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THE STATE AGRICULTURAL COLLEGE
OF COLORADO

THE FORTY-SECOND
ANNUAL REPORT

— OF —

The Colorado Agricultural
Experiment Station

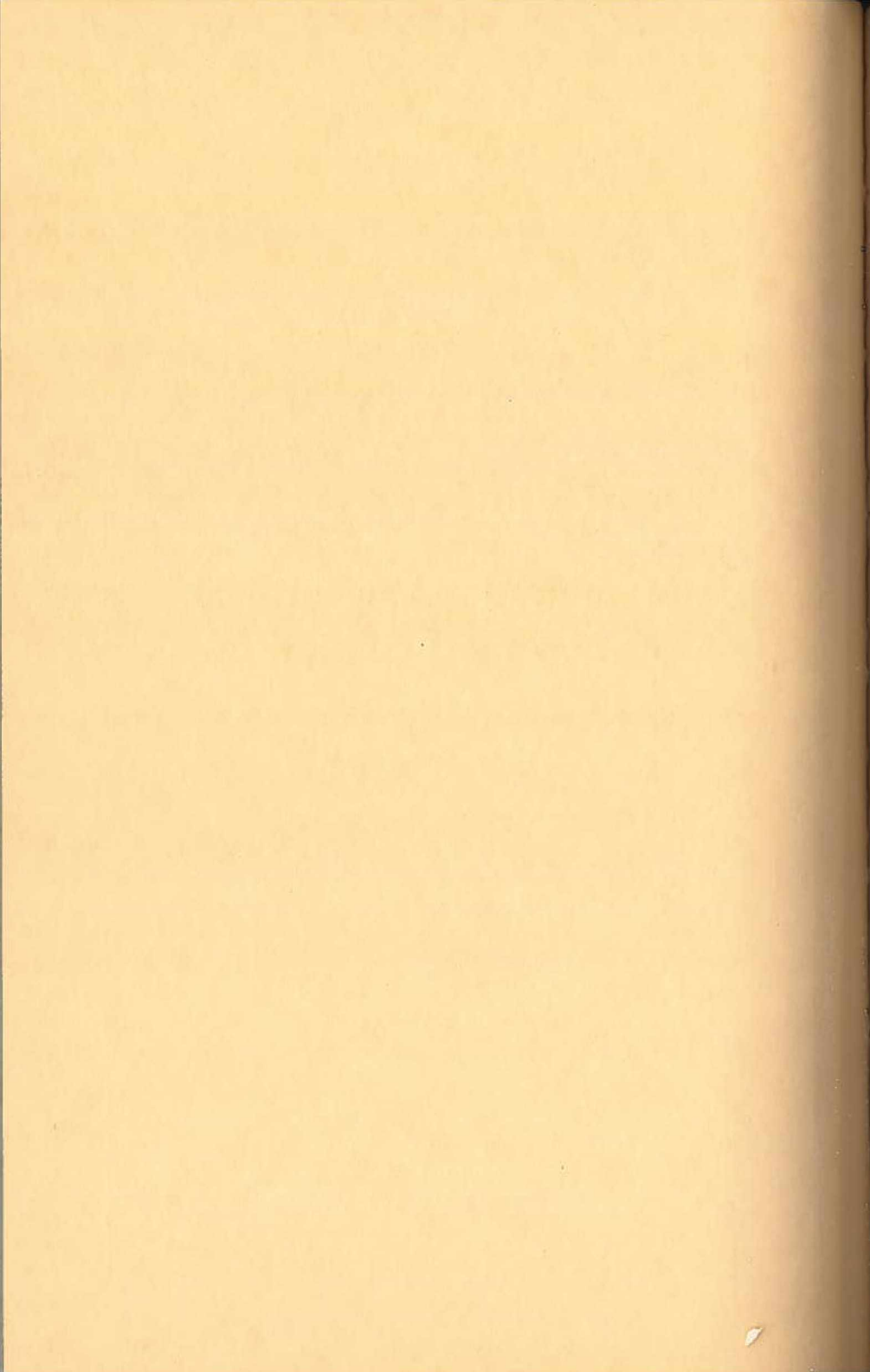


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COLORADO STATE UNIVERSITY

FOR THE YEAR 1929



THE STATE AGRICULTURAL COLLEGE
OF COLORADO

THE FORTY-SECOND
ANNUAL REPORT

— OF —

The Colorado Agricultural
Experiment Station



FOR THE YEAR 1929

The Colorado Agricultural College
FORT COLLINS, COLORADO

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FLORENCE N. SCHOTT, B.S., M.S.....	Associate in Home Economics
JULE LOFTUS, D.V.M.....	Assistant in Veterinary Pathology
DON CATION, B.S., M.S.....	Assistant in Botany

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.....	Assistant in Mechanical Engineering

FINANCIAL REPORT OF THE COLORADO EXPERIMENT STATION

For the Fiscal Year ending June 30, 1929

	Hatch Fund	Adams Fund	Purnell Fund	State Mill Levy Fund	Special Fund	Pure Seed Fund	Irrig. Cash Fund	Total Funds
DR.								
Balance, July 1, 1928				\$ 19,798.84	(\$ 1,608.56)*		(\$ 740.09)*	\$ 17,450.28
From the Treasurer of the United States as per appropriations for the fiscal year end- ing June 30, 1929, under acts of Congress approved March 2, 1887. (Hatch Fund), March 16, 1906, (Adams Fund), and Feb- ruary 24, 1925, (Purnell Fund)	\$15,000.00	\$15,000.00	\$50,000.00					80,000.00
Other sources than the United States				108,065.76	44,992.46	16,000.00	3,517.11	172,575.33
	\$15,000.00	\$15,000.00	\$50,000.00	\$127,864.60	\$43,383.90	\$16,000.00	\$2,777.11	\$270,025.61
CR.								
To Salaries	14,567.80	15,000.00	40,711.85	34,583.16	24,453.94	362.50	1,084.00	130,763.25
Labor			1,352.50	23,053.70	660.42	22.65	113.00	25,202.27
Stationery and Office Supplies			254.78	1,093.72	175.91	60.68	56.30	1,650.39
Scientific supplies, consumable			552.70	1,773.42	1,842.67		1.95	4,170.74
Feeding stuffs			194.36	11,252.19	175.74			11,622.29
Sundry supplies			141.71	3,238.25	451.19	111.55	46.06	3,988.76
Fertilizers				57.00				57.00
Communication service			71.04	1,052.82	237.22	139.22	1.80	1,502.10
Travel expense			3,463.39	9,406.23	507.77	313.00	621.72	14,312.11
Transportation of things			2.41	615.84	57.27	1.30		676.82
Publications	432.20		303.20	4,144.76	76.90		197.35	5,154.41
Heat, light, water, power			168.00	2,354.39	142.61			2,665.00
Furniture, etc.			872.96	973.75	42.89	542.75		2,432.35
Library			202.44	953.65	36.55			1,192.64
Scientific equipment			1,071.95	2,154.63	199.87	1,115.25	352.77	4,804.47
Livestock			48.00	12,842.65	1,154.40			14,045.05
Tools, machinery, appliances			9.25	4,134.62	4.60	54.88	588.65	4,792.00
Buildings and land			219.46	4,283.49	1,268.12		90.99	5,868.06
Contingent expenses			360.00	384.26	103.00			847.26
Total expenditures	\$15,000.00	\$15,000.00	\$50,000.00	\$118,352.53	\$31,591.07	\$ 2,732.78	\$3,160.59	\$235,836.97
Balance on hand June 30, 1929				9,512.07	11,792.83	13,267.22	(383.48)*	34,188.64
Grand Total	\$15,000.00	\$15,000.00	\$50,000.00	\$127,864.60	\$43,383.90	\$16,000.00	\$2,777.11	\$270,025.61

(*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 the Forty-second Annual Report of the Colorado Agricultural Experiment Station for the state fiscal year, December 1, 1928 to November 30, 1929, and the financial statement for the federal fiscal year, July 1, 1928 to June 30, 1929.

The report contains brief summaries of the work done by those in charge of the different sections of the Experiment Station, as well as a full list of projects upon which work has been done during the year.

C. P. GILLETTE, Director

Agricultural Experiment Station
Fort Collins, Colorado
December 1, 1929

AGRICULTURAL DIVISION

Report of the Director

To the President:

I am presenting the forty-second annual report of the Colorado Agricultural Experiment Station which covers the investigational work carried during the 12 months just closing, and gives the financial statement covering the federal fiscal year from July 1, 1928 to June 30, 1929.

The departments in which work is being carried have not changed since 1 year ago. The number of projects has increased from 71 to 80. The number of workers is practically the same. A few new projects have been undertaken and a few old ones have been completed. There have been a number of resignations of good workers to take positions in other institutions at higher salaries. In some cases this has interfered rather seriously in the investigational work carried here. The institution has reached its maximum income until some additional federal or state appropriations are made for the extension of its work which really is very much needed. During the past year there has been some extension of the work at Akron, at Rocky Ford and at Avon. Increased budgets are much needed for work at Cheyenne Wells, Fort Lewis and at the home station, but no extension of work can be undertaken without reducing the work in some of the investigations that are already in progress.

As in the past, I am glad to report that, on the whole, a very good spirit of cooperation exists among the workers in the different sections of the station, and considerable cooperative work is being carried with bureaus of the U. S. Department of Agriculture. I feel that there is a need of a fuller correlation of the station work with the work of the extension division and shall work to this end in the immediate future.

At the recent meeting of the Association of Land Grant Colleges and Universities, there was expressed a rather strong general sentiment to the effect that investigational work in the immediate future should be stressed along the lines of economic and quality production and in fundamental researches which will lay the basis for the building of a stable agriculture in the country. Fortunately we have been directing our attention strongly along these lines for some years, and shall continue to do so for some time to come.

It becomes more and more evident as the years go by that it is the quality rather than the quantity of a farm product that deter-

mines whether or not it will bring a net return to the producer. In all sections of the station a special effort should be made to direct the investigations to economic production rather than quality production. Researches that will give information upon which to base more economic marketing of crops are also needed.

The station has spent considerable money in permanent improvements at Rocky Ford, Avon and Austin during the year.

The station has published 17 bulletins and 4 press bulletins during the year, and station workers have furnished manuscripts for a number of extension bulletins and scientific articles published in technical journals of the country.

I am giving below the projects upon which work has been carried during the past year.

AGRICULTURAL DIVISION

Agronomy Section

- Relation of Soil Moisture, Structural Development and Acre Yields in Small Grains. Adams and State funds.
- Correlation of Characters in Grains. Hatch and State funds.
- High-altitude Crops. State funds.
- Plains Crops and Management. State funds.
- Improved Seed. State funds.
- Control of Excessive Soil Nitrates in the Arkansas Valley. Purnell and State funds. (Co-op. with Bacteriology)
- Studies in the Control of Bacterial Wilt and Winter-killing. Purnell and State funds. (Co-op. with Bacteriology)

Animal Investigations Section

- Ration Experiments with Cattle. State funds.
- Summer Cattle-fattening Experiments. State funds.
- Range and Pasture Improvement. State funds. (Co-op. with Botany).
- Ration Experiments with Lambs. State funds.
- Cornfield Lamb-feeding Experiment. State funds.
- Summer-fallow Experiment at Akron, Colo. State funds.
- Winter Maintenance of Breeding Ewes. State funds.
- Poultry Experiments. State funds.
- Beet By-products for Fattening Beef Calves. Purnell fund.
- Comparative Value of Different Kinds of Molasses in Lamb-fattening Rations. Purnell and State funds.
- Hog Feeding in the San Luis Valley. State funds.
- Utilization of Dryland Feeds. State funds.

Bacteriology Section

- Heat-resisting Bacteria in Fresh and Canned Vegetables. Adams fund.
- Value of Certain Carbon Compounds as Sources of Energy for Azotobacter. Adams fund.
- Natural Inoculation of Colorado Soils with Legume Bacteria. Hatch and State funds.
- Winogradsky Method of Testing Soil Deficiencies. Purnell fund.
- Control of Excessive Soil Nitrates in the Arkansas Valley. Purnell and State funds. (Co-op. with Agronomy).
- Studies in the Control of Bacterial Wilt and Winter-killing. Purnell and State funds. (Co-op. with Agronomy).

Botany Section

- Range and Pasture Improvement. Purnell and State funds. (Co-op. with An. Inv.)
- Cereal and Field-crop Disease Studies. Hatch and State funds.
- Truck-crop Disease Studies. Hatch and State funds.
- Identification of Species of Beta and Brassica. Purnell fund.
- Weed Control. State funds.

Chemistry Section

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

Entomology Section

- Plant-louse Investigations. Adams fund.
- Ants in Relation to Plant Lice. Hatch 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. State funds.
- General Insect Investigations. State funds.
- Rodent Poisoning. State funds.
- Rodent Life Habits. State funds.
- Colorado Insect Fauna. State funds.
- Resistance of Bees to American Foul-brood. State funds.

Economics and Sociology Section

- An Economic Study of the Peach Industry in Colorado. Purnell fund. In co-operation 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.
- A Study of the Social Status of the Spanish-speaking People in Rural Colorado. Purnell fund.
- 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 handling Potatoes on Farms in the San Luis Valley. State funds. In cooperation with Colorado Division of Markets.
- An Economic Study of the Apple Industry of Colorado. Purnell fund. In co-operation 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 Varieties. State funds.
- Garden-pea Variety and Breeding. State funds.
- Onion Projects. State funds.
- Development of a Tipburn-resistant Variety of Head Lettuce. Purnell fund.
- High-altitude Vegetable Production. State funds.
- Garden Pod Bean Project. State funds.
- Orchard Management. State funds.
- Small Fruits. State funds.
- Certified Seed Potatoes. State funds.

Irrigation Investigations

- Measurement of Water. Hatch and State funds.
- Evaporation. Hatch and State funds.
- (a) From a Free Water Surface.
- (b) From Moist Soils.
- 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.
 Icterohematuria. State funds.
 General Disease Investigations. State funds.

Veterinary Section

Animal Diseases. State funds.

ENGINEERING DIVISION

Civil Engineering Section

Road Materials of Colorado. State funds.
 Frost Heaving Investigation on Concrete Slabs. State funds.
 Capping of Concrete Cylinders. State funds.
 Light Asphaltic Road Surfaces. State funds.

Mechanical Engineering Section

A Proximate Analysis of Colorado Coals. State funds.
 Gasoline Economy in Automobile Engines. State funds.
 Drying Potatoes for Stock Feed. State funds.

Following are brief statements from section heads concerning the investigational work in the several sections. I hope you will find it possible to read these rather carefully as I wish to avoid, in a short report like this, calling attention to outstanding results in one or two departments and appear to overlook equally good work in others.

Respectfully submitted,
 C. P. GILLETTE, Director

AGRONOMY SECTION

To the Director:

I am submitting my annual report for the period ending November 30, 1929.

The staff of the Agronomy Section has changed somewhat during this period. Roy D. Hockensmith who has both teaching and experiment station duties, took the place in soils made vacant by the resignation of Rudger H. Walker. Mr. Robert Gardner became soil chemist at Rocky Ford replacing Justus C. Ward. With the resig-

nation on the teaching staff of Clark H. Alford, we have employed Warren H. Leonard who will have teaching and experiment station duties. The staff as now organized consists of: Alvin Kezer, chief; D. W. Robertson, associate, C. Warren Deming, assistant; Roy D. Hockensmith, part-time assistant and Warren H. Leonard, part-time assistant located at Fort Collins, J. W. Adams located at Cheyenne Wells, Robert Gardner at Rocky Ford and Dwight Koonce at Fort Lewis. Thru cooperation of dryland agriculture, Joseph F. Brandon functions as an associate at Akron.

During the year the work has been on critical-period project, improved-seed project, methods of determining fertilizer needs, alfalfa-disease control, residual effects of irrigation water and some minor projects at Fort Collins.

Under the improved-seed project, we carried on a series of experiments in possible pasture crops and crop mixtures. These experiments have shown adapted species. They have also shown the survival of these adapted species in associations. We have harvested the forage produced in two ways,—first, as a meadow crop and second, by frequent cuttings to simulate animal grazing. This work has now gone far enough so that we know species survival and association relationships—that is, how species survive in the pasture mixtures. The better of these mixtures should now be subjected to actual grazing so as to find out the effect of tramping and the selective eating by the animals. Enough information is at hand to add quite materially to our knowledge of species adaptation and species relationships in pasture mixtures.

The methods of determining fertility needs are carried on in cooperation with the Bacteriology Section. The Neubauer, Winogradsky and Hofer methods have been tested extensively in the laboratory. All of these methods are checked by actual fertilizer treatment in the field. I think we have gone far enough to indicate the Hofer method can be discarded as useless in our territory. Both the Neubauer and Winogradsky methods appear to give results comparable to actual field tests. We appreciate that 1 year's work is not sufficient but all work this year correlates the laboratory indications with actual field results. The economic implications of this project are very important. If it can be shown that a reliable indication can be obtained in the laboratory for fertilizer practice, it will obviate the necessity of long-time experimental fertilizer application plots throught the state. Up to the present time, long-time experiments where the fertilizers are actually tried in the field have been the only reliable method of getting the fertilizer needs. While the method was reliable, it required a number of year's work in each case. It

also had to be carried out on each considerable soil type or soil series. If we can reliably determine the fertilizer needs in the laboratory, this expensive work can be eliminated.

In one case, the application of phosphorus to sugar beets gave a 300 percent increase in yield. Both the Neubauer and Winogradsky tests indicated need for phosphorus. On those farms where good farm practices have been carried out and where yields were high, neither the Winogradsky or Neubauer tests indicated any need for fertilizer. On such places, the fertilizer would not improve the yield. We appreciate that further and extended tests are necessary, but the preliminary work of this year indicates a wonderful correlation by the laboratory results and field requirements.

The alfalfa-disease-control project has been attacked from two standpoints. First has been the search for alfalfa varieties which may be resistant to the disease. These varieties are planted on lands known to be infected. Second, we are trying soil treatments which lend some hope of building up physiological resistance in the crop itself.

It can be appreciated that a successful solution of the alfalfa-disease problem will mean much to our agriculture when we consider that in 1928 better than 30 percent of the alfalfa of Larimer County, about 40 percent of Weld County and about 25 percent of Boulder County was killed out by the alfalfa wilt. It takes time in the solution of this problem because the disease seems to require about 3 years to obtain full development.

At Akron, we are carrying projects on the rate and date of planting small grains and corn, tillage and cultural experiments, plains forage crops and variety tests. Work on barley, especially, is promising. It indicates that the broad-leafed barleys are not adapted to dryland growing.

Our work has been carried a sufficient number of years so we are now ready to recommend dryland barley varieties. Club Mariout, Selection Strain from White Smyrna and Flynn are our superior dryland barleys. One year with another, barley will produce as much feed grain per acre as corn.

We have been experimenting with forage crops for years. One of the so-called forage crops, hog millet or proso, is developing into a feed grain crop. Hog millet has been under experiment at the Akron station and somewhat also at Cheyenne Wells station for over 20 years. Back in 1913-14, a number of farmers in Northeastern Colorado were induced by us to try feeding hog millet to fatten livestock. The suggestion was carried out by one or two farmers who reported

excellent success. Similar farmer feeding was conducted in Southwestern Nebraska. In spite of these demonstrations, hog millet did not gain much popularity. However, with the definite experimental work of the Animal Investigation Section in the last 2 or 3 years, the crop has suddenly jumped into popularity as a grain feed crop. It is well adapted to practically all of the northeastern section. Its water requirements are low and it grows in a short season.

At Rocky Ford our studies have been continued. We believe that we now have sufficient data to justify an extended study and probably a number of publications on different phases of the subject. If we can make suitable personnel arrangements, we hope to have Mr. Gardner come to Fort Collins during the winter and devote all of his time to such data studies.

The work at Fort Lewis is for high-altitude agriculture, and consists of variety adaptation work with grains, pasture, meadow and forage crops, together with a study of cultural and irrigation practices. Data obtained at Fort Lewis for this period consist of one publication—our wheat bulletin. Other data are to appear in forthcoming publications on barley, oats and probably pasture crops.

At Cheyenne Wells, work has been at a standstill because of no state appropriation. It would not be good policy to divert any small fund from other work to Cheyenne Wells because such a small diversion would not be sufficient to accomplish results and would reduce effective work elsewhere. It would be highly desirable, however, to have the state properly finance work at Cheyenne Wells.

Our plains agriculture which is partially served by Akron needs additional help from experimental work in the mid-region represented by Cheyenne Wells and needs further work in the southeastern region represented by eastern Las Animas and Baca counties. The dryland country straddling the Arkansas Valley has so low a rainfall that at present it should not be dry farmed. By that I mean to say that there are so many dry-farming areas where the rainfall is better adapted for production that they should be studied and developed first. Dryland agriculture is an important part of Colorado's agricultural production. Over 70 percent of the wheat, about 80 percent of the corn and around 70 percent of the barley are dryland grown. Practically all of the millets including proso, the major part of the sorghums, nearly all of the beans from a general market consideration, are dryland produced.

The Experiment Station needs to be in advance of agricultural needs and practices in this important field.

In addition to the work just reported, Professor J. W. Sjogren, teacher in farm mechanics has spent his summers and a portion of

his school year studying certain farm engineering problems which we designate as farm mechanics. A bulletin is nearly ready for the editor on adobe buildings. Studies have been made for several years, in cooperation with the U. S. Department of Agriculture, on the measurement of hay in the stack. There is much more work of a similar nature that should be undertaken and carried to a conclusion whether that conclusion give favorable or unfavorable results.

We need to know comparative costs of performing many farm operations with horses and tractor power. We need to know the adaptability of different types of tractor power to different lines of farm work, for the double reason of knowing the comparative horse and power adaptability for these operations and to learn the best methods of hitch and power application. We should also learn the limitations of tractor power as compared with horse power.

We are equipped in man power to make these studies but do not have the necessary budget or material equipment.

Respectfully submitted,

ALVIN KEZER, Agronomist.

REPORT OF THE ANIMAL HUSBANDMAN

To the Director:

Following is a report on the various projects carried on by this section:

Beet By-product Rations for Fattening Beef Calves (Purnell)

Wet Beet Pulp for Fattening Beef Calves.—Altho feeders have long recognized the high fattening value of wet beet pulp for aged cattle, there has been very little known concerning its value when fed to calves, and many have considered it too bulky a feed for satisfactory results on the younger animals. An average of two tests recently completed demonstrates clearly that wet beet pulp actually makes a very efficient feed in fattening beef calves as well as older cattle.

Siloed vs. Pressed Beet Pulp.—Wet beet pulp coming directly from the diffusion cells at the factory, contains as high as 95 percent moisture. This "green" pulp is at the present time either siloed at the factory or run thru cold presses and delivered to the feeder as pressed pulp containing about 85 percent moisture. A comparison of fattening rations containing siloed and pressed pulp has indicated that the fattening value is largely dependent on the dry-matter content of the pulp at the time of feeding.

Corn Silage as a Supplement to Wet Beet Pulp.—Because of the limited supply of wet beet pulp available to satisfy a strong demand, feeders often lack sufficient pulp to fatten the desired number of cattle. A test to determine the value of corn silage when used as a supplement to wet pulp has indicated that, altho corn silage is neither as cheap nor efficient as wet pulp at present prices, it may be used to advantage to supplement a limited supply of wet pulp in increasing the number of calves fattened. Seventy-five tons of pulp with grain, cottoncake and hay were sufficient to fatten out only 35 calves. The same amount of wet pulp, with addition of 43 tons of corn silage, proved sufficient to finish 66 calves but at a cost of 64 cents per cwt. more for gains.

The Fattening Value of Sugar-Beet Tops.—Beet tops fed with a basic ration composed of barley, cottonseed cake and alfalfa hay, showed a feed-replacement value of \$6.41 per ton of tops fed.

Ration Experiments with Cattle

Comparison of Gains and Cost of Gains on Steer and Open-Heifer Calves.—Open-heifer calves produced only 80 percent as much gain as steer calves fed the same ration over a 203-day feeding period. The feed cost per unit of gain was only 92.7 percent as much for steers as for the open heifers.

Storage Studies with Pressed Beet Pulp.—A comparison of a trench silo and an above-ground straw silo for storing pressed beet pulp showed practically equal losses amounting to 29.21 percent for the trench and 26.89 percent for the straw silo. The cost of the trench silo, however, amounted to only 29 percent the cost of the above-ground straw silo.

Summer Cattle-Fattening Experiment

Beef calves fed thru the winter on a warming-up ration composed largely of roughages, were fattened during the following summer on irrigated pasture and a heavy grain ration. A comparison was made of alfalfa pasture, sweet-clover pasture and a perennial pasture-grass mixture (Morton's), while a mixture of equal parts corn and barley was used for a concentrate. The cheapest gains were secured on the perennial pasture-grass mixture. The highest net profits on pasture were secured where a protein concentrate was added to the perennial pasture-grass mixture, but higher net profits were realized with cattle fattened in drylot. Cattle fattened on irrigated pastures showed a characteristic yellow color in the carcass fat which was partially eliminated where a protein concentrate was added.

Range Management

A study is being made of the carrying capacity of low foothill range in the maintenance of a beef breeding herd. The value of protection to the forage during the early spring growing period is shown thru actual practice. Systematic rotation of cattle on the pastures as a means of increasing forage production is another phase of the investigation. Winter maintenance investigations with heifers are also being conducted.

Cornfield Lamb Feeding

Different methods for lambing down corn have been practiced in an effort to establish an economical practice that will cheapen fattening costs and eliminate excessive death loss. Altho a satisfactory method has not yet been evolved, it is planned to continue this work. With the idea that the pasturing of stock beets (mangels) may offer possibilities in the field-fattening of lambs, some tests in grazing off beets with a supplementary feed of alfalfa hay and with and without grain are being carried on at the present time.

Ration Experiments with Lambs

Barley proved to be a better fattening feed when supplemented with available carbonaceous feeds than when fed alone with alfalfa hay. Fed alone with alfalfa hay, barley produced more growth but less finish than corn. Average results for two feeding tests indicate that a No. 2 grade of barley has 89.4 percent and a No. 3 grade of barley, 83.5 percent the fattening value of corn.

In two fattening tests a No. 2 barley, steamed rolled, showed only 86.7 percent the feeding value of corn. In this test, the addition of .25 pound cottonseed meal to the barley-alfalfa ration increased the gain per lamb 5.25 pounds and produced gain for 91.8 percent the feed cost required with barley and alfalfa alone.

Corn silage fed with the basic ration at the rate of 2.5 pounds per head showed a feed replacement value of \$7.45 per ton which was 51.4 percent the value of alfalfa hay. Corn silage had practically 40 percent the feeding value of cut, dried, corn fodder fed with the basic ration at the rate of 1.25 pounds daily, giving the cut fodder a value of \$18.63 per ton.

Pressed beet pulp proved by far the most efficient carbonaceous supplement. Costing \$2.64 per ton fed, it showed a feed-replacement value of \$6.94.

Feed cost of gains on light 40-pound lambs amounted to only 87.5 percent the cost of gains on 60-pound lambs but the lighter lambs did not sell for as high a price per cwt. According to average

results secured, the light lambs purchased at 50 cents per cwt. less than medium weights, would have returned the same profit.

A comparison of narrow panels and self-feeders for feeding long alfalfa hay indicated that self-feeders, all costs included, were more profitable. A 30-pound gain on 1000 lambs cost \$3000 with self-feeders and \$3156 with panels while there was a difference in total cost of equipment of only \$160. A yearly saving of \$156 would nearly pay for the feeders in one year.

Comparative Value of Different Kinds of Molasses in Lamb-Fattening Rations (Purnell)

A general summary of more recent lamb-feeding experiments with molasses has indicated a higher value for beet molasses than for cane molasses where proper care has been exercised in gradually introducing the beet molasses into the ration.

With the new barium process for extracting additional sugar from Steffens discard molasses, a new final discard molasses is being produced and used as a stock feed in Colorado. Altho this molasses, called "Johnstown Final Discard," contains a higher percentage of carbohydrate than the Steffens discard molasses, a considerable portion is in the form of trisaccharide, raffinose.

Insistent inquiry from lamb feeders regarding the relative feeding value of cane molasses and the different kinds of beet molasses has made it advisable to test these different kinds of molasses available to Colorado feeders. The first test comparing cane molasses, beet molasses, Steffens discard molasses and Johnstown final discard molasses fed with shelled corn and alfalfa to fattening lambs, indicated that the palatability of the different molasses was practically the same, that the Steffens discard was slightly more efficient than the others, followed in order of efficiency by straight beet molasses, Johnstown discard and cane molasses. This test is being duplicated.

Winter Maintenance of Breeding Ewes

In the range, ewe-maintenance experiment which has been run for 1 year, we can state a few facts which are indicated by this 1 year's work. In the first place it seems to be very desirable to add cottonseed meal to a South Park hay ration, when the results are based on weight alone. The feeding of calcium and of both calcium and phosphorous shows some beneficial results, but they are so slight that they may be within the range of experimental error. However, when a chart is made of the weights of these ewes at various times, we note a residual effect of the calcium and phosphorous which later experimental work may prove to be important. For example, during

the time of gestation, calcium or calcium and phosphorous did not affect the weight in any definite degree. During the time of parturition and also during the early part of lactation, the same was true, but as the lactation period advanced, the weight curve for the lot receiving calcium, cottonseed meal and South Park hay, and for the lot receiving calcium, phosphorous, cottonseed meal and South Park hay, ran above the other weight curve and showed a very interesting beneficial effect.

Not enough data have yet been compiled on the measurements of the lambs to draw any definite conclusions, but the few measurements which were made last year during the first year's work, lead us to believe that we will be able to show a larger diameter for the heart girth, and a larger diameter for the cannon bone when mineral is fed than when it is left out of the ration.

Sheep Summer Fallow (Akron)

Sheep have been carried on two standard dryland rotations and on native sod pasture for a series of years to determine their value on dryland farms. The practice has been successful in keeping down weeds on summer fallow and the sheep have been maintained satisfactorily on home-grown feeds.

Winter maintenance rations for ewes, including the common forage crops of the drylands, sweet clover and a protein concentrate, have been compared. A carrying-capacity test on native sod has also been carried. Enough data are now available on this work to furnish reliable information on the results that may be expected in carrying sheep on the average non-irrigated Eastern Colorado farm.

Utilization of Dryland Feeds

Non-irrigated Eastern Colorado produces a large portion of the state's grain crop. The carbonaceous grains and forage crops produced there offer opportunities for feeding livestock.

Hog millet is an important emergency crop for the dryland. Planted as late as July 1 when other crops have failed on account of hail or drouth, it will still mature a grain crop. The fattening value of the different grains available and especially hog millet when fed with carbonaceous roughage and supplemented with a protein concentrate, is a problem that has been worked upon this year.

Winter Hog-fattening Test.—Ground barley self-fed with protein and mineral mixture supplements showed 88.1 percent the feeding value of shelled corn in winter fattening tests. Hog millet showed 103 percent the feeding value of shelled corn in the same experiment. Protein and mineral supplements were reduced in increasing amounts

by the substitution of (1) barley for corn, (2) hog millet for corn and (3) a corn-and-hog-millet mixture for corn.

The palatability of grains fed ranged in the following order: Hog millet (ground), hog millet and corn, shelled corn and ground barley. Pigs fattened on hog millet showed a higher dressing percentage and a lower carcass shrinkage in the cooler than pigs fattened on corn or barley. The pork from millet-fed pigs was of excellent texture and flavor, both when cooked fresh and after curing.

Summer Hog-fattening Test.—Hogs were fattened on a succession of annual pastures including fall-sown rye, spring-sown barley and sudan grass with a self-fed grain and protein supplement. These hogs were finished for a late August market and produced very satisfactory gains. The grain supplement used was composed of ground barley and hog millet fed in separate compartments of a self-feeder. The greater palatability of the hog millet was demonstrated by the fact that the pigs consumed only about 17 percent barley.

Lamb-fattening Test.—Hog millet (ground) had 84 percent the feeding value of shelled corn when fed with cane hay and a protein supplement to fattening lambs. A protein supplement composed of $\frac{1}{4}$ pound of cottonseed meal and $\frac{1}{4}$ pound No. 2 alfalfa meal proved just as efficient and much cheaper than $\frac{1}{2}$ pound of cottonseed meal when fed to both growing and fattening lambs.

According to these tests, well-balanced fattening and growing rations in non-irrigated sections of Colorado proved as cheap and efficient in non-irrigated sections as in irrigated sections of the state.

Hog Feeding in the San Luis Valley

A study of fattening rations for hogs pastured on field peas in the San Luis Valley is being made. Considerable inquiry as a result of poor gains and rather high death losses has prompted this line of investigation. Feeds used include field peas, barley, alfalfa meal, tankage, cull potatoes and skimmilk.

All-mash Feeding vs. Scratch-and-mash Feeding of Poultry

During the past year our work on comparing the results when feeding all-mash to laying pullets as against a mash-and-scratch ration did not give satisfactory results because colds and roup threw the groups out of condition. We, therefore, felt that it was necessary to carry on another season. On October 1 we placed two groups of pullets in a divided house. They are now being fed the two rations and records are being kept.

We are also working on a new problem of heating old kerosene lamp incubators by electricity. This work will be carried on until hatching season is completed.

Following is a list of the projects upon which we desire to prosecute work during the year:

1. Beet By-product Rations for Fattening Beef Calves (Purnell)
2. Ration Experiments with Cattle
3. Summer Cattle-fattening Experiment
4. Range Management
5. Cornfield Lamb Feeding
6. Ration Experiments with Lambs
7. Comparative Value of Different Kinds of Molasses in Lamb-fattening Rations (Purnell)
8. Winter Maintenance of Breeding Ewes
9. Utilization of Dryland Feeds (Akron)
 - a. Winter Hog Feeding
 - b. Summer Hog Feeding
 - c. Winter Lamb Feeding
 - d. Winter Maintenance of Ewes
10. Hog Feeding in San Luis Valley
11. All-mash Feeding vs. Scratch-and-mash Feeding of Poultry
12. Electric Heating of Small Kerosene Lamp Type Incubators

Recommendations

Our work in the Animal Investigations Section has been confined to a very limited part of our field; that of fattening meat-producing animals. We should take care in the immediate future of certain problems arising with regard to the feeding of dairy cows and the raising of dairy calves both in irrigated sections and dryland sections. We should also look some years ahead to financing experimental work in connection with dairy manufactures. There are problems now existing upon which we should be doing work but it is impossible for us to undertake it on our present budget.

Respectfully submitted,

GEO. E. MORTON

REPORT OF BACTERIOLOGIST

To the Director :

I have the honor to submit herewith the annual report of the Bacteriological Section of the Colorado Experiment Station for the year December 1, 1928 to November 30, 1929.

During the past year, we have directed our efforts along four lines of study as described briefly below. Three of our projects have been supported by the Purnell fund and one by the Adams, Hatch and State funds jointly.

The personnel of the section has changed somewhat since last year. Miss Laura C. Stewart, formerly a fellow on half time, has been made a full-time assistant; Robert Gardener has followed Justus C. Ward as soil chemist of the Rocky Ford Laboratory; Mrs. Mildred Brown Carpenter, a former member of the staff, has replaced Miss Ferguson, resigned; Miss Esther Elliott has succeeded Miss Ann Roberts as student laboratory assistant.

Projects

I. Alfalfa Wilt—Purnell Fund.—There is no more vital problem in the agriculture of Colorado than restoring our alfalfa fields to their former state of productiveness. The rather general decline of this crop which has been observed during the last 5 years appears to be due to two causes: Winter injury resulting from the planting of unhardy varieties, and the bacterial wilt, a root infection, which follows winter injury. The most practicable solution of this trouble lies in the discovery of varieties that are adapted to our winter conditions and which are also resistant to the wilt.

Two years ago and again this spring the Bacteriology Section and the Agronomy Section, cooperating, planted a number of variety-test plots in Boulder, Larimer and Weld counties. The list of varieties included Grimm, Cossack, Hardigan, Ladak, Canadian Variegated, Turkestan and Utah Common.

Excellent stands were secured with all plantings in 1929, with the exception of one plot in Weld county which was destroyed by grasshoppers. While the plots are still too young to yield significant results, there is some indication that Grimm and Canadian Variegated are superior to the others. Similar tests are to be made next year in Prowers county in cooperation with the Denver Alfalfa and Milling Products Company.

II. Botulism Poisoning.—Adams and Hatch Funds.—Hardly a year passes but one or more deaths result from eating either spoiled vegetables or meat that has been improperly canned. When we realize

that a human life is valued at \$5000 and that last year there were three deaths in the state from botulism poisoning, a preventable disease, at a cost of \$15,000 to the community, the importance of this investigation needs no argument.

We have completed over 6,000 tests for the purpose of determining how long a time and at what temperature it is necessary to heat the spores of the germ that causes botulism poisoning to kill them. The temperatures we have used correspond to the boiling point of water for all elevations ranging from the altitude of Rocky Ford to Cripple Creek, and the exposures from $\frac{1}{2}$ hour to 8 hours. Our results indicate that there is no place in Colorado where vegetables and meat can be canned with absolute safety against this form of food poisoning unless the cans are heated at the temperature of boiling water for more than 6 hours which is wholly impracticable. Canning in the pressure cooker where temperatures above the boiling point of water can be obtained appears to be the solution of the problem.

Further experiments on the determination of the lag in canned peas and carrots have been made.

It is our plan to make a further study of the distribution of the germs of botulism poisoning in Colorado soils during the coming year.

III. Winogradsky Method of Testing Soil Deficiencies.—The value of this method in determining fertilizer needs and its importance to the agriculture of the state was set forth at some length in the semi-annual report of this section.

During this year we have compared this method with that of Neubauer, a chemical method, and find that a very close correlation exists. In our opinion the method is sufficiently reliable to warrant our recommending it as a routine procedure in testing soils for phosphate, potash and lime deficiencies. The Great Western Sugar Company, the Holly Sugar Company, The American Beet Sugar Company, The National Sugar Company and the Utah-Idaho Sugar Company have all been using the Winogradsky method the past season with excellent results. Just recently we have examined a number of soils for the Kuner-Empson Packing Company. The fact that these large industrial corporations place so much reliance in the test speaks well for the value of the method.

Our records show that we have examined soil from more than 200 farms during 1929 for fertilizer deficiencies. In general we can say that most of our soils would be improved by the addition of phosphate.

In order to check the reliability of the method, we carried on extensive fertilizer experiments with sugar beets on six different farms in Larimer county the past season. Two of these were located near

Wellington, one near Harmony, one east of Loveland and two near Berthoud. Our tests showed the soil on two of these farms to be deficient in phosphate but not in potash or lime. On each of the farms four different fertilizer treatments were used: Acid phosphate, at the rate of 200 pounds per acre, potassium sulfate 100 pounds per acre, acid phosphate 200 pounds and potassium sulphate 100 pounds, and a check to which nothing was added. At the end of the season, tonnage and percentage of sugar were determined for each treatment on each farm. The results showed an increase of 134 percent in tonnage on one farm where phosphate was added and 13.7 percent on another with a like deficiency and like treatment. Where our tests showed nothing lacking there was no benefit from the fertilizer.

The field work of this project has been under the immediate direction of Dr. D. W. Robertson of the agronomy section to whom much credit is due for the successful outcome of the experiment.

So far as I know our laboratory is the first one in the United States to perfect and put into use this bacteriological method of determining fertilizer needs, and if it is as valuable as it promises, it will be one of the greatest contributions to agriculture that has ever been made, for by it we shall be able to tell every farmer in Colorado what particular fertilizer his land requires to make it more productive, and this information can be available for his use in less than 1 week after he sends in the soil sample. I submit to you this question: What measure of farm relief can possibly benefit the farmer more than this?

IV. Rocky Ford Niter Investigation—Purnell Fund.—Investigations at the Rocky Ford Experimental Farm have been largely continuations of the previous year's work. The Bacteriological Section has been particularly concerned with the following lines:

1. The control of bacterial blight of beans by means of 2 and 3-year-old seed.

In the light of this season's results we question very seriously whether it is safe to plant diseased seed, even if it is 2 years old, with the hope of controlling blight.

2. Relation of blight, mosaic, wilt, nitrates and plant lice to cucumber failures.

Our experiments point rather conclusively to mosaic as the most important factor in cucumber failures in the Arkansas Valley, and to the melon aphid as the agent which carries the virus from the common milkweed to the cucumber plants.

3. The use of crop residues in reducing the accumulation of soil nitrates.

Experiments over a period of 3 years indicate that the amount of nitrate in a soil can be reduced appreciably by plowing under sawdust, straw or corn fodder. In view of these findings, these residues should be applied cautiously to a land already low in nitrate, but they can be used to advantage when nitrates threaten to become excessive. If funds will permit, it is our plan next year to utilize this information in the reclamation of certain lands in the Western Slope where the soil nitrates have become so concentrated that the soil is no longer productive.

4. Crop rotation experiments for the control of soil-nitrate accumulation.

A brief report by Mr. Gardener, chemist of the Rocky Ford Laboratory and Experimental farm follows:

"The general trends of nitrate production and accumulation in the cultivated soils of the Arkansas Valley were so well established by the laboratory prior to the present season that it seemed advisable to direct the continuation of the work toward a more quantitative measure of the effect of the contributing factors. As the station facilities, both in personnel and laboratory equipment, impose a definite limit to the volume of work which can be done, the more intensive attack made it necessary to narrow the scope of the work to fewer aspects of the subject. Consequently only two principal phases of the problem have received detail study this year—the two phases being the effect of crop residues and fertilizers on nitrates in fallow soil, and the effect of specific crops and crop rotations on the production and accumulation of nitrates.

"The procedure previously followed with the former of these phases was adopted without modification for the present season. Forty-six plots, including the 23 plots sampled last year, and a new series of 23 plots were sampled weekly for analysis. The five green-manure plots formerly studied were similarly sampled.

"The study of the effect of crops and crop rotations was modified to permit more intensive observation on fewer plots. The vine crop and new alfalfa with nurse crop on the 8-year rotation were selected for study. Samples were taken both of surface and sub-soil every other day in an attempt to get a quantitative measure of the total amount of nitrate produced, including the portion carried downward by the irrigation water. Samples of the irrigation water were taken daily to determine the amount of nitrogen which might be introduced by irrigation.

"Including the water samples, approximately 2500 samples have been analyzed since sampling began on April 1.

“Report cannot be made on the conclusions drawn from the season’s work, as the work of analyzing and interpreting the accumulation of data has not been completed, but the general conclusions of previous years have been verified. That there is an invariable accumulation of nitrates in excess of utilization in the upper few inches of the soil growing cultivated crops during the season of maximum temperature, that this condition is less pronounced in uncultivated crops, and that the addition of green manure reduces the excess, are a few of the facts again definitely confirmed. It has been further confirmed that within the scope of the investigation any source of nitrogen found in the soil, except that introduced with fertilizers and crop residues or by fixation within the soil, is of negligible importance.

“Improved methods of farming, including more rotation in cropping, addition of more organic matter, better irrigation practices and improved drainage conditions are acting to reduce the importance of nitrates as a toxic factor in crop production. But the effect of abnormal amounts of nitric nitrogen and the excessive bacterial activity in the soil on the general problem of soil fertility are problems pressing for solution, and the fact of a condition existing where the nonsymbiotic fixation of nitrogen is in excess of the needs of crops makes the explanation of the factors involved in producing this condition a question of world-wide importance. With few exceptions the addition of more nitrogen to the soil than is accumulated in the ordinary cropping sequence is a universal need.”

Respectfully submitted,

WALTER G. SACKETT, Bacteriologist.

REPORT OF THE BOTANICAL SECTION

To the Director:

The following is a report on the projects carried by the Botanical Section, December 1, 1928 to November 30, 1929:

Range and Pasture Improvement

1. **College Foothill Pasture, Fort Collins.**—Records continued of quadrats, growth, phenology and environmental factors in relation to the continuous and deferred-rotation systems of grazing.

2. **Laramie River Valley.**—Quadrat studies continued on the improvement of sagebrush range by burning.

3. **North Park.**—Experiment started in cooperation with extension service on the improvement of sagebrush range.

4. **Upper Foothills, 7,000 feet, Virginia Dale.**—Composition and abundance of the vegetation, reseeding abandoned plowed areas, growth habits, quadrat studies, environmental factors, readings, mapping—in relation to better range management and the range improvement.

5. **South Park.**—Much of the sheep loss in the park traced to *Triglochin maritima*. Data collected and recommendations given on range improvement and range management.

6. **Irrigated Pastures.**—Analysis of seeding mixtures and resulting stands. Quadrats studied on six pastures under various farm conditions. Many valuable data collected on the composition of the pastures in relation to grazing practice.

7. **Methods of Quadrating.**—Data have been gathered in an effort to devise quadrating methods adapted to range studies. The area-list method has proved especially valuable.

8. **Miscellaneous.**—A beginning has been made on studying the use made of various native species by sheep and by cattle. We do not know enough about this yet to "size up" ranges adequately.

Recommendations have been given to a number of stockmen on range utilization and reseeding.

Weed Control.—The work on weed control the past year has consisted chiefly of testing in the field various chemicals as weed killers. Previous work has shown that arsenical sprays do little but kill the tops of weeds under Colorado conditions. Emphasis this year was laid on testing chlorates.

During the first of the season Walter Ball, who was in charge of the work, accepted a position in charge of the weed control for California and B. J. Thornton took charge of the work here.

Weed plots were laid out in the Arkansas Valley, near Manzanola, in the San Luis valley 8 miles south of Alamosa and on the Western Slope 3 miles northwest of Grand Junction. These plots were sprayed with sodium chlorate and calcium chlorate and also treated with crystalline sodium and calcium chlorates. Several rates of treatment per acre were tested to get an idea of proper strength of the chemical to be used. Part of the plots were irrigated, the rest left dry. Untreated check plots were left adjoining. Also areas were treated with carbon disulfide as a further check.

The above-mentioned plots were chiefly bindweed but experiments were also tried on poverty weed, Russian knapweed, Canada thistle and white weed.

Local plots, to test the killing effect of chemicals, were also laid out at Wellington and Ft. Collins in Larimer county and also at two locations in Weld county and additional plots in Denver county.

All of these plots were extensive enough and properly planned so as to test the effect of the various strengths of the chemicals used and to show the influence of time of application, manner of application and irrigation, on chemical treatment of weeds.

Three trips were made to each of the plots during the season to make treatments and observations. The results of the 1928 tests indicate that the effects of chemical treatment with chlorates are frequently most evident the spring following the previous year's treating.

In some instances excellent results were obtained from use of sprays. Conditions, such as time and method of application, irrigation and weather, appear to play an important part in the success of chemical weed treatments. No definite conclusions can as yet be arrived at.

In addition to field tests, greenhouses and laboratory experiments are being conducted by Mr. Cation on the physiological reaction of chlorates on plants.

Cereal Diseases.—Intensive study has been made of the physiology of *Tilletia laevis* causing stinking smut of wheat. Mr. Henderson returned from Ames in June to complete the write-up of his studies formerly carried on here. Mr. Bodine is continuing the study which he started last year and is writing up his results.

Truck-crop Disease Studies.—The work the past year on truck-crop diseases has centered around the study of onion diseases, particularly those in storage.

The increased onion acreage in the Arkansas valley the past year has resulted in increased trouble from diseases. In June, Mr. LeClerc established a field laboratory at Rocky Ford working out from that point as a base.

His studies and observations are as follows:

"Pink Root.—This new disease was first found in the state near Littleton in 1928. This past season it has been found in isolated fields near Canon City and around Rocky Ford. The disease in some cases caused a complete loss. It was apparently introduced into the state on Bermuda sets from Texas. Circular 57, "Pink Root of Onions," was published January, 1929, describing the disease and recommending control measures.

"Purple Blotch.—This disease was found the past season in severe form around Rocky Ford. In one field an estimated loss of

10,000 pounds per acre resulted. The disease is of fungus origin and directly follows continued growing of onions. Sanitation and rotation will keep the disease in check.

“Fusarium bulb rot was also found in two fields near Rocky Ford.”

Neck Rot.—Observations were made on this disease thruout the valley. Mr. LeClerg has made a study of storage conditions affecting onions conducive to neck rot. Some of the results of this study are published in bulletin 301-A.

Thruout this season observations and notes were made on various other diseases of crops in the valley. A comprehensive report on this has been turned in to the director and also sent to the Office of Plant Disease Survey, Washington, D. C.

Report of the Seed Laboratory for 6 Months Ending December 1, 1929

Samples Tested. —Current Samples.....	180
Referee Samples A. O. S. A. N. A.....	10
International Seed Testing Congress	15
Investigational	30
	235

Most seeds are dormant at this time of year so the total germination tests made is 735.

Investigational—Dormancy in Wild Oats and False Wild Oats.—Thirty samples of wild oats were obtained from several western states. Threshing of these and germination tests of all samples have been made. Counts are now ready for later additional tests in regard to dormancy.

In connection with a study as to the possibility of detecting mixtures of *Melilotus alba* and *officinalis*, detailed microscopic examinations have been made of 27 samples of hand-threshed sweet-clover seed. The seed has been secured from various parts of Colorado and from other states. More samples are on hand and are being examined as time permits.

Three months' training have now been given a student in order to have additional help for the busy season which will probably begin about December 15. Arrangements have also been made by which Miss Lyon will return to the laboratory for the busy season, January 1 to June 1, 1930.

New Equipment Installed.—

1 blower	1 Marchant calculator
1 seed-counting equipment	4 new table tops.
1 balance for large samples	2 germinators

During the time, May 27 to June 25, Miss Lute made a study trip visiting several of the most important seed laboratories in North America. Her report in brief is as follows:

"I spent 3 days at the Virginia Seed Laboratory. Virginia enforces its seed law more satisfactorily than any other state. A study of their plans and procedure in law enforcement has given me numerous ideas for the enforcement of our law with the increased appropriation which we are pledged to use for that purpose.

The Virginia laboratory had recently installed new equipment and was adapting uniform laboratory practice to special seeds and conditions.

June 3, 4 and 5 were spent in a meeting of the executive committee of the Association of Official Seed Analysts of North America. The enforcement of seed laws must be based upon the use of similar methods, and a uniform interpretation of results secured in seed testing. At this meeting plans were made for various cooperative projects looking toward unifying results from all laboratories. The results of this work are to form a part of our program at the coming meeting in Des Moines. I am chairman of the committee on cooperation between laboratories.

The following 4 weeks were spent working in the seed laboratory of the United States Department of Agriculture.

This laboratory has experts and investigators in all lines of seed work. I was able to carry on special work under Mr. Hillman on the various species of bent grass and the various species of Brassica. Dr. Toole and Mr. Goss gave me much time and opportunity to study germination methods in chambers and greenhouses and the interpretation of results obtained. Miss Serrine, who has charge of all purity testing, assisted me to familiarize myself with all the latest knowledge in that field.

The problem I am investigating in connection with wild oats involves a study of the chromosomes of wild oats and false wild oats. While in Washington I was able to familiarize myself with the methods used by Dr. Langley in the study of chromosomes so that next spring I hope to be able to finish this problem.

Several days were spent in the Maryland laboratory. This laboratory has very fine equipment of all kinds, expertly installed.

The New York laboratory is organized and equipped differently than any other seed laboratory and gave special help in simplicity of keeping records and reporting results of tests.

It was possible to make a trip from Buffalo to Toronto and spend July 4, which is not a holiday in Canada, studying the work

there. The Canadian laboratories work under a seed-grading system which they feel is better than the American systems of labelling exact quality.

The Wisconsin laboratory ranks next to Virginia in efficiency of enforcement of the state seed law. The time spent there was taken up largely in discussing methods and plans for law enforcement.

The Northrup King and Company in Minneapolis furnished excellent opportunity to study testing of vegetable seeds on a large scale."

Cooperative Work.—Cooperative relations have been continued during the past year with the United States Department of Agriculture on barberry eradication.

The Office of Sugar Crops and Diseases established a laboratory in association with the Botanical Section during the past year. Dr. Stewart and Charles Lavis are located here studying the problems of beet disease and breeding for resistant varieties.

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- Hanson, Herbert C. Range Resources of the San Luis Valley.
Colo. Sta. Bul. 335:1-60.
- Grazing Types in Colorado.
The Cattleman 15:57-63 (April)
- Reseeding Waste Range Land.
The Cattleman 15:31 (May)
- Intensity of Grazing in Relation to Proximity to Isolation Transects.
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- Analysis of Seeding Mixtures and Resulting Stands in Irrigated Pastures of Northern Colorado.
Journ. Am. Soc. Agronomy 21:650-659.
- Discussion on "Eradication of Brush and Weeds from Pastures" by A. E. Aldous.
Journ. Am. Soc. Agronomy. 21:666.
- Pasture Plants for Sheep.
American Sheep Breeder, July.
- LeClerg, E. L. Some Common Diseases of Ornamental Plants.
Colo. Sta. Bul. 351.
- Neck Rot of Onions.
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- _____ *Zygophyllum fabago* in Colorado. Science.
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Respectfully submitted,

L. W. DURRELL, Botanist.

REPORT OF THE CHEMIST

To the Director:

During the past 12 months this section has finished the project designated "effects of clover and alfalfa in rotation; carbon dioxide in the soil." The results have been presented in four parts, one of which has been published as Bulletin 319. The main features of the results were that we did not find any significant increase in the total nitrogen in the soil, and the nitric nitrogen was continuously very low.

The carbonic acid in the soil atmosphere was maintained at very much larger quantities under these crops than in fallow land. The soil complex in the soil experimented with corresponded to 13 hydrogen atoms and was not affected by the crops.

The water-soluble potassium was quite abundant in the soil and varied in different portions of the plot, but in all cases was greatly increased by the growing crops. There is in this soil a large quantity of potassium that forms no part of the soil complex. The variation in the water-soluble phosphoric acid was not followed.

Supplemental to the main project, small plots of wheat were grown on the land after the crops had been plowed under during the preceding fall. A part of the fallow plot used had been planted to corn. This is how we came to have three crops and a fallow in this experiment; the crops were clover, alfalfa and corn with a fallow.

The wheat yield was the largest after fallow and smallest after alfalfa, the difference being 18 bushels per acre. The protein content was highest after alfalfa and lowest after corn. After alfalfa it was 19 percent; after corn 12.25 percent; after clover, 17.5 percent, and after fallow, 17.25 percent.

This wheat experiment was repeated using the whole plot of land. This year the differences of the preceding season had largely disappeared and the general effects seemed to be those of fallowing. The various plots yielded around 55 bushels per acre. We do not wish to prosecute this work further.

The only active project now being prosecuted is a study of the extent and character of the changes effected in alfalfa hay by weathering or injury by rain in the field. This is really an extension of work done 32 or 33 years ago, so far as the analytical features are involved, but this work is being supplemented by biological work in feeding rats. It may require longer to complete this work than we originally anticipated, but the results so far promise to be of considerable interest. They confirm and explain observations previously made. It may be safe to state at this time that the vitamins of alfalfa hay are quite easily soluble, so the loss in this respect is very large.

Respectfully submitted,
WM. P. HEADDEN, Chemist.

REPORT OF THE ENTOMOLOGICAL SECTION

To the Director:

The following is my annual report upon the work carried in the Entomological Section of the Colorado Experiment Station during the 12-month period just closing.

The Entomological Section has carried 10 active projects upon all of which some work has been done. These projects are listed below with brief comments upon the work done in each.

The investigational work is so coordinated with teaching and the regulatory work under the state entomologist, as to give the section part-time service of 10 people. Two of the projects deal with rodents and are zoological rather than entomological in nature.

The insect injuries to crops during the past year have been serious at times, but on the whole, the losses have not been unusual. Better control methods are continually being used by the growers of farm, fruit and vegetable crops in the state which offset the occasional introduction of a new pest and the enlarged area in which these crops are grown.

Projects of the Year

Plant-louse Investigations.—This project is carried chiefly on Adams and Hatch funds. The work is rather technical in nature and is carried by Miss M. A. Palmer and the writer. Two technical papers have been published on this work during the year in which host plants, life histories and descriptions of new species have been given. These papers were published in *Annals of the Entomological Society of America*. An annotated list of Colorado Aphidae, upon which we have been working for some time, has made considerable progress.

Ants in Relation to Plant Lice.—Dr. C. R. Jones is in charge of this project. It is supported on the Hatch fund. This is also a technical study for the most part, but includes methods of control. Bulletin 341, *Ants and their Relation to Aphids*, published during the year, gives the results of a large portion of this work. It is condensed from a rather lengthy thesis written for the Ph.D. degree in the Department of Entomology, Iowa State College.

Codling-moth Studies.—The codling-moth, which has proved to be so difficult to control in the Colorado Valley in this state, has called for continuous work because of its changing habits, which also call for more refined methods for control which are not yet altogether satisfactory in parts of Mesa County. Good control is secured in other sections of the state where our recommendations have been followed.

This project is being carried under the direction of George M. List and J. H. Newton, with the assistance of Louis Davis.

Codling-moth Control by Means of an Egg Parasite.—This investigation is rather a unique one and has called for a great amount of ingenuity to meet the unexpected difficulties that have arisen in the work. The project started off with great promise, when suddenly we became aware of the presence of two mites, one, *Pediculoides* sp., attacking the Angoumois grain moths used in the experiment, and another, a Gamasid, attacking the eggs of the moth upon which the parasites were being reared. These mites were about to ruin the experiment when Mr. List succeeded in controlling them with flowers of sulphur. Following this, the parasites refused to ovaposit in the eggs, which we believed to be due to the sulphur in the breeding cages. This difficulty seems now to be overcome, and at this writing all promises well again for the work.

Grasshopper Control.—The work on this project has been in charge of Frank C. Cowan as deputy state entomologist, and has been directed against the Mormon cricket (*Anabrus simplex*) which is a wingless grasshopper. This insect has been quite destructive to the crops, especially of the new settlers in Northwestern Colorado, for a number of years. The work has been in collaboration with the Bureau of Entomology of the U. S. Department of Agriculture and has been supported upon special appropriation by congress and the budget of the state entomologist. Mr. Cowan reports most satisfactory results from his work of the past year. It seems probable that by next July this insect will be practically exterminated for many years to come in Moffat and Routt counties of this state. A bulletin manuscript giving the results of the work done on this project by Mr. George Langford is in the hands of the printer.

Potato Flea-beetle.—Bulletin 337 gives the results of this work up to a year ago. The past year the work has been carried further by Leslie B. Daniels, who has added materially to our knowledge of the habits of this very destructive insect and the methods that may be used for its control.

Resistance of Bees to Foul Brood.—This is a new project in charge of R. G. Richmond, deputy bee inspector for Colorado, upon which considerable work has been done the past year.

Colorado Insect Fauna.—This is a continuing project in charge of Sam McCampbell. It has for its purpose to get together as full a collection of Colorado insect fauna as possible, with notes on food plants, the hosts, dates of collection, name of collector and other im-

portant information. It also includes the determination of material collected and the making of exchanges with other entomologists in this and in foreign countries. Good progress has been made during the year.

General Insect Investigations.—This project is carried from year to year to enable this section to do emergency work on short notice whenever any insect outbreak occurs within the state. Some work on this project is called for practically every year.

Rodent Life Habits.—W. L. Burnett is in charge of this project which has been undertaken to obtain more definite information concerning the life habits of some of our most destructive rodents in order that methods of control may be made more efficient. Good progress has been made this past year.

Rodent Poisoning.—This project is closely correlated with the preceding, under the direction of Mr. Burnett. Its purpose is to improve present methods of rodent control by means of food poisons.

The insect collection and the entomological laboratory are being moved into the new fireproof building constructed in connection with the building which houses the department of zoology and entomology. This building will be greatly appreciated in our work. We shall have a feeling of security now, as the danger of losing our insect collection by fire is made very small.

Respectfully submitted,
C. P. GILLETTE, Head of Entomology Section.

REPORT OF THE AGRICULTURAL ECONOMIST

To the Director:

During the year ending November 30, 1929, the Section of Economics and Sociology has given attention to the study of nine projects, eight of which have been approved for development with Purcell funds.

Project No. 1.—During the year 1926-27 the Division of Farm Management and Costs, Bureau of Agricultural Economics, U. S. D. A., conducted an extensive fruit survey which was nation wide in scope. In this study certain districts of the western slope were included. Subsequently this work was expanded by the Extension Service and the Department of Economics and Sociology of this institution. For three successive seasons the members of the staff, in this department in cooperation with the Extension Service, have visited

farmers in Mesa, Delta, Montrose and San Miguel counties, and have secured data relative to the acreage and production of farm crops, together with the disposal of these crops; also information pertaining to numbers, values, production, purchases and sales of livestock; an itemized list of farm receipts and farm expenses; estimates relative to the value of food raised on the farm for home consumption; and investment in real estate, livestock, machinery and feed. Each individual record has been summarized and returned to these men. In addition, a preliminary report covering the major features of the survey has been taken back to cooperating farmers each year. A special report covering the 3-year period is in preparation and will be published in due time.

Project No. 2.—Detailed accounting records have been obtained from several farmers in the Greeley area and for some of these units the study has been continued for the eighth year. Financial records have been secured from several farms in the same general region. For the northeastern section of Colorado the work is in its third year.

At the beginning of the year 1929 a few representative dairy farms in Weld and Larimer counties were included in the project with the object of investigating the status of the dairy enterprise as it is being developed on these irrigated farms. The entire group of farms in this project has been selected for the purpose of providing a continuous record of economic changes in this area and in order to determine the relative profitableness of the different types of farming which are representative of the region.

Colorado station bulletin No. 353 entitled "The Cost of Producing Crops on Irrigated Farms" has been published and distributed during the year. A manuscript is practically completed relating to cattle-feeding and lamb-feeding costs and returns covering a 7-year period.

Project No. 3.—In our reorganization of this study contacts have been established with 19 North Park cattlemen who have agreed to cooperate in the matter of keeping the necessary records. Complete inventories have been obtained on each of these ranches as of January 1, 1929. An average of five visits has been made to each ranch during the year for the purpose of getting acquainted with management practices and to inspect and check the records which these men are keeping.

During the summer a survey was made of the feeder cattle to be marketed during the fall months. At that time approximately 25 of the ranches in addition to those cooperating in keeping ranch records, provided information in regard to their feeder cattle. These data were summarized and distributed to interested parties during the

early autumn. Special data have also been collected on the labor requirements involved in cutting and putting up hay in the North Park area. It is our purpose to issue a preliminary report on the latter phase of this project so that ranchmen in this general area may be in a position to check their work with the records which have been compiled.

Project No. 4.—In our analysis of the social status of the Spanish-speaking people of rural Colorado, information has been assembled with respect to the economic, religious, social and educational conditions under which these people have lived in previous years. An attempt has been made to study the habits and life practices of the members of this group. Records have been taken regarding citizenship ideas and the present situation in Old Mexico which has led in many cases to immigration to the United States. Several typical regions have been visited during the present year and additional records have been assembled with the idea of making our report on this project more complete.

Project No. 5.—An intensive study has been made of county revenues and public expenditures in Larimer County and a manuscript giving the details of this investigation has been completed. Prior to publication this outline will be reviewed by the Division of Finance in the Bureau of Agricultural Economics, Washington, D. C.; also by individuals who have cooperated in supplying the information.

During the year Colorado station bulletin No. 355 entitled "An Outline of Colorado Tax Laws for Farmers and Ranchmen" has been published and distributed.

Another manuscript relating to the cost of operating schools in Larimer County is in preparation. An analysis of receipts and expenditures for educational purposes in 10 typical counties in Colorado is now in progress. Most of the statistical tabulations have been completed.

Project No. 6.—In April, 1929, farm business-analysis records were secured from a representative group of farm operators in the San Luis Valley. Substantially all of these operators have furnished information regarding the storage and marketing of the potato crop on their farms. Three years' work has been completed on this project and the results of this investigation are being compiled for publication at an early date.

Project No. 7.—A farm organization survey was conducted in the apple districts on the western slope during the month of May and some 80 or more records were obtained from farm operators who had previously given information for their farm business in 1927. Our

purpose in this study was to compare the results on farms where the major attention was directed to apple production with other types of farming in which other enterprises constituted an important part of the system. The records which have been assembled to date appear to indicate that farmers who rely upon apples as their chief source of income are not making as good returns as farmers who combine crop production with one or more classes of livestock.

Project No. 8.—In the summer of 1927 the Colorado Agricultural College, in cooperation with the Division of Land Economics, U. S. D. A., began a study of land utilization in Northwestern Colorado and farm business-analysis records for the year 1926 were secured from representative operators in Moffat, Routt and Grand counties. This study has been continued for 3 successive years. Information has been assembled relating to the area, production and sale of crops: the number, value and purchase of livestock. Miscellaneous income and all items of expense were secured for each farm each year. Some were crop farms, some livestock ranches, while others had no one outstanding source of income. Some farmers operated their farms part of the year and worked out the rest of the year in order to increase their incomes.

It would seem from our review of the more successful farms in this group that where there is sufficient area and livestock and where an attempt is made to keep down expenses, a man has a fair chance to succeed in this region. On the whole, livestock farming appears to offer the best chance for profitable returns, altho farms giving major attention to wheat and potato production did well in Moffat County.

Project No. 9.—During the past year the work in this field has been expanded until there is now available more or less information relating to the business of 80 Colorado cooperatives. These data have been assembled by personal interviews with men in charge of cooperative organizations and thru contacts with managers and individual farm operators who have been, or who are now connected with cooperative associations. The present available list includes: 22 elevators, 14 potato associations, 6 fruit associations, 4 cooperative creameries, 5 livestock associations, 9 central exchanges and 20 miscellaneous organizations. The miscellaneous group includes vegetable, honey, coal, turkey and oil associations, as well as cooperative stores.

Information pertaining to a small percentage of the organizations is somewhat incomplete. This is due to encountering some opposition because of misunderstanding concerning the motive behind the investigation. In some cases the present manager had been with the organi-

zation a relatively short period of time and he was therefore unable to furnish much information. These records will be summarized as promptly as possible and the material will be incorporated in bulletin form for distribution.

Respectfully submitted.

L. A. MOORHOUSE, Head of Economics Section.

REPORT OF HOME ECONOMICS SECTION

To the Director :

From this section of the station the report is necessarily brief, for the reason that not until early in the summer was it possible to secure a worker adequately trained in the physical and mathematical sciences.

The project underway is the baking of flour mixtures at high altitudes, part II. In this part II of the project it is the purpose to interpret from a physical-chemical standpoint the results obtained in part I.

Miss Florence Schott, appointed to carry on this research, reported for duty July 1. Miss Margaret Scheve entered upon her duties as laboratory assistant on the same date.

During July the time of both workers was spent in acquainting themselves with the problem and with the facilities for the research work to be undertaken. This involved much reading and correspondence.

Preliminary baking experiments in the altitude laboratory occupied a part of the month of August. These experiments demonstrated that accurate physical-chemical measurements on cake batters could not be made in a laboratory in which there was so great a fluctuation in temperature as was shown in the pressure chamber.

In addition to the study of temperature changes and the plotting of these on graph paper, much time was spent in studying the wattage of the oven and of the heat radiated, this, in order to find out to what extent the air in the pressure chamber would need to be heated or refrigerated for constant temperature.

During the past year Professor J. H. Scofield of the Mechanical Engineering Department did considerable work on the altitude laboratory. This work included a general overhauling and necessary repairs and adjustments to the motor, blower, pressure regulator, safety valves, etc. Also an extensive study was made on the effects of weather upon the laboratory temperature when running at various pressure, and various designs for insulation were worked out. The

insulation has also been installed. Steam heat was added to the outer machine room. Study and correspondence were carried on in an effort to find a way to control heating and refrigerating devices which will control the temperature to within 1° F. in the laboratory with a blast of air entering at all times ranging from — 20° to + 100° F. Another series of tests were run at all altitudes and all speeds of the motor and various pressures recorded which will permit thermodynamic calculations to determine the correct blower speed for each altitude.

In the interval during which the work of insulation was going forward, preliminary experiments and the assembling of apparatus has occupied the time of both workers.

Early in the summer the courtesy of the altitude laboratory was extended to Earl Working, of the Milling Department of the Kansas State Agricultural College for experimental work on his project on bread-making.

Respectfully submitted,

INGA M. K. ALLISON, Head of Home Economics Section.

REPORT OF THE HORTICULTURIST

To the Director:

I beg to submit herewith a brief report on the various projects carried by the Horticultural Section during the past year.

Onion Projects

1. **Cultural Projects.**—The importance of the onion industry in the state is well recognized. With the rapid growth of the Valencia onion industry, particularly in the Rocky Ford section, the department has undertaken to study the comparative yield and cost of growing the Valencia onion from field-sown seed and from transplanted seedlings grown in the cold-frames or greenhouse.

In Northern Colorado the season is too short for the development of a maximum crop of Valencia onions from field-sown seed and the transplanting method has proved the most successful. This work at Fort Collins has been carried on for four seasons and during three seasons records have been kept of the yield from transplants. In 1927 the yield was 1250 some odd bushels. In 1928 the yield was 1541 bushels and 16 pounds. In 1929 the yield was 1235 bushels. This is reckoned on 52 pounds to the bushel. The yield for 1928 was remarkable but the season was very favorable for the development of the crop and one would naturally not expect yields of this size every

year. However, on the whole, the yields are very high and the transplanting method for the Valencia onion should prove profitable to this part of the state.

At Rocky Ford, from incomplete figures, there was very little difference in the transplanted onions and the field-sown onions; in fact, not enough to warrant the extra cost of growing the seedlings and transplanting. However, this first year's trial is no criterion, since the plants for transplanting were grown at Fort Collins and had to be shipped to Rocky Ford, resulting in a considerable loss in planting. Secondly, the season being 3 or 4 weeks earlier so far as onions are concerned, they were not planted until after the field-sown onions were planted, so that there was little advantage in the length of the growing season. Another year we plan to grow the plants at Rocky Ford and to have them in condition so that there will be an advantage in the length of the growing season for the transplants. We can then get a better comparison than from our first year's operation.

The cost per acre of growing the onions by these different methods according to figures kept at Rocky Ford, was \$176.86 for the transplants and \$108.93 for the field-sown onions. This difference as given would not hold good under proper conditions, as \$20.00 of the \$176.86 was the cost of replanting, which would not have occurred had conditions been right. A figure of \$150.00 per acre as a cost for growing transplanted onions should be about correct. However, cost in onion growing is only relative. So much depends upon the character of the land and its conditions. A weedy piece of land would, of course, cost more, while the cost would be considerably reduced on very clean land. However, there is probably a difference of one-third in the cost of the two methods and this difference must be made up in heavier yields, otherwise transplanting in the Rocky Ford section would not be profitable.

2. **Variety Tests.**—There has been a considerable amount of complaint about onion seeds as obtained from various sources, and there was an urgent demand for a thoro test of seed and strains of seed as obtained from different seed houses. The results of these tests are very interesting. They are discussed and tabulated in the report of Mr. Allen, who was in charge of the onion work at Rocky Ford, and a copy of his report is attached herewith. It is very apparent that the present method of buying seed indiscriminately is a very serious one and has much to do with low yields and poor quality. This work has been of special interest to growers in the valley, and from their expressions during those visits, we are sure that the lesson has been a good one.

3. Onion-Seed Breeding and Selection.—This phase of our onion work is progressing very satisfactorily. It is being carried on at Fort Collins. The first part of this project consisted in developing by selection a desirable type of Valencia onion so that we would have a pure strain of a desirable type. The second part of this program is to cross this type obtained as above with the Brown Australian onion. This onion is noted for its keeping quality. It has a hard, thick, brown skin, a color that is very desirable in the trade, but its yield is unsatisfactory and it does not seem to be adapted to our climatic conditions. It is now grown almost exclusively in California. We believe that if the yielding and eating qualities of the Valencia onion can be combined with the keeping qualities of the Brown Australian, we shall have an ideal onion for Colorado.

Considerable progress has been made in developing pure strains of the Valencia. It remains, however, to be seen whether the type selected will remain permanent or whether type is a variable factor that changes from season to season. Some very interesting results have been obtained from this work, but it is not ready for a report, since we have not been able to tabulate all the data in connection with this project.

4. Onion Storage.—The heavy losses in the storage of onions during the past season made it necessary to investigate the problems associated therewith. The following factors were considered: The effect of varying length of field curing prior to storage and state of maturity of the bulbs at harvest; the effect of close topping versus long topping, and effect of careful sorting to eliminate disease; moisture and temperature conditions in storage.

An adobe storage house was built, divided into two compartments and suitable self-registering instruments were installed. It is hoped that this project will give valuable data regarding the factors causing present losses in onion storage.

Head-Lettuce Projects

1. Development of Tipburn-resistant Varieties of Head Lettuce.
—This work has been in progress at Fort Collins for the past 3 years and we have several crosses between the New York head lettuce and the small purple-tipped Mignonette head lettuce. The latter variety is resistant to tipburn but is too small for commercial planting. As would be expected, the cross breeds show various degrees of resistance and color. Some excellent heads or crosses were obtained and these have been isolated for further selection. This kind of work is necessarily slow and often disappointing, but we believe there is great possibility connected with it and the work will be continued.

2. **Fertilizer Work on Head Lettuce.**—The fertilizer work on head lettuce has given negative results indicating that the ordinary garden soil is not materially benefited from the use of commercial fertilizers and for the present we are convinced that the use of barnyard manure with crop rotation is the best and most economical method of maintaining or increasing production. We desire to drop this project from our program for the present, as there is other work more important.

3. **Irrigation.**—For 2 years we did considerable work with the use of water in head-lettuce growing. This whole subject of irrigation is possibly the most baffling of all the cultural practices used in the growing of the crop. No formula can be given for irrigation. There are, however, periods in the growth of the plant when the use of water may be very injurious to the crop. This is particularly true at the final stage of growth after the plant is headed but the heads have not hardened. If heavy irrigation is given at this time, the results have invariably proved fatal, especially during bright, relatively warm weather. Seed stocks develop rapidly and the plant is soon unsaleable. Different types of soils require different amounts of water and different temperatures and humidity call for different amounts or numbers of applications of water, so that it is impossible and impracticable to state how many irrigations should be given a crop of lettuce. Head-lettuce growing under irrigation is not only a science, but a fine art, and the average farmer has to learn by experience and observation how to use water properly.

Garden Pod Bean Projects

Under this project is included the work connected with the seed certification and naturally the bean projects are very closely connected.

1. **Variety Testing.**—During the past season we had planted and under observation 175 varieties and strains of garden beans. A large percentage of these were from Germany, France, England and Canada, besides all available varieties and strains grown in the United States. In this work we are principally interested in developing varieties or strains for the canning industry and for vegetable growers in different parts of the country.

At present there is a great deal of confusion in naming varieties, for duplications and interchange of names are frequent. Our first task is to get pure and disease-free strains from these varieties to use as foundation stock for the work of seed certification. The importance of this work has been pointed out in previous reports.

Among the foreign varieties under observation there are some very promising ones, particularly from England. These would be superior to any of our own home-grown varieties, were it not for the stringiness of the pod which makes them undesirable to the consumer. We hope to be able to make selections from these desirable types and eliminate stringiness from them. This, of course, will necessitate several seasons' work and the growing of a considerable number of plants.

2. Selection.—With the beginning of the coming season we shall start a systematic selection from the best varieties and use these as foundation for wider testing and ultimate distribution among the growers. In connection with this selection, the disease question will be taken up and disease resistance stressed in making the selections. Bacterial blight has been one of the most destructive bean diseases that have occurred in the state and work for the control of this disease has been started.

We were fortunate during the past season in finding a 3-acre field badly infected with bacterial wilt. The whole field was completely destroyed with the exception of 50 to 70 plants that were found scattered over the field and unaffected by the disease. We harvested these plants and are going to use them as a foundation stock for strain selection, with reference to freedom from this particular disease.

3. Foundation Stock.—(Seed Certification).—With the development of a seed-certification program it is necessary to develop a reliable seed supply from which the growers may obtain their seed stock for the growing of certified seed. This work of developing foundation stock entails considerable work in the way of roguing for undesirable types and off varieties so as to obtain a pure line that is reasonably free from diseases of all kinds. The limited acreage at our disposal made it impossible to plant our own stock in large quantities. Our supply of seed stock of the most important varieties will possibly amount to 5000 or 6000 pounds. This seed stock is not all that we desired it to be, but it is a beginning and with improvements, that is, by careful roguing in the field during inspections, I believe that the seed will be far superior to anything in the market. Meanwhile, we should make every effort to develop superior strains to replace those that we now have ready. The work must be one of continuous progression and improvement. Further, there should always be original seed stock available, as the old seed stock in the hands of the average grower soon deteriorates and should be discarded.

Garden Pea Project

This project has been active for the past 3 years. Our chief interest is in the development of improved varieties suited for the

production of pod peas in the mountains. We have been fairly successful in this work and are now growing as much as 10 acres of pea seed of this improved variety. The seed is sold to vegetable growers and the demand has always been greater than the supply. This work will be continued. Besides the work of selection as indicated above, we have about 50 new varieties under observation. Several of these are of the canning type. It is possible that some superior varieties will be obtained from this testing and selection work.

Orchard Management

This project is carried at Austin. The results have been valuable to the growers. The best cover crops for apples are yellow-blossom sweet-clover and red clover for a two-season crop, while winter rye has proved best for peaches and one-season cover crop for apples. Hubam clover gives great promise as an annual cover crop but it is often difficult to obtain a stand.

European-Grape Project

We now have about three-fourths of an acre planted to the European grapes. Varieties like Tokay, Malaga, Thompson Seedless and Muscat have done well and are producing fair crops. All the European varieties require winter protection at Austin. The canes have to be taken down and covered with earth each fall and uncovered and tied up in the spring. This entails considerable work. We feel that these grapes can be successfully grown in many places on the Western Slope, at least to the extent of supplying the local and even the state market. As an extensive commercial crop it would come in direct competition with California and Arizona and this competition would be hard to overcome. However, for our own market grape growing has considerable possibilities.

The native grapes do exceedingly well and all varieties can be grown without winter protection. Considerable planting of this type of grape has been made.

General variety testing of fruits at Austin is in progress, especially with several sports of the Delicious and Rome varieties. These give great promise and will in the near future replace the old varieties. It is the intention not to give these sports new names, but to retain the old, since the chief difference is in the color and general attraction of the fruit.

Small-Fruit Projects

These projects are in care of Professor Lott and his report is attached. There are also attached reports by Professor Binkley.

Fruit Farm at Austin

The general situation in fruit production is very much the condition in farming. Specialization has developed to a remarkable degree

tho there are many indications of a change. Exclusive apple growing or exclusive peach growing is a very risky proposition in most of our fruit-growing sections, since there is only one source of income. It is just as easy to diversify in fruit growing as in farming, and to make fruit growing safe and profitable the growers should grow a number of fruits. Diversification does not necessarily mean large acreage. It can be done on small tracts with better labor distribution and with greater safety in income.

Primarily the fruit farm was bought to demonstrate how fruit growing should be done under proper methods of management and cultural practices. In addition, it was believed that all kinds of fruits that the soil and climate would permit should be grown. At the same time, we did not want to make the farm a fruit museum and a variety-testing farm. When the farm was purchased it was in a run-down condition. The land was impoverished and the trees neglected. The work of reconstruction has been accomplished and we believe that we have a model fruit farm. The following fruits are now being grown: Apples, 12 acres; peaches, 3½ acres; pears, 1½ acres; cherries, 1½ acres; plums, 1 acre; apricots, ½ acre; grapes, 1½ acres; miscellaneous fruits, 1 acre. There is enough of each kind to make it commercial.

Apples and peaches can be shipped in carload lots, while the other fruits are usually shipped, either with other growers or by express. The local market has been fairly good. The work of changing the farm from one-line production to many was necessarily slow, since we could not destroy the only source of income by removing the old trees. Over half of the apple trees were of unprofitable varieties and these were top-worked to more desirable kinds. The old trees were planted only 15 feet apart in the rows and half of the trees were pulled out. It was all done gradually and we suffered little in the quantitative reduction by gaining in quality. The top-grafted old trees bore their first crop last year and from now on we should just about double our production on the farm.

In spite of all this work, the farm has been paying and the main reason for this has been the quality of the fruit grown. The fruit growers in Delta County have taken a great interest in the farm and are frequent visitors. We believe we have demonstrated that we can grow fruit and this is, after all, what the growers want and expect.

Avon Farm

We wish to briefly outline our program at Avon, in order that the administration and the board may have a better or fuller knowledge of this important work. When this farm was purchased it was the intention to use it as a mountain vegetable demonstration farm

and to carry on certain experimental projects connected with the growing of vegetables. While these objects as stated still remain, our work, time and experience have shown us that vegetable production in the mountain sections of our state cannot be divorced from general crop production and livestock if it is to be permanent and profitable. Exclusive vegetable growing in the mountains is at best of short duration, for the reason that only a few kinds of crops can be grown due to climatic limitation and hence crop rotation cannot be practiced, nor can the fertility of the land be maintained. A general statement of the situation as we see it would read as follows:

Vegetable growing in our mountain sections should be carried on in connection with a well-organized system of general farming and livestock production. Vegetables should be included as a definite part in the system of crop rotation. It would be the cash crop. It would provide seasonable work for the help. The part and importance of vegetable growing in the general crop rotation should depend upon the farmer and his ability of handling the work. The livestock part of the program should be fully developed and include such kinds as can be carried. This would in many cases call for not only cattle, but sheep and, to a limited extent, hogs and poultry. The mountain sections as a whole are adapted to diversified agriculture including livestock. The crying need today is for more sources of income or crop diversification. The present condition in agriculture is due to over-specialization, resulting in over production of the stable crops.

With this in mind we have started a general program for operating the farm apart from the experimental projects: An 8-year crop rotation system has been adopted as follows: Potatoes first year after alfalfa, peas the second year, vegetables (lettuce, cauliflower, spinach, beans, etc.) the third year, grain seeded to alfalfa the fourth year, and the fifth, sixth, seventh and eighth years to alfalfa. Manure to be applied to grain and alfalfa fields. On the livestock side, we want to keep as many head and kinds as the farm can support. No grain, hay, straw or by-products are to be sold, but fed on the farm. On the other hand, no feed of any kind should be purchased. The farm should be self-sustaining or self-supporting in this respect.

The kind of livestock to be carried may well be a question of difference. However, we believe that we should raise our own stock, first to insure the right quality, second to make the farm independent from buying every year, and the uncertainty of obtaining the stock and kind wanted. Our aim is to have a fairly definite number to market every year, instead of a yearly investment.

In connection with the livestock program, we wish to make a confession. For several years past we have studied and dreamed about mountain farming in connection with the Avon farm and after some

experience and study we have reached certain conclusions, but knowing the impossibility of putting over a complete program at once because of lack of funds, we have been following the installment method of asking for a few things at a time.

Our confession is, that we hope to obtain permission to add 200 sheep and some brood sows to our livestock program. This expansion need not entail the expenditure of much money as we can build up in number after getting a foundation stock. Our desire is to develop a model farm and to demonstrate what can be done and what we mean when we preach diversified farming. We believe that it will be worth all that we can put into it and we hope you will agree with us. The experimental work should not suffer; in fact, we should be able to do this work under more favorable conditions.

State Horticulturist

The data for the year are not as yet available, and only a general statement can be made at this time. The peach crop was a total failure due to heavy spring freezes. The apple crop was normal and for what has been sold good prices were obtained.

The new cottage was completed at a cost of \$2400.00, representing the profit of the last year. Mr. Green, in charge of the work on the Western Slope, had a busy season traveling over this large territory and giving help to the fruit growers. The orchard at Austin has had a signal influence on the growers and the industry. The growers are convinced that our institution knows how to operate a fruit farm and they constantly come to the farm to see how things are done and to ask for advice.

During the winter months growers' meetings are held all over the slope where their problems are discussed and where demonstrations in pruning and propagation are given.

During the packing season, demonstrations in packing and grading are held at different packing houses.

We have demonstrated that Colorado apples, properly grown, graded and packed, can compete successfully in the open markets. For 2 years in succession we have shipped a carload to the auction market in Chicago and have topped the market both times against the Northwest. This was done to show the growers that selling of the fruit is half accomplished if the grading and packing is properly done.

Each spring at the farm a demonstration is held to teach the growers how to make various spray mixtures at half the cost of the ready-made mixtures on the market. Instruction is also given on the washing and drying of the fruit to remove the arsenical residue. Many valuable data on fruit growing have been accumulated and these will be embodied in a general report of the state horticulturist.

The past season was on the whole a very favorable one for our work and progress was made on all projects. Particular attention was given to the bean and onion work with special reference to seed production in connection with the seed-certification program.

The report on work with small fruits is prepared by Richard V. Lott, horticultural assistant, as follows :

Small Fruits

1. **Varietal Trials of Red, Black and Purple Raspberries, Strawberries, Currants, Gooseberries and Grapes.**—In this work the standard varieties and all of the promising new varieties that can be obtained are used. At the present time there are growing on the station grounds, 18 varieties of red raspberry, 6 varieties of the black raspberry, 2 varieties of the purple raspberry, 5 varieties of the ever-bearing strawberry, 24 varieties of the June-bearing strawberry, 4 gooseberry varieties, 4 currant varieties and 12 grape varieties. There are also 25 plants of the Youngberry. New and promising varieties of each of these fruits will be added as they become available.

“The varieties of raspberries and strawberries that have given best results at Fort Collins are also being grown at the High-altitude Station at Avon. These trials have not been conducted long enough at either station to make definite recommendations.

“2. **Fruiting Habit of the Red Raspberry.**—Since the methods of pruning and training red raspberries vary widely in different sections of the state, this investigation was started in 1929 to determine the normal fruiting habit and the fruiting habit under different systems of training and pruning. The data that have been secured indicate that the most efficient method of pruning the Cuthbert red raspberry under the hill system of culture is thinning to 8 canes per hill and removing 12 to 15 inches from the tip of the cane. The data also indicate that the hedgerow system of training is preferable to the hill system, since the yield per cane was found to be inversely proportional to the number of canes per hill. It was found that in the Cuthbert red raspberry the yield per cane and weight per berry were significantly greater from canes of large diameter than from those of small diameter. This investigation will be continued using more varieties and also black raspberry varieties.

“3. **Time of Uncovering Red Raspberries.**—It has been found that the most desirable time for uncovering red raspberries in those sections where winter covering is necessary, is just before the buds start to push out into fruit spurs or vegetative shoots. Canes uncovered at this stage in both the seasons of 1928 and 1929 were subjected to near zero temperature without apparent injury to the fruit buds. When canes are uncovered after the buds have pushed out

shoots $\frac{1}{2}$ inch or more in length there is often severe injury to these shoots from sudden drops in temperature, bright sunshine, or wind or all of these factors working together.

“4. Grape Training.—It has been found that the high renewal system of training to a 3-wire trellis is most desirable in these sections where winter protection is necessary. Under this system the canes can be easily laid down and taken up and the developing fruit gets the maximum amount of sunlight and air. Good light and air conditions are essential in the short growing season that prevails in many parts of Colorado.”

The report on work with sweet corn by A. M. Binkley is as follows:

Sweet-Corn Improvement Work for Canning-Factory Varieties

“During the past few years there has been considerable increase in the acreage of sweet corn being grown for the canning factories. The quality of the corn being grown has not been up to the standards set for eastern producing sections and the yields have been deteriorating quite rapidly. This has been more especially true in the late varieties rather than with the mid-season varieties.

“In cooperation with the Kuner-Empson Canning Company, the work of improvement was started this year by selecting good strains of canning varieties of sweet corn for this state. There are two main varieties now being grown for canning—the Crosby Early and the Country Gentleman variety. The Crosby Early is probably the most popular of the canning varieties and it requires around 76 days to properly mature for canning in this state. The grains are medium sized, deep and very high in quality. The Country Gentleman is the leading late variety, requiring around 96 days to mature, and it produces small, fine grains which are very attractive when canned. They are small, slender and are packed so tight on the ear that when shelled they have the appearance of shoe pegs. The quality is as a rule very good in this variety.

“The problems of production have been such that the Kuner-Empson people have not been able to secure seed of high-yielding strains of these two varieties for their acreage in this state. Their particular problem with the Crosby Early variety was that the strain they were using had picked up a reddish blotch in the kernel which made it undesirable for canning. In accordance, we were furnished with samples of this variety and during the past growing season we have made selections for high yields, quality and freedom from the undesirable red blotch in the kernel.

Most of their trouble in securing good seed has come up in the Country Gentleman variety. They have found that the kernels, as produced in this state, will lose their peg-shaped type after growing one season under our climatic conditions. Instead of producing the same peg-shaped kernel, the kernels revert to a narrow, wide, flat type which is undesirable from the canning standpoint. It appears that in marketing the canned product the flat kernels are discounted on quality.

“The second problem with this variety is that the strains they have been using mature 10 to 15 days too late to secure the prime quality for canning. The third problem connected with the matter of selecting the best strains is that of barrenness. It appears now that the seed furnished to growers by the canning company is very high in the percentage of barrenness. In accordance, a strain test was conducted on the better strains of the Country Gentleman, furnished by commercial seed companies, and strains that were selected by the canning company men in the Brighton district. An improvement program was laid out which was planned for the purpose of selecting an early maturing variety, one which maintained its peg-shaped kernel and one which produced a small percentage of barren stocks.

“The results of this year’s work have produced some very promising selections of pure-line individuals. The plan this past season was to select self-pollinated or pure-line individual plants and the process of stabilizing the desired characteristics started. After such plants have been inbred for two or three generations, it is planned to cross-breed such selections. Self-pollinated individuals as a rule lose vigor, are slightly reduced in size, and are low in yielding ability. Therefore, it is thought by crossing the inbred or pure-line strains that the vigor and yielding power can be brought back into the plants.

“The following table shows that the quality of the seed corn being used by the canning factories is very low and that there is considerable need for improvement by careful methods of selection. It will be noted that the percentage of barren stocks varies widely in different strains. This factor is of considerable importance to the growers of canning-factory sweet corn, as the yields are reduced from 33 to 66 percent per acre, due entirely to barren stocks in the field.

“From a study of the foregoing table it will be observed that there is a wide range in the days required to mature and the percentage of barren stocks. The seed that has been selected in this state shows a much smaller percentage of barren stocks in comparison with that from the middle western part of the United States. However, in all cases the time required to properly mature the corn for the canning factory is from 11 to 14 days longer than the standard

time required for the variety. The earliest maturing corn is the No. 2 strain of the E. B. Clark Seed Company, which matured in 98 days. However, the percentage of barren stocks was around 44 percent which makes it undesirable for use in this state.

CANNING-FACTORY SWEET CORN STRAIN TEST
COUNTRY GENTLEMAN VARIETY

Strain	No. of Hills	No. of Stalks	No. of Barren Stalks	Days to Mature	Percentage Barren
E. B. Clark Seed Co. No. 1	44	71	35	102	49
E. B. Clark No. 2	83	159	76	98	44
Hoopston Seed Co.	44	75	40	105	53
Home Grown No. 1 Brighton	88	194	73	103	37
Home Grown No. 2 Brighton	88	200	66	100	33

Time of maturity based on the number of days between date of planting and the date the ears were in full silk stage.

The most desirable strain from the home-grown viewpoint is the No. 2 selection of the seed grown at Brighton, Colorado. The percentage barren stocks amounted to 33 percent which is approximately 40 percent lower than the average of the seed secured from the commercial seed companies. There has been some progress made on early maturity. However, the strain is not quite high enough as far as quality is concerned. The table does not include the shape or character of the ear or the quality of the kernel, all of which must be considered in the selection of a desirable seed form.

“The results show conclusively that the quality of seed corn being used is very low and emphasizes the active need for seed-selection work. Unless this is taken care of it will be impossible for the canning companies to compete with the canned corn on the market as grown in the mid-western states.”

The report on the work with horticultural seeds by Mr. Binkley is as follows:

Progress Report on Certification of Horticultural Seeds

The horticultural seed situation within the state and in the southern states is very unsatisfactory and has occasioned heavy losses to

growers. During the past growing season there have been many complete crop failures reported on a good many of the vegetable crops. A good percentage of these losses were reported principally on snap beans, due to the use of ordinary seed sold by seed companies which in many cases carried seed-borne diseases. The losses on pod pea and onion yields can also be largely attributed to the purchase and planting of poor seed.

Besides the losses experienced by growers in this state, there have also been many failures reported on such crops by vegetable growers in the southern and eastern states. During the past growing season there have been requests for high-grade snap-bean seed which requests ran up as high as 600,000 pounds of good seed. In addition there has been an active demand in the East for several thousand pounds of certified onion seed. Also, there have been requests for carefully selected cucumber and cantaloupe seeds.

In consideration of the above demands, it can be readily seen that there is an urgent call for certified seed for interstate trade. These states recognize the fact that Colorado is favorably located so far as soil, climate and elevation are concerned, to produce the highest-grade seeds obtainable. It can also be observed that from the unsatisfactory reports and the demand for good seed, the seed companies are not furnishing the growers with the quality seed they demand.

The problems confronted in the production of certified horticultural seeds differ considerably from those common to the growing of field crops. In the first place, the intensive cultural requirements of horticultural crops are such that they are grown on high-priced land and the production costs per acre are usually high. Furthermore, profitable crop requirements in horticulture call for high standards of earliness, uniformity and quality, coupled with high quantity production per acre.

In considering all the factors which enter into the profitable production of intensively grown crops, the seed planted is of the greatest importance. It is fundamentally important to know the yielding ability of varieties, their disease resistance, the uniformity in quality and the other factors which ultimately determine the market value of the crop. Therefore, in looking and planning ahead, the horticultural department has recognized these factors and their importance in producing a profitable crop. Recognizing the limiting factors in production as being more or less of a hereditary nature and seed borne, the certification plans were based on extensive variety trials.

In accordance, a pea-variety trial was started 3 years ago which contained something over 650 varieties of peas collected from all over

the world, for the purpose of standardizing and eliminating varieties which were unadapted to conditions within this state. As a result of this variety trial, we now have very superior strains of the Dwarf Telephone variety which are now being certified. During the past growing season, around 13,000 pounds of pod-pea seed were officially certified. In addition to seed certification, the department has been increasing foundation stocks of several of the varieties which have proved to be especially desirable for planting by the canning factories and the market growers. These foundation stocks have been increased so that the coming year more certification will be conducted on pod peas.

On snap-bean seed during the past growing season an extensive variety trial was conducted which contained all of the principal snap-bean varieties now being grown in this country and in Europe. The purpose of this trial is to study the different varieties observed and performance under our conditions and eventually select the most desirable ones for use in the state. Since the main difficulty in the production of snap beans comes from the transmission of three seed-borne diseases, it is essentially important that very careful attention be given to roguing and the selection of individual plants to eliminate the disease hazard. The department has been carrying on a selection and roguing of the Giant Stringless and Stringless Refugee for the past 3 years, and these 2 stocks are practically free from disease and are the increase from high-yielding individuals. During the past year there were around 40,000 pounds of late Stringless Refugee seed certified for use in this state. Of the Giant Stringless there were around 40,000 pounds certified from the original selected for interstate trade.

From the experimental side during the growing season of 1928, individual plant selections were made of the following varieties:

Burpee's Stringless Greenpod	Bountiful
Late Refugee	Refugee 1000 to 1

In addition to this, mass selections were made, both on the Littleton sub-station and at Fort Collins, from carefully rogued strains of

Black Valentines	Currie's Rust Proof
Full Measure	Davis White Wax

In summarizing the amount of bean-seed stock on hand at the present time for next season's work:

Increase in Foundation Stock—1929

Variety	Avon	Amount Grown Fort Collins	Western Slope
Davis White Wax	200 lbs.	100 lbs.	300 lbs.
Currie's Rust Proof	100	200	300
Burpee's Stringless Greenpod	1000	.....	.....
Bountiful	.....	24	.....
		(2 strains)	
Late Stringless Refugee	300	100	400
Early Refugee	1000	100	.....
Black Valentine	Discard	150	.....
Giant Stringless	100	40	.....
Full Measure	.....	125	.....

The above list is from foundation stock increase and represents disease-free stocks. During the coming season it will be necessary to increase these selections on a mass scale in order to produce sufficient seed for distribution.

In carrying on the certification of horticultural crops it is the policy of this department to carry on a test plot of each strain of seed certified by the department. This policy is now being followed in connection with the certification of seed potatoes, and every grower is required to send a sample to the high-altitude farm for observation and study. This practice will also be followed in certifying vegetable seeds. It is very important. For example, the tendency is for snap-bean seed to pick up disease and run to flat pods. There are three seed-borne diseases which must be carefully checked before the seed can be certified. This can be partly accomplished by careful records taken during the germination and purity test by the state seed analyst and a further check will be had when the seed is planted in the test plots after it is certified.

At the present time there has been no onion seed certified because of the small acreage now being grown in the state. As with the other two above-mentioned crops, an onion variety trial has been started for the purpose of establishing a set type for each variety. After these varieties have been standardized, such seed as meets the requirements of the state horticulturist's office will be certified.

On vine-seed crops there is an active demand for certification, but due to the lack of standardization and confusion among seed-growers and the large number of varieties, no intensive certification program has been outlined. There has been a small quantity of cantaloupe seed of one established variety certified during the past season.

Estimated Amount of Certified Seed—1929

Pea Seed

Variety	Pounds of Seed Certified
Dwarf Telephone	1500
	(14,000 rejected)

Snap-bean Seed

Variety	Pounds of Seed Certified
Stringless Refugee (Canning Type)	43,000 lbs.
Giant Stringless (Fresh Market Type)	40,000 lbs.
	<hr/>
Total	83,000 lbs.

Cantaloupe Seed

Greeley Wonder	250 lbs.
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The report on the work with onions was prepared by Earl J. Allen, and is as follows:

Report of the Work at the Rocky Ford Station—1929

1. **Onion Variety Trials.**—Yields were low in the variety trials, as was the case with all the onion yields, but very good comparative results were secured. The Valencia onion was first in tonnage produced, with the Denia and Gibraltar next in order. The Mountain Danvers gave the lowest yield. Detailed information resulting from these trials will be found in the accompanying tables.

2. **Onion Strain Tests.**—The strain tests gave some interesting results, showing marked difference in yield and demonstrating the value of a good source of seed. This information is also presented in tabular form.

3. **Transplants and Field-Sown Onions.**—In this project, an acre of each type of onions was grown. Exact costs of production, including harvesting, were kept on each plot. The cost of producing the acre of field-sown onions was \$108.93. That of the transplants was \$176.86. The yield for each acre plot was 426 crates. However, due to the variation in the amount each crate held, the exact yield for the plots will not be determined until the onions are sacked and weighed when sold.

4. **Storage of Onions.**—At the present time, several experiments are being carried on in regard to storage of onions. The results from this work will not be available until the storage season is over.

The projects being carried on are as follows:

1. A comparison is being made of onions kept in the experimental compartment, having added ventilation by means of bottom ventilators, as to onions kept in the check compartment, wherein ventilation is supplied with windows and doors only. Twenty-five crate lots of onions are being used in this experiment and loss in moisture and from rot will be determined.

2. Two crates of onions were topped very close to the bulb. Two crates were topped leaving a top length of 1 to 1½ inches. Rot and moisture losses are being determined.

3. Ten crates of cull onions, 10 crates of graded onions and 10 crates of field-run onions are being kept under similar conditions. Losses from rot and moisture are being recorded. The possibility of cull and rotten onions in field-run bulbs being a factor in causing loss in storage will be studied and the value of grading onions before storing considered.

4. Ten crates of onions were cured under canvas. These are being compared in keeping quality with 10 crates cured in the open.

5. In the field-curing project, 5 crate lots were used. In curing, the length of time the onions were cured in the field ranged from 1 to 21 days. The object of this experiment is to determine the length of time onions should be cured in the field, and whether or not thorough drying-out will improve their keeping qualities.

6. Fifty crates of the transplanted onions are being compared as to keeping qualities with 50 crates of field-sown onions.

7. Records are being kept on the onion varieties and strains in order to compare their keeping qualities.

8. The effect of freezing upon the keeping quality of onions in storage is being studied.

Cantaloupes.—Approximately 1 acre of the land was planted to cantaloupes for seed production. The vines were slow in getting started but were coming along nicely until the first part of September, when the entire patch became infected with rust, the vines going down at once. It was decided that the melons were too immature to harvest for seed and the project was abandoned.

ONION-VARIETY TRIALS

Stake No.	Variety	Yield Per Plot	Yield of U. S. No. 1				Yield of Culls	Yields per Acre			
			Large	Med.	Small	Ex. Lg.		Total	U. S. No. 1	Culls	Total
7	Ohio Yellow Globe	199	39.5	88.5	29.5		157.5	41.5	4899.82	1291.06	6189.89
8	Yellow Globe	220	106.5	70.5	16.5		193.5	26.5	6099.79	824.41	6844.2
9	Gibraltar	398	230.	84.5	19.5		334.	64.	10390.74	1991.04	12381.78
10	Denia	448.5	320.	75.5	21.		416.5	32.	12917.31	995.52	13912.83
11	Australian Brown	180	21.5	69.5	54.5		145.5	34.5	4526.61	1073.19	5599.8
12	Prizetaker	86	34.	29.	9.5		72.5	13.5	2255.48	419.98	2675.46
13	Arizona Str. Valencia	539.5	390.5	50.	5.		445.5	94.	13859.5	2924.34	16783.84
14	Aggeler-Musser Valencia	568	419.5	54.	8.5		482	86	14795.02	2675.46	17470.48
15	Yellow Globe Danvers	195.5	54.5	87.	24.		165.5	30.	5148.7	933.3	6082.
16	Mountain Danvers	134.5	56.5	50.5	18.		125.	9.5	3888.75	295.54	4184.29
17	Ailsa Craig	176	102.	25.5	4.		131.5	44.5	4090.97	1384.39	5475.36
18	Aggeler-Musser Valencia	482.5	391.5	33.5			425	57.5	13221.75	1788.82	15010.57
19	Yellow Globe Danvers	232	52.5	113.	27.5		193	39.	6004.23	1213.39	7217.52
20	Mountain Danver	128	59	49.5	12		120.5	7.5	3749.76	233.32	3981.08
21	Ailsa Craig	324	238	35.			273	51	8493.08	1586.61	10079.69
22	Ohio Yellow Globe	259.5	61	137	27		225	34.5	6999.75	1073.29	8073.04
23	Yellow Globe	259	132	89	15.5		236.5	22.5	7357.52	699.97	8057.49
24	Gibraltar	452	271	115.5	19.5		406	46.	12631.65	1730.06	14061.71
25	Denia	442.5	313	89.	17.		419	23.5	13035.09	731.08	13766.17
26	Australian Brown	140	29.5	67.	27.5		124	16.	3857.64	497.76	4355.4
27	Prizetaker	114.5	61.5	38	6.5		106	8.5	3297.56	264.43	3562.09
28	Arizona Str. Valencia	636.5	495.	52.			547	89.5	17017.14	2784.37	19801.51

AVERAGED RESULTS OF ONION-VARIETY TRIALS

Variety	Aver. Yield Per Plot	Yields Per Acre			Percentage Culls	Percentage U. S. No. 1	Percentage Stand	Corrected Yields Per Acre		
		U. S. No. 1	Culls	Total				U. S. No. 1	Culls	Total
Ariz. Valencia	588.	15438.32	2854.35	18292.67	15.63	84.37	38.16	40448.4	7478.39	47926.79
Aggeler Musser Valencia	525.2	14008.38	2232.14	16240.52	13.74	86.26	33.83	41909.53	6584.81	47909.53
Denia	445.5	13026.2	813.3	13839.5	5.87	94.13	40.83	31782.93	1984.45	33767.38
Gibraltar	425.	11511.19	1710.55	13221.74	12.93	87.07	44.66	25554.84	3797.42	29352.26
Ailsa Craig	250.	6292.02	1485.5	7777.52	18.95	81.05	23.16	27118.61	64025.	33521.11
Yellow Globe	239.5	6688.65	762.19	7450.84	10.22	89.78	32.5	30434.15	2339.92	22774.07
Ohio Yellow Globe	229.2	5949.48	1130.98	7131.46	15.85	84.15	42.5	14101.13	2657.8	16758.93
Yellow Globe										
Danvers	213.7	5576.46	1073.34	6649.76	16.14	83.86	40.83	19000.57	2887.28	17887.85
Prizetaker	200.5	2776.52	342.14	3118.66	10.97	89.03	15.5	17908.55	2206.8	20115.35
Australian Brown	160	4192.14	785.46	4977.6	15.77	84.23	37.16	11276.86	2112.88	13389.74
Mountain Danvers	131.2	3819.25	263.43	4082.68	6.45	93.55	22.33	17072.64	1177.53	18249.57

ONION-STRAIN TESTS (A SERIES)

Stake No.	Strain or Variety	Yield Per Plot Lbs.	Yield of U. S. No. 1				Yield of Culls	Yield Per Acre			
			Large	Med.	Small	Ex. Large		Total	U. S. No. 1	Culls	Total
29	Assoc. Seed Co.	434.	218.	20.		117	355.5	76.5	13956.93	3081.91	17038.84
30	Arizona Strain	463	300.5	39.5		44	384.	79	15075.84	3101.84	18177.38
31	Aggeler Musser	592	412.	55.		43.5	510.5	82	20142.23	3119.32	23261.55
32	Pieter Wheeler	576	418.5	42.		49.5	510	66	20022.60	2591.16	22613.76
33	Burrell's Strain	653	492.5	38.		79.5	611	42.	23987.86	1648.92	25636.78
34	Ryan Bros.	490	334.5	18.5		94.	447	43	17549.22	1688.18	19237.4
35	Rohnert's Strain	217.5	137.5	45.5			183.5	34.5	7244.58	1393.47	8638.05
36	C. C. Morse	667	514.5	43.5		59.5	617.5	49.5	24243.25	1943.37	26186.62
37	Barteldes Riverside Strain	545	386	67		15	468	77.	18373.68	3023.02	21396.7
38	Hort. Dept. Selection C. A. C.	410	281	42.5		18.5	342	68	13426.92	2669.68	16096.6
39	Gum Strain	341	243.5	27.		15.5	286	55	11228.56	2159.3	13387.86
40	Pieter-Wheeler	432.5	352.5	40.5		7.5	400.5	32	15723.63	1256.32	16979.95
41	Burrell's Strain	448	346	28.5		31.5	406	42	15939.56	1648.92	17588.48
42	Ryan Bros.	340.5	260	18.5		34.5	313	27.5	12288.38	1079.65	13368.03
43	Rohnert's Strain	206	118.5	49			167.5	38.5	6576.05	1511.51	8087.56
44	C. C. Morse	537.5	432	41		36.5	599.5	28	19902.77	1999.28	21102.05
45	Barteldes Riverside Strain	553	411.5	54.5		24.5	490.5	62.5	19257.03	2453.75	21710.78
46	Hort. Dept. Selection	261	180.5	26.5		10.5	217.5	43.5	8539.15	1707.71	10246.86
47	Gumm's Strain	275	189	28.5		15.	232.5	42.5	9027.95	1668.55	10696.5
48	Associated Seed Co.	246	174.5	11.5		28	214	32	8402.64	1255.32	9657.96
49	Arizona Strain	327.5	220.5	31.		15	296.5	61	10452.79	2394.86	12847.65
50	Aggeler-Musser	279.0	206.5	27.5		5.5	239.5	39.5	9407.77	1550.77	10958.54

AVERAGED RESULTS OF ONION-STRAIN TESTS

Valencia Strain	Av. Yield Per Plot (Ranked)	Yields Per Acre			Corrected Yield Per Acre					
		U. S. No. 1	Culls	Total	Culls	U. S. 1.	Stand	U. S. No. 1	Culls	Total
C. C. Morse	602.2	22073.01	1571.32	23644.33	6.64	93.36	47.16	46794.78	3331.19	50125.97
Burrell's Strain	555.5	19963.71	1648.92	21612.63	7.63	92.37	38.66	51501.37	4254.21	55760.58
Barteldes Riverside	549.	18815.35	2738.38	21553.74	12.7	87.30	49.5	38007.03	5531.52	43538.55
Pieter-Wheeler	504.2	18873.61	1923.24	19796.85	9.71	80.29	38.33	46571.39	5000.42	51571.81
Aggeler-Musser	435.7	14775.	2335.04	17110.04	13.64	86.36	38.83	37971.75	6001.05	43972.8
Ryan Bros.	415.2	14919.15	1383.56	16302.71	8.48	91.52	28.	58484.07	5422.55	63906.62
Associated Seed Co.	340	11179.78	2168.62	13348.4	16.24	83.76	37.5	29738.22	5768.52	35506.74
Arizona Strain	395.2	12764.31	2748.2	15512.51	17.71	82.25	35.83	40611.43	7667.47	48279.9
Hort. Dept. Selection	335.5	10983.03	2188.70	13171.73	16.61	83.39	31.33	35135.86	6981.95	42117.81
Gumm's Strain	308.	10128.3	1913.88	12042.18	15.89	84.11	21.66	46691.38	8822.98	55514.36
Rohnert Strain	211.7	6910.31	1452.49	8362.8	17.36	82.64	30.33	22734.93	4778.68	27513.61

TOTAL COST OF GROWING AND HARVESTING ONE ACRE OF FIELD-SOWN ONIONS

Planting	Irrigating	Cultivating	Furrowing Out	Hoeing	Pulling	Topping	Preparation of Land	Rent of Land	Total Cost
Mar. 18	Mar. 19	Apr. 26-2 hrs.	Mar. 19	May 27	Sept. 19	Sept. 26	\$4.16	\$50.00	
Man & Team	4 hrs. 40 min.	May 1-8 hrs.	Man & Mule	4 hrs.	4 hrs.	27, 28			
1 hr.	Apr. 2	23-6 hrs.	1 hr.	June 5	20-1 hr.	426 crates			
	4 hrs. 40 min.	31 Man & Mule 2½ hrs.	June 1	6 hrs.	1 hr. 30 min. @ 3c				
	May 20	June 4	Man & Mule	18-5 hrs.	20-10 hrs.				
	5 hrs.	1½ hrs.	1 hr.	July 5	40 min.				
	May 3	18-3½ hrs.	19-1 hr.	4 hrs.	21-1 hr.				
	5 hrs.	July 8	July 8	July 17					
	June 1	28-Man & Mule 2½ hrs.	Man & Mule	17-4 hrs.					
	5 hrs.	July 4	45 min.	30 min.					
	14-5 hrs.	Man & Mule	Aug. 2	Aug. 16					
	20-6 hrs.	2 hrs. 45 min.	1 hr.	1 hr.					
	July 11	23-2½ hrs.							
	5 hrs.	Aug. 13-2 hrs.							
	26-5 hrs.								
	Aug. 3								
	3 hrs.								
	17-3½ hrs.								
Team Hr. @ 40c 1 hr.		Single horse @ 20c 5 hrs.	Team Hrs. 45 min.	Man Hrs. 24 hrs.	Man Hrs. 17 hrs.				
Man Hr. @ 30c 1 hr.	Man Hrs. 51 hrs. 50 min.	45 min. Man Hrs. 33 hrs. 15 min.	Single Horse Hrs. 2 hrs. Man Hrs. 4 hrs. 45 min.	30 min.	10 min.				
\$0.70	\$15.55	\$11.12	\$2.12	\$7.35	\$5.15	\$12.78	\$4.16	\$50.00	\$108.93

TOTAL COST OF GROWING AND HARVESTING AN ACRE OF TRANSPLANTED ONIONS

Setting Out Plants	Irrigating	Cultivating	Furrowing Out	Hoeing	Pulling	Topping	Preparation of Land	Rent of Land	Total Cost
Apr. 17 66 hrs. 30 min.	Apr. 10-4 hrs. 13-8 hrs.	May 4-10 hrs. 23-6 hrs.	Apr. 10 Man & Team	June 5 7 hrs.	Sept. 17 4 hrs.	426 crates @ 3c	\$4.16	\$50.00	\$66.75 18.75
Apr. 18 59 hrs.	May 9-4 hrs. 13-4 hrs.	31-Man & Mule 2 hrs.	1 hr. June 1	18-3 hrs. 30 min.	19-2 hrs. 30 min.				11.60 2.32
Apr. 26 58 hrs.	21-3 hrs. June 1-5 hrs.	30 min. June 5	Man & Team 19-1 hr.	July 5 5 hrs.	20-10 hrs.				6.15 4.95
May 10 16 hrs.	3-5 hrs. 14-5 hrs.	1 hr. 30 min. 18-4 hrs.	July 8 Man & Team	19-4 hrs. Aug. 16					12.78 4.16
May 2 16 hrs.	20-7 hrs. July 10-5 hrs.	28-Man & Mule	45 min. Aug. 3-1 hr.	1 hr.					50.00
May 11 2 hrs.	26-4 hrs. Aug. 3-3 hrs.	2 hrs. 30 min. July 4							
May 13 5 hrs.	17-3 hrs. 30 min.	Man & Mule 2 hrs. 30 min.							
		July 25 2 hrs. 40 min.							
		Aug. 1 13-2 hrs.							
Man Hrs. @ 30c 222 hrs. 30 min.	Man Hrs. 60 hrs. 30 min.	Single Horse @ 20c 7 hrs. 30 min. Man Hrs. 33 hrs. 40 min.	Team Hrs. @ 40c 1 hr. 45 min. Single Horse 1 hr. Man Hrs. 4 hrs. 45 min.	Man 20 hrs. 30 min.	Man 16 hrs. 30 min.				
\$66.75	\$18.75	\$11.60	\$2.32	\$6.15	\$4.95	\$12.78	\$4.16	\$50.00	\$178.86

Broccoli.—Four rows, approximately 125 feet long, of this crop were set out. The plants seemed to do very well, but due to my unfamiliarity with the crop and to lack of knowledge as to how it was harvested, no yield records were taken. From the success that growers in the Pueblo district had with broccoli during the past year and from its seeming adaptiveness to the Rocky Ford district, it would be well to carry on further trials with this crop during the coming year.

Tobacco.—Plants of four varieties of tobacco, namely, Banner of Brazil, Leaf, White Burley, Havana and Cuban Shade, were sent down from Fort Collins. These were set out but a great number failed to live. Replants were obtained but an error was made in replanting which so hopelessly mixed the varieties that it was impossible to differentiate between them. The plants grew very well but the one hail of the season came during the second month of the summer and so badly riddled the leaves of the plants that the quality was ruined. This seemingly indicates that tobacco as a commercial crop would be too risky a proposition in a region subject to hails.

Cauliflower.—Two thousand plants of the Early Snowball variety were set out along with approximately 100 plants each of the Danish Perfection and Matchless Spring varieties. These plants did not do very well. Growth was slow. Harvesting commenced during the latter part of July. A total of 871 heads were cut; of this number 29.60 percent were good, 44.64 percent ricy, 21.92 percent leafy and 3.44 percent had thrown up seed stalks. The remainder of the crop was in such bad shape from attacks of grasshoppers and cabbage worms that harvesting was stopped.

Carrots.—Due to the increased interest in carrots as a commercial crop, a few varieties were tried out. These varieties were: The

YIELD OF CARROTS BY PLOTS

AVERAGE YIELD OF CARROTS

Plot No.	Variety	Yield Per Plot	Yield Per Acre		Variety	Yield Per Acre
51	Hutchinson	229.5	37,488.82	}	Hutchinson	31,404.19
52	Long Orange	125.5	20,500.42		Long Orange	20,401.37
53	Oxheart	282	46,064.7		Plots Oxheart	45,171.55
54	Chantenay Half-Long	133.5	21,807.22	} 160 ft. long	Chantenay	
55	Danver's Half-Long	127.5	20,827.12		Half-Long	20,588.05
56	New Coreless Nantes	24.5	4,002.07		Danver's	
57	Danver's Half-Long	290.	69,774.64	}	Half-Long	45,300.98
58	New Coreless Nantes	49.5	11,551.32		New Coreless	
59	Long Orange	87.	20,302.32		Plots Nantes	4,276.69
60	Hutchinson	108.5	25,319.56	} 112 ft. long		
61	Oxheart	190.	44,338.4			
62	Chantenay Half-Long	83.	18,368.88			

Hutchinson, Long Orange, Oxheart, Chantenay Half-Long, Danvers Half-Long and the New Coreless Nantes. The results obtained are presented in tabular form.

Respectfully submitted,
E. P. SANDSTEN, Horticulturist.

REPORT OF THE IRRIGATION ENGINEER

To the Director:

I wish to submit the following as a brief report concerning the work of this section during the past 12 months:

Pumping Project.—This project was started in 1928 and is supported by state funds. Resulting from the preliminary survey of the state, a brief report was prepared by W. E. Code, entitled, "Suggestions Concerning Small Irrigation Pumping Plants," which was published by the Experiment Station as bulletin 350, January, 1929. During the past summer season a detailed study was made in Weld County for the purpose of determining the relative costs of irrigation by pumping and that supplied as ditch or reservoir water. Thirteen individual farms were under consideration, where five were served by ditch and reservoir water, and eight served by pumping from wells and low-lying laterals.

This study also included the gathering of data relative to crop production, soils and other pertinent facts. During the past 2 years, data have been collected as to underground water-bearing areas in various parts of the state, and it is intended to ultimately prepare maps indicating the areas most probable for dependable underground water supplies.

Measurement of Water.—This project has been active for a number of years and was originally carried as an Adams project; later the work was supported by Hatch funds, and at present by both Hatch and state funds. Government funds have been used to support this project since its inception. Under this project has come the development of the improved Venturi flume, which at present is concerned with large-sized structures.

In December, 1928, a 40-foot reinforced concrete improved Venturi flume was completed on the Fort Lyon Canal near La Junta, the largest yet constructed. Since its completion a number of current-

meter check measurements of the rate of discharge have been made. These measurements appear to agree remarkably close to the computed value, where the computation is based on the law of flow set up at the time the structure was designed. Measurements made on the 20-foot reinforced-concrete improved Venturi flume on the Holbrook Canal near Rocky Ford, built October, 1927, show very close agreement with the law of discharge. For submerged-flow conditions on this Holbrook flume, tests indicate a marked consistency in the relation to the computed discharge. Because of the apparent reliability of these large flumes now operating under conditions which heretofore were entirely unsatisfactory, there is now contemplated the installation of several more large flumes of this type on the canals diverting from the Arkansas River between Pueblo and the Kansas state line.

Information has reached us from the Hawaiian Islands to the effect that a large number of the smaller-sized improved Venturi flumes and now in use in the measurement of irrigation water on several of the large sugar plantations. Communications from many foreign countries cite the use of this measuring devise.

At the hydraulic laboratories a new type of measuring device is being investigated called the adjustable tube meter which is intended for the measurement of relatively small flows, that is to say, less than 50 second-feet. The experimental model has a capacity of about 7 second-feet. This device possesses the following desirable characteristics: The ability to operate under excessive sand or silt conditions; measurement with small loss of head, or, in other words, in a channel of slight grade. It is so equipped that the rate of discharge can be determined by the simple multiplication of two indicated values. It is believed that when this new scheme is fully developed, it will be possible to successfully meet all conditions of measurement under irrigation practice. This adjustable tube meter will be particularly well suited to the distribution of the water supply to the farmer which will result in a more equitable apportionment, a greater satisfaction to the user, and a tendency to broaden or increase the beneficial use of the present water supply which is of inestimable value.

Instruments have been developed as accessories both to the improved Venturi flume and the adjustable tube meter. A double-head recording instrument has recently been perfected to be used in connection with the flume, especially the large sizes now in use in the Arkansas Valley. The instrument, as an accessory to the adjustable tube meter, indicates the square root of the difference or effective head, where this reading, multiplied by another indicated constant, gives the rate of discharge.

Some special work has been done at the Bellvue laboratory in connection with a study of the measured discharge by use of the current meter in comparison with this identical flow over a standard calibrated rectangular weir. This work is primarily to round out the previous current-meter study and incidentally to provide basic data for guidance in the current-meter measurements in the field on the discharge thru large improved Venturi flumes where the depth of water is comparatively shallow.

A few days were spent at the Bellvue laboratory during November in making some preliminary studies as to the recovery of head in an outlet transition section.

Evaporation from a Free Water Surface.—This project, carried cooperatively on government funds, and supported by Hatch and state funds, has been virtually completed. A detailed report covering this extensive study has been prepared by Carl Rohwer. This report includes the results of the laboratory work done here at Fort Collins, as well as studies made at various points thruout the West in the determination of the relation of altitude to the rate of evaporation. To complete the full range of altitude, Mr. Rohwer made observations at Imperial, California, at an elevation of 68 feet below sea level, and at the summit of Pikes Peak at an elevation of 14,109 feet above sea level. This report is to be published as a bulletin issued by the U. S. Department of Agriculture. Subsequent to the preparation of this report, a series of evaporation observations has been conducted, where the water surface was covered with a thin film of light oil.

In connection with this project, there has been conducted a minor study on the rate of evaporation from the surface of moist soils and sands, with water tables at 1, 6 and 12 inches below the evaporating surface. This last season the moist-soil equipment was altered so as to have the water table at 6, 12 and 18 inches below the surface, and instead of maintaining an exposed surface void of vegetation, there was provided a sod covering of blue grass and sedge or swamp grass, in duplicate in the tanks having the different water tables. Check tanks were maintained without crop.

Meteorology.—This has been a continuing project for many years and is supported wholly on state funds. R. E. Trimble, observer, who has had charge of this work for about 39 years, has prepared a report on the Climate of Colorado, published as Bulletin 340, Colorado Agricultural Experiment Station, December, 1928. This bulletin reports the averages for the past 41 years for Fort Collins, as well as for a period of years for other points in Colorado where cooperative weather stations are maintained.

Project Work for the Coming Year.—Projects which are to be given attention next year will be the continued study on the large improved Venturi flume, with the ultimate view of preparing and publishing a report covering the investigation of the larger sizes of this type of measuring device. This will be under the general project on measurement of water. Under this same project, it is expected that further work will be conducted on the subject of weirs, and at the conclusion of which a revision of the entire study on weirs will be prepared for publication. The matter of further extended research on the adjustable-tube meter is highly desirable, and it is the intention also at this time to test this device in the laboratory for discharges of 50 to 75 second-feet. This work is also under the project on measurement of water.

The project on pumping for irrigation and drainage will be continued. No definite plans as to a special field study for next year have been made, but because of all the necessary equipment available for such a study, it is believed to be highly desirable to continue at least one more year in the study of the relative costs of ditch and pumped water for irrigation. General observations on pumping and well data will be secured, also detailed information on the study of a well near Eaton which is expected to show results from the standpoint of pumping for drainage.

The work on the evaporation from moist soil surfaces will be continued, where sod grass is maintained as previously described. This work will be done under the project on evaporation.

Published Articles.—Only one article has been contributed for publication outside of the official bulletins, namely, Experiments to Determine Rate of Evaporation from Saturated Soils and River-bed Sands, by R. L. Parshall, appearing in the April, 1928, Proceedings of the American Society of Civil Engineers.

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

SECTION OF VETERINARY PATHOLOGY

To the Director:

Sheep Losses in Feedlots

Coccidial dysentery seems to be unusually prevalent this fall, we having been privileged to study six different outbreaks. While the disease has affected several hundred lambs, the mortality is comparatively small, especially when skillfully treated.

There were also an unusual number of cases of pneumonia giving us opportunity to extend our observations on the bacteriology of this condition.

We were able to find another outbreak of paratyphoid dysentery which is the first since the large epidemic we described in 1923. We have submitted a paper on this outbreak for publication. The history indicates that going without feed and long-distance shipping were large factors in the causation of the disease. The total loss out of 1600 lambs was only 30.

At the request of the U. S. Biological Survey we carried on a few experiments on the toxicology of thallium sulphate with sheep. A sheep weighing 83 pounds and receiving 14 grains of thallium sulphate mixed with oats died in 9 days. One weighing 103 pounds and receiving 7 grains of the poison, survived but lost most of its wool. In other animals the loss of hair is considered quite typical of thallium poisoning, but it was not known until now that the same result would be had with sheep. This work will shortly be offered for publication.

Death Losses in Lambs on Heavy Grain Feed

The work on the presence of spore-bearing pathogenic anaerobes in the spleens of sheep has been finished and accepted by the Journal of Infectious Diseases for publication. It shows that 66 organisms of this type were encountered in the spleens of 200 sheep. Of these 66, 58 were *C. edematis*; 6, *C. welchii* and 2, *C. novyi*. On the basis of the clinical diagnosis, it is apparent that these organisms have no relation to overeating nor any of the other clinical diseases in which they were found. The longer the animal has been dead the greater is the likelihood of one of them being isolated from the spleen, indicating that they are merely cadaver bacilli.

The examination of the urine of cases of overeating continues to reveal quantities of sugar in most instances.

Icterohematuria

The survey of this disease in the state made by Dr. Floyd Cross during the summer shows that it is most prevalent in the mountainous area of Jackson, Grand, Routt and Moffat counties, with single outbreaks occurring in sheep from Lake, San Miguel and Dolores. The survey shows that during the last 9 years the disease has not materially increased as we had presumed, but that it develops in proportion to the new sheep brought in and run under our mountainous condi-

tions. The high point was reached in 1927 when 614 animals were lost from this disease. Apparently the heaviest loss comes in the first winter after the animals have been ranged on our forest reserves. Following this the disease subsides until outside animals are again imported. The solution seems to be to raise our own breeding stock as far as possible.

Contagious Abortion

The college herd continues clean.

The range-management herd suffered a serious outbreak in February of this year, due, as we learned later, to neighboring cattle being allowed to water in the same lake with our range animals. By 30-day testing and sale, the herd now appears again to be clean.

The herd at Fort Lyon suffered three successive waves of re-infection in the course of approximately 2 years. This finally resulted in the infected herd being moved to an entirely different farm, since which time the clean portion has passed two tests without a reactor.

Abortion disease as transmitted to man going under the names of undulant or Malta fever, is receiving increasing attention. Two human cases have come under our observation, both of which gave positive agglutination tests and from one of which we were able to isolate the organism from the blood stream. The report of one of these cases has been published in "Colorado Medicine" in collaboration with Dr. J. D. Carey in whose practice the case occurred.

Coccidiosis in Cattle

We must again report no progress on this project thru lack of material and time of the workers.

General

Tabulation of our diagnostic work done in the laboratory follows:

Avian	693	Miscellaneous	423
Bovine	278	Ovine	63
Canine	97	Rodents	25
Equine	25	Suis	44
Baby chicks examined for white diarrhoea	151 lots		100 positive
Examinations for rabies	59		29 positive
Blood Tests			
Contagious Abortion (Bovine)	2992	705 positive	23.56 percent positive
Contagious Abortion (Swine)	40	6 positive	15.00 percent positive
White Diarrhoea	10704	1121 positive	10.47 percent positive

Respectfully submitted,

I. E. NEWSOM, Veterinary Pathologist.

REPORT OF THE VETERINARY SECTION

To the Director :

In the Veterinary Section there is but one project, that of animal diseases. This is a state fund project and as the name indicates, is a general project and does not contemplate prolonged field and laboratory investigations. Such work is carried on in the Section of Veterinary Pathology. We are cooperating by supplying material for both clinical and laboratory diagnosis and by field observations.

Diseases of livestock that were conspicuous a few years back are now relatively unimportant. New disease conditions are constantly appearing and must be met by adequate prophylactic and therapeutic measures. Malignant catarrhal fever has been quite prevalent but in most instances has appeared in a mild form. Among the newer diseases, or perhaps more appropriately, those which have more recently been recognized, are anemia in pigs, preparturient paralysis in ewes, coccidiosis in several species of farm animals, paratyphoid conditions, undulant fever associated with the abortion disease of cattle, and chronic progressive pneumonia of sheep.

The heavy losses of lambs in the feedlots appears to be caused both by over-feeding of concentrates and a variety of infections. No one infection stands out conspicuous in this respect. The vitality of animals and shipping conditions seem to constitute the key to shipping losses.

We wish to continue with the one project of animal diseases. Articles written for publication have been in connection with the editorial news service of the college, and for farm journals.

Respectfully submitted,

GEO. H. GLOVER, Veterinarian.

ENGINEERING DIVISION

To the Director :

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

Respectfully submitted,

L D CRAIN, Chairman and Vice-director.

REPORT OF THE CIVIL ENGINEER

To the Vice Director :

I submit herewith the annual report of the Civil Engineering Section of the Colorado Experiment Station.

The work of this section during 1929 may be summarized under three main divisions:

1. Research and experimentation.
2. Testing highway materials for use in state and federal-aid roads.
3. Cooperative testing and investigation of materials and processes which are to be used in actual highway construction and the use of information so gained as a basis for conclusions in connection with Experiment Station projects.

I. The work under research and experimentation has been confined to one project, the heaving of concrete slabs, which was started in the winter of 1927-28 under the supervision of D. J. Tripp. Before his resignation on September 1 of this year, Mr. Tripp tabulated all the data which had been collected on the experiment up to August 1, 1929. From this data he plotted curves of slab movements, soil temperatures and soil-moisture conditions and wrote a progress report of the entire project from its start up to August 1, 1929.

It is our opinion that sufficient data have not yet been collected to form a basis for any definite conclusions as to the effect of sub-soil heaving on concrete slabs. It is, therefore, thought advisable to continue the observations thru another winter and summer and at the same time, to make some observations on slabs of pavement in actual service to supplement those on the test slabs. I have consulted Mr. Maloney, assistant engineer of the State Highway Department, and have his sanction on my proposal to place plugs and reference bench marks in the pavement for the purpose of making these supplementary observations. The data up to the present time show a very small and an irregular movement in the slabs. If future data are the same we shall get little out of this experiment.

Nothing has been done on the project recently outlined and submitted by Mr. Tripp on light asphaltic road surfaces. A similar experiment has been outlined by the Bureau of Public Roads to be worked out this coming season somewhere in the West and my first thought on learning of this, was that we should drop this project in order to avoid duplication of work. However, after talking with

Mr. Maloney and with Mr. Williamson of the Bureau of Public Roads, I find that the bureau's project may be carried out in New Mexico or even as far away as California, which would mean that results obtained would not apply to conditions in Colorado. In that case, I believe we should plan to carry out the experiment next summer. Mr. Maloney expressed the belief that the State Highway Department would be willing to construct the road which would consist of about 10 miles of experimental sections $\frac{1}{2}$ to $\frac{3}{4}$ miles each in length, as a part of the 1930 improvement program, the specifications for each section to be written jointly by the testing engineer at this institution and the highway engineers, and all data and observations to be taken by the testing engineer of this institution.

It is my opinion that the 1 year suggested by Mr. Tripp in his outline of the project would be inadequate to allow us to observe the wearing qualities and maintenance costs on such a road and I would suggest that at least 3 years be taken in which to make observations before we draw our final conclusions. It is true that much will be learned in the first winter after the road is built and this knowledge will be immediately available as a tentative guide in building future roads, but I feel that our final conclusions should be based on more mature observation.

II. Testing materials, concrete cylinders and pavement cores for the State Highway Department has composed a large part of the laboratory work during the past year. A total of 1755 samples and test specimens has already been tested since January 1, 1929 and this total will reach approximately 1900 by December 31. Of the specimens handled up to date, 1476 were concrete cylinders from new pavement and structural work; 130 were subsoil samples; 30 were surfacing material for oil treatment; 6 were surfacing aggregates not to be treated; 64 were road oils; 44 were concrete core samples of old pavement and 5 were asphalt.

We now have on hand 163 cores; 621 soils and 15 oil samples which we shall work on this winter while road work is quiet. It will take all our laboratory force all winter to do this work.

III. Under the heading of cooperative testing, some work was done during the year on oil mixtures and also on subsoils. It is my understanding that samples of road oil were sent in for tests by the highway department and that while these tests were being run, mixtures were made of the oils and the mixtures were also tested with the idea of arriving at a method of controlling the product to be used by blending or mixing oils having varying properties.

Samples of subsoil sent in by the highway department were tested for stability as pavement foundation and the data obtained in addition

to being reported for the information of the Highway Department were preserved and used as a basis for conclusions in connection with our own subsoil studies for the Experiment Station.

Since taking over the work of testing engineer on October 1, 1929, Mr. Carpenter has found it necessary to make rather extensive repairs on much of the equipment in the laboratory and he now has in mind several improvements which, while not expensive, will greatly improve the appearance of the laboratory and expedite the work therein.

Respectfully submitted,

E. B. HOUSE, Civil Engineer.

Approved: L D CRAIN, Vice-director.

REPORT OF THE MECHANICAL ENGINEER

To the Vice-director of the Experiment Station:

Following is the annual report of the Mechanical Engineering Division of the Experiment Station of the Colorado Agricultural College.

During the past year, this section has devoted its time to the following projects: Proximate analysis of Colorado coals, ventilation of new library, drying potatoes for stock feed, and gasoline economy in automobile engines.

Project No. 1 was completed during the year. Samples of the commercial coals in northern fields of Colorado, North Park, and Southern Wyoming were tested for moisture, volatile matter, ash, fixed carbon, and B. T. U. content. Results of these tests are kept on file for use in determining the particular coal to buy for a given purpose.

Project No. 2 was an investigation to determine the reason why the ventilating system of our new library did not give the required results. This investigation demonstrated that the system was not properly installed. Corrections were made so the system would work perfectly.

Project No. 3 was an investigation of the commercial value of drying potatoes for stock feed. Such food has been used to a limited extent, but our investigation demonstrated the doubtful commercial value of a plant to operate on a large scale. The price of potatoes

usually would prohibit their use in the manner considered. The cost of drying, also, would make this feed too expensive.

Project No. 4.—The work on this project consisted of assembling the apparatus for the tests. This assembling has been only partially completed.

In addition to the above projects, many samples of lubricating oils have been tested for various persons.

In June, 1929, Charles A. Logan, the assistant in charge of our research work in this department, resigned, the resignation to become effective September 1, 1929. A successor to Mr. Logan has not yet been appointed. For this reason research work in the department has been suspended pending the selection of a new worker.

Respectfully submitted,
L D CRAIN, Mechanical Engineer.

REPORT OF THE EDITOR

To the Director :

Practically the same amount of editorial work has been done for the Experiment Station this year as last. Seventeen bulletins, 4 press bulletins and the annual report, totaling 756 pages have been handled, as compared with 752 pages in 1928.

Fully 30 percent of the 647 stories sent out in our mimeographed news service have been from station workers or about station work.

We have cooperated with workers in charge of farmers' day at Avon, the farmers' day at Akron, and both feeders' days on the campus, in getting suitable announcements and information to the farmers and feeders.

Following are the publications issued during the past year :

Experiment Station Publications

- Bul. 335—Range Resources of The San Luis Valley.
62 pages. 3,000 copies.
- Bul. 338—Financing the Western Cattleman.
88 pages. 2,000 copies.
- Bul. 340—The Climate of Colorado.
68 pages. 2,000 copies.

- Bul. 341—Ants and Their Relation to Aphids.
96 pages. 1,700 copies.
- Bul. 344—The Principles of Bread-making.
38 pages. 4,000 copies.
- Bul. 345—The Australian Saltbush.
28 pages. 1,200 copies.
- Bul. 346—Farm Taxation in Colorado.
48 pages. 3,000 copies.
- Bul. 347—Use of Carbon Disulfide for the Eradication of Perennial Weeds. 24 pages. 3,000 copies.
- Bul. 348—Canada Thistle and Russian Knapweed and Their Control.
44 pages. 3,000 copies.
- Bul. 349—Effect of Lumnite Cement and Plaster Paris Caps on the Strength of Concrete Test Cylinders. 16 pages. 1,500 copies.
- Bul. 350—Suggestions for Small Irrigation Pumping Plants.
24 pages. 7,000 copies.
- Bul. 351—Some Common Diseases of Ornamental Plants.
28 pages. 3,000 copies.
- Bul. 352—Sulphide Sulphur Content of Sprays.
12 pages. 2,500 copies.
- Bul. 353—Factors Influencing Cost of Production.
72 pages. 2,500 copies.
- Bul. 355—Outline of Colorado Tax Laws.
20 pages. 3,000 copies.
- Bul. 356—Improvement of Sagebrush Range in Colorado.
12 pages. 2,000 copies.
- Press Bul. 67—A New Smooth-awned Barley for Irrigated Conditions in Northeastern Colorado. 4 pages. 3,000 copies.
- Press Bul. 68—Progress Report of Livestock Feeding Experiment, 1929. 8 pages. 2,000 copies.
- Press Bul. 69—Progress Report. Fattening Rations for Pigs.
8 pages. 2,500 copies.
- Press Bul. 70—Summary of 1928 and 1929 Tests. Fattening Rations for Calves. 8 pages. 2,500 copies.
- Forty-first Annual Report. 48 pages. 1,500 copies.
- Cattle Feeders' Day Programs (Tenth Annual). 8,000 copies.

Respectfully submitted,

I. G. KINGHORN, Editor.



