 shows that at least one of these varieties passed thru the winter successfully, which will enable the harvest of seed to come at an earlier date than the spring planting of the same crop would permit. This work must be carried further to reach a safe conclusion but it has gone far enough to indicate that we can probably grow the winter peas as a feed crop and some others as seed crops for use in the South; thus, possibly adding one other industry to our long list.

We are doing considerable work on adapted forage crops and pasture crop possibilities for the plains. Broomcorn and the grain sorghums are largely limited to Southeastern Colorado altho forms are now being tried out which push the range of growth further north. Roughly, south of the divide, the sorghums become increasingly important in dry-farming sections and north of the divide, corn is increasingly important and sorghums decreasingly valuable.

We are cooperating with the federal government in a soil survey. A modern survey has been completed for the Arkansas Valley and published. A Fort Collins section of Northern Colorado has been surveyed and published and a survey is under way for the irrigated territory south of the Fort Collins area. Our cooperation in this consists in furnishing a man during the summer and checking the work done and assisting on the publication.

Due to a lack of funds, the work at Cheyenne Wells is at a standstill. The place is being operated entirely on a rental basis which precludes any experimental work but does permit occasionally some demonstration work.

Corn is now becoming one of the greatest of our Colorado crops. We have done the biggest help to the corn growers by advising on methods which have been adopted. This is due to the fact that corn, for the most part, is well adapted only to limited sections. Consequently, the biggest part of the problem is to get growers to use the right methods to adapt corn to their specific neighborhoods and to find varieties most likely to be good material upon which to start. We are doing this. In the last 23 years, the corn picture has entirely changed. In 1909, there were about 5 million bushels of corn produced and better than 70 percent of it was unsound—that is, not fully matured. At the present time, our corn production runs from 24 million to 37 million bushels and better than 95 percent of it

is mature, sound corn and so recognized on the market. This improvement has been brought about by a reasonable following of good methods of breeding and work.

We are studying, at the home station, and studying very intensively, methods to bring out the principles of corn improvement which may be applied anywhere in the state. We have to learn the best varieties by neighborhood tests which we are carrying out in our regional variety test work.

Respectfully submitted,

ALVIN KEZER, Chief Agronomist.

REPORT OF THE ANIMAL HUSBANDMAN

To the Director:

Following is a report of the various projects carried on by the Animal Investigations Section:

Ration Experiment with Calves (Purnell).—Eight lots of 10 steer calves fattened during the past winter are almost ready for market. Feeders' day will be held May 26 and the calves will be shipped shortly thereafter. Two phases of work have been tested in this experiment. One, a study of protein supplements in a standard beet by-product ration consisting of grain, wet beet pulp and alfalfa hay, and the other, a study of corn, barley, wheat and mixtures of these grains. The experiment included a determination of maximum protein supplement requirement for most economical gains and also a comparison of various kinds of protein supplements such as cottonseed cake, linseed oil cake and flax. This experiment is the first of a new series and will be duplicated this next year.

Range Management.—The study made of the effects on range vegetation, thru various methods of management of cattle on the low foothill pastures; is being continued. The range is divided into three pastures; one of these is grazed continuously; on the second, deferred grazing is practiced; and on the third pasture deferred and rotated grazing is followed. In connection with this work a second creep-feeding experiment has been started with early calves produced on this range. One lot of calves has access to a self-feeder containing rolled oats; the other lot, only their mothers' milk. During the coming month the late-born calves will be started on a similar test. Indications thru practical experience are that early born calves are better adapted to creep feeding than late calves.

Rations for Fattening Lambs (Purnell).—The objects of our first year's work of the new series of lamb fattening experiments were:

1. To compare cottonseed meal, linseed oilmeal, ground flaxseed and wheat mixed feed and screenings as protein supplements to well-known fattening rations used as basic rations.

2. To determine the comparative fattening value of shelled corn and whole wheat.

3. To compare gains and cost of gains when various supplemental feeds were added to the whole-wheat-and-alfalfa-hay ration.

The first year's work of this experiment is complete and the press bulletin has been prepared. The contributions that this experiment made were:

1. It has added to the list of protein supplements for Colorado lamb feeders, ground flaxseed and wheat mixed feed and screenings. The latter one will probably prove of the greatest economical importance.

2. It has added information concerning the feeding value of wheat and the various methods of supplementing the wheat-and-alfalfa-hay ration. The value of these various supplements for any given period is to be determined by figuring the cost of gain upon the reported figure of feed required for 100 pounds of gain.

Creep Feeding.—The calves of the 1931 calf crop were divided into two groups late in the spring. One group of these calves was fed rolled oats in addition to running with their mothers on the pasture and the other group was fed no supplemental feeds. At the end of the pasture period, the creep-fed calves were 8.39 pounds heavier than the others but the cost of this additional gain was very high—26 cents per pound. Both of these groups of calves were put into the drylot following the pasture season and fed on an identical ration of corn, barley, cottonseed cake, corn silage and alfalfa hay in order to determine the effects of creep-feeding on the finishing ability of the calves. At the end of the fattening period the creep-fed calves weighed 18.2 pounds more and were appraised 50 cents above the non-creep-fed calves. Taking all costs into consideration, the creep-fed calves lost 57 cents less per head than the other calves.

Yearling Heifers.—The heifer calves of the 1930 calf crop were carried thru the first winter in a test comparing cottonseed cake with North Park hay vs. North Park hay alone. The heifers fed cake showed 105.93 pounds more gain at the end of the win-

ter feeding period. The following fall after both lots had run on the same range during the summer, the calves fed hay alone during the previous winter had out-gained the other calves 29.40 pounds. In other words, 75.19 pounds of additional gain per head were produced by feeding 135 pounds of cottonseed meal which cost \$2.84. During this last winter these heifers were all fed a ration of alfalfa hay and 1 pound of cottonseed meal. Weights taken this spring at the time the heifers were turned back on pasture again showed the non-cake-fed calves with an 11.25 pound greater gain than the cake-fed heifers. However, in average weight per heifer the cake-fed heifers are still 65.28 pounds heavier. The heifers will be used as replacement stock and will furnish further data in regard to the breeding work with heifers.

Heifer Calves.—Sixteen head of home-grown steers and heifers which were fed during the past winter, one lot on a ration of North Park hay and rolled oats and the other on North Park hay and cottonseed cake, were turned into the foothill pasture May 3, 1932. At that time the calves fed cottonseed cake had gained an average of 242.50 pounds per head and the oat-fed calves, 233.45 pounds per head, a difference of 9.05 pounds in favor of cottonseed cake. Taking daily feed and gain into consideration, it requires 2.25 pounds of rolled oats to equal 1 pound of cottonseed cake in wintering calves. The relative costs of the two supplements will largely determine which is the more economical to use. This wintering period completes the first part of this heifer study. The calves will be carried thru the summer on the range and comparative gains will be recorded at the end of the pasture season. Later, these heifers will be used as replacement stock and will furnish additional data in regard to the breeding work with heifers.

Winter Maintenance of Ewes, Akron.—The ewes have been used to study costs of carrying a farm flock thru the winter on home-grown roughage and a small amount of protein concentrate. Further studies are to be made with this flock on weed eradication on dryland rotations.

Winter Pig-Feeding Experiment, Akron.—Eleven lots of seven pigs each were fed 90 days at the U. S. Experiment Station, Akron, Colorado. Results showed corn, wheat and hog millet practically equal in fattening value. Barley was only 90 percent as efficient as either of the above-mentioned grains. A comparison of various protein supplements when fed with hog millet showed double mixture composed of 50 percent tankage and

50 percent cottonseed meal, the most economical supplement, followed by triple mixture composed of 50 percent tankage, 25 percent cottonseed meal and 25 percent alfalfa meal. Tankage and double mixture, composed of 65 percent tankage and 35 percent cottonseed meal, were about equal in fattening value. Flaxseed used as another protein supplement was more efficient when fed with tankage rather than alone. Flax fed alone with hog millet produced the lowest gain of all lots in the test and a carcass study revealed fat which was soft and yellow. These objectional qualities were not present where one-third flax was mixed with two-thirds tankage. Soybeans fed with ground hog millet produced small gains and also soft carcasses.

Winter Lamb-Feeding Experiment, Akron.—A comparison of various roughages gave the following results with fattening lambs: Bean straw and cane hay were practically equal; followed by mature millet hay, immature millet hay and ground Russian thistles in the order named. Grinding cane of medium stalks costing \$3.50 per ton did not pay when a \$2-charge was made for grinding 1 ton. The different protein supplements used in the experiment ranked as follows in efficiency: Cottonseed cake, flaxseed, soybeans, linseed oil cake and a mixture of one-half cottonseed and one-half sudan-grass meal. No difference could be detected in the firmness of carcass of these various lots of lambs.

Summer Hog-Feeding Experiment, Akron.—Thirty-three pigs were fed on a succession of annual pastures including fall sown rye, spring sown barley and sudan grass with a self-fed grain supplement. This last test was rather contradictory in outcome when compared with the 1930 summer pasture work. This test showed that a protein supplement apparently is necessary not only in drylot but also in the pasture lot. These contradictory results perhaps may be explained by the fact that the 1931 summer was extremely dry and the pastures were lacking in succulence, while in the 1930 work the pasture stayed green throughout most of the period, due to favorable moisture conditions.

Another experiment is being started at the present time duplicating work done the two previous years.

The Influence of Starters on the Keeping Quality and Curd Content of Butter.—Difficulties were experienced in arranging for scoring of the butter in connection with this project so that it was not started during the past year. A butter-scoring committee is now being selected and the work will be started during the coming fiscal year.

Advanced Registry Testing.—Following is a summary of the work done since May 1, 1931:

Month	1-Day	2-Day	Herd Improvement	Fees
May	51		18	\$14.55
June	47		19	13.65
July	51		17	14.45
August	45		16	12.85
September	51		20	14.75
October	58		32	17.70
November	53		22	15.45
December	50	7	25	16.75
January	45		25	13.75
February	37		25	11.75
March	37		25	11.75
April	40		25	12.50
	<hr/> 565	<hr/> 7	<hr/> 269	<hr/> \$169.90

In connection with our Animal Investigations work, I urge a reconsideration of our station budget on the face of the figures as compared to plant industry.

There are several important problems that we are unable to work upon because of lack of funds. Two of these are the hog-feeding work upon field peas and garden peas in the San Luis Valley and another is the steer-fattening work in the dryland section, in connection with which the Extension Service has carried work by means of demonstrations, which have gone ahead of the experimental work. This demonstrational work is not satisfactory without experimental work with accurate figures to fall back upon. Also, the utilization of dryland feeds for dairy cows is probably far behind the knowledge we have with regard to cultural methods and varieties.

Following is a list of the projects which we wish to carry during 1932-33:

1. Ration Experiment with Calves (Purnell).
2. Range Management Experiment.
3. Rations for Fattening Lambs (Purnell).
4. Creep-Feeding Experiment.
5. Yearling Heifer Experiment.
6. Heifer Calf Experiment.
7. Summer Pasture Steer Fattening.
8. Winter Maintenance of Ewes, Akron.

9. Winter Pig Feeding, Akron.
10. Winter Lamb Feeding, Akron.
11. Summer Hog Feeding, Akron.
12. Dryland Rations for Fattening Cattle.
13. Peafield Pig-Feeding Experiment.
14. Advanced Registry.
15. The Influence of Starters on the Keeping Quality and Curd Content of Butter.

Respectfully submitted,
GEO. E. MORTON, Animal Husbandman.

REPORT OF BACTERIOLOGIST

To the Director:

I have the honor to submit herewith the report of the Bacteriological Section of the Experiment Station for the year July 1, 1931 to June 30, 1932.

Five lines of investigation have been carried on as follows:

1. Studies in the control of winter killing and bacterial wilt of alfalfa. (Cooperation with Agronomy).
2. Energy relations of *Azotobacter*.
3. A comparative study of the Soil-Plaque (Winogradsky), Neubauer and Hoffer Methods of determining soil-fertility requirements. (Cooperation with Agronomy).
4. Heat resistant bacteria in fresh and canned vegetables. Botulism poisoning.
5. The control of excessive soil nitrates in the Arkansas Valley. (Cooperation with Agronomy).

Projects

Studies in the Control of Winter Killing and Bacterial Wilt of Alfalfa.—Our observations for the past year have shown but little difference in the relative resistance of the several varieties being tested with the exception of Common and Argentine which exhibited disease in 1931. The mortality has been low, thus far, in all other strains, but 3 years are usually required before appreciable losses can be noted. We are now in the fourth year of the test, and this spring some of the plots in the Greeley district are showing many diseased plants. If this dying continues thruout the season, we shall probably have some rather outstanding results by fall.

Energy Relations of Azotobacter.—Without doubt, the most basic question in our niter problem is the source of energy for Azotobacter. Our studies with crop residues have demonstrated that these materials have little value in this role unless first broken down by other soil bacteria. It has been shown that microorganisms can produce certain organic compounds from these residues which are toxic for higher plants, but not for bacteria, and in our present investigation we are endeavoring to find out to what extent these toxic bacterial decomposition products are produced in our soils, their source and whether Azotobacter can utilize them as sources of energy.

A Comparative Study of the Soil-Plaque (Winogradsky), Neubauer and Hoffer Methods of Determining Soil Fertility Requirements.—The results of this study can be summarized as follows:

The soil-plaque and Neubauer methods are equally reliable for the determination of mineral soil deficiencies.

The Hoffer cornstalk method is satisfactory in the majority of cases for the determination of potash and nitrogen needs of corn when marked deficiencies or abundant supplies exist, but for borderline cases, it is not so dependable.

Close correlations were obtained between the different methods when comparisons were possible.

The soil-plaque method is well adapted to the determination of phosphate deficiency and may prove equally valuable in relation to potash.

Taking into consideration reliability, ease of manipulation, time required, expense involved and the general applications to the determination of mineral soil deficiencies for all crops, the soil plaque is the most desirable of the three methods investigated.

A detailed report of this investigation is being published as Bulletin 390 of the Experiment Station.

In a former report we called attention to the bacteriological soil-plaque method for determining mineral soil deficiencies which was developed in our laboratory. A full description of this new procedure for testing soil has been published as Bulletin 375. Briefly stated, the bacteriological soil plaque offers a rapid and dependable method for determining phosphate and lime deficiencies in soil and may prove equally useful for potash. The test is not only qualitative, showing the mineral elements needed, but also is sufficiently quantitative to indicate, with suf-

ficient accuracy for all practical purposes, the amount of fertilizer to apply in the field.

Heat-Resistant Bacteria in Fresh and Canned Vegetables.—Botulism Poisoning.—Two outbreaks of botulism poisoning have been investigated. One was in connection with canned cauliflower and the other with smoked ham.

A new method has been developed for detecting the presence of botulinus toxin in canned foods and soil without the use of guinea pigs. This has been accomplished by means of a serum reaction. The results of this phase of the investigation are being published under the title "A Method for Determining the Lo and L+Dose of the Toxin of *Clostridium botulinum* by Complement-Fixation."

In a former paper we have called attention to the difficulty in detecting botulinus toxin in the presence of other soil anaerobes. In order to eliminate the organisms responsible for this antagonistic action we have employed selective dyes and various enrichment media, but as yet we have reached no satisfactory solution of the difficulty. As soon as this can be accomplished we expect to proceed with an extensive botulinus soil survey of the state.

The Control of Excessive Soil Nitrates in the Arkansas Valley.—Because of lack of funds we were unable to do anything on that part of this project which pertains to the effect of carbonaceous materials, phosphates and available nitrogen on the amount and rate of accumulation of nitrogen by *Azotobacter*.

A new phase of the niter problem was begun to determine the effect of spring and fall plowing-in of green manures upon the nitrate content of the soil with special reference to the early disappearance and late reappearance of the nitrates thru bacterial transformations.

All of the analytical data for the season are not yet available and therefore no results can be given at this time. This is an extremely important problem basic to the agriculture of the whole state and should have been continued for at least 2 years longer, but because of a change in the administrative policy of the State Board of Agriculture for operating the Experimental Farm at Rocky Ford, where these experiments were carried on, it has been necessary to discontinue all of our work on the niter question so far as the Arkansas Valley is concerned.

Projects To Be Carried in 1932-1933

1. The occurrence and distribution of *Clostridium botulinum* in Colorado soils, (Supplementing "Heat-Resisting Bacteria, etc."). Adams fund.
2. Energy relations of *Azotobacter*. Adams fund.
3. Studies in the control of bacterial wilt and winter killing of alfalfa. Purnell fund. (Cooperative with Agronomy).
4. The soil-plaque method of testing for soil deficiencies. (Supplementing "Comparative study of Soil-Plaque, Hoffer, etc."). Purnell fund.
5. The control of excessive soil nitrates. Purnell fund.
6. The Psyllid diseases of potatoes. Purnell fund. (Cooperative with Entomology).

Publications

"A Bacteriological Method for Determining Mineral Soil Deficiencies by Use of the Soil Plaque." By Walter G. Sackett and Laura C. Stewart. Bulletin 375, Nov., 1931.

"A Method for Determining the L_0 and L_+ Dose of Botulinus Toxin by Complement-Fixation." By Sarah E. Stewart, Jour. Infectious Diseases, 1932.

"A Comparison of the Soil-Plaque Method with the Neubauer and Hoffer Cornstalk Methods for Determining Mineral Soil Deficiencies." By Laura C. Stewart, Walter G. Sackett, D. W. Robertson and Alvin Kezer. Bulletin 390, April, 1932.

In the different investigations reported here, I have been assisted by Miss Laura C. Stewart, Mr. Robert Gardner, Miss Sarah E. Stewart and Dr. D. W. Robertson, whose efficient services I am pleased to acknowledge.

Respectfully submitted,

WALTER G. SACKETT, Bacteriologist.

REPORT OF THE BOTANIST

To the Director:—

I herewith submit the report on the projects of the Botanical Section for the past year.

Diseases of Greenhouse Plants.—This project is carried in cooperation with the Colorado Growers Association and is partly financed by that organization. The following work has been done on this project by Mr. E. J. Starkey, Assistant Pathologist.

Number of greenhouses visited.....	67
Number of calls answered.....	683
Ranges where definite experiments carried....	21

Surveys during the year have indicated 19 plant diseases occurring in the greenhouses visited.

The major study on this project has been on carnation diseases and it has been proved that root rot of carnation can be transmitted by cuttings and from diseased to healthy stock in the sand bench; also, it may be carried in diseased soil. Sanitation and use of clean stock have given splendid results. Houses where losses a year ago ran 25 percent are now free of disease. The Lee Holberg house has had excellent success following the prescribed control methods. Mr. Holberg was fortunate in taking first prize at the national show, for the finest carnations in America.

Study has also been made of branch rot and stem rot of carnation and burning due to fertilizer.

Black root of sweet peas has been studied and also work done on sprays for mildew and the black spot of roses.

A serious dying of cucumbers was studied in cooperation with Mr. Hockensmith of the Department of Agronomy. This dying was found to be due to excessive use of sodium nitrate that resulted in a flocculation of the soil. Control measures were put in practice and the soil condition remedied. The result was that the plants that were dying and producing but 60 dozen cucumbers per day revived and are now producing 268 dozen per day.

Diseases of Truck Crops.—Study has been continued during the last year on the rots of onions at the field station at Rocky Ford under the direction of Mr. Bodine, Assistant Pathologist. Spraying for purple blotch in the field was fairly successful in reducing the disease. A successful method of inoculating onions with *Macrosporium porri* has been developed.

A number of strains of cabbage resistant to yellows are being tested in the Brighton district.

Collar rot of tomatoes has been studied in the Grand Junction district and the Arkansas Valley. In these regions it has been found that *Macrosporium solani* is the causal organism first attacking the plants in the seedbed and transferred on the sets to the field.

Cereal Diseases—Physiological studies on *Ustilago levis* causing stinking smut have been continued. A circular on the foot rot of wheat is prepared for publication.

Range Improvement—Seeding of pastures in the mountain regions has proved fairly successful under the direction of Mr. M. S. Morris, Assistant Botanist. Reseeding of range areas is being attempted on seven representative areas of the state. A study of the forage value of chaparral has been completed. Also a study of the palatability and chemical analysis of certain range grasses has been made.

A study of the relation of the soil profile to the root development of range grasses is being carried on in cooperation with Mr. Hockensmith of the Department of Agronomy.

Results of 7 year's studies of tame pasture-grass mixtures made in cooperation with Dr. Robertson of the Department of Agronomy have been assembled for publication.

Complete plane-table survey maps have been made of the hay meadows of North Park and a survey of the native grasses made to accompany these maps.

Forty-six exotic grasses are being studied in grass nurseries at different localities. The grasses have been obtained from Siberia, South Africa, Spain, Australia, etc., with the hope that a grass could be found that will be useful in reseeding range areas.

Weed Control—The work on this project has been chiefly confined to the testing of chlorates under Colorado conditions. The weeds worked with are bindweed, white weed, the poverty weeds, Canada thistle and Russian knapweed. Mr. Thornton, Assistant Botanist, in charge of the weed work, has made careful tests of all the common weed-killing materials on the market. The use of sodium chlorate has shown high efficiency in many localities. Several new compounds are being tried and look very promising.

Seed Laboratory—

Samples voluntarily submitted:

Cereals	847
Forage crops	
Legumes	383
Grasses	335
Miscellaneous	5
Lawn and pasture grasses	83
Vines	212
Vegetables	843
Flowers	28

Total 2,736

Samples taken by inspector:
Field crops 750

Total Tests Made

Purity	2,431
Germination	3,136
Identification	25
	<hr/>
Total	5,592

34 samples were tested for other departments on the campus.

104 samples were tested in connection with the cooperative longevity studies.

261 samples were tested for Seed Registration Service.

Data from the inspection samples of 1929-1930 and 1930-1931 were compiled and failure to comply with the seed law brought to the attention of dealers in various ways.

All data in regard to inspection samples of alfalfa for those years were compiled and published as a bulletin under the title "Quality of Alfalfa Seed Sold in Colorado in 1929-30 and 1930-31."

A map of North America was prepared showing the alfalfa-seed-producing sections of the United States and Canada. The amount produced in each section was emphasized to show the large amount of southern seed produced and hence the care necessary in order to obtain hardy seed in Colorado.

Cooperative relations have been continued with the U. S. D. A. on grain-rust control and on the study of diseases of sugar beets.

Publications.—The following papers and bulletins have been published by members of the staff or presented at scientific meetings:

Poisonous Plants of Colorado. Colo. Sta. Bul. 316 revised.

Purple Blotch of Onion, Colo. Circ. 1194-A, December, 1931.

Smutts of Colorado Grains, Colo. Exten. Bul. 306-A, Sept. 1931.

Quality of Alfalfa Seed Sold in Colorado, 1930-1931, Colo. Sta. Bul. 389, March, 1932.

Good Seed, an Economic Necessity, Western Farm Life, April 15, 1932.

Comparison of Root and Top Development in Varieties of Strawberry, Am. Journ. of Bot. 18, Oct. 1931.

Distribution of Certain Fungi in Colorado Soils, Phytopathology 21, Nov. 1931.

Carnation Root Rot Spread Through Roots. Florists Review, December 10, 1931.

Carnation Root Rot Spread Through Cuttings, Florists Review, December 3, 1931.

Wettable Sulfur—a New Fungicide. Florists Review, November 12, 1931.

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Protect Livestock Range in Early Spring, Western Farm Life, May 15, 1931.

Factors Influencing the Establishment of Irrigated Pastures in Northern Colorado. Colo. Sta. Bul. 378, July, 1931.

Forest Pathology, The Colorado Forester, 1932.

Papers Presented By the Members of Staff at Scientific Meetings:

The Structure of Chaparral Vegetation in Northern Colorado, Melvin S. Morris.

Illustrating the Life History of a Myxomycete, E. C. Smith.

Zonation of Fungi Due to Ultra-Violet Light, W. A. Kreutzer.

Measurement of Palatability and Capacity of Foothill Ranges, L. A. Stoddart.

Collar Rot of Tomatoes, Wm. A. Kreutzer.

Methods of Control for *Erysiphe communis* on *Lathyrus odorata*, Kenneth W. Taylor.

Utilization and Palatibility of Browse Vegetation in Northern Colorado, Melvin S. Morris.

Inoculation of Onions with Oidia of *Macrosporium porri*, E. W. Bodine.

The Fluorescence of Fungi Under the Ultra-Violet Light, E. M. Kreutzer.

Some Soil Characteristics Under Mixed Prairie Vegetation, Melvin S. Morris.

Young Plasmodia of *Fuligo varians*, E. C. Smith.

Sanitation as a Control for Carnation Root Rot, E. J. Starkey.

A Chemical Analysis of Two Important Range Grasses, L. A. Stoddart.

Temperature as Related to Spread of Carnation Root Rot, E. J. Starkey.

Respectfully submitted,

L. W. DURRELL, Botanist.

REPORT OF THE CHEMIST

To the Director:

During the fiscal year 1931-32, only one project has been carried on—that of “Deterioration of Alfalfa Hays Resulting from Rain.” Insofar as the work already outlined is concerned, this project ought to be nearly finished by the end of the fiscal year.

This project has been in progress for nearly 3 years, and when first started only the comparison in composition of alfalfa hays which had been damaged by various amounts of rain was considered important. When the problem was expanded to include a determination of the vitamins in the various hays much more time was required to complete the necessary determinations.

In order to have uniform samples, a plot of common alfalfa was selected on the Experiment Station Farm. This eliminated differences in soils and varieties of alfalfa. Samples were taken at the bud, one-half-bloom and full-bloom stages of growth of the first, second and third cuttings of this alfalfa. The samples were taken to the laboratory where some were partially dried and then treated with water while other samples were dried either in sunlight or in the diffused light of the laboratory. The samples which had been partially dried were arranged in a circle around a rain-maker sprinkler and 0.5, 1 and 2 inches of water applied, the amount being measured with rain gauges set in the middle of the canvases upon which the hays were placed while being sprinkled.

With this brief survey of the samples a few of the results of the vitamin determinations may be reported.

The vitamins were determined by means of standard rats—a biological assay, as it is called.

The figures for vitamin A in alfalfa cured in diffused light are 60 units in the first cutting, 32 units in the second cutting and 64 units in the third cutting calculated to 1 gram of hay.

The same hays cured in sunlight gave 36, 18 and 28 units respectively, showing that sunlight destroyed a large part of the vitamin A.

The effect of the application of water to the hay was rather a surprise. Since vitamin B is soluble in water, it was supposed that there would be a heavy loss of this vitamin, but vitamin A being fat-soluble was not thought of as being easily lost. However, after a 1-inch rain, 56 percent of the vitamin A content of

the sun-cured first cutting hay was lost and the loss from the third cutting was equally heavy.

After a 2-inch rain, the first cutting lost 73 percent of its vitamin A, the second cutting lost 28 percent, and the third cutting, 55 percent. These losses of vitamin A may be due to the extra sunshine necessary to dry the hay rather than to the leaching effect of the water.

There is a progressive increase in both vitamin A and vitamin B from the bud to the one-half-bloom stage of growth.

Unlike the results for vitamin A, the first cutting has nearly twice as much vitamin B as the third cutting. It is highest in the first cutting, lower in the second cutting and about half as much in the third as in the first cutting.

Like vitamin A, there is nearly twice as much vitamin B in hay cured in diffused light compared with that dried in sunlight.

The results which are hardest to explain are those found for vitamin B in hay treated with a light rain, say of 1 inch, and afterwards dried quickly in sunlight. There was, in these cases, an actual increase in vitamin B, one hay showing over twice the amount of this vitamin after 1 inch of rain. The samples receiving 2 inches of rain did lose vitamin B.

During this year we finished the vitamin A and B determinations and then turned our attention to the determination of vitamin G in the samples of alfalfa hay taken from the Experiment Station Farm. In addition to these samples, two samples of alfalfa hay were obtained from Northern Ohio, three samples from Georgia and two samples from Mississippi. We also obtained another series of four samples from the same plot on the Experiment Station Farm and wet these more with the idea of drying slowly so that mouldy hay would be secured and to find out whether the mouldy hay would lose its vitamins.

On the above-mentioned samples, determinations of vitamins A, B and G are being run but the results are not yet available as the work will not be completed until about July 1. In a general way the vitamin G seems to be about half that of vitamin B calculated in units per gram of hay. There seems to be a wider variation in the amount of vitamin G compared with vitamin B in the hays obtained from other states.

Chemical analyses of the samples obtained this year must be run before this work is completed and this is being done at the present writing.

Some of the results of our vitamin determinations suggest some very practical conclusions regarding the harvesting of alfalfa hay in Colorado.

As far as the chemical analyses are concerned practically no differences can be found between those hays which have been dried in the sunlight and those dried in diffused light and only small differences can be detected between alfalfa hays which have been rained on and those which have been kept dry. Farmers know, however, from practical experiences that in the latter case there are often large differences in the feeding value and palatability. These differences seem to be due to differences in the vitamin content and it would be decidedly to the farmer's advantage to conserve these vitamins.

From the data already gathered, it would seem the best practice to dry the hay as quickly as possible and keep it out of the sunlight as much as possible. To accomplish this, a side-delivery rake is the best tool at present available as it rakes the alfalfa into a long roll which allows the air to circulate freely, as well as diminishing the effects of direct sunlight.

Another farm practice which would seem to be called for from the results already obtained is larger stacks to prevent so much alfalfa being exposed to the sunlight and weathering. It might be even a better practice to bale the hay in the field and put it under cover as is done at present in California.

We might look forward to the time when a superior alfalfa hay may be produced in Colorado without the expense and inconvenience of drying the hay by machine, as many eastern and southern farmers are now compelled to do in order to obtain undamaged hay.

From a consideration of these practical applications, a continuation of this project in an expanded form seems necessary. The exact title of this project has not been decided upon.

Dr. Wm. P. Headden, who was the head of this department until his retirement July 1 of last year, died on February 5, having passed his eighty-first birthday last September. He had been head of the Chemistry Department for 38 years and had seen a large part of the development of agriculture in Colorado. His early work with alfalfa is still a standard reference on that subject.

Dr Headden took an active interest in our soil and alkali problems. Probably his greatest contribution along these lines was the study of the formation of nitrates by azotobacter, which raised a storm of controversy but which has been increasingly

acknowledged as the correct explanation. Dr. Headden was active to within a few months of his death and was always interested in new developments in chemistry and agriculture.

Respectfully submitted,

EARL DOUGLASS, Acting Chemist.

William Parker Headden, Ph. D., was born September 2, 1850, in Monmouth County, N. J. He died in Fort Collins, Colorado, February 5, 1932, in his eighty-second year. He prepared for college in Pennington Seminary, N. J., and graduated from Dickinson College, Carlisle, Pa., with the degree of A. B. in 1872 and received the degree of A. M. from the same institution in 1875, one year after he had received the degree of Ph.D. from the University of Giessen, Germany, where he spent 2 years in post graduate work. He also received the honorary degree of D. Sc. from Colorado State University in 1919.

From 1874 to 1876, Dr. Headden served as assistant in the Department of Chemistry at the University of Pennsylvania; from 1879 to 1883, he was Professor of Chemistry in the Maryland Agricultural College. He was then called to Denver University as head of the Department of Chemistry, which position he held until 1888, when he accepted the position of Dean and Professor of Chemistry in the South Dakota School of Mines. Here Dr. Headden remained until the fall of 1891, when he was made head of the Department of Chemistry and Chemist to the Experiment Station at the Colorado Agricultural College, where he distinguished himself as a teacher and a research worker of rare ability.

The results of Dr. Headden's researches have been published, for the most part, in bulletins of the Colorado Agricultural



DR. WILLIAM P. HEADDEN

Experiment Station and in Proceedings of the Colorado Academy of Science, but many of his papers have appeared in other scientific journals. The more important of the bulletins giving the results of his researches in the Experiment Station are given below.

His last research project in the Experiment Station had to do with the losses in the feeding value of alfalfa hay, due to the effects of rain and sunshine while curing, which work was not completed at the time of his death, but will soon be finished and published by his associates.

On July 1, 1931, Dr. Headden was retired as chief chemist to the Colorado Experiment Station, and was engaged to devote his time to analytical research on some of the rare earths, especially columbinum ores. Of these he had a large collection from many counties.

Probably the most outstanding piece of original research, from the standpoint of the economic results, as well as scientific interest, was his studies of the excessive occurrence of nitrates in many of the soils of Colorado and other states in the arid West. Some of his announcements concerning these soil nitrates were so startling that soil chemists, unacquainted with western conditions, were unable for a time to accept his data and conclusions, but time and the accumulation of data have proved the correctness of his findings. His suggestions as to the course that might be pursued to correct the bad soil conditions, due to excessive nitrates produced in the soil by bacteria, have been found by later investigators to give excellent results.

In the passing of Dr. Headden, the Experiment Station has lost its Dean of Research; the world, a scientist of exceptional ability, and those who knew him best, a genial and trusted friend.

Dr. Headden is survived by his widow, whose maiden name was Alice Ralston, of Carlisle, Pa., a son, William R. Headden, of Westfield, N. J., and three daughters, Miss Helen Headden, of Fort Collins, Colo., Mrs. Wyeth Pope, of Pueblo, Colo., and Mrs. Loren S. Willis, who, with her husband, Colonel Willis, of the U. S. Marine Corps, is in Nicaragua at this time.

A list of the more important Experiment Station bulletins written by Dr. Headden includes the following:

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| No. 35 | Alfalfa. |
| 39 | A Study of Alfalfa and Some Other Hays. |
| 42 | Sugar Beets in Colorado in 1897. |
| 46 | A Soil Study, Part I: Sugar Beets. |
| 58 | A Soil Study, Part II: Sugar Beets. |

- 63 Sugar Beets, a Resume.
- 65 A Soil Study, Part III: The Soil.
- 72 A Soil Study, Part IV: The Ground Waters.
- 82 Colorado Irrigation Waters and Their Changes.
- 83 Colorado Irrigation Water and Their Effects.
- 93 Colorado Hays and Fodders.
- 99 How Can We Maintain the Fertility of Our Colorado Soils?
- 110 Alfalfa; Results Obtained at the Colorado Experiment Station.
- 124 Colorado Fodders; Their Composition.
- 125 Colorado Fodders; Their Comparative Values.
- 155 The Fixation of Nitrogen in Some Colorado Soils.
- 183 Deterioration of Sugar Beets Due to Nitrates Formed in the Soil.
- 186 The Fixation of Nitrogen in Colorado Soils (Distribution and Relation to Alkalis).
- 205 Yellow-berry in Wheat.
- 208 A Study of Colorado Wheat; Part I.
- 217 A Study of Colorado Wheat; Part II.
- 219 A Study of Colorado Wheat; Part III.
- 230 The Waters of the Rio Grande.
- 231 Black Alkali in the San Luis Valley.
- 237 The Properties of Colorado Wheat.
- 239 Alkalis in Colorado, Including Nitrates.
- 244 A Study of Colorado Wheat: Part IV.
- 258 The Fixation of Nitrogen in Colorado Soils, Wellington District.
- 267 Titanium, Barium, Strontium and Lithium in Certain Plants.
- 277 Fixation of Nitrogen in Colorado Soils (on Rocks).
- 286 A Peculiar Soil Condition in the San Luis Valley.
- 291 The Effects of Nitrates on the Composition of the Potato.
- 319 Effect of Clover and Alfalfa in Rotation, Part I.
- 325 Effects of Nitrates on Composition of the Potato.
- 362 Effects of Clover and Alfalfa in Rotation, Part II.
- 363 Effects of Clover and Alfalfa in Rotation, Part III.
- 364 Effects of Clover and Alfalfa in Rotation, Part IV.

REPORT OF THE AGRICULTURAL ECONOMIST

To the Director:

During the period beginning June 1, 1931, and ending May 31, 1932, the Section of Agricultural Economics and Rural Sociology has continued its research activities on nine projects. Eight of these projects have been approved for development with Purnell funds.

Project No. 1—An Economic Study of the Peach Industry in Colorado.—This study was undertaken in 1926-27 in cooperation with the Division of Farm Management and Costs, Bureau of Agricultural Economics, U. S. Department of Agriculture, and it has been continued during the past 4 years in cooperation with the Extension Service of the Colorado Agricultural College. The financial analysis of typical farms in the Palisade district has been confined largely to the intensive peach area in this vicinity. There is evidence that it would be desirable to modify this plan and add some records for peach orchards in adjacent areas where local adaptation to peach production may be problematical. However, in view of the existing financial conditions it seems unwise to make any radical change in our program at this time.

Project No. 2—An Economic Study of Farm Organization and Management in the Greeley Area and in Northeastern Colorado.—This study was made effective in 1922 in cooperation with the Division of Farm Management and Costs, Bureau of Agricultural Economics, U. S. Department of Agriculture, and this relationship was continued for 4 years when the entire responsibility for this project was assumed by this department. Detailed farm accounting records from this area have been summarized for 10 consecutive years. This is the most complete record of irrigation farming now available in the mountain area and it continues to furnish valuable information along practically every line.

During the year a manuscript on "Profits from Winter Feeding in Northern Colorado" has been prepared from data assembled in this study. This analysis indicates the importance of lamb and cattle feeding in the previous development of the area. The 1930-31 feeding year was the most unsatisfactory during the past 10 years; however, it appears that feeding reduced the severity of the depression and a combination of crop growing and feeding has shown greater returns than non-feeding. In the coming year more stress will be placed upon an analysis of the credit needs of these business units together with a study of changes in the net worth of farm operators in this group.

A comparison of landlord and tenant relationships is also contemplated. There is need for reliable information regarding the necessary modifications in lease contracts to meet changing price levels.

Project No. 3.—A Study of Costs and Methods of Producing Cattle and Sheep on the Range in Colorado.—Four departments are represented in the study and analysis of this project and two distinct but closely related regions are involved. The cooperating agencies are the Bureaus of Animal Industry and Agricultural Economics in the U. S. Department of Agriculture, the Wyoming Experiment Station and this department. Approximately 20 records are being maintained for the North Park area in Colorado.

During the early part of the summer the ranch records for 1931 were summarized and a detailed financial statement was returned to each of the 19 cooperators. This report included comparisons with the preceding year. It was found that the average cash operating expense was reduced nearly 18 percent in 1930 as compared to cash operating expense for 1929. Only two of the items included in these expenditures showed material increases. These were taxes and forest grazing fees which increased 22.4 percent and 12.4 percent respectively. In the matter of pasture breeding versus range breeding, the 1929 figures show an 8.3 percent better calf crop in favor of the former plan while the 1930 data indicate 10 percent more calves for the cows that were bred in pastures. This would mean an increase in the gross income per cow in the breeding herd of about \$2.20 for each of the above years. Other advantages of pasture breeding are coming to light such as a lower death loss for calves, fewer bulls required and therefore a lower bull expense, etc.

Project No. 4.—Rural Social Agencies in Colorado, Classification and Evaluation.—In the preliminary work on this project some assistance was received from the Division of Population and Rural Life, Bureau of Agricultural Economics, U. S. Department of Agriculture. This study is being developed under five distinct phases: (a) The rural church; (b) educational agencies; (c) health agencies; (d) recreational agencies; and (e) specific social agencies. Practically all of the information relating to the rural church has been assembled and a preliminary statement relating to these records has been prepared. The former project dealing with the social status of the Spanish-speaking people in rural Colorado has been completed and as soon as certain corrections

are inserted in the manuscript this report will be submitted for publication as a station bulletin.

Project No. 5—A Study of Taxation in Colorado, Particularly in Its Relation to the Agricultural Industry.—This investigation was begun in 1927 as a joint study with the Division of Finance, Bureau of Agricultural Economics, U. S. Department of Agriculture. During the past 4 years the work has been carried mainly by this department. In the development of certain phases of the project this year the department has had the assistance of Mr. Henry C. Pepper and special attention has been directed toward a study of county government. A 24-page mimeographed pamphlet, *Saving the Taxpayer's Money*, has been published and 1500 copies have been distributed. The material included in this report has proved to be popular and helpful. Bulletin 382, *Reading References for the Study of Taxation*, has been completed and a part of the issue has been distributed. Members of our staff in this department cooperated in the compilation and publication of a report on the *Reconstruction of the System of Financing Public Schools in the State of Colorado*, published by the Colorado Education Association in 1931. A manuscript relating to *State Income and Other Types of Taxes* is now in preparation. We are also compiling material on the reorganization of state and local government in Colorado.

Project No. 6.—A Study of Methods of Storage and Marketing Practices in Handling Onions on Farms in the Arkansas Valley.—The Division of Markets in Denver has assisted in assembling records on the storage and handling of onions. The Division of Markets also assisted in assembling information concerning marketing practices and storage costs in handling potatoes in the San Luis Valley. The latter study embraced a 4-year period. A manuscript dealing with potato-storage costs and marketing expense has been prepared and is under revision at this time.

Project No. 7.—An Economic Study of the Apple Industry in Colorado.—Originally this project was carried in cooperation with the Division of Farm Management and Costs, Bureau of Agricultural Economics, U. S. Department of Agriculture. Within the past 4 years the field work has been conducted in cooperation with the Extension Service of this institution. Some reliable records relating to economic changes in the system of farming on the Western Slope have been made available. While the project centers around apple-producing areas, other types of farming have been considered and additional records have been

secured for the purpose of comparison. During the past year the local use of these records by the Extension Service has aided in bringing to the attention of farmers in that section a greater appreciation of the relative importance of different items of expense as well as returns and has helped in devising plans for needed readjustments in farming methods. This piece of work has served to illustrate the beneficial results that may be derived from a close cooperation of research and extension workers.

Project No. 8.—An Economic Study of Land Utilization in Northwestern Colorado.—This research enterprise was undertaken in 1927 in cooperation with the Division of Land Economics, U. S. Department of Agriculture, but for the past 3 years it has been developed independently by this department. Our studies in this region indicate a distinct contrast between the older livestock types of farming and the newer homestead systems of farming. New settlers had to learn, in many instances, how to farm as well as how to make wise selection of enterprises. At the present time there is a decided trend among homesteaders to combine livestock with cash crops, thus providing two distinct sources of income. Formerly the sale of crops constituted the sole income on many farms. Economic conditions during the past 2 years have been critical and have caused several abandonments. One notable feature of the newer homestead sections of this general region has been the heavy dependence upon income from some outside source. Many settlers have held their property largely thru these additional sources of income during a period when they were clearing and developing their farms. These outside activities have included coal mining, road construction, railroad work, school teaching and bus driving, operating tourist cabins, and miscellaneous work.

Project No. 9.—A Study of the Major Types of Cooperative Organizations or Associations in Colorado.—In the early development of this project the department had the assistance of the Division of Cooperation in the Bureau of Agricultural Economics, U. S. Department of Agriculture. We are now preparing a summary of the data obtained from approximately 20 elevator operators. These records cover both grain and various sidelines.

In 1929-30 the business of these 17 firms averaged \$220,713. The smallest amount of business reported by a single unit was \$54,263 and the largest \$489,124. The average volume of grain handled was 191,450 bushels, with a range from 28,000 to 451,000 bushels. The turnover range was from 1.4 to 19.2. In 1930-31 the

business of these same elevators was slightly higher. The average for all firms was \$241,941. The largest business was \$599,089 and the smallest reported a volume of \$20,572. The average volume indicating grain handled was 356,850 bushels with a range from 58,200 to 984,700 bushels. The turnover for the latter year ranged from 1.2 to 40.5.

During the past year a comprehensive analysis of each business was placed in the hands of each board of directors. This program was sponsored by the department in cooperation with a member of the Federal Farm Board. Defects in business methods were pointed out and constructive suggestions regarding improvements were presented. This service was greatly appreciated by all of the cooperating elevators.

Respectfully submitted,

L. A. MOORHOUSE, Agricultural Economist.

REPORT OF THE ENTOMOLOGIST

To the Director:

Following is a brief report of the work of the Entomology Section for the fiscal year ending June 30, 1932.

The Entomologist of the Experiment Station is by law made State Entomologist. The two lines of work have been closely correlated to the benefit of both. A number of projects herein reported on are supported in part by State Entomologist funds. Several lines of work that are supported entirely by the State Entomologist are not reported here.

Plant-Louse Investigations.—The entire attention in this project has been centered on the preparation of the aphidae of Colorado. Part I, consisting of more than 100 pages, was published in December. Part II is in the hands of the printer and work has been started on Part III. A number of species new to science were described in technical journals.

The Syrphidae of Colorado.—This is a new project in the section; however, some work had been done on it several years ago. Attention has been given largely to collecting. Approximately 10,000 specimens were added to the collection, most of which have been identified to genus and some to species. Some attention has been given to life-history studies.

Codling-Moth Studies.—Experimental orchards for codling-moth control were handled in Mesa and Delta counties. Fish oil as a "sticker" increased the effectiveness of arsenate of lead, but

made more difficult the removal of the spray residue at harvest. Cryolite compared favorably with arsenate of lead for control. The spray residue resulting from different spray schedules was determined.

Spraying apple trees with water, by means of an overhead sprinkling system during the evening twilight period when the greatest moth activity occurs, showed some promise of protection. Work on the testing of chemically treated bands was continued in cooperation with the U. S. Bureau of Entomology. Bands properly treated with betanaphthol and engine oil gave practically 100 percent kill thruout the season.

Preliminary work indicates a possibility of using steam to destroy the codling-moth larvae hibernating under loose bark, in the soil immediately about the tree and in picking boxes.

Codling-Moth Control by Means of an Egg Parasite.—There are two phases of this project. 1. The rearing of the parasite, *Trichogramma minutum* Riley. 2. The orchard liberations.

The rearing work has been carried at Fort Collins while most of the liberations were made in Mesa County, with a few in Delta County. A steady supply of the parasites, altho not large, was maintained thruout the season. Probably the most important development was a method of feeding the adult parasites that practically doubled their length of life and greatly increased their rate and certainty of increase. Of the various foods tried raisins have proved the most satisfactory. The feeding method was developed too late in the season to determine its possible effect upon parasites liberated in the orchard.

The Cadelle beetle and a small cucujid *Cryptolestes ferrugineus* Stephn. have caused some damage in the grain-moth breeding units by preying upon different stages of the moth. The Cadelle beetle is a well-known insect but practically nothing can be found in literature on *Cryptolestes ferrugineus*. The life cycle of it has been worked out and many valuable observations made on its food and relation to the grain moth, as a graduate-student project.

Two general plans of orchard liberations have been followed:

1. A "flooding" method or "mass" liberation thruout the season with the hope of always having enough parasites present to effect control.
2. The liberation of smaller numbers sufficient only to establish colonies.

The orchards handled under plan No. 1 showed varying results. The Ingraham orchard that had a medium to a light cod-

ling-moth infestation for the section, showed practically no parasitism. In the Myers orchard, with a heavy codling-moth infestation, egg counts showed the following parasitism: July 2—20.4 percent; July 22—87.32 percent; July 28—85.3 percent.

One liberation, totaling 40,000 parasites on 28 trees in the Hartzler orchard, resulted in a parasitism, as indicated by a count at the end of the season, of 40.56 percent.

One liberation of 500 to the tree in the Harvey orchard showed at the end of the season a parasitism of 57.4 percent.

Fruit counts at picking time did not indicate any marked control from the parasitism. A total of approximately 2,000,000 parasites were liberated. In contrast with 1930 there was practically no natural parasitism in orchards where liberations were not made.

Grasshopper Control.—The most serious grasshopper outbreak in years gave an excellent test of the control recommendations, but created such heavy demands for the organization work that planned tests were interfered with. A number of tests, however, were made. These indicated that salt in the poison formula is not beneficial and may even be detrimental, molasses adds to the effectiveness, the cane slightly more than the beet, and there are no substitutes for bran as a carrier of the poison. Dried beet pulp, however, shows promise enough to justify further tests.

Potato Flea Beetle.—A large series of tests for the control of this pest was carried again in the Greeley section, with special attention being given to the time and number of applications necessary for control. Calcium arsenate dust continues to be the most promising material. The work with this material was taken to eight farms in addition to the experimental plots, with pleasing results to the cooperators. Studies definitely established a correlation of flea-beetle abundance to soil moisture.

The Relation of the Potato Psyllid *Paratrioza cockerelli* (Sulc.) to the Potato Disease known as "Psyllid Yellows."—This is a new project that was drawn up late in the season after this condition had destroyed a large portion of the early potato crop in a number of localities, notably in Weld and Morgan counties. A considerable work, however, was done on the problem earlier. This consisted largely of a survey of the early potato fields in Weld and Morgan counties, and a rather close study of 22 fields. This indicated that the condition was independent of irrigation and cultural methods. The purple ground cherry *Quincula lobata*, *Solanum rostratum*, *Physalis lanceolata* are the most important

wild hosts. The life cycle of the insect has been worked out but we failed to find how and where the insect winters.

The Onion Thrip.—Work on this project was carried on the college farm at Rocky Ford. Nicotine in summer oil sprays gave the most promising results. Soaps cannot be used as spreaders with the water generally available in the Rocky Ford section. Sweetened arsenicals showed promising controls early in the season but produced serious injury to the onions before the season was over.

General Insect Investigations.—This has permitted work upon a number of emergency problems that has given valuable data for control recommendations. The life cycle and a promising control were worked out for *Stretchia plusiaeformis* Hy., a rather serious pest on gooseberries in the Arkansas Valley. Work was done on the false chinch bug, the Harlequin cabbage bug, numerous species of cutworms, cherry insects, shade tree pests, etc., and many general tests of new insecticides were made.

Colorado Insect Fauna.—Many valuable notes have been made on the occurrence and distribution of many species in the state and several thousand specimens have been added to the collection. The collection material, representing the orders of Orthoptera and Hemiptera, has been rearranged according to late lists. Much material has been determined by our own workers and specialists at other institutions. More progress than usual has been made in this project.

Rodent Life Habits.—Conditions permitted only a small amount of time to be given this project but valuable observations were made on the life habits of the pocket gopher and the Kangaroo rat.

Resistance of Certain Strains of Bees to American Foulbrood.—Three colonies of the bees used in this test were able to survive a heavy artificial inoculation.

Range Insects.—On account of the urgent call for work on other projects this one has been held in abeyance.

Projects to be Carried in 1932-1933

Plant Louse Investigations.

Codling-Moth Studies.

Codling-Moth Control by Means of an Egg Parasite.

Grasshopper Control.

Syrphidae of Colorado.

Potato Flea Beetle.

The Relation of the Potato Psyllid *Paratrioza cockerelli* (Sulc.) to the Potato Disease known as Psyllid Yellows.

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Grasshopper Control.—The most serious grasshopper outbreak in years gave an excellent test of the control recommendations, but created such heavy demands for the organization work that planned tests were interfered with. A number of tests, however, were made. These indicated that salt in the poison formula is not beneficial and may even be detrimental, molasses adds to the effectiveness, the cane slightly more than the beet, and there are no substitutes for bran as a carrier of the poison. Dried beet pulp, however, shows promise enough to justify further tests.

Potato Flea Beetle.—A large series of tests for the control of this pest was carried again in the Greeley section, with special attention being given to the time and number of applications necessary for control. Calcium arsenate dust continues to be the most promising material. The work with this material was taken to eight farms in addition to the experimental plots, with pleasing results to the cooperators. Studies definitely established a correlation of flea-beetle abundance to soil moisture.

The Relation of the Potato Psyllid *Paratrioza cockerelli* (Sulc.) to the Potato Disease known as "Psyllid Yellows."—This is a new project that was drawn up late in the season after this condition had destroyed a large portion of the early potato crop in a number of localities, notably in Weld and Morgan counties. A considerable work, however, was done on the problem earlier. This consisted largely of a survey of the early potato fields in Weld and Morgan counties, and a rather close study of 22 fields. This indicated that the condition was independent of irrigation and cultural methods. The purple ground cherry *Quincula lobata*, *Solanum rostratum*, *Physalis lanceolata* are the most important

wild hosts. The life cycle of the insect has been worked out but we failed to find how and where the insect winters.

The Onion Thrip.—Work on this project was carried on the college farm at Rocky Ford. Nicotine in summer oil sprays gave the most promising results. Soaps cannot be used as spreaders with the water generally available in the Rocky Ford section. Sweetened arsenicals showed promising controls early in the season but produced serious injury to the onions before the season was over.

General Insect Investigations.—This has permitted work upon a number of emergency problems that has given valuable data for control recommendations. The life cycle and a promising control were worked out for *Stretchia plusiaeformis* Hy., a rather serious pest on gooseberries in the Arkansas Valley. Work was done on the false chinch bug, the Harlequin cabbage bug, numerous species of cutworms, cherry insects, shade tree pests, etc., and many general tests of new insecticides were made.

Colorado Insect Fauna.—Many valuable notes have been made on the occurrence and distribution of many species in the state and several thousand specimens have been added to the collection. The collection material, representing the orders of Orthoptera and Hemiptera, has been rearranged according to late lists. Much material has been determined by our own workers and specialists at other institutions. More progress than usual has been made in this project.

Rodent Life Habits.—Conditions permitted only a small amount of time to be given this project but valuable observations were made on the life habits of the pocket gopher and the Kangaroo rat.

Resistance of Certain Strains of Bees to American Foulbrood.—Three colonies of the bees used in this test were able to survive a heavy artificial inoculation.

Range Insects.—On account of the urgent call for work on other projects this one has been held in abeyance.

Projects to be Carried in 1932-1933

Plant Louse Investigations.

Codling-Moth Studies.

Codling-Moth Control by Means of an Egg Parasite.

Grasshopper Control.

Syrphidae of Colorado.

Potato Flea Beetle.

The Relation of the Potato Psyllid *Paratrioza cockerelli* (Sulc.) to the Potato Disease known as Psyllid Yellows.

General Insect Investigations.

Rodent Life Habits.

Colorado Insect Fauna.

Resistance of Bees to American Foulbrood.

Publications from the Entomology Section

Bulletins and articles published or offered for publication during the year were as follows:

Aphidae of Colorado, Part I, Annals of Entomological Society of America, Vol. 24, No. 4, pp. 827-934. C. P. Gillette and Miriam A. Palmer.

Aphidae of Colorado, Part II. To appear in Annals of Entomological Society of America, Vol. 25, No. 2, June, 1932. C. P. Gillette and Miriam A. Palmer.

Six New Aphids from Colorado. Annals of Entomological Society of America, Vol. 25, No. 1, pp. 136-151. C. P. Gillette and Miriam A. Palmer.

Life-History Studies of the Wyoming Ground Squirrel *Citellus elegans elegans* in Colorado. Colo. Exp. Sta. Bul. 373. W. L. Burnett.

A Cherry Pest in Colorado. Colo. Exp. Sta. Bul. 385. Geo. M. List.

Red-Clover Pollination by Honeybees in Colorado. R. G. Richmond.

The Alfalfa Weevil in Colorado. J. H. Newton.

Five papers were presented by members of the Section at the Rocky Mountain Conference of Entomologists, August, 1931, four at the Colorado-Wyoming Academy of Science, Nov. 1931, and two (to be presented) before the Pacific Branch of the American Association of Economic Entomologists, June, 1932.

Miscellaneous Activities.—The various workers of the Entomology Section participate in a number of miscellaneous activities that render valuable service to people of the state. Some of these are in cooperation with the Extension Service and others with the State Entomologist. Under the present organization the Extension Service does not have an Extension Entomologist, so all of these duties naturally fall to the Station and State Entomologist's workers. There has been a very heavy correspondence in regard to pest problems, a number of meetings have been attended, short popular articles prepared and several radio talks given.

An important service that has been handled on a revolving fund supplied by the Experiment Station and in cooperation with the State Entomologist, has made certain pest poisons available

to people of the state, at cost. Some years ago, in order to make poison grain for rodents readily available, the section started selling this material at cost. This has rendered a very valuable service as indicated by the amounts sold this last year. Three thousand six hundred eighty-five gallons of this grain were shipped out and in addition ingredients for the poison formula were sold to counties and other organizations in quantities that would prepare 9,580 gallons.

A similar service has been rendered in connection with the grasshopper work. When the Colorado grasshopper formula was developed a few years ago many of the ingredients could not be secured locally. We have found that the supplying of these at cost has materially assisted in the grasshopper work of the year. In fact, under the conditions that existed this last season, it proved to be one of the principal features of the service that we were able to offer. The sodium arsenite and the amyl acetate used in the Colorado formula were put up in one-half gallon units each of which would prepare 200 pounds of bran. The total of 10,748 cans were sent out. This was enough to prepare 2,149,600 pounds of bran. Fully this amount of the same material was prepared under our direction in a number of counties. There is little doubt but what the success of last season's grasshopper campaign, which was rather outstanding in the Western States, was due to the availability of this service.

Respectfully submitted,

GEORGE M. LIST, Entomologist.

REPORT OF THE HOME ECONOMIST

To the Director:

The annual report of the Home Economics Section of the Experiment Station is given herewith:

During the year closing May 3, 1932, work on the project—The Baking of Flour Mixtures at High Altitudes—has been in abeyance. Only within the past few weeks has the installation of equipment for temperature and humidity control proceeded far enough to warrant the running of tests. The completion of these engineering features has been slow because it was necessary to have the parts constructed to meet the specific requirements of our laboratory. Engineering companies dealing in air-conditioning equipment had nothing to offer on the smaller

scale and giving the accuracy of control required for the fundamental research next to be undertaken.

Because the problems involved can only be approached by a worker with sufficient training to make physico-chemical interpretation, it has not been an easy matter to come in touch with such an available candidate. Not until early this month was the Executive Committee asked for authorization to make such an appointment. The appointee reports for duty the first of June.

The 3,000-copy issue of Bulletin 365 which gives a full account of observational data and a supplementary baking guide for housewives, is practically exhausted. The second 3,000-copy issue of Bulletin 366 is being rapidly drawn upon. This means that before long we will have met 9,000 requests for aid in meeting baking problems. These requests come, in the main, from housewives in the higher range of altitudes in the United States, tho some come from foreign countries. Commercial concerns, hospitals and extension officers, and baking institutes have also sent requests and their representatives have been interested visitors.

For the year to come it is the plan to formulate some minor projects of immediately practical value.

The generous support of the director is very much appreciated.

Respectfully submitted,

INGA M. K. ALLISON, Chairman,
Division of Home Economics.

REPORT OF THE HORTICULTURIST

To the Director:

I beg to submit a brief report of the work in the Horticultural Section for the past year. I have tried to give you a summary of the work and progress on the different projects, making it, however, as brief as possible.

Pod Pea Variety and Selection—(State Project).—This project was started in 1927. Five hundred seventy-five varieties and strains were planted. This number has been gradually reduced by selection until this year when we have planted 25 varieties and strains that have shown the greatest promise for cultivation in the state. Prior to 1927 the department had developed improved strains of the Dwarf Telephone and Alderman vari-

eties. These two varieties seemed best adapted to the mountain sections. Seed of these improved strains has been widely distributed among the pea growers in the state. With the expansion of the pod-pea industry, the demand for a dark green pod developed and the paler-colored pods of the Dwarf Telephone and Alderman varieties are gradually being eliminated.

The ideal pod pea should have five main qualities: (1) It should have a dark green color that will not fade in transit. (2) It should be of large size, from 8 to 12 green peas in the pod. (3) It should be straight. (4) It should be sweet. (5) It should be prolific.

Some of the established American varieties possess some of these qualities to a greater or lesser degree, and the work thus far gives hope that continuous selection will result in great improvement. In connection with the selection work, we have made some crosses to obtain larger size and darker color. The crossing work was started 2 years ago and it is too soon to judge what the result will be.

When the growing of pod peas first started in the state we found that the seed stock was not adapted to the high altitude, nor were the seeds uniform. The work on this project is being carried on both at the home station and at Avon in order that the results may be more applicable to the commercial pod-pea growing regions.

Orchard Management—(State Project).—This project is carried at Austin in connection with the State Horticultural Department. Cover crops and fertilizer experiments have been carried for several years past and we are preparing a bulletin giving results of the work, together with definite recommendations that can be used by the fruit growers. We have found that commercial fertilizers alone are less valuable than cover crops, and on most soils, cover crops alone will supply the elements of plant food for some time to come more economically than by any other system of fertilization.

Extensive planting of new varieties of tree fruits and testing their value for production in the state comprise a yearly program of special value in helping the growers to select suitable varieties for their orchards.

General orchard-management projects dealing with cultural practices, pruning and irrigation are a part of the program and are of special value in demonstrating the best methods. The general interest in the work of the fruit station by the growers visiting the station and seeing how the work is done is strong

evidence that the station is serving the fruit industry in a most direct way.

Grape Growing on the Western Slope with Special Reference to European Varieties—(State Project).—This project was started 6 years ago. During this time, the standard varieties grown in California have been tested. Many of these were obviously not adapted to Colorado because of our relatively short season and severe climate. Some varieties like the Thompson Seedless, Tokay, Black Hamburg and Muscat can be grown successfully with winter protection, and the quality is equal to the best California production. In addition the station is testing out some of the newer and more promising varieties of American origin.

Potato Variety Testing and Improvement by Selection—(Hatch Project).—This project was started definitely in 1928, tho the work had been carried as a general project in connection with the state potato certification work. The object is primarily to improve the seed supply to enable the growers to produce larger yields and better quality. Considerable progress has been made with the following varieties: Russets, Peachblow, Brown Beauty, Cobbler and Triumph. Considerable seed stock has been distributed among the growers.

Potato Breeding Work.—We now have 200 seedling varieties growing at Avon. The seed was obtained 2 years ago by Professor A. M. Binkley during his visit to Scotland and England from their best early and late varieties. Among these seedlings are several promising early varieties that will be given extensive trials in our important potato-producing sections.

In connection with this project, Professor C. H. Metzger is promoting the 600-Bushel Club by the use of better seed and cultural practices. Potato-seed certification is another important service to growers and thru this agency good work has been done in encouraging the rise of better seed, resulting in higher yields and better quality.

The work of selecting disease-free potato plants has progressed to a point where the farmer can, by plant or hill selection in his own field, keep disease down to the minimum.

Strawberry Investigations—(State Project).—The principal object of this work is to develop better cultural practices with special reference to soils and climate in Northern Colorado; also, testing out new and improved varieties that are constantly being placed on the market. Our heavier soils are, as a rule, not well adapted to strawberry growing, and there is considerable

difficulty in getting a good stand, especially when plants are shipped from some distance. The everbearing varieties, with one exception, have not proved to be commercially profitable. Prospective growers should make a careful selection of soil before venturing into the business of commercial production. A very promising new variety originated by Mr. Pennock, at Bellvue, gives considerable promise for Northern Colorado.

Head Lettuce Breeding; Tipburn Resistance—(Purnell Project).—This project was definitely started in 1930, tho considerable preliminary work had been done, particularly along the line of cultural control and selection, and a bulletin was published. From the experience gained in the preliminary work, it was believed that crossing the head lettuce with some resistant variety or varieties would be the surest way of obtaining the desired end. During the past 3 years numerous reciprocal crosses have been made, using the resistant Mignonette type of head lettuce and the Cos varieties. The hybrids are now under observation. It will necessarily take several years to fix the type when promising individuals are obtained. A number of these are now under observation.

Bean Breeding and Selection—(State Project).—The growing importance of pod beans and pod-bean seed production in the state prompted the department to make a collection of all obtainable varieties of garden beans in order to study their value to the state. Selection and purification of some of the best varieties have been made and considerable seed has been distributed to growers. Efforts to develop blight-resistant varieties have been made and a number of promising selections are under observation.

During the past year several crosses were made between the best of the English and American varieties. The object is to combine the desirable characters such as length and shape of the pods of the English varieties, with the brittleness and stringlessness of the best American varieties. A large number of seeds from these crosses have been planted this year.

General Vegetable Project—(State Fund).—This general project deals with variety testing and selection. Vegetables like sweet corn, beets, carrots, cabbage, cauliflower and tomatoes are included. Selection for better seed stock, greater yield and purity is the aim, as well as testing out the different varieties as to their value to Colorado growers.

Raspberry Investigations — (Purnell Fund).—Raspberry growing is an important industry in Northern Colorado, but due

to our rather changeable climate, cultural practices, winter protection and methods of pruning have to be studied and correlated with the above factors. Pruning and its effect upon production is the main problem of this work. A preliminary bulletin was published a year ago. The project entails a large amount of tagging and recording data on many hills. Histological studies on fruit-bud formation are also made.

Spanish-Onion Breeding Work—(Purnell Project).—Considerable progress was made during the past season. We now have a large number of F_1 and F_2 generations. Reciprocal crosses were made, using as parents Valencia and Mountain Yellow Danvers, Valencia and Brown Australian. The ends sought are new varieties that mature earlier than the Valencia, and better keeping qualities. Early maturity is sought thru Valencia and Mountain Yellow Danver crosses, and keeping qualities thru Valencia and Brown Australian crosses. This work will require several years before the new varieties can be fixed.

Considerable progress has been made in selecting new and improved strains of Valencia onions. The factors guiding the selection work have been high yields, desirable shape and early maturity. The selection work has been in progress for several years and last season our improved strain was tested at Fort Collins and two other places in the state. In this trial it showed a marked superiority over a number of strains obtained from commercial seed growers. Interesting results have been obtained in selection of bulbs of a desirable shape. We found that increasing the depth in proportion to the diameter we decrease the size and yield, and by selecting for greater diameter and lesser depth we increase the yield. This would indicate that the factors of yield and size are closely correlated with the shape. This particular phase will be subject to further study. The work on this project will be carried both at Fort Collins and at Rocky Ford.

Onion Storage Project—(State Project).—This project has been carried at Rocky Ford for the past three seasons. A modern storage house was constructed holding approximately 10,000 bushels and equipped with necessary instruments for the study of temperature and moisture conditions. Methods of handling and curing the crop previous to storage were carefully worked out. A preliminary report in the form of a bulletin was published to give the growers an opportunity to profit by the results.

This work is being continued and the effect of different combinations of commercial fertilizers on maturity and keeping qualities has been added. This work is of vital importance to the growers, since losses in storage with the Valencia onions have been very heavy.

General Vegetable Farm Management at Avon—(State Fund).—The development and the future of the mountain vegetable industry depends largely upon a rational management of the soil. The rapid rise and early success of the industry were due to the virgin and fertile soil available for vegetable production. After a few short years production as well as quality declined, resulting in many failures and financial disappointments. All vegetables require a fertile soil well supplied with organic materials for profitable production. To study the problem of how to maintain high production in the mountain areas, the farm at Avon was purchased. The farm is at an elevation of about 7750 feet, and has black sandy mountain soil, with ample irrigation water and typical mountain climate. The farm had been used principally for grain and potato production before purchased by the station and was in rather a low state of fertility. A 7-year crop rotation system was inaugurated. A variety of vegetables with alfalfa and potatoes as staple crops comprised the rotation system. It was early recognized that crop rotation alone would not maintain the soil fertility, let alone increasing it.

A herd of high-grade Hereford cattle was added to the program. The size of the herd was to be regulated by the amount of available feed on the farm, and summer range on the forest reserve utilized. On the 120 acres of tillable land we have carried over 100 head, and last winter 150 head without buying any kind of feed. This amount of livestock furnishes a liberal supply of fertilizer and the results in crop yields have been very marked.

The farm also is used as a demonstration farm where growers from the mountain sections can go and see what is being done to aid farmers. An annual farmers' day is held in August each year with an attendance of from 500 to 800 farmers and their families. Aside from the demonstration work, experiment station projects with potatoes and garden pod peas are also carried on, together with variety testing and selection of vegetables.

Rocky Ford Station.—With the turning over of the farm at Rocky Ford to the Horticultural Department this spring, we have been busy formulating a program to suit the needs of the vege-

table industry of the valley. As we see the problem before us, two lines of work seem to be desirable, experimental work with a few of the leading crops, and a general demonstration of vegetable production in the valley. The more technical parts of the work will be carried at Fort Collins where we can give closer supervision and where we have the necessary facilities.

We believe that by combining demonstration with timely experiments, we can best meet the needs of the growers and better satisfy their demands.

Respectfully submitted,

E. P. SANDSTEN, Horticulturist.

REPORT OF THE IRRIGATION ENGINEER

To the Director:

The following is a brief summary of the work of the Irrigation Investigations Section for the fiscal year 1931-32:

Measurement of Water.—The use of the Parshall measuring flume is growing rapidly in the measurement of ditch and canal diversions, as well as in the distribution of water to the user. During the last year, several large flumes have been built in the South Platte River Valley, the largest being a 20-foot reinforced concrete structure on the Bijou Canal near Greeley; also a 12-foot flume on the Sterling No. One Ditch at Sterling. It is expected that sooner or later, many of these canals in this valley will be provided with this device.

The shortage of irrigation water the past 2 years has demonstrated to the water user the necessity of more accurately determining his prorated share of the available supply. The interest of the user in meeting this problem is apparently evidenced by the demand for information on the construction and use of the smaller sizes of the Parshall measuring flume suitable for measuring an individual right. There are some irrigation systems in Colorado that are employing these flumes almost exclusively in the distribution of their supply. Farmers' Bulletin 1683, of the United States Department of Agriculture, entitled "Measuring Irrigation Water in Open Channels," January, 1932, by R. L. Parshall, describes the methods of measuring small streams by means of weirs and the Parshall measuring flume. Also, Experiment Station Bulletin 386 on "Parshall Flumes of Large Size," May, 1932, by R. L. Parshall, has been issued, dealing with structures having throat widths ranging from 10 to 50

feet, where discharges may be measured from about 10 second-feet as a minimum to 3,000 second feet as a maximum.

The importance of the conservation of the water supply by more accurate measurements is being recognized, and it is expected that the use of the Parshall measuring flume in meeting these problems will be increasingly extended. At the present time it is estimated that more than 1,000 of these flumes are in operation in the state.

A report has been prepared by Carl Rohwer on the current meter investigation which has been carried on for some time. This report gives the results of the study of the action of different current meters when rated under various conditions, and of the comparison of the discharge from a standard Francis weir with that determined by different kinds of current meters under various conditions using different methods of measurement.

Evaporation.—The investigations relative to the study of evaporation from a free water surface has been virtually closed, this work having been reported in U. S. D. A. Technical Bulletin 271, "Evaporation from a Free Water Surface," December, 1931, by Carl Rohwer. Secondary studies have been made concerning the loss of water by evaporation from salt solutions, and also the effect of oil film on water surfaces as a means of retarding the rate of this loss.

The work on evapo-transpiration studies grew out of studies made on the evaporation from moist soils and river-bed sands. Last year, crops were grown in tanks having water tables at different depths, these crops being sweet clover, sugar beets, wild sunflower and tules. One of the most outstanding results of this study indicates that during August at maximum growth, the sweet clover consumed from 10 to 13 times as much water as was lost from a free water surface, thus indicating the excessive draft on the soil moisture due to vigorous growths of this and similar plants. This year there is being studied the consumption of water by the common Russian thistle and also the common red root weed. It is believed that weeds in general are extravagant users of soil moisture, and from an economic standpoint it is thought that soil moisture is greatly depleted because of their growth.

Meteorology.—The project on meteorology has been continued, this consisting in the collection of meteorological data such as temperatures, wind velocity, precipitation and other pertinent factors. From time to time the summation of these

records is published in bulletin form, presenting valuable data for research and popular use.

Pumping Investigations.—Since the commencement of this work, three Station bulletins by W. E. Code have been published. Bulletin 350, "Suggestions Concerning Small Irrigation Pumping Plants," January, 1929, and Bulletins 387 and 388, "Cost of Pumping for Irrigation in Colorado," March, 1932. The latter includes descriptive and detailed cost data on each plant studied.

For the past 2 years considerable interest has been taken on the part of the farmer in providing a supplemental water supply by pumps in connection with wells or surface supplies. Present methods of sinking wells, consisting of setting metal casing with perforated side walls, has presented the problem of determining the most economical diameter as related to drawdown and yield. Mr. Code has made detailed studies concerning this matter, both in the Greeley area and also in the Arkansas Valley. This study seems to indicate that considerable money can be saved by the farmer in putting down wells of lesser diameter and still obtaining a satisfactory yield. One of the outstanding results of the investigation on pumping for irrigation has been the marked improvement in fitting pumps to the hydraulic conditions in order to obtain more efficient plants. The extreme need for supplementary water supply has greatly emphasized the use of pumping plants.

During the past few months, considerable attention has been given to the subject of trapping sand from irrigation canals by the use of the vortex tube and also riffle deflector sandtrap. Preliminary studies at the Bellvue laboratory indicate that the riffle deflector is capable of catching practically the entire bed load carried in the stream. So promising was this method that an experimental structure has been built on the Wanamaker Ditch on Clear Creek, near Golden, for the purpose of studying the action where mill tailings from the mining districts constitute practically the entire bed load. The accumulation of sand in this small ditch is so excessive that our experimental apparatus has been virtually overtaxed. By means of sampling the effluent from this trap, it was found that it was catching at the extreme, more than 600 tons of sand per 24 hours, and this is estimated to be only about one-half of the sand carried in this ditch, which has a capacity of some 20 second-feet. However, this excessive load was for a discharge of about 10 second-feet. Studies are to be continued at the Bellvue laboratory on the riffle deflector sand-trap as well as various types of the vortex tube. It is expected

that a vortex tube sandtrap will be installed on a small ditch near Colorado Springs, but final arrangements for this installation have not yet been made.

Respectfully submitted,
R. L. PARSHALL, Irrigation Engineer.

REPORT OF THE VETERINARY PATHOLOGIST

To the Director:

The projects on which we have worked the past year are: Sheep losses in the feedlots; death losses in lambs on heavy grain feed; icterohematuria; contagious abortion; coccidiosis in cattle; and general.

Sheep Losses in the Feedlots—(Hatch and State).—Four outbreaks of coccidiosis were studied, which gave us an opportunity to verify our previous findings that changing the sheep to native hay instead of alfalfa and cutting off all grain resulted in a rapid subsidence of the disease. The usual mineral oil, bismuth sub-nitrate and tannic acid combination, was administered but the indication was that the change in the diet has much greater value than the medicinal treatment.

A number of lambs running on beet tops showed sugar in the urine early in the feeding season. Whether this had any relationship to the larger percentage of sugar in the beets is open to question.

Death Losses in Lambs on Heavy Grain Feed—(Purnell).—In our second experiment with 50 lambs in which the animals were given all the corn they would consume, no satisfactory means of reproducing the condition of overeating could be devised. Many of our lambs did show a trace of sugar in the urine but no definite relationship was shown between this and the amount of grain fed. The indication at the present time is that the sugar appears in the urine in considerable quantity just before death and is not the result of a true diabetic condition. Whether the coma is of a diabetic nature or is only incidental to the disease is still an open question, at least it has not been possible to show the presence of sugar in any considerable quantity prior to the development of the disease.

Contagious Abortion—(Purnell).—Both the college breeding herds and the range herd remain free from abortion reactors as shown by the annual test. The same may be said of the Veterans Bureau herd at Las Animas, altho in that instance the

number of aborters has increased to some extent. It is evident that abortions there are due to some other cause than the Bang disease.

We have not been able to encourage breeders generally to adopt the agglutination test as a means of eradication. Since more than half of the states now require the agglutination test before breeding animals can be shipped into their borders, it is evident that our breeders will have to eliminate the disease or else confine their sales to the state.

There has been considerable activity in the promotion of an abortion vaccine which practice is now generally frowned upon because of the production of reactors to the blood test.

No work has been done on icterohematuria or coccidiosis in cattle during the past year because of lack of material.

General.—An outbreak of blackleg in sheep caused by shearing wounds has just come under our observation. Out of 2,000 sheep sheared something over 100 have been lost with typical lesions of blackleg. From these animals *Clostridium chauvei* has been isolated.

Poultry diseases continue to take their toll, white diarrhea and infectious bronchitis being particularly prevalent this spring.

During the winter leukemia and fowl paralysis were responsible for much loss.

The tabulation of our diagnostic work in the laboratory follows:

Avian	215	Feline	3
Bovine	190	Homo	157
Canine	18	Ovine	19
Equine	5	Miscellaneous	54
		Suis	21

Blood Tests

Contagious Abortion	1,459 samples	199 positive	12.2 percent
White Diarrhea	1,086 samples	93 positive	8.5 percent
Undulant Fever	22 samples	0 positive	
Widal	23 samples	4 positive	1.7 percent

Publications

"Some Bipolar Organisms Found in Pneumonia in Sheep."

I. E. Newsom and Floyd Cross.

American Veterinary Medical Association, Vol. 80, p. 711, 1932.

Respectfully submitted,

I. E. NEWSOM, Veterinary Pathologist.

REPORT OF THE VETERINARIAN

To the Director:

From the standpoint of morbidity, livestock conditions in Colorado may be considered as normal. New disease conditions are constantly arising, whereas certain other diseases that at one time were considered a menace have subsided into comparative obscurity.

There has been about the usual amount of hog cholera in the state, confined to the Eastern Slope and the San Luis Valley. Diseases of a pestilential nature outside of the state are a constant menace. In this connection there has recently been reported from California another outbreak of foot-and-mouth disease, which, however, appears to be of a very low degree of virulency. The European Swine Erysipelas, in an acute form, has been reported from South Dakota.

There has been but one project carried in the veterinary section, that of animal diseases. This is supported by state funds, is general in nature, and contemplates incidental investigations of disease outbreaks, and cooperation with the department of pathology and other agencies, in animal-disease control. We wish to continue with the one project, animal diseases, for another year.

A bulletin on the Poisonous Plants of Colorado was published in conjunction with Doctor L. W. Durrell of the botanical department. Several articles have been published in professional magazines and newspapers.

Respectfully submitted,

GEO. H. GLOVER, Veterinarian.

ENGINEERING DIVISION

To the Director:

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

Respectfully submitted,

L D CRAIN, Vice-Director.

REPORT OF THE CIVIL ENGINEER

To the Vice-Director:

Following is the annual report of the Civil Engineering section of the Experiment Station from June 1, 1931 to June 1, 1932:

The Civil Engineering section has had one active project for this year, namely oil-gravelled roads.

During the summer of 1931 Mr. Wigle, our testing engineer, collected many samples from the different oil-gravelled roads of the state, extracted the oil from each sample, made the mechanical analysis of the gravel used, determined the water content of the soil forming the sub-grade immediately under each sample, noted the condition of the road, and noted the number of years of service for the same. In this way we were able to tell the cause of failure, if any. Where the road has gone to pieces by ravelling we found in each case a low percentage of oil had been used, and where the road had formed corrugations we found a high percentage of oil had been used, and in almost every instance we found also a high water content in the sub-soil.

The object of the project is to determine the correct percentage of oil to be used with the different gravels of Colorado that are being put on our highways, and the work of last summer and last fall was sufficient to give us a very good idea of what this percentage of oil should be.

It now remains to construct an experimental road using different oils in different ways, and different percentages of oil in each section of road.

The State Highway Commission is cooperating with us on this project and since an oil-gravelled road is to be constructed this summer running from Fort Collins to Ault, Colorado, we have arranged for a stretch of this as our experimental road.

The road will be carefully constructed with these different oils. Extra care will be used in the oil content of the same, and as time goes on those sections having the right percentage of oil will prove themselves by wearing well, while those sections having too little or too much oil will go to pieces if our theories are correct. It is for the purpose of testing the results obtained from our sample analysis that the road is to be constructed.

When the correct percentage of oil is known for the different grades of Colorado aggregate we will then be able to construct these oiled roads with a certainty that they will wear well. It is by no means certain at present.

Respectfully submitted,

E. B. HOUSE, Civil Engineer.

REPORT OF THE MECHANICAL ENGINEER

To the Vice-Director:

Following is the annual report from the Mechanical Engineering section of the Experiment Station for the year ending June 1, 1932:

Four projects have occupied the time of this section during the past year, all of which are still incomplete. The project on Sugar-Beet Machinery Investigations has been in charge of Mr. E. M. Mervine who is now located at this station. Mr. Stanley W. McBirney has also recently been transferred to this station as his assistant. Both are United States Department of Agriculture workers. All other projects in this section have been in my charge.

A Study of Hair Cracks in Concrete.—This project was carried over from the previous year. The specimen slabs constructed under various conditions have all developed hair cracks. This result completely upset the theory that the kind of finish the slab received had something to do with the tendency to form cracks. Treatments applied to slabs and steps on the campus have so far not been satisfactory. Observation of the slabs is continuing.

Poultry House and Equipment Plan.—This project, a cooperative one with the Extension Division, was carried over from the previous year. Plans for two laying houses and two brooder houses were completed and published. Plans for remodeling old houses, poultry house layout and equipment are still incomplete due to pressure of other work but will be completed in a short

time. A bulletin, in cooperation with the Extension Poultryman, giving instructions, details of building materials and bills of materials, is also practically completed for publication and will be sent out with the plans.

College Heating System.—This project was begun during the year and has occupied the major portion of the time during the past winter because it can be carried on only during the heating season. Thermostatically controlled master valves were installed on three of the campus buildings and extensive tests carried out to determine if the cost of heating could be reduced and more comfortable conditions maintained in the buildings. Results have shown that a saving of 35 to 40 percent in steam consumption can be obtained in addition to a greater degree of comfort. This saving not only paid for the installation but turned in a profit of almost 65 percent above cost. The total saving amounted to about \$1650. Further studies on a more extensive scale will be carried on during the next heating season.

Sugar-Beet Machinery Investigations.—This project is in cooperation with the Bureau of Agricultural Engineering of the United States Department of Agriculture. Progress has been made along four lines in the study of methods of reducing costs of sugar-beet production by use of mechanical appliances. Mechanical blocking of beets has been shown to be a sound practice and experiments with a mechanical harvester have shown that it is a possibility. Experimental equipment has also been developed which will make possible the determination of the kind, amount, and location of fertilizer to be used for best results with beets and a number of plots in this vicinity have been sown under various sets of conditions. Some tests on the relative suitability of various types of equipment for planting and as aids to the growing of the beet seedlings have also been made. The project will continue during the next year.

A project on farm water systems has been approved and will be begun as soon as possible. Other tentative projects for the coming year are studies of humidification apparatus for buildings and fuel values of Colorado coals.

Respectfully submitted,

F. E. GOETZ, Associate Mechanical Engineer

REPORT OF THE EDITOR

To the Director:

Approximately 30 percent of the 870 news and feature stories sent by the Editorial Service during the past year to the weekly and daily newspapers of Colorado, to 160 farm papers and magazines and to nearly 100 metropolitan dailies of the country, have concerned experiment station work and workers.

The service has edited and published a few more bulletins and circulars than last year, but there have been a few less pages.

Attached is a detailed list of publications handled.

Respectfully submitted,

I. G. KINGHORN, Editor

Experiment Station

- Bul. 374—Improvement of Home Grounds in Colorado. 52 pages. 4,000 copies.
- Bul. 375—A Bacteriological Method for Determining Mineral Soil Deficiencies by Use of the Soil Plaque. 36 pages. 5,000 copies.
- Bul. 376—Taxation and Public-School Finance in Colorado. 38 pages. 10,000 copies.
- Bul. 377—Effects of Different Systems of Grazing by Cattle Upon a Western Wheat-Grass Type of Range. 82 pages. 2,000 copies.
- Bul. 378—Factors Influencing the Establishment of Irrigated Pastures in Northern Colorado. 54 pages. 1,500 copies.
- Bul. 379—Colorado Drylot Fattening Rations for Lambs. 64 pages. 3,000 copies.
- Bul. 380—Silage and Trench Silos in Colorado. 21 pages. 3,000 copies.
- Bul. 381—Field Peas for Fattening Pigs. 18 pages. 2,500 copies.
- Bul. 382—Reading References for the Study of Taxation. 26 pages. 3,000 copies.
- Bul. 383—Proso or Hog Millet in Colorado. 12 pages. 3,000 copies.
- Bul. 384—The Action of Strychnine on the Wyoming Ground Squirrel. 20 pages. 1,500 copies.
- Bul. 385—A Cherry Pest in Colorado. 106 pages. 2,000 copies.
- Bul. 386—Parshall Flumes of Large Size. 48 pages. 3,000 copies.
- Bul. 387—Cost of Pumping for Irrigation in Colorado. 32 pages. 2,500 copies.

- Bul. 388—Cost of Pumping for Irrigation in Colorado, with Data. 64 pages. 1,500 copies.
- Bul. 389—Quality of Alfalfa Seed Sold in Colorado 1930-1931. 32 pages. 3,000 copies.
- Bul. 316—Poisonous Plants in Colorado. Reprint. 36 pages. 3,000 copies.
- Press Bul. 60 sp.—Poisoned Grain for Rodents. Reprint. 4 pages. 1,000 copies.
- Press Bul. 76—Feedlot Fattening Rations for Lambs. 20 pages. 2,000 copies.
- Press Bul. 77—Feedlot Fattening Rations for Cattle. 8 pages. 2,500 copies.
- Forty-Fourth Annual Report. 52 pages. 1,500 copies.
- Cattle Feeders' Day Program (Thirteenth Annual). 4 pages. 3,000 copies.
- Bulletin list. 1 page. 100 copies.

