1-1925

Bulletin No. 192 - Biennial Report of the Director: For the Years 1923 and 1924

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BIENNIAL REPORT OF
THE DIRECTOR

For the Years 1923 and 1924

Experiment Station Administration Building

UTAH AGRICULTURAL
EXPERIMENT STATION

LOGAN, UTAH
UTAH AGRICULTURAL EXPERIMENT STATION

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D. W. PITTMAN, M. S. ................................................................................ Assistant Agronomist
A. F. BRACKEN, M. A. ................................................................................ Assistant Agronomist
T. H. ABELL, M. S. ...................................................................................... Assistant Horticulturist
A. L. WILSON, B. S. ................................................................................... Superintendent, Davis County Farm
L. F. NUFFER, M. S. ...................................................................................... Assistant Botanist
HERBERT J. PACK, M. S. ........................................................................... Associate Entomologist
GEORGE D. CLYDE, M. S. .......................................................................... Assistant in Irrigation
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DAVID A. BURGOYNE, B. S. ................................................................... Secretary to the Director

IN CHARGE OF COOPERATIVE INVESTIGATIONS WITH THE
U. S. DEPARTMENT OF AGRICULTURE

L. M. WINSOR, B. S. .................................................................................. Irrigation Engineer

*On leave of absence.
INTRODUCTION

No report (either annual or biennial) of the work of the Utah Agricultural Experiment Station has been published separately since 1906. There has been so much inquiry regarding the present status of research projects that a brief report at this time is considered opportune. The report is an attempt to give the reader a brief but concise and comprehensive survey of the research work now under way at the Utah Agricultural Experiment Station as well as a brief description of the work being attempted on each of the experimental farms.

Altho the budget for the past biennium was decreased $20,000, an attempt has been made to carry all the major unfinished projects as far as conditions would permit. As a result, many of the workers have been handicapped for lack of budget allotment. The work on the Davis County Experimental Farm is only partially completed, and it is very important that arrangements be made to continue this farm. This will necessitate either the releasing or purchase of the farm.
Repeated requests have been made for new experimental work. These requests include, among other things, research in the production of alfalfa seed. Utah is producing nearly half the alfalfa seed grown in the United States and the industry is very important in Millard, Beaver, Emery, Duchesne, and Uinta Counties and will probably be developed as a major industry in Iron and San Juan Counties. It is very important that certain research be started to stabilize the industry.

Reconnaissance survey and careful estimate show that in the state of Utah there are at least 500,000 acres of tillable land between 6000 and 8000 feet in elevation. These high areas generally are covered with deep, rich soil and have an annual rainfall of from 12 to 30 inches. The growing season on these highlands is long enough to give promise of maturing many of the grains and forage plants grown on the colder lands in the northern regions. The conditions warrant a project of plant adaptation to subsidize the livestock industry.

A 6-acre tract of land has been purchased for the purpose of conducting fertilizer tests. This land is now being studied as to uniformity of composition and productivity. Both artificial and natural fertilizers will be studied as to (1) influence on the immediate productivity of the soil, (2) influence on the lasting productivity of the soil, and (3) influence of the various fertilizers upon the chemical, physical and biological properties of the soil as well as their effect upon the chemical composition of the crop.

PERSONNEL

Appointments.—The average number of persons regularly employed on the scientific staff during the past biennium was twenty-nine. A total of three appointments was made. These appointments are as follows:

George D. Clyde, Assistant in Irrigation and Drainage, 1 July 1924 (half-time).
D. H. Nelson, Assistant in Bacteriology and Chemistry, 1 July 1924 (half-time).
D. C. Tingey, Assistant in Agronomy, 1 July 1924 (half-time).

At the beginning of the present fiscal year (1 July 1924) William Peterson, who has been Director of the Experiment Station since September 1921, was made joint director of the Experiment Station and the U. A. C. Extension Service.

Advanced Study by Staff Members.—During the past two years a special effort has been made to encourage members of the Station Staff to improve their scientific and professional
status. As a result of this effort, the following members have availed themselves of the opportunity to take advanced work at other institutions:

R. J. Becraft, In Charge Range Management, for fiscal year from 1 July 1922 to 30 June 1923.

E. B. Brossard, In Charge Farm Management, for fiscal years from 1 July 1923 to 30 June 1925.

E. G. Carter, Associate Bacteriologist, for fiscal year from 1 July 1924 to 30 June 1925.

*H. J. Frederick, Veterinarian, for fiscal year from 1 July 1924 to 30 June 1925.

*O. W. Israelsen, In Charge of Irrigation and Drainage, for fiscal year from 1 July 1923 to 30 June 1924.

H. J. Pack, Assistant Entomologist, for fiscal years from 1 July 1923 to 30 June 1925.

*George Stewart, Agronomist, for fiscal year from 1 July 1924 to 30 June 1925.

Distribution of Time.—During the past two years the working time of the members of the Experiment Station Staff was distributed on the average as follows:

Research .................................................. 4
Research with part-time teaching............................ 25
Research with part-time Extension.......................... 3

Salaries.—In general, the salaries paid to the Utah Experiment Station workers are lower than those of other stations of about the same standing. Several moderate increases are therefore desirable.

EQUIPMENT

The Utah Experiment Station has sufficient machinery and equipment on hand for normal continuation. The present approximated value of the equipment and other appurtenances of the Experiment Station are as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furniture, Fixtures, and Books</td>
<td>$14,508.54</td>
</tr>
<tr>
<td>Machinery, Equipment, Tools, and Other</td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>9,876.51</td>
</tr>
<tr>
<td>Scientific Apparatus</td>
<td>8,832.41</td>
</tr>
<tr>
<td>Livestock</td>
<td>5,790.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$39,007.46</strong></td>
</tr>
</tbody>
</table>

*Sabbatical leave.
FARMS OR BRANCH EXPERIMENT STATIONS

The Experiment Station maintains six farms in addition to the Central Experiment Station which is located two miles north of the college in North Logan (Greenville). These branch experiment stations are designed to render service to the farmers in the various parts of the state. They are as follows:

1. Central Experiment Station at North Logan (Greenville).—This farm consists of 45 acres of good irrigated land. It is located beyond the gravel bench of the Logan River Delta and below the steep and rough soils at the base of the mountains, yet above the seeped land of the center of the valley. It thus represents quite accurately the best irrigated land. The soil is a uniform loam of good depth and free from sudden irregularities. Eleven acres of the farm have been operated as an experimental farm since 1900, and on this area have been determined (as shown in the discussion of its separate projects) some of the most fundamental points that must be known in order to successfully operate an irrigated farm in Utah. Many of these experiments grow more valuable each year as showing more clearly the effects on the productivity of the soil of continuing in the various farm practices represented. The newer portions of this farm operated since 1920 and 1921 are being used for miscellaneous and temporary experiments or are being prepared for further long-time experiments.

A 10-acre field has been set aside for a future experiment with pasture grasses and is being cropped as uniformly as possible with clean cultivated crops to get it in shape for this experiment. The patch was originally extremely weedy, and it requires very careful treatment to clean it. Another 6-acre field has been designated for a future experiment on fertilizers. This patch has been divided into 84 plats of one-twentieth acre each with alleys between the plats. It is being cropped as uniformly as possible, the crops being harvested by plats to determine the variability of the plats. There is a greater variation than was anticipated, and it will be necessary to continue this process for some time before the plats are in fit shape for use.

The experimental work of the farm is divided into certain definite projects, each of which aims to answer certain specific questions. A description of the projects now in operation is given under the general Project heading for the Agronomy Department.

2. Nephi Substation.—This station, established in Juab County in 1903 and composed of 103 acres, is located in the
center of the dry-farming area of the state. The farm is located on the main Utah-California highway. The government began cooperation in 1908 and continued this cooperation until October 1920. Due to lack of funds the U. S. Department of Agriculture withdrew its support at this time. Therefore, the entire cost of experimentation and maintenance since October 1920 has been borne entirely by the Experiment Station. Some striking developments in dry-farming have been produced. A full account of the work done on this farm during the past two years is found under the general Project heading for the Agronomy Department.

3. Davis County Experimental Farm.—This farm, begun in 1920, is situated in the truck-crop area of the state. It is located just nineteen miles from Salt Lake City and an equal distance from Ogden. The farm is on the main state highway. As indicated, the major part of the work deals with truck-farming with onions and tomatoes the outstanding problems. The irrigation of peas, the raising of lettuce, celery, and strawberry varieties as well as silage corn are also studied from the experimental side. Double-cropping systems and varieties of miscellaneous truck crops are also given special attention. Because of the great interest taken throughout the state in the last few months in regard to celery culture, the question of expanding the farm by a few additional acres is under advisement for the near future.

4. Widtsoe Farm.—This farm, which consists of 40 acres, is located in Garfield County at an elevation of 7800 feet. At the time of its establishment the purpose of this farm was to investigate the possibilities of dry-farming in Emery Valley, or John’s Valley as it is popularly called. However, during the past biennium a storage reservoir was constructed in this valley, and as a result the plans have been modified to make the farm an irrigated demonstration farm. This phase of the work has not been in operation sufficiently long to draw any conclusions.

5. Kanab Farm.—This farm, consisting of 40 acres, is located near Kanab on the extreme southern border of the state in Kane County. The elevation is 5700 feet. The farm was established to explore the possibility of dry-farming in this vicinity. All promising varieties of wheat (both winter and spring) have been tried. Corn and sorghum have been tried as forage and have been found to grow successfully. Drought and other causes during the past two years have prevented any worth-while crops on this farm.
6. Panquitch Farm.—The farm at Panquitch, Garfield County, consists of 106 acres, house, and barn equipment. The farm was first established as a dairy farm but was changed after a few years’ trial to the production of breeding animals which would be helpful to the beef-cattle industry in the surrounding country.

7. Cronquist Dairy Farm.—This farm, consisting of 86 acres, was rented early in 1924 for a period of ten years. During the past summer it has been equipped completely for experimental work. The owner, Olif Cronquist, built a new modern thoroughly up-to-date barn and a 100-ton silo which accommodate 30 cows. A well-equipped cement milk house has been constructed since the Station assumed entire responsibility. At present the farm is stocked with 45 head of grade and purebred Holstein cows, 14 of which were lent to the Station for experimental purposes by the Dairy Division of the U. S. Department of Agriculture. It is planned to test other breeds as the experiment progresses.

8. County Farm.—This farm consists of 100.5 acres and is located within a quarter of a mile from the college campus on the main road to the Cronquist and Central Experimental Farms. It has been leased from Cache County for a period of five years. While listed under the general heading of Branch Experiment Stations, this farm is in no sense at present an experimental farm. However, later it may be used for experimental work in problems in connection with the sheep and wool industry.

PUBLICATIONS

The Utah Experiment Station serves as an investigational and research agency endeavoring to solve those problems of most importance to the agricultural industry of the state. Results of these experiments are published in three forms: (1) bulletins, (2) circulars, and (3) scientific articles which appear in various technical publications.

As soon as a bulletin or circular is received from the printer, advance notice (including a short summary of its contents) is sent at once to the various editors and publishers in the state. Copies of the particular publication are then sent out to all who respond to this notice at the time it appears in the local papers. This method of sending bulletins and circulars is separate and distinct from the regular system of mailing publications to those whose names appear on the regular mailing list.
During the past two years a decided change in the method of mailing bulletins and circulars to the regular mailing list has been instituted. Formerly the bulletins and circulars issued by the Station were sent out to the entire list except in the case of technical bulletins which were not sent to the names on the "general" list. However, this practice has been discontinued except in the case of libraries which receive the entire series. For the past two years, at one-year intervals, a notice of publications printed during that period has been mailed to the entire mailing list. Those receiving these notices have been requested to check the publications desired and to return the checked list to the Publications Division. Upon receipt of this checked list such publications as are checked are sent to those requesting them. Since the adoption of this system it has been found that the printing expense has been cut at least in half, since it is now necessary to order but half, and sometimes less, the number originally ordered. The aim of the entire Station Staff is to serve in the most efficient manner the farmers of the state and all others who may be interested in the results obtained.

The classified mailing list at the end of 1924 was as follows:

I. Utah

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
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<tr>
<td>General</td>
<td>2200</td>
</tr>
<tr>
<td>Scientific</td>
<td>195</td>
</tr>
<tr>
<td>Publishers and Editors</td>
<td>87</td>
</tr>
<tr>
<td>Libraries</td>
<td>69</td>
</tr>
<tr>
<td>U. A. C. Board of Trustees, Commission of Agriculture, County Agents</td>
<td>50</td>
</tr>
<tr>
<td><strong>Total for Utah</strong></td>
<td><strong>2601</strong></td>
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II. States (Other than Utah)

<table>
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<th>Number</th>
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</thead>
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<tr>
<td>General</td>
<td>496</td>
</tr>
<tr>
<td>Scientific</td>
<td>750</td>
</tr>
<tr>
<td>Publishers and Editors</td>
<td>200</td>
</tr>
<tr>
<td>Libraries</td>
<td>317</td>
</tr>
<tr>
<td><strong>Total for Other States</strong></td>
<td><strong>1763</strong></td>
</tr>
</tbody>
</table>

III. Foreign

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>359</td>
</tr>
</tbody>
</table>

IV. U. S. Department of Agriculture and and State Experiment Station Workers | 2100 |

**Total Number Carried on Mailing List...6823**
All residents of the state are entitled to have their names on the Station Mailing List if they will let their wants be known to the Publications Division.

Following is a summary of the bulletins and circulars issued by the Utah Experiment Station during the past two years:

**Bulletin 178.**—Irrigation of Barley, by F. S. Harris* and D. W. Pittman.—This publication reports the results of a 3-years’ experiment on the irrigation of barley conducted on the Central Experiment Station at North Logan (Greenville). It shows the results of using different quantities of irrigation water on barley and of applying it at different periods in the growth of plants.

**Bulletin 181.**—Duty-of-Water Investigations on Coal Creek, Utah, by Arthur Fife.**—This bulletin contains the results of a 5-years’ investigation on Coal Creek, Iron County, to determine how the yields of various crops were affected with the application of different amounts of water. The crops experimented with were alfalfa, spring wheat, barley, oats, potatoes, and corn. As about 85 per cent of the farming land on Coal Creek was in alfalfa, the water requirements for that crop were given most weight in determining the duty of water.

**Bulletin 182.**—Net Duty of Water in Sevier Valley, Utah, by O. W. Israelsen and L. M. Winsor.—This bulletin gives seven years’ experiments on the most economical use of water for the more common crops on typical soils in Sevier Valley. The crops given major consideration were sugar-beets, potatoes, and alfalfa.

**Bulletin 183.**—Water-holding Capacity of Irrigated Soils, by O. W. Israelsen and F. L. West.—In this bulletin is presented the results of investigations on the water-holding capacity of soils as a means of saving irrigation water and preventing the water-logging of low-lying soils. Experiments were conducted on the Central Experiment Station at North Logan (Greenville) and in Sevier Valley, Utah, as well as in Gem Valley, Idaho.

**Bulletin 184.**—A Farm Management Study of the Great Salt Lake Valley, by George Stewart.—A farm-management study in Salt Lake, Davis, and Weber Counties, as shown in this publication, indicates that the most profitable general farms in these three counties are those which combine several enterprises—especially sugar-beets, grain and hay, and dairying.

**Bulletin 185.**—The Influence of Nitrogen in Soil on Azofication (Technical), by J. E. Greaves and D. H. Nelson.—A labora-

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*Formerly Director and Agronomist.
**Formerly Assistant in Irrigation and Drainage.
tory and field study of a highly calcareous soil showed that the
application of either organic or inorganic nitrogen to the soil
increased nitrogen fixation. The increase varied with the
specific nitrogen compound added. The same was found to be
true when organic carbon was applied to the soil. The application
of five tons of manure over a period of 11 years increased the
nitrogen of the soil 1370 pounds an acre. This was 486 pounds
more than was applied in the manure. This gain is due to
nitrogen fixation resulting from the increased carbon content.
Even when 15 tons to the acre were applied yearly to the soil for
11 years, 80 per cent of the nitrogen applied was found in the
soil at the end of this period. Hence, large quantities of nitro­
gen can be stored in this soil and appreciably increase fixation
of elementary nitrogen by Azotobacter.

Bulletin 186.—Irrigation Experiments with Sugar-beets, by
F. S. Harris and D. W. Pittman.—The results reported in this
experiment are similar to those reported in Bulletin 187. Less
than 10 acre-inches of irrigation water caused frequent crop
failure. Over 25 acre-inches of irrigation water reduced the yield
of sugar-beets except in very dry years. Withholding the first
irrigation on sugar-beets did not increase the length of the sugar­
beets but did render them more susceptible to disease.

Bulletin 187.—Irrigation Experiments with Potatoes, by F. S.
Harris and D. W. Pittman.—The results reported in this bulletin,
as in Bulletin 186, represent ten years’ work carried on at the
Central Experiment Station (Greenville). It is definitely shown
that potatoes are very sensitive both to over- and under-irriga­
tion. The largest yields for the same quantity of water were
obtained where the water was applied in several small rather
than fewer larger irrigations. Excessive irrigation produced a
large number of small potatoes.

Bulletin 188.—Maintaining the Productivity of Irrigated
Land, by D. W. Pittman.—This bulletin shows, as a result of 21
years’ study and observations at the Central Experiment Station
(Greenville), what is the cause of loss of productivity and how
the soil may be restored by proper rotation of crops and the most
effective use of manure.

Bulletin 189.—Ridding the Land of Wild Morning Glory, by
George Stewart and D. W. Pittman.—This bulletin reports the
results of an experiment to determine the most effective way to
control or exterminate wild morning glory. It was found that
sprays were ineffective in killing the roots in this dry climate
and that frequency of treatment (either by spray or cultivation)
was the most important factor in controlling the weed. As a whole, cultivation was better than spraying; shallow cultivation was as good as deep cultivation; frequent cultivation was essential to success; and pasturing and shading were only partially successful.

Bulletin 190.—Corn Silage in a Dairy Ration, by W. E. Carroll.—A brief summary is given in this bulletin of the results of two years’ experimental work on the value of corn silage in the ration of milking cows. A direct comparison is made between alfalfa hay and corn silage; thus the proportion of grain consumed was the same throughout the test. It was fed in proportion to the amount of butterfat given. The results indicate that from 2.5 to 2.9 tons of corn silage were required to replace one ton of alfalfa hay under the test conditions.

Bulletin 191.—Oedipodinae of Utah (Technical), by W. W. Henderson*.—This publication, which is highly technical in character, is a taxonomic and ecological consideration of the Oedipodinae. It gives the results of a technical study of the grasshopper order, the purpose of which was to bring to light a correct understanding of the economic species. It is found that a different set of insects constitute the prevailing species of the high, arid lands of the Great Basin than is commonly found to prevail elsewhere. These prevailing species are those common to the sub-family, Oedipodinae, of the family Acrididae and the order Orthoptera.

Circular 47.—Celery Culture for Utah, by T. H. Abell.—In this circular is given a detailed discussion of the various factors which go toward the successful production of first-class celery. It is shown that Utah has the kind of soil upon which celery thrives. This, together with the climate, gives it a peculiar crispness and sweetness. Probably the most important phase in the production of celery is blanching of the stems which may be accomplished with boards or with earth. However, for Utah conditions the best flavor is obtained when celery is blanched with earth. Irrigation and cultivation methods are also discussed.

Circular 48.—Rural Credits in Utah, by E. B. Brossard.—A complete and comprehensive resume of the Federal Farm Loan System is discussed in this publication. The purpose of the circular is to give general information about the agricultural credit conditions in existence at the time the publication was issued with special reference to mortgage credit in Utah and the Federal Farm Loan System.

*Formerly Station Entomologist.
Circular 49.—This Public Domain of Ours, by George Stewart.—The relation of dry-farm lands to grazing and what lands can safely be used for settlement are important problems. Overgrazing, which involves tremendous cattle losses, timber destruction, range erosion and floods, cannot be prevented without control of government lands. These topics and others of similar importance are discussed in detail in this circular.

Circular 50.—Brooding and Feeding Baby Chicks, by Byron Alder.—The most important problem of the poultry-raiser during the spring and summer is raising a flock of good, vigorous pullets either to renew the flock or to put into the laying house the coming fall. Failure in this regard means a poor crop of eggs in the fall and winter when the price is highest. Good care of the growing pullets from the time they are put into the brooder as baby chicks until placed in the laying house in the fall is just as important for profitable egg production as the care given these pullets during the laying period. The problems of brooding and feeding baby chicks and the methods used and recommended by the Utah Experiment Station are given in this publication.

Circular 51.—Foot-and-Mouth Disease, by H. J. Frederick.—This circular briefly describes the status of foot-and-mouth disease at the time the circular was written as well as the cause, history, symptoms, differential diagnosis and treatment of the disease.

Circular 52.—Rules and Regulations for the Utah Intermountain Egg-laying Contest, by Byron Alder.—General information is given in this circular in regard to the egg-laying contest to be held by the Utah Agricultural Experiment Station from 1 November 1924 up to and including 30 October 1925.

Circular 53.—Summary of Publications, by B. C. Pittman.—This circular contains a summary of the publications of the Utah Agricultural Experiment Station issued since September 1923.
Data relative to cost of printing, cost of cuts, and number of publications ordered follow:

<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
<th>No. Ordered</th>
<th>Cost of Cuts</th>
<th>Cost of Printing</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>178</td>
<td>Irrigation of Barley</td>
<td>12,000</td>
<td>$38.91</td>
<td>$229.34</td>
<td>$268.25</td>
</tr>
<tr>
<td>181</td>
<td>Duty-of-Water Investigations on Coal Creek, Utah</td>
<td>11,000</td>
<td>$30.17</td>
<td>$254.36</td>
<td>284.53</td>
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<td>182</td>
<td>Net Duty of Water in Sevier Valley, Utah</td>
<td>11,000</td>
<td>$16.18</td>
<td>$414.23</td>
<td>430.41</td>
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<tr>
<td>183</td>
<td>Water-holding Capacity of Irrigated Soils</td>
<td>12,000</td>
<td>$10.41</td>
<td>$295.05</td>
<td>305.46</td>
</tr>
<tr>
<td>184</td>
<td>A Farm Management Study of the Great Salt Lake Valley</td>
<td>6,000</td>
<td>$46.42</td>
<td>$418.30</td>
<td>464.72</td>
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<tr>
<td>185</td>
<td>The Influence of Nitrogen in Soil on Azofication (Technical)</td>
<td>3,000</td>
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<td>$138.21</td>
<td>138.21</td>
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<td>186</td>
<td>Irrigation Experiments with Sugar-beets</td>
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<td><strong>351.96</strong></td>
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<td>187</td>
<td>Irrigation Experiments with Potatoes</td>
<td>6,500</td>
<td></td>
<td>$156.70</td>
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<tr>
<td>188</td>
<td>Maintaining the Productivity of Irrigated Land</td>
<td>6,500</td>
<td>$20.85</td>
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<tr>
<td>189</td>
<td>Ridding the Land of Wild Morning Glory</td>
<td>7,500</td>
<td>$37.73</td>
<td>$326.24</td>
<td>363.97</td>
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<td>190</td>
<td>Corn Silage in a Dairy Ration</td>
<td>6,500</td>
<td>$3.60</td>
<td>$138.74</td>
<td>142.34</td>
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<tr>
<td>191</td>
<td>Oedipodinae of Utah (Technical)</td>
<td>3,500</td>
<td>$35.48</td>
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**Total Cost of Bulletins**

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<table>
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<tr>
<th>No.</th>
<th>Title</th>
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<th>Cost of Cuts</th>
<th>Cost of Printing</th>
<th>Total Cost</th>
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<tbody>
<tr>
<td>47</td>
<td>Celery Culture for Utah</td>
<td>6,000</td>
<td>$12.88</td>
<td>$181.78</td>
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<td>Rural Credits in Utah</td>
<td>6,500</td>
<td>$2.45</td>
<td>$413.19</td>
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<td>This Public Domain of Ours</td>
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<td>50</td>
<td>Brooding and Feeding Chicks</td>
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<td>$275.10</td>
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<td>51</td>
<td>Foot-and-Mouth Disease</td>
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<td>52</td>
<td>Rules and Regulations for Utah</td>
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<td>53</td>
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<td><strong>$42.70</strong></td>
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</table>

**Total Cost of Circulars**

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*First publication issued after change in mailing was instituted.

**Bill for cuts for Bulletins 186 and 187.
In addition to the bulletins and circulars regularly issued by the Experiment Station during the past two years, numerous scientific articles have been written by various members of the Experiment Station Staff. These articles have appeared in various technical and scientific publications. An enumeration of these articles is given below:

<table>
<thead>
<tr>
<th>Title, Author, Source, etc.</th>
<th>No. Reprints Ordered</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tillage Experiments with Wheat in the Western United States. By A. F. Bracken (Utah), et al. <em>In U. S. D. A. Dept. Bul. 1173 (Sept. 1923), pp. 1-60</em></td>
<td>*</td>
<td>------</td>
</tr>
<tr>
<td>A Statistical Study of the Distribution of Soil Material in the United States according to the Size of Its Particles. By D. S. Jennings. <em>In Soil Sci.,</em> Vol. 17, No. 6 (June 1924) pp. 469-485</td>
<td>250</td>
<td>11.60</td>
</tr>
<tr>
<td>A New Method of Mechanical Analysis of Soils. By D. S. Jennings, M. D. Thomas, and Willard Gardner. <em>In Soil Sci.,</em> Vol. 14, No. 6 (Dec. 1922)</td>
<td>300</td>
<td>17.03</td>
</tr>
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</table>

*1500 copies furnished gratis by U. S. D. A.*
<table>
<thead>
<tr>
<th>Title, Author, Source, etc.</th>
<th>No. Reprints Ordered</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Further Studies on the Pathogenicity of <em>Corticium vagum</em> on the Potato as affected by Soil Temperature. By B. L. Richards. <em>In Jour. Agri Rsch.</em>, Vol. 23, No. 9 (Mar. 1923)</td>
<td>500</td>
<td>22.00</td>
</tr>
</tbody>
</table>

Total Cost of Technical Articles: $516.21

Thru the courtesy of our Utah Congressmen the Experiment Station has received liberal supplies of the soil survey reports on the Delta Area and the Ashley Valley Area. It will be noted from the tabulated material above that the work done on these two projects was cooperative between the U. S. Department of Agriculture and the Utah Experiment Station.

(B. C. Pittman)

LIBRARY

Previous to the summer of 1924 the Utah Agricultural Experiment Station Library occupied three of the rooms on the second floor of the Experiment Station Building. Because these rooms were to be occupied by the members of the Extension Service it was necessary to move the Station Library to Room 132 of the Main Building.

The Experiment Station Library is as complete as it is possible to make it with present funds. It is used constantly by station staff members, advanced students, and a number of
others. The bound volumes found on the shelves are classified as follows:

<table>
<thead>
<tr>
<th>Classification</th>
<th>Volumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>U. S. Department of Agriculture</td>
<td>900</td>
</tr>
<tr>
<td>State Experiment Stations, including Insular Experiment Stations</td>
<td>1186</td>
</tr>
<tr>
<td>State Departments of Agriculture</td>
<td>382</td>
</tr>
<tr>
<td>Technical and Scientific</td>
<td>183</td>
</tr>
<tr>
<td>Smithsonian Institution</td>
<td>144</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>231</td>
</tr>
<tr>
<td>Library of Congress</td>
<td>26</td>
</tr>
<tr>
<td>Department of Commerce</td>
<td>16</td>
</tr>
<tr>
<td>Department of Interior</td>
<td>166</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>23</td>
</tr>
<tr>
<td>Foreign</td>
<td>274</td>
</tr>
<tr>
<td><strong>Total Bound Volumes</strong></td>
<td><strong>3300</strong></td>
</tr>
</tbody>
</table>

A complete card index of all U. S. Department of Agriculture publications from the earliest index obtainable to the present is maintained and is ready for reference at all times. The index for the various state experiment stations is complete to the time of its discontinuance by the government in 1918.

Because of the frequent reference to and the demand for certain scientific and technical publications, subscriptions to the following are maintained:

- Agricultural Index
- American Association of Soil Survey Workers
- American Fertilizer
- American Food Journal
- Botanical Abstracts
- Breeders' Gazette
- Cereal Chemistry
- The Field, Illustrated
- Genetics
- Journal of American Society of Agronomy
- Journal of Heredity
- Journal of Farm Economics
- Physiological Abstracts
- Scientific Agriculture
- Soil Science
- Utah Farmer
- World Agriculture

The list indicated is inadequate to supply the demand, and it is hoped that during the next biennium this phase of the library
work may be extended and that many of the other technical publications now lacking may be supplied.

Thru the exchange of the Utah Experiment Station publications the Station Library is in receipt of some sixty or more journals and magazines from various publishing firms and institutions. These include such publications as Country Gentleman, Natural History, Review of Applied Entomology, Better Fruit, Reliable Poultry Journal, Facts About Sugar, Brooklyn Botanic Garden publications, Missouri Botanical Garden Annals, Baking Technology, publications of the International Institute of Agriculture (Rome, Italy), etc. On this exchange basis the Library is also in receipt of the journals of the departments of agriculture of New South Wales, South Australia, New Zealand, London, Union of South Africa, etc.*

In addition to the publications which are now taken care of in Room 132 of the Main Building, the northeast room of the Experiment Station Building has been retained for publications issued by the U. S. Geological Survey. During the past year it has been possible to secure an almost complete file of the following U. S. Geological Survey publications: Bulletins, Water-Supply Papers, Professional Papers, and Annual Reports. Some of the Monographs have been secured, but this series is at present rather incomplete and lacking in its entirety. Few of these U. S. Geological Survey publications are bound at present, but it is hoped that this need can be taken care of during the next biennium in order to insure their permanency and safe-keeping.

Thru the efforts of one of Utah's congressmen the Utah Experiment Station Library was made a special depository of the Government Printing Office to receive the different series of U. S. Geological Survey publications as issued. During the last few weeks, however, because of curtailment of government funds it has been necessary to remove this library from this special depository list.

On the average about 150 books are bound each year. If it is possible to bind the U. S. Geological Survey publications within the next year this number will be somewhat exceeded.

(B. C. Pittman)

*This does not include any of the U. S. D. A. nor state experiment station publications, all of which are sent to the Library without charge.
The following list gives data in tabular form regarding the active projects carried during the past two years. Complete reports on these projects are included in this biennial report.

<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
<th>Source of Support</th>
<th>Leader or Leaders</th>
<th>Remarks and Publications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nephi Substation*</td>
<td>State</td>
<td>Bracken</td>
<td>U. S. D. A. Bul. 1173</td>
</tr>
<tr>
<td>2</td>
<td>Other Dry-farm Substations</td>
<td>State</td>
<td>Stewart</td>
<td>Buls. 178, 186, 187</td>
</tr>
<tr>
<td></td>
<td>A. Widtsoe</td>
<td>State</td>
<td>Stewart</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B. Kanab</td>
<td>State</td>
<td>Stewart</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Irrigation Practice</td>
<td>State</td>
<td>Stewart</td>
<td>Bul. 188</td>
</tr>
<tr>
<td>4</td>
<td>Tank Experiments on Soil Moisture</td>
<td>State</td>
<td>Pittman</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Irrigation and Manuring Studies with Corn</td>
<td>State</td>
<td>Stewart</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Potato Breeding</td>
<td>State</td>
<td>Stewart</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Rotation and Fertility Tests</td>
<td>State</td>
<td>Pittman</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Miscellaneous Field Studies</td>
<td>State</td>
<td>Stewart</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Action of Alkali</td>
<td>Adams</td>
<td>Thomas</td>
<td>**</td>
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<tr>
<td>12</td>
<td>Soil Moisture Studies</td>
<td>Adams</td>
<td>Thomas</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Pumping for Irrigation</td>
<td>State</td>
<td>Winsor</td>
<td>**</td>
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<tr>
<td>17</td>
<td>Soil Moisture Constants</td>
<td>Adams</td>
<td>Gardner</td>
<td></td>
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<tr>
<td>19</td>
<td>Dairy Rations</td>
<td>Hatch</td>
<td>Carroll</td>
<td>Bul. 190</td>
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<tr>
<td>20</td>
<td>Hog Rations</td>
<td>Hatch</td>
<td>Carroll</td>
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<tr>
<td>22</td>
<td>Factors Influencing Bacterial Activities of the Soil</td>
<td>Adams</td>
<td>Greaves</td>
<td>Bul. 185, **</td>
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<tr>
<td>23</td>
<td>Permanent Fertility Studies</td>
<td>Adams</td>
<td>Greaves</td>
<td>**</td>
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<td>25</td>
<td>Ground-water Development</td>
<td>State</td>
<td>Peterson</td>
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<td>31</td>
<td>Potato Diseases</td>
<td>Adams</td>
<td>Hill, G. R.</td>
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<td></td>
<td>A. Physiological Studies</td>
<td>Adams</td>
<td>Richards</td>
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<tr>
<td></td>
<td>B. Rhizoctonia Studies</td>
<td>Adams</td>
<td>Richards</td>
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<tr>
<td></td>
<td>C. Mosaic Studies</td>
<td>Adams</td>
<td>Richards</td>
<td></td>
</tr>
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<td>33</td>
<td>Canning Crop Diseases</td>
<td>Hatch</td>
<td>Richards</td>
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<td>34</td>
<td>Plant Disease Survey</td>
<td>Hatch</td>
<td>Richards</td>
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<td>36</td>
<td>Poultry Breeding</td>
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<td>Alder</td>
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<td>37</td>
<td>Incubation Studies</td>
<td>Hatch</td>
<td>Alder</td>
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<td>Canning Crops</td>
<td>Hatch</td>
<td>Abell</td>
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<td>Horticultural Survey</td>
<td>Hatch</td>
<td>Abell</td>
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<td>41</td>
<td>Breeding Horticultural Plants</td>
<td>Hatch</td>
<td>Abell</td>
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<tr>
<td>42</td>
<td>Grain Varieties</td>
<td>State</td>
<td>Stewart</td>
<td>Inactive, 1923-24</td>
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<tr>
<td>48</td>
<td>Range Survey</td>
<td>State</td>
<td>Becraft</td>
<td></td>
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</tbody>
</table>

*Project No. 1 (Nephi Substation) has several subdivisions, each of which is discussed in detail under Report on Projects.

**Publications listed under Scientific—not Station bulletin or circular.
<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
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<tr>
<td>49</td>
<td>Soil Survey</td>
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<td>Jennings</td>
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<tr>
<td>51</td>
<td>Miscellaneous Insects</td>
<td>Hatch</td>
<td>Hawley</td>
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<tr>
<td>51</td>
<td>Nutrition of Infants</td>
<td>Hatch</td>
<td>Hill, R. L.</td>
<td>**</td>
</tr>
<tr>
<td>54</td>
<td>Farm Organization</td>
<td>State</td>
<td>Brossard</td>
<td>Inactive, 1922-23</td>
</tr>
<tr>
<td>55</td>
<td>Types of Farming</td>
<td>State</td>
<td>Brossard</td>
<td>Inactive, 1923-24</td>
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<tr>
<td>56</td>
<td>Miscellaneous Farm Management Studies</td>
<td>State</td>
<td>Brossard</td>
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<td>Poultry Feeding</td>
<td>Hatch</td>
<td>Alder</td>
<td>Cir. 48</td>
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<td>Davis County Experiment Farm</td>
<td>State</td>
<td>Wilson</td>
<td>Cir. 50</td>
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<td>Range Reseeding</td>
<td>State</td>
<td>Beckett</td>
<td>Inactive, 1922-23</td>
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<td>62</td>
<td>Cereal Breeding</td>
<td>State</td>
<td>Stewart</td>
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<td>64</td>
<td>Cultural Methods</td>
<td>State</td>
<td>Stewart</td>
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<td>65</td>
<td>Weed Control</td>
<td>State</td>
<td>Stewart</td>
<td>Bul. 189, **</td>
</tr>
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<td>66</td>
<td>Panguitch Farm (Garfield County)</td>
<td>State</td>
<td>Bateman, J. R.</td>
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<tr>
<td>69</td>
<td>Truck Crop Production</td>
<td>Hatch</td>
<td>Abell</td>
<td>Cir. 47</td>
</tr>
<tr>
<td>70</td>
<td>Seed Certification***</td>
<td>State</td>
<td>Stewart</td>
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<tr>
<td></td>
<td>A. Grain</td>
<td>State</td>
<td>Stewart</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B. Potatoes</td>
<td>State</td>
<td>Richards</td>
<td></td>
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<tr>
<td>71</td>
<td>Methods of Dairy Manufacture</td>
<td>State</td>
<td>Wilster</td>
<td></td>
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<tr>
<td></td>
<td>A. Effect of Clarification on Quality of Cheese</td>
<td>State</td>
<td></td>
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<tr>
<td></td>
<td>B. Manufacture of Butter from Sweet Cream</td>
<td></td>
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<tr>
<td>72</td>
<td>Snow Survey</td>
<td>State</td>
<td>Clyde</td>
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<td>73</td>
<td>Production Costs in Dairying</td>
<td>State</td>
<td>Caine</td>
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<td></td>
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<td>Carroll</td>
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<td></td>
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<td>Bateman, G. Q.</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alder</td>
<td></td>
</tr>
</tbody>
</table>

**Publications listed under Scientific—not Station bulletin or circular.  
***In cooperation with U. A. C. Extension Service and State Department of Agriculture.
NEW PROJECTS

The following new projects were started during the biennium:

No. 69—Truck Crop Production
No. 70—Seed Certification
A. Grain
B. Potatoes
No. 71—Methods of Dairy Manufacture
A. Effect of Clarification on Quality of Cheese
B. Manufacture of Butter from Sweet Cream
No. 72—Snow Survey
No. 73—Production Costs in Dairying
No. 74.—Egg-laying Contest

PROJECT REPORTS

AGRONOMY

1. Nephi Dry-farm Substation.—This project is divided into the following heads, each being a complete project within itself:

Cereal Breeding.—This project includes a study of pureline wheat selection and hybridized strains. Selection No. 26, propagated at the Station and which equals the yield of KANRED, is now rather widely grown in the state. Crosses between TURKEY and KOFOD uniting the qualities of TURKEY and the beardless character of KOFOD in one plant are now under yield test. Intensive work is being done in this project with the hope of developing more adaptable wheat varieties for the dry-lands. (Stewart, G. and Bracken, A. F.)

Plowing and Cultural Tests.—Parts of this test, which has been in operation for a number of years, indicate that either fall plowing or plowing done in early spring to a depth of eight inches followed by enough tillage to keep weed growth down and prepare a good seedbed is sufficient. Deep plowing, very frequent tillage of fallow, double plowing, and disking preceding plowing are not necessary. The time-of-spring-plowing test indicates that all spring plowing for the best returns should be done within a period of two weeks after the season for plowing starts. The land which cannot be turned in this period should be fall plowed. (Bracken, A. F.)

Cropping Experiments.—The alternate cropping system, wheat after fallow, has proved to be the safest method under all conditions. The next best method is two crops of wheat followed by one fallow season. (Bracken, A. F. and Stewart G.)
Fertility Tests.—In the results from application of barnyard manure, increases in yield of wheat have been recorded for every application with ten tons which was the highest amount with the largest yield. This not only holds for the years of normal precipitation but also occurs in seasons of drouth.

In the green-manure test with wheat and peas plowed under at various stages of growth each advanced stage of wheat showed decreases in the following yield of this cereal. With peas the yield of wheat which followed showed increases up to the time when the peas were in the bloom stage. (Bracken, A. F. and Stewart, G.)

Varietal Tests.—This project includes varietal trials of winter and spring wheat, winter and spring barley, and potatoes. Of the winter wheats, KANRED, TURKEY Selection No. 26, SEVIER Selection Nos. 34 and 59, and CLARK'S BLACKHULL are outstanding varieties. CHUL, EARLY BAART, and KOTA of the spring wheats lead. THOROBRED of the potato varieties stands first. BULGARIAN winter barley, which is now being distributed, ranks first. (Bracken, A. F.)

Forage Crop Tests.—Alfalfa and rye, of all the forage crops tested, have been found best adapted to the dry-lands. (Bracken, A. F.)

Miscellaneous Tests.—This main project is further subdivided into the following:

Rate and Date of Seeding Winter Wheat.—The rate and date of seeding TURKEY wheat, extending from 2 to 8 pecks, inclusive, sown on August first and every fifteen days thereafter until November first, indicates a decided advantage for sowing not less than five pecks of good clean seed not later than October first. (Bracken, A. F. and Stewart, G.)

Cultivation of Growing Wheat.—In this test wheat was sown in rows the normal distance of seven inches, fourteen inches, twenty-one inches, and twenty-seven inches apart. One series of replication was cultivated, the other two left uncultivated. In most cases the cultivation decreased yields. (Bracken, A. F.)

Irrigated Seed vs. Dry-land Seed.—Better quality, darker color, heavier weight, and larger yield is claimed by some farmers for irrigated seed sown on the dry-lands. This test so far shows no significant difference. (Bracken, A. F.)
Smut Control Test.—A test showing the efficiency of formalin, blue stone, and the copper carbonate dusting treatment in smut control and a yield of wheat showed that copper carbonate would prevent smut. In addition, it was found that it increased the yield over the two wet treatments. (Bracken, A. F.)

Experiment on Sap Properties of Winter and Spring Wheat Grown under Irrigation and Dry-land Conditions.—This experiment is being conducted on the Nephi Substation under the direction of Dr. J. Arthur Harris of the Carnegie Research Institution. Dr. Harris has studied the sap properties of cereal varieties and selections at Nephi during the last four seasons and has found important sap differences. He hopes to find methods of locating easily and quickly high-yielding, drouth-resistant varieties by chemical and physical means.

Seeding of Winter Wheat with Furrow Drill and Ordinary Drill.—Several of the plats in the tillage test, cropping experiment, barnyard-manure test, and green-manure test are included in this fundamental experiment. Nitrate accumulation has been found to be directly correlated with the moisture content. Any tillage which tends to conserve moisture, such as fall or early spring plowing followed by normal summer cultivation, also stimulates nitrate formation. Barnyard manure added to plats receiving normal tillage also stimulates nitrate accumulation. (Bracken, A. F.)

A Study of Threshing Losses from Different Types of Harvester-threshers and Headers and Threshers on the Nephi-Levan Ridge.—In all, about twelve harvester-threshers were tested for losses. The losses were found to vary from about four pounds to an acre to nearly twenty pounds for the harvester-threshers. This is a surprisingly low loss. In most cases the loss from the headers equalled the loss from the combines and in addition the stationary gave a loss of about 1.75 per cent. Reasons for losses when above the normal were determined. (Bracken, A. F.)

2. Dry-farm Substations (Other than Nephi).—In addition to the Nephi Substation two small dry-farms are maintained. One is at Widtsoe and the other at Kanab. At Widtsoe, where the elevation is 7800 feet, winter wheat has been found to grow successfully. TURKEY has been the best variety so far given a fair trial. Of the spring varieties EARLY BAART and PACIFIC BLUESTEM are best. At Kanab corn and sweet sorghum for forage have both done well. KHERSOM oats, COAST barley, and common rye have given fair results. (Stewart, G.)
3. Irrigation Practice.—This is one of the oldest projects on the Central Experiment Station farm. It aims to answer these questions for each of our common crops: (1) How much irrigation water applied to each crop gives the largest yield? (2) What causes the optimum amount to vary from year to year? (3) What is the best seasonal distribution of each different quantity of irrigation water? The older portions of the farm have been equipped with a system of wooden flumes for conveying measured quantities of irrigation water to each plat, and as each plat is surrounded by earthen dikes to prevent runoff any predetermined quantity of water can be applied at any time.

Prior to 1922 each plat in this project grew the same crop and with the same irrigation treatment each year in order to determine the residual effect on the soil of these treatments. It was definitely established that the heavier the irrigation treatment the more rapid was the exhaustion of the soil.

In 1922, since several parts of the experiment had completed a 10-year run with quite consistent results and it was noticed that the lowered fertility of the soil was becoming an important factor in the yield, these parts of the experiment were moved to other plats that were in good condition of fertility and the crops placed in a good 10-year rotation with sufficient manure included so that the experiment may be continued indefinitely without being disturbed by fertility conditions. Each of the ordinary crops—alfalfa, sugar-beets, wheat, and potatoes—is given (in separate plats) different amounts of irrigation water, each amount being distributed thruout the season in the manner previously shown to be best. The amount which gives the highest yield varies from year to year, and by a careful comparison of the weather records, soil and crop conditions an attempt is being made to determine the extent and the cause of this variation.

During the biennium three bulletins on the work of this project have been published. Bulletin No. 178 entitled “Irrigation of Barley” shows that barley, like other small grains, needs on the average no more than 15 inches of irrigation water here and that this water is more beneficial when applied early in the season about the time the plants have five leaves. This is important because there is always more water available earlier in the season. Bulletin No. 186 entitled “Irrigation Experiments with Sugar-beets” shows that the optimum amount of irrigation water for this crop varies greatly from year to year but that frequent small irrigations are more efficient than the same amount of water used in fewer and larger applications. Bulletin No. 187 entitled “Irrigation Experiments with Potatoes” shows that this crop is very similar to sugar-beets in that frequent small irrigations within reason are most efficient and that this
crop is quite sensitive to short periods of drouth or over-irrigation. (Pittman, D. W. and Stewart, G.)

4. Tank Experiments on Soil Moisture.—This project supplements Project No. 3. The plants are grown in tanks containing 600 pounds of soil which is maintained at different moisture content. Alfalfa, corn, wheat, and sugar-beets have been used in these tests. The results have shown the maximum yield of all these crops when this soil is maintained at a moisture content of from 20 to 25 per cent of saturation (about optimum for tillage). The more the soil has been allowed to deviate from these figures the less has been the yield of the crop. The greatest efficiency in the use of water closely approximates the point of maximum yield. (Pittman, D. W.)

5. Irrigation and Manuring Studies with Corn.—This project, which has been continued since 1911, aims to answer the questions: (1) How much irrigation gives the best yield of corn? (2) What is the value of manure to corn grown continuously on the same soil? (3) What effect does manure have on the water requirement, and vice versa? To date the results show that the maximum yield of corn is secured with 20 to 30 inches of irrigation water and that good manuring will to a certain extent make up for the loss occurring thru insufficient or excessive irrigation and that conversely proper irrigation would partly compensate for lack of manure. These results are included in Bulletin No. 188—"Maintaining the Productivity of Irrigated Land." (Pittman, D. W. and Stewart, G.)

8. Potato Breeding.—Hill selection may increase the acre-yield of potatoes from 60 to 90 per cent. Selected stock grew more quickly, gave better stands, and produced higher yields that were of better quality. Improvement in quality came in two respects: (1) smoother and more uniform tubers and (2) fewer culls. In 1922 the selected strains yielded 598.3 bushels an acre as compared with 284.5 bushels for unselected stock. In 1923 the yield was 476.6 bushels an acre for the selected and 248.7 for the unselected. This is an average gain of more than 121.8 per cent. In the selected strains 95 per cent were marketable tubers as compared with 80 per cent for the unselected. (Stewart, G.)

9. Rotation and Fertility Tests.—This project aims to determine the effect of different cropping and manuring systems in maintaining or depleting the fertility of the soil. Our most common crops are grown continuously and in various types of rotations with manure, without manure, and with green manure.
The results of this experiment up to a recent date have been published as Bulletin No. 188. They show that under a system of continuous cropping without manure our soil quite rapidly deteriorates in producing-power and that of our common crops the small grains are probably most exhaustive and sugar-beets and potatoes least exhaustive of the soils. Under a good rotation system even without manure the yield of the small grains was maintained quite well, but no beets were successfully grown on worn-out soil without manure. The value of even a small amount of manure in increasing the yield of sugar-beets was remarkable. Manure has also been shown to be very effective in combatting the dry rot (Phoma boeta) in sugar-beets. So far the experiments with green manure have not shown it to be effective, but it is possible that some additional information is necessary on the handling of green manure under irrigation. (Pittman, D. W. and Stewart, G.)

10. Miscellaneous Field Studies.—

A. Silage Corn
B. Flax
C. Alfalfa

A. Silage Corn.—At the Davis County Experimental Farm a test has been made of seven varieties of silage corn. IMPROVED LEAMING is the common variety of the state, but it was felt that larger strains could be used by planting early in order to lengthen the growing season. Strains were collected locally and from the U. S. Department of Agriculture. The average acre-yields for the biennium are as follows:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Acres Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEAMING</td>
<td>15 tons</td>
</tr>
<tr>
<td>LANCASTER</td>
<td>14 3/4 tons</td>
</tr>
<tr>
<td>MILLION DOLLAR</td>
<td>16 1/2 tons</td>
</tr>
<tr>
<td>BOONE COUNTY WHITE</td>
<td>19 tons</td>
</tr>
<tr>
<td>U. S. SELECTION NO. 77</td>
<td>18 tons</td>
</tr>
<tr>
<td>U. S. SELECTION NO. 182</td>
<td>17 1/2 tons</td>
</tr>
<tr>
<td>U. S. SELECTION NO. 119</td>
<td>19 1/4 tons</td>
</tr>
<tr>
<td>RED COT ENSILAGE</td>
<td>18 tons</td>
</tr>
<tr>
<td>PUSSY CLOUD</td>
<td>17 tons</td>
</tr>
</tbody>
</table>

U. S. Selection No. 77 and BOONE COUNTY WHITE are recommended for yield and quality.

B. Flax.—Seed flax has been grown successfully in rod rows and small plats on the Central Experiment Farm for the past three years.

C. Alfalfa.—Several selected strains of alfalfa are being
maintained until opportunity offers to continue this experiment which was begun several years ago. (Stewart, G.)

11. Action of Alkali.—The extensive laboratory studies of former years on the toxicity of alkali for different plats have been brought temporally to a close with the publication of the results under the following title:

"Toxicity and Antagonism of Various Alkali Salts in the Soil."

This work has defined the tolerance of many important agricultural plants for a great variety of salt mixtures and has indicated what may be expected of chemical treatments in combating "soil alkali." The data are invaluable for judging alkali land.

During the biennium three lines of work have been considered:

(1) A study is being made of the composition and concentration of the different soluble salts as they exist in the soil solution in contact with the soil mass at different moisture contents.

(2) A study of the leaching of the heavy clay soils in the CACHE VALLEY CONSERVATION PROJECT No. 1, in cooperation with the Soil Survey Department, is being conducted. A method of taking the soil samples without disturbing their natural field structure has been worked out. The progress of the leaching of these samples is then carefully followed in the laboratory. It has been found that when the salt concentration of the soil is materially decreased in part of the soil column the percolate becomes alkaline and the soil column becomes extremely impermeable to water, a condition which might cause the failure of an attempt to reclaim the land thru drainage. The problem of devising a method of preventing or correcting this puddled condition in the soil is therefore of great practical importance in the drainage of heavy clay soils.

(3) As a result of a preliminary survey, in cooperation with the Soil Survey Department, of the natural vegetation as an indicator of the amount of alkali in the soil a single species of salt weed (Atreplex carnosa) has been selected for intensive study, and a graduate student is working out its water relations as well as the composition and concentration of the salt in the soil and plant juice. When other plants have been similarly studied the information will be invaluable for judging alkali land. (Thomas, M. D.)

12. Soil Moisture Studies.—The principal work under this
project has been a continuation of the vapor-pressure studies of preceding years. The investigation has been carried to dry soils of a wide range of texture and chemical composition. The results have been published under the following title:

“Aqueous Vapor Pressure of Soil, II. Studies in Dry Soils.”

This study has been materially advanced thru the publication entitled:


Much light has thus been thrown on the structure of the soil mass and the energetic processes involved in the soil-water relations.

Continuing the work, a few heavy clays have been intensively studied by subjecting them to a number of mechanical treatments in order to produce flocculated and deflocculated conditions and measuring the effect by means of the vapor-pressure function. In this way data are being obtained which will serve as a guide in leaching experiments described above as well as to add knowledge of the colloidal chemistry of the soil.

As a minor activity under this project critical experiments have been performed on the “moisture equivalent” method which illustrates the underlying principles and also the limitations of this much-used process.

It is planned to continue the theoretical studies as outlined above.

Both Project 11 and Project 12 are closely related and must be developed together. The work has now progressed far enough so that the methods and results may be applied to the solution of practical problems. It is planned to continue vigorously the drainage study. (Thomas, M. D.)

42. Grain Varieties.—During the past few years the variety DICKLOW has been established as the most desirable spring wheat for the irrigated sections of Utah. FEDERATION, a new wheat from Australia, has also done well but not quite so well as has DICKLOW. The Idaho-irrigated experimental farm at Aberdeen has reported higher yields from FEDERATION, but nowhere in Utah has this result been substantiated. The variety SEVIER is a high yielder if lodging can be avoided. However, this is nearly impossible on account of its excessively weak straw. It has proved a wonderful parent variety in crosses with DICKLOW (See Project 62). (Stewart, G.)
62. Cereal Breeding.—Up to the present it has been possible to include only wheat improvement in the cereal-breeding program. Improvement work has come under three phases: (1) introduction and test of promising new varieties from any part of the earth; (2) individual plant-selection work in SEVIER and DICKLOW at Logan and TURKEY and KOFOD at Nephi (See Project 1); and (3) hybridization of DICKLOW and SEVIER to unite the good qualities of both into one new sort.

Out of about 150 strains of DICKLOW five promising sorts have been isolated. Strain No. 21 has short stiff straw and seems promising for wet land or other land where lodging is likely to occur. Strain No. 3 is promising on highly fertilized land. Several strains of SEVIER have proved excellent parents on account of hardness, yield, and rust resistance.

In the last analysis, hybridization is the method necessary to ultimate improvement. Only in this way can new sorts be obtained; only in this way can desirable qualities from different varieties be united. It is a long and tedious process, involving several years' work. Results in 1924, however, indicate it to be highly worth while. Many sorts are now isolated which combine the stiff straw of DICKLOW with the hardness and non-shattering of SEVIER. Some of these are very high yielders and at least two are highly resistant, both stem and leaf, to rust.

Two Australian wheats—FEDERATION and HARD FEDERATION—have also proved excellent partner varieties. Crosses are now being studied between FEDERATION x DICKLOW and FEDERATION x SEVIER and between HARD FEDERATION x DICKLOW.

Many data of great genetic importance are being accumulated, some of them of such a character as to add to present information on the genetic behavior of wheat.

Studies in oats, barley, and corn (perhaps also on rye) are highly important. If only sufficient help were available it is now known to be possible to produce sorts adapted to wet land, elevated, and possibly alkali land. Corn offers a dove-tailing of possibilities not clearly understood. (Stewart, G.)

64. Cultural Methods.—This experiment aims to determine the best cultural practices in the growing of sugar-beets under different weather conditions. This last year it was demonstrated that sugar-beets can be watered-up after planting when there is not sufficient moisture in the ground for germination. Very careful cultivation, however, was required early in the season. It had been shown previously that irrigation before planting was a much more successful method. It has also been shown that beets thinned to 12 inches apart give a higher yield in most
years than a greater or less distance and that it is advisable to start irrigation rather early after thinning as very little drying at this stage permanently injures the beet. (Pittman, D. W. and Stewart, G.)

65. Weed Control.—This experiment was conducted for three years on a piece of land recently purchased which was badly infested with wild morning glory. It has been shown that the morning glory can be practically eliminated by one year with frequent cultivation, never allowing any leaf growth to show above the soil, followed by one or two years of carefully tended cultivated crops. Spraying with equal frequency with sodium arsenite was also quite effective tho not quite as thoro as cultivation. The spray was useful only in keeping down the top growth. Smothering with a dense growth of sunflowers was fairly effective. Other methods tried, such as infrequent spraying or cultivating, deep plowing, shading, salting, treating the soil with crude oil or gas, smothering with corn, or pasturing with hogs and sheep, were not especially effective. These results have been compiled and are found in Bulletin No. 189—“Ridding th Land of Wild Morning Glory.” (Stewart, G. and Pittman, D. W.)

ANIMAL HUSBANDRY

19. Rations for Dairy Cows.—The object of this experiment has been to discover cheap yet effective rations for milk production. Three years' results indicate that there is little difference in the feeding value of first, second, and third crops of alfalfa hay for milk production, provided each crop of hay is cut at about the same stage of maturity and properly cured. These results were published in Bulletin No. 126. The hay value of corn silage was studied for two years. It was found that the addition of corn silage to a ration of alfalfa hay and a light grain allowance did not appreciably increase the milk flow. From 2.5 to 3.0 tons of corn silage replaced one ton of alfalfa hay for milk production. Bulletin No. 190, entitled “Corn Silage in a Dairy Ration,” contains the results of this experiment.

Dried beet pulp soaked before feeding was found to be unpalatable to most of the cows in the college herd. It proved less valuable than pasture in the summer dairy ration and less productive than corn silage in the winter ration. These are the results of but one year's study and further investigation may modify them.

A commercial dairy feed was found to be approximately equal to bran and shorts for milk production when fed as a light grain ration. A grape-seed residue was found to be an extremely poor feed and distinctly inferior to mixed grain.
It is planned to continue the search for cheap yet effective rations for milk production. The addition of the dairy farm should make progress in this project much more rapid. The whole problem of the use of succulence in the dairy ration, including the kind of succulent feed as well as the amounts and methods of feeding, should be investigated. The amount of grain to feed cows of different productive capacities with and without a succulent feed also needs attention. Profitable year-round systems of feeding dairy cows should be studied. (Carroll, W. E.)

20. Hog Rations.—The object of this experiment has been to study profitable systems of pork production. In cooperation with the Salt Lake Union Stockyards a test was run in which the following four rations were fed to forty-four head of 100-pound hogs: (1) rolled barley and meat meal tankage; (2) shelled corn and meat meal tankage; (3) bran, shorts, and buttermilk; and (4) rolled barley and alfalfa hay. The test extended over a period of fifty-six days. The average daily gains of the respective lots were 1.55, 1.42, 1.18, and 1.23 pounds. In making 100 pounds of gain the following amounts of feed were required:

Lot 1—tankage, 22 lbs.; rolled barley, 414 lbs.
Lot 2—tankage, 33 lbs.; shelled corn, 411 lbs.
Lot 3—bran, 124 lbs.; shorts, 251 lbs.; buttermilk, 634 lbs.
Lot 4—rolled barley, 422 lbs.; alfalfa hay, 8 lbs.

Another comparison test in which eighteen purebred Tamworths for eighty-two days were fed whole, steam-rolled, and chopped barley for fattening hogs when they had access to alfalfa hay in racks. In making 100 pounds of gain whole barley was found to be 19 per cent less efficient than chopped and 22 per cent less valuable than the rolled. While the rolled barley was actually about 2.5 per cent more valuable than the chopped, the difference is probably too small to be significant.

As a part of this project a study was also made of the effect of prolonged maintenance of young pigs on their subsequent growth and development. Pigs weighing from 30 to 50 pounds were held at these weights for as long as seven months. When they were put on full feed they gained more rapidly and on less feed than did similar pigs which had been full-fed from the beginning. In no case were pigs permanently stunted by preventing their growth for as long as seven months.

Work has been started to determine if it is possible to breed one strain of economical-gaining pigs and one requiring a large amount of feed upon which to make gains.
The following article has been published on work under this project:


(Carroll, W. E.)

21. Rations for Fattening Cattle.—Two years' work has been done on the most profitable amount of grain to feed with alfalfa hay to fattening cattle. One lot each year was fed nothing but alfalfa hay. Grain was fed the other lots for one year only in amounts of 3, 5, 8, and 12 pounds, respectively. Where three pounds were fed as against no grain each pound of grain replaced 6.1 pounds of hay. The hay value of one pound of grain decreased to 5.5 pounds for the 5-pound ration and 4.5 pounds for the 8-pound ration. Feeding three pounds of grain as compared with five and eight pounds resulted in hay values of 4.4 pounds and 3.1 pounds, respectively. In feeding eight pounds as against five pounds of grain, each pound of added grain replaced only 2.1 pounds of alfalfa hay.

One comparison has been made of the feeding value of wet beet pulp and corn silage when 4.8 pounds of chopped barley and alfalfa at will made up the remainder of the ration. A ration of alfalfa hay and 9.4 pounds of chopped barley was included in this test. The cattle weighed 970 pounds and were fed for ninety days. The hay and barley group gained 1.93 pounds a head daily, the silage group 1.9 pounds, and the pulp group 2.21 pounds a head daily. The silage was limited to 20 pounds a head daily, while pulp was limited to 50 pounds. A ton of pulp replaced approximately 1100 pounds of silage, 64 pounds of chopped barley, and 150 pounds of hay. This work should be continued in order to determine a large number of economical rations for fattening cattle as well as the place of cattle-feeding in our prevailing types of agricultural production. To carry on this work at all properly a feeding plant is much needed with the necessary yards, sheds, feed storage, etc. (W. E. Carroll.)

BACTERIOLOGY AND CHEMISTRY

22. Factors Influencing Bacterial Activities of the Soil.—The quantity of ash in wheat, oats, and barley has been found to increase progressively as the irrigation water used in its production increased. This increase was as follows: wheat, 46 per cent; oats, 31 per cent; and barley, 36 per cent. A very marked increase has been found in the calcium, magnesium, phosphorus, and potassium of the grain, grown on irrigated land over that grown on unirrigated soil. This irrigated grain, from the viewpoint of fertility, cost more to produce than unirrigated;
moreover, it has a different nutrition value. A scientific article which has appeared on this phase of the project is as follows:


This difference also occurs in the sulfur content but not in the iron and chlorine, the results of which experimentation are shown in the following:


This increase in ash and mineral constituents is due to the direct solvent action of the water and the increased bacterial activity which results in an increase of the available food, since where fertilizers are added the increase is not so pronounced on the irrigated over the unirrigated. The results of this study are explained in detail in the following publication which is in press:


(Greaves, J. E.)

**23. Permanent Fertility Studies.**—The nitrogen content of the soil can be greatly increased by the application of manure and thus result in an increased nitrogen-gathering power of the soil, as is shown in Utah Experiment Station Bulletin 185.

The organic content of manure is rapidly decomposed and the mineral nutrients are stored principally in the surface foot-section of the soil.

“The Influence of Manure and Irrigation on the Carbon, Phosphorus, Calcium, and Magnesium Contents of the Soil.”
By C. T. Hirst and J. E. Greaves. (In Press).

Arsenites have been found to be exceedingly toxic to the microflora of the soil, whereas arsenates are devoid of such toxicity unless present in high concentration. This is more fully discussed in the following publication:

“Influence of Sodium Arsenite on the Microflora of the Soil.”

It is planned to continue the work along the same lines during the coming biennium. (Greaves, J. E.)

**24. Composition of the Irrigation Water of the Intermountain Region.**—In the past considerable work on this project was accomplished. Utah Experiment Station Bulletin No. 163, entitled
“Composition of the Irrigation Waters of Utah,” covered the results of the work up to the time of its publication in 1918. To continue this work there should be a fund of $1600 available either from Station or Extension Division funds to offer a half-time fellowship to a graduate student for making analyses of water (as well as various agricultural products) received from various parts of the state. (Greaves, J. E.)

67. Changes in Flour during Storage.—This is a comparatively recent project and not a great deal of data has been collected. However, from the analysis of samples of flour received the results seem to indicate that the storage of flour increases its bread-making properties, increases the PH value, increases the diastatic and proteolytic cleavage products, and slightly changes the nature of the phosphorus content of the flour. The last analyses are now in process of preparation and the material resulting from this study should be ready for publication within two or three months. (Greaves, J. E.)

BOTANY

*31. Potato Diseases.—

A. Physiological Studies.

A. Physiological Studies.—For some time it has been felt that environment plays a great part with potatoes as to their value for seed the following year. The growers have repeatedly said that seed produced in the high mountain valleys was better than that produced in the larger, warmer valleys below. This experiment is being conducted to determine if there is a measurable difference in the potato crop as affected by seed grown at high elevation, at medium elevation, and at lower elevation in the state and produced on plants which were grown early, medium, and late.

The results of the past five years clearly indicate that there is a relationship, but there are so many factors concerned that the results are by no means the same for each year. During the past year potatoes grown last year in Logan and Farmington (on the Davis County Experimental Farm) were planted in Logan, Midvale, Morgan, and Farmington three different times at each place. Due to the excessively dry season the maintenance of uniformity was more difficult than in previous years. The final results on these potatoes will be obtained next year when they will be planted at Logan, but the results seem to indicate a marked variation which it not constant nor constantly uniform.

*Project 31 is divided into three parts, Part A being carried by G. R. Hill, Botanist, while Parts B and C are carried by B. L. Richards, Plant Pathologist.
Very careful notes have been taken on each hill separately and any symptoms of mosaic or other diseases have been carefully noted.

In normal plants, showing no symptoms of disease, there is considerable difference between the high-elevation and the low-elevation potatoes. The potatoes produced in 1923 in Logan are distinctly better in yield than those produced in Farmington in the same year. However, the results of the previous year were exactly the reverse. It would be worth hundreds of thousands of dollars each year to the potato growers of Utah if it could be ascertained how to produce seed resulting in the yield that the Morgan potatoes gave.

Additional work is needed in measuring the various environmental factors with which potatoes are surrounded. Necessary apparatus for temperature should be procured. Soil air thermographs are absolutely imperative as well as additional meteorological instruments. Environment plays an important role in the culture of potato seed, but just exactly what this is and how it may be controlled cannot be determined until the factors of the environment are measured more quantitatively. (Hill, G. R.)

DAIRYING

71. Methods of Dairy Manufacture.—

A. Effect of Clarification on Quality of Cheese
B. Manufacture of Butter from Sweet Cream

A. Effect of Clarification on Quality of Cheese.—Clarification of milk is widely used in market milk plants. The process consists of subjecting milk to centrifugal force and thereby extracting foreign material such as hair, straw, and dirt which have accidentally been introduced into the milk as well as numerous bacteria and cellular material. It was thought that if the milk were clarified prior to the manufacture of cheddar cheese, an improvement in the quality of the cheese could be effected.

A number of experimental batches of cheese have been made. To date the results indicate that the flavor of cheese obtained from the clarified milk is better than the flavor of the unclarified milk cheese. The cheese has been scored by judges from the U. S. Department of Agriculture. The following average scores have been obtained:

<table>
<thead>
<tr>
<th></th>
<th>Clarified</th>
<th>Unclarified</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 month old</td>
<td>38.18</td>
<td>37.8</td>
<td>0.38</td>
</tr>
<tr>
<td>3 months old</td>
<td>37.5</td>
<td>36.63</td>
<td>0.87</td>
</tr>
</tbody>
</table>

B. Manufacture of Butter from Sweet Cream.—Experimental batches of butter have been made during the year and samples
for scoring have been sent to the Western Office of the U. S. Dairy Division. A total of fifteen samples was scored and the average score obtained for the year was 93.5. A total of 779 samples of butter was sent from 197 creameries located in eleven western states to the eight scorings held throughout the year. The average score of all samples was 90.05, whereas the highest score obtained for U. A. C. butter was 95 and the lowest 92. The average score obtained for U. A. C. butter for the year was higher than that obtained by other butter entered in the contest. The results indicate that if a high-quality raw material is used while still in a fresh and sweet condition and this is carefully pasteurized and ripened with a fine-flavored pure culture to a low acidity and then made into butter according to the most modern methods, a high-quality product possessing keeping qualities can be obtained.

It was demonstrated that very fine butter, possessing excellent keeping qualities, can be made from sweet cream. When churning sweet unripened cream with a small hand churn it was found advisable first to pasteurize the cream, then hold it at churning temperature (which should be from 2 to 4 degrees Fahrenheit lower than that used when churning ripened cream), and then churn it for 40 to 50 minutes agitating a little more vigorously than when churning ripened cream at the higher temperature. Sweet cream butter made by a small hand churn has been kept for six weeks at 10 degrees Fahrenheit and has then received an official score of 94 points. (Wilster, G.)

73. Production Costs in Dairying.—The financial status of dairy farming is such that this project has been outlined to determine, if possible, whether an average dairy project, well handled with good cows, will be an interest-paying investment for a dairy farmer. The work of this project has been begun during the last few months on what is known as the Cronquist Farm, which is described under the general Farm heading. The alfalfa, silage, and pasture will be taken care of by the farm itself, while it will be necessary to have the grain furnished from some other source. At present the herd consists of 45 Holstein cows ranging in age from two to eight years. A number of these cows have official yearly records ranging from 380 to 560 pounds' butterfat. The herd is better than the average herd of the state but not more productive than can be developed in a few years' time by good breeders. It is planned to add a number of 2-year-old heifers to the herd within the next few weeks.

The herd will be managed in the most practical manner possible. Extra labor against the cows will not be charged against them. Careful and accurate records were begun on
November first. These records will continue throughout the experiment. The data will include the following:

(1) **Debit Charges**
   - Original investment of each individual cow
   - Amount of feed consumed
   - Labor (for regular work)
   - Depreciation of cattle and equipment
   - General maintenance including
     - Taxes
     - Interest
     - Bull and veterinary service, etc.

(2) **Credit Income**
   - Milk
   - Butterfat
   - Manure
   - Calves
   - Carcass

In case of the sale of a purebred bull as a breeder from a high-record-purebred cow, proper credit will be given for the sale.

Careful breeding records will also be very necessary. The number and sex of all calves dropped and raised as well as the number of abortions will be kept. Record of the disposition of all animals is also very important in determining whether or not the young stock will replace the original and what can be sold as a surplus. (Caine, G. B., Carroll, W. E., and Bateman, G. Q.)

**DAVIS COUNTY EXPERIMENTAL FARM**

59. **Davis County Experimental Farm.**—During the biennium the following lines of investigation have been pursued under this project:

1. Onion Variety Test
2. Green Bean Variety Test
3. Watermelon Breeding for Wilt Resistance
4. Irrigation Studies of Canning Peas
5. Cost of Producing Strawberries
6. Miscellaneous Researches
   (a) Sweet Potato Culture
   (b) Carrot Varieties
   (c) Fancy Cucumber Varieties
   (d) Development of Pedigreed Strain of VALENCIA Onion
   (e) Keeping Qualities of Onions
   (f) Double-Cropping Systems

In addition to the work outlined above the Superintendent has
participated in the following cooperative projects with other departments:

1. Strawberry Varieties (Department of Horticulture, Project 41 B)
2. Tomato Type Studies (Department of Horticulture, Project 41 A)
3. Celery Varieties and Culture (Department of Horticulture, Projects 41 C and 69 C)
4. Fall Lettuce Studies (Department of Horticulture, Project 69 B)
5. Silage Corn Studies (Department of Agronomy, Project 10)
6. Ornamental Shrubs and Trees (Department of Horticulture, Project 40 B)
7. Method of Planting Canning Peas in Relation to Yield (Department of Horticulture, Project 38)
8. Variety Test of Wheat (Department of Agronomy, Project 42)
9. Seed Potatoes—Environmental Studies (Department of Botany, Project 31 A)
10. Rhizoctonia Accumulation in the Soil (Department of Plant Pathology, Project 31 B)
11. Mosaic Studies of Irish Potatoes (Department of Plant Pathology, Project 31 C)
12. Control of Onion Thrip (Department of Entomology, Project 51)
13. Tomato Wilt Studies (Department of Plant Pathology, Project 33 B)

These items are reported by the departments interested.

The following report under this project includes summaries of work accomplished for the first six projects listed. Each division of the main project is a complete project within itself.

Onion Variety Tests.—This project was extended slightly over that of other years. In 1923 fifty-three varieties and strains were under test, while in 1924 there have been eighty-eight varieties and strains. The extension of the current year includes: (1) all strains which have been in previous tests but which were eliminated for various reasons and (2) strains and varieties of early-bunch onions. This general extension anticipates the culmination of the project at the close of the 1924 season. The significant result of the 1923 and 1924 seasons was the very definite superiority of the VALENCIA variety over all others in point of yield. In 1923 the average for six strains of VALENCIA
was 77,418 pounds to the acre and of its nearest competitor (two strains of GIBRALTAR), 52,751 pounds to the acre. Moreover, the lowest-yielding strain of VALENCIA exceeded the highest-yielding strain of GIBRALTAR by nearly 4000 pounds to the acre, while the highest yielding VALENCIA produced sixteen tons more onions than the best yielding strain of GIBRALTAR. The next in order were: DENIA—51,691 pounds to the acre and SOUTHPORT YELLOW GLOBE—42,108 pounds to the acre. These results are comparable to those of previous years.

Variety Tests of String Beans.—This work has advanced along the lines previously reported. At the close of the current year all row work will be abandoned in favor of plat work with a limited number of the best varieties. Detailed botanical descriptions will be made together with a compilation of yield data for four years. Cooking tests have also been made with all varieties.

Watermelon Breeding for Wilt Resistance.—The attempts to breed a wilt-resistant watermelon by crossing the stock citron upon various varieties of commercial watermelons to date have not been successful. Out of eleven original crosses not a single edible melon was found in the F₂ generation. The possibility of obtaining an edible melon is extremely limited, and at the same time this possibility is further handicapped (1) by lack of available land to breed out all possibilities, and (2) by the fact that pollination was not controlled in the F₁ generation. The work has been reorganized on a much more limited basis with two standard varieties instead of eleven as used previously.

Irrigation Studies on Canning Peas.—The object of this experiment is to determine the best time to begin the irrigation of canning peas in order to produce the largest yield of shelled peas. It was assumed in 1923 that three irrigations were sufficient to mature a crop of peas. In 1924 climatic conditions were so much different that four irrigations were given in most cases; however, the initial irrigation conformed to the same plan as followed in 1923, viz.: (1) the first application was made before the vines showed the slightest need for water; (2) another group of plats received irrigation when the vines exhibited definite signs of insufficient moisture; and (3) still a third group of plats when the vines showed unmistakable signs of drouth as indicated by a checking of the growth and some burning of lower leaves. However, this checking was not severe enough to inhibit blossoming or pod formation. The second and third applications in each group followed the initial irrigation in intervals of one week to ten days. The 1923 results showed a very definite advantage in favor of the latest initial application as indicated in
the following table where each figure is an average of five and six plats:

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<td>4450</td>
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The 1924 results completely reverse those of 1923 in that the highest average yield was obtained by the early use of water. This fact is accountable for in terms of climatic variation. The spring of 1924 was an unusually moist one, characterized by frequent showers during April, May, and most of June. In 1923 3.35 inches of rain fell from May 16 to June 25. In 1924 four inches of snow fell on April 14, two days after planting, with no other rainfall until May 28 and 29 when 1.91 inches of moisture fell; 0.93 inch fell during June. In addition to the scanty rainfall poorly distributed, the season was extremely windy.

Cost of Producing Strawberries.—The aim of this investigation is to determine the cost of producing market strawberries. A tract of 0.38 acre was planted to the MARSHALL variety in 1922. Two crops have been harvested at the following costs:

- 218 man hours at 20c (boys) ........................................ $43.60
- 146 man hours at 37½c (men) ....................................... 54.75
- 75 horse hours at 12½c ............................................. 9.37
- Cost of plants ................................................................ 11.00
- Cost of cups and cases .................................................. 51.03
- Land rental, including irrigation water and its maintenance (0.38 acre at $50 for 3 years) ....................... 57.00
- Picking 228 cases at 20c (15 cups a case) ....................... 45.60
- Picking 118 cases at 15c (12 cups a case) ....................... 17.70
- 10 days' labor supervising pickers at $3 ......................... 30.00

Total Cost ................................................................. $320.00
Total Harvest ......................................................... 4836 cups
Cost of Production (a cup) .......................................... $ 0.066

The 1924 crop was about one-half normal. With a full crop the cost a cup would be considerably less.

Miscellaneous Researches

(A) Sweet Potatoes.—Two varieties of sweet potatoes considered to have possibilities in Utah were obtained thru the courtesy of Dr. J. I. Lauritzen of the Bureau of Plant Industry, U. S. Department of Agriculture. One of these, PORTO RICO YAMS, failed to make any crop, while the other, LITTLE STEM JERSEY, yielded at the rate of 300 bushels marketable potatoes to the acre in 1923 and 260 bushels in 1924.
(B) Carrot Varieties.—Nine of the leading varieties of table carrots were planted in 1924 to study types. AMSTERDAM FORCING, CORELESS, and CHANTENAY stand out as superior to other varieties.

(C) Cucumbers.—It has been suggested that a market could be developed for fancy cucumbers during late summer and early autumn after the main crop has been harvested. In order to find a suitable variety for this purpose, fifteen varieties of the long green type were planted in 1924. The VAUGHAN and PERFECTED DAVIS PERFECT proved to be the best varieties of those under observation.

(D) Keeping Qualities of Onions.—This work is subsidiary to the onion-variety tests. A known number of bulbs of most of the sorts in the variety test were weighed and placed in a frost-free cellar for storage. While the cellar used was frost-free it was lacking in other essential features for good onion storage. Records were taken at intervals of about one month beginning in February. From three years’ results the following varieties have been the best keepers: AUSTRALIAN BROWN, VALENCIA, YELLOW GLOBE DANVERS, and the SOUTHPORT GLOBE. The exact order of these varieties has varied each year. The significant result, however, is that VALENCIA, a high-yielding strain, is comparable in keeping qualities to the much lower yielder, BROWN AUSTRALIAN, and very much superior to any other Spanish type in this respect.

(E) Development of a Pedigree Strain of VALENCIA Onion.—There is a wide variation between the various strains of VALENCIA onions grown in Utah in point of color and types. These variations are almost as extreme within most of the strains. This piece of work is intended to produce a pedigree strain of acceptable type and color thru the process of pedigree selection.

(F) Double-cropping Systems.—The following double-cropping systems have proven to be successful:
1. Spring-planted lettuce followed by cabbage.
2. Canning peas followed by fall lettuce.
3. Canning peas followed by table beets.

Recommendations.—The following recommendations in regard to the Davis County Experimental Farm are suggested:

1. That a building be constructed as soon as permanency is
assured to be used as a machine shed and a seed store room and work room, equipped with such benches, bins, and cabinets as will accommodate the work of the department and provide suitable storage facilities for miscellaneous supplies and seed stocks.

2. That in case of purchase, a tract of land of about four acres lying immediately west and adjoining the present acreage be purchased to provide adequate land suited to celery, onion, cabbage, and cauliflower investigations. At the present time the farm is seriously handicapped in this regard.

3. That a technical assistant be employed during the months of May to October, inclusive; such a man to be assigned to record-keeping, to making technical observations, and to do such other scientific work that ordinary help is not prepared to do. The scientific value of the farm would be materially strengthened by such an arrangement.

4. That the attention given to variety tests be curtailed and that some of the following studies be substituted:
   (1) Fertilizer studies for truck crops
   (2) Cropping systems and rotations for truck crops
   (3) Irrigation studies for truck crops
   (4) Bush fruits—varieties and culture
   (5) Seed studies—especially onions, tomatoes, and celery.

 Variety tests cannot be eliminated because the Station should be prepared to extend to the gardeners of the state information concerning new varieties or, as is often the case, to discover that a new variety is merely a new name for some well-known sort. Extensive areas would not be required for this.

5. Utah spends a large sum of money each year for hot-house-grown vegetables, and yet there is not a single vegetable greenhouse of any consequence in the state. Probably there should not be. The Experiment Station could render an estimable service in determining this question. This farm is well located to undertake the solution. (Wilson, A. L.)

ENTOMOLOGY

51. Miscellaneous Insects.—This main project has been divided into several subdivisions and the work on each separate project is reported herewith.

Fruit-tree Leaf-roller.—This insect winters in the egg stage on apple twigs. Forty-four different dormant oil spray treatments were applied in an effort to prevent the hatching of these eggs. In some cases 96 per cent control has been obtained, but it is very apparent that there is a wide variation in effectiveness.
Sprays were applied at two different times: one before the buds burst and the other when the first leaves were out. The results of this year were just the opposite to what they were last year. This year the early spray gave the best control. The difference may be explained by a difference in the season. Eggs hatched much earlier this year than last. Some of the oils used were commercial products, while others were made of lubricating oil, soap or calcium caseinate as an emulsifier, and water. These oils are cheaper than the commercial oils and just as effective. Arsenate of lead was used with poor success against caterpillars. This project is closed and the data are ready for publication. (Hawley, I. M.)

**Blister Mite.**—This mite, which is so small that it cannot be seen with the naked eye, passes the winter beneath the terminal bud scales of apple twigs. Twenty-five fall and spring applications of commercial oil and sulfur compounds have been used in this test to kill the over-wintering mites. Some sulfur compounds, such as lime-sulfur, dry lime-sulfur, and soluble sulfur, applied either in the fall or spring gave a control running in some cases as high as 99 per cent. Some oils gave fair control, but others had as many scars on the leaves as did the checks. This project is closed. (Hawley, I. M.)

**Sugar-beet Root-maggot.**—The life history of this little-understood pest has now been practically worked out, and some data that should influence its control have been collected. The insect winters as a larva in beet fields, and the fly appears in the spring about thinning time and deposits its eggs in the ground near the young beets. The maggots that hatch from these eggs feed on the roots of the beet and often cut off the tip. In this case the beet dies. Early watering of beets is believed to keep the insect feeding above the tip of the beet so it will not be cut off. The insect is always worse in dry, sandy soils. The project is to be continued. (Hawley, I. M.)

**Insectivorous Reptiles.**—This work is completed and will soon be published. This work is a study of the lizards and snakes of Utah. In addition to a systematic study, the food of each species has been determined by examining the stomach contents of many species. (Pack, H. J.)

**Peach-tree Borer.**—This insect works beneath the ground on the base of the tree. The tree is weakened and may be killed. The tests were made in Box Elder County. Four separate treatments of paradichlorobenzene were applied to find out the best time for application of this product. Three were applied at 2-week
intervals in the fall and one the following April. The control was nearly 100 per cent effective in all cases. Spring and fall applications were equally effective. The project is closed. (Hawley, I. M.)

Field Ants.—Thirty-six combinations of insecticides were used against four common species of ants. These ants are common in peach orchards and gardens as well as in grain fields. Calcium cyanide was most effective when driven into the nests with a dusting machine, but it is dangerous for general recommendation. Carbon disulfide gives good control in some cases, and a bait of sodium fluoride, sugar and cornstarch was effective against some species. It is planned to test the baits one more season and to try out an emulsion of carbon disulfide and water. (Hawley, I. M.)

Dusting.—Nicodust, a preparation of nicotine sulfate and a finely powdered carrier such as lime, sulfur, or gypsum, was used against several species of aphids or plant lice—in particular the pea aphis on sweetpeas. Nicodust was also tried out on currant and cabbage aphids. Good control was obtained. This plant louse, tho not injurious to field peas, was very destructive to sweetpeas grown for seed. This product is not at present in commercial use in Utah. It has advantages over contact sprays and should be given further tests. It can be made at home by any one. This is cheaper than the manufactured material. However, it is still expensive. (Hawley, I. M.)

There are several insect problems of the state that need investigation at this time. The green soldier bug has been very destructive in Davis County. The alfalfa-seed chalcis fly needs study both in Millard County and in the Uinta Basin. The symphylid, a millipede-like form, is a serious pest in Davis County. There are also several newly-introduced pests that need some attention. The need for entomological work was never more apparent.

There are twenty-five colonies of bees in the Station Apiary. These have been used in teaching work in the past. However, in the future they will be used in experimental work. (Hawley, I. M.)

**GEOLOGY**

25. Ground-Water Development.—The studies under this project include an attempt to map the entire state to show the areas where artesian water might be developed; where underground water might be developed for pumping either for irrigation or for culinary supply; where the flow of individual springs might be increased; where tunneling might promise new develop-
ment in water supply; and where it is possible to develop watering places to better utilize the range.

In the beginning only a small fraction of time was given to the work and as a result data were collected slowly. Partial or complete data have now been collected from every important area in the state, indicating the available ground-water supply. Annual measurements have been made on the flowing wells of most districts to determine whether or not the flow and static head are maintaining. Many measurements have been recorded on pump, well, spring, and tunnel supply.

Special effort has been given to determine the available supply by correlating the structure, rainfall, and area of the drainage basin. Sufficient data have been collected to warrant publication. The future work will be a study to determine the maximum water available with definite protection to those who have expended large sums for water development. The work has been retarded by lack of rain gages distributed thru the drainage areas and maps of more detailed topography. Much land is being watered both from artesian supplies and pumps and many watering holes have been developed on the range as a result of these studies. (Peterson, W.)

HORTICULTURE

38. Canning Crops.—Pea aphis has occasionally threatened ruin to the pea crop for the cannery. Since peas are planted solidly across the field with a grain drill it seemed that some method of planting to allow for spraying machinery to pass without injuring the vines would some time be necessary. Hence, for three years a study has been made on the Davis County Experimental Farm on the effect of various systems of planting on the yield.

Four methods of planting were tested: (1) Single row, in which the seed was planted in single rows 36 inches apart; (2) double rows, planted 36 inches apart in double rows spaces 6 inches apart; (3) single drill width in which the seed was sown with a grain drill with a 3-foot space left between strips; and (4) solid planting, the ordinary field method with a grain drill. ALASKA and ADMIRAL, the popular canning varieties, were used.

The single- and double-row methods reduced the yields so much below the other two methods that in 1923 only the latter were used. For the three years of the test the single-drill-width method reduced the yield on the average 17.3 per cent. In actual practice it would not be necessary to reduce the yield this much, for, on account of the possibility of using long spray booms, spaces need not be left between all strips. (Abell, T. H.)
39.—Utilization of Horticultural Products.—On account of the great waste from cull apples during the World War, an attempt was made to find new and useful methods for their utilization. The result was to show that apples could be made into a delightful chocolate-coated confection. Selling tests in local stores showed that the public would actually call for and buy this product. The first report may be found in Utah Experiment Station Bulletin No. 179. After the publication of this report further improvements in method were made, and new possibilities in this field were uncovered. At the present time this project is inactive. (Abell, T. H.)

40. Horticultural Survey
A. Ornamental Trees and Shrubs for Utah
B. Commercial Strawberry Culture in Utah
C. General Horticultural Survey

A. Ornamental Trees and Shrubs for Utah.—In order to increase the variety of plant materials for landscape gardening in this state a collection of six specimens each of 103 species of trees and 136 species of shrubs were secured in the spring of 1920. Three specimens of each were planted on the Central Experiment Station (Greenville) which is located in the comparatively cool Cache Valley where peaches thrive only in particularly favored places. The other three specimens of each were planted on the Davis County Experimental Farm which is located about twenty miles north of Salt Lake City in a belt where peaches, almonds, and sweet cherries thrive. Most of the species were new in this climate, but a few common hardy sorts were planted for comparative observation. Out of 136 species in Davis County twenty died the first or second season due to the climate and partly because they had arrived in poor condition; 157 proved to be tender in the top and were usually killed to the snow line; 38 were suited to the climate but were subject to a slight winter-killing of the tips; 63 were perfectly hardy. In Logan a larger percentage was half hardy, tender, or killed outright by the winter's cold. Similar data were secured for the trees. A published report including blooming data and suggested uses is being prepared for publication. The best of the plants have been used for landscaping on the college campus at Logan where future observations will be continued.

B. Commercial Strawberry Culture in Utah.—Extensive field surveys of the strawberry were made to determine the extent of this industry, its success, methods used, serious problems, varieties most used and most successful, and markets available. Commercial strawberry-growing extends from Cache Valley in the
north to Payson south of Utah Lake, with an acreage many times too large for local use and shipping of the MARSHALL being attempted. However, MARSHALL has a reputation for quick deterioration; hence, the need for a better shipping berry. AROMA is growing in popularity for shipping purposes but is inferior to the MARSHALL in yield, quality, and color. The following varieties are now indicated as being most generally suitable for Utah:

- Early................PREMIER
- Home Market........(MARSHALL (Great Salt Lake Basin))
- Canning and Jam........MARSHALL
- Everbearing..............SUPERB
- Shipping................AROMA and MARSHALL

It is planned to continue this survey along the lines of production costs.

C. General Horticultural Survey.—Visits to many farms in several districts have revealed several problems which are pressing for solution. Among these the following may be noted:

1. Soil fertility troubles in apple orchards as evidenced by a characteristic shortened terminal growth and a poor setting of fruit.

2. The necessity for orchard cover crops or sod crops other than alfalfa which appears to have several faults, especially that of harboring insects.

3. Needed information regarding the adaptability of many varieties of fruits and vegetables desirable for market purposes.

4. Pollination troubles in sweet cherries and apples.

5. Orchard renovation problems. The majority of apple orchards have been planted about 16x20 to 20x25 feet. The result in 12- to 16-year-old orchards is a tangled mass in the rows.

6. Lack of information on hardiness in apricots and sweet cherries. What is the nature of tenderness and can cultural treatments be devised to increase hardiness?

7. Can the Utah fruit grower make a blanket adoption of the Long-arm System of tree-pruning? If not, to what extent can it be used?

8. There is a wide divergence in methods of handling grapes, with consequent variations in quality and quantity of crops. Especially does this refer to methods of training. Mildew, to which TOKAY and MUSCAT OF ALEXANDRIA grapes are especially susceptible, needs expert attention. May it not be partially controlled by a higher system of training than that now practised?
(9) Utah canneries are interested in a cling-stone peach run, but there is now insufficient acreage and no certainty as to what variety to plant. A variety study must be made.

(10) Commercial possibilities and value of thinning apples, peaches, pears, and apricots.

(11) A promising almost subtropical agricultural region is being opened by the approach of the railroad in the Virgin River Valley in Washington County. The total area available for cultivation is limited by water for irrigation to approximately 10,000 acres. A study is needed of the possibility for the production of vegetables in winter and of early fruits in spring and summer to supply Utah markets which are now supplied from without the state. Warm springs especially favor vegetables in late winter. The fruit culture in the past has been almost entirely a matter of seedlings. The same is true in regard to walnuts and pecans which do very well. Fig preserves and sugared figs of both white and black varieties are confined to home industry, but they present a splendid opportunity for commercial enterprise.

Similar climate of perhaps a wider range calls for the same investigational effort in the region of Moab in Grand County along the Grand River. (Abell, T. H.)

41. Breeding Horticultural Crops.—

A. A Better Cannery Tomato
B. A Better Shipping Strawberry
C. To Purify Utah Celery

A. A Better Cannery Tomato.—Altho Utah is distinguished by having the highest yield per acre of canning tomatoes in the United States, the varieties in general use are not entirely satisfactory. There are various reasons for this: (1) The season is rather late and there are really satisfactory varieties to precede it; (2) it frequently degenerates into inferior types or else there are really superior and inferior strains; (3) it is susceptible to western yellow blight, wilt, mosaic, etc. which make periodic ravages in this state; and (4) the color is not always as dark as the canners would like for canning and for catsup. Hence, the attempt to find a better canning variety or at least something to supplement STONE and GREATER BALTIMORE.

This investigation was begun in 1918 as a variety test. Since that time about 100 varieties have been tried but none have so far been found that could supplant STONE and GREATER BALTIMORE. Varieties possessing some promise are: RED HEAD, TRIUMPH, NORTON, CRIMSON CUSHION, and IGNOTUM. In 1923 the variety testing was subordinated to
permit greater efforts on (1) strain-test work with STONE and GREATER BALTIMORE which is next to STONE in popularity, (2) plant row-tests of superior strains, (3) a study of seed-selection methods, and (4) a study of transmission of yellow blight by means of seeds. Seeds were secured from all known growers of STONE and BALTIMORE; the plants were grown in fortieth-acre plats triplicated. Striking differences in fruit type are apparent in strains from different sources. Careful plant selections have kept our own strains up to standard. Selections are made with respect to earliness, large yield, and high-canning quality of fruit. Western yellow blight is apparently not transmitted thru the seed. It is too soon to indicate definite results.

A few crosses were made between STONE and EARLANA types with the view of getting an earlier STONE. Nearly all EARLANA characters are dominant. The work will be continued as planned above with special stress on strain tests and strain selections of STONE and GREATER BALTIMORE.

B. A Better Shipping Strawberry.—Altho the MARSHALL strawberry is by far the most satisfactory for Utah climate and soils, the fruit is usually too soft and tender for anything but home use and nearby markets. AROMA is becoming popular for shipping because it ships well and is known on the market, but it has a lower yield, a lighter color, and a poorer flavor than MARSHALL. It is, therefore, proposed to find or create a shipping variety especially suited to this climate. Sixty varieties recommended by nurserymen as suitable for market have been collected and planted in plats on the Davis County Experimental Farm where they will be observed for yield and quality; tests will be made of shipping quality.

CHEASAPEAKE, which is outstanding in Boxelder County as having both quality and "shippability," fails to bear a good crop of large berries except under most favorable conditions. It is, therefore, unsuited to general planting. It is planned to use MARSHALL and CHEASAPEAKE as parents in crosses with each other and with other varieties which appear promising.

C. To Purify Utah Celery.—One of the things which tends to retard the celery industry in Utah is the fact that the variety called UTAH is a mixture of many types and that several distinct strains are grown either separately or together. This variety is supposed to have been bred up by the Chinese near Salt Lake City, and authentic seed has been difficult to procure. Seed has been secured from seven different sources to determine purity of type. Selections of distinct types have been made in a commercial field with the view of determining if pure types can be segregated and propagated.
Since any GOLDEN SELF-BLANCHING celery, which was heretofore raised in Utah, has been bitter, tough, and stringy, seeds were secured from every known grower of this variety in an attempt to discover if there were really any strains which had eating as well as shipping qualities. Out of eleven strains, two were found to give promise. Many other varieties have also been grown for comparison with those already mentioned. EMPEROR is excellent for home gardens, but it is too brittle to ship and is subject to rust. EASY BLANCHING and NEW-ARK MARKET have been among the best in two years' trials. (Abell, T. H.)

69. Truck Crop Production.—

A. Spinach

B. Head Lettuce

C. Celery

A. Spinach.—A test has been started of varieties and seasons in which spinach may be planted.

B. Head Lettuce.—Out of seven varieties tested on the Davis County Experimental Farm NEW YORK has proved superior to the others. A study has also been made of the proper time for planting. Head lettuce planted about August first will not mature before severe freezing weather. Lettuce planted on August 20 was left to grow over winter in the field and a fair crop was harvested about June first.

C. Celery.—One factor which has hindered the progress of the celery industry in Utah is the laborious and expensive cultural methods practiced by the Chinese and imitated by the white farmers. This consists of planting the crop in double rows in deep trenches, and, consequently, hilling the crop for blanching almost entirely by hand labor. Experiments performed on the Davis County Experimental Farm showed that if plants were set in single rows most of the hilling could be done with a common 2-way celery hiller and even better with a large John Deere reversible disk harrow. To force compact growth the bunches can be quickly tied with a continuous piece of 2- or 3-ply cotton twine tied on the first and last plant of each row and given a complete turn around each plant in succession. The string decays and does no damage.

Green types of celery, such as UTAH, are almost completely blanched without rust injury, if the hilling is begun from August 15 to 20 when the mean daily temperature begins to drop.

It is of interest to note that growers are now successfully
hilling celery with hand plows, orchard disks, and Martin ditchers. Both pine boards and patented paper have been tried, but the boards induce a bitter flavor and the paper "cooks" the plants in this hot, dry climate.

Utah Experiment Station Circular, No. 47, entitled "Celery for Utah," has been published. (Abell, T. H.)

HUMAN NUTRITION

52. Human Nutrition.—The purpose of this project has been to study the milk from various cows in regard to their digestibility and food value for infants. In order to study these milks from the standpoint of digestibility, a curd test was developed for determining the hardness of cows' milk. This test has been shown to be of sufficient reliability to publish an article describing the same:


As a result of this study the curd character of the milk was shown to vary with individual cows and also with the breed. The Holsteins in the college herd were shown on the average to have a softer-curded milk than the Jerseys. While no single experiment has been outlined on it, yet the infants fed on the milk shown by the test to be soft-curved have responded very favorably in all cases.

The nature of the curd of each individual cow's milk was found to be fairly uniform for the entire period of this study, and subsequent work has shown that it is also fairly uniform for the next lactation period. Very wide variance has been shown between the curd character of individual cows within the breed and also between different breeds. A survey of typical Holstein and Jersey herds at Richmond was made and the curd character of the milk was shown in general to check with the observations made on the U. A. C. dairy herd. The effect of heat-treatments of milk upon its curd character was next studied, and the milk heated to boiling was shown to be much softer than the untreated milk. In general there was a softening of the curd of from 50 to 70 per cent by the heat treatments of the milk.

It is planned to continue this study of the effects of breed, lactation period, etc., on the curd character of the milk. If sufficient funds are available analytical work will be conducted to determine if possible the reason for curd variance. Feeding experiments will also be conducted to check on the curd character as indicated by the test with the digestibility and food value of the milks when fed. (Hill, R. L.)
IRRIGATION AND DRAINAGE

Irrigation experiments have been concerned largely with the following problems: (1) duty of water, (2) pumping water for irrigation, (3) soil moisture, storage and movement, (4) water measurement, (5) water supply, (6) canal company organization, (7) water rights, and (8) control of flood water debris. Some of the investigations have been cooperative with other departments of the Experiment Station and others in cooperation with the Irrigation Division of the U. S. Department of Agriculture. Systematic experiments in drainage are urgently needed. Studies on the duty-of-water have been conducted in Cache, Sevier, Iron, and Uinta Counties. Studies on soil moisture, storage and movement were made in these same counties. Water-measurement studies have been confined to Cache and Uinta Counties. Water-supply studies are comparatively new and have to date been conducted largely in these two counties. Canal company organization has been given particular attention in Iron, Uinta, and Wasatch Counties. Water-right surveys were made throughout all of the major irrigated valleys of the state in cooperation with the Water Rights Commission preceding the extensive 1919 irrigation legislation. The control of flood water debris, a comparatively new project, has been conducted largely in Iron, Juab, and San Pete Counties. (Israelsen, O. W.)

14. Duty-of-Water Investigations on Coal Creek, Utah.—This project was to determine the most economic distribution of the waters of Coal Creek and to arrive at a scientific basis for the distribution of these waters. The results of this study are published in Utah Station Bulletin 181. (Fife, A. *)

15. Pumping for Irrigation and Canal Improvement.—Originally the intention of this project was to cover ground-water investigations only, but later (1919) it was enlarged to include all studies conducted under the cooperative agreement with the Division of Agricultural Engineering, U. S. Department of Agriculture. These investigations have included:

A. Ground-water Development
B. Pumping for Irrigation
C. Consolidation of Irrigation Companies
D. Use of Early and Late Water in Irrigation
E. Control of Flood Waters and Prevention of Deposits of Drifting Gravel in Canals

A. Ground-water Development.—With the passage of the Enlarged Homestead Act dry-farming was attempted on a considerable acreage of desert land in Millard, Beaver, Iron, Tooele, and other counties. Most of these claims were later abandoned,
but not until failure had repeatedly attended the efforts to produce a crop. In the meantime, an endeavor was made under this project to determine to what extent ground water might be obtained for supplemental irrigation in the more favorably located areas. The effort has resulted in a steady, consistent development in parts of Iron, Beaver, Millard, and Tooele Counties.

B. Pumping for Irrigation.—To determine the kind and size of pump required under certain conditions, a large number of tests were made where ground water is used for irrigation. In addition, efficiency tests have been made on pumping plants in Sevier, San Pete, Cache, and Box Elder Counties. The work undertaken has been completed and results are now being prepared for publication. Many of the efficiency tests run as low as 20 per cent.

C. Consolidation of Irrigation Companies.—The purpose of this project has been to determine to what extent a unification of the numerous independent irrigation units in any community might provide a means for making better use of the water supply. Solution of problems undertaken includes San Pete County north of Manti. Here it is proposed to secure additional water from another water-shed to the east and also to develop drainage water and return flow from the new supply. Ultimately, it will be endeavored to operate the entire system as one mutual company. The first project unit to be completed is on Coal Creek where thru consolidation the irrigated area has been increased 300 per cent without additional water supply and without reducing the yield per acre on any part of the district.

D. Use of Early and Late Water in Irrigation.—Large increases of total yield have been obtained by irrigating the seed-bed before planting grain when compared with planting under natural conditions and irrigating in the usual way. Two and three crops of alfalfa have been obtained by use of early water alone, where only one crop was harvested without the early water. By irrigating in the fall the appearance of burned spots during the following season has been prevented.

E. Flood Control and the Checking of Drifting Gravel at High-water Time.—The purpose of this project is to provide a means of utilizing high water in early spring without the menace of drifting gravel and sand which fills ditches and prevents the use of fluctuating streams coming from melting snow. The study also includes the design and construction of diversion dams which will not be carried away during a flood period in mid-summer. Flood-control diversion dams have been built at Beaver, Spring City, Enterprise, Kaysville, and Escalante. Gravel barriers have been built at Nephi, Fillmore, Kanosh,
Farmington, Willard, Davis Creek, and Summit; construction is under way at Mt. Pleasant, Junction, and Kanarraville. Successful control of floods seems assured as well as the complete stoppage of drifting sand and gravel. (Winsor, L. M.)

16. Size of Irrigation Streams for Different Soils.—In the irrigation of upland soils, which are largely open and porous, serious losses of water occur from excessive deep percolation. The use of small irrigation streams and their application to long strips of land tend to increase these losses. The use of large streams on short strips of land tend to decrease these losses. The purpose of this particular project has been to investigate the relation of soil porosity to the abovementioned losses in order to direct more intelligently the preparation of upland soils for irrigation and also to direct the selection of size of stream to be used. (Israelsen, O. W.)

18. Irrigation Institutions.—The purpose of this project has been to accumulate, analyse, and classify data having to do with the determination and adjudication of vested water rights and thus be able to intelligently advise irrigators, irrigation company officers, irrigation engineers, legislators, and others who seek information on these topics. This project was particularly active from 1917 to 1919 when the State Water Rights Commission was investigating and revising Utah’s irrigation and drainage laws. A detailed report of field studies outlining the salient features of the more advanced laws on water rights appeared in Utah Experiment Station Circular 38.

It is recommended that this project be developed cooperatively with the Irrigation Division of the U. S. Department of Agriculture. Mr. Wells A. Hutchins, Associate Irrigation Economist for the U. S. Department of Agriculture, has recently made a preliminary study of mutual irrigation companies. Since mutual companies have long served a large percentage of Utah’s irrigated land, it is highly desirable that the Station cooperate with the U. S. Department of Agriculture in making a very thorough study of mutual companies in Utah. (Israelsen, O. W.)

58. Ashley Valley Irrigation Studies.—This project was begun in 1919 as a result of urgent requests from water users. Preliminary observations reported in October 1919 were published by the Ashley Valley canal companies in cooperation with the Farm Bureau, the county commissioners, and the U. A. C. Extension Service. That the five major irrigation companies be combined into one central mutual irrigation company is considered the most important of the final recommendations. The report shows convincingly that such a reorganization would make
possible (1) more economical flood control, (2) better distribution of water, (3) increased water supply, (4) a decrease in operation costs, (5) necessary improvements at low cost, (6) more economical financing and administration of irrigation affairs, and (7) elimination of much community antagonism.

So far as irrigation studies within the Ashley Valley are concerned the project is closed, but the Experiment Station should contribute the time of its geologist, if possible, to examine and report on the structure of the formation in which the several sinks and springs occur. The time of an irrigation engineer should also be provided to direct field studies on the motion of ground waters below the sinks. After this phase of the work is completed, the Extension Service should stimulate and guide the recommended combination of canal companies on the basis of the investigations above briefly discussed. (Israelsen, O. W.)

72. Snow Survey.—In the semi-arid West, where agriculture depends on irrigation, the major portion of the annual precipitation falls in the form of snow. This snow piles up in the mountains and forms the main source of the water in the creeks and rivers which drain the mountain areas. Some of these streams are intermittent, flowing only so long as the snow in the mountains lasts. The depth, extent, and density of the snow cover on any area indicates the amount of the water supply and indirectly the amount of crops that can be produced on irrigated land tributary to a given basin. To determine the extent of the snow cover and thus the probable runoff from any watershed it is necessary to have fairly accurate precipitation records over the area in question. As a rule, such records are lacking at the higher elevations throughout the West where the major portion of the precipitation occurs in the form of snow. It seems desirable therefore that a study of the extent and distribution of the precipitation on the watersheds be made to facilitate the early seasonable determination of the available water supply.

A knowledge of the extent of the season’s water supply two or three months in advance would be of great value to the farmer in planning his crops, to the banker who lends money on crops, to the power companies, to municipalities which depend on streams for their water supply and in the operation of reservoirs for flood control. It has been demonstrated in Nevada, California, and Idaho that accurate forecasts of stream flow can be made from a study of the extent and water content of the snow cover. In Idaho these forecasts are used by the bankers as a basis for loans to the farmers. The farmers use these forecasts in the planning of their crops and the river commissioners in the distribution of water.

For the past ten or twelve years the U. S. Weather Bureau
has been collecting some snowfall data in Utah. However, most of these data have been collected at the lower elevations, there being few stations on the high watersheds. The existing knowledge of the precipitation on and the runoff from the high watersheds of Utah is clearly inadequate. Therefore, the purpose of this project is essentially to collect meteorological data on the high watersheds, to study the relation between the seasonal snow cover and the spring and summer runoff, and to forecast seasonal water supply. To carry out this purpose annual snow surveys will ultimately be made on all of the important watersheds in the state.

Work on this project was begun in the fall of 1923. During the winter of 1923-24 a detailed survey of the Logan Drainage Basin was made and fixed survey courses were established. Measurements of depth, density, and water content were made at 100-foot intervals on each course. In addition to the five regular courses which are surveyed annually, measurements were made of the U. S. Weather Bureau snow stakes on Mt. Logan on the second day of January, February, March, April, and May, respectively. Stream-flow records of the Logan River were kept up to date for the purpose of studying the relation of the rate of runoff to the snow cover. Precipitation data were obtained by means of a standard rain gage established at the college as well as at Franklin Basin, Tony Grove, and Mt. Logan during the early spring and summer of 1924. These gages furnish precipitation data during the summer months to supplement the snow surveys. (Clyde, G. D.)

PANGUITCH FARM

66. Panguitch Farm.—The farm at Panguitch is maintained as a general livestock farm. There is a splendid herd of Short-horn beef cattle on the farm at the present time, the original herd on the farm at the time the project was begun having been culled and improved thru breeding and feeding. The object of this project has been to produce good range bulls for the southern section of the state, and this is being accomplished. The herd at the present time is made up of thirty head of cows, heifers and calves, one herd bull, and six service bulls from one to two years of age. All of these animals are in good flesh. Six bulls were sold this last spring.

During the past biennium various improvements have been made on the farm. The barn has been painted. Feed racks and a corral for bulls have been constructed. The fences have been repaired and the wire restretched. With these various improvements noted the farm is in better condition than at any time since the beginning of the project. (Bateman, J. R.)
PHYSICS

*17. Fundamental Soil Moisture Constants.—This project is a study of fundamental principles underlying the movement of moisture in the soil. The problem is primarily one of hydromechanics and is approached from this standpoint. Results have been published in a series of technical articles which should be regarded as the foundation structure for future work in the field. The experimental work has been confined almost entirely to the laboratory. From a careful survey of the literature it would appear that there has been a considerable amount of confusion in the minds of investigators in this field. It is not to be expected that well-established mechanical and thermodynamical principles which have been so successfully applied in other fields will fail to apply here. It is hoped that the application of these principles will lead to a proper explanation of the variety of phenomena encountered in an experimental study of soils.

A large number of so-called soil moisture constants have been measured and tabulated. The magnitude most directly involved in the analysis has been almost entirely overlooked. This magnitude has been called the capillary potential. This magnitude with its associate, the gravitational potential, plays a very important role in the analysis of the moisture problem. The differences in the value of the capillary potential for different points in a moist soil are measures of the amount of energy involved in moving the moisture from the one point to the other. The space rate of change of this potential is a measure of the capillary attraction. However, the attractive force itself is a magnitude that cannot be readily measured, whereas the capillary potential may now be measured with precision and the capillary attraction calculated therefrom.

In irrigation and drainage practice such problems as the design of a drainage or irrigation system might be very much more efficiently carried out with the aid of a science of "soil hydraulics," and it is with this ultimate practical end in view that led to an approach of the subject from the theoretical side, supplementing it in the first instance by laboratory studies.

The results obtained have attracted the interest of some of the best engineers, and the analyses together with the experimental results are now being assembled with the hope of presenting a monograph in the near future. It is felt that when this problem is properly understood it will have considerable influence in determining the character of research in the various experiment stations.

The future plan is to cooperate with other departments,

*In cooperation with Irrigation and Drainage Department.
particularly with the Department of Irrigation and Drainage, in making application of these principles to practical problems encountered in the field of agricultural engineering.

Further progress in the technical aspects of this problem has been made in cooperation with the Division of Irrigation Investigations and Practice and the Division of Agronomy of the University of California. The results of this work, now in press, will be published by the University of California Press in the Scientific Series, under the joint authorship of F. J. Veihmeyer, O. W. Israelsen, and J. P. Conrad.

Under this project the following publications have been issued:


(Gardner, W. and Israelsen, O. W.)

PLANT PATHOLOGY

31. Potato Diseases.—

B. Rhizoctonia Studies

C. Virus Disease Studies (Mosaic, etc.)

B. Rhizoctonia Studies.—Two phases of this problem—methods of seed treatment and accumulation of Rhizoctonia fungi in the soil—were given special attention during 1921 and 1922. However, the work in this division of the project because of lack of time and financial aid was suspended during 1923 and 1924. The enormous losses occasioned by this particular disease make it rather imperative that research on this problem be resumed during the coming biennium.

C. Virus Disease Studies.—Mosaic and leaf-roll diseases of the potato have been studied under this division of the main project. The phases of the subject now under consideration follow:

(1) Distribution and economic importance of virus diseases
(2) Symptoms as they normally occur on the different commercial varieties of transmission

*Part A (Physiological Studies) of this project is carried by G. R. Hill, Jr., Botanist.
(3) Rate and distance of spread for each disease and rate of degeneration of the various potato varieties under western conditions

(4) Methods of virus disease control

The symptomology of the two diseases studied has been determined for the principal potato varieties known commercially in the state. In addition, the studies have shown that the degree of isolation generally recommended is entirely inadequate under Utah conditions and further that only with a sufficient degree of isolation are the roguing and selection methods effective.

The surveys conducted during the biennium show clearly the serious ravages of mosaic and leaf roll and the necessity for further research as well as for the selection of such regions in the state as will make possible seed-potato production. This latter division of the work will be intensified during the coming biennium, together with the selection and development of potato strains free from these diseases. A new and destructive disease of the potato, "spindling tuber," especially important in degeneration of seed, has been found generally distributed in the state. This latter trouble will necessitate attention during 1925 and 1926. (Richards, B. L.)

33. Canning Crop Diseases.—Under this project research work has been conducted on the root rot and the black leaf of the pea. During 1924 it has been extended to include the Fusarium wilt, the western yellow blight, and the mosaic of the tomato. Of the four fungi apparently responsible for the root rot of the pea Aphanomyces sp. has been found to be most important. The relation of this destructive fungus to systems of crop rotation is at present under consideration. The black leaf of the pea has been found generally distributed in North Cache and Morgan Counties. The present work consists of the life history studies of the causal organism, methods of dissemination, relation of the parasite to climate, and control measures.

During 1924 Fusarium wilt, the most destructive disease of western tomatoes, has been found in upwards of 60 per cent of the tomato fields in Utah and is rapidly becoming a limiting factor in tomato production in the state. During the past year eighteen varieties of tomatoes were tested for disease resistance. One of these varieties, NORTON, has been found to exhibit a high degree of earliness. From results obtained, this variety appears definitely as a favorable substitute for the present canning varieties in Utah when diseased soil is encountered. Further tests of resistance, together with selections for earliness in this variety, will be carried on during the next biennium.

Western yellow blight produced a loss of 35 per cent of Utah's potato crop during the year 1924. The nature and cause of
western yellow blight and means of control are now under investigation, as is the case with Fusarium wilt and mosaic. Research activities on these three tomato diseases should be greatly increased during the coming biennium. (Richards, B. L.)

34. Plant Disease Survey.—The purpose of this project is to determine the presence, distribution, and economic importance of various plant diseases occurring in the state as well as to discover the relationship of this disease to cultural and irrigation practices. A further purpose of such survey is served in giving direction to research in working out control measures for plant diseases. During the past two years attention has been given to a number of the most important diseases such as seedling rot, dry-rot canker, and leaf spot of sugar-beets; pea root rot; barley stripe; watermelon wilt; and various diseases of the potato.

The survey has emphasized the serious importance and dangers to crops of more or less obscure plant diseases. Among these are Cytospora of poplars, dry rot or Phoma rot of sugar-beets, chlorosis of perennial plants, and a number of diseases of the raspberry and strawberry which are peculiar to our intermountain region. The nematode of alfalfa, which is a very serious and destructive disease to this plant, has been discovered in Utah during the past year for the first time. Another destructive disease of the alfalfa, crown wart, has been shown by the survey to be very generally distributed in certain alfalfa-growing districts of the state and is probably responsible for the rapid degeneration of the alfalfa fields in these districts.

During the next two years it is proposed to intensify the survey of both crown wart and nematode of alfalfa and to determine more accurately the economic importance and general occurrence of the various virus diseases of the potato and tomato crops. Further survey should be made on the various diseases affecting the raspberry and strawberry since these crops are succumbing rapidly to diseases which as yet are little understood by scientists. (Richards, B. L.)

60. Sugar-beet Diseases.—Under this project three diseases of the sugar-beet have received attention. These are dry-rot, seedling sickness, and late blight or Phoma rot. The work on the dry-rot canker during the past biennium has been concerned with studies of special local areas within the fields where this disease occurs to such an extent as to practically eliminate the possibility of beet growth. These studies consist of the more accurate determination of symptomology and rate of distribution together with such crop rotation practices and other methods as appear to be of value. Formerly the work on the Phoma rot or
late blight has proceeded along the following lines: (1) survey; (2) isolation, identification, and cultural studies; (3) local climatic features responsible; and (4) cultural practices responsible for its occurrence and for its eradication. Studies on this particular disease have been greatly minimized during the past biennium. However, the isolated observations and studies made emphasize definitely the conclusion drawn from the work done in 1921 and 1922—that the trouble is closely correlated with drouth during late June and July. These studies further show that when this gap in the seedling development is carefully bridged by cultural practices and early application of irrigation water so as to promote a condition of uniform growth of the seedling there is little fear of the late-blight malady. (Richards, B. L.)

POULTRY

36.—Breeding for Egg Production.—The work on this project was begun in 1907 and has been continued as outlined since that date. The aims have been to develop a strain of fowls that will be heavy producers over a period of at least three years and to study the methods of selection of the breeders and the methods of inheritance of high production. There has been a gradual improvement in the average production of the flock, and a few outstanding individual producers have been found. During this past biennium one of the hens finished her record of 1054 eggs. A number of hens in the flock have now produced over 600 eggs in three years, and one has a total of 646 eggs for this period. (Alder, B.)

37. A Study of Incubation Problems.—The work on this project during the past biennium has been a study of the time of hatching and its effect on egg production where the hens are held for three years. The pullets used were Single Comb White Leghorns and were hatched about the first of March, April, May, and June, respectively. They were given the same care as far as possible after that date. There are records to date on the pullets hatched in 1920-23, inclusive. The April-hatched pullets have given slightly better results during the entire period. Except for the first fall and early winter the March-hatched birds have given the poorest production. The results obtained to date indicate that the Leghorn pullets hatched about the first of May and June have made a higher 2- or 3-year production than have those hatched the first of March, and in some cases they are equal to those hatched in April. It will be necessary to accumulate considerable more data before definite conclusions can be drawn. (Alder, B.)

57. Poultry Feeding.—The first three years’ results on this project have furnished very conclusive data on the importance
of some protein feeds in addition to the grains and mill by-products in an egg-producing ration. The value of skim milk as a part of an egg-producing ration is also definitely shown. In those pens fed only the grains with no protein feeds, the hens did not produce enough eggs to pay for the feed consumed. In other pens, by the addition of skim milk or meat meal to balance up the ration, egg production was increased so that the balance between cost of feed and value of eggs averaged over $2 for each hen for the year. The best results were obtained in those pens where both skim milk and meat meal were used in the ration to give it a proper balance.

A test was also made where home-produced feeds were checked against corn and other imported feeds and ready-mixed or commercial feed. The results in total production and lower cost of production were in favor of the home-grown and home-mixed feeds when properly fed. (Alder, B.)

74. Egg-laying Contest.—In the early fall of 1924 an egg-laying contest building was added to the equipment at the poultry yards. On the first of November the contest was started with 24 entries of 10 pullets and 2 alternates in each entry. This contest is to run for 52 weeks. The purpose of the contest is to impress on the poultry raisers the importance of greater care in the selection of fowls and the value of proper feeding and housing. It will also make it possible for any breeder to have his strain of fowls tested for production and compared with other strains under the same conditions. It will give the producer an individual trap-nest record of each hen entered from which he may select the foundation for a breeding pen. It will also show the necessity of discarding these fowls to start with something better. Because of the general lack of interest among the poultry raisers of the state in the development and hatching of better strains approximately one and a half million chicks are shipped into the state each spring. It is hoped that the results of the egg-laying contest will offset this general importation and that the same stock can be produced in Utah for the poultry raisers of the state. (Alder, B.)

RANGE MANAGEMENT

48. Range Survey.—The purpose of this project has been two-fold: (1) to obtain general information on Utah’s range resources and (2) to determine the relative importance of specific problems. The general plan includes a classification as to forage classes and types and their extent and location, natural units for seasonal use, adaptability of types to the different classes of livestock, land tenure with its effect on
management of livestock, carrying capacity, and possible improvement (to include consideration of water development, reseeding, and management of range livestock). The reseeding phase of the project has been developed to a considerable extent. It is ranked high in importance and entails a smaller budget than problems of livestock management. Consideration is being given to the survey as to the advisability of one or two seasons being devoted almost exclusively to such work with the idea of completing the general phases of the problem. (Becraft, R. J.)

61. Range Reseeding.—A great part of Utah's range land at some time has been overgrazed; as a result, it is not producing a maximum of feed. Stockmen are constantly requesting "grass" seed for range plantings. The U. S. Forest Service has tested out the principal cultivated forage plants and has found them generally unadapted to range conditions. Our native species have not been given due consideration. It seems reasonable that in the wealth of variety presented by our native flora some valuable forage species can be found that will yield profitable returns in seed production. This would hasten the improvement of our ranges.

Work on this project has been pursued with the following objectives in mind: (1) selection of valuable forage species, (2) collection of seed, (3) experimentation with seed production, and (4) selection and planting of suitable test areas on the range. An effort has been made to locate isolated areas wholly or largely protected from grazing where seed might be collected in considerable quantity at small expense. In this connection results were not altogether satisfying, and doubtless a few plats for seed collection should be protected by fencing. Small quantities of seed have been obtained from a number of species. In addition, an agreement has been entered into for cooperation with the Great Basin Experiment Station of the U. S. Forest Service from whom it may be possible to secure seed of mountain brome grass and violet wheat grass in sufficient quantity for half- and quarter-acre plats.

The past season was spent largely on an ecological study of the local flora, with emphasis on distribution and successional position of individual species. This is to be supplemented by information from the U. S. Forest Service. It is evident that these combined data are of direct value in selecting desirable species, obtaining seed, and locating adapted range sites for test plantings. It is planned to gradually extend the local study to other areas of the state where additional valuable species are obtainable. (Becraft, R. J.)
49. Soil Survey.—A soil survey is a detailed classification and definition of the different types of soil found in any valley. At first the classification of soils was largely made from field observations and borings, by interpreting from the color, texture, structure, etc. the class in which it should be placed. It has been found much more complete to supplement the field work with chemical analysis of the soil and thus be able to predict what is necessary in the handling of the soil to bring it to full production under methods for which it is best adapted.

Soil-survey work in the state began as early as 1898, and since that time areas in the Weber Valley, Sevier Valley, Salt Lake Valley, Provo Area in the Utah Valley, Bear River Valley, Cache Valley, Delta Area, and Ashley Valley have been surveyed. These reports have been completed and have been published cooperatively with the U. S. Bureau of Soils. The Uinta River Valley Report has been partially finished and should be completed during this next year. In all of these surveys the work has been done in cooperation with the Bureau of Soils, U. S. Department of Agriculture.

Extra detailed study and mapping with laboratory tests have been made on CACHE VALLEY CONSERVATION DISTRICT No.1. Unfortunately, the work came after instead of before the district was organized.

Urgent requests have been made for soil surveys in other areas. Davis County is particularly anxious that the farming area of the county be surveyed in the near future. Request has come from the U. S. Reclamation Service that new reclamation projects have the soil areas carefully classified previous to the time of settlement on the project. Most of the other states have gone further in their soil survey than has Utah, and it is urgently requested that provision be made for the soil-survey work to go on continuously until the entire farming area has been covered. The data collected in the farm survey should be a definite guide in cropping programs and in irrigation and drainage projects.

The following publications have been issued during the past biennium:


(Jennings, D. S.)

(College Series No. 200.)