

Letter of Transmittal

Fiftieth Annual Report
Colorado Experiment Station

HON. TELLER AMMONS

Governor of Colorado:

In compliance with the law, I herewith present the Fiftieth Annual Report of the Colorado Agricultural Experiment Station for the fiscal year of July 1, 1936 to June 30, 1937, inclusive.

A handwritten signature in cursive script, reading "E. P. Sandstee". The signature is written in dark ink and is positioned above the printed name and title.

Director.

Fort Collins, Colo.

July 1, 1937

COLORADO STATE COLLEGE

FORT COLLINS, COLORADO

State Board of Agriculture

H. B. DYE, President.....	Manzanola	MRS. MARY H. ISHAM.....	Brighton
J. W. GOSS, Vice-President.....	Pueblo	ROBERT F. ROCKWELL.....	Paonia
THOMAS J. WARREN.....	Fort Collins	JOHN J. DOWNEY.....	Cortez
O. E. WEBB.....	Milliken	J. P. MCKELVEY.....	La Jara

Ex-Officio { GOVERNOR TELLER AMMONS
PRESIDENT CHARLES A. LORY

OFFICERS OF EXPERIMENT STATION

CHARLES A. LORY, M.S., LL.D., D.Sc.....	President
E. P. SANDSTEN, Ph.D.....	Director
L. M. TAYLOR.....	Secretary
ANNA T. BAKER.....	Executive Clerk

EXPERIMENT STATION STAFF

Agronomy

Alvin Kezer, A.M., Chief Agronomist
David W. Robertson, Ph.D., Associate
Robert Gardner, M.S., Associate (Soils)
Warren H. Leonard, M.S., Associate
Dwight Koonce, M.S., Assistant
Robert Whitney, B.S., Assistant (Soils)
Otto Coleman, M.S., Assistant
L. A. Brown, Ph.D., Associate
Ralph Weihing, Ph.D., Assistant

Animal Investigations

George E. Morton, M.S., in Charge
H. B. Osland, M.S., Associate
John O. Toliver, M.S., Assistant
R. C. Tom, M.S., Assistant

Botany

L. W. Durrell, Ph.D., in Charge
Bruce J. Thornton, M.S., Associate
E. W. Bodine, M.S., Assistant
A. O. Simonds, Ph.D., Assistant
C. G. Barr, Ph.D., Assistant
W. A. Kreutzer, M.S., Assistant

Chemistry

J. W. Tobiska, M.A., in Charge
Earl Douglass, M.S., Associate
C. E. Vail, M.A., Associate
Earl Balis, B.S., Assistant

Civil Engineering

E. B. House, M.S., in Charge
A. R. Legault, B.S., Testing Engineer

Mechanical Engineering

Dudley P. Craig,* B.S., M.E., in Charge
E. M. Mervine, M.E., Agr. Engineer,
U. S. D. A.

Entomology

Charles R. Jones, Ph.D., in Charge
George M. List, Ph.D., Associate
Miriam A. Palmer, M.A., M.S., Associate
Leslie B. Daniels, M.S., Associate

Home Economics

Inga M. K. Allison, M.S., in Charge
Mark A. Barmore, Ph.D., Research
Associate

Horticulture

A. M. Binkley, M.S., in Charge
E. P. Sandsten, Ph.D., Horticulturist
Carl Metzger, M.S., Associate
George A. Beach, B.S., Assistant
Louis R. Bryant, Ph.D., Assistant
L. E. Evans, M.S., Assistant

Irrigation Investigations

Ralph L. Parshall, B.S., Sr. Irrig. Engr.,
U. S. D. A., in Charge
Carl Rohwer, B.S., C.E., Assoc. Irrig. Engr.,
U. S. D. A.
W. E. Code, B.S., Associate
H. O. Caperton, B.S., Meteorologist

Pathology and Bacteriology

I. E. Newsom, D.V.M., in Charge
H. W. Reuszer, Ph.D., Associate
Bacteriologist
Frank Thorp, Jr., D.V.M., Ph.D.,
Associate Pathologist
C. W. Barber, D.V.M., Ph.D., Assistant
A. H. Groth, B.S., D.V.M., Assistant

Poultry

H. S. Wilgus, Jr., Ph.D., in Charge

Range and Pasture Management

E. W. Nelson, M.S., in Charge
Terrill D. Stevens,† B.S.F., Assistant

Rural Economics and Sociology

L. A. Moorhouse, M.S., in Charge
R. T. Burdick, M.S., Associate
D. N. Donaldson, M.S., Associate
G. S. Klemmedson, M.S., Associate
Olaf F. Larson, M.S., Associate
R. C. Whitney, M.S., Assistant

Seed Laboratory

Anna M. Lute, A.B., B.Sc., Seed Analyst

Horticultural Substations

Herman Fauber, M.S., Superintendent,
Rocky Ford
Ralph Manuel, B.S., Superintendent, Avon
Ferris M. Green, B.S., in Charge, Austin

Editorial Service

James R. Miller, Editor

*Deceased

†Resigned

511
L4
50th
1936/37

Contents

	Page
Letter of Transmittal.....	1
Board, Officers, and Staff of Station.....	2
Financial Report.....	4
The First Half-Century.....	5
Director's Report.....	9
Agronomy Section.....	15
Animal Investigations Section.....	18
Botany Section.....	21
Chemistry Section.....	24
Civil Engineering Section.....	26
Mechanical Engineering Section.....	27
Entomology Section.....	27
Home Economics Section.....	32
Horticulture Section.....	34
Irrigation Investigations Section.....	38
Pathology and Bacteriology Section.....	41
Poultry Section.....	46
Range and Pasture Management Section.....	47
Rural Economics and Sociology Section.....	51
Seed Laboratory.....	55
Editorial Service.....	58

LIBRARIES
COLORADO STATE UNIVERSITY
FORT COLLINS, COLORADO 80523

FINANCIAL REPORT, COLORADO EXPERIMENT STATION

For the Year Ending June 30, 1937

DR.	Hatch fund	Adams fund	Purnell fund	Bankhead-Jones fund	State mill levy fund	Special fund	Pure-seed fund	Total funds
Balance, July 1, 1936.....					\$ 23,091.01	\$ 21,045.33	\$ 5,127.06	\$ 49,263.40
From the treasurer of the United States as per appropriations for the fiscal year ending June 30, 1937, under acts of Congress approved March 2, 1887 (Hatch Fund), March 16, 1906 (Adams Fund), February 24, 1925 (Purnell Fund), and June 29, 1935 (Bankhead-Jones Fund).....	\$15,000.00	\$ 15,000.00	\$ 60,000.00	\$ 11,215.48				101,215.48
Other sources than the United States.....					81,177.78	48,241.98		129,419.76
	\$15,000.00	\$ 15,000.00	\$ 60,000.00	\$ 11,215.48	\$104,268.79	\$ 69,287.31	\$ 5,127.06	\$279,898.64
CR.								101,215.48
To salaries.....	14,954.25	15,000.00	46,304.93	3,688.03	51,095.95	7,970.26	3,569.04	142,582.46
Labor.....			7,101.79	4,879.23	16,332.59	9,630.19	1,170.20	39,114.00
Stationery and office supplies.....			495.71	200.95	676.26	355.74	123.66	1,852.32
Scientific supplies, consumable.....			803.75	74.79	631.99	2,305.52	99.82	3,915.87
Feeding stuffs.....			250.65		6,881.43	723.80		7,855.88
Sundry supplies.....			149.03	27.60	1,118.85	2,374.24	2.92	3,672.64
Fertilizers.....			54.75		121.35	83.74		259.84
Communication service.....			171.72	6.47	1,093.08	363.85	21.87	1,656.99
Travel expense.....	45.75		1,828.18	1,077.03	1,859.13	3,154.81	76.05	8,040.95
Transportation of things.....			54.44	63.95	1,403.70	389.42		1,911.51
Publications.....			22.12		1,928.73	541.51		2,492.36
Heat, light, water, power.....			340.25		3,563.90	3,526.91		7,431.06
Furniture, furnishings, and fixtures.....			114.53	30.08	425.19	1,271.26		1,841.06
Library.....			161.38	12.12	161.26	169.87	10.00	514.63
Scientific equipment.....			1,535.71	583.66	1,546.36	1,403.54	53.50	5,122.77
Livestock.....					2,059.32	2,116.80		4,176.12
Tools, machinery, and appliances.....			372.67	542.82	1,863.54	5,826.01		8,605.04
Buildings and land.....			231.83	28.75	1,661.06	10,805.82		12,727.46
Contingent expenses.....			6.56		62.70	257.43		326.39
Balance on hand, June 30, 1937.....	\$15,000.00	\$ 15,000.00	\$ 60,000.00	\$ 11,215.48	\$ 94,486.39	\$ 53,270.72	\$ 5,127.06	\$254,099.65
					9,782.40	16,016.59		25,798.99
Grand total.....	\$15,000.00	\$ 15,000.00	\$ 60,000.00	\$ 11,215.48	\$104,268.79	\$ 69,287.31	\$ 5,127.06	\$279,898.64

81177.78
48241.98
129419.76

61267.71
17355.61

The First Half-Century

A Record of Scientific Service to Colorado Agriculture

WITH THE ending of the fiscal year of 1936-37, the Colorado Experiment Station brings to completion a half-century of notable scientific service to the agriculture of Colorado and of the nation. This, the Fiftieth Annual Report, marks the end of a period of most gratifying achievement, starting from a meager and somewhat unpromising beginning.

An experimental department was maintained in connection with the State Agricultural College, now known as the Colorado State College of Agriculture and Mechanic Arts, from the time of its organization in 1879. In February 1888 the Colorado Experiment Station was organized under the provisions of a Congressional act of the preceding year.

Management of the station was vested in an executive committee consisting of three members of the State Board of Agriculture, the board which had control of the State Agricultural College. Officers of the station were the director and the secretary-treasurer, with a working staff representing the various departments of the experimental work.

The State Board of Agriculture consists of eight members appointed by the governor with the consent of the state senate; the president of the college and the governor of the state serve as ex-officio members. The board at the time the station was organized was composed of the following members: President, George Wyman, Longmont; secretary, Frank J. Annis, Fort Collins; John J. Ryan, Loveland; Robert C. Nisbet, Del Norte; W. F. Watrous, Fort Collins; B. S. LaGrange, Greeley; R. A. Southworth, Denver; and Charles H. Small, Pueblo. Ex-officio members of the board were Governor Alva Adams and President C. L. Ingersoll of the college.

The station organization was effected at a special meeting of the board held at Del Norte on February 20, 1888. The officers named at that time were the following: Executive committee, John J. Ryan, W. F. Watrous, and George Wyman; director, C. L. Ingersoll; secretary-treasurer, Frank J. Annis. The station staff consisted of the following: A. E. Blount, agriculturist; James Cassidy, botanist and horticulturist; David O'Brine, chemist; Louis G. Carpenter, meteorologist and irrigation engineer; William McEachran, veterinarian; R. H. McDowell, assistant agriculturist; C. M. Brose, assistant horticulturist; Lewis A. Coffin, assistant chemist; H. H. Griffin, in charge of the San Luis Valley Experiment Station; and Frank Watrous, superintendent of the Bent Agricultural Experiment Station.

The Sixth General Assembly of the State of Colorado had made provision for the organization of experiment stations in addition to the main station at the college. Two auxiliary stations were organized

the first year: one at Del Norte, in Rio Grande County, known as the San Luis Valley Agricultural Experiment Station; and the other at Rocky Ford, first known as the Bent Agricultural Experiment Station, and later as the Arkansas Valley Agricultural Experiment Station.

The treasurer's report for the period shows that the total receipts of the station for the fiscal year of 1888, ending on June 30, were \$15,000 received from the United States Treasury, and that the balance in cash on hand at the end of the period was \$36.76. In striking contrast is the provision for the station indicated by the financial statement in this report of the fiftieth year, showing receipts of \$101,215.48 from federal sources and \$81,177.78 provided by the state through a mill levy.

During the half-century of its existence the work of the Colorado Experiment Station has been under the supervision of the following men, who have served as directors: C. L. Ingersoll, 1888-91; Walter J. Quick, 1891-93; Alston Ellis, 1893-99; L. G. Carpenter, 1899-1910; C. P. Gillette, 1910-32; E. P. Sandsten, 1932 to date.

The policy of making results and conclusions from research available to the public in printed form was formulated by the college experimental department before establishment of the station. The first bulletin issued was by Elwood Mead, professor of physics and engineering, the subject being "Report of Experiments in Irrigation and Meteorology." An "announcement" in the bulletin by Frank J. Annis, secretary of the State Board of Agriculture, made known the establishment of the bulletin service as follows: "It is the design of the State Board of Agriculture to disseminate information from time to time concerning the experimental work carried on at the State Agricultural College, so that the character and progress of these scientific investigations, closely connected with agriculture and the related industries of the state, may be studied and utilized at the earliest opportunity by all who are interested in such subjects."

Two other bulletins were issued before the station's establishment: number 2, "Report of Experiments with Grains, Grasses, and Vegetables," by A. E. Blount, professor of agriculture; and number 3, "Concerning the Duties of the Secretary of the State Board of Agriculture, and Distribution of Seeds," by Frank J. Annis, secretary.

The station, upon beginning publication of bulletins, numbered them from that point, the first being number 4. As a matter of convenience, the three earlier bulletins are considered station bulletins.

The scope of the station's early experimental work may be indicated by the subjects of bulletins subsequently issued during the following 5 years:

4. Report of Experiments with Potatoes and Tobacco, by James Cassidy, professor of botany and horticulture.

5. Report of Experiments in Apiary, by C. Max Brose, assistant horticulturist.
6. Notes on Insects and Insecticides, by James Cassidy, botanist and horticulturist.
7. Potatoes and Sugar Beets, by James Cassidy, horticulturist and botanist, and David O'Brine, chemist.
8. Alfalfa: Its Growth, Composition, Digestibility, etc., by A. E. Blount, professor of agriculture, James Cassidy, botanist and horticulturist, and David O'Brine, chemist.
9. Soils and Alkali, by David O'Brine, chemist.
10. Tobacco, by C. L. Ingersoll, director, and James Cassidy, botanist and horticulturist.
11. Sugar Beets, by David O'Brine, chemist.
12. Some Colorado Grasses and Their Chemical Analysis, by James Cassidy, botanist and horticulturist, and David O'Brine, chemist.
13. On the Measurement and Division of Water, by L. G. Carpenter, meteorologist and irrigation engineer.
14. Progress Bulletin on Sugar Beets, by David O'Brine, chemist.
15. Two Insect Pests, the Codling Moth and the Grape-vine Leaf-hopper, by C. P. Gillette, entomologist.
16. The Artesian Wells of Colorado and Their Relation to Irrigation, by L. G. Carpenter, meteorologist and irrigation engineer.
17. A Preliminary Report on the Fruit Interests of the State, by Charles S. Crandall, horticulturist and botanist.
18. Index Bulletin, by Walter J. Quick, director.
19. Observations Upon Injurious Insects, Season of 1891, by C. P. Gillette, entomologist.
20. I. The Best Milk Tester for the Practical Use of the Farmer and Dairyman; II. The Influence of Food Upon the Pure Fat Present in Milk, by W. J. Quick, director and agriculturist.

During the first half-century of its existence the Colorado Experiment Station printed and distributed a total of 433 bulletins of the "regular" or "popular" type, and in addition 90 "press" bulletins and 19 "technical" bulletins.

The growth of the station since its unpretentious beginning of 50 years ago, including the increases in physical properties and in the scope of scientific investigations and experimentation, is indicated in detail by the text of the director's report marking the close of this historic period in the station's existence. The increase in financial provision for the station by both the state and federal governments, in recognition of the service returned by the station, is shown in the financial report. The enlargement of staff to meet the demands of modern agriculture for scientifically sound information is reflected by the staff list, on page 2.

It is an adage that the best way to judge the future is by the past. The men and women who have been responsible for the establishment and operation of the Colorado Experiment Station during its pioneering stages have built well. Their record over the past half-century constitutes a decided challenge to those who follow.

Director's Annual Report

Fiftieth Fiscal Year, 1936-37
Colorado Experiment Station

To the President and the State Board of Agriculture:

HEREWITH is presented my annual report as director of the Colorado Agricultural Experiment Station.

The station, on the whole, has been fortunate in keeping its personnel practically intact during the past year. The few vacancies occurring have been satisfactorily filled by competent young men, and we believe that better research will be realized. The station has now completed 50 years of service to the state and nation.

Financial Situation

The director has been connected with the station for the past 24 years, and in a degree at least can appraise the progress that has been made. While the resources of the station have been considerably augmented, we are still unable to work on many problems that call for solution. On the whole, the station has been protected by the fact that the state appropriation is on a mill levy, and therefore not subject to uncertain biennial appropriations. The change in valuation

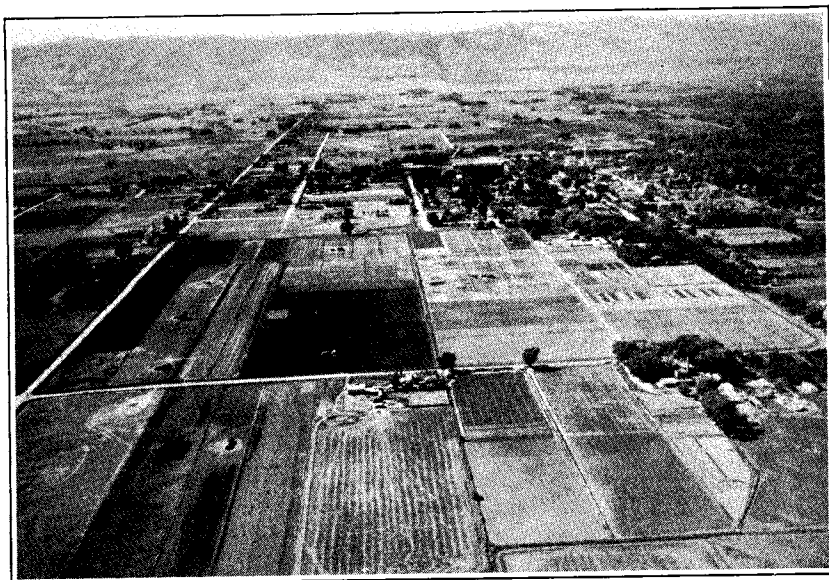


Figure 1.—Aerial view looking west across some of the fields of the Colorado Experiment Station; Colorado State College campus and edge of city of Fort Collins at upper right; Rocky Mountains in background.

has materially affected state income, but this is offset to some extent by the increase in federal funds through the Bankhead-Jones bill. The finances of the station are on a satisfactory basis, and budgets balance regularly from year to year.

Scope of Research

In the early history of the station the research work was mostly on local problems that called for immediate solution, and with some exceptions long-time research on more fundamental problems was necessarily deferred. With the passing of these immediate and pressing demands from our farmers, the station has been able to initiate a number of fundamental research projects which are necessary for the development of a stable agricultural program.

The problem of integrating state projects with federal projects has been, and is, a difficult one. The director has to be on constant guard to protect the state work and state funds from federal encroachments. The bewildering number of federal agencies in the field has made this task difficult, and at times it may have seemed that the director was unwilling to cooperate with federal agencies. This situation, however, does not exist with respect to cooperative work with the old-established bureaus of the U. S. Department of Agriculture, but only with the newer activities in the general field.

The policy of the station is, first, to pursue research of a fundamental character which is designated in a given field, and second, to conduct investigations on problems of immediate concern to the agriculture of the state.

Sociology Research

During the past 3 years the station has been able to develop a research program in sociology in connection with economics. This field is relatively new, but the present economic situation in this country has clearly shown that agriculture, as well as industry, has been neglectful of studying the social and personal phases of agriculture. After all, success in any line of human endeavor is, in the last analysis, a personal one, and the human element can not be ignored. In the future more attention should be given to this line of research.

The reports from the different sections give a condensed resume of station work and accomplishments during the past fiscal year. The final results will be published in bulletins and distributed to the farmers of the state. The scope and complexity of our agricultural problems are constantly being enlarged, and new demands on the resources of the station are being made.

Animal Disease Problems

Chief among the new problems is that of animal diseases. There have been several cases of livestock poisoning from feeding oats and barley hay. These occurred in different sections of the state, and

serious losses to farmers have resulted. It will require both time and money to solve these problems, which involve not only the efforts of the Veterinary Section, but also of the Chemistry Section, particularly with respect to biological chemistry.

Additional federal funds from the Bankhead-Jones Act have been assigned to the Agronomy and Range and Pasture Management Sections, as approved by the Washington office, and for which an offset or equal amount of state funds is required.

Considerable progress has been made in a study of the agricultural resources, both in soil and coverage, of the Plains Area. We intend to push this work as rapidly as possible, as this knowledge is fundamental to any and all problems that concern the future of agriculture in that section.

New Sections Operating

The Range and Pasture Management Section started last year is now well organized and doing good work. The teaching in this section is growing rapidly, and if this continues an increased teaching personnel will be necessary.

The Poultry Section, also established a year ago, is now well under way and equipped, although further laboratory facilities will be needed. No separate budget was provided for buildings, laboratories, and equipment. The station has spent approximately \$9,000 from its Special Fund to provide these necessary facilities, making a heavy drain upon its balance. It was thought advisable to do this so as not to handicap the department or its head, who is proving himself to be an excellent man. Happily, these heavy expenditures are past, and the present budget of the section is modest and reasonable.

New Feeding Program

In the Animal Investigations Section we contemplate a new program insofar as the feeding of livestock is concerned. This matter was discussed with several members of the board during the past year, and we believe it is the consensus that we should not continue to carry on feeding demonstrations or experiments at the college, particularly since this type of work has been carried on for an indefinite number of years. Further, the work did not apply to other sections of the state where encouragement should be given to the fattening and finishing for market of livestock on the farm. The professional feeders in the sugar beet-growing districts have been abundantly taken care of, and the growing need in agriculture, particularly in Colorado, is for more livestock on the farm so as to maintain soil fertility and to market the farm products in the form of livestock. A definite program for this work has not yet been developed, but it will be before the summer is over. We believe this new set-up will be a distinct aid to farmers and stock growers in the state.

College Farm

It is now 3 years since the director took over the management of the College Farm. These 3 years have been a period of reconstruction and of building up soil fertility. Briefly, some of the improvements that have been consummated are the following:

Control of bindweed was well established on some 70 acres of the farm. While this weed is not completely eradicated, it has been brought under perfect control and is not interfering with crop production, either in quantity or quality.

Extensive leveling of the land has been carried on for the past 2 years to make possible an economical distribution of irrigation water. Approximately 1½ miles of pipe line have been installed directly from the ditch to the farm, eliminating open ditches and insuring full delivery of water without interference by the neighbors. In addition to this main pipe line, numerous cross lines have been installed to promote a better distribution of water to all parts of the farm.

During the past year between 2 and 3 miles of new fences have been erected, using the best grade of fencing and creosoted posts.

The farm driveways have been graded and graveled. Two bridges have been enlarged to meet the traffic requirements and to facilitate the movement of traffic without interruption and danger.

We have constructed a conduit of 150 feet where the Arthur Ditch passes through the recently acquired land south of the military horse barns. We also have removed several trees and the old house and sheds on this tract, making it more sightly and eliminating the fire hazard to the barns.

As authorized by the board, the hog runs north of the main farm driveway have been removed, old fences taken out, new ones erected, and the land prepared for pasture.

Considerable extra work has been done in grading around the hydraulic laboratory and the poultry plant.

The equipment on the farm was greatly run down and much of it useless. A new tractor has been purchased and new hay-loading machinery, including a tractor, power mowers, and a loader. Four rubber-tired wagons, constructed from motor trucks, have been made, making it possible to operate in the fields in all kinds of weather.

From this brief account it would seem that there has been considerable progress in making the College Farm what it should be. An interesting part of this program is the fact that crop yields on the farm have increased from 25 to 50 percent. The heavy expenses now are over, and net income from the farm should show a considerable increase. The director does not wish to take the entire credit for the results obtained; it belongs in a larger measure to William P. Kintzley, the farm superintendent.

Experiment Substations

Work at the Avon Substation is being continued along the same lines as heretofore. We are placing more emphasis on potato breeding and improvement, recognizing that the potato industry is one of the largest and that agriculturally it is very important to the state.*

Improvement in the livestock at Avon is moving forward as rapidly as finances will permit. We are stressing the best type of farming for the mountain sections, a matter which is becoming important to the whole western part of Colorado. The mountain farmer should carry as many head of livestock as he can grow feed for during the winter months and as he can pasture for the summer; in addition, he should raise such cash crops as will keep him busy during the summer and provide supplementary income.

Variety tests of grains, vegetables, and potatoes are conducted to determine which are best adapted to high altitudes. Experiments in range rotation and controlled breeding are also on the program.

The interest in this substation is growing, as indicated by the attendance at Farmers Day, held in August of each year. Ralph Manuel, the superintendent, is doing admirable work and looking after the interests of the institution very satisfactorily.

The substation at Austin, which is supported mainly by state horticulturist funds, is continuing the same line of work in soil improvements, orchard management, and testing of new varieties of

*The cover sketch is of a scene at the Avon Substation, with potato-breeding plots in the foreground and the farm buildings in the background.

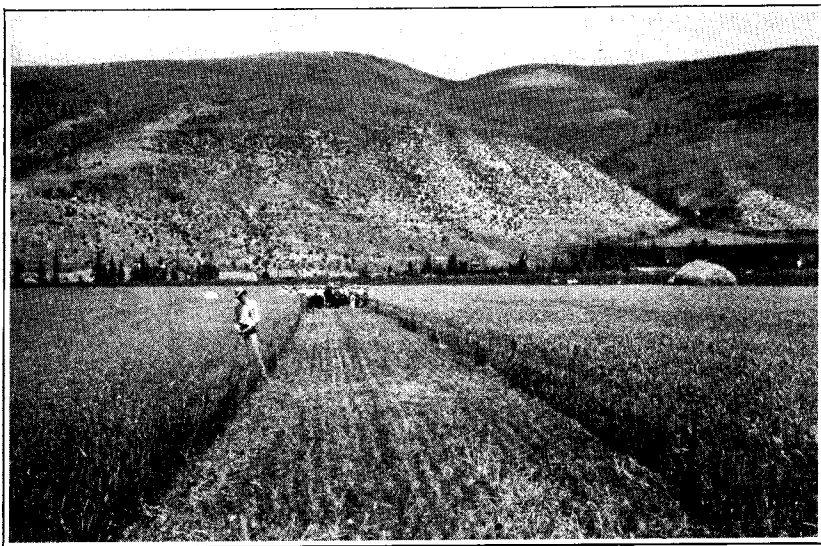


Figure 2.—Farmers' Day group inspecting high-altitude agronomy tests at the Avon Substation.

fruits, as well as work in the control of the codling moth and such work in connection with the handling of fruit crops as removal of spray residues and packing and grading. Ferris M. Green has been superintendent of this station for the past 15 years and is giving satisfactory service, not only to the Experiment Station but to the fruit growers in that section of the state.

The Rocky Ford Substation, while originally intended strictly as a vine-crop station—that is, for cucumbers and melons—has extended its work to include all vegetables and small fruits, and some agronomic crops such as alfalfa and beans. The most important work undertaken at Rocky Ford is the Valencia Onion Improvement project. The Horticultural Section has brought out several new varieties of this type of onion, and these have been tested out at the Rocky Ford station and are now being gradually disseminated among the growers. Unfortunately, the station is too small to permit operating it as economically as it should be operated. The overhead is too great for the acreage. Herman Fauber, superintendent, has been doing excellent work and has done much to bring the experiment station and the college favorably before the public.

Budget Policies

The problem of balancing the budget this year was much more difficult than in the past. There is a greater demand for service and for salary increases. Obviously, we can not increase budget allowances beyond our income, and this fact must be borne in mind. In many cases, however, it was possible to grant or recommend small increases when the section head was willing to curtail other expenditures to meet this particular demand. Frequently, economies can be made to offset salary increases, and when this is possible and where increases are deserved, we have not hesitated in recommending them. However, the director wishes to assure the board that under no conditions will he recommend salary increases unless certain that such raises are deserved. This is the only way he can hope to retain the strong young men who are now employed.

Cooperation

As a whole there has been a fine spirit of cooperation, which has greatly strengthened the work of the station. Several sections can now participate in a given problem, which could not have been done previously.

The director wishes to acknowledge the whole-hearted support of the State Board of Agriculture and the President of the college. Their interest in the station has made his work much easier.

The pages which follow summarize the year's activities of the various sections of the station as reported by their respective section heads.

Agronomy Section

Project Completed

CRITICAL PERIODS IN USE OF IRRIGATION WATER.—During the year this project has been completed. One of the interesting results has been to show that the chlorosis or yellowing of wheat produced by the application of irrigation water in the spring was caused by nitrate deficiency in the soil, and not by the use of cold water as commonly supposed.

Projects in Progress

CONTROL OF EXCESSIVE SOIL NITRATES.—The project has been investigated during the past season, continuing the work with sugar beets as a test crop. Analysis of plant petioles promises to give a measure of fertility needs as well as nitrate measurements and effects. Excessive soil nitrates exist, but they are more often the result of movement of the nitrates in water solution and their accumulation at certain soil points. The problem is resolving itself into a nitrate-utilization problem fully as much as a control problem.

CONTROL OF BACTERIAL WILT AND WINTER KILLING IN ALFALFA.—The present work consists largely of procedure necessary to develop selfed lines. Self-fertilization for a period of generations is necessary to create homozygous strains in order to be able, for a certainty, to make use of genes for hardiness, yield, resistance to wilt, resistance to leaf-spot, and resistance to mildew. Strains which show resistance to alfalfa wilt, one of the worst diseases, are not resistant to leafspot and mildew. Strains resistant to leafspot and mildew are susceptible to alfalfa wilt. Enough work has been done to indicate that these characteristics, susceptibility to and resistance for the various diseases, are heritable. This means a program of hybridization in order to create eventually the desired resistance in a single strain.

GENETIC STUDIES IN LINKAGE RELATIONSHIPS.—This fundamental piece of research under Dr. D. W. Robertson is producing new information. Some papers have appeared during the year in the publication "Genetics." Others have been accepted for publication in that journal. One practical development has been the production of a very promising new strain of barley.

SOIL PLAQUE METHOD OF DETERMINING MINERAL DEFICIENCIES IN SOILS.—Slight improvements in procedures of the modified Das method have been put into use and published during the year. Water soluble methods give some promise and have been further developed. Analysis of the plant itself or of some plant parts, such as plant petioles, promises a new approach. The major attention has been de-

voted to the so-called normal plant foods. Some attention is being given to so-called rare elements.

LAND USE.—This Bankhead-Jones project was carried aggressively in Washington County during the summer of 1936, both in the soil survey and the plant cover survey, the soil survey being under the direction of Dr. L. A. Brown and the plant cover survey under that of Prof. E. W. Nelson. After the close of the season for detail surveys, Dr. Brown and Dale Hodgell spent the time up to December making a reconnaissance survey with the idea of locating broad soil types for future use in detail surveys. A reconnaissance survey will be made of the counties adjoining Utah, in cooperation with the Soil Conservation Service. Aerial base maps which we hope to be able to use in the survey are being made by the Soil Conservation Service.

An accurate inventory of the soil and plant resources is necessary fundamental information. When this inventory is completed, economic surveys will need to be made in each soil district to give indications of the size of farm units.

High Altitude Studies

HIGH ALTITUDE CROPS.—The program for the Fort Lewis Substation includes high-altitude crop studies. By an arrangement with Fort Lewis, this program will be enlarged during the season of 1937, beginning with the new fiscal year on July 1. During the past year bulletins on oats and barley in Colorado have been put out by the Agronomy Section, covering the high-altitude work with these crops at Fort Lewis. In addition, Dwight Koonce has presented a manuscript entitled "Altitude Studies on Dry-land Grasses and Clovers at the Fort Lewis Experimental Farm." The new arrangements may include provision for some soil-conservation studies and possibly some range studies in cooperation with the Range and Pasture Management Section.

Plains Crops Studies

PLAINS CROPS AND MANAGEMENT.—The 1936 crop season at the Akron Dry-land Field Station was a fairly good one. Although crops were low in yield in that immediate vicinity, station crops produced good yields. Winter wheat yielded up to 28 bushels per acre; adapted varieties of barley, Club Mariout and Flynn, gave yields up to 40 bushels; oats gave yields above 40 bushels; corn and bean yields were fair. The sorghum-breeding program progressed. Some strains have reached the stage of increase for distribution to farmers.

Cooperative Corn Tests

IMPROVED SEED.—In the cooperative tests with several other states, one of our corn hybrids yielded first in some states and not lower than fifth in any outside Colorado. Newspaper publicity on corn hybrids

has caused considerable popular pressure. We have anticipated this pressure and will soon have our own hybrid lines for distribution. Numerous hybrid lines are available. Not all the outside F_1 corn hybrids are adapted. Corn hybrid seed is more expensive and should not be used unless it does better than existing varieties. Tests are under way to determine which are worth while and which are not.

Sudan Grass Poisoning

SUDAN GRASS.—Considerable complaint during the last few years that sudan grass had caused stock poisoning has caused investigation of three possibilities: First, Is the poisoning caused by mechanical mixing of sorghum seed with the sudan grass seed? Second, Is it due to sorghum-sudan hybrids? Third, Is it due to sudan itself? Enough work has been done to show that the first two conditions exist, the mixture of sorghum in the seed and sorghum-sudan hybrids in the field. The control of those two conditions depends upon the careful control of seed and upon field management. The third supposition investigates the possibility of there being a difference in the production of hydrocyanic acid or the glucoside which carries it in different strains of sudan grass. Accordingly, selfed lines are being created and tested.

Otto Coleman has developed his thesis on a preliminary study of this problem. Further investigation of the problem must be made because of the importance of sudan grass as an annual pasture in plains agriculture and as a catch pasture in some irrigated agriculture.

This section is planning to continue the study. The preliminary work indicates a great difference in the inheritance or possible inheritance of the ability to produce hydrocyanic acid. If further tests show that this a gene-controlled characteristic, we will be able to breed safe sudan grasses. It is perhaps worth while to state in passing that, while many of the selfed lines do not show loss of vigor or yield, some of them do.



Figure 3.—An exhibit of apples and grapes produced at the Austin Substation.

Animal Investigations Section

Project Completed

RANGE MANAGEMENT.—The 16-year experiment in which three systems of management of range were tested was completed this past fall. The records have not been summarized as yet. In a general way we can say that continued grazing definitely was detrimental to the range, while neither the deferred nor the deferred-rotated grazing showed the same depleting effect on the forage of the range.

Western Slope Lamb Feeding

DELTA LAMB FEEDING.—Following are the results secured on the Delta lamb-feeding experiment:

Addition of cottonseed cake to a ration of corn and alfalfa was very beneficial, since it increased the rate of gain, reduced the cost of gain, and produced a more uniform finish on the lambs.

Sugar-beet molasses proved to be a satisfactory substitute for part of the corn in a corn and alfalfa hay ration, since it produced the same rate of gain as corn alone, and a much cheaper gain. Even though the degree of finish was not quite as great as that on lambs fed straight corn, nevertheless, feeding a limited amount of beet molasses was very profitable.

Self-feeding a cut mixture composed of corn, molasses, and alfalfa hay increased the rate of gain but also increased feed cost over hand-feeding the same mixture. The cut mixture did produce a much higher finish which quite materially enhanced the selling price, but not sufficiently to overcome the greater cost of using a ground mixture.

Steer Feeding Continued

BEEF TOPS FOR FATTENING STEERS.—This experiment, in which we are carrying eight lots of 10 yearling steers each, was not completed in time for recording results in this report.

The objects of the experiment are the following:

To determine changes in chemical analyses of beet tops at periodic intervals after topping.

To show changes in feed nutrients during storage when tops are stored as silage, as stacked tops, or as dried tops.

To show loss of moisture at periodic intervals after topping.

To determine tonnage ratio existing between tops and beets under field conditions with yields of 10, 12, 14, and 16 tons of beets per acre.

To determine the value of dried beet tops as a partial substitute for alfalfa hay in a standard beet by-product ration.

To find the relative feeding values of dried beet tops, stacked tops, and beet-top silage in a standard beet by-product ration.

To determine the feeding value of beet-top silage when fed with and without beet pulp.

To show the feeding value of "C" beet molasses as a partial substitute for corn in a standard beet by-product ration.

Wintering Test Near Completion

WINTERING STEER CALVES.—Five lots of 15 steers each are being carried through the winter on maintenance rations. This experiment, although nearing completion, was not completed at the time this report was compiled.

The objects of the test are as follows:

To determine the comparative feeding values of alfalfa hay, North Park hay, oat straw, and barley straw as wintering roughages for steers.

To compare the values of alfalfa hay and cottonseed cake as a supplement to oat straw and to barley straw in wintering rations.

Advanced Registry

The annual reports of the various breed associations are not yet available, but in view of the high production of a number of cows in various Colorado herds, and of previous national ratings given

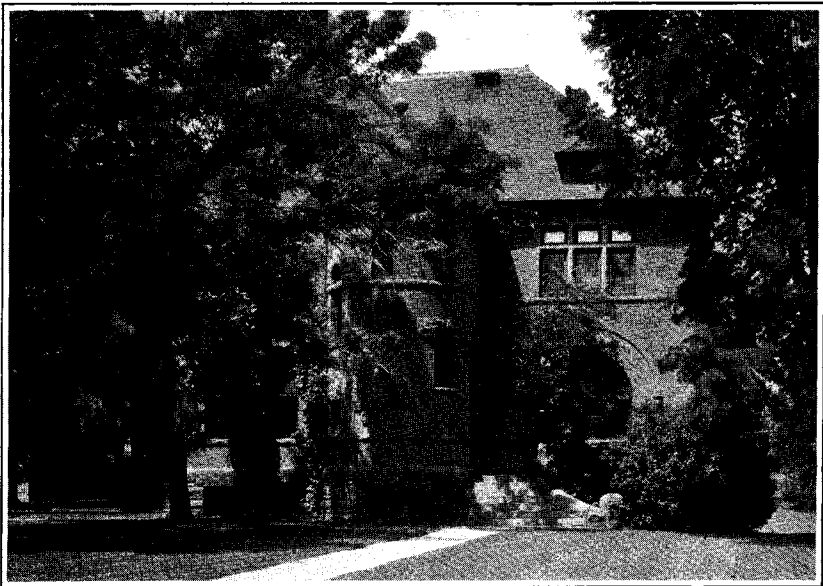


Figure 4.—Agronomy Building, Colorado State College.

some of these animals, there is little doubt that several will be on the honor roll when reports are received.

HOLSTEIN.—The C. W. Henry herd of registered Holstein cows, located near Greeley, achieved national distinction by leading the Herd Improvement Division of official testing for herds of more than 15 cows. This herd produced an average of 14,453 pounds of milk and 543.3 pounds of butterfat. This is an average increase of 27 pounds of fat per cow over the previous year's record for this herd and placed it in the first rank of the breed's herd-test division for the nation.

The cow Pauline Gerben Skylark, bred and owned by Colorado State College of Agriculture and Mechanic Arts, completed her fifth lactation, and the advanced registry records show that during this time she has produced a total of 103,773.9 pounds of milk and 3,308.5 pounds of fat. A senior 3-year-old cow, Rose Columbine Wayne, also bred and owned by Colorado State College, made a new state record in Class B when she produced 19,615.1 pounds of milk and 694.7 pounds of fat. This cow has since calved within the limit of time set for a new 10-months' record, and while verification has not yet been received from the breed association, credit will no doubt be given at an early date.

GUERNSEYS.—New state records were made by three cows in the Robert Roemer herd, located near Fort Collins. Sunset Golden Lenorill raised the old record in the AAA Class by 181 pounds when she produced 629.7 pounds of fat. A junior 2-year-old cow, Sunset Golden Chergue Beda, produced 417.9 pounds of fat for a new record. Sunset Dairy Gold, as a junior 4-year-old, set a new state record in her class by producing 666.4 pounds of fat in Class C of the breed's Herd Improvement Division.

The senior 2-year-old cow, Interlochs Pride's Marigold, bred and owned by F. C. Kay of Pueblo, Colo., made a new state record in Class FF by producing 543.8 pounds of fat.

A summary of the testing work done since May 1, 1936, shows the following: Cows on yearly test, 1 day per month, 313; cows on yearly test in Herd Improvement Division, 1,133; fees, \$197.30.

Future Activities

Plans for next year's work are not submitted in this report because they are yet in the formative stage. They are planned to be in the form of experiments or demonstrations in various parts of the state, using the stock owned by ranchmen, the demonstrations being carried upon the ranch at the expense of the ranchmen with the exception of the cost of supervision by one of our men and possibly the installation of scales in some cases. This is in accordance with board action taken recently.

Botany Section

Combating Fruit Disease

PEACH MOSAIC.—The Botany Section has assisted the U. S. Bureau of Entomology and Pest Control in eradicating mosaic-diseased peach trees in Colorado. The result of this eradication work has been a reduction in the disease and the arrest of its spread. Only 3,100 new cases of the disease had been found this year up to June 1, as compared with 9,835 for 1936 and 30,467 new cases in 1935.

Circular 427, U. S. D. A., was published jointly with the station this past year. This circular describes the peach mosaic disease and gives proof of its infectious nature, the length of incubation period, varietal characteristics, and control.

The Botany Section the past year has studied the host range of peach mosaic and found all peach varieties grown in the Palisade region susceptible. Maynard plums have been found carriers of the disease, though they themselves do not show symptoms. Peach mosaic has also been transmitted to apricots, and Hungarian prunes grafted on diseased peach showed symptoms.

The section has cooperated with the Entomology Section in a study of insect vectors.

Truck Crop Diseases

CUCUMBER ROT.—During the past year several new truck-crop diseases have been found in the state. One of these is a rot of cucumbers which causes destruction of the fruit, either green or ripe, and reduces it to a soft jelly mass. The causal organism, a species of *Phytophthora*, has been isolated and its pathogenicity proved. It appears to be the same organism that causes pepper wilt.

BEET PARASITE.—A species of *Rhizoctonia* which is a weak vascular parasite was found on beets. The organism has been repeatedly isolated and the symptoms produced experimentally.

ONION PINK ROOT.—A detailed study is being made of the pink root of onions. This disease has been in the state for a number of years, and present indications are that there are several strains of the organisms responsible for the disease. Those isolated in certain soils are particularly virulent.

ELM STORAGE PROBLEM.—The rotting of Chinese elms in storage was a problem this spring. It appears that the method of storage of the young trees commonly used prevents aeration, and there is an accumulation of many molds that injure the bark. Aeration and sterilization were found to eliminate the trouble.

Some study was made this past spring of the fungi found on hay that caused stock poisoning.

Greenhouse Crop Diseases

CARNATION PROBLEMS.—In cooperation with the state horticulturist and entomologist, technical service has been given to the greenhouse men in the Denver district. Many isolates of *Fusarium* species have been made from root-rotted carnations. It appears that a number of these are either different strains or possibly species. Four of them have been proved pathogenic by reinoculation experiments.

Tests are under way to determine possible varietal resistance, and soil sterilization as a control for root rot also is being studied.

MISCELLANEOUS.—Several new diseases of greenhouse plants have been found; a new fungus of snapdragons has been isolated and its pathogenicity proven. A species of *Fusarium* has been isolated from diseased gardenias, and an *Alternaria* leaf spot has been noted and studied.

Weed Control

The work on weed control has been continued and considerably extended, both in the field and in the laboratory. The data from our field plots have been analyzed statistically, and much is ready for publication.

FIELD TESTS.—From these field tests the following conclusions have been drawn:

Shallow cultivation at a depth of 2 inches every 2 weeks apparently eradicated bindweed as effectively as weekly or semi-weekly cultivation, at a cost of \$13.50 per acre as compared with \$19.50 for weekly cultivation and \$29.00 for semi-weekly cultivation.

Plowing at the beginning of the cultivation operations showed no advantage over shallow cultivation. The most economical method of cultivation showed a cost of \$10.00 per acre for the 2-year period.

A new 10-acre experimental tract was started last year on the Reed farm. From the work on this plot to date it is evident that cultivation 6 inches deep has no advantage over 3-inch cultivation because of the greater power need for pulling cultivator.

Tests on the Blevins plots with acid-arsenical previous to cultivation show that this treatment does not materially decrease the cultivation period necessary for eradication. Similar tests on the McClelland plots gave the same result.

From experiments on the Reed farm, results indicate that acid-arsenical applied to crushed foliage gave significantly better kill than when applied to normal foliage. The application of the sprays at 1-hour intervals was no more effective than a single application.

The results with a commercial compound indicate that it is significantly inferior to straight sodium chlorate, and that applying it as a spray to foliage was not significantly more effective than applying it to bare soil, indicating that adsorption of the chemical is through the roots largely and not through the foliage.

On the Reed farm barley plots planted on bindweed patches previously treated with arsenical spray gave two and one-half times the yield of those planted on untreated weedy patches.

BIBLIOGRAPHY.—An extensive bibliography of the bulletins and other literature on weeds has been assembled; some 3,000 references have been compiled, with cross-index both of subject and author.

LABORATORY STUDIES.—A complete microscopic study of the anatomy of whiteweed has been made, showing its development from seed to mature plant. This work is about ready for publication and is to be amply illustrated.

Analytical studies have been run in close cooperation with the field work on cultivation and chemical treatments. Samples from bindweed roots taken from plots cultivated at 3-, 6-, 9-, 12-, 15-, and 18-day intervals show that the food reserves are depleted most effectively by the more frequent cultivations. However, cultivations more frequent than every 9 days do not reduce food reserves enough to warrant extra expense.

Results to date on complete carbohydrates analysis of both bindweed and whiteweed show the trend of food reserves in roots and indicate that the period of most rapid accumulation of food reserves is late in the season. Plots on an acre of whiteweed cultivated at 1- and 2-week intervals resulted in destruction of food reserves and nearly complete eradication.

Measured by chemical analysis of food reserves in the roots as well as by stand, there appears to be some advantage in applying dry sodium chlorate later in the season.

Based on field tests and chemical evidence, early cultivation followed by chlorate treatments hastens eradication of bindweed and appears better than either treatment alone.

It has been found that the standard methods of analysis are not satisfactory in determining the reserves in whiteweed. Certain substances are present which prevented complete analysis. Considerable research was necessary to establish new methods, but this has been accomplished, resulting not alone in greater accuracy but in shortening the time and cost of the tests.

Chemistry Section

Projects Completed

Two projects of the Chemistry Section which were carried over into the present fiscal year have been completed, and their status is as follows:

VITAMINS IN ALFALFA HAY.—This work was published as technical bulletin 18, in September 1936. It was a sequel to technical bulletin 4, involving a study of vitamin factors A, B, and G in four varieties of alfalfa commonly grown in Colorado and the fate of these factors under varied conditions of curing and storage. The later bulletin is entitled, "Further Studies on Vitamins in Alfalfa Hay."

NUTRITIONAL CHARACTERISTICS OF MOUNTAIN MEADOW HAY PLANTS IN COLORADO.—This has been a cooperative project of the Chemistry and Botany Sections, and more recently of the Range and Pasture Management Section.

In this project were studied the vitamin factors A, B, and G and also the feed values and mineral ash of 12 individual species and three mixtures of North Park hay grasses. The samples covered two growing seasons and were taken each year at the time of hay harvest in the North Park region.

The chemical investigations have been completed and written up for some time and at present are in the hands of the station editor for publication. The section has been waiting for the written contribution from the Botany Section of its angle of the project. Melvin S. Morris, who did this work, is no longer in the employ of the station, and to date his manuscript has not been received.

Projects in Progress

Of projects which are still in the course of investigation, there are the following:

STARCH AND MINERAL CONTENT OF COLORADO POTATOES.—This is a project of the Chemistry Section with the Horticultural and Home Economics Sections. Over a period of 4 years there have been accumulated chemical and physical data on the six varieties of potatoes commonly grown in Colorado: Irish Cobbler, Peach Blow, Triumph, Katahdin, Rural New Yorker, and Brown Beauty. The chemical analytical work should be completed by the end of June 1937. The data are being studied, and the manuscript is being prepared for publication.

Much interesting information has been gained from this study. Only the principal findings may be summarized here as follows:

Colorado soils do not appear to be deficient in any of the principal minerals required by the potato plant, although some degree of unbalance may exist. Under our growing conditions, sunshine is always plentiful, but moisture appears to be a prime factor in yield and starch content of the tubers produced. With the exception of the Cobbler variety, which is unique in its equal starch production under irrigated or dry-land conditions, all varieties produce a higher starch content under regular irrigation conditions.

Potatoes in Colorado perform well under soil reactions ranging from pH 6.2 to pH 8.5, although under alkaline conditions the scab disease is more likely to occur. The varieties studied differ consistently and to a marked degree in starch production, indicating that genetic factors as well as environmental factors are operative in starch production. Mineral uptake appears to be selective to a marked degree, since wide ranges of available soil minerals produce only very small differences in the quality and quantity of mineral ash in the tuber. The soil reaction does not alter pH of potato juice to any appreciable extent. Fertilizer tests to date indicate that they affect the yield to a much greater extent than they affect the chemical composition of the tubers.

This investigation is being continued for another year to clear up two important points, one dealing with starch production and the other with the effect of fertilizers on chemical composition and culinary qualities.

EFFECTS OF IRRIGATION UPON COLLOIDAL COMPLEX AND AVAILABLE SOIL MINERALS OF SOME COLORADO SOIL TYPES.—“Arid” and “humid” climatic conditions give rise to distinct types of soil evolution. Irrigation practice in a normally semi-arid region affords a splendid opportunity to study the trend of soil minerals, both for immediate effects and also for those dealing with the maintenance of future fertility.

To date we have collected 19 soil profiles in 4-inch sections, and for better representation we intend to obtain about six more profiles. These represent native soils never cultivated, dry-land cultivated soils, and irrigated soils.

We have already determined the status of the easily available minerals in these soils, a process which yielded some interesting information. Much more remains to be done, but we feel that this study is very important to the future of agriculture in our state and to the maintenance of continued soil fertility.

Service Projects

The Chemistry Section has continued to carry some service projects for other sections of the station, as well as extension services to farmers over the state. These are as follows:

FOR ANIMAL INVESTIGATIONS SECTION.—Chemical analyses have been made of all fodders used in stock-feeding experiments.

IN COOPERATION WITH STATE FRUIT INSPECTOR.—During September and October 130 analyses for arsenic, lead, and fluorine were made for the inspector and for the fruit substation at Austin. Owing to crop shortage, the volume of this work was not as great as in the preceding year.

FOR ENTOMOLOGY SECTION.—Chemical analyses were made of crickets and grasshoppers. Poultry, particularly turkeys, consume large numbers of these insects; hence, it was thought important to know their value as feeds.

FOR HORTICULTURAL SECTION.—Assistance was given in the testing of greenhouse soils. This was done in an effort to aid florists of the state in solving their soil problems.

MISCELLANEOUS CHEMICAL SERVICES.—Again this year various requests for chemical service to farmers and other citizens have been met, although no funds have been provided for this work. Such services included water analyses, soil tests, tests for poisons in feeds, and other services.

Civil Engineering Section

Experimental Road

SEAL COATS APPLIED.—By September 1 the various seal-coat materials had arrived, and work was begun immediately to apply these to the surface sections of the experimental road previously constructed. The seal coats were applied to those sections which were beginning to pit. Applications were made both with and without a light covering of sand for each type of seal-coat material.

Comparisons were made at this time regarding ease of application and the amount necessary for effective covering. Comparisons of relative stability and impermeability will be made this summer.

MATERIALS TESTED.—Laboratory tests have been made on penetration, impermeability, and bonding strength of the various materials. These tests have been moderately successful but somewhat disappointing in that the differences between the materials as noted are not as marked as was expected.

The tests on bonding strength are being made at this time. Check tests will have to be made on penetration and impermeability. We hope to have sufficient data to warrant a bulletin by late summer.

Mechanical Engineering Section

Machinery Projects

BEET HARVESTER TESTS.—The outstanding result of the year's work on sugar-beet machinery is shown by the tests on the harvester. The performance of this machine indicates its commercial acceptability. Under ordinary conditions it delivered a product comparable to hand-harvested beets at a lower cost and at a desirable speed. Under severe conditions an additional man is necessary to hand-trim, making the cost of harvesting a little higher but still under present hand methods.

ADDITIONAL BEET MACHINERY.—Equipment for planting, cultivating, and harvesting of "ridge-planted" beets has been developed and used on a commercial basis.

Experimental development of planting equipment shows the feasibility of planting more uniformly, to the end that "mechanically thinning" beets may be practical.

Fertilizer Tests

The location of fertilizer with reference to the beet seed has been shown to affect tonnage materially. More elaborate testing has been done this year, leading to recommendations for proper treatment to apply fertilizer.

Entomology Section

Projects in Progress

PSYLLIDS IN RELATION TO POTATOES.—The work on this project during the year, conducted by Leslie B. Daniels, was limited to the Colorado Potato Experiment Station at Greeley, where further tests were made on lime-sulfur combination and the number of sprays required. This work has combined very satisfactorily with the newer project, "Sprayer Efficiency." Potato insects were studied with these projects, and it developed that combinations of sulfur dust with calcium arsenite, zinc arsenite, and a commercial dust produced only moderate control of psyllids and flea beetles.

The Entomology Section of the Colorado Experiment Station, through its activities on psyllid and flea-beetle control, has been responsible for saving the growers \$4,000,000 annually. The estimated

yield of the 1936 crop of 27,000,000 bushels has been protected to the extent of more than 10 percent. This amounts to the saving of 2,700,000 bushels of potatoes and means \$4,050,000 to Colorado growers.

SPRAYER EFFICIENCY.—This new project, conducted also by Mr. Daniels, is worked in connection with the psyllid and the potato-insect investigations. Power and traction sprayers were used. Ratings on delivery per minute were from 10 to 11 gallons, varying with motor speed. The coverage method experiments proved to be useful for field work.

NON-ARSENICAL INSECTICIDES.—This project was continued during the year by Dr. George M. List with pyrethrin- and rotenone-bearing materials. As far as possible, the new commercial compounds of these products were tested. Certain thiocyanates compounds and other materials were tested under field conditions, and when possible population counts were made before and after the application. The efforts were directed toward a better control of cabbage and cauliflower worms, cabbage aphid, Mexican bean beetle, and cherry slug.

IMPORTED CABBAGE WORM.—Rotenone was found superior to pyrethrins in controlling this pest; 2.84 pounds of rotenone dust per acre gave a significant kill. There was no significant difference in the effectiveness of the pyrethrins from pulverized flowers and from activated dust or colloidal clays, diatomaceous earth, and dusting sulfur as carriers.

CABBAGE LOOPER.—The tests of the season failed to give a satisfactory control of cabbage loopers.

DIAMOND-BACK MOTH.—The diamond-back moth larvae rank about midway between the imported cabbage worm and the cabbage looper in resistance to pyrethrins and rotenone.

MEXICAN BEAN BEETLE AND CHERRY SLUG.—Non-poisonous dusts were also used on the Mexican bean beetle and the cherry slug. A dust containing .75 percent rotenone used on the bean beetle failed to give satisfactory control. A spray of rotenone, 2 pounds of derris containing 4 percent of rotenone to 50 gallons of water, gave control equal to that effected by arsenite of zinc and arsenate of magnesium or phenothiozene, 2 pounds to 50 gallons of water, under heavy infestation.

On the cherry slug, rotenone sprays, with 2 pounds of either derris or cube powder containing 4 percent rotenone to 50 gallons of water, gave controls equal to those effected by arsenate of lead.

TOMATO PSYLLID.—All work on the tomato psyllid was in its relation to the tomato. In tests with wettable sulfur, liquid lime-sulfur, gas-house dusting sulfur, and 300-mesh dusting, no significant difference in kills was shown, each averaging a 95.7-percent kill.

PLANT LOUSE.—This project, conducted by Miss Miriam A. Palmer, has been directed toward the preparation of an aphid key for use by general entomologists, county agents, and other field workers. The key will deal largely with the species on a single host or on a group of hosts, using primarily only the structural characters that can be readily seen, and depending largely upon color, size, and effect of the feeding upon host appearance, with such other characters and symptoms as can be observed in the fields. Tentative keys have been prepared for the species found upon a number of trees. These have been submitted to field workers for use and criticism. Life habits and host relationships of many species are being studied, and a paper continuing the "Aphidae of Colorado" has been published.

INSECT VECTORS OF PEACH MOSAIC.—This project has been revised, and Mr. Daniels is in charge. The project has not been carried far enough to warrant any definite statements. However, there are good indications that *M. persicae* is a vector. *Lygus pratensis*, *A. helichrysi*, *M. persicae*, and other forms are under consideration.

SYRPHIDAE OF COLORADO IN RELATION TO PLANT LOUSE CONTROL.—Besides the addition of a few specimens of Syrphidae to the collection, very little was accomplished on this project the past season. This was because the time of the section head was practically filled with other station and state duties.

However, other experimental work was carried on when opportunity afforded. Two items were carried to considerable extent: one on blister beetles and the other on a nymphalid butterfly. These may be placed under "General Insects," along with other species dealt with this season.

The summary of experiments on the blister beetle is as follows: Arsenicals do little good, as they have to be applied in such concentrated form. Several commercial dusts cause the beetles to leave the plants in about 24 hours. One commercial mixture actually kills the beetles in less than 24 hours and is therefore the most effective dust used but is rather expensive.

The larvae of the nymphalid butterfly, a butterfly *Phycoides variota* (?) are gregarious and feed in clusters of as many as 50 on one leaf. They completely skeletonized plants of *Ambrosia trifida*, *Iva xanthium*, *Helenthus*, wild and tame, and artichoke. They appeared generally from the foothills from Denver north and as far east as Nebraska. Ensilage sunflowers at Merino, Colo., were damaged to the extent of about 40 percent. Artichokes at Brush were completely defoliated. One commercial dust effected a complete control. Arsenate of lead, 2 pounds to 50 gallons of water, also was very effective in field experiments.

SQUASH INSECTS.—In cooperation with the Horticulture Section, John L. Hoerner conducted this project. Experiments were princi-

pally on the squash bug, cucumber beetle, Mexican bean beetle, and thrips. Various substances, such as kerosene emulsion, sodium fluoride, and various commercial preparations, were tested. Some of these substances are used as spreaders. Of the sprays used on the squash bug, one commercial product was the most promising. One commercial dust gave a 100-percent kill where it hit the insects. This dust is more effective when blown on the bugs with some force than when allowed to settle on them. Sulfur as a carrier was as good as this commercial dust, but in some cases it showed burning in hot weather.

Insect Pests of the Year

During the season of 1936-37, subject cards of all insect pests reported to this office were kept in the files; the name of the insect reported, with abundance, locality, and date of appearance, were recorded. Each entry card contains all records of reports on various insects, together with reports on host plants. In all cases where larvae accompanied the inquiry, the insects were reared in order to make certain of the species. Each inquiry was answered by giving the best known spray, dust, or other method of control.

GRASSHOPPERS.—The grasshopper was undoubtedly the most serious and general insect pest of this season. The outbreak was the most severe in years, owing undoubtedly to climatic conditions and to lack of fungus disease and predacious and parasitic enemies, and to other factors.

Approximately 660 tons of bran and sufficient sodium arsenite to complete the mix were supplied by the federal government. This was supplemented by approximately 1,000 tons of bran and 80 tons of beet pulp used in mixing county-purchased poison.

The majority of infestations were limited to the eastern half of the state, the western half having only two counties infested with grasshoppers and one with Mormon crickets. Twenty-seven counties in all required intense grasshopper control, with 18 having very severe outbreaks.

During July several flights of *Melanoplus differentialis* and *M. bivittatus* were recorded on hot days, and in August a very severe immigration of *Dissostera longipennis* appeared in the grazing district of southeastern Colorado. In this sparsely settled area no preparation had been made for fighting grasshoppers; consequently, the invading swarms were allowed to go unmolested. The adults of this species feed upon gramma and buffalo grass, and the damage done to winter range was conservatively estimated at 20 percent of the total grazing areas.

SNOWY TREE CRICKET.—The snowy tree cricket (*Oecanthus neveus* De Geer), a new pest to Colorado fruits, especially to the small varieties, appeared during the past season at Loveland. This insect

causes damage to all types of fruit trees, both large and small, by laying its eggs in canes of small fruits and in small branches of the large varieties.

TUSSOCK MOTH.—While tussock moths (*Hemerocampa* sp. [?]) usually feed upon deciduous trees, some larvae were taken at Colorado Springs feeding upon evergreens. The section was unsuccessful in rearing them to adults, consequently the species was undetermined, but in all probability it was the fir tussock moth (*H. pseudotsugata* McDun) which is so prevalent on Douglas fir in Idaho, Nevada, and Oregon.

MORMON CRICKET.—The Mormon cricket (*Anabrus simplex* Hold.) problem in southwestern Colorado has been steadily increasing since the tremendous outbreak that occurred in 1932. During that year the crickets infested practically all Routt and Moffat Counties and the country south to Price Creek and Meeker, Rio Blanco County. After the vigorous campaign in 1932, the crickets were practically eliminated from these localities except for two small areas on Blue Mountain, where eggs from isolated cricket bands were known to have been deposited. These cricket bands increased until, in 1936, almost the entire top of Blue Mountain was infested. Bands of crickets were also located in Axil Basin, Price Creek, Crooked Wash, and Cross Mountain.

HARVEST MITE.—A severe infestation of the harvest mite (*Pediculoides ventricosus* Newport) was reported from Morgan County. This pest was attacking the inhabitants in the wheat-growing areas and was reported principally from Fort Morgan and Brush.

PIGEON HORNTAIL.—The pigeon horntail (*Tremex columba* Linn.) attacks deciduous trees. In Denver numerous maple trees from 2 to 3 feet in diameter were killed by this pest.

TERMITES.—Termites (*Reticulitermes flavipes* [?] Koller), generally known as "white ants," were especially abundant the past season. This insect is a pest of wooden structures or of any substance that has a cellulose base, and it has been reported as doing serious damage in various counties the past season and in Colorado Springs, Cheyenne Wells, Sterling, and elsewhere.

EARWIGS.—Until the past 2 or 3 years earwigs were unknown in Colorado. About 2 years ago an infestation was discovered at Fitzsimons General Hospital, near Denver. The distribution of this pest was not very extensive; in fact, it was isolated to the area around the post greenhouse. It has now spread to Aurora, a suburb of Denver, and it is only a question of time until it reaches Denver and becomes permanently established in Colorado.

Home Economics Section

High Altitude Baking

BAKING OF FLOUR MIXTURES AT HIGH ALTITUDES.—Considerable time has been utilized in attempting to make practical application of the scientific findings of this project. The Extension Service, through the county home demonstration agents, has very willingly carried out a series of practical tests of our calculated recipes at various altitudes. About 130 reports of these tests have been received from housewives scattered throughout the state. A summary shows that 68 percent had from good to excellent results, and 25 percent reported fair results. This seems to be rather successful, since the tests were made under so many different conditions of experience and equipment. Therefore, it seems safe to release this information for general use.

In all this baking work one of the most uncontrollable factors has been the addition of the flour to the otherwise completed batter. A machine for this task has been designed, and models constructed and tested, and now the machine itself is completed, and its use should eliminate largely this troublesome variable.

Prof. J. H. Scofield has completed the installation of the device which is designed to make the maintenance of the conditions in the altitude laboratory more fully automatic. It consists of a mechanism to adjust the machinery that maintains the constant temperature and humidity in the laboratory; it is actuated by weather conditions.

CULINARY QUALITIES OF POTATOES.—The most important characteristic of potatoes, from a culinary point of view, is the texture or mealiness. Attempts have been made to correlate mealiness with various ingredients of the soils and tubers that were determined by the Chemistry Section of this station. To date starch content is the only factor which yields a correlation coefficient high enough to be considered valuable. This only substantiates the literature. There must be other factors which contribute to mealiness and account for the difference between the coefficient for perfect correlation (1.00) and the .54 obtained.

In order to make a more thorough investigation, the variable of starch content was eliminated by choosing pairs of equal starch content, of the same variety grown at separate locations, but of different mealiness. Analyses after cooking were made of these four pairs for pectin and material soluble in various peptizing agents. While none of these analyses were satisfactory in that they are very inaccurate, no consistent results were obtained. Microscopic examination yielded no apparent consistent difference in appearance of the cells nor in their size.

In other words, we have found nothing during our past 3 years' work on this project that is significantly correlated with mealiness except starch, and that has been reported several times in the literature.

However, in our study of the softening of tubers during cooking we have made some positive advance. The penetration of a 2 mm. needle into tubers cooked for 25 minutes is very highly correlated $-.70 \pm .080$ with the starch content. This means that potatoes of high starch content are much more solid after cooking than those of low starch content. Penetration is not a measure of "doneness," since tubers can be cooked "done" to the taste and have very different degrees of softness, which in turn, is dependent on the starch content. This effect was also discovered by Rath sack in Germany by other means and came to our attention after the effect was noted by us.

On investigating the progressive change in penetration during cooking, it was found that at about the time the tuber was "done" the softening was arrested and may even be decreased slightly on further cooking. Following this, progressive softening is again continued. Rath sack, who used two entirely different methods, also noted this same hardening effect.

While these effects are of no practical value, it is believed they contribute to the knowledge of the cooking process, and it is only by such a method that we will be able to determine what the other factors are, besides the starch content, which causes potatoes to be mealy.



Figure 5.—Farmers' Day visitors assembling at the farmhouse of the Avon Substation to hear a program of addresses on agricultural subjects.

Horticulture Section

Cooperative projects of the Horticulture Section are carried with the Chemistry, Agronomy, Botany, and Home Economics Sections.

Potato Projects

POTATO CULTURAL AND BREEDING INVESTIGATIONS.—Under this project, the breeding of new varieties and the testing of recent introductions are carried, and one of the outstanding contributions has been the introduction of the dark-red Peachblow variety. This was introduced to potato growers several years ago, and the selection work has steadily improved the seed stock until it is now as good as the old standard Peachblow variety.

The Katahdin variety, introduced by the U. S. Department of Agriculture, has been tested for a number of years by the station and is now being further tested in all parts of Colorado. This new variety holds its shape well under adverse growing conditions and produces a higher percentage of No. 1 marketable tubers than other varieties. It also yields with the best standard variety grown in the state and is resistant to mild mosaic. It has many defects, however, among which are susceptibility to scab, haywire, and spindle tuber. The tubers tend to grow too large and to become hollow if not planted close together. This variety sets the tubers shallow, and they are inclined to sunburn; they also have a thin, tender skin that bruises easily in handling. Despite these defects, the Katahdin variety is fast becoming a standard variety in all districts in the state.

The Chippewa variety is another that is being grown all over the state this year, and from last year's comparisons it may be better adapted to some districts than Katahdin.

Houma is another U. S. Department of Agriculture introduction that is showing considerable promise in preliminary tests.

Many other seedlings and promising varieties are included in this work, and among them are several introductions by the Department of Agriculture and from the University of Minnesota. In addition to these, there are a large number of our own seedling crosses which are being increased at Avon for further tests.

COMMERCIAL FERTILIZERS FOR POTATOES.—Commercial fertilizer tests were carried in the main potato districts of Colorado this past year, and the results show that the only significant increases in yields were obtained by the addition of 160 pounds of ammoniated phosphate per acre. While there was no significant increase in yield obtained by the addition of 200 pounds of treble superphosphate per acre, there was an increase in the percentage of U. S. No. 1 potatoes

and a noticeable increase in the toughening of the skin on the tuber. The tubers were also better shaped, being blunter on the ends in the Russet Burbank variety, the netting was more pronounced, and the crop matured earlier. The other fertilizer treatments did not produce any significant difference in yield or quality. The experiments are to be continued in various potato districts of the state.

DATES OF PLANTING FOR RUSSET BURBANK VARIETY.—One year's results show that the highest yields and best quality potatoes were produced at the mountain substation at Avon by planting this variety the third week in May.

FACTORS AFFECTING CHEMICAL COMPOSITION OF POTATOES.—This project is carried in cooperation with the Chemistry and Home Economics Sections. The object in carrying this work during the past 4 years was to determine why the yields and quality of potatoes have declined in the old districts of the state. The results indicate that the decline is due to loss in market quality rather than to a loss in cooking quality. The results of this preliminary survey are now ready for publication. The first part will deal with the effects of environment (such as location, year, and soil) and variety on starch, dry matter, protein, fat and fiber, ash, and cooking quality. The second part is to be published later and will deal with the effect of environment and variety on the constituents of the ash, and the effect of ash constituents on cooking quality.

POTATO BREEDING.—Of several thousand seedlings started in 1932, only 21 are left which show excellent characters and are being carried for further breeding work; 37 inbreds are being used in crosses. Further crosses were made in 1935 and 1936, and we now have about 1,000 seedlings that are being grown this year for further test.

POTATO SOIL TREATMENTS.—During the past year the soil at the mountain substation at Avon was treated with calomel, yellow oxide of mercury, zinc amalgam, and copper amalgam to determine the effect of these chemicals on reducing the amount of scab. The results indicate that there was no significant decrease in the amount of scab with any of the treatments, but copper amalgam did produce a significant increase in yield.

Chiseling the soil, a process similar to subsoiling, at a depth of 24 inches in the row before planting, did not give any significant increase in yield at the mountain substation in 1936.

Fruit Studies

SMALL FRUITS INVESTIGATIONS.—Strawberry variety testing is carried on at the Fort Collins station and at the Avon and Rocky Ford substations. The differences in the behavior of the varieties under different growing conditions indicate the necessity of testing the new

varieties for local adaptability. The two most promising varieties tested last year at the Fort Collins station were Dorsett and Fairfax for the main crop varieties. A complete new list of varieties has again been distributed to the substations. Strawberries seem to be particularly well adapted to the mountain substation for late production.

This year a test of raised beds in comparison with level plantings on heavy soil has been started at Fort Collins to determine the effect of these treatments on production and strawberry root-rot. Comparisons are also being made with strawberries grown on well-drained and poorly-drained soil to determine the effects of these conditions on strawberry root-rot.

With raspberries the first yield comparisons were secured this past year on the hill and hedgerow systems of planting. These yield records did not show any statistical significance in favor of either system of growing.

TREE FRUIT VARIETY TESTING.—The testing of tree fruits, as included in this report, refers only to the work at Fort Collins. There are now 92 varieties of apples and crabs, 37 varieties of plums, and 14 varieties of cherries planted in the orchard. The plantings have been increased again this year by the addition of 32 varieties of plums and bush cherries. This group includes types which should have some possibilities as dry-land material, and included with it are nine bush-cherry hybrids and 12 varieties of hardy apricot seedlings from Manchuria, which were recently introduced by Dr. N. E. Hansen of the South Dakota Experiment Station. Since it requires a number of years for fruit trees to come into bearing, all that can be reported on at the present time are losses due to winter injury or other causes. These reports are available in detail for this past year, with a complete list of all fruit varieties under trial.

CULTURAL METHODS WITH SOUR CHERRIES.—This project has not been in progress long enough to show definite results on the work with pruning tests. The trees on the Mahaleb root stocks are much more vigorous than those on Mazzard root stocks.

SOUR CHERRY ORCHARD MANAGEMENT.—This project is carried in cooperation with the Soils Division of the Agronomy Section, and was started 2 years ago. As yet no definite reactions are shown on the various series of soil treatments used, which include commercial fertilizer applications and green-manure crops. The work has not been in progress long enough to report definite results.

Flower Project

FLORICULTURE COOPERATIVE PROJECT.—The work on floriculture is carried in cooperation with Denver flower growers. An experiment is under way to determine the effects of steam sterilization on availability of plant nutrients and to follow the changes that take place in

the soil during the carnation cropping season. While the present results are of a preliminary nature, the trend shows an initial increase in nitrogen, followed by a decrease, and an increase in potassium and a decrease in phosphate after steam sterilization of the soil.

Improving Onions

SWEET SPANISH ONION BREEDING.—The object of this project is to produce a variety or strain that will maintain the yielding ability of the old Sweet Spanish variety, yet which will be an improvement in color, mildness, and storage characteristics. Sweet Spanish No. 6, developed by the station, is an improvement over the standard variety in color and keeping qualities, but does not yield significantly more per acre. This selection was planted last year in the commercial districts of the state, and favorable reports were received on its behavior. The No. 6 strain has virtually been introduced and is being planted in the various onion districts for further comparisons by growers.

In addition to this stock, other selections and inbreds are being carried for further trial, and several are now included in the plot test for comparisons.

Growing onions on raised beds, a new method tested last year, showed significant increases in yield over the level or standard method of planting. This method may be of value on low, flat, or level fields with poor drainage and has a practical application under those conditions.

ONION STRAIN TRIALS.—Seed grown by local growers in the onion districts and from carefully planted and isolated bulbs has consistently produced better onions than seed produced in other states.

COMMERCIAL FERTILIZER TESTS ON ONIONS.—Commercial fertilizer tests were carried in the Rocky Ford and Fort Collins districts during the past growing season, and the results indicate to date that there is no significant increase in yield on any of the commercial fertilizer plots. Phosphate treatments improved the color of the bulbs and also produced a little earlier maturity.

DATES OF SEEDING ONIONS.—The crop is planted at weekly intervals, starting the early part of March. Last year's results were contrary to those secured in previous years, and the first and last dates of planting yielded significantly more than the other plantings. In all previous tests the earliest three dates of planting yielded significantly more than later plantings.

Lettuce Breeding Difficulties

HEAD LETTUCE BREEDING.—Progress on this project has been very slow, primarily owing to lack of seed production under conditions at Fort Collins. This condition set back the progress of the project be-

cause of failure to get sufficient seed for increase of the hybrids. It was largely caused by virus diseases.

Miscellaneous Activities

GENERAL VEGETABLE VARIETY TESTING.—Many new varieties released by seedsmen and growers and from the Foreign Plant Office are planted to test their value commercially and for disease resistance. Several hundred varieties of vegetables are planted on a trial-ground basis to observe their performance. Last year trial-ground tests on most of the new varieties of hybrid sweet corn, market pod peas, tomatoes, head lettuce, and onion varieties were carried and records taken of their type performance. Some of the outstanding varieties noted are the following: Golden Cross Bantam sweet corn; Improved Stringless Greenpod and Tendergreen varieties of beans; Scarlet Dawn variety of tomatoes, and Bilbo variety of pod peas.

PYRETHRUM INVESTIGATIONS.—The selection work for higher pyrethrin content is being carried by this section. The selections are now averaging slightly higher than the best commercial strains. The progress on this project is slow, due to the limited number of chemical analyses that can be run each year.

Irrigation Investigations Section

Work of this section is in cooperation with the Bureau of Agricultural Engineering, United States Department of Agriculture. Assignments on other than regular project work this year have retarded experimental laboratory work. However, work with the vortex tube sand trap, the adjustable tube orifice meter, and the Parshall measuring flume has been advanced.

Apparatus Design and Invention

ADJUSTABLE TUBE ORIFICE METER.—Last summer at the Bellvue Laboratory a series of tests were conducted on 18-, 24-, and 36-inch settings of the adjustable tube orifice meter, and it was found that deviation of the measured head from the calculated discharge was well within practical limits.

This type of meter is not yet fully developed, as we have not been able satisfactorily to observe the pressure heads in a practical manner. Apparatus is now being set up to demonstrate the possibility of a new method of making these observations, and if successful, this meter can be introduced as a useful measuring device for irrigation practice.

An 18-inch laboratory model of the adjustable tube orifice meter is to be used on the Fort Lyon Canal in the Arkansas Valley this summer to determine the practical limitations of this meter as now developed.

SINGLE VORTEX TUBE SAND TRAP.—A single vortex tube sand trap was installed in the Jackson Ditch at the Bellvue Laboratory. This design of trap was based on the results of the experiments made at the Bellvue Laboratory by Carl Rohwer during 1935. This trap was in constant operation from about April 15 to October 1, 1936. No actual tests were made, but because of the quantity of sand and silt discharged through the outlet from the trap and deposited in the pool at the laboratory, it was concluded that a considerable saving in the operation of the ditch had been accomplished.

MEASURING FLUMES.—Last September the designs for two reinforced-concrete flumes were prepared. These structures were built in the Grand River Ditch and the Skyline Ditch, which are a part of the Water Supply and Storage Company's system, in the upper Poudre area. The measuring flume in the Skyline Ditch was installed to make it possible to comply with the U. S. Supreme Court decision affecting the diversion of water from the Laramie River drainage into that of the Cache la Poudre River. Also, in this connection, an inspection was made of the ditches diverting water from the Laramie River and McIntyre Creek for use on the meadow lands along these two streams. The court decree limits the use of water on these lands to 1 acre-foot per acre of meadowland irrigated. Therefore, it is necessary to install measuring devices on all diversions in order to comply with the decree.

Recommendations have been made to the state engineers of Colorado and Wyoming concerning the improvement of conditions on these ditches and installing a suitable measuring device in the diversion channel from the Laramie-Poudre Tunnel to the Laramie River. Small wooden flumes ranging in size from 1 to 4 feet will be installed in the small ditches. For measuring the tunnel water, either a 10- or 12-foot reinforced concrete flume will be built. Other improvements are to be made on the diversion dam in the river, on the headgates and diversion canal.

A 12-foot flume was designed for the Lake Canal near Fort Collins and a 15-foot flume for the Upper Platte and Beaver Canal near Fort Morgan. Both of these structures have been built.

Miscellaneous Activities

SNOW SURVEYING.—During September and October the following additional snow courses were established in Wyoming and Colorado: Sour Dough, near Basin, Wyo.; Red Fork, near Kaycee, Wyo.; Granier Meadows, near South Pass City, Wyo.; Big Creek Lake, near

Pearl, Colo.; Alexander Lake, near Grand Junction, Colo.; Maroon Lake, near Aspen, Colo.; Snowshoe Mesa, near Paonia, Colo.; Mesa Lakes, near Grand Junction, Colo.; Jefferson Creek, near Como, Colo.; Ironton Park, near Ouray, Colo.; Silver Lakes, near Antonito, Colo.; Whiskey Creek, near Trinidad, Colo.; River Springs, near Conejos, Colo.; Deadman Hill, near Redfeather Lakes, Colo.; and University Camp, near Nederland, Colo.

A model of a moisture-proof weighing balance for use in weighing the snow samples has been made, but it requires further development.

PUMPING FOR IRRIGATION.—The continued water shortage has made it necessary to obtain supplemental water for irrigation. It is reported that about 1,000 wells were in operation this past season in Northern Colorado, and it is estimated that about 100,000 acre-feet of water was pumped from these wells. Water users in the lower South Platte Valley have expressed the opinion that excessive pumping from wells has reduced the return flow to the river and thus produced a shortage in their water supplies. It is assumed that there is a direct loss to the underflow back to the river because of pumping. In order to study this problem it would be necessary to set up extensive field operations extending from 3 to 5 years.

Variation of the water table over a period of years in widely scattered areas has been observed. These observations have been taken in the spring and fall in about 125 wells, and in order to extend these records it is suggested that two locations be chosen in each of the following areas: the Arkansas Valley, the vicinity of Denver, the Lower South Platte Valley, and the vicinity of Fort Collins or Greeley, where special observation wells could be put down to the water table for the purpose of obtaining record of the water level. Recording instruments are available for this purpose.

COLORADO-BIG THOMPSON PROJECT.—Considerable time has been spent on the agricultural economic study relative to the Colorado-Big Thompson project. This work consisted of aiding in the collection of water-supply records, as stream flow, ditch diversions, reservoir storage, and other data in water districts 1, 2, 3, 4, 5, and 64, in the South Platte drainage. The work was done as a Works Progress Administration project under the direction of L. L. Stimson. W. H. Sawhill assisted in the preparation of an agricultural economic report covering the area of some 600,000 acres of irrigated lands in Boulder, Larimer, Weld, Morgan, Logan, and Sedgwick Counties, in Northern and North-eastern Colorado, which would be affected by this project. The scope of the study included the gathering and compiling of agricultural data relative to crops, livestock, valuations, social relations, use of water, economic losses due to water shortage, and other factors relating to the problem.

METEOROLOGY.—Meteorological observations have been taken by H. O. Caperton, who succeeded R. E. Trimble. There has been con-

tinuous interest shown in the weather records, not only in the current data but also in the records extending over a period of more than 50 years. Several agencies have compiled data from the information on file in connection with land use, watershed protection, and agricultural economic studies. Various institutional departments, as well as local business and industrial agencies, have used these records.

Because of the growth of trees, plans are being considered to change the location of the meteorological plot to a more favorable site in order that weather observations may be more representative of actual conditions.

RIO GRANDE JOINT INVESTIGATION.—Another special study which required considerable time is the Rio Grande joint investigation. Carl Rohwer was assigned to the work on the project in Colorado from June 1936 to February 1937. The work consisted of mapping the irrigated crops and the native vegetation, and the study of the use of water in the San Luis Valley. A mimeographed report was prepared in collaboration with others working on the project. This report will be published by the National Resources Committee.

Pathology and Bacteriology Section

Meeting Immediate Problems

POISONOUS PLANTS.—Reports came to the Pathology and Bacteriology Section that a cattle disease existed on ranches in the mountains west of Golden similar to that which was investigated in Moffat County in 1934 and 1935. In cooperation with Dr. L. W. Durrell of the Botany Section, the range there was surveyed, and at least three species of timber milkvetch were found to be prevalent. The cattlemen suspected a plant which is very common throughout the mountain regions and locally known as "yellow banner" (*Thermopsis*). Naturally, the milkvetch was suspected.

Four cattle were sent to the region, two being fed the banner and two the vetch. The two animals were kept on the banner for 2 weeks, during which time they ate very little, as it seemed to be decidedly unpalatable. Finally, to keep them from starving they had to be removed. The other two were kept on the vetch for 3 weeks, at the end of which time one of them developed typical symptoms such as had been seen in Moffat County. The other, although kept on the same material for an additional week, never developed symptoms. While this vetch is a different species (*Astragalus decumbens*), it apparently contains the same poisonous element as that in Moffat County, although not in such concentrated form. Horses are also reported as

having been poisoned in the same vicinity, but no trials were made with those animals.

OAT HAY POISONING.—New outbreaks of this condition continue to be reported. On March 26 of this year 11 head of cattle died following the feeding of stacked hay during a snowstorm and under conditions similar to those previously described. This outbreak occurred on the same ranch near Franktown where the 67 head died last year and where 21 head died in 1923. The difference this year was that the hay was largely composed of barley, pigweed, and some native grass. There appeared to be no oats in it at all. Tests made on some of the animals the following day by means of picric-acid paper gave negative reactions for hydrocyanic acid. The same was true of hay brought to Fort Collins and examined in the chemical laboratory here.

On the same day that this loss occurred, 5 animals were lost out of 30 fed oat hay during a snowstorm a few miles west of Fort Collins. Again, on April 7, out of the 25 left, 5 more sickened and 3 died under similar conditions. The peculiar part of this is that the hay had been previously fed without ill effect and was continuously fed in the interim. In each instance also the top, which was wet, was fed to the dairy cattle with the result noted, and that underneath, which was dry, was fed to the stock cattle at the same time without ill effect.

At Gulnare, near Trinidad, oat hay of good quality was fed during a snowstorm on April 7 with the loss of 8 head of cattle. This same hay was fed continuously until April 24, at which time another snowstorm occurred. By this time the stack bottom was thoroughly wet, and the owner felt that it might be unsafe. He therefore removed the top of another stack and fed the hay from underneath, with the result that 10 more animals died.

These outbreaks are interesting because they show a repetition in the same year and on the same feed. Reports have also come from other areas indicating the possibility of barley hay and wheat straw being toxic when wet. Dr. Van Es of the Nebraska Experiment Station has informed us of an outbreak in which 24 cattle died after eating oat hay during a storm in that state.

ENCEPHALOMYELITIS.—The outbreak of encephalomyelitis in 1936, which was the fourth in the last 5 years, involved chiefly the northern Colorado area from Denver to Fort Collins and east to Fort Morgan. A total of 1,724 cases were reported by the veterinary practitioners, with a mortality of around 20 to 25 percent. It seems probable that as many more horses were affected in cases which were not reported to veterinarians. It is probable, also, that in the untreated cases the mortality was heavier. There were only 63 cases reported from the Arkansas Valley, where the disease has been very prevalent in previous years, and only 6 cases from the Western Slope, where it was

quite prevalent in 1935. No cases were reported from the San Luis Valley, in which a rather serious outbreak occurred in 1932.

One peculiarity of this outbreak was the presence of either a recurrence or a new brain disease in October and November. Some animals were affected that had recovered from encephalomyelitis earlier in the season. A considerable percentage also had previously received serum as an immunizing agent. Since, however, nearly 30 percent of those affected had not been injected with serum, the disease could hardly be attributed to previous administration of that product. While the evidence still remains clouded, there is much reason to believe that this so-called recurrence was a separate malady. Because the disease has developed four times in the last 5 years, it seems wise this year to recommend vaccination of all horses in the exposed areas prior to the usual time of the outbreak, which is July and August.

Sheep Problems Studied

DEATH LOSSES IN LAMBS.—The work with intestinal filtrates previously mentioned has continued during the past winter. Out of a total of 95 filtrates examined, 37 were found to be toxic. All these toxic filtrates came from lambs dead of what was clinically regarded as overeating. Seventy-five lambs dead of overeating were examined, so that approximately half were non-toxic. The other intestinal contents were from lambs dying of various other diseases, but not a single one of these was toxic. Some 30 cultures of *Cl. welchii* have been isolated from these, but the particular type has not yet been determined.

SOREMOUTH.—From a limited experience in vaccinating lambs on arrival in feedlots, it would seem that this practice is not only a wise procedure but is quite effective in the prevention of complications, even though the disease has already made its appearance.

PARASITES.—In 92 consecutive autopsies on feeder lambs, 72 were found to be carrying coccidia; 24, stomach worms (*Hemonchus contortus*); 17, worms which are commonly found in the small intestines (*Nematodirus fillicolis*); 7, hookworms (*Trichuris ovis*); 10, fringed tapeworms in the intestines and 11 of the same parasite in the bile ducts; and 3 showed the large tapeworm (*Monezia expansa*). This work was done in order to get a cross section of the parasite infestations in feeder lambs and indicates, as in previous years, that coccidia are almost universally present in these animals, whereas the other parasites are not present in sufficient numbers to give serious concern.

Cattle Disease Problems

URINARY CALCULI.—So many reports of urinary calculi in both cattle and sheep are coming to the station that a comprehensive experiment to throw more light on this question is urgent. While a great deal of work has been done at various stations there is still no

clear understanding as to the relationship of the various causative factors, such as water, feed, infection, and vitamin deficiency. Heavy losses occurred in several feedlots during the past winter, one of which went above 5 percent. Whenever money is available, an experiment should be set up designed to gather more information on this increasingly important problem.

BANG'S DISEASE.—The cattle belonging to the experiment substation at Avon were tested on November 13, 1936. Of 103 cattle tested, 24 were classed as positive and 17 as suspects. The positive ones were sold. On April 26, 1937, 97 cattle were tested, with 5 reactors and 15 suspects; disposal of the 5 reactors is recommended, and the herd should be tested again in 60 days.

Our cooperation with the federal Bang's disease control program, in which 23,800 tests have been run during the past year, continues.

Studies of Soils

MICROBIOLOGICAL TESTS FOR AVAILABLE PHOSPHORUS.—Adaptability of the Cunninghamella method as a test for available phosphate in the calcareous soils of Colorado was studied. Tests on plots of the Agronomy Section receiving treatments of nitrogenous and phosphatic fertilizers indicated that the Cunninghamella growth was affected only by the phosphatic fertilizer, and that it was well correlated with crop growth. Further tests on field soils with a known response to phosphate showed a general agreement between the Cunninghamella and field tests. There were a number of exceptions, however, and the method cannot be applied as a routine test without further study. Approximately 100 additional soil samples are now available and awaiting test.

Studies have also been made on the relation between the rate of decomposition of mannitol and sodium benzoate in a soil and the availability of its phosphate.

MICROBIOLOGICAL ACTIVITIES OF SLICK-SPOT SOILS.—Work on this project has continued to center around a study of the non-symbiotic nitrogen-fixing bacteria. Investigations during the past year have dealt with the effect of organic materials such as straw, mannitol, and sodium benzoate, used either alone or in combination with the inorganic elements iron, molybdenum, potassium, and phosphorus. Determinations of the abundance of Azotobacter cells and of nitrogen fixed were made.

It was found that the chief need for increased activity of Azotobacter in soils was a supply of available organic material. The inorganic nutrients, when used alone, brought about no increase in Azotobacter population. When used in conjunction with organic materials, phosphorus and potassium exerted a significant effect in increasing the number of Azotobacter cells present in the soils tested.

There was no significant correlation between the abundance of Azotobacter and the amount of nitrogen fixed.

The information now accumulated indicates that Azotobacter probably does not play an important part in adding to the nitrogen content of Colorado soils.

DECOMPOSITION OF ORGANIC MATTER.—Investigations on nitrogen sources for cellulose-decomposing bacteria have shown that differences in pH of the medium induced by different nitrogen compounds were important factors. Further, selective absorption of the nitrogen radical by the bacteria brought about pH changes in the medium sufficiently great to materially affect the decomposition process.

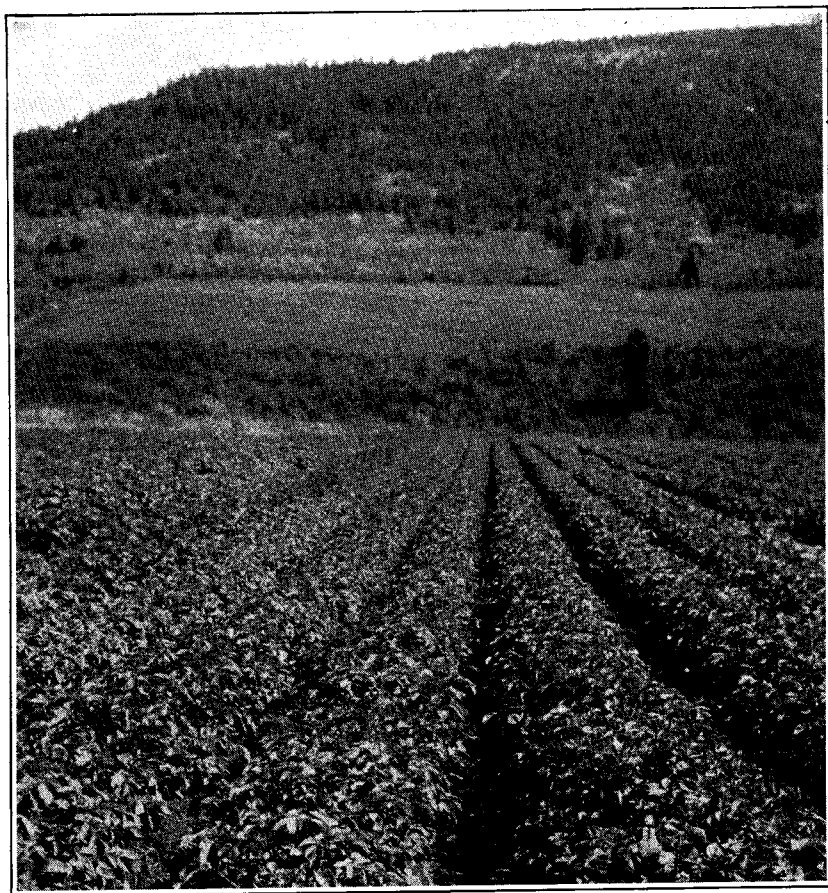


Figure 6.—Russet Burbank potato seed improvement test plots at the Avon Substation.

Poultry Section

Equipping the Plant

During the past year the Poultry Section has developed the nucleus of an experimental plant. The Poultry Building includes offices, a classroom, and a well-equipped chemical laboratory. The Poultry Experimental Laboratory has an incubator room and a brooder room in the basement and breeder pens on the main floor. The incubator room contains several incubators, a pedigree table, and a candling booth. The brooder room has 16 floor pens equipped with wire floors, and several battery brooders. There are 12 breeder pens on the main floor, completely equipped. At present they are being used to house breeding and experimental chickens and turkeys.

The poultry feed house has a new feed mixer, scales, and ample storage space for feed. The poultry range is fenced and in use. At present, there are three range shelters for chickens, with three more for turkeys and an automatic water system in process of construction.

Projects Under Way

INORGANIC ELEMENTS IN POULTRY NUTRITION.—Preliminary results indicate that ferric citrate increases the severity of perosis when added to the basal diet, presumably due to interference with manganese metabolism. The lack of causative effect of a sample of phosphoric acid is contrary to results of other workers with phosphates, indicating the necessity for further work on this sample.

VITAMIN-G REQUIREMENTS OF TURKEY BREEDERS.—This project has been started and is in cooperation with the Pathology and Bacteriology Section. No results are yet available.

SOURCES OF GREEN FEED FOR POULTRY.—Attention is being given to green feeds as sources of vitamins A and G and of protein, since these nutrients appear to be limiting factors in many poultry rations in Colorado. A preliminary assay showed that sprouted oats and beet-top silage contained about 15 chick units of vitamin G per gram and soybean silage about 8 units. Further studies on these products are planned. One is now in progress on the substitution of sprouted oats for dried buttermilk and alfalfa meal in a breeder ration. As another phase of this project, a small area in the range has been seeded to replicate plots of seven different pasture grasses in an effort to determine their suitability for poultry ranges where irrigation water is available. This phase is being conducted in cooperation with the Range and Pasture Management Section.

Range and Pasture Management Section

Range Utilization Important

An important land use in Colorado is the utilization of our range resource by livestock. The economic importance of both the range resource and of the production of livestock in Colorado are brought out in a recent report of the United States Bureau of Agricultural Economics. According to the report, there are approximately 5,000,000 head of livestock (farm and range) in the state. The value of all range livestock exceeds \$91,000,000 and produces an annual income to the livestock raisers of nearly \$60,000,000 in beef, mutton, and wool. It is estimated that 50,000,000 acres of land in the state are of value for livestock grazing, which amounts to 75 percent of the total land area of the state. Profitable production of range livestock is dependent upon the permanency of the range forage resource; however, its permanency may be jeopardized by adverse climate and overstocking.

Vegetative Regions

The native range land of the state may be grouped into five main vegetative regions: plains grassland, approximately 27.5 million acres; open forest, 9.2 million acres; sagebrush, 5.9 million acres; salt desert shrub, 2.7 million acres; and pinyon-juniper, 4.7 million acres. The plains grassland and open forest regions rank as the most important vegetative regions from the viewpoint of the range resource and grazing of livestock. The native forage in these regions is by all means the cheapest feed that the stockman has for his livestock, but it ceases to be cheap feed once it is overstocked.

Projects Initiated

The program of range research in the section during the past year consisted of the following projects:

ARTIFICIAL REVEGETATION OF DEPLETED RANGE AND ABANDONED CROP LANDS.—Studies in this project consisted of testing out native and introduced species in the grass nursery at Fort Collins. Field data were obtained on the behavior and growth requirements of the various species. Studies were started to determine the most practical methods of artificial revegetation of several native grasses. A recent inventory of the nursery shows that there are 79 species of grasses, grass-like plants, and herbs, of which 95 percent are grasses. Twenty-seven introduced species, mostly grasses, were obtained during the past 5 years from the Bureau of Plant Industry, Department of Agriculture, at Washington, D. C. Six of the grasses failed, and of the

remainder at least 15 show promise. The most promising species are several Manchurian wheatgrasses; namely, *Agropyron cilarae*, *A. semicutatum*, and *A. caninum*.

An important phase of artificial reseeding is to determine the best depths for sowing range-grass seed. Tests were conducted at depths of $\frac{1}{4}$ inch, $\frac{1}{2}$ inch, $\frac{3}{4}$ inch and 1 inch, $1\frac{1}{2}$ inches and $1\frac{3}{4}$ inches, 2 inches and $2\frac{1}{2}$ inches. Earlier and better germination occurred at depths of from $\frac{3}{4}$ inch to 2 inches. Germination at the more shallow depths was less and uncertain because of the rapid desiccation of the soil. Results indicate that crested wheatgrass (*Agropyron cristatum*) should be sown at $\frac{3}{4}$ inch to $1\frac{1}{2}$ inches, smooth brome (*Bromus inermis*) 1 to 2 inches, and western wheatgrass (*Agropyron smithii*) 1 to $1\frac{1}{2}$ inches.

Excellent results were obtained in transplanting sod cubes of blue grama, buffalo grass, and western wheatgrass to various spacings on bare soil.

The plan in the nursery is to approximate dry-land conditions as nearly as possible; therefore, irrigation water is not used.

It is planned to extend the artificial revegetation studies to field tests in the near future. Studies are also to be undertaken under controlled grazing.

MANAGEMENT OF NATIVE RANGES AND IRRIGATED PASTURES.—In the period 1920-35 the Animal Investigation Section, in cooperation with the Botany Section, conducted range investigations to determine the effects of various grazing systems on range livestock production and on native range. An experimental range area, consisting of approximately 600 acres of short-grass and foothill range located four miles west of Fort Collins, was available for the study. The range area was fenced and cross-fenced in order to meet the requirements of the three grazing systems: continuous grazing from the start of vegetative growth in the spring until late fall, deferring grazing until the prominent range grasses attain vegetative readiness, and a system of deferred and rotation system (two pastures).

A new project was outlined in cooperation with the Animal Investigations Section. The more important changes are concerned with the plan of management of the various pastures. Some additional fencing is to be done in order to eliminate a lake and to make two pastures more comparable in respect to vegetation.

The new plan of management makes use of four pastures: two under the deferred and rotation system, one conservatively grazed throughout the grazing season, and the fourth a chaparral-grass pasture grazed conservatively from early fall to late fall. The season and manner of use of each pasture were determined from range-survey field data obtained in 1936. The cattle are to be weighed at 20-day intervals during the grazing period. Careful records are to be obtained on weighing days on the growth of the vegetation through the

main growing season and on the utilization of the prominent grasses by livestock.

Studies on irrigated farm pastures are to be started in the near future. Pertinent phases of work, namely, the perpetuation of irrigated pastures over a period of years based upon the best methods of management and their rehabilitation by artificial reseeding, are to be studied.

MANAGEMENT OF NATIVE HAY MEADOWS IN HIGH MOUNTAIN PARKS.—The native-hay meadows of Colorado are mostly located in the high mountain parks and valleys. These meadows were formerly sagebrush or open park lands that were cleared and originally sown to tame hay species. Many of the meadows have reverted to native sedges and rushes. The yield of native hay in the meadows appears to be on the decline. A project was started in North Park in 1932 to determine scientific and practical methods of increasing their productivity and at the same time securing more economic use of irrigation water.

A study on regulation and distribution of irrigation water was started in 1933. The common practice in North Park is season-long irrigation to start May 15, in some years earlier, and to continue until about July 10. Besides this common practice of irrigation, two other practices were introduced on experimental meadow areas: (1) Early intermittent irrigation to start May 15, then continue for 3 days, discontinue for 3 days and then repeat; and (2) late intermittent irrigation to start June 1 and to continue for 3 days, discontinue for 3 days, and again repeat throughout the irrigation season.

Better yields of hay were obtained on the continuously irrigated plots over a 4-year period than under the other practices. The average yield of hay under continuous irrigation was at the rate of 1.56 tons per acre; under early intermittent irrigation, 1.39 tons per acre, or 10.8 percent less yield than the first practice; and under late intermittent irrigation, 1.13 tons per acre, or 27.6 percent less yield than under the first practice.

The various methods of irrigation showed a marked influence on the different classes of vegetation from 1933 to 1936. Grasses, notably timothy (*Phleum pratense*) and tufted hairgrass (*Deschampsia caespitosa*), decreased 12 percent in area under continuous irrigation and 2 percent under early intermittent irrigation, but increased 5 percent under late intermittent irrigation. The grass-like plants, *Carex* spp. and *Juncus* spp., increased 7 percent under the first type of irrigation but declined as much as 10 percent under late intermittent irrigation. Indications are that too much water is detrimental to the stand of grasses but improves the stand of the grass-like plants.

Additional studies are needed to determine the water requirements of the various hay species, that is, how much irrigation water is required to produce a ton of hay; to determine the effect of early spring and late fall grazing of meadows on ultimate hay yield; and

to determine practical methods to improve the meadows, either by artificial reseeding or by some mechanical means.

RANGE RESOURCE SURVEYS IN WASHINGTON COUNTY.—An intensive range-resource survey project was started in May 1936 in Washington County. The purpose of the project is to obtain factual data concerning the agricultural resources of the county, particularly the native-vegetation resource. Such information is needed primarily to develop long-time land-use plans that will assure the best use of the land resource on a more stabilized basis. Plowing, overstocking, and recurrence of droughts are responsible for the reduction of the original area of native-grass cover. Considerable dry-land farmed areas are abandoned because of drought and depression. These conditions are responsible for the existing uncertain economic situation.

The field work was started in May 1936 with a crew of two senior students, and on June 1 two more students were assigned to the crew. The crew completed a survey of 27 townships (622,080 acres) in the 1936 field season. The native pasture land, cropland, and abandoned cropland were surveyed and located on field maps. The vegetation on the native pasture lands and abandoned croplands was mapped and classified as to vegetative types in order to determine their plant successional trends and grazing capacities.

The analysis of the field data has progressed to a point where it is possible to give several tentative conclusions of the survey. In the hardlands (heavy clay soils) 65.4 per cent of the land area is at present used for agricultural crops as contrasted to 26.9 percent in the sandhills; native vegetation occupies 23.8 percent of the hardlands as against 69.0 percent in the sandhills.

Considerable abandonment of cropland was found in the north central part of the county, in the hardlands. In an area of 10 townships, 16.0 percent of the land area was abandoned, and 71.0 percent of the abandonment occurred in the last 10 years.

The native vegetation in the hardland soils consists chiefly of the two short grasses, blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). These grasses occur in mixture and make up 90 percent of the total vegetation. Consequently, they are the most important vegetative species in the consideration of grazing capacity on the short-grass plains. Preliminary analysis of the grazing capacity data indicates that the rate of stocking for the short-grass ranges should be 4.4 surface acres per cow-month and in the sandhills 6.4 acres per cow-month, or 18 and 12 head per section on an 8-months basis, respectively.

The resource survey of Washington County is to be completed during the 1937 field season. It is planned to publish the results of the survey during 1938.

Rural Economics and Sociology Section

Agricultural Adjustments

During the current year the Economics and Sociology Section cooperated with the Division of Farm Management and Costs of the Bureau of Agricultural Economics, the U. S. Forest Service, and the Soil Conservation Service, U. S. Department of Agriculture, in an analysis of economic conditions affecting farmers in Routt and Moffat Counties in northwestern Colorado, and in Logan, Phillips, and Washington Counties in northeastern Colorado.

In the former area special attention was given to economic conditions affecting the permit-distribution policy on public range lands of the Yampa River drainage basin, while in the latter region consideration was given to a study of farm organization and soil-management practices, particularly in relation to agricultural conservation and adjustment, with special reference to the formulation of programs under the Soil Conservation and Domestic Allotment Act. The Bureau of Agricultural Economics contributed \$1,202.52 to this project.

ECONOMIC SURVEY OF YAMPA AREA.—This is a good agricultural area. It has suffered from drought and low prices, but its cattle and sheep production compares favorably with that of most western range country. The people are agreed upon the need for some changes. They fear arbitrary action. They are ready to sit down around the conference table and to aid in working out their common problems. It is our conviction that the community as a whole should unite to assist in bringing some improvements into the area such as a shift from small, unsuccessful farms to larger sized livestock farms; an increase in milk production for a cheese factory; a concentration of population in the fertile valleys, with a consequent reduction in the cost of maintaining scattered roads and schoolhouses on the higher, rougher grazing lands; a reduction in the present rate of stocking the winter range; an increase in the use of hay for the winter feeding of sheep; an increase in the use of irrigated pasture for beef production; and more uniform rules for the administration and use of public lands.

CONCLUSIONS, NORTHEASTERN COLORADO.—It is apparent that part of the difficulties in dry-land farming may be found in an unwise use of land. Trained observers are in agreement with regard to the need for improved practices in cultivating these lands and also in setting aside certain areas for grazing purposes. Special problems exist on each individual farm, and there is no one program that will fit all cases. One experienced dry-land farmer suggests, "We must be continuously learning and adopting other ideas and practices which will mean better farming. Every year appears to be different, and each

recurring season brings new problems which must be met as they arise. These variable conditions which must be handled individually are the basis of my belief that a person never learns how to farm precisely for the production of wheat in this country. He must keep discovering new facts and adopting new practices."

It would seem to be desirable to adjust the cropping system so as to increase the stability of income and to aid in conserving soil moisture. This will undoubtedly involve a reduction in cash crops; it will mean an increase in feed crops, and it will undoubtedly bring additions to the numbers of livestock maintained in this region. There is need for a continuous study of dry-land agriculture, particularly from the standpoint of the practices employed by the more progressive farmers. The results of such a study should aid in developing a more permanent and satisfactory type of farming for the various grades of land which are common to this region.

Type of Farming

In a former report it was pointed out that the adjustment project may be considered an extension of our type-of-farming study. While the latter was based in part upon detailed census figures for 1930 and was supplemented in turn with farm and ranch organization data, it has been apparent that we need much additional information for practically all the major type-of-farming areas in this state in order to permit us to offer specific recommendations with respect to the most profitable combinations of crop and livestock enterprises for each area. The records obtained in Moffat and Routt Counties and the information assembled from northeastern Colorado have provided a much more adequate picture of types of farming in these two sections, and from these records it will be possible to suggest improved plans and programs for these areas. These studies will be continued during the coming year.

Sheep and Cattle

In our cooperative work with the Forest Service in northwestern Colorado contacts were made with a number of individuals who are giving primary attention to the production of lambs and wool. Records were secured from other individuals who are engaged in the production of beef cattle. Several of these men agreed to cooperate further in a detailed study of their business. A few have adopted a simple method of keeping the ranch account. It is our plan to visit this area during the coming season for the purpose of assisting these men with their records and also to secure additional information with respect to the organization and operation of these two types of ranches.

Highway Taxation

Approximately two years ago a project was undertaken in cooperation with the Bureau of Public Roads in Washington, D. C., with

the State Highway Department and with one or more other agencies here in Colorado, in order to make a careful analysis of highway utilization and finance and the relation of expenditures on roads to other state governmental activities. A report covering these activities was completed early this year but the publication of this manuscript has been delayed somewhat pending agreement with respect to certain changes and modifications of the report.

Farm Mortgages

Cooperation was also undertaken with the Bureau of Agricultural Economics, U. S. Department of Agriculture, with regard to a study of farm mortgages in this region. In this analysis approximately 200,000 farm-mortgage records have been assembled. The study has indicated that federal loaning agencies are now supplying approximately 50 percent of the long-term credit in the plains area and a considerable portion of this same type of credit for the mountain counties.

Rural Sociology

Our major research efforts during the current year have been devoted to the cooperative relationships with the Rural Section, Division of Social Research of the Works Progress Administration. In the development of these activities Prof. O. F. Larson of this department has represented the station, but this work has been done without additional remuneration. A total of \$11,493.06, all but \$264 of which was allotted by FERA and WPA, will have been expended for rural research under these cooperative agreements during the period from July 1, 1936 to June 30, 1937. The \$264 was provided by the Council for Research of the Social Sciences of Columbia University. Our accomplishments in this field during the year have been as follows:

A continuation of DRS-162, which has involved a study of public and private assistance in rural areas for the purpose of securing an adequate picture of trends in this field. Monthly results and comparisons for Colorado are published in Current Statistics of Relief in Rural and Town Areas, by the Rural Research Section, Division of Social Research, Works Progress Administration, Washington, D. C.

The inauguration of DRS-275, a study of public assistance extended to households in drought areas in four sample counties to ascertain all types of aid extended by public agencies, duplication of aid, and characteristics of cases receiving help. This analysis covers the period from July to December 1936. The field work is completed, and an analysis of the records is in process. This study has had the practical result, in the sample counties at least, of securing close coordination of public agencies, of eliminating padding and needless duplication, and of improving local administration and local records.

Several county departments of public welfare have installed statistical cards devised by our research personnel for record keeping.

Special studies have been made for WPA administrative purposes, including a survey of the use, value, and cost of the federal surplus commodities program and an examination of the employability of cases receiving general relief in January, February, and May.

A complete census has been made of two rural villages for the purpose of making a study of rural youth in collaboration with the National Youth Commission, the U. S. Department of Agriculture, and the Works Progress Administration. This project was financed by the Council for Research in Social Science, Columbia University.

An experiment station project relating to the social aspects of land utilization is in progress at this time. This will emphasize the human phases of land use and policies.

R. W. Roberts, graduate research assistant, has been doing some work preparatory to a rural standard-of-living study.

The services rendered in connection with these various projects have included special reports for the Soil Conservation Service, for the Resettlement Administration, and for the State Department of Public Welfare. At the request of the Station Youth Association, suggestions were made for a National Youth Association program adapted to the needs of rural youth.

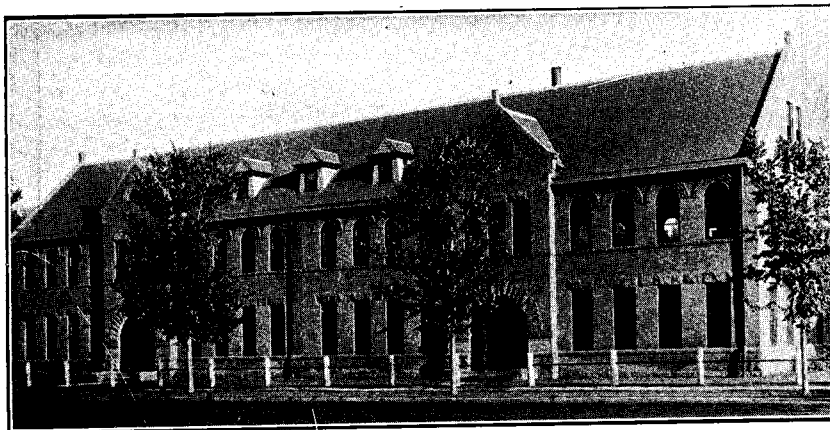


Figure 7.—Mechanical Engineering Building, Colorado State College.

Seed Laboratory

The most perplexing problem of the Seed Laboratory has been how to use the appropriation of \$5,000.00 most advantageously. The purpose of the Colorado Seed Laboratory, financed for the most part from state funds, is to promote the use of better seeds by farmers.

Recent reports give the number of farms in Colorado as approximately 65,000. It is obviously impossible for one small laboratory to test even one sample for each of these farms. Seed surveys made by this laboratory in various communities show that the use of uncleaned, untested seed is the chief source of noxious-weed infestations on Colorado farms.

Seed Surveys

The following brief summary of results of tests of seeds collected from drills in Larimer County indicates that farmers are seriously infesting their farms by planting seeds of noxious weeds.

Kind of seed	Source of seed	Number with noxious weeds	Number free from noxious weeds	Total number
Oats	Raised by planter.....	18	1	19
"	From neighbor.....	3	1	4
"	From elevator.....	2	1	3
Barley	Raised by planter.....	24	8	32
"	From neighbor.....	4	2	6
"	From elevator.....	4	3	7
Wheat	Raised by planter.....	7	5	12
"	From neighbor.....	2	2	4
"	From elevator.....	6	3	9

Approximately 75 percent of the samples of cereals planted contained noxious weeds. One farmer planted 239,000 seeds of wild morning-glory, and two kinds of povertyweed on 20 acres.

A survey made by the seed inspector in several Colorado counties this year shows that there is little sentiment favoring the use of seeds of known quality in these counties. Lists put out as "Seed for Sale" in these counties appear to be lists of the grain on these farms. One county put out a list of 231 lots which, in round numbers, make up the following large totals: 14,635 bushels of corn; 40,000 bushels of wheat, oats, barley, and rye; 29,000 bushels of cane, milo, kaffir, and sudan; 30,000 pounds of alfalfa.

There was no indication whatever that any of this so-called seed had been tested or was labeled to conform to the provisions of the pure-seed law. The inspector visited all farms with large lots being offered as seed and talked by telephone with many others. He found

complete ignorance in regard to the seed law and in regard to the quality of seed he was offering for sale. So far as these farmers were concerned a test on seeds is something the dealer requires the farmer to have before the dealer will buy his seed.

A few counties sponsor a good seed program, that is, the planting of good seed, but the situation outlined in the foregoing paragraph is typical of many counties.

Seed Inspection

When it has been possible to carry on seed-inspection work for several successive years, the laboratory has been able to obtain cooperation of dealers to an extent that all large lots of seeds are adequately labeled. When inspections are not made, dealers grow lax. The following summary shows results of inspection of alfalfa seeds in one community in Colorado when no inspection had been carried on:

Larimer County alfalfa-seed inspection:

Samples collected	41
Samples of Colorado-grown seed.....	10
Samples of Utah-grown seed.....	11
Samples of seed from all other states.....	20
Samples containing noxious weeds.....	20—Approx. 50%
Samples from Colorado containing noxious weeds	2—20%
Samples from Utah containing noxious weeds	11—100%
Samples from all other states contain- ing noxious weeds.....	11—Approx. 50%

Approximately 25 percent of the lots of alfalfa seed offered for sale in Colorado were from New Mexico and Oklahoma and are therefore considered unadapted for use in Larimer County.

If farmers could be persuaded to use only good seed, no general inspection would be necessary.

During recent years the seed-selling situation has changed. Formerly, there were approximately 600 merchants of various types and an occasional farmer selling seeds. There are now nearly the same number of dealers, but thousands of farmers have turned seed merchants. The cost of inspecting seeds offered for sale by farmers is prohibitive. The only feasible solution appears to be a state-wide program to encourage the use of good seeds.

Laboratory Tests

The following is a brief summary of the seed testing of the laboratory to date:

Current samples.....	2,828
Seed survey of Wellington community.....	100
Inspection samples completed.....	123
Inspection samples on hand.....	600
	<hr/>
Total samples received.....	4,651

The large number of samples received daily for some weeks made it impossible to report samples in less than 3 weeks. During the active wholesale-buying season this resulted in large numbers of telegrams and long-distance telephone requests for immediate attention to those samples. In most cases the tests were desired that seeds might be sold by farmers to dealers. The ideal, of course, is the reverse.

Seeds are still being received, but at the present time we are able to report in a reasonable length of time.

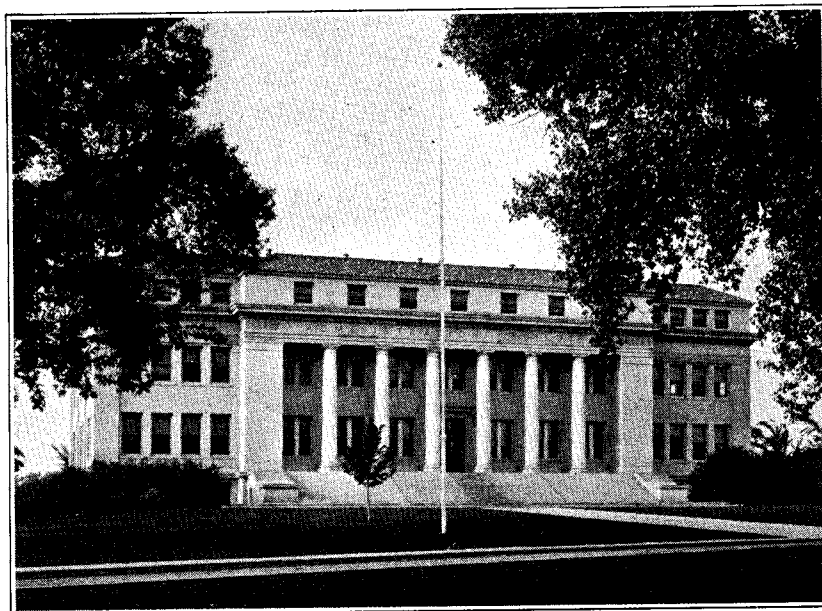


Figure 8.—Administration building, Colorado State College; location of station administrative offices.

Editorial Service

The Editorial Service during the year has published 12 bulletins, totaling 340 pages, as follows:

Popular Bulletins

No.

- 426—"Oiled-Gravel Roads of Colorado," by E. B. House; 29 pages.
428—"Pyrethrum Plant Investigations in Colorado," by C. B. Gnadinger, L. E. Evans, and S. C. Corl; 29 pages.
429—"Poisonous and Injurious Plants of Colorado," by L. W. Durrell and I. E. Newsom; 75 pages.
430—"Oat Production in Colorado 1928-1935," by D. W. Robertson, Dwight Koonce, J. J. Curtis, and J. F. Brandon; 31 pages.
431—"Barley Production in Colorado 1928-1935," by D. W. Robertson, Dwight Koonce, J. J. Curtis, and J. F. Brandon; 36 pages.
432—"Western Rose Curculio," by John L. Hoerner; 19 pages.
433—"Equipping a Small Irrigation Pumping Plant," by W. E. Code; 55 pages.

Press Bulletins

- 89—"Some Injurious Plant Lice of the American Elm," by George M. List and C. P. Gillette; 7 pages.
90—"Beet Tops for Fattening Steers," by George E. Morton, H. B. Osland, and R. C. Tom; 11 pages.

Technical Bulletins

- 17—"Notes on *Cryptolestes Ferrugineous* Steph.," by Elwood H. Sheppard; 20 pages.
18—"Further Studies on Vitamins in Alfalfa Hay," by C. E. Vail, J. W. Tobiska, and Earl Douglass; 19 pages.
19—"Protein Content of Corn as Influenced by Laboratory Analyses and Field Replication," by Warren H. Leonard and Andrew Clark; 9 pages.

Miscellaneous Publications

Two publications other than bulletins, totaling 60 pages, have been published as follows:

- Forty-ninth Annual Report, Colorado Experiment Station; 44 pages.
Accomplishments of the Colorado Experiment Station; 16 pages.

Technical Articles

In addition to the regular station publications, many of the findings of the Colorado Experiment Station appear each year in scientific publications. This year, for the first time, an effort has been

made by the station editor to compile a list of these articles for the period covered by this report. It appears desirable to make such a list, not only that the authors may receive the credit they deserve, but that the list may be made available because of its reference value.

Section heads have cooperated in this effort, and in addition the lists published by the U. S. D. A. Library in "Agricultural Library Notes" have been consulted. It is possible that there are errors of omission in the case of this first list. However, it represents a beginning, and it is hoped that with its establishment as a feature of the annual report it may command sufficient cooperation in succeeding years to permit the compilation of complete lists.

The editorial service has no record of these articles in its own files, since they are not handled through the office of the station editor. However, by a recent order of the station director the services of the editor have been made available upon request to the authors of such articles, and this service promises gradually to grow into an important part of the editor's work.

For the period from July 1, 1936 to June 30, 1937, the following technical articles have been published:

- (Barber, C. W.). Ward, J. C., Barber, C. W., Garlough, F. E., and Munch, J. C. Red Squill V. The Susceptibility of Hogs to Red Squill. *Jour. Amer. Pharm. Assoc.*, 26:137-139. Feb. 1937. (J. C. Ward, F. E. Garlough, and J. C. Munch, U. S. D. A.)
- Barmore, Mark A. Recent Developments in the Chemistry of Storage and Preparation of Foods. *Food Research*, 1:383-399. Sept.-Oct. 1936.
- Barr, C. Guinn. Preliminary Studies on the Carbohydrates in the Roots of Bindweed. *Jour. Amer. Soc. Agron.*, 28:787-798. Oct. 1936.
- Bodine, E. W. and Durrell, L. W. The Maynard Plum—A Carrier of the Peach Mosaic Virus. *Science n. s.*, 86:81. July 23, 1937.
- Bodine, E. W. Control of Peach Mosaic in Colorado (abstract). *Phytopathology*, 27:954. 1937.
- Bodine, E. W. The Maynard Plum—A Carrier of Peach Mosaic (abstract). *Phytopathology*, 27:954. 1937.
- (Bodine, E. W.). Hutchings, Lee M., Bodine, E. W., and Thornberry, H. H. Peach Mosaic, Its Identification and Control. U. S. D. A. circular 427. May 1937. (Lee M. Hutchings, U. S. D. A.; H. H. Thornberry, Ky. Exp. Sta.).
- Burdick, R. T. Adjusting Forest Service and Public Domain Permits to Land Ownership. *Western Farm Econ. Assoc. Proc.* 1936.
- Donaldson, D. N. Do Present Trends in the Teaching of Economics Jeopardize the Future Value of Research? *Jour. Farm. Econ.*, 18:755-758. Nov. 1936.
- Gardner, Robert. A Method of Measuring the Capillary Tension of Soil Moisture Over a Wide Moisture Range. *Soil Sci.*, 43:277-283. April 1937.
- Hoerner, John L. Dry Pyroicide and Gypsum for Control of the Squash Bug, *Anasa tristis* De G. *Jour. Econ. Ent.*, 30:375. April 1937.
- Hoerner, John L. Control of the Squash Bug (abstract). *Jour. Colo.-Wyo. Acad. Sci.*, 2:80. June 1937.

- Kreutzer, W. A. A Vascular Rhizoctonosis of Sugar Beet (abstract). *Phytopathology*, 27:955. 1937.
- Kreutzer, W. A. A *Phytophthora* Rot of Cucumber (abstract). *Phytopathology*, 27:955. 1937.
- Larson, Olaf F. Rural Relief and Agricultural Adjustment. *Western Farm Econ. Assoc. Proc.* 1936.
- McCrorry, B. R. and Ward, Justus C. The Toxicity of Thallium Sulfate for Cattle. *Jour. Amer. Vet. Med. Assoc.*, 89:301-312. Sept. 1936.
- Metzger, C. H. Some Preliminary Notes on the Effect of Psyllid Yellows on Seed Stock from Infected Plants. *Amer. Potato Jour.*, 13:277-285. Oct. 1936.
- Metzger, C. H. Curly Dwarf in Colorado. *Amer. Potato Jour.*, 13:316-317. Nov. 1936.
- Metzger, C. H. The Influence of Planting Date on the Yield, Quality, and Development of the Russet Burbank Potato. *Amer. Soc. Hort. Sci. Proc.* 33 (1936) 34:437-438. 1937.
- Moorhouse, L. A. President's Address. *Western Farm Econ. Assoc. Proc.* 1936.
- Moorhouse, L. A. Sweden the Middle Way (book review). *Colo. Coop. Inst. Proc.* Nov. 1936.
- Moorhouse, L. A. The Second United Order Among the Mormons (book review). *Jour. Farm. Econ.*, 19:365-368.
- Newsom, I. E., Barber, C. W., Groth, A. H., Stout, E. N., and Thorp, Jr., Frank. Oat Hay Poisoning. *Jour. Amer. Vet. Med. Assoc.*, 90:66-75. Jan. 1937.
- Newsom, I. E. Strangles in Pigs. *Vet. Med.*, 32:137-138. March 1937.
- Palmer, Miriam A. Four New Aphids from Colorado. *Ann. Ent. Soc. Amer.*, 29:272-278. June 1936.
- Palmer, Miriam A. Additions and Corrections to the "Aphidae of Colorado." *Ann. Ent. Soc. Amer.*, 29:729-748. Dec. 1936.
- Reuszer, H. W. Nitrogen Transformations in Certain Colorado Soils (abstract) *Jour. Bact.*, 33:82. Jan. 1937.
- Reuszer, H. W. Results from Cunninghamella Plaque Tests for Available Phosphorus in Calcareous Soils. *Soil Sci. Soc. Amer. Proc.* (1936), 1:197-209. 1937.
- Reuszer, H. W. Total Nitrogen Changes in Certain Colorado Soils as Determined by the Kjeldahl Method (abstract). *Soil Sci. Soc. Amer. Proc.* (1936), 1:195. 1937.
- (Robertson, D. W.). Austin, W. W. and Robertson, D. W. Inheritance of Resistance to *Ustilago levis* (K & S) Magn. (Covered Smut) in a Cross Between Markton and Colorado 37 Oats. *Jour. Amer. Soc. Agron.*, 28:467-471. June 1936. (W. W. Austin, Soil Conservation Service).
- Robertson, D. W. Maternal Inheritance in Barley. *Genetics*, 22:104-113. Jan. 1937.
- Robertson, D. W. Inheritance in Barley II. *Genetics*, 22:443-451. July 1937.

Mimeographed Bulletins and Circulars

The following list of mimeographed bulletins and circulars which have been published during the year by various sections, independent of the Station Editorial Office, has been compiled as a matter of record:

- Binkley, A. M. The Growing of Baby Lima Beans (reprint). April 1937.
- Burdick, R. T. and Clawson, Marion. Economic Considerations Affecting Permit Distribution Policy on Public Range Lands, Yampa River Drainage, Colorado. III The Agricultural Situation: An Economics Survey. Oct. 1936. (Marion Clawson, U. S. D. A.)
- Burdick, R. T. and Whitney, R. C. Study of Farm Organization and Soil Management Practices in Colorado. April 1937.
- Gunesch, W. E. Fertilizer Costs. Oct. 1936.
- Gunesch, W. E. Cost of Landscape Construction. Dec. 1936.
- Gunesch, W. E. Greenhouse Pest Control. Dec. 1936.
- Hoerner, John L. Control of the Squash Bug, *Anasa tristis* DeG. June 1937.
- Jones, C. R. and McCampbell, Sam C. Control of Clothes Moths. Mar. 1936. (Sam C. McCampbell, Colo. Ext. Serv.)
- Jones, C. R. and McCampbell, Sam C. Cockroach Control. Mar. 1936.
- Jones, C. R. and McCampbell, Sam C. Control of Bed Bugs. Mar. 1936.
- Jones, C. R. and McCampbell, Sam C. Ant Control. Mar. 1936.
- Jones, C. R. and McCampbell, Sam C. Termites or White Ants. June 1936.
- Larson, Olaf F. With Rural Relief in Colorado. April 1936.
- Larson, Olaf F. Social Security and Rural Relief in Colorado. June 1936.
- Larson, Olaf F. Rural Youth and Relief in Colorado. June 1936.
- Larson, Olaf F. Beet Workers on Relief. May 1937.
- (Nelson, E. W.). Palmer, L. J. and Nelson, E. W. The Range Resources of Colorado. April 15, 1937. (L. J. Palmer, Rocky Mountain Forest and Range Exp. Sta.)
- Palmer, M. A. and McCampbell, S. C. Control of the Douglas Fir Aphid. Jan. 1936.
- Palmer, M. A. and McCampbell, S. C. Control of the Woolly Apple Aphid. Mar. 1936.
- Wilgus, Jr., H. S. and Ufford, O. C. Pullet Management. Oct. 1936. (O. C. Ufford, Colo. Ext. Serv.)
- Wilgus, Jr., H. S. and Ufford, O. C. Rations for Growing and Finishing Turkeys. Oct. 1936.
- Wilgus, Jr., H. S. and Ufford, O. C. Feeding for Egg Production and for Hatchability. Feb. 1937.

- Wilgus, Jr., H. S. and Ufford, O. C. Specifications for Feedstuffs Used in Poultry Rations. Feb. 1937.
- Wilgus, Jr., H. S. and Ufford, O. C. Suggestions for Chick Rations. Feb. 1937.
- Wilgus, Jr., H. S. and Ufford, O. C. Turkey Production in Colorado. Mar. 1937.
- Horticulture Section Staff. Colorado's Second Annual Florists' Short Course. April 1937.

Respectfully submitted,

E. P. Sandsteen

Director.