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Bulletin No. 294 - Research Aids Utah Agriculture: Biennial Report Utah Agriculture Experiment Station 1938 - 1940

R. H. Walker

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RESEARCH AIDS UTAH AGRICULTURE
Biennial Report
Utah Agricultural Experiment Station
1938-1940

R. H. Walker, Director

Agricultural Experiment Station
Utah State Agricultural College
Logan, Utah
President E. G. Peterson,
Utah State Agricultural College,
Logan, Utah.

Dear President Peterson:

I have the honor to transmit herewith the biennial report of the Utah Agricultural Experiment Station for the biennium ending June 30, 1940.

Respectfully submitted,

R. H. Walker
Director.
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THE SOLUTION OF AGRICULTURAL PROBLEMS IS DEPENDENT ON RESEARCH

The foundation of progress in agriculture as in any other industry is research. Research has resulted in knowledge now daily applied in soil treatment, in irrigation practices, in dealing with insect pests, in breeding new varieties of plants, in animal improvement, in better farm practices, and in better land-use planning. Research undertaken by the Utah Agricultural Experiment Station has been outlined to solve specific problems facing Utah agriculture, among them the problems of irrigation, dry farming, range management and animal production. The prosperity of the state is dependent upon the success of these agricultural enterprises. Agricultural research should not, therefore, be considered a luxury marked for elimination, or materially decreased support, every time the state or nation is faced with an emergency.

The progress of research is necessarily slow. Experiments must be carried over a period of years before definite conclusions can be drawn. On the average, it is about 8 years before a successful research project attains the profit stage. Moreover, its success may be based on fundamental discoveries that were a half century or longer in development.

Therefore, the report of the results of two years’ work does not contain much that is startling, although it does contain findings that should aid Utah agriculture in solving many of the troubling problems with which it has to contend.

Utah Has a Small but Varied Agricultural Area

Only about 2.5 percent of the total land area of the state or less than one and a half million acres is used for irrigated agriculture. About one percent of the area is in dry farms. A little less than one half (47.4 percent) of this cropped land is in alfalfa and an additional 12 percent in grass and wild hay. Not quite one third (31.8 percent) of the total acreage is in grain. Sugar beets occupy 4.4 percent and potatoes 1.5 percent of the cropped acreage. This leaves less than 5 percent for vegetables, fruits and all other crops.

About 92 percent of all cropped land is in feed crops and wheat, which is planted on 20 percent of the cropped land.

About 85 percent of the land of the state is designated as grazing land which is valuable only for the grazing of livestock. So that any research program must take these facts into consideration in planning points of attack.
Utah has a mean average temperature of 48 degrees F., but the temperature varies in different parts of the state from 59 to 38 degrees. The length of the growing season between the latest killing frost in spring and the earliest in autumn is from 185 to 200 days in “Utah’s Dixie;” 150 to 160 days in the principal agricultural valleys; and 80 to 90 days in the higher agricultural valleys. The average growing season for the state is about 128 days or approximately from May 20th to September 25th.

The state has a general average precipitation of 13 inches, consequently irrigation from impounded waters or mountain snows must be depended upon for the growth of all crops outside of 500,000 acres of dry-farm land where crops, mostly wheat, are grown every other year. About 50 percent of the annual precipitation occurs from January to May, inclusive, and 25 percent from June to September.

Scope of the Research Program

These varied conditions throughout the agricultural area of the state require a broad research program to be adopted by the Station. And although the Station has neither personnel nor financial resources to attack all the problems needing solution the scope of the work is wide. There are 76 major problems on which investigations are now being conducted in cooperation with various federal and state agencies. Some of the more outstanding results of the experimental work on these projects that can be put to use immediately by farmers to improve their agri-
cultural practices are listed in the next few paragraphs. More detailed information on these accomplishments may be found in the section on project reports.

1. The Physics Department, as a result of long years of empirical research, has discovered information that may completely revolutionize drainage systems now in use. It has shown first, that land which is waterlogged as the result of artesian pressure can be drained economically only by vertical pump wells. In other types of waterlogged land the tile drains should never be placed immediately next to an impervious layer if a maximum drainage flow is desired.

2. Studies in agricultural economics have shown that farm income and the success of the farm business in Utah are closely related to crop yields and rates of production from livestock (fig. 1). Farms, to be successful, must have greater total yields, either through the addition of more land, increased yields per acre, or more intensive use of present acreage, by growing more intensive crops or raising livestock.

Among the factors accounting for success in sheep and cattle ranching, two of the most important are lowered death loss and higher lamb and calf crops.

3. Effective methods of weed control have been found by the Agronomy Department whereby most of the noxious weeds of the state may be controlled. These methods may be used alone or in combination according to the condition: (1) chemicals (sodium chlorate, atracide, and carbon bisulfide seem the most promising) used only on small areas because of cost, (2) clean cultivation for two years gives good control with a minimum of cost (fig. 2), (3) combinations of cropping and cultivation (fig. 3). Some perennial crops involving grass mixtures or

Fig. 2. Sugar-beet field in Salt Lake County following clean cultivation to eradicate wild morning glory
such plants as smooth brome and Reed canary have shown promise as being able to favorably compete with white top and morning glory.

4. More has been accomplished in the soil survey and land classification work during the past biennium than any other like period in the past. Five hundred and twenty square miles were surveyed in the Uinta Basin, 228 square miles in Utah County, 270 square miles in the Beryl-Enterprise Area and 804 square miles in Sevier, Sanpete, Juab and Millard Counties (fig. 4).

5. Strawberry clover has been found by the Agronomy Department to be suitable for planting in wet locations including those with considerable alkali.

6. Investigations by the Animal Husbandry Department on the feeding of ewe lambs on the farm the first winter have shown that such lambs gain more, produce more and better grade wool, and are more efficient in breeding.

7. Chlorosis in Concord grapes in Utah can be controlled by the grafting of the Concord scions on vinifera rootstocks (fig. 5). This remedy for the control of chlorosis in grapes was found by the Botany and Plant Physiology Department after years of study on this project.

8. Varieties of tomatoes have at last been developed that are resistant to curly top (western yellow blight) disease (fig. 6). However, these

Fig. 3. Sugar-beet cultivator equipped with 12-inch sweeps used in weed control. The sweeps overlap so that all weed growth is cut off by going over the land once
strains do not have the qualities of a commercially desirable tomato. This is now the problem of the plant breeders working on this project — to produce a tomato with an adequate degree of resistance with com-
commercially desirable qualities. Work is also progressing on the production of a tomato resistant to Verticillium wilt.

9. A new process has been evolved by the Bacteriology and Biochemistry Department whereby the Jerusalem artichoke may be used as a source of raw material for the fermentative production of dextro lactic acid for use in food and beverage products and poultry and stock feeds.

10. One percent rotenone bearing derris and cube dusts have been found by the Entomology Department to be effective insecticide for the control of the pea aphid in Utah (fig. 7). Nicotine vaporizers give quick, almost 100 percent kills.

11. Motor lubricating oil has been found much more effective as a moistener of poisoned bran in bait for Mormon cricket control than water. Tests also indicate that sodium fluosilicate and sodium fluoride are better as poisons for cricket baits than paris green and sodium arsenite because they are not repellant to crickets as are the latter two poisons.

12. Cheese cloth covers to protect tomato plants over the period of spring dispersals of leafhoppers have been found to reduce substantially

FIG. 6. A general view of the Hurricane trial grounds showing the remarkable growth of the highly wilt resistant species (*Lycopersicon peruvianum* var. *dentatum* Dun. and *L. peruvianum* var. *bumifusum* C. H. Mul.) of tomato from South America in a field with selections of the common commercial tomato (*L. esculentum* Mill.) practically entirely destroyed by the disease.
the amount of curly-top injury. They also protect the plants from late frosts (fig. 8). Although the initial cost of the covers is rather high they may be used for a number of years.

13. Placing two tomato plants in each hill gave 44 to 59 percent reduction in curly-top damage during 1939 experiments and produced yields sufficiently greater to pay for the extra plants used.

Fig. 7. Power duster in operation, protecting canning peas from pea aphid injury

Fig. 8. Cheese-cloth covers protect tomato plants from curly-top injury as well as late frosts

14. Tomatoes do not decrease in vitamin-C value with storage either at room temperature or in the refrigerator. Tomatoes from vines supported on poles were found higher in vitamin-C content than those from vines not supported, presumably because of the greater amount of sunlight
FIG. 9. Typical trees in cherry rootstocks experiments—left to right; Bing on Mahaleb, Napoleon on Stockton Morello, and Bing on Mazzard. The Mahaleb rootstocks produced the largest trees and the best stand at the end of the first nine-year period. Illustration shows trees during the eighth growing season received by the tomatoes on the poles. These conclusions are the results of a study by the Department of Home Economics.

15. Methods of preservation of Utah fruits and vegetables by freezing is a new project being sponsored by the Station in cooperation with the U. S. Bureau of Agricultural Chemistry and Engineering and a number of commercial concerns. These frozen products are being used in beverages, ice creams and sherbets, as well as for table use. Peaches, apricots, cherries, Satsuma and Santa Rose plums, raspberries, strawberries and boysenberries are among the most promising fruits for freezing.

16. Final measurements by the Horticulture Department of sweet cherry trees at the end of nine seasons' growth show the marked superiority of Mahaleb roots over Mazzard and Stockton Morello for cherry trees in this region (fig. 9).

17. Turkey feeding experiments have demonstrated to the growers in the state that Utah-grown feeds are cheaper and just as good when measured in terms of finished weights, in condition of birds at market

FIG. 10. Dressed turkeys showing the finished condition produced on a low protein (17 to 18 percent crude protein) ration, with barley and wheat as the only grains
time, in pounds of feed required to produce a pound of gain or in livability (fig. 10). Mashes containing 17 to 18 percent of protein gave as good results as mashes containing a higher percentage.

18. Too early and too heavy grazing on range lands reduce the density of the plant cover, the seed produced, the root depth, and the weight of the roots (fig. 11). The Range Management Department also found that the quantity of sugar and starch stored in the roots of late grazed plants was materially greater than that in the early grazed, thus giving such plants a better food reserve to begin growth the next year.

PROGRESS REPORT ON PROJECTS UNDER INVESTIGATION DURING THE BIENNIA 1938-1940

Much of the work of the Station is conducted in cooperation with various federal, state, and private agencies under cooperative memoranda of agreement. Aside from the federal workers stationed on the campus, the U. S. Department of Agriculture, through cooperative memoranda of agreement, supplies money and other aid to the Experiment Station. Financial support is also given by state and private agencies, so that much of the work now underway would be impossible were it not for support other than that made by regular state and federal grants. Consequently these various agencies should receive much credit for the progress of the work herein reported.
An Analysis of the Economic Problems of Utah's Agriculture

The outstanding results of the work of the Department of Agricultural Economics during the past two years have been the economic analysis of Utah's agriculture by counties and areas, enterprise studies of sheep, beef cattle and dairy production, agricultural credit and indebtedness, methodology in classifying lands according to their economic productivity, and reducing to measurable form some of the variables involved in the economic studies being conducted. With these measurements more specific statements of relationship of certain variables of success or failure of the farm business is possible.

Closely associated with this is the problem of measuring size of farm business and determining its effect upon farm income, particularly the prevailing small-sized farms in Utah, with small farm incomes. The large number of part-time farms and the surplus labor on farms in areas of the state where opportunity for supplementary income from labor is extremely scarce has also been measured. Better measurements of effect of rates of production of crops and livestock upon farm success have been made available.

Since 1929, Utah's increased number of farms and decreased agricultural production and income have been measured. This reduction in farm income per farm largely resulted from: (1) unusually low precipitation, (2) low prices of farm products, (3) increase in the number and decrease in size of farms in Utah—a critical problem facing Utah's agriculture, and (4) failure to increase, or in some aspects, maintain yields and intensity of crop and livestock production.

Studies of Farm Organizations by Types

Sanpete and Sevier Counties. In the Sanpete Area, 65 percent of the land area is federal land, while only 6.5 percent is cropped farm land. Hay occupied 58 percent of the cropped land in Sanpete, and 66 percent in Sevier County. Grain is second in acreage, accounting for 23 percent of cropped acreage in Sanpete and 21 percent in Sevier.

In 1935, 94,258 animal units of livestock were owned by farmers in Sanpete and Sevier Counties, of which 54,548 were sheep and 29,195 cattle. Total feed required for these (in terms of hay equivalent) was 389,925 tons, of which 56 percent was from harvested crops and 44 percent from grazing. About 15.8 percent of this was obtained from grazing outside of the two counties largely on the public domain. Obtaining additional grazing from adjacent counties enabled livestock men, particularly in Sevier County, to fatten feeder lambs.

Analysis of the general irrigated farms for the year 1936 showed that Sevier County farms on the average had 2 acres more cropland, $1,180 larger investments, 29 percent larger crop yields and 0.42 fewer animal
units of livestock than farms in Sanpete County. Farm receipts on general farms in Sevier County averaged $1,846 and labor income $303, as compared with $1,449 and $172 in Sanpete County.

Analysis of types of farms was made for five predominant types: general irrigated farms, crop and livestock farms, sheep ranches, lamb-feeding, and part-time farms. There were marked differences among type of farms. Capital investment ranged from $3,798 on part-time to $42,255 on sheep ranches and around $9,000 on general irrigated farms and $12,000 on crop and livestock and on lamb-feeding farms. Acreage of crops grown per farm ranged from 15.25 acres on part-time farms to 102.05 on sheep ranches. Receipts, expenses and income showed similar wide variations.

The sheep ranches had the highest labor income with $1,697. The part-time farms had a minus labor income of $87. The general irrigated farms had a labor income of $222. Seventy-six percent of the general irrigated farms had a labor income of over $500 and 47 percent over $1,000.

The major factors affecting farm income were type of farming, size of farm business, and rates of production.

_Ogden Milk Shed Area_. A three year study of dairy farms in the area which market dairy products in Ogden is underway. The area includes Weber and Morgan Counties, and the southern part of Box Elder County.

Summary of data for the crop year 1938: The average investment per farm was $14,408. The total land resources per farm consisted of a total of 142 acres, of which 42 were irrigated cropland. Approximately half of the irrigated acreage was in alfalfa. Crop yields were 44 percent above the 1926-31 average of the state. Sugar beets in particular yielded abundantly. The total farm receipts were $2,851, which was $10 less than for 1937, while total expenses averaged $1,559, or $9 more than for 1937. Of the total receipts, $1,351 were from crop sales and $868 from sales of livestock products. The average labor income was $569 and the value of farm privileges $305. The average family earnings were $1,171.

The average farmer had invested $1,106 in the milking herd which averaged 10.1 cows. Total receipts from the herd averaged $1,018 and total expenses including man labor at 25 cents per hour were $1,189. The total return for labor was $236 per farm or 14½ cents per hour. The average cow produced 6,536 pounds of milk and 253 pounds of butterfat (fig. 12). The average value of butterfat at the farm was $0.329. The data show a close correlation between size of farm business and financial success, and also between rates of production and financial success.

_Sheep Production in Iron, Washington and Beaver Counties_. A three year study of sheep ranches located in southwestern Utah, centered at Cedar
City, was begun in November, 1938. The sheep on the ranches studied represent approximately one-half of the sheep in the area.

The average rancher was operating 1,177 head of breeding ewes and a total of 1,425 head of stock sheep. The ranchers in the smaller group had an average of 219 head of stock sheep and the larger operators had over 3,000. The acreage of land owned and leased in addition to forest and grazing service lands was 640 for the small operators and 6,888 for the larger operators. The value of the operator's investment was $11,319 for the smallest ranches, $64,148 for the largest ranches, and an average for all ranches of $33,916. The proportion of the investment that was covered by debt increased as the size of the ranch increased.

The labor earnings increased with size of the ranch. Operators with less than 250 breeding ewes received $623, those with 250 to 749 ewes received $1,159, operators with 750 to 1,499 ewes received $2,455, and the largest operators with more than 1,500 ewes received $2,638. The operators with 750 to 1,499 ewes made the highest return on their capital, with 10.8 percent; the smallest group made 1.8 percent and the average return of all operators was 9.3 percent.

The analysis of the sheep enterprise showed that the operators with 750 to 1,499 head of breeding ewes made the greatest profit per ewe with $1.62; and the smallest received $0.08 per ewe.

The profit per ewe was closely related to lamb crop, weight of lambs sold, death losses, wool clip, and economies in operation costs. A com-
Comparison of 15 ranches with the most profit per ewe and 15 ranches with the least profit shows that the most profitable group raised 20 more lambs per 100 ewes; the lambs were 12 pounds per head heavier. They sheared 9/10 of a pound more per fleece and sold their wool for 2.4 cents more per pound. They lost 5 less stock sheep and nearly 8 less lambs per 100. In spite of all these advantages, the costs of operation per ewe on the most profitable ranches were about the same as those of the least profitable ranches.

**Beef Cattle Production in Rich County.** Records from 22 beef cattle producers in Rich County were obtained. These are now being summarized prior to the analysis and the preparation of a report.

**Agricultural Resources in Western Box Elder County.** In the western Box Elder area, 87 percent of the land area is owned by the government and railroads. Waste land occupies 32 percent and cropped land a little more than 1 percent of the total area. Over 85 percent of the cropped land was in hay. Crop production has been unstable because of variable precipitation and lack of water-storage facilities. There were, in 1939, over 22,000 animal units of livestock owned in the area.

Analysis of the farms was made for three types of farming: general farms, beef ranches, and sheep ranches. There were 285 animal units\(^1\) of livestock per ranch on sheep ranches, 149 on beef ranches, and only 29 on general farms. The value of the operator's capital was $18,545 for sheep ranches, $19,688 for beef ranches, and $5,642 for general farms. The farm receipts were $6,161 for sheep ranches, $2,995 for beef ranches, and $1,027 for general farms.

The sheep ranches had the highest labor income with $963; beef ranches had $130; and general farms had $35. Higher earnings by the sheep ranches were primarily the result of their control of large areas of grazing land at a cost less than ownership would be. The income available for family spending and saving was $1,832 for sheep ranches, $1,079 for beef ranches, and $404 for the general farms.

**A Study of Utah's Agricultural Resources and Their Utilization**

*An Economic Study of the Uinta Basin*\(^2\). Of the 4,838,400 acres of land in the Uinta Basin about 20 percent was under private ownership, 8 percent belonged to the Indians, 40 percent was public domain, and 21 percent was in the national forest. The balance belonged to the counties and the state. Only about 2 percent of the land area was cropped in 1929.

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\(^1\) An animal unit is a common measure for combining numbers of various kinds of livestock. One mature range cow equals one animal unit and other livestock are equated to this. Work horses and mules are not included in productive animal units.

\(^2\) Results of this study have been published in Bul. 285. A study of farm organization by type of farms in Uinta Basin, Utah, by George T. Blanch.
For the purpose of analysis the farm business records were classified and grouped according to the 6 types of farming represented: general farms, dairy farms, mixed livestock ranches, beef ranches, sheep ranches, and part-time farms. The basin was also divided into two areas for study, the Reservation Area and Ashley Valley.

Of the 388 farms included in the study, 19 percent were classified as range livestock ranches. The others were: general farms, 50 percent; dairy farms, 15 percent; and part-time farms, 16 percent.

For general farms in the Reservation Area, the average cropped area was 52 acres per farm and the area of idle cropland was 31 acres. In Ashley Valley for the same types of farms, the average was 50 acres of cropped land and 10 acres of idle cropland. The range livestock ranches had larger acreages per farm, while the part-time farms had only about 15 acres of crops.

The sheep ranches had by far the most livestock with an average of about 286 animal units. The general and part-time farms had fewer than 20 animal units per farm.

The total capital invested per farm in general farms was $4,980 in the Reservation Area and $7,678 in Ashley Valley. This was the smallest capital for any full-time type of farm. The sheep ranches had the largest capital with $24,766 in the Reservation Area and $32,676 in Ashley Valley.

The average indebtedness of the general farmers in the Reservation Area was $978 and in Ashley Valley $1,219. Sheep ranchers in the Reservation Area had an average debt of $3,660 and in the Ashley Valley $6,502.

In the Reservation Area, about two-thirds of the cropped acreage was in alfalfa. In Ashley Valley slightly more than 50 percent was in alfalfa. Wheat, oats, barley and corn were the other principal crops grown.

In the Reservation Area the average yield of alfalfa hay was about 1.3 tons per acre while in Ashley Valley it was from 2 to 2.5 tons. The average crop yield index of all crops in the Reservation Area was just a little more than 50 and in Ashley Valley just a little less than 100 when the average state yields of 1926-31 are considered as 100.

The total farm receipts for general farms in the Reservation Area were $759 per farm. For similar farms in Ashley Valley they were $1,080. The total receipts from sheep ranches averaged about $6,000. The other range livestock farms averaged about $1,500 in the Reservation Area and $3,000 in Ashley Valley.

The return from capital and operators' labor (the difference between total receipts and total expenses when interest and the value of the operator's labor are not considered as expenses) per farm, in the Reservation Area ranged from $94 for general farms to $2,078 for sheep ranches.
This item was less than $500 for every type except sheep ranches. In Ashley Valley the range was from $390 for general farms to $1,922 for sheep ranches. The other range livestock ranches averaged more than $1,500.

The important factors affecting the financial success of farms in the Uinta Basin apparently are: (1) type of farming, (2) rates of production, including crop yields, percent lamb and calf crop, wool per sheep, and pounds butterfat per cow, (3) death loss of livestock (4) size of farm business and (5) efficiency in the use of man-labor. The most successful farms were better than average in several of these factors.

Correlation of Results of Studies on Soils, Irrigation, Range Lands, and Economic Phases in Uinta Basin Area. The work during 1939-40 has consisted largely in the development of a technique of bringing together and summarizing the data assembled by the Soils, Irrigation, Range, and Agricultural Economics Departments of the Experiment Station.

The tentative technique that has been worked out gives promise of being satisfactory as applied to the Uinta Basin, and it is thought that it can, when needed, be used for the state as a whole.

The application of the methodology results in a land classification which reflects not only present land use and results but also the future probable best use when the major physical and economic factors affecting land use are all considered.

Business Analysis of farms in Utah County, Utah. During the past 20 years annual fluctuation in water supply has been the principal factor in accounting for yearly changes in average crop yields in Utah County. The effects of these changes have been in the same direction, low water supply being accompanied by low yields, fewer acres of harvested crops, and over a protracted period, less intensive crops.

Type of farming areas. Seven type-of-farming areas may be distinguished in Utah County: the Bench Fruit Area characterized by fruit production, North and South Lake Areas containing a large portion of the better farm land and half of the farms, Alpine Area, Southeast Bench, and Santaquin. The Cedar Fort area was not included in this study.

While area differences are considerable, differences among farms within each area are even greater and present more possibilities for improving the efficient use of agricultural resources. The agriculture of Utah County is organized on a family farm basis. Since 87 percent of the farms are owner-operated, the immediate responsibility for organizing

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3 Results of this study have been published in Bul. 289. Business analysis of farms in Utah County, Utah, by Walter U. Fuhriman and W. Preston Thomas.
and directing the utilization of most agricultural resources lies with the
4,000 individual farm families in the county.

Diversified farms. The most typical farms in Utah County are diversi­
fied farms having about 40 acres of irrigated cropland, approximately
40 percent of which is in hay, slightly less in grain and from 12 to 15
percent in such cash field crops as sugar beets, peas, tomatoes, onions and
potatoes. In addition to crops, these farms have livestock enterprises which
utilize most of the hay and much of the grain produced. It is with respect
to livestock enterprises that differences of great economic importance
occur among diversified farms.

That the more intensive livestock enterprises resulted in more profit­
able employment of the farmer's time is evidenced by the generally large
income on diversified farms having intensive livestock enterprises on a
commercial scale. While diversified farming is well suited to Utah County
conditions, dispersion of the farmers' activity over too many enterprises
is not conducive to effective farm operation. Particular care should be
exercised in selecting livestock adapted to the physical and human resources
of the farm and to provide for economic units of these.

A prime essential to satisfactory income on Utah County farms is
adequate physical production. Small acreage of arable land per farm
necessitates either very intensive crops or some intensive livestock enter­
prise if adequate physical production on the diversified farms is to be
achieved.

Specialized farms. Specialized farms in Utah County include dairy,
poultry, fruit, truck and field-crop farms. Some of these, such as fruit
and truck farms, have taken advantage of special soil and climatic con­
ditions while land and water resources of other specialized farms are com­
parable to those of diversified farms.

Intensity of both crop and livestock production averaged somewhat
higher on specialized than on diversified farms.

Average capital investment including rented property ranged from
$5,039 on truck to $12,931 on dairy farms, the average for specialized
farms being $8,219 as compared with $9,295 for diversified farms. Cash
receipts ranged from $1,256 on field crop to $4,052 on poultry farms,
cash expenditures from $705 on field crop to $2,672 on poultry, while
labor earnings on field crop farms were $360 as compared with $1,210 for
poultry. Differences in yield and in size (as measured by size index)
appear to have been factors of greatest importance in accounting for
differences in income among specialized farms in Utah County in 1935,
differences in these resulting in a production index of 74 on field-crop
farms as compared with 134 on poultry farms.
With the exception of field-crop farm, the organization of specialized farms, on the whole, appears to be fairly well adapted to existing conditions. Field-crop farms with more than average irrigated cropland present opportunities for increasing yields, for providing more and better balanced employment, for increasing total production and for obtaining a more satisfactory farm income by the addition of commercial units of intensive livestock enterprises.

Part-time farms. One-fifth of the farms in Utah County required less than 151 man-work-days to perform the productive labor on the farm. These farms—designated part-time farms—followed lines of production similar to those of diversified farms.

The most significant feature of part-time farms was their size. In acres of cropland and number of animal units, they averaged about one-third of that of full-time diversified farms. The size and the production indexes both averaged only 30.

Only slightly more than one-third of the part-time farmers did 50 or more days of work away from the farm. Labor earnings averaged $134 for part-time farms as compared with $517 for full-time diversified farms. Part-time farms in Utah County in 1935 were essentially miniature diversified farms providing much leisure but little income rather than well tilled gardens or intensive livestock enterprises.

If a farmer expects to make a living from 15 acres of cultivated land in Utah County, the land must be capable of intensive fruit or vegetable production. Crops grown on the average part-time farm preclude the possibility of providing adequate income from crops. Some farmers with only about 15 acres of land have attained the status of full-time farmers by establishing commercial poultry or dairy units. A part-time farm affords opportunity for an avocation for persons whose main employment and inclinations permit, but the fact that only one-third of the part-time farmers had more than 50 days of work away from the farm in 1935 shows that farming was their principal occupation. Part-time farms may also prove desirable for elderly persons. The average age of part-time farmers (52 years) was only 4 years above that of full-time farmers. Most of the part-time farms in Utah County did not present favorable adjustments to the existing agricultural conditions.

Relation of income to production. From the point of view of the individual farmer, the key to better income per farm, under given price and cost conditions, is greater production per farm. There are numerous ways of increasing production, but most of them may be included under two concepts — yield and size.

Yields on individual farms may be increased by seed selection, improved practices, increased use of fertilizer, and by more efficient use of the water
Yields are influenced by management as well as natural conditions. The size factor frequently admits of greater response to change than do yields. Size, as used in this discussion, is not measured in terms of acres alone but includes numbers of animals and also kinds of crops and of livestock. The size of a farm may, therefore, be increased by increasing the acreage, the number of livestock, or the intensity of crop and livestock enterprises. Analyses of Utah County farms show many cases where the most effective and least expensive way of increasing size, and thereby production and income, is to increase intensity, particularly of livestock enterprises. This conclusion is supported by the fact that the percentage of farms in the higher income groups rises with increases in the relative importance of the more intensive livestock enterprises on the farm.

*Trends in Utah's Agriculture.* Acreage of harvested crops in Utah increased until about 1920, then remained fairly constant to 1933. Acreage decreased markedly during the drought of 1934 and although it has increased each year since 1934, acreage in 1937 was still 4 percent less than the 1926-31 average.

The number of productive animal units on Utah farms during the past 30 years has been affected by cyclical movements in sheep and cattle numbers, but the trend was generally upward until about 1931. There was a marked decrease in 1935. Since then numbers have remained from 5 to 10 percent below the 1926-31 average.

Intensity of crop production increased about 15 percent from 1910 to 1920, and then decreased about 15 percent during the next decade so that during recent years intensity has been only slightly above that of 1910. Up to 1905 the trend in crop yield was sharply upward. Since then it has fluctuated rather widely. These fluctuations have, to a marked degree, coincided with fluctuations in annual precipitation. The 7-year period 1931-37 experienced yields lower than for any period of like length in 50 years.

The trend in yield of livestock products per animal appears to have been generally upward until about 1926. Since then it has remained fairly constant except for the low year, 1932.

As a result of lower prices the cash income from crops and livestock products for 1931-37 averaged only $34,131,000 — 60 percent of that for the preceding 7 years.

The number of farms in Utah increased from 25,992 in 1925 to 30,695 in 1935, an increase of 18 percent. Smaller total production and more farms reduced the average production per farm for the period 1931-37.
to 76 percent and cash income to 53 percent of that for the preceding 7 years.

This halving of the income per farm was largely the result of (1) unusually low precipitation, (2) low prices of farm products, (3) increase in the number and decrease in the size of farms in Utah, and (4) failure to increase, or in some aspects, maintain yields and intensity of crop and livestock production.

The operation of physical and economic forces will eventually remove some causes of distress but the correction of others lies ultimately in the hands of Utah's farmers.

Agricultural Credit and Farm Mortgage Debt in Utah

During the past two years, the major work on this project has been on farm mortgage indebtedness in Utah, Sevier, Weber, Cache and Box Elder Counties. A study of the annual recording of farm loans in these counties shows that:

The years 1933-35 witnessed a marked change in source of funds covered by new farm-mortgage recordings in Utah. From 1917 to 1932 national and state banks accounted for 38 percent of the new farm-mortgage recordings, and loans from individuals for 30 percent, while loans from the federal land banks accounted for but 12 percent. For the period 1933-35 loans from individuals constituted 6 percent, loans from state and national banks 20 percent and loans from federal banks 39 percent of all mortgages recorded. State and county agencies (State Land Board) accounted for 4 percent of all loans during 1917-32, but for less than 0.5 percent in 1933-35.

The average rate of interest on new farm mortgage loans decreased from a high point of 7.7 percent in 1921 to a low of 5.4 percent in 1935. Rates differed considerably among lending agencies. Average rates in 1935 were as follows: national and state banks, 7.2 percent; individuals, 6.1 percent; federal land bank and commissioner loans, 4.9 percent.

Causes of Country Bank Difficulties

Causes of bank difficulties in Utah and their effect on the supply of the farmer's credit has formed the basis of a study conducted during the past biennium. Accordingly, the books of most of the banks closed during the depression and a like number of solvent banks have been examined as well as careful analysis made of the agricultural credit problems and practices and the resulting financial condition of the country banks in Utah. Credit facilities and need for agricultural credit by areas are now being studied and analyzed. The results of this study should show (1) the
quality of service rendered to agriculture by country banks in the state and (2) how the banking policy of an individual bank may affect farmers and agricultural production within a given area.

Crops and Soils

Disease-Resistant, High Yielding Wheat. A number of the selections of winter wheat, especially from the Relief x Ridit cross, show a high degree of resistance to all the known races of covered smut. Some of these selections were inoculated with about 130 different field collections of bunt obtained from different sections of Utah and southern Idaho and seeded in the fall of 1939, and this season they showed a high degree of resistance to all these collections. One wheat selection was increased in 1938 with the idea of distributing seed to a few farmers for further trial. However, before harvest it was apparent that under some conditions this selection had the tendency to shed its flowering glumes, which resulted in some shattering. This tendency to shatter is similar to that of the Relief parent. Ridit, on the other hand, shows quite the opposite tendency. Some sister selections have exhibited an equal degree of resistance and do not seem to have inherited this tendency to shatter. It is hoped that one of these will soon be ready for release.

In spring wheats a new selection from the Federation x Hope cross was increased this year and it will be distributed to a few farmers in the spring of 1941 for further trial before being released for general distribution. The new selection is highly resistant to all the races of bunt, to loose smut, and rust. It resembles Federation in growth habit, but possesses the Hope resistance to these diseases.

Several strains of wheat resistant to smut developed at Logan have been tested at Nephi under dry-land conditions. Many of these produced yields equal to or higher than Utah Kanred which served as a check. In addition 228 strains involving crosses between pure lines of Turkey and Kofod and Utah Kanred and Sevier were under trial (fig. 13). One of the pure lines, Turkey 926, has proved superior in trial plots and is now being distributed to farmers. Ten of the best crosses between Sevier and Utah Kanred are being tested under irrigation to determine yield as well as straw strength.

The Mineral Content of Wheat.\(^4\) Spring wheats grown on the Nephi dry farm were found to carry greater percentages of ash, calcium, magnesium,

\(^4\) Additional data on this project are contained in the articles: The influence of variety, seasons and green manures upon the composition of wheats, by J. E. Greaves, A. F. Bracken and C. T. Hirst, published in Jour. Nut. 19:179-186. 1940; and Influence of variety and treatment on the phytin content of wheat, by S. M. Young and J. E. Greaves, published in Food Res. 5:103-108. 1940.
potassium, iron, phosphorus and sulfur than did winter wheats grown on the same soil.

A significant difference was found in the calcium content of different varieties of winter wheat grown on the same soil. A highly significant correlation was found to exist among most of the mineral constituents of wheat. When the wheats of different years were compared, a high variation was found to occur in the various mineral constituents from year to year. The addition of green manures to a typical dry farm soil caused a highly significant difference with respect to calcium and phosphorus. The use of green manure materially increased the phosphorus content of wheat, probably because of its effect in increasing bacterial activities which in turn increased the available plant food in the soil.

Some of the wheats were found to carry twice as much phytin phosphorus at others. There were greater differences between varieties than in the same variety under different manural treatments. The amount of phytin phosphorus varied from 1.52 to 3.28 grams per 1,000 grams of wheat. The phytin phosphorus was found to vary from 52.3 to 94.3 in percentage of the total phosphorus, with an average of 74.3 percent.

The Nutritive Value of High vs. Low Calcium and Phosphorus Carrying Wheats. The following wheats which were grown under similar conditions at the Nephi dry farm were fed to rats under controlled conditions: Alton, Turkey, Kanred, Kofod, Bart, Sevier, Dicklow, and Federation.
FIG. 14. U. S. Hybrid 52 corn grown for silage. Corn is a good crop to grow to clean up weeds and to produce a large amount of feed with a minimum of irrigation water.

The quantity of wheat required to produce a unit gain in weight varied with the different wheats. The phosphorus and calcium of the blood and the ash calcium and phosphorus of the bone also showed a difference. This difference was caused in some degree by the quantity of phosphorus and the form in which it occurred in the wheat. When the low phosphorus wheats were supplemented with sodium phosphate, their nutritive values became more nearly the same as those of the high phosphorus carrying wheats.

Commercial Grading and Protein Analysis of Wheat Samples. Commercial grading and protein analysis of wheat samples were begun in 1939 at the request of the Agricultural Adjustment Administration in Utah and Idaho to determine grades and protein content of samples of wheat in connection with loans to farmers on the wheat crop of 1938. A small fee is charged for each test, thus making the laboratory self-supporting.

In 1939 there were 171 protein determinations made for Utah growers and 548 for Idaho growers. Prices paid for the wheat crop were based on the percentage of protein contained in the wheat.

This seems a worthwhile project as it not only serves as a protection to the grower and a guide to the buyer and the United States Government in making its loans but will also furnish much fundamental data useful to the Experiment Station in its research program.

Hybrid Corn Outyields Standard Varieties. Since 1936 a number of corn hybrids have been introduced from the Corn Belt and tested under Utah conditions at Logan, Salt Lake, Richfield, and Cedar City.

Most of the hybrids have produced yields for silage production at least

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5 The results of this study have been printed in Bul. 287, Tests of corn varieties and hybrids in Utah, by R. W. Woodward, D. C. Tingey and R. J. Evans.
equal to the standard grown varieties (fig. 14). A few of the better adapted corn hybrids have given from 20 to 30 percent increased yields. Among these are U. S. 52, Funks G53 and G94, U. S. hybrid 44 and Iowa hybrid 13. Many others show promise in the first year tests.

U. S. hybrid 52 was the first to show its superiority over standard varieties. It has been recommended for commercial production with the result that large quantities of seed have been sold in the state. A successful attempt to produce hybrid seed was made in Brigham City in 1939 with a follow up of increased acreage. A new corn hybrid may be found at any time which will be superior to U. S. hybrid 52. Some 55 hybrids are under observation this year.

Unofficial estimates show considerably more land throughout the state planted in corn than in previous years.

**Forage Crops**

*Pasture Fertility Studies.* Pasture forage yields during 1938 were no greater on fertilized plots than on plots that had received no fertilizer, showing that fertilizers applied in 1934 were probably exhausted in the production of the 1934 to 1937 crops. Consequently a second application of fertilizers was made. Treble superphosphate was applied at the rate of 600 pounds per acre, a combination of treble superphosphate and ammonium sulfate at 300 pounds each per acre, and ammonium sulfate at 500 pounds per acre as in the previous applications. Manure was applied at the rate of 20 tons per acre, instead of 10 tons, the amount applied in 1934. The commercial fertilizers were applied May 29th and manure in October.

During the pasture season of 1939 the fertilizers giving the highest returns were manure and manure and phosphorus. In all plots where phosphorus was applied there was an increase in the percentage of clover in the forage.

All the plots produced at a much lower rate than during previous years.

Fig. 15. Harvesting plots of alfalfa that have been seeded to pasture by three different methods of seeding. The data indicate that drilling the seed into alfalfa stubble gave better results than when the seed was broadcast on the ground, or when the seed was broadcast and then harrowed into the soil.
This is undoubtedly owing to the continuous clippings made at thirty-day intervals for the past 5 years.

Pasture Mixtures Planted in Alfalfa Stubble. The planting of pasture mixtures in alfalfa stubble without breaking the sod is a great saving in labor and has proved successful in experiments at the Dairy Experimental Farm.

Three methods were used to seed the pasture: (1) drilling the seed into the stubble (the grass seed was mixed and drilled, while the clovers were mixed separately and drilled through the small seed box on the front of the drill, (2) broadcast in the stubble with no cultural treatment, (3) broadcast in the stubble then harrowed in.

The pasture mixture used was:

<table>
<thead>
<tr>
<th>Plant</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smooth brome (Bromus inermis)</td>
<td>4 pounds</td>
</tr>
<tr>
<td>Orchard grass (Dactylis glomerata)</td>
<td>4 &quot;</td>
</tr>
<tr>
<td>Kentucky bluegrass (Poa pratensis)</td>
<td>4 &quot;</td>
</tr>
<tr>
<td>Perennial ryegrass (Lolium perenne)</td>
<td>3 &quot;</td>
</tr>
<tr>
<td>Meadow fescue (Festuca elatior)</td>
<td>3 &quot;</td>
</tr>
<tr>
<td>White clover (Trifolium repens)</td>
<td>3 &quot;</td>
</tr>
<tr>
<td>Alsike clover (Trifolium hybridum)</td>
<td>2 &quot;</td>
</tr>
</tbody>
</table>

The mixture was seeded April 1, 1939. During the summer the entire area was cut three times for hay (fig. 15). The field was irrigated three times, first in May, and soon after the first and second crops of hay had been harvested.

Although the stand with all three methods of planting was good, plots where the seed mixture had been drilled were superior to the other seedings (fig. 16).

Clover Tests. The numerous requests for information on the many old and new varieties and strains of clovers have motivated the seeding
of a rather extended series of plots of the trifoliums. These tests include twenty-two strains furnished by the U. S. Department of Agriculture and by several of the state experiment stations.

**Strawberry clover.** The strawberry clover tests were continued. Many of the seedings are promising in wet situations including those with considerable alkali. It seems inadvisable to seed this variety on better land except for seed purposes.

**New Alfalfa Varieties.** A new varietal test which contains the new selections made at this Station and by other agencies, and consists of 20 varieties or strains, is underway. The uniform national variety test was continued for the third year. It includes about 100 varieties and strains, most of which are included in similar tests at 37 other stations.

A limited amount of inbreeding was continued in order to fix certain flower colors and to further test the effects of continued inbreeding. There are now some lines in the fifth generation of inbreeding without any apparent reduction in vigor. Other lines show definite marks of reduced vigor.

In the hybridization work numerous crosses were made in 1938 involving a large number of varieties including the varigated ones, the Turkistans, commons, and falcates. The seed from these crosses was seeded in the greenhouse and later 1,800 plants were transplanted into the field.

Seed was collected from many F₁ plants in 1939 and the seed lots divided. One portion of this seed was planted in pots and in the greenhouse to insure an ample supply of F₂ plants for study in the field. Another portion was planted in plots and the young plants will be inoculated with the wilt organism before they are transplanted to the field. This latter seed will furnish several thousand seedlings for inoculation studies.

**Bacterial Wilt of Alfalfa.** During the biennium, work on this project has been prosecuted largely with the view of selecting and propagating strains of alfalfa resistant to the bacterial wilt organism, *Phytomonas insidiosum* McCullock. In this connection approximately 130,000 alfalfa seedlings of the various strains of Utah Pioneer, Turkestan No. 96696, and genetic materials from the Agronomy Department have been artificially inoculated with the bacterium and transplanted to the field to await infection. Resistance has been found in all these varieties and strains employed: in Utah Pioneer from 12 to 20 percent, and in the Turkestan, from 40 to 50 percent.

Plants surviving the original inoculation will be reinoculated in 1940-41. Those plants found healthy subsequent to this second inoculation will provide a basis for further breeding and multiplication.
Stem blight of alfalfa. During the spring of 1940 isolation studies were made from stems exhibiting symptoms of stem blight, or black stem of alfalfa. Two organisms were isolated with uniformity dependent upon the stage of development of the disease, one, a bacterium corresponding in all respects to *Pseudomonas medicagenis* Sackett, and the other a species of the genus *Ascocbyta*. The results in general indicate that the bacterium is primary in its virosis invasion and that the *Ascocbyta* form is essentially a secondary invader living on the tissue formerly invaded by bacterium.

![Adult pale western cutworm](image)

**Fig. 17.** Adult pale western cutworm

Further progress can be made only with a better understanding of the environmental factor responsible for infection, or by obtaining strains of alfalfa with greater susceptibility to the disease than those so far used. During the winter and spring of the current year this latter condition was obtained in a number of inbred strains provided by the Division of Forage Crops and Diseases, U. S. Bureau of Plant Industry. Stem blight occurred naturally in a severe form in the greenhouse. Additional inoculation studies are now in progress.

*Insects Infesting Alfalfa.*

*The pale western cutworm.* During the biennium the pale western cutworm population in all infested districts became progressively reduced. During the season of 1938 crop damage varied from 1 to 5 percent
in different infested areas of Juab, Salt Lake and Utah Counties, but in 1939 none of these areas suffered a crop loss of more than 1 percent.

Because of the existence of only small, scattered populations of pale western cutworm during 1938 and 1939 it was found impractical to carry out contemplated cultural tests for the control of this pest.

Studies of the general biology of this insect were continued (fig. 17). Adult emergence and activity in both of these seasons covered approximately the same period, that is from September 1 to October 15 (fig. 18).

Fig. 18. Studies of the biology of the pale western cutworm, Lehi west hills, Utah County, September, 1938

Hatching of pale western cutworm eggs was found to take place in early spring soon after the snow disappeared from the ground in which the eggs were situated. First instar larvae were found in Utah County on January 16, 1938. In this same district hatching began about March 1, 1939. Larval maturity in both seasons was found to have been attained by June 1. Estivation of prepupae began near June 10 and first pupae were found on August 10, 1939.

During the past biennium the following natural enemies attacking different stages of the pale western cutworm have been identified:

A. Predators of adult moths
   1. Arachnida
      a. Phidippus spp. (Attidae)
      b. Xysticus (Thomisidae)
2. Insecta
   a. *Litaneutria minor* (Scudd.) (Mantidae)
   b. *Leptoglossus clypealis* Heid. (Coreidae)
   c. *Sinea undulata* Uhler (Reduviidae)
   d. *Phymata pennsylvanica americana* Mel. (Phymatidae)

B. Parasites of larvae and pupae
   1. Insects
      a. *Gonia longiforceps* Tothill (Tachinidae)
      b. A species near *Gonia aldritchi* Tothill (Tachinidae)
      c. *Bonnetia compta* Fallen (Tachinidae)

C. Bird predators of larvae and pupae
   1. Desert horned lark, *Otocoris alpestris leucolaema* Coues
   2. Western vesper sparrow, *Poecetes gramineus confinis* Baird

*Lygus-bug control in seed alfalfa.* Lygus bugs (fig. 19) appear to constitute one of the major factors limiting the production of alfalfa seed in Utah.

In an effort to find an effective insecticide for the control of these bugs experimental tests have been performed in alfalfa-seed fields in Millard County during the seasons 1938 and 1939 (fig. 20). The following insecticides were used in this work: (1) sulfur, 100 percent; sulfur, 85 percent plus paris green 15 percent; (2) sulfur, 75 percent, plus pyrethrum powder, 25 percent; (3) sulfur, 50 percent, plus pyrethrum powder, 50 percent; (4) cyanogas (H-dust), 100 percent; (5) lethane dust, 100 percent; (6) sulfur, 75 percent, plus calcium arsenate, 25 percent; (7) pyrocide dust, 5 and 10 percent, respectively, plus pyrophyllite as a carrier.

Fig. 19. Adult lygus bug (enlarged 12 times)
In 1939 when the alfalfa was first dusted after reaching the full-bloom stage all sulfur-bearing dusts caused more or less burning of the flowers. This condition was observed 24 hours following application. No such injury had been observed in 1937 nor in 1938. The 1939 injury was restricted to those flowers which were open at the time of application.

Although the bug population was significantly reduced on most of the treated plots, yet statistical analysis of resulting seed yields showed no significant difference resulting from the various insecticidal treatments.6

Weed Control Investigations

Weed control experiments have been continued on whitetop, morning glory, Canada thistle, and perennial sow thistle. Whitetop experiments were conducted at Richfield and Fountain Green; morning glory at Ephraim and Manila (Utah County); Canada thistle at Midway, in Wasatch County; and perennial sow thistle at Vernal.

Whitetop. The treatments on whitetop were made during the season of 1938, and the estimates of the percentage kill during 1939. Additional repeat treatments were made during 1939.

The experiments consisted of 3 general series of treatments: (1) chemical studies, (2) clean cultivation, and (3) combination of cultivation and cropping.

Results showed no significant difference between various dates of application of chlorates, the stage of plant growth when the chemical was applied, the time of application, the method of application, or irrigated or dry soil. The only significant difference was in rate of application. In a few cases the kills approached 90 percent. These were mostly cases where comparatively large amounts of chemicals were applied (6 pounds or more per square rod per season). It was also apparent that Pentox was not effective in the eradication of whitetop.

6 Results of this study have been published in Bul. 284, *Lygus hesperus* Knight and *Lygus elinus* Van Duzee in relation to alfalfa-seed production, by C. J. Sorenson.
Combination cropping and cultivation experiments on whitetop eradication looked promising, but are of too short a duration to draw specific conclusions yet.

A factorial experiment similar to the one at Richfield was set up in an area of whitetop at Fountain Green with similar results.

Morning Glory. The experiments on morning glory (fig. 21) were similar to those conducted on whitetop; namely, (1) chemical, (2) clean cultivation, (3) combination of cultivating and cropping, or cropping alone. Results showed no significant difference between dates of application of chlorates, stage of plant growth, time of application, method of application, or irrigated or dry soil. The only significant difference was in rate of application. Pentox is inefficient as a weed killer. A solution of sodium chlorate applied with different pH concentrations failed to influence the efficiency of the chemical.

Experiments were started at Ephriam late in the season of 1937; consequently some treatments were made during this year. The data were taken in the summer of 1938 and repeat treatments again made the same season.

The percentage kills for one year's treatment were low, consequently, a number of treatments were repeated again in 1938, and the data collected in the season of 1939. Again it was evident that there was a highly significant difference between treatments. The percentage kill after two years' treatments was much greater in all cases except for those plots.

Fig. 21. Wild morning glory (Convolvulus arvensis L.) staked out into small plots to receive different treatments in studies on control.
treated with Pentox. There seems to be no appreciable difference when the solution is applied at different pH concentrations.

The treatments involving clean cultivation have not as yet been completed so that data are not available. Two years are usually required for this method of control.

An experiment was set up in 1938 to compare the relative effectiveness of sodium chlorate, calcium chlorate, carbon bisulfide, Phenox and burning. The main effects showing significant differences were stage of growth, rate of application, and chemical used. As good or better results were obtained by burning with the low rate of burning as with the heavier rate of burning, whereas with the other chemicals, sodium chlorate, Atlacide, and carbon bisulfide, the more effective results were obtained with the heavier applications.

Canada Thistle. The experiments on Canada thistle at Midway were started in the summer of 1938, and these plots were continued through the season of 1939 (fig. 22). It is evident that there is a highly significant difference in the treatments. Phenox, as in previous studies, was inefficient or practically worthless in the eradication of perennial weeds. Under the conditions of the experiment the carbon bisulfide gave unsatisfactory results. This may be because the water table was rather close to the surface. For some reason the quantity of material failed to be an important factor under the conditions of this experiment. Two pounds of both sodium chlorate and Atlacide appeared to be nearly as effective as four pounds. This is somewhat contrary to all of the other experimental data.

Fig. 22. Canada thistle plots near Midway
**Perennial Sow Thistle.** The treatments on perennial sow thistle at Vernal were all concluded in 1938 after one year's clean cultivation, chemical treatments in the summer of 1937 and in 1938, and fall wheat in 1937 followed by fallow in 1938 after harvest.

The entire field was turned back to the owner for cropping in 1939. Corn was grown on the field with ordinary cultivation. On August 20, 1939, the field was finally checked and it was found that all plots were free from thistle except the three replicated plots treated with Phenox.

The cultivations at two-week intervals were just as effective as the shorter intervals. All chemical treatments except Phenox were successful.

As a part of the State Weed Eradication Program the Utah Agricultural Experiment Station, upon request of the county weed committee, has the responsibility of checking the fields which have been in cultivation one or more years. These fields are checked either in the spring or late summer.

**Miscellaneous Crops**

**Sugar-Beet Variety Tests.** This project was set up to determine if the new curly-top resistant varieties of sugar beets yield as well as the old standard varieties under conditions where there is practically no injury by the sugar-beet leafhopper and the curly-leaf disease which it carries. There is seldom any noticeable injury from this disease at the Greenville Experiment Farm at North Logan.

Beets of the 7 different varieties, U.S.12, A 735, U.S. 33, A 500, U.S.22, A 636 (all resistant), and R. & G. (non-resistant), were grown in replicated plots at the Greenville Farm under favorable conditions.

Differences in yield between the varieties were not significant. All produced good yields.

**Potato Variety Tests.** The potato variety and genetic strain tests were continued during the biennium. Twenty-four varieties were tested. The 10 leading varieties and the acre yields for 1938 and 1939 are given below:

<table>
<thead>
<tr>
<th>Variety</th>
<th>1938 Acre yield</th>
<th>First grade tubers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Golden (Montana) (2 yr.)*</td>
<td>840</td>
<td>733</td>
</tr>
<tr>
<td>2. Golden (2 yr.)</td>
<td>830</td>
<td>719</td>
</tr>
<tr>
<td>3. Katahdin (3 yr.)</td>
<td>795</td>
<td>690</td>
</tr>
<tr>
<td>4. Sebago (1 yr.)</td>
<td>784</td>
<td>717</td>
</tr>
</tbody>
</table>

*The designations (1 yr., 2 yr., or 3 yr., etc.) mean that the said variety has been grown at this Station in yield plots for that many years; for example, Russet Rural (1 yr.) means the seed was obtained that year.
5. Katahdin (1 yr.) .................................................. 770 658
6. Golden (1 yr.) .................................................. 750 613
7. Chippewa (3 yr.) ................................................. 745 644
8. Katahdin (2 yr.) .................................................. 740 648
9. 46,000† (1 yr.) .................................................. 733 585
10. Chippewa (2 yr.) ................................................. 718 634

†U. S. D. A. number, not yet named.

Variety 1938 Acre yield bushels First grade tubers bushels
1. Russet Rural (1 yr.) 780 624
2. White Rose (1 yr.) 745 451
3. Katahdin (3 yr.) 717 483
4. Katahdin (4 yr.) 696 456
5. Houma (1 yr.) 693 534
6. Katahdin (1 yr.) 685 532
7. Golden (3 yr.) 684 ...
8. Sebago (1 yr.) 672 513
9. Katahdin (2 yr.) 670 ...
10. Sebago (2 yr.) 670 ...
11. Chippewa (3 yr.) ...
12. Chippewa (1 yr.) ...
13. Houma (2 yr.) ...

Soil Borne Diseases of the Potato. Work during the year 1939 when this project was begun has been conducted to determine and characterize the various soil and tuber borne diseases (exclusive of virus diseases) affecting the potato in Utah. Three phases have been emphasized: (1) isolation from wilting potato stems collected in various parts of the state, (2) a determination of vascular flora of the mature potato tuber, and (3) a study of bacterial ring rot (fig. 23).

Isolations were made from 586 different stem collections from the counties of Cache, Box Elder, Weber, Davis and Salt Lake. From these isolations a total of 38 different forms of fusaria have been separated. Studies on the vascular flora of the mature tuber have consisted of isolations from the discolored vascular system of 496 tubers. By far the greater number of tubers showing vascular discoloration appeared sterile. Fifteen percent gave various species of fusaria, 8 percent gave members of the genus Alternaria, and 1 percent various other forms representing the genera of Botrytis, Penicillium, Ramularia and Verticillium. Four percent of the tubers from which isolations were made showed ring rot symptoms.

Fig. 23. Three stages in the development of ring rot in the potato tuber.
Surveys showed bacterial ring rot in ten counties of the state: Cache, Box Elder, Weber, Morgan, Davis, Salt Lake, Tooele, Utah, Piute, and Sevier. A number of field studies showed infestation of from 50 to 65 percent of the plants.

_Tuber Index of Seed Potatoes Grown or Offered for Sale in Utah._ This project, in cooperation with the State Crop Improvement Association, as carried out during the months of January, February, March, and April, 1940, consisted of testing or tuber indexing a total of 120 lots of seed submitted by growers of potato seed in Utah. Results are summarized as follows:

- 35 lots were free of mild or severe mosaic
- 34 lots showed both mild and severe form of mosaic
- 33 lots showed only mild mosaic
- 18 lots showed only severe forms of mosaic
- 70.8 percent of the lots showed virus disease in some form

_Soybean Tests._ For 4 or 5 years tests have been conducted with several varieties of soybeans. The results have shown that yields of 22 to 27 bushels of beans per acre or 3 to 4 tons of hay per acre may be obtained under favorable conditions on good manured, irrigated land, but that there is considerable risk of damage by fall frosts with the highest yielding

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Fig. 24. Soybeans growing on the agronomy farm. Right are cultivated rows; left, rows planted with a grain drill
varieties. A better quality of hay is obtained when the beans are planted in mass with a grain drill, but weeds may be better controlled by planting in rows and cultivating (fig. 24).

Utilization of the Jerusalem Artichoke. This project was primarily concerned with the utilization of the Jerusalem artichoke as a source of raw material for the fermentative production of dextro lactic acid. The artichoke, producing 18 tons of tubers of 20 percent carbohydrate, would yield 7,200 pounds of fermentable material per acre. The cost of production would be less than that of corn or black-strap molasses, which are the chief sources of raw material for fermentation processes at present. If dextro lactic acid could be obtained at a reasonable price a large market would undoubtedly be created for it. It has definite advantages over the other organic acids now used in the beverage and pickling industries.

Using a new species of the genus Bacillus, a process has been developed using the Jerusalem artichoke as a source of fermentable material and nutritive requirements. Since the culture used does not ferment inulin it was necessary to hydrolyze the material. From experiments the conditions for satisfactory hydrolysis were found to be: pH 2.0, temperature 95 degrees C. and time 60 minutes.

The constituents of the medium and the concentrations which have proved optimum are indicated:

- Hydrolyzed artichoke juice (1 + 2) ........................................ 500 cc.
- (NH₄)₂SO₄ .................................................. 3.0 gms.
- KH₂PO₄ .................................................. 0.5 gms.
- Additional sugar .................................................. 100 gms.
- CaCO₃ .................................................. 75.0 gms.
- Water .................................................. 430 cc.

It was found that the ground Jerusalem artichokes diluted with 2 parts water for hydrolysis could be further diluted and still give a rapid fermentation. As the material was diluted sugar was added to keep the concentration between 13 and 14 grams per 100 cc.

The incubation temperature of 48 to 50 degrees C. previously established as optimum for the culture used, is sufficiently high to prevent trouble from contamination.

The analysis of the fermented liquor from a number of experiments indicates that 92.60 to 94.25 percent of the sugar is converted to dextro lactic acid.

Mormon Cricket Control. During the biennium 1938-40 Mormon crickets seriously threatened farm crops in areas of Juab, Millard, Sanpete,  

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7 This study is also discussed in the article, Mormon crickets and their control in Utah since 1923, by C. J. Sorensen and H. F. Thornley, published in Proc. of Utah Acad. Sci., Arts and Letters 15:63-70. 1938.
Tooele and Utah Counties. However, because of the prosecution of an annual cooperative federal-county control campaign, only minor damage was done to farm crops, but considerable injury was inflicted on range forage.

Objectives of the work of this project during the past biennium have been: (1) to investigate the efficiency of poisoned baits as a means of controlling Mormon crickets. (2) to test various chemicals as attractants in cricket baits. (3) to test the efficiency of various oils as moisteners of bran in the preparation of cricket baits. (4) to obtain further data concerning the biology of Mormon crickets. During 1938 these studies were made in the Scipio Valley, Millard County, and during 1939-40 in the Benmore district of Tooele County.

In previous work of this project 12 different insect stomach poisons had been tested in baits with the result that fluosilicate and sodium fluoride proved most effective. In the preparation of baits thereafter use of poisons was restricted to these two. In addition to bran, dried apple and other fruit pumace were tested as carriers of the insecticides. Results of these tests indicate that no material was superior to bran for this purpose.

The object of using oil as a moistener was to prevent the bait from drying out and therefore becoming more or less unpalatable. The following 7 oils and fats were used in the preparation of cricket baits: motor lubricating oil, neatsfoot oil, mutton tallow, lard, cottonseed oil, coconut oil, and oleic (fatty) acid. Incomplete results of these comparative tests indicate that oil is superior to water as a bait moistener. Further tests are necessary to determine the relative efficiency of different oils for this use.

The following 20 chemicals have been tested as attractants in cricket baits: (1) N-butyl sulfide, (2) N-dibutyl amine, (3) diamyl sulfide, (4) N-tributyl amine, (5) diamylamine, (6) ethyl benzol sulfide, (7) potassium diamyl dithiocarbonate, (8) diamyl amide of metachlor benzoic acid, (9) N-butyl acetyl sulfide, (10) new lethane 384, (11) diamyl amide of dichloro acetic acid, (12) diethylene monothio dioxide, (13) monoamylamine, (14) amyl laurate, (15) ethylene glycol ethyl thioether, (16) ethyl isobutyl sulfide, (17) metahallyl disulfide, (18) N-butyl disulfide, (19) benzyl mercaptan, and (20) amyl mercaptan.

Fig. 25. Turkeys eat millions of grasshoppers each year in Utah
Numbers 1, 2, 10, 11, 12, 13, 14, 15, 18, 19 and 20 gave indications of increasing the attractiveness of poison baits to Mormon crickets.

**Grasshopper Control.** Grasshopper control (fig. 25) in 1938 was again carried on in cooperation with the U. S. Bureau of Entomology and Plant Quarantine and the state and counties of Utah. Bait was applied by 5,117 farmers to 76,244 acres of cropland, 2,380 acres of pasture and 100 acres of range lands and roadside. The 1938 grasshopper control program resulted in an estimated crop and range-forage saving of $1,062,350; the estimated crop loss was $650,000.

In grasshopper control in 1939 approximately 667 tons of wet mixed bait were used; this bait was spread by 3,301 farmers to protect 169,860 acres of crops, garden, pasture and some adjoining range land, resulting in an estimated crop saving of $674,286. It was estimated that $543,891 worth of crops were destroyed in Utah by grasshoppers during 1939. During 1940, grasshopper and Mormon cricket control work was actively carried on. Grasshopper attacks on crops were more severe during June of 1940 in many counties than during the same month of 1939.

**Investigations of Dry-Farming Practices**

The following represents a brief summary of the results obtained from dry-farming practices at the Nephi station and other locations in the state covering the years of 1938 and 1939 together with long-time averages.

**Plowing and Cultural Tests.** The results of plowing and tillage tests show striking difference between the yields of wheat in 1938 and 1939 caused by a favorable amount and seasonal distribution of rain in 1938 and a low price situation and frost in 1939. In 1938 the results appear to favor fall plowing over spring plowing and either no cultivation with weeds hoed or ordinary tillage of fallow as compared to frequent cultivation. The 24-year averages show little or no difference.

The data from plowing tests for the years 1938 and 1939 as well as the 30-year averages point to the fact that subsoiling to a depth of 18 inches tends to reduce yields and 15-inch subsoiling is no better than ordinary plowing. The yields of 1938 and the long-time average appear to indicate that 5-inch plowing in fall reduces yield.

The wheat yields for both 1938 and 1939 slightly favor the use of the large disk plow as compared to the moldboard. The 11-year averages show no difference for either of the methods.

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8 Additional information on this study is contained in an article, Grasshopper control in Utah—1938, by George F. Knowlton, published in Proc. of Utah Acad. Sci., Arts and Letters, 16:43-47. 1939.
The first yields from the time of plowing test were obtained in 1939. The data obtained show the advantage of either fall or early spring plowing with little or no difference between no tillage and medium tillage of fallow. A slight advantage is indicated for frequent tillage of fallow.

Fertility Experiments.

Barnyard manure tests. The yields for 1939 are slightly higher with the application of 10 tons of manure each alternate year but none for the other treatments. For 1938 this heavier application reduced the yield as the result of "burning." The 25-year averages show an advantage for 10 tons of manure applied every four years and 10 tons each alternate year. This increased yield largely occurred in the earlier years of the test.

Green manure tests. Results of green manure tests using wheat and peas show a reduction in yield of wheat in nearly every instance where peas were plowed under as green manure in the bloom and pod stages and little or no effect at the earlier stages. The results for 1938 and 1939 as well as the 24-year averages show a progressive reduction in yields with the advanced stages at which wheat was plowed under as green manure.

Results from a stubble disposal test show little difference for the various treatments. The surprising thing is that after 24 years the plots on which the stubble has been burned continuously show no reduction in yield.

Cropping Experiments. The data on yields of wheat using different methods of cropping show that the total yield is greatest from the alternate system of cropping. This cropping system is also highest in acre yield.

In 1938 there was a much more marked reduction in wheat yields following row crops as compared to fallow than was the case for 1939 or the 31-year average. The average indicates that the reduction amounts to approximately 2 bushels per acre.

Rotations. In the test where row crops were rotated with fallow the yield of peas, compared to peas alternated with wheat, showed no reduction, potato yields were somewhat reduced, but corn yields showed a marked reduction.

Winter Wheat Varietal Trials. Data from winter wheat varietal trials show an interesting relationship between Turkey 926 and Sevier 59. In favorable seasons Sevier 59 leads in production, but in average or poor seasons Turkey 926 heads the list.

Forage Crops. Crested wheatgrass gave the highest yields in the 1937 and 1938 forage production tests but in 1939 both cuttings of rye produced higher yields. This grass has come to be considered one of the most adaptable forages for dry-farm planting.
An emergence test of crested wheatgrass was set up on a factorial basis at Nephi, Benmore and Howell to impose every treatment on every other treatment. The data showed that either early fall or late fall seeding was the only seeding date to give stands at Benmore and Howell. At Nephi, fall seeding was much better. Depth of seeding favored broadcasting and seeding to a depth of one inch as compared to 2 inches. The rate of seeding test shows better stands with 7 and 14 pounds to an acre.

The survival results of trials of forage seeding made at Howell on 1/5 acre plots showed marked reduction in stand of both slender wheatgrass and western wheatgrass. No change occurred in the other forages. From observations made in the spring of 1940 the surviving plants of slender wheatgrass had largely died out. Western wheatgrass had also been further reduced and the brome stands had partly died out. Crested wheatgrass and alfalfa both survived with good stands.

Eighteen alfalfa varieties now under test for three years show that for 1939 Turkestan 86696, 15754 and 19300, and Hardistan and Argentina 15996 gave the highest yields.

Wheat Quality Studies. These studies included analyses of wheat grown in the green manure and barnyard manure tests, cropping systems, rotation trials, and the varietal tests. In the green manure tests, wheat used as a green manure crop had little or no affect on quality of grain. When peas were used as a green manure, however, a marked increase in the protein content of wheat occurred. In the cropping tests no effect was found except in plots cropped one season following two fallow periods. In the rotations, wheat following alfalfa showed a high protein content. In the varietal trials such wheats as Turkey 926, Utah Kanred, Kharkof, and Montana 36 produced highest yields.

Weather Observations. Marked differences occurred in the crop yields of 1938 and 1939. In 1938 the crop yields were approximately 145 percent of normal while the yields of 1939 were only 64 percent. The high yields of 1938 were the result of the amount as well as the distribution of precipitation. During the year the rainfall amounted to 14.07 inches with 2.06 inches in March, 1.29 in April, and 2.94 in May. The total amount was 1.32 inches above normal. In 1939 the rainfall amounted to only 10.79 inches which was 1.96 inches below normal and the rainfall in the spring months was low. Then on June 7, and again on June 17, freezing temperatures damaged the grain.

Factors Responsible for Loss of Nitrogen and Organic Matter from Dry Lands. In 1938 and 1939 samples of soil were taken on land which had grown wheat since breaking from brush. Adjacent virgin land and land which had been seeded to alfalfa for 2 to 25 years were also sampled.
It was found that wheat land as compared to virgin land had lost approximately 20 percent of the nitrogen, but land in alfalfa for 4 years or more had recovered 60 percent of the nitrogen lost. It was also found that in every case the loss of organic matter had exceeded the loss of nitrogen showing a narrower carbon-nitrogen ratio. This ratio widened when alfalfa was included in the cropping system.

Soils and Fertility

Soil Survey. The soil survey consists of a careful inspection and study of the soils in a particular area to determine the type, quality, depth, and extent of the respective soils and the crops they are adapted to produce. The results of a survey serve as a guide in planning and adjusting the crop program and in developing a permanent system of agriculture.

During the biennium, soil survey work has been under way in the following areas: (1) Uinta Basin, (2) Utah and Goshen Valley areas, and the Beryl-Enterprise Area, Iron County, (3) Sevier, Sanpete, Juab and Millard Counties.

Uinta Basin. Field work of approximately 911 square miles was completed in the Uinta Basin with conservation symbols and soil type and alkali maps. Of this area 520 square miles were completed during the biennium. Part of the work consisted of checking and reclassifying the old Uinta River Valley soil survey map, another part consisted of placing the conservation symbols on the soil type map which was completed in 1937, a third part consisted of a reconnaissance and detailed survey of entirely new areas. Land classification maps completed to date cover an area of approximately 812 square miles or 520,026 acres.

Utah County. Soil type and alkali maps have been completed during the biennium for an area of approximately 228 square miles, bringing the total area of that county to 530 square miles. Land classification and alkali maps have been completed for the area as far south as Payson.

Beryl-Enterprise area. The field work was completed during the biennium for detailed soil type and alkali maps on 270 square miles in the Beryl-Enterprise Area.

Colorado River-Great Basin project. A regular detailed soil type map was made as a basis for the classification of lands likely to be involved in the proposed Colorado River-Great Basin Irrigation Project. The survey was conducted in Sevier, Sanpete, Juab and Millard Counties. The areas classified are:
Physical and Chemical Properties of Soil Types in Utah. The purposes of this project are to study the physical and chemical properties of the soil types established by the soil survey and to investigate the changes of these properties with the accumulation or removal of alkali.

Complete chemical analysis of the whole soil from several horizons and the material finer than 0.002 mm. in diameter from the same horizon have been completed for two important soil types of Cache Valley. In addition a study has been made of the solubility of calcium and magnesium oxides in 2N acetic acid. The object sought in this solubility study was a measurement of the proportion of these oxides combined as silicates and carbonates. The solubility data include a measurement of the whole soil of each horizon for each soil, as well as of the clay fraction from each horizon. The soil types from the Cache Valley area are the Mendon silty clay loam prominently developed on the west side of Cache Valley and a heavy clay of the Salt Lake series from the forage experimental farm south of Logan. Both soils have well developed profiles thought to be approaching maturity and were selected after careful field study as standards for judging degrees of profile development. Additional analytical data are under way for three profiles from the Uinta Basin and three from the Beryl-Enterprise Area.

Important conclusions that appear to be reasonable at this time are:

The silica sesquioxide ratio of the clay fraction shows no regular variation with the horizon, the lowest ratio being 3.82 and the highest, 4.95.

The silica sesquioxide ratios indicate soil colloids of a montmorillonitic composition.

The calcium carbonate distributed in the profile is the one most disturbed during the process of development.

Factors Influencing the Erodability of Soils. This project is an attempt to find a correlation between some soil properties that can be observed in the laboratory and the tenacity or resistance of the soils to a uniform erosive force in the field.

Samples of 13 soils of entirely different types, mostly virgin, from dif-

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9 Some of the findings in this study were published by J. Darrell Peterson and D. S. Jennings in an article, A study of the chemical equilibrium existing between soluble salts and base exchange compounds, in Soil Sci. 45:277-292. 1938.
ifferent parts of the state were determined. Microscopic slides from these samples have also been prepared to study the structure by reflected light and with the polarized microscope.

Factors Influencing the Bacterial Activities of the Soil. A study has been made of the nitrogen-fixing powers of cropped and virgin soils of Cache and Juab Counties. The nitrogen fixed by the Cache County soils was considerably greater in amount than that fixed by the Juab County. This is probably the result of two factors: (1) The Cache County soils contain more organic carbon than do the Juab County. (2) Azotobacter are present in the Cache County soils to a much greater extent than they are in the Juab County soils. The nitrogen fixed by cultivated soil is greater than that fixed by virgin soil. This is especially noticeable in the alfalfa soils.

The addition of ground alfalfa, ground pea vines, or ground straw to the Nephi Dry Farm soil materially increased nonsymbiotic nitrogen fixation. This was most pronounced where the ground alfalfa was added to the soil.

Phenylalanine and d organic were the only amino acids of the seventeen studied which retarded nitrogen fixation by Azotobacter chroococcum when applied to the soil in small quantities. Cystine and dl methion increased fixation approximately 20 percent. Their actions nearly paralleled each other throughout the concentrations used.

A. chroococcum was cultured in sand, soil, agar and liquid media, with various species of bacteria-free protozoa to learn the influence of these organisms on nitrogen fixation. The protozoa in general stimulated nitrogen fixation and Azotobacter were more numerous in the presence of the protozoa than in their absence. Suspensions of Colpoda, heat killed at 65 degrees C., for one half hour, when introduced into Azotobacter cultures in small amounts stimulated nitrogen fixation in a degree comparable to that obtained with the living protozoan cells.

Effects of Various Fertilizers on Crop Yield. An experiment on the effects of various fertilizers on crop yield was conducted on permanent plots on the Greenville Experiment Farm at North Logan. The crops grown were potatoes, sugar beets, barley, wheat, and alfalfa (two years) which were grown in rotation in this order, one belt of plots being in each crop each year (fig. 26). The fertilizers used were nitrogen as ammonium sulfate (240 lbs. per acre), phosphorus as treble superphosphate (350 lbs.

per acre), potash as potassium chloride (167 lbs. per acre), gypsum as plaster of paris (330 lbs. per acre), barnyard manure at 10 tons per acre, raw rock phosphate at 1,000 lbs. per acre (used only in connection with manure), and elemental sulfur at 250 lbs. per acre (used only in connection with raw rock phosphate and manure). The same fertilizer treatment was applied year after year to each plot.

This experiment has been in progress for 12 years or two complete 6-year rotations.

Raw rock phosphate, potash, gypsum and sulfur seem to have had no noticeable effect on the crops. None of the fertilizers except manure gave any consistent results with barley or potatoes. Phosphorus increased the yield of sugar beets 49 percent, nitrogen and phosphorus, 67 percent, and manure and phosphorus, 72 percent. Wheat yields were consistently increased by nitrogen and phosphorus and by phosphorus and manure.

Fertility Trials. In this investigation an attempt has been made to compare the relative efficiency of different phosphate fertilizers by cropping tests in the field and greenhouse. An attempt was also made to improve
the soil test for available phosphate to a point where it may be used as a reliable index of the need of a soil for phosphate.

The experiment consists of several field and one greenhouse test (fig. 27) with different kinds of phosphate fertilizers and analyses of the soils from these test plots by various methods in the hope of finding a method that will agree with field results. Alfalfa was the indicator crop in all of the cropping tests.

In a replicated test on alfalfa plots using different phosphate fertilizers, superphosphate (18 percent $P_2O_5$) applied at the rate of 554 pounds per acre produced the greatest increase in yield, more than doubling the yield of the plots receiving no fertilizer. Calcium metaphosphate (T.V.A.) applied at the rate of 166 pounds, treble superphosphate (43 percent $P_2O_5$) applied at the rate of 232 pounds per acre also significantly increased yield. Fertilizers having no effect on increased yield were "Soil Aid" (roast rock and coal), and Anderson phosphate (raw rock).

Permanent Fertility Studies. A study has been made during the past two years of the quantity and distribution of moisture, nitrogen, phosphorus and calcium in beets receiving different fertilizer treatments. The average yield of the 8 plots studied was 15.41 tons of beets per acre and 8.46 tons of tops. As an average 49.20 percent of the total nitrogen was in the beets and 50.79 percent in the crowns and tops. The beets carried 35.33 percent of the phosphorus, whereas 64.67 percent was in the crowns and leaves. In the case of the calcium only 28.85 percent was in the beets and the remainder in the crowns and tops. More of the magnesium, 55.20 percent, was in the leaves and crowns and 44.80 percent in the beets.

There was a marked variation in the composition of the beets grown

\footnote{The description of an inexpensive photo-electric colorimeter for phosphorus determinations, by D. W. Pittman and R. Parry is contained in Jour. of the Amer. Soc. Agron. 32:155-156. 1940.}
on land to which fertilizer had been added compared with the beets grown on land receiving no fertilizer. It is evident from the work so far done that the crowns and leaves contain large quantities of the essential plant elements and should be returned to the soil either by plowing under or by feeding.

**Vegetable Production**

**Davis County Experimental Farm**

Although the Davis County Experimental Farm was established as a truck-crop station, studies in pomology and plant pathology are now major projects at this farm. Some preliminary studies are made of various vegetable crops, such as asparagus, carrots, castor beans, celery, sweet corn, and lima beans.

**Factors Affecting the Formation of Doubles and Scallions in Onions**

The death of Dr. A. L. Wilson caused some interruption of this work, but some parts of this project have been completed and after a full analysis of the data the report will be published.

**Factors Affecting the Keeping Quality of Onions**

The death of Dr. A. L. Wilson caused some interruption of this work, but the project has been completed and the results are now being analyzed.

**Tomato Disease in Utah**

*Wilt Diseases of the Tomato.* Verticillium wilt (*Verticillium alboatrum* R. and B.) is the most prevalent and serious wilt disease of the tomato in Utah (fig. 28). The development of a tomato that will resist the disease is being emphasized in the wilt disease studies.

No commercial variety of tomato has been found with more than a moderate degree of resistance to Verticillium wilt. Efforts to increase the degree of resistance in these varieties by selection have failed. Two red fruited wild tomatoes—i.e., *Lycopersicon esculentum var. cerasiforme* (Dun.) Gray collected in southern Peru by Cook many years ago and *L. pimpinellifolium* (Jusl.) Mill. collected in the Urubamba River of southern Peru by Blood in 1938, have been found to possess a degree of resistance to the disease closely approaching immunity. One green fruited species *L. glandulosum* C. H. Mul. collected along the western slopes of the Andes Mountains in Central Peru by Blood in 1938 appears to be practically immune to the disease.

The two species of the red fruited type hybridize readily with varieties of the commercial tomato *L. esculentum* Mill. Hybrids of *L. esculentum* Mill. (Stone and Century) by *L. esculentum var. cerasiforme* (Dun.)
Gray in the third generation with fair fruit size and high resistance to the disease are being tested. These hybrids are being back crossed to commercial tomato to increase size and quality. The red fruited *L. pimpin-*
ellifolium (Jusl.) Mill and the green fruited \textit{L. glandulosum} C. H. Mul. have been only recently included in the breeding program.

\textbf{Bacterial Canker (Aplanobacter michiganense E.F.S.).} Seed treatment studies for the control of bacterial canker of the tomato indicate that the extraction of tomato seed by fermenting the highly macerated fruit pulp containing the seed for 96 hours or a seed soak in 0.9 to 1 percent acetic acid for 24 hours before the seed has been dried following extraction are still the most effective treatments for the control of the seed-borne phase of the disease (fig. 29).

Survey data indicate that infested seed beds are the most serious single source of bacterial canker infection of tomato plants in Utah. Preliminary studies of methods for the control of the seed bed inoculum have not revealed any positive soil treatment that may be relied upon for the control of the disease. The only recommendations that can be given are the complete destruction of the infested bed and the erection of a new one on soil that has never grown tomato plants and that is removed far enough from the old bed site that tomato plant debris of any kind has had no opportunity to become mixed with and contaminate the soil at the new site. Old bed frames may be used again if thoroughly washed with three percent formaldehyde solution. The treatment has to be thorough or contamination is carried to the new bed site by the old frames. Sash cover must be washed thoroughly in a formaldehyde solution and canvas or cloth covers laundered.

Longevity studies have shown that the bacterial canker pathogen (\textit{A. michiganense} E.F.S.) will remain viable in air-dried plant tissue with little evidence of loss in pathogenicity for over five years.

\textbf{Fig. 29.} A field of tomatoes destroyed by bacterial canker (\textit{Aplanobacter michiganense E. F. S.}). Control measures have been developed at this Station that will prevent destruction by this disease if they are properly followed. There is no longer any need for the farmers to suffer such losses from this disease.
Tomato Mosaic (Virus). A modification of the tobacco mosaic virus No. 1 in the host Datura meteloides D.C. was observed and studied\(^2\) (fig. 30). The modified virus was found to be viable in air-dried plant tissue and in vitro at the end of thirty-six months.

The systemic or modified form of the tobacco mosaic virus appeared in from five to six percent of the D. meteloides D.C. plants inoculated with the crystalline tobacco mosaic virus No. 1. These results if confirmed indicate that a basic change occurs within the virus itself in a small percentage of the inoculated Datura plants and not in some supplement that may be present in the juices of the host that could influence the behavior and expression of the virus.

Curly Top (Western Yellow Blight) of Tomatoes.\(^3\) Prior to 1938 approximately eight hundred varieties and strains of commercial tomatoes of Lycopersicon esculentum Mill. had been tested for resistance to the curly top (virus) disease, which is disseminated by the sugar beet leef-hopper Eutettex tenellus (Baker), on the Hurricane trial grounds in the midst of a large insect-breeding area. None of these strains or varieties proved to be sufficiently resistant to the disease. A few collections of wild tomatoes from South America and Mexico and of novelty tomatoes from the local trade were included in the trials. Selections of a Mexican wild tomato named Ojo de Venado were made that have proved to be highly resistant to curly top and to drought when planted on the Hurricane and Hooper trial grounds (fig. 31). A dwarf selection of the novelty tomato Red Peach possesses considerable resistance to the disease. During the past two years large numbers of reselections of these two resistant tomatoes have been made in repeated trials at Hurricane in an effort to increase the degree of resistance possessed by these collections.

New accessions introduced from South America in 1937-38 were tested in sufficient numbers to indicate that some of the green fruited types of the tomato genus Lycopersicon are more highly resistant to the curly top than the red fruited wild and novelty types of L. esculentum Mill. from which resistant selections have been made. Strains of L. glandulosum C. H. Mul., L. peruvianum var. humifusum C. H. Mul., and L. peruvianum var. dentatum Dun. are highly resistant to the curly-top disease.

The F\(_2\) and F\(_3\) generation of crosses of resistant selections of Ojo de

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\(^3\) Work on this study is also discussed in an article, A method of measuring the relative resistance of varieties of tomato and bean to curly top, by H. L. Blood, published in the Proc. of the Utah Acad. of Sci., Arts and Letters 15:21-24. 1938.
Venado and Red Peach with commercial varieties of tomato have all been lacking in resistance and in fruit quality. Crosses and back crosses are being repeated in the hope of obtaining a cross that will yield resistance to the disease as well as fruit size and quality.

Repeated attempts to cross the green fruited types that possess resistance to curly top with commercial tomatoes have failed. Attempts have been made to cross *L. hirsutum* H.B.K. with the curly-top resistant green fruited types with some promise of success. The F₁ generation of a few such crosses are being propagated at the present time. If crosses with these members are successfully made an attempt will be made to combine the *L. hirsutum* H.B.K. x *L. esculentum* Mill. hybrids with the *L. hirsutum* H.B.K. x *L. glandulosum* C. H. Mul. and *L. peruvianum var. dentatum* Dun. crosses. In this manner a recombination of the resistant qualities of the green fruited types with the commercial quality of the varieties of *L. esculentum* Mill. may be obtained.

**Fig. 30.** Upper—*Datura meteloides* D. C. infected with tobacco mosaic. The virus is localized in the necrotic portion of the inoculated leaf (drooping at the right) and in the necrotic streak along the stem below the axil of the leaf. Lower—*Datura meteloides* D. C. infected with the modified tobacco mosaic virus that appears in from 5 to 6 percent of the plants inoculated with the tobacco mosaic virus (upper picture). The modified virus appears in the leaves of the lateral shoots that develop from auxiliary buds adjacent to the necrotic streaks on the stems of *Datura* plants infected with the ordinary tobacco mosaic as illustrated in the upper picture.
FIG. 31. Lower—A plot of Stone tomato on the Hooper trial grounds with over 90 percent of the plants destroyed by curly top. Stone is one of the parents used in crosses. Upper—A plot of a Red Peach resistant selection on the Hooper trial grounds with less than 20 percent of the plants destroyed by curly top. This selection is used as the resistant parent in a breeding program to develop a commercial tomato that will resist curly top.
A study of the usefulness of root growth-stimulating chemicals in the vegetative propagation of varieties of green fruited tomatoes that do not fruit readily under Utah conditions indicates that idolebutyric acid gives the best results with the greatest number of tomato types. *L. hirsutum* H.B.K., however, reacts unfavorably to this chemical.

A method has been devised for the study of the relative susceptibility of tomato and bean species and varieties by controlled inoculation procedure. *L. glandulosum* C. H. Mul., *L. peruvianum var. humifusum* C. H. Mul., and *L. peruvianum var. dentatum* Dun. when inoculated according to this procedure are found to be practically immune to curly top and the selections of Red Peach and of Mexican wild tomato are highly resistant when compared with the behavior of commercial varieties of tomato such as Stone.

**Ecological and Physiological Experiments with Curly-Top of Tomatoes**

Experiments with direct seeding by means of the drill method gave excellent results both in disease control and yield. The disease was reduced from 61/2 percent in the check to slightly over 1 percent and the yield was 1 1/2 tons higher than in the checks. Early planting proved better than midseason or late planting. Tomatoes planted about April 20 showed only 5 percent curly-top infection whereas tomatoes planted in May showed 20 percent infection. Shading the plants with alternate rows of corn gave no control of the disease and lessened the yield.

Spacing experiments showed that the highest yields and the best disease control were obtained from the most densely planted plots giving 16 1/2 tons of the total fruit per acre and nearly 14 tons of marketable fruit compared with about 12 tons of the total fruit from control plots.

**Beet Leafhopper Investigations**

Studies have shown that the beet leafhopper, *Eutettix tenellus* (Baker), feeds and breeds upon a large number of plants including cultivated crops, native plants and introduced weed hosts. A sequence of suitable host plants is necessary to permit the production of a high beet-leafhopper population leading to seriously destructive abundance. Weather conditions play an important part in regard to abundance or scarcity of a number of the native and weed host plants, such as Russian-thistle, mustards and filaree. Studies devoted to desert and range breeding areas of this pest indicate that spring leafhopper movements from breeding areas are closely synchronized with drying or maturing of a large amount of the plant material upon which the leafhoppers have been feeding.
Range improvement, eliminating or greatly reducing the area of beet leafhopper breeding hosts through replacement of host plants by grasses, shows promise as a means of reducing beet leafhopper injury to tomatoes, beets and other cultivated crops. Attempts to control beet leafhoppers in tomato fields have not proved to be practical.

Several species of big-eyed flies (*Pipunculus* sp.) are parasitic upon the beet leafhopper in its nymphal stages; big-eyed and damsel (hemipterous) bugs, several desert lizards and numerous insectivorous birds feed on *E. tenellus* in its breeding areas, particularly reducing fall populations. Such biological control, while of importance, is not sufficient to keep the leafhopper in check during years favoring abundance. Egg parasites also extend some aid in leafhopper control.

Investigations have indicated that filaree (*Erodium cicutarium*) is a particularly important winter and spring host of the beet leafhopper in a number of Utah areas. Studies in the greenhouse on the percentage of viruliferous leafhoppers collected from various hosts have shown that a higher percent of the leafhoppers overwintering on filaree carried the virus than those overwintering in areas where several mustards are the principal hosts. Few leafhoppers collected from the mustards *Cheirinia repanda* and *Malcolmia africana* transmitted the virus. During the spring of 1939, 18.5 percent of the leafhoppers collected from filaree transmitted curly-top virus to young sugar beets in the greenhouse, while in 1940, 58.7 percent transmitted the disease. Thus the host plant origin of the spring dispersal leafhoppers plays an important part in determining the extent of damage likely to result to the tomato plants from leafhoppers entering such fields. It is estimated that approximately 75 percent of the yearly tomato curly-top damage results from the local spring dispersal of the leafhoppers. Some resistance to the curly-top disease appears to be built up gradually in tomato plants as they become older.

Cheese cloth covers, protecting tomato plants during the period of spring dispersals, have shown promise as a control measure, substantially reducing the amount of curly-top injury in fields treated. During 1939, cloth cover experiments gave control of curly top ranging from 74 to 83 percent. Similar experiments conducted during 1940, at the end of June appeared to have given substantial protection. Leafhoppers do not, as a rule, survive for many days on tomatoes, if weed hosts are not available.

Insecticide repellent tests, using sulfur, pyrethrum combinations, naphthalene, zinc sulfate, wettable sulfur, dynamite spray, nicotine Bentonite-soybean oil, nicotine sulfate, lime, derris-pyrethrum-sulfonated castor oil, fullers’ earth, and a combination of paris green and calcium arsen-
ate, have not afforded measurable protection from curly top in tests undertaken.

Double planting, placing two plants in each hill, gave a 44 to 59 percent reduction in curly-top damage during 1939 experiments, and produced yields of tomatoes sufficiently greater to pay for the extra plants used. No advantage seemed to result from removing one plant after the peak of leafhopper invasion had passed.

**Tomato Fruitworm Investigations**

Studies have shown most tomato fruitworm (*Heliotris armigera* Hubn.) eggs to be deposited around the periphery of the tomato plants and near to the blossoms, indicating the need for careful insecticidal treatment of the entire plant.

![Tomato fruitworm](image)

**Fig. 32.** Tomato fruitworm, *Heliotris obsoleta* (Fabr.), and its injury to a tomato fruit

Tomato fruitworm populations have been relatively low in Utah during the past two seasons; however, insecticidal tests have indicated that cryolite has given better control than calcium arsenate. Synthetic cryolite appeared to be superior to natural cryolite in tests conducted during 1939. Application schedules beginning early in July in 1939 were superior to those beginning later. Two and three insecticide applications gave better control than a single application. An interval of two or three weeks between treatments gave better control than a shorter interval for the same total number of treatments. Use of 20 pounds of insecticidal dust for the first treatment, and approximately 30 pounds each for the second and third applications, seemed necessary with hand duster applications.

Late season tomato fruitworm injury is not uncommon in Utah (fig. 32) and later applied control applications may be necessary when such
injury is severe. However, more efficient control of worms may be expected if application of insecticides are made while the worms are small and before they enter the fruit.

**Adaptation of Two New California Tomato Varieties to Utah Conditions**

In recent years two new varieties of tomato were developed by the U. S. Department of Agriculture in connection with the California Experiment Station, a shipping variety "Riverside" and a canning variety "Essar." In view of a higher resistance of these varieties to Verticillium wilt which is prevalent in this state, and certain superior horticultural qualities, it seemed desirable to test them for their adaptability to tomato-growing sections of Utah. It has been found during the first years of trials that further selection would be necessary with the view of shortening the growing season and increasing their resistance to the wilt disease. For this purpose some recent selections have been made from plants grown on heavily infected soils at Farmington and Roy which appear to be promising and deserving of further trials under the same severe conditions. If sufficiently improved in their productivity and commercial qualities, they may be used in plant breeding by crossing with importations totally immune to wilt to obtain highly resistant, first-class horticultural varieties for the tomato industry of this state and possibly other similar sections.

**Curly-Top of Beans**

A highly curly-top-resistant white pea bean and a number of types of curly-top-resistant pinto beans have been developed. These beans are good yielders and have excellent quality. They have not been released to the trade because they do not possess resistance to the bean mosaic (virus). Single plant selections for mosaic resistance are being made with good selections of the curly-top resistant beans in an effort to obtain pea bean and pinto bean types resistant to both curly top and mosaic.

**Cultural and Harvesting Practices in Relation to Yield and Quality in Canning Peas**

Field experiments during 1939 showed that the time of the first irrigation of peas made no difference in (1) the juice content, (2) screen size, (3) yield of shelled peas, (4) total weight of crop, and (5) chemical analysis of shelled peas.

Different combinations of nitrogen, phosphorus and potassium fertilizers were made on Perfection peas grown on productive land. Addition of fertilizers did not increase yield nor improve quality. However, the peas lost considerable juice as the time in the field between harvesting and winery was increased from one to seven hours.

These tests will be continued.
Pea Aphid Control

Pea aphid control plot experiments during 1938 indicated that a one percent rotenone bearing derris or cube dust usually gave control, but that the actions of the dusts were less constant and averaged slightly less effective than rotenone spray applications. In cooperation with canners, 35 to 45 pounds of fresh Agicide 1 percent rotenone bearing dust per acre was applied with an Agicide power duster. This treatment usually gave satisfactory control. When the dosage was reduced below 35 pounds per acre, the equipment driven a little too fast, or when much wind existed at the time of treatment, results were noticeably less effective. Nicotine vaporizer treatments on short peas (approximately 5 inches tall) gave a 95 percent control during 1938 as compared with a 99 percent average control on taller peas in treatments conducted during the season of 1937.

When factors of speed of treatment, cost of applications, cost of materials, and effectiveness of the insecticides used in 1939 were taken into consideration, Cubore dust was rated first under the conditions which existed during the tests, followed rather closely by Agicide spray and nicotine-soap spray. It is often impossible to use the heavy spray equipment in Utah pea fields, because of recent irrigation. Agicide dust and Cubore spray gave less consistent control results and would not be recommended on the basis of 1939 performance.

Western Celery Mosaic

A survey shows that western celery mosaic has become generally established in Salt Lake County. It is estimated from observation made during the survey that 75 percent of the celery fields in the county were affected during 1939 and that the greater percentage of these fields showed approximately 100 percent infection.

In such heavily infected fields the decrease in yield equalled 50 percent or more. In the survey a member of the carrot family was found generally distributed in the mosaic infected areas. These species might be considered as possible suspects for the virus causing the mosaic of celery.

Heart Burn of Celery

Heartburn disease of celery is apparently induced by a mineral deficiency. Some preliminary work has indicated a favorable response to the application of boron.

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FIG. 33. Blackjon—a new earlier and darker coloring bud sport of Jonathan which appears to yield a higher percentage of extra fancy colored fruit than ordinary Jonathan, especially on shaded branches

**Fruit Production and Processing**

**Variety Testing**

Out of more than 300 new varieties under test in the Station orchards at Farmington and Logan which were begun in 1928, a considerable number of new fruits stand out as promising enough to warrant trial by Utah fruit growers.

In apple varieties the new Early Red Bird, Close, Lodi, Early McIntosh, Wilson June and Red Gravenstein appear promising among the early varieties. Early Red Bird precedes Red Astrachan a week in season; Lodi appears to be superior to Yellow Transparent which it resembles; Close and Wilson June are larger June or strawberry dessert type apples which extend the season. Of the later apples, Black Mack, Macoun, 

FIG. 34. Sweet Delicious—a promising new apple for local market and home use
Blackjon (fig. 33), Sweet Delicious (fig. 34), Sweet McIntosh and Turley appear promising. The Turley is a long-keeping Winesap-type apple of large size; Black Mack is a solid red bud sport of McIntosh; and Macoun, a dark red later McIntosh-type apple. Sweet Delicious and Sweet McIntosh are large attractive, sweet apples for home use and local markets. Blackjon is an earlier and darker coloring bud sport of Jonathan. Blaxtayman is a solid colored bud sport of Stayman. All appear worthy of further testing. See and O Red Winesap colors better than the old Winesap, but does not size up as well as the Turley and Blaxtayman. Texola, Milton, U.S.D.A. 49, Ranier, and Dr. Matthews do not appear to be well enough adapted for general Utah planting.

Of the new pears, Gorham, Phelps (fig. 35), Pulteney (fig. 36), and Conference appear worthy of testing by growers, although Gorham and Conference both seem to be as susceptible to blight as Bartlett. A new pear variety of seedling or unknown varietal origin which appears quite promising because of earliness, good size and quality, growing on the grounds of Mary E. Milner of Salt Lake City, was called to public attention by winning a sweepstakes award in Stark Brothers' New Fruits Show at Louisiana, Missouri.

Among cherries\textsuperscript{15}, Seneca, Early Burbank and Milton Tartarian seem promising for early home or roadside stand use, while Deacon, a large

\textsuperscript{15}New cherry varieties are discussed by F. M. Coe in an article New early cherries tested, in Better Fruit 33:3. 1938.

Fig. 35. Pulteney—one of the new varieties of pear worthy of testing by growers, although susceptible to blight
black, and Victor (fig. 37), a large white canning and maraschino cherry, appeared promising for pollinizers.

Of the apricots, the early Riland and several unnamed Station F₁ Chinese seedlings look promising.

The early peaches that are worth testing by growers are Golden Jubilee (fig. 38), Halehaven (fig. 39), July Elberta, Redelberta, and Christiansen Elberta. Main crop and late sorts of promise are Hardee and
Fig. 38. Golden Jubilee—a large Elberta type peach of good quality which ripens three weeks earlier. Promising for home use, roadside stand trade, and limited trade for local market.

Klondyke, Early Elberta types; Candoka, Halberta and Rio Oso Gem of the Hale type.

Of Japanese plums, Formosa, Santa Rosa, Duarte, Flaming Delicious and Elephant Heart seem most promising, while of the domestica type, Peach, Imperial Epineuse (fig. 40), Yakima, Pacific (fig. 41), Stanley, Hall and President are outstanding.

Fig. 39. Halehaven—one of the most promising of the new peaches.
New Berries Promising. Of the new strawberries, Corvallis, Red Heart, Dorsett and Fairfax appear most promising of the June bearers, while Twentieth Century and Green Mountain seem to be the most promising everbearers.
In the raspberry test planting, Taylor, Newburgh, Tahoma, Washington, Sodus Purple, Indian Summer Everbearing, and Dundee Blackcap seem the most promising, although several New York Station seedling look good.

The new boysenberry appears to be a heavy yielder of large loganberry-type berries that are in demand, but the plants will probably require winter protection.

**New Varieties Planted.** During the biennium over 30 new varieties of grapes, 41 new varieties of plums, apricots and cherries, 20 new peaches and 40 selections of peaches for hardiness were planted or top-worked in the Station test orchards and vineyards at Logan and Farmington.

**Progress in Breeding New Fruit Varieties.** A total of 13,548 seedlings of apricots, peaches, cherries and plums have been propagated and are now growing in the nursery, greenhouse, and seedling orchards of the Station. Completion of a new greenhouse and purchase of 15 acres of land north of the campus are aiding in this promising line of research designed to produce hardier new varieties of stone fruits better adapted to Utah conditions.

**Influence of Cover Crops, Fertilizers and Moisture Supply on Yield and Grade of Fruit in Orchards**

Two late Elberta peach orchards, one in Box Elder County and the other in Utah County were selected for orchard studies on the influence of cover crops, fertilizers and moisture supply on yield and grade of fruit. Blocks of 30 trees were set up in each orchard. Five fertilizers and three cover crop treatments are used in each block.

Commercial and barnyard fertilizers were applied in March and alfalfa seed planted in the alfalfa plots. Trunk diameter measurements of all experimental trees were made at pruning immediately above two guide nails in the tree trunk. Last year’s tip growth was measured on twenty shoots on each tree. Samples of soil taken from the first and second foot depths under each pair of experimental trees are being analyzed for nitrate nitrogen and organic matter. Methods of moisture determinations in the field are being investigated.

**Orchard Rootstock Investigations**

*Mabaleb Rootstocks Superior for Cherries.* Measurements and observations in the nine-year old sweet cherry rootstocks block at Farmington, planted in 1931, show the marked superiority of trees of Bing, Lambert,
and Napoleon on the Mahaleb rootstock (*Prunus mahaleb*). This superiority with the stony loam soil and lower bench conditions in the test block is shown not only by the larger size of trees on Mahaleb stock as compared to those on Mazzard (*P. avium*) and those on Stockton Morello (*P. cerasus*), but also by the better stand of trees remaining on Mahaleb stocks. Trees on Mazzard roots have suffered heavier losses from winter injury, while many of those on Stockton Morello have been short lived.

Mean trunk circumference measurements are as follows: Mahaleb, 20.34 inches; Mazzard, 14.04 inches; Morello, 15.67 inches. Considering the mean circumference of trees on Mazzard as 100, the mean circumference of trees on Mahaleb would be equal to 144, a difference of 44 percent in favor of Mahaleb stock. Similarly with the mean circumference of trees on Morello considered as 100, those on Mahaleb equal 129, or a difference of 29 percent in favor of Mahaleb. All of these differences are statistically significant, the odds against their being the result of error being higher than the 100 to 1 generally used as a standard of precision.

These results differ markedly from those obtained at the New York Agricultural Experiment Station at Geneva where trees on Mazzard were much superior and longer lived on heavy soil. However, since the results of this experiment at Farmington, Utah, agree with experiences and observation under Utah conditions, it would seem wise for cherry growers and nurserymen to confine propagation and plantings to trees of the Mahaleb stock. Likewise, major efforts on improvement of cherry rootstocks for Utah conditions appear to lie in selection and testing of superior types of Mahaleb stocks. For this purpose several selections of Mahaleb from the California Experiment Station are being grown, also several Myrobolan plum rootstock selections from the same source.

**Chlorosis and Related Mineral Deficiency Diseases of Horticultural Crops in Utah**

The most outstanding results of the biennium on the chlorosis study were obtained with grapes. Concord scions grafted on vinifera rootstocks in 1936 continued green and vigorous, while Concors on their own rootstocks were killed out almost entirely by chlorosis on the campus test plot. Grafted plants distributed to growers in several areas of the state proved entirely successful in resisting chlorosis. Of the several vinifera varieties employed as rootstocks the most promising were Rose of Peru, Tokay and Malaga. At the present time some twenty or more commercial and native stocks are under test in an effort to obtain a rootstock resistant to other grape maladies as well as to chlorosis. The results obtained thus far in the grafting work appear to offer a promising solution of the chlorosis problem in the Concord grape.
Effort has been continued to obtain an explanation for the resistance of vinifera roots to chlorosis, though little progress has been achieved. Solution culture experiments have shown that vinifera cuttings thrive in alkaline solutions from which apparently all soluble iron has been precipitated or absorbed. Either the iron requirements of these varieties are low or they are able to absorb iron which has been absorbed by the calcium phosphate precipitate in the solutions. This latter possibility is being studied.

Selection for chlorosis resistance in strawberry and raspberry varieties has been continued. Fertilizer tests with small fruits have included the application of numerous acid forming substances, particularly sulfur and sulfates. Spraying with iron sulfate solution continues to be the most practical method of combating chlorosis in these plants.

Little Leaf of Sweet Cherries. Some preliminary experiments on the control of "little leaf" of sweet cherries indicate that this disease is probably a zinc deficiency (fig. 42). Trees injected with zinc sulfate last year showed marked improvement in many instances this spring. This disease affects cherries, apples, apricots, plums and peaches and a recent survey indicates that the condition is widely distributed over the state and apparently is increasing in amount.

Virus and Virus-Like Diseases of Stone Fruits

Attention has been given to four disease conditions of the stone fruits in Utah, which in their general symptomology suggest the possibility of
virus origin: (1) cherry leaf mottle or crinkle, (2) lace leaf of the cherry, (3) leaf sport of the Italian prune, and (4) "X" disease or related disease of the peach and chokecherry.

Cherry Leaf Mottle. In survey studies during the past two years this disease has been found generally distributed in cherry orchards throughout the state. The affected trees in orchards were found to vary from a fraction of one percent to as high at 26 percent of the trees planted.

In diseased trees both the leaves and fruits are affected and in a way to greatly decrease both yield and quality of fruit. In extreme cases the tree is found useless and should be removed even though final results of research may prove the condition nontransmissible.

In 1938 one hundred trees (one year old) were budded with buds from diseased trees. In March 1939, 65 whip grafts were made by placing disease-free Bing scions into branches of two diseased Bing trees. In addition to budding and grafting work, 122 trees have been charted in 5 different orchards for the purpose of determining possible spread through the tree and from tree to tree in the orchard.

Up to the present time, no definite proof of transmission has been obtained.

Lace Leaf of the Cherry. This is a disease of the cherry wherein practically all the mesophyllial tissue of the leaf becomes necrotic and droops, leaving merely a lacy skeleton. The condition under which it occurs and the absence of parasitic forms suggest the possibility of a virus. In August 1939, 20 Bing trees were budded with buds from diseased trees. These will be watched during the year for possible transmission.

Leaf Spot of the Italian Prune. During 1940 a peculiar leaf spot was found on three Italian prune trees in the Brigham City district and in the same orchard in the proximity of peach trees affected with what was thought to be yellow-red virosis. In isolation studies the affected areas of the leaf failed to yield pathogenes of any type. With the idea that the condition might be of a virus nature, ten trees of the Italian and ten of the French varieties of prune were budded each with 5 buds from the diseased Italian prune trees.

The "X"? Disease of the Peach and Chokecherry. In the spring of 1937 a peculiar diseased condition of the chokecherry (Prunus dimessa) resembling the "X" disease of the East was noted in a few limited areas in Mantua and Box Elder Canyons (fig. 43). By 1939 the disease had spread until it could be found rather generally throughout the two canyons mentioned and in addition had spread into the Sardine Canyon area to the north. This evident spread, together with its close resemblance to the
"X" or yellow-red virosis, suggested the possibility of its presence in the peach orchards in the localities adjacent to the chokecherry-infested areas. Surveys showed the disease generally distributed in the peach areas of Box Elder, Weber and Davis Counties (fig. 44). In Davis County 20 orchards were surveyed—two only were found free; the average incidence of infection was 23.2 percent of the trees planted. Five of the orchards gave percentages above 40 and two above 50. In one of the latter orchards 68 percent of the trees were affected and so completely damaged that the planting was considered unprofitable and pulled out during the winter of 1939. Finding of a few infected fields in Salt Lake and Utah Counties indicates possible spread from Davis County as a center. Facts indicate that the disease provides a major problem in peach production and that control will become a difficult and costly task.

During August, 1939, 120 one-year-old peach trees were budded each with 5 buds from trees showing the disease. These were planted during the autumn in the newly established experimental plot in Bountiful. In the spring of 1940, 200 cherry varieties, 700 peach varieties, and 630 chokecherry seedlings were planted to serve as a basis for later inoculation work.

Insects of Stone Fruits

Results of tests on control of the peach twig borer in Box Elder and Utah Counties (fig. 45), using different insecticides and times of application, indicate that the addition of lead arsenate to each of the dormant sprays increased the degree of control of the over-wintered brood approximately 20 percent. As between lime-sulfur alone and miscible oil alone, applied in the pink-bud stage, the former was much more effective. Basic lead arsenate applied just before emergence of the first larval brood of the season gave the highest percentage of uninfested mature fruits.

Green soldier bugs (fig. 46) were not found in sufficient numbers to justify the execution of control tests in orchards. Preliminary experimental tests conducted in the laboratory indicated that calcium cyanide possesses some possibilities for the practical control of these bugs, particu-
larly if the gas is retained for a short period within a tent of canvas or similar material.

\[ \text{Fig. 44. The crate to the left has 35 unripened fruits from the healthy portion of an Early Elberta tree, the one to the right has fruits from a diseased limb of the same tree} \]

**Berry Insect Investigations**\(^{16}\)

Strawberry root-weevil bait experiments against *Brachyrhinus ovatus* (L.) and *B. rugosostriatus* Goeze showed good control by means of one, or when necessary, two applications of poisoned baits. During the 1939 experiments, the best control was obtained with ground dried apples and ground raisin-bran baits poisoned with sodium fluosilicate, these giving 94 and 90 percent kills of adult beetles, respectively. Baits composed of ground dried prunes, dried apples, raisins and bran, using calcium arsenate as the poison, killed from 71 to 84 percent of the beetles. Poisoned bran baits without fruit were less effective in each case than the poisoned fruit baits.

**Freezing Preservation of Utah Fruits and Vegetables**

*Fruits.* The objectives of this project are to lay the foundations for development of a fruit-freezing industry in Utah which will provide an additional outlet for Utah tree fruits and berries.

\(^{16}\) Some of the work of this project is also reported in Notes on berry insects of Utah, by George F. Knowlton and Leonard L. Hansen in Proc. of Utah Acad. Sci., Arts and Letters 15:127-130. 1938.
Work during the first season has been devoted to preliminary testing of varieties of strawberries, raspberries, peaches, nectarines, plums and prunes and apricots to determine which ones are worthy of more detailed study and which can be discarded as not suitable for freezing. About 3,500 samples representing 400 varieties were frozen during 1939 and approximately 600 samples of berries and fruit juices were frozen in 1940.

The fruit samples were frozen in three forms for testing for different purposes: (1) whole, halved, or sliced for direct consumption as dessert
or culinary preparations in the home, (2) coarse crushed for ice creams and sherbets, (3) fruit pulps or purees for direct consumption as frozen desserts, frozen bars and cold drinks.

Of the products frozen, the berries, fruit purees and pulps, and juices appear to be the most promising for commercial development. Of the strawberries, Marshall, Red Heart, Corvallis and Fairfax appeared promising from preliminary tests. Utah Cuthbert raspberries ranked high, together with a number of new varieties. Seedless raspberry pulp appears to have possibilities for ice cream making. Boysenberry and black and purple raspberries appear promising. Frozen Montmorency cherries are gaining in demand for pie use, while cherry juices and ciders made from this tart variety in combination with colored juiced Morellos and sweet Black Tartarian and other varieties offer a promising outlet for Utah cherries unsuited for shipping. Frozen fresh purees and coarse crushed fruits for sundae toppings seem to offer promise.

Chinese apricot pulp met with wide approval for direct use as a frozen dessert, for ice cream and for beverages. Likewise puree of Satsuma and Santo Rose plums and many peach varieties appears to have possibilities. Red Astrachan apple frozen pulp has a tart fresh apple flavor that was widely commended.

Whole, halved or sliced peaches, plums, apricots and sweet cherries have more limited possibilities in competition with the canned product, being better suited to salad and fruit cup or cocktail uses, as well as in commercial baking, rather than direct dessert use. Rapid oxidation after defrosting must still be overcome to popularize these fruits for direct use.

Frozen Fruits in Ice Cream. Different varieties of fruits have been used in ice cream made from the regular college creamery mix. Later the same varieties will be used in sherbets. One pound of frozen fruit was added to each gallon of ice cream. The samples of ice cream were numbered and judged in replicate on different days by a selected jury.

In drawing conclusions on the suitability of a variety or kind of fruit in making ice cream, one must keep in mind that the condition and degree of ripeness of the fruit will influence the quality of ice cream made with it. Therefore the judgment of the jury should only be used as a guide. The experiment must be repeated in two or three different years.

The following peach varieties were selected as leaders in the making of fine peach ice cream: Libbee x Paloro, Champion, Sunbeam, Ontario x Paloro, Arp Beauty, White Hale and Ontario Elberta. Varieties considered not so good were J. H. Hale, Carman, Leeton, Early Elberta, Fay Elberta, Strawberry Free, Klondyke, South Haven and Rosebud. Peach varieties considered inferior were Ideal, Jubilee, Maxine, Red Bird and Tuscan Cling.
The consensus of opinion of the jury was that plums and prunes were not as suitable for ice cream as some of the other kinds of fruit. Possibly the plums will prove more suitable in sherbets.

The varieties of cherry ice cream liked best were: Napoleon, Giant, Bing, Elkhorn, and Black Tartarian. Royal Duke, Centennial, Lambert, Reine Hortense were acceptable or average in quality. Wragg, Montmorency and Dyehouse were considered inferior as ice cream varieties.

To obtain information on consumer acceptance of the various kinds of fruits in ice cream, two kinds were sold each month along with the four standard varieties (vanilla, strawberry, chocolate and maple nut) and some miscellaneous ones in the sales room of the college creamery. No advertising or suggestions were made to the customer as to the merits of any variety. From this introductory survey of consumer acceptance it was found that the kinds of fruit ice cream were favored in the following order: strawberry, peach, cherry, apricot, raspberry, Satsuma plum and cantaloupe.

In analyzing these sales to students one should keep in mind that the consumer demand may be different in commercial sales areas than on a college campus. All the ice cream sold on the campus went over the counter in cones. Sundaes, malted milks and ice cream sodas generally require vanilla ice cream.

From a summary of ice cream sales in the State of Utah it was found that 16.74 percent of the sales were fruit ice cream and 9.15 percent fresh fruit varieties as compared with 23 percent on the college campus.

Vegetables. Two crops, peas and lima beans, were selected for this experiment, but other crops may be added later. Last year twenty-one varieties of peas which have been found most desirable in the Northwest were used for the work here. Samples of the frozen peas were taken out and tested at various times during the year by the Home Economics Department.

From the results of last year, the following varieties can be suggested as most promising: Early—dark podded Thomas Laxton, Thomas Laxton, Glacier, Improved Gradus, Laxton’s Progress, World’s Record; medium—Asgrow 40, Onward 78, Morses Market, Morses 2286, Improved Stratagem; late—Dwarf Alderman, Stratagem.

Because of the fact that the land used in 1940 was heavily infested with disease, most of the peas on the plot had either died or were in poor condition by July 1.

The work on lima beans will be of more or less preliminary nature until the poorest varieties are eliminated. There is considerable expense involved
in the preparation of the beans for freezing so it was felt desirable to wait until later for a study as complete as is being made on peas.

*Appraisal of Quality In Frozen Peas.* Appraisal has been made on frozen peas cooked without thawing. A cooking period of eight minutes actual boiling time was decided upon, after repeated trials, as the time of cooking which gave the best product from the standpoint of tenderness without mushiness.

A score card based upon United States tentative standards for grades of frozen peas and upon opinions of various persons with foods training as to what constitutes quality in cooked frozen peas, was used for scoring. Scores ranged from 63 to 75 on the basis of 100 points.

Ascorbic acid determinations, as a part of quality appraisal, were made on unthawed peas by the 2-6-dichlorophenolindophenol titration procedure. Values ranging from 7 to 17 milligrams ascorbic acid per 100 grams of peas were found.

**Irrigation, Drainage and Groundwater**

*Irrigation Surveys*

Irrigation surveys have been made on more than 207,000 acres for which the land use is recorded on 1,300 field maps (fig. 47). Areas irrigated by each of the 70 irrigation companies and by groups of individual irrigators are shown on 4 master maps which constitute a part of a detailed report.

The irrigation surveys were made on the lands in Utah, Wasatch, and Summit Counties which are provided with water from the Provo and Spanish Fork Rivers and their tributaries and from Hobble Creek and other tributaries to Utah Lake.

The report shows fully the need for the investigations, the organization of the research, the areas of land irrigated by each of 70 irrigation companies, the amounts of water delivered to the major canal companies during a 10-year period, the areas of different crops grown on the land provided with water by each company, and a resume of the court decrees under which water is distributed to irrigation companies and other water users.

**Water-Application Efficiencies in Irrigation and Their Relation to Irrigation Methods**

The amounts of water delivered to each of 14 typical Utah County farms have been measured (fig. 48) and a considerable number of water...

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application efficiency tests made with a view to learning what factors have the major influence on water application efficiencies under ordinary farm practices. The farms studied are located on three classes of soil, namely; (1) high, well-drained bench lands, (2) medium-elevation, heavy lands not appreciably affected by ground water, and (3) low-lying lands usually of fine textured soils, having inadequate drainage.

The amount of water annually applied to the class 1 soils is relatively high, ranging from 3 to 5 acre-feet per acre; to class 2 soils the amounts ranged from about 1.8 to 2.7 feet, and on class 3 soils the amounts ranged from less than 0.5 up to 1.7 feet.

In class 1 soils the amount of water consumed was smaller than the amount of irrigation water applied, in class 2 soils the amount consumed was more nearly equal to the amount applied, and in class 3 soils not adequately drained the amount consumed usually exceeded that applied.

Irrigators may contribute to water conservation by increasing water-application efficiencies on all three classes of soils, and also thus contribute especially to the conservation of class 3 soils by prevention of water logging and alkali concentrations.

Snow Surveys

During the biennium master sheets of precipitation and runoff have been completed to date and daily hydrographs, isographs, and thermographs have been completed dating back to 1920.

Soil moisture measurements have been continued during the past two years in the fall and again in the spring under the snow cover. These measurements, although available for only a few years, are furnishing valuable information as to the effect of water and spring precipitation

Results of this study are also published in the article, Costs and benefits of snow surveying in Utah, by George D. Clyde, published in the Trans. of the Amer. Geophysical Union 19:707-711. 1938.
and the rate of melting on runoff that can be expected from a given snow cover. During this year a new technique and new equipment for determining moisture content of the soil under the snow cover is being developed. This equipment will be installed on representative watersheds so that initial measurements may be made during the season of 1940-41.

Winter monthly measurements at approximately 15 key courses have been made during the past two years.

During this biennium one snow course has been abandoned and two new courses added; namely, abandoned, Blacksmith Fork; added, South Willow Creek in the Grantsville Mountains and Beaver Meadows in the Uinta Mountains.

The Application of Hydromechanics to the Design of Structures for Controlling Groundwater

During the biennium special attention has been given to two phases of the problem: (1) The design of well networks for irrigation and drainage, and (2) model tests of the theory of movement of water through the soil.

It is a matter of common knowledge that the resistance to flow of water through pipes and from water-bearing material into wells decreases with increasing diameter. Recent researches conducted by the Physics Department have revealed quantitative information as to methods of increasing the effective diameter of well networks. Special attention has been given during the biennium to the problem of minimizing the cost of construction and operation of such networks.

The problem of draining lands overlying artesian basins offers unique difficulties and in past years the problem has been considered from a theoretical standpoint. It is possible on the basis of fundamental theory to predetermine the performance of a network of drains installed in an area having known characteristic features. It may be shown in particular that the character of the flow from an artesian stratum lying near the surface requires a drain spacing that would be prohibitive in cost and it is for that reason that attention has been given to drainage by means of wells.

However, owing to the somewhat unexpected results of the theory it has been thought advisable to conduct experimental tests by means of models in the laboratory (fig. 49). Interesting results confirming the theory have been obtained in special cases.

As stated, some of the results of the theoretical studies of the groundwater problem have seemed somewhat revolutionary in character and

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19 Additional data on this project is given in an article, Artificial drainage of land: stream-line experiments. The artesian basin, by Don Kirkham, published in Trans. of the Amer. Geophysical Union. 1939: 677-680.
for that reason additional laboratory tests are contemplated in order to aid in the convincing presentation of these findings to those concerned. It seems likely that they may have far-reaching influence on the design of drainage systems for the reclamation of the bottom lands of the state which have been rendered nonproductive because of excess water in the subsoil.

Fig. 49. Laboratory model illustrating with coloring matter the course of water as it seeps upward into a drain. Seven of the paths shown lead to the drain, whereas the remaining ones lead almost directly upward to the soil surface, thus serving as a permanent source of waterlogging.

Sheep Studies

Ewe Lamb-Feeding Investigations. This study was conducted to determine the effects of feeding range ewe lambs during their first winter. During each of three years three groups (25 lambs per group) of ewe lambs were fed on rations typical of those available in southwestern Utah. During each year a group of 50 lambs was marked and maintained in the original range herd as controls. The lambs that were fed during the winter were returned to the original herd in the spring.

The results show that greater gains were made by the lambs that were given special feed during their first winter. Most of this advantage in weight was lost when these lambs were put on the range the following summer, since they gained only slightly more than the range lambs from the beginning of the feeding period until breeding time.

Greater yields of unscour ed and scoured wool were obtained from the lambs that were farm fed. The staple was significantly longer in the fleeces of these lambs.

Death losses were less in the group receiving special feed during their first winter.

The percentage of ewes lambing at two years of age, of those alive at breeding, was 64.7 in the group that was fed, and 45.5 in the range group.

Animal Husbandry

20 Results of this study are published in Bul. 292, Effects of feeding ewe lambs during their first winter, by Alma C. Esplin, Mitlon A. Madsen, and Ralph W. Phillips.
**Germ Plasm Testing of Sheep.** Since 1936 monthly body weights and the fleece weights of sheep have been obtained. Side samples are taken from each fleece and analyzed to determine the fineness, length of staple and amount of clean wool produced per ewe. During the past two years 309 photographs have been taken of the sheep to show body development and to provide a means of permanent identification of each individual for future studies.

The data obtained on the birth weights and average weekly gains of lambs indicate that for the first six months after birth there is a tendency for single lambs to make slightly more rapid gains than twin lambs. Under the methods of management used at the Station there is little difference in average gain in body weight between single and twin lambs at 12 months of age.

The Rambouillet ewes sheared larger fleeces than the Corriedales. On account of the lighter shrinkage of Corriedale wool there was no significant difference in scoured fleece weights between the Rambouillets and Corriedales (fig. 50). Hampshire sheep have been developed primarily for mutton purposes and are not heavy shearing sheep.

Wool samples taken from the shoulder, side and thigh areas of Rambouillet sheep are being used for a more detailed study of the fineness, length and density of wool fibers.

**Grading and Scouring Investigations of Commercial Fleeces.** Wool shrinkages vary with the grades, i.e., fine wool shrinks more than coarser wool; therefore, it is necessary for studies of shrinkages to be useful in wool production to be reported by grades.

The study shows rather wide variation in shrinkages: (1) within a grade, (2) between grades, (3) between first-shear ewes and older ewes, and (4) from year to year.

There is a marked variation within a grade. The lowest shrinkage for

*Fig. 50. Rambouillet sheep before and after shearing with the sheared fleece*
1939 Station Rambouillet (fine wool) ewes was 45 percent, and the highest 66.9 percent. For the Corriedale ewes the lowest was 38.96 percent, the highest 63.65 percent.

Wool scouring has for its principal purposes the basis of valuing grease wool from a scoured basis quotation, and a guide to breeding and management. Without doubt, wool growers of Utah changed breeding and management practices to reduce shrinkages, as a result of information received from wool scouring.

Value of Molasses in Hog Feeding

In the winter of 1936 and 1937 an experiment was conducted in which two lots of hogs averaging 122 pounds were fed a ration of barley, tankage and alfalfa hay. One lot received, in addition to these feeds, 25 percent as much molasses as barley. The result of this experiment was that the pigs receiving the molasses made slightly more gains, and made 100 pounds of gain at $1.38 less than did the pigs which were fed no molasses.

In the fall of 1939 it was decided to conduct a similar experiment with a view of determining the optimum amount of molasses to feed. The pigs used in this experiment were somewhat younger than those used in the first; they weighed only 53 pounds. Forty pigs were divided into four lots according to type, size, quality, condition and sex.

Each lot was hand fed barley and tankage. The tankage amounted to 12 percent of the ration until the pigs averaged about 125 pounds, it was then cut to 10 percent. All lots were self fed alfalfa hay in racks. Lot 2 was fed 25 percent as much beet molasses as barley; lot 3, 50 percent; and lot 4, 75 percent as much beet molasses as barley. The molasses was fed by mixing it with equal parts of water and pouring it over the grain.

None of the lots which received molasses made as good gains as the one which had a ration of barley, tankage and alfalfa hay. Also, the gains were more costly in all of the molasses-fed lots. In the lots which were fed molasses the pigs finished unevenly, while in the one which received no molasses there was not much variation between the heaviest and the lightest. In general the pigs which failed to do well in the lots which were fed molasses were the ones which were the smallest at the beginning and the ones which did the best were the ones which were largest.

Not only did some of the pigs fed molasses do poorly, but the death loss was rather heavy. Four pigs died. The pigs would first begin to stagger around as though they were drunk, and some in four or five days would reach a stage where they could scarcely walk. About a fourth of
the pigs became affected in this way, but most of them recovered in a couple of weeks. During this period little or no gain was made and some of them did not gain well afterward. The pigs which died were examined by the animal pathology department and the cause of their death described as gastroenteritis.

The results of this investigation seem to point to the fact that pigs should not be fed molasses until they weigh around 100 pounds.

Lot No. 5 cannot be compared with the other four lots since the pigs which were used in this lot were the twelve which were left out of 52 after the 40 head had been taken for the other four lots. These pigs were fed the same basal ration as was fed in the other experiment and in addition molasses was self fed to them by keeping it in a trough at all times.

When fed in this way there were no death losses. The pigs seemed to be in good health at all times, except there was a tendency for some of them to show rather rough coats. It is thought that when the pigs were self fed they did not eat more of the molasses than was good for them. They consumed about 48 percent as much molasses as they did ground barley, which was offered in a self feeder. They consumed on the average of 8.96 percent as much tankage as they did molasses and barley.

Before any definite recommendations can be made in regard to feeding molasses to pigs it will be necessary to complete further investigational work.

Work now under way is designed to determine the specific dietary deficiency in beet molasses and to find sources of the deficient element that can be used in practical hog feeding.

Range Studies

Phosphorus Content of Summer Range. Mineral deficiency of range plants has been studied on mountain cattle ranges for a number of years. Final analysis of data indicated that poor balance between calcium and phosphorus was probably the cause of low gains rather than a phosphorus deficiency as was suspected. Bone meal supplement appears to have little or no value under such conditions.

Plans are under way for extensive studies in this field on winter, spring-fall, and summer ranges. As a preliminary to this study considerable attention has been given to plant collection methods. Material was collected for chemical analysis from various soil types and sites and
at various dates. An incomplete analysis of these data indicates that surprisingly little difference exists between plants from different soils and sites. Season, however, greatly influences the plant composition.

Range Resources. The range management department has for several years surveyed the range resources of individual counties of the state. During the past two years the range resources of Rich County were surveyed and the potential livestock production of the county evaluated.²¹

Range Survey Methods and Vegetation Analysis. Field studies have been conducted on range survey methodology. Present survey methods have been studied as to accuracy and the various influencing factors isolated. The data analysis is now underway. Preliminary findings indicate a high variation between individual surveyors and wide deviation of group estimates from actual vegetation production. Plans are underway for utilization studies which it is hoped can be used in developing a new and more effective method of evaluating range lands.

Range Revegetation. Studies on revegetation have dealt with reseeding of native and introduced species. Many native forage plants can be reseeded with success though seed is obtainable only with difficulty. Among the most promising are Hedysarum pabulare, Agropyron spicatum, Bromus carinatus, Elymus canadensis, Agropyron subsecundum, Festuca idahoensis, Stipa columbiana, Eurotia lanata and Atriplex canescens. Of the plants recently introduced from six foreign countries the following appear to be

²¹ Results of this study have been published in Bul. 291, Range Resources of Rich County, Utah, by L. A. Stoddart.

Fig. 51. Keeping stock on farm pastures in the spring helps protect the range
best fitted to withstand the drought and cold characteristics of Utah’s ranges—*Elymus juncus*, *Agropyron desertorum*, *Agropyron sibericum*, *Lolium westernworldicum*, *Lathyrus cicera*, and *Vicia perigrina*.

Study has been conducted on reseeding methods though no results are yet available. Among the investigations are the effect of various tillage practices versus no tillage upon grass seeding on spring range lands and the effect of a cereal nurse crop upon the establishment of grass seedings on winter, spring, and summer ranges. Preliminary observations indicate that nurse crops are not only valueless but probably do great damage to grass seedlings.

Natural revegetation of range lands has been studied in connection with degree of grazing use. Intensive study has been conducted upon native wheatgrass in lightly grazed and heavily grazed stands (figs. 51 and 52). This study showed that properly grazed plants produced over 50 times as many viable seeds per unit area as did heavily grazed plants. Likewise they produced materially more forage and more root material, which in turn contained significantly more stored food material.

Long time studies are being conducted by means of periodical clippings which are designed to show the effect of spring and fall grazing upon forage production and seeding habits of grass. Preliminary study indicates

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22 This study is reported in greater detail in an article, Effects of grazing upon bunch wheatgrass, by W. R. Hanson and L. A. Stoddart, published in Jour. Amer. Soc. of Agron. 32:278-289. 1940.
a definite decline in the number of seeds produced as grazing intensity increases but little or no influence seems to exist upon seed germination.

Germination studies were conducted on many native species. Especially important was an experiment on Oryzopsis hymenoides, a valuable desert grass which has shown notably poor germination habits. This study showed that the seeds of this range grass were frequently undeveloped and hence were incapable of germination though their appearance was normal. The developed seeds, which can easily be isolated since they alone sink in water, germinate poorly unless treated to weaken the seed coat. Concentrated sulfuric acid was found to be the best method to weaken the coat, and through treatment with this acid for various time periods depending upon size of seed, germination could be raised to over 50 percent.

Dairying

Production Studies in Dairying. During the past biennium 3 more daughters of the proved sire H-145 have completed production records. In addition 4 daughters have partially completed records.

To date 18 daughters of this sire have completed lactations in the dairy experimental herd. A daughter-dam comparison shows that this sire is transmitting high test and high butterfat production to his daughters, while the milk production on the average is 180 pounds less than the dams. Ten daughters exceed their dams in milk production, 12 in butterfat production and 16 of the 18 exceed their dams in butterfat tests.

The average production of the 18 tested mature daughters, milked twice a day for 305 days, was 12,325 pounds of milk containing 442 pounds of butterfat with an average butterfat test of 3.58 percent. The daughters surpassed their dams in butterfat production by 30 pounds and had an average increase in test of 0.28 of a percent in butterfat.

The proved sire H-145 is in active service at the age of 14 years 9 months.

Feeding Dairy Cows. Work on this project has been completed. The data pertaining to feed consumption, production and reproduction is reported in U. S. Department of Agriculture Technical bulletin 724.

Man, Horse and Machine Hours Required per 100 Pounds Total Digestible Nutrients from Feed Crops. It required on the average for the two

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23 Results of this work are published in an article, Inducing germination in Oryzopsis hymenoides for range reseeding, by L. A. Stoddart and K. J. Wilkinson, in the Jour. of the Amer. Soc. Agron. 30:763-768. 1938.
years 0.37 of a man hour, 0.19 of a horse hour and 0.06 of a machine hour to produce 100 pounds total digestible nutrients from pasture. The time required for similar production from alfalfa hay was 41, 105 and 250 percent greater, respectively, for the three factors.

In the case of corn silage it required 354 percent more man hours, 474 percent more horse hours and 533 percent more machine hours than was required with pasture.

For barley per 100 pounds total digestible nutrients produced, the time requirement was 124, 442, and 617 percent greater in man, horse and machine hours, respectively, than was the case with pasture.

The number of irrigations given the different crops were as follows: pasture, 7; alfalfa hay, 3; corn silage, 1.7; and barley, 1.5. Both years the first three irrigations for pasture were made with high water, water that if not used at this time would be wasted.

The butterfat production per acre for these different crops was calculated to be 110 and 130 pounds for pasture for the first two years, respectively, 186.7 pounds per acre for alfalfa, 240.4 pounds for corn silage, and 158 pounds for barley. The crop yield on which the butterfat production was based was 144 and 209 days grazing per acre for pasture; alfalfa hay, 4.43 tons; corn silage, 16.3 tons; and barley 100 bushels per acre.

Post-Parturient Hemoglobinemia. Post-parturient hemoglobinemia is common in the intermountain areas. It occurs only in dairy cows and usually about 3 weeks after calving, and is characterized by blood-colored urine, anemia and weakness (fig. 53). It affects only high producing cows and is especially prevalent when rations are fed which are low in phosphorus. Studies conducted continue to point toward a low intake of phosphorus contributing to the disease; however the process by which the disease attacks remains obscured. Studies on the pH of the blood have not shown appreciable change and it is doubtful if hemolysis of red blood cells results from any pH change.

Treating affected cows by intravenous injections of 60 gms. dibasic sodium phosphate dissolved in 500 cc. distilled water has been used. This is supplemented by drenches of bone meal or dibasic sodium phosphate (Na$_2$HPO$_4$) given at the rate of one half pound twice daily for several

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FIG. 53. Because of the severe anemia caused by parturient hemoglobinemia the feet of this cow were frozen and gangrene resulted

days. It has been determined that this treatment readily restores the phosphorus in the blood to normal levels but that red cell destruction is not immediately arrested. Clinical reports on its use however are generally encouraging.

Control of Mastitis in a Dairy Herd. Over a period of 4 1/2 years the disease mastitis, as measured by the Hotes test, has been contracted in the Station dairy herd by 9 cows. In most of these cows the disease has been of low virulence.

Teat injuries have been responsible for several of the new infections. The results of this study suggest that a program of milking sanitation as outlined in this herd will do much to control the disease. The method followed consists of keeping the stables clean and well bedded, making tests to determine the carrier cows and milking them last, and wiping the teats with chlorine solution and sterilizing the teat tubes twice daily.

Relationship of Soft-Curd Milk to Subclinical Mastitis. It has been demonstrated that the chronate method used for the determination of subclinical mastitis in milk gave too high a reading. The method devised by Sanders has been found to be a more accurate method and one that checks with the gravimetric methods. Using this method the dairy herds in Washington, Utah, Salt Lake, Weber and Cache Counties were rechecked on the relationship of subclinical mastitis to soft-curd milk. The new chloride was found to check much more closely with brom thymol blue test for mastitis. The results of all these tests and also those previously made are being compiled.

Animal Disease Laboratory

This laboratory offers a general diagnostic service to the livestock and poultry interests of the state. All of the cattle blood samples tested for Bangs’ disease in the state are tested here in cooperation with the U. S. Bureau of Animal Industry. During the past two years 135,930 blood samples have been tested. In 1939 the average infection was 5 percent.
In 1940 the average infection was 3 percent. This shows that definite progress has been made in control.

The following diagnoses were made of animal and poultry specimens submitted to the laboratory:

<table>
<thead>
<tr>
<th></th>
<th>Consignments</th>
<th>Birds examined</th>
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</thead>
<tbody>
<tr>
<td>Chickens and baby chicks</td>
<td>139</td>
<td>756</td>
</tr>
<tr>
<td>Turkeys and turkey poults</td>
<td>131</td>
<td>630</td>
</tr>
<tr>
<td>Turkey blood samples tested</td>
<td>4</td>
<td>31,716</td>
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<tr>
<td>Total poultry specimens</td>
<td>270</td>
<td>33,102</td>
</tr>
<tr>
<td>Miscellaneous specimens</td>
<td>19</td>
<td>112</td>
</tr>
</tbody>
</table>

**Poultry (fig. 54)**

**Chickens**

*Types of grit.* Limestone appears superior to granite as a grit for Leghorn hens from experiments conducted the past two years. Hens receiving fine ground mashes show a higher mortality and lower average egg production than hens receiving coarse mash. Medium coarse mash has given the best results in all cases.

*Breeding for egg production.* Data obtained during the past two years indicate that hatchability of eggs is an inherited characteristic. Some families show a marked increase in hatchability as a result of selective breeding. Selections are being made on a basis of family rather than individual records.

*Forced summer molting of leghorn hens.* There appears to be a slight advantage in the average egg production during the second year's record or the 12 months following the molting period, if White Leghorn hens are forced to molt during August, according to data obtained over the
past two years. Forced molting was effected by taking the mash and part of the grain fed away from the hens from the first until the end of the month. Egg production of birds forced to molt in June and July was not significantly greater than that of birds allowed to molt normally.

**Turkeys.**

*Turkey production studies.* Results from turkey feeding studies show that during the first six or seven weeks pouls grew more rapidly on an all mash feed containing a fairly high percentage of protein (21 to 24 percent). A combination of milk, meat meal, and fish meal was used for the protein supplement. Some grains were hopper fed after the fourth week.

Skim milk to drink replacing from eight to ten percent of dried milk in the mash resulted in a lower percentage mortality, but gave no increase in the rate of growth. There was somewhat more labor required when feeding the skim milk to keep feeding conditions clean and sanitary. But when skim milk is available on the farm it makes an excellent supplement to a starting ration.

A mixture of corn and wheat as a part of the mash or grain mixture gave no advantage over barley and wheat, or barley, wheat, and oats, when measured in terms of finished weight, in condition of the birds at market time, in pounds of feed required to produce a pound of gain, or in livability of the flock. Since in Utah corn is usually higher in price than barley or wheat the heavy feeding of corn resulted in from 1/2 cent to as high as 4 cents increase in feed cost per pound of turkey.

After the birds were eight weeks old a mash containing seventeen to eighteen percent of crude protein gave just as good results in rate of growth and feed consumed per pound of gain, but at lower feed cost, as similar mashes containing higher percentages of protein. Both grains and mash were hopper-fed and the birds permitted a free choice of these feeds.

The feeding of soaked or wet feeds appeared to have no advantage but did add to the labor cost in feeding the flock. Comparatively simple mixtures largely of home produced feed gave satisfactory results. The growing ration that gave the best results under these conditions was made up as follows:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
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</thead>
<tbody>
<tr>
<td>Mill run (bran and shorts)</td>
<td>23 pounds</td>
</tr>
<tr>
<td>Ground wheat</td>
<td>24 pounds</td>
</tr>
<tr>
<td>Ground barley</td>
<td>24 pounds</td>
</tr>
<tr>
<td>Meat meal (50 to 55 percent protein)</td>
<td>8 pounds</td>
</tr>
<tr>
<td>Fish meal (60 to 65 percent protein)</td>
<td>8 pounds</td>
</tr>
<tr>
<td>Limestone, fine</td>
<td>2 pounds</td>
</tr>
<tr>
<td>Salt</td>
<td>0.7 pounds</td>
</tr>
<tr>
<td>Alfalfa meal</td>
<td>10.3 pounds</td>
</tr>
</tbody>
</table>

**Total**: 100.0 pounds
A grain mixture of equal parts of wheat and barley, or wheat 40 pounds, barley 30 pounds and oats 30 pounds should be hopper fed and always available to the birds. When the birds are on range where there is green feed there would be no particular need for the alfalfa meal, but without fresh green feed this amount of a good grade of bright green alfalfa meal in the mash is necessary.

The etiology of bone deformities in growing turkeys.25 The object of this study was to gain information regarding the relationship of certain rations to bone deformities which are characterized by a twisting or bending of the bone at the tarsal joint (fig. 55).

Results of a feeding test point to the conclusion that the incidence of the deformity is related to a low manganese ration but apparently bears some relationship to a high level of bone meal, presumably calcium and phosphorus. A ration supporting rapid growth seems to be one requisite for a high incidence of bone deformity.

Blood phosphatase was significantly increased in the group of turkeys in which the incidence was the highest. Rations high in calcium and phosphorus and low in manganese appeared to depress the activity of blood phosphatase in turkeys fed these rations. However, when the calcium and phosphorus were reduced to a more optimal level, even though the manganese was low, the phosphatase remained normal.

When the blood serum of turkeys affected with this deformity was examined at the time of slaughter and compared with normal turkeys it

25 This study is reported in greater detail in an article, The difference in serum calcium and inorganic phosphorus content of normal turkeys and of turkeys affected with a bone deformity, by H. M. Nielson and D. E. Madsen, published in Poultry Sci. 19:198-200. 1940.
was found that in affected turkeys the serum inorganic phosphorus was significantly increased and the calcium significantly decreased.

**Nutrition**

**Nutritional Status Indices for Rural and Urban Utah School Children**

The work on this project for the 1939-40 fiscal year has consisted of computation and comparison of nutritional indices for the two groups of children. There are at present no consistent trends in indices which would indicate superior nutritional condition of either group.

**Ascorbic Acid Metabolism of College Students**

Nutritional status of college students with respect to ascorbic acid was determined by measurement of blood plasma ascorbic acid by the Farmer and Abt micromethod.

Two different sampling procedures were followed: (1) Blood samples were obtained from subjects within one-half hour after breakfast on two alternate mornings in one week—no ascorbic acid-rich foods were included in the breakfast. (2) Two blood samples were obtained in the same morning, one fifteen minutes before a breakfast of eggs and toast, another fifteen minutes after breakfast. The latter method of sampling gave less variable results.

Of the 119 individual determinations made, 75 or 63 percent were below the figure (0.7 mgms. per 100 ml. plasma) considered by authorities to mark the lower level of satisfactory ascorbic acid nutrition. Only 9, or 7.6 percent were as high as 1.0 or more mgms. per 100 ml. plasma.

**Capillary Resistance Test as an Indicator of Vitamin C**

No additional data has been collected on this project during the biennium.

**The Vitamin C Value of Tomatoes at Various Intervals During the Tomato Season**

Study of the vitamin-C (ascorbic acid) content of the Stone tomato was continued during the 1939 season on tomatoes grown on a North Logan plot. The average ascorbic acid value, 19.8 mgms. per 100 grams, of tomatoes was noticeably lower than the values found for the 1937 and 1938 seasons which were 27.9 and 26.8 mgms. per 100 grams, respectively.

No consistent decrease in ascorbic acid values was found when vine-ripened tomatoes were held up to eighteen days after harvesting, either at laboratory temperature or in the refrigerator at 44 degrees F. Tomatoes from vines supported on poles gave significantly higher ascorbic acid values than did tomatoes from neighboring vines not so supported.
Miscellaneous Investigations

Studies of Towns and Villages

Appraisals has been made of housing and home conveniences in Tremonton, Lewiston and Plain City, and the data tabulated.

Crime and Delinquency in Ogden and in Rural Residence Types of Six Utah Counties

At the close of the last biennium basic plans for this project were complete and schedules and field cards were in readiness. Consequently the first part of the current biennium was devoted to the collection of crime data (type, amounts of crime) on the prepared forms at penal and correctional units. The State Penitentiary, State Industrial School, juvenile court, district records and other institutional fields were drawn upon for the six counties and the years in question. The next step is to obtain justice of the peace dockets and school coordinator records.

Collecting of data in Weber County and a small part of Box Elder County remains unfinished.

Intermountain Herbarium

The Intermountain Herbarium has now reached the stage where it serves as an effective research instrument to general and economic florestic studies of the State of Utah, and to special graduate revisionary studies in plant taxonomy.

The plant collection has attained approximately 60,000 specimens. The special library treating the taxonomy of flowering plants has reached several hundred volumes and is steadily acquiring essential literature necessary to the researches of the herbarium.

One of the more important aspects of the activities of the herbarium is its general service. During the past two years it has identified nearly 2,000 plants for various departments of the Institution, county agents, and agricultural workers, a number of government agencies and numerous private individuals.

Bee-Loss Investigations

Serious bee losses have occurred periodically in Utah for many years, while losses of varying degrees have occurred almost every season. The most extensive death of bees occurred during 1939, estimates of adult bee
losses for the season ranging from $100,000 to $200,000. Most serious bee losses of 1939 occurred during the latter half of June and up to mid-July in the counties of Utah, Davis, Salt Lake, Box Elder, Juab and Wasatch.

Supposed causes of bee losses have varied from locality to locality and from year to year. Serious losses which occurred in the Beaver, Minersville and Panguitch areas during 1932 were attributed to loco-weed poisoning. In some areas the 1939 losses were blamed to sugar-beet webworm sprays, others blamed grasshopper poisoned bait, and mosquito control activities. Other suspected causes of loss during recent years included calcium arsenate tomato fruitworm dusts, orchard sprays, garden sprays and dusts, smelter smoke, starvation, management practices, accumulation of arsenic on the soil surface from smelter smoke thought to blow around and into the blossoms of the flowers through wind action, and some new disease. A number of beekeepers believe that bees may be killed from obtaining dew or other moisture accumulated in the axils of previously sprayed sugar beets when the bees go forth in the morning seeking moisture.

Dead bees analyzed for arsenic by the cooperating federal agency usually showed it present in varying amounts. Normal, active field bees usually carry some arsenic also. Field studies during 1940 are attempting to determine the cause of individual cases of bee losses (fig. 56). Reports of losses have been carefully investigated and samples of the dead bees analyzed for arsenic.

During August and to mid-September of 1939, various combinations of grasshopper bait were repeatedly spread out near beeyards, under constant observation. Even when applied in quantities from 10 to 15 times as great as in recommended grasshopper control practice, few honey-bees came to the baits, and these seldom remained to feed. Preliminary studies during 1939 in tomato fields dusted with calcium arsenate or cryolite to control the tomato fruitworm, showed few honey bees on tomato blossoms, although bees were often abundant upon nearby blossoms of sweet clover, alfalfa, or other flowering plants.

Fig. 56. Regular inspection of bees in a Kaysville apiary by Federal and Experiment Station entomologists.
INFORMATIONAL SERVICE

Aside from conducting technical research on specific problems to which they have been assigned, members of the Station staff are called on for a great deal of service by farmers and others writing for information. These requests range from the identification of insects, plant specimens, the diagnosis of diseases, soil tests, questions on the raising of various crops and livestock to outlining the entire set-up on a farm. The staff members not only spend much time answering letters, they visit farms, attend farm meetings, give radio talks and hold demonstrations in the various parts of the state.

Field days are also held in which farmers visit the experimental plots and the many phases of the work are explained to them, and they see at first hand the results of different practices.

Staff members also give technical advice to state and local committees; they cooperate with various agencies in formulating action programs, and they take part in short courses and conventions.

RESULTS OF RESEARCH MADE AVAILABLE TO THE PUBLIC

The public is informed of the results of research investigations through a number of channels. Extension Service specialists carry the information into the rural areas. It is broadcast over the radio, and sent out to the local newspapers throughout the state. Where investigations are of local or sectional interest, the men who have supervised them go to the communities and discuss the findings with the people most interested.

The results of experimental work are also published by the station. During the past biennium 11 bulletins, 4 circulars, and 2 numbers of Farm and Home Science have been issued, making a total of 17. These 17 publications contain a total of 714 pages. In addition, 62 articles by staff members have appeared in scientific and technical publications with a total of 336 pages, making a grand total of 1,050 pages.

Sixty-two mimeograph sheets on subjects of immediate importance were issued for state distribution. Each month a partial list of publications received by the Station was also issued in mimeographed form.

Beginning March 1940 a new publication, Farm and Home Science, was initiated. The publication is issued in an attempt to find a more adequate means of acquainting farm and home people with what the Ex-
experiment Station is doing to solve the agricultural problems of the state. This publication is made up of a number of short timely articles covering various phases of Station work. It is planned to publish it quarterly.

Over the two year period there has been an average monthly distribution of 2,000 publications in answer to requests. This is in addition to publications sent out on the regular mailing list and those given out to people calling at the office.

Publications are sent to libraries, publishers and experiment stations throughout the United States. Besides this they are sent in exchange to 226 institutions in foreign countries. The complete mailing list at the present time contains about 3,700 names.

**Bulletins Published During the Biennium**


B282—Pioneering in western agriculture; a resume of the first half-century of research, 1888-1938, at the Agricultural Experiment Station, including the biennial report, 1936-38. R. H. Walker, director. 160 p.


B284—*Lygus hesperus* Knight and *Lygus elisus* Van Duzee in relation to alfalfa seed production. C. J. Sorensen. Entomology Department. 61 p.


**Circulars**

C110—Annual summary of publications, 1937/38. 4 p.


C113—The minerals of wheat and their relation to human and animal nutrition. J. E. Greaves. Department of Bacteriology and Biochemistry. 15 p.
Articles Published in Scientific and Technical Journals


R429—Influence of variety and treatment on phytin content of wheat, by Silas M. Young and J. E. Greaves. Food Res. 5: 103-108. 1940.


R431—Trichomoniasis in the Utah Experiment Station dairy herd, by D. E. Madsen and Rue Jensen. Vet. Med. 35: 170-175. 1940.


ORGANIZATION OF THE EXPERIMENT STATION

The Utah Agricultural Experiment Station consists of the Director’s office, 17 technical research departments at Logan and two substations, the horticultural farm in Davis County and the Dry Land Substation at Nephi.

Agricultural Experiment Station at Logan

Agricultural Economics
Agronomy and Soils
Animal Husbandry
Animal Pathology
Bacteriology and Biochemistry
Botany and Plant Pathology
Chemistry
Dairy Husbandry
Entomology
Home Economics
Horticulture
Irrigation and Drainage
Physics
Poultry Husbandry
Range Management
Rural Sociology
Vegetable Crops

The experiment Station staff is composed of 76 persons. Of this number only 7 members including clerical and administrative workers devote their full services to agricultural research; the others spend some time in teaching or extension work or are engaged in cooperative employment with the federal government.

ACTIVE PROJECTS OF THE STATION

At the close of the biennium work was in progress on 76 projects. These have been undertaken with the desire to attack the most pressing problems facing the farmers of the state. However, the limitations of funds and staff, laboratory, and land facilities must also be taken into consideration when prospects are planned. A list of active projects is given in table 1.
<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Fund</th>
<th>Departments</th>
<th>Leaders</th>
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<td>1</td>
<td>Nephi farm</td>
<td>State</td>
<td>Agronomy and Soils</td>
<td>A. F. Bracken</td>
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<tr>
<td>10</td>
<td>Miscellaneous field studies</td>
<td>State</td>
<td>Agronomy and Soils</td>
<td>R. J. Evans</td>
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<td>22</td>
<td>Factors influencing the bacterial activity of the soil</td>
<td>Adams</td>
<td>Bacteriology and Biochemistry</td>
<td>J. E. Greaves</td>
</tr>
<tr>
<td>23</td>
<td>Permanent fertility studies</td>
<td>Adams</td>
<td>Bacteriology and Biochemistry</td>
<td>J. E. Greaves</td>
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<td>33</td>
<td>Tomato diseases in Utah</td>
<td>Purnell</td>
<td>Botany and Plant Pathology</td>
<td>H. L. Blood</td>
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<td>34</td>
<td>Plant disease survey</td>
<td>State</td>
<td>Botany and Plant Pathology</td>
<td>B. L. Richards</td>
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<td>Breeding for egg production</td>
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<td>Poultry feed studies</td>
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<td>Davis County experimental farm</td>
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<td>Vegetable Crops</td>
<td>L. H. Pollard</td>
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<td>62</td>
<td>Genetic study of resistance of wheat to physiologic forms of Purnell</td>
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<td>Cultural methods with soybeans</td>
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<td>Weed control</td>
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<td>from seasonal surveys of snow cover on mountain watersheds</td>
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<td>Production studies in dairying</td>
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<td>Studies of Utah towns and villages</td>
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<td>Effect of fertilizers on various properties of a highly calcareous</td>
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<td>soil and on the yield of crops produced</td>
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<td>Willard Gardner</td>
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<td>Orchard rootstock investigations</td>
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<td>The nutritive value of high versus low calcium and phosphorus</td>
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<td>Factors affecting the keeping quality of onions</td>
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<td>Miscellaneous fertilizer tests</td>
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<td>Agronomy and Soils</td>
<td>D. W. Pittman</td>
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<td>138</td>
<td>Grasshoppers and their allies with species which menace farm crops</td>
<td>Hatch</td>
<td>Entomology</td>
<td>W. W. Henderson</td>
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<td></td>
<td>and range forage</td>
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<td>C. J. Sorensen</td>
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<td>140</td>
<td>Animal disease laboratory</td>
<td>State</td>
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<td>141</td>
<td>Curly top and psyllid yellows of tomato</td>
<td>Purnell</td>
<td>Botany and Plant Pathology</td>
<td>H. L. Blood</td>
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<td>143</td>
<td>Farm mortgage, land values and transfers, and farm taxation</td>
<td>Purnell</td>
<td>Agricultural Economics</td>
<td>W. U. Fuhriman</td>
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<td>Analyses of factors responsible for loss of nitrogen and organic</td>
<td>Purnell</td>
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<td>Types of farming in Utah</td>
<td>Purnell</td>
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<td>W. P. Thomas</td>
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<td>151</td>
<td>Water-application efficiencies in irrigation and their relation to</td>
<td>Purnell</td>
<td>Irrigation and Drainage</td>
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<td>Grading and scouring investigations of commercial fleeces</td>
<td>Purnell</td>
<td>Animal Husbandry</td>
<td>A. C. Esplin</td>
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<td>157</td>
<td>Relationship of soft curd milk to subclinical mastitis</td>
<td>Purnell</td>
<td>Human Nutrition</td>
<td>R. L. Hill</td>
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<td>158</td>
<td>Forced summer molting of Leghorn hens as a method of increasing</td>
<td>Hatch</td>
<td>Poultry</td>
<td>Byron Alder</td>
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<td>fall and winter egg production</td>
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<td>Studies in root reserves and chemical changes in relation to control</td>
<td>Adams</td>
<td>Agronomy and Soils</td>
<td>R. J. Evans</td>
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<td>160</td>
<td>Pasture improvement studies</td>
<td>State</td>
<td>Agronomy and Soils</td>
<td>D. W. Pittman</td>
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<tr>
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<td>Title</td>
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<td>Phosphorus content of summer range</td>
<td>Purnell</td>
<td>Range Management</td>
<td>L. A. Stoddart</td>
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<td>Animal Husbandry</td>
<td>H. H. Smith</td>
</tr>
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<td>Berry insect investigations</td>
<td>Purnell</td>
<td>Entomology</td>
<td>G. F. Knowlton</td>
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<td>165</td>
<td>Capillary resistance test as an indicator of vitamin C</td>
<td>Purnell</td>
<td>Home Economics</td>
<td>A. P. Brown</td>
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<td>168</td>
<td>The application of hydromechanics to the design of structures</td>
<td>Adams</td>
<td>Physics</td>
<td>Willard Gardner</td>
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<td>for controlling groundwater</td>
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<td>Soil survey of the state</td>
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<td>D. S. Jennings</td>
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<td>Physical and chemical properties of soil types in Utah</td>
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<td>Agronomy and Soils</td>
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<tr>
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<td>Erosion studies</td>
<td>State</td>
<td>Agronomy and Soils</td>
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<td>172</td>
<td>Turkey production studies</td>
<td>Bankhead-Jones Off.</td>
<td>Poultry</td>
<td>Byron Pittman</td>
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<tr>
<td>173</td>
<td>Tomato insect investigations</td>
<td>Purnell</td>
<td>Entomology</td>
<td>G. F. Knowlton</td>
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<td>H. E. Dorst</td>
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<td>174</td>
<td>A study of post-parturient hemoglobinuria</td>
<td>Adams</td>
<td>Animal Pathology</td>
<td>D. E. Madsen</td>
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<td>175</td>
<td>Insects of stone fruits</td>
<td>Purnell</td>
<td>Entomology</td>
<td>C. J. Sorenson</td>
</tr>
<tr>
<td>176</td>
<td>Causes of bank difficulties in Utah</td>
<td>Purnell</td>
<td>Agricultural Economics</td>
<td>W. P. Thomas</td>
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<td>178</td>
<td>Investigations to determine the feeding value of molasses and the</td>
<td>State</td>
<td>Animal Husbandry</td>
<td>R. A. Rasmussen</td>
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<td>advisability of adding steamed bone meal to hog fattening rations</td>
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<td>179</td>
<td>A study of the agricultural resources of Utah and their utilization</td>
<td>Bankhead-Jones Off.</td>
<td>Agricultural Economics</td>
<td>W. P. Thomas</td>
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<td>Number</td>
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<td>H. E. Dorst</td>
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<td>181</td>
<td>The etiology of bone deformities in growing turkeys</td>
<td>Hatch</td>
<td>Animal Pathology</td>
<td>D. E. Madsen</td>
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<td>182</td>
<td>Breeding and improvement of range and pasture grasses in reseeding</td>
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<td>Agronomy and Soils</td>
<td>R. J. Evans</td>
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<td></td>
<td>investigations</td>
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<td>The vitamin C value of tomatoes at various intervals during</td>
<td>Purnell</td>
<td>Home Economics</td>
<td>A. P. Brown</td>
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<td>the tomato season</td>
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<td>Nutritional status indices for rural school and urban Utah students</td>
<td>Purnell</td>
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<td>A. P. Brown</td>
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<td>Range Management</td>
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<td>Germ plasm testing of sheep</td>
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<td>M. A. Madsen</td>
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<td>A. C. Esplin</td>
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<td>188</td>
<td>Ewe lamb-feeding investigations</td>
<td>State</td>
<td>Animal Husbandry</td>
<td>M. A. Madsen</td>
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<td>A. C. Esplin</td>
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<td>Agronomy and Soils</td>
<td>D. W. Pittman</td>
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<td></td>
<td>in canning peas</td>
<td></td>
<td>Vegetable Crops</td>
<td>L. H. Pollard</td>
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<tr>
<td>191</td>
<td>A study of range survey methods and vegetation analysis</td>
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<td>Range Management</td>
<td>L. A. Stoddart</td>
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<tr>
<td>193</td>
<td>Sugar beet variety tests</td>
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<td>D. W. Pittman</td>
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<td>Control of mastitis in a dairy herd</td>
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<td>Animal Pathology</td>
<td>D. E. Madsen</td>
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<td>Dairy</td>
<td>G. Q. Bateman</td>
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<td>196</td>
<td>Ascorbic acid metabolism of college students</td>
<td>Purnell</td>
<td>Home Economics</td>
<td>A. P. Brown</td>
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<tr>
<td>197</td>
<td>Influence of fertilizers, seed inoculation of peas and harvesting</td>
<td>Purnell</td>
<td>Vegetable Crops</td>
<td>L. H. Pollard</td>
</tr>
<tr>
<td></td>
<td>practices on yield and quality of canning peas and tomatoes</td>
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<td>Agronomy and Soils</td>
<td>D. W. Pittman</td>
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</table>
Table 1. Station projects, active during the biennium, listed by number, giving title, fund, departments and leaders—Continued

<table>
<thead>
<tr>
<th>Number</th>
<th>Title</th>
<th>Fund</th>
<th>Departments</th>
<th>Leaders</th>
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</thead>
<tbody>
<tr>
<td>198</td>
<td>Freezing preservation of Utah fruits and vegetables</td>
<td>Purnell</td>
<td>Horticulture</td>
<td>F. M. Coe</td>
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<td>Vegetable Crops</td>
<td>L. H. Pollard</td>
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<td></td>
<td></td>
<td></td>
<td>Home Economics</td>
<td>A. P. Brown</td>
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<td></td>
<td></td>
<td></td>
<td>Dairy Manufacturing</td>
<td>A. J. Morris</td>
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<tr>
<td>199</td>
<td>Utilization of Jerusalem artichokes</td>
<td>Adams</td>
<td>Bacteriology and Biochemistry</td>
<td>A. A. Anderson</td>
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<tr>
<td></td>
<td></td>
<td>Hatch</td>
<td></td>
<td>J. E. Greaves</td>
</tr>
<tr>
<td>200</td>
<td>Commercial grain grading and testing</td>
<td>Self-supporting</td>
<td>Agronomy and Soils</td>
<td>R. J. Evans</td>
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<tr>
<td></td>
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<td>D. C. Tingey</td>
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<td></td>
<td></td>
<td>A. F. Bracken</td>
</tr>
<tr>
<td>201</td>
<td>Virus and virus-like diseases of stone fruits</td>
<td>Adams</td>
<td>Botany and Plant Pathology</td>
<td>B. L. Richards</td>
</tr>
<tr>
<td>202</td>
<td>Soil borne diseases of the potato</td>
<td>Adams</td>
<td>Botany and Plant Pathology</td>
<td>B. L. Richards</td>
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<tr>
<td></td>
<td>yield and grade of fruit in orchards</td>
<td></td>
<td>Agronomy and Soils</td>
<td>D. W. Thorne</td>
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<td>204</td>
<td>Factors affecting lamb crop in range sheep</td>
<td>Purnell</td>
<td>Animal Husbandry</td>
<td>R. W. Phillips</td>
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<td>A. C. Esplin</td>
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<td>R. A. Rasmussen</td>
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<td>M. A. Madsen</td>
</tr>
<tr>
<td>205</td>
<td>Tuber index of seed potatoes grown in or offered for sale in Utah</td>
<td>State</td>
<td>Botany and Plant Pathology</td>
<td>B. L. Richards</td>
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</tbody>
</table>
THE RESEARCH of the Utah Agricultural Experiment Station is supplemented by investigations conducted by specialists of the U. S. Department of Agriculture working cooperatively with the Station. During the biennium 17 scientists paid by the federal government were located on the College campus investigating problems of vital concern to Utah agriculture. A list of the investigations conducted jointly is given in Table 2.

Table 2. Cooperative investigations conducted jointly by the federal government and the Utah Agricultural Experiment Station during the biennium ending June 30, 1940

<table>
<thead>
<tr>
<th>Federal agency cooperating</th>
<th>Station department cooperating</th>
<th>Nature of problem under investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>U. S. Department of Agriculture</td>
<td>Agricultural Economics</td>
<td>To make a general description of the type of farming in Utah</td>
</tr>
<tr>
<td>Agricultural Adjustment Administration</td>
<td>Agricultural Economics</td>
<td>Study of farm and ranch organization and operation and present land use</td>
</tr>
<tr>
<td></td>
<td>Range Management</td>
<td>A study of range lands and range management practices in relation to agricultural conservation and adjustment with special reference to formation of programs under the Soil Conservation and Domestic Allotment Act</td>
</tr>
<tr>
<td>Bureau of Agricultural Chemistry and Engineering</td>
<td>Horticulture, Home Economics, Dairy Manufacturing, Vegetable Crops</td>
<td>A study of preservation of Utah fruits and vegetables by freezing</td>
</tr>
<tr>
<td>Bureau of Agricultural Economics</td>
<td>Agricultural Economics</td>
<td>Investigation of farm mortgages and reasons for foreclosures and transfers</td>
</tr>
<tr>
<td>Division of Finance and Taxation</td>
<td>Agricultural Economics</td>
<td>To compare loan and credit policies of Utah banks which closed during the depression and those that did not</td>
</tr>
<tr>
<td></td>
<td>Agricultural Economics</td>
<td>To make a general description of the type of farming in Utah</td>
</tr>
<tr>
<td>Division of State and Local Planning</td>
<td>Agricultural Economics</td>
<td>Study of farm and ranch organization and operation and present land use</td>
</tr>
<tr>
<td>Division of Land Economics</td>
<td>Range Management</td>
<td>A study of range lands and range management practices in relation to agricultural conservation and adjustment</td>
</tr>
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</table>
Table 2. **Cooperative investigations conducted jointly by the federal government and the Utah Agricultural Experiment Station during the biennium ending June 30, 1940—Continued**

<table>
<thead>
<tr>
<th>Federal agency cooperating</th>
<th>Station department cooperating</th>
<th>Nature of problem under investigation</th>
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<tbody>
<tr>
<td>Division of Land Economics</td>
<td>Agricultural Economics, Agronomy and Soils, Irrigation and Drainage</td>
<td>A study of the agricultural resources of Utah and their utilization</td>
</tr>
<tr>
<td>Bureau of Agricultural Engineering</td>
<td>Experiment Station</td>
<td>To develop machinery suitable for eradication and control of weeds on irrigated land</td>
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<td></td>
<td>Irrigation and Drainage</td>
<td>Study of snow cover with reference to forecasting the supply of irrigation water</td>
</tr>
<tr>
<td>Agricultural Economics, Agronomy and Soils, Irrigation and Drainage</td>
<td>Irrigation and Drainage</td>
<td>To study water application efficiencies and the improvement of irrigation methods</td>
</tr>
<tr>
<td></td>
<td>Agricultural Economics, Agronomy and Soils, Irrigation and Drainage</td>
<td>A study of the agricultural resources of Utah and their utilization</td>
</tr>
<tr>
<td>Bureau of Animal Industry</td>
<td>Animal Pathology</td>
<td>Agglutination testing for Bang’s disease to eliminate affected cattle</td>
</tr>
<tr>
<td>Bureau of Chemistry and Soils (Now Bureau of Plant Industry)</td>
<td>Agronomy and Soils</td>
<td>To make soil and land classification maps of Utah to aid in land planning projects</td>
</tr>
<tr>
<td></td>
<td>Agricultural Economics, Agronomy and Soils, Irrigation and Drainage</td>
<td>A study of the agricultural resources of Utah and their utilization</td>
</tr>
<tr>
<td>Bureau of Dairy Industry</td>
<td>Dairy Husbandry</td>
<td>To work out problems in feeding, breeding and management that will be useful to the dairy industry of the state</td>
</tr>
<tr>
<td>Bureau of Entomology and Plant Quarantine</td>
<td>Botany and Plant Pathology</td>
<td>To eradicate the peach mosaic disease in Utah</td>
</tr>
<tr>
<td></td>
<td>Entomology</td>
<td>Check on grasshopper abundance as an indication of points of outbreak during the coming season</td>
</tr>
<tr>
<td></td>
<td>Entomology</td>
<td>To report upon insect outbreaks and abundance</td>
</tr>
<tr>
<td></td>
<td>Entomology</td>
<td>To investigate methods of control of insect pests that attack tomatoes</td>
</tr>
</tbody>
</table>
Table 2. Cooperative investigations conducted jointly by the federal government and the Utah Agricultural Experiment Station during the biennium ending June 30, 1940—Continued

<table>
<thead>
<tr>
<th>Federal agency cooperating</th>
<th>Station department cooperating</th>
<th>Nature of problem under investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bureau of Plant Industry</td>
<td>Entomology</td>
<td>To investigate beet leafhoppers relative to tomatoes and other truck crops</td>
</tr>
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<td></td>
<td>Entomology</td>
<td>To protect crops from grasshopper damage</td>
</tr>
<tr>
<td></td>
<td>Entomology</td>
<td>To investigate the causes and extent of honeybee losses in Utah</td>
</tr>
<tr>
<td>Division of Fruit and Vegetable Crops</td>
<td>Botany and Plant Pathology</td>
<td>To find tomato varieties resistant to the diseases most prevalent in the intermountain west</td>
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<td></td>
<td>Botany and Plant Pathology</td>
<td>To investigate curly top and psyllid yellows of tomatoes</td>
</tr>
<tr>
<td></td>
<td>Agronomy and Soils</td>
<td>To conduct potato breeding and cultural experiments with special reference to breeding for disease resistance</td>
</tr>
<tr>
<td></td>
<td>Vegetable Crops</td>
<td>To conduct onion breeding and cultural experiments with special reference to breeding insect and disease resistant onions</td>
</tr>
<tr>
<td>Division of Forage Crops and Diseases</td>
<td>Agronomy and Soils, Range Management</td>
<td>To test strawberry clover under a wide range of conditions as a forage crop in Utah</td>
</tr>
<tr>
<td></td>
<td>Agronomy and Soils</td>
<td>To improve range forage crops</td>
</tr>
<tr>
<td></td>
<td>Agronomy and Soils</td>
<td>For alfalfa breeding and improvement</td>
</tr>
<tr>
<td></td>
<td>Agronomy and Soils</td>
<td>Breeding and improvement of range and pasture grasses and reseeding investigations</td>
</tr>
<tr>
<td>Division of Cereal Crops and Diseases</td>
<td>Agronomy and Soils</td>
<td>To develop varieties of corn that are disease resistant and good silage yielders</td>
</tr>
<tr>
<td>Division of Soil Survey</td>
<td>Agronomy and Soils</td>
<td>To make soil surveys and land classification maps of Utah to aid in land use planning studies</td>
</tr>
<tr>
<td></td>
<td>Agricultural Economics, Agronomy and Soils, Irrigation and Drainage</td>
<td>A study of the agricultural resources of Utah and their utilization</td>
</tr>
</tbody>
</table>
Table 2. Cooperative investigations conducted jointly by the federal government and the Utah Agricultural Experiment Station during the biennium ending June 30, 1940—Continued

<table>
<thead>
<tr>
<th>Federal agency cooperating</th>
<th>Station department cooperating</th>
<th>Nature of problem under investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm Credit Administration</td>
<td>Agricultural Economics, Agronomy and Soils, Irrigation and Drainage</td>
<td>A study of the agricultural resources of Utah and their utilization</td>
</tr>
<tr>
<td>Federal Land Bank, Berkeley, California</td>
<td>Agricultural Economics</td>
<td>To compare loan and credit policies of Utah banks which closed during the depression and those that did not</td>
</tr>
<tr>
<td>Forest Service</td>
<td>Irrigation and Drainage</td>
<td>Study of snow cover with reference to forecasting the supply of irrigation water</td>
</tr>
<tr>
<td></td>
<td>Range Management</td>
<td>A study of range lands and range management practices in relation to agricultural conservation and adjust­ment</td>
</tr>
<tr>
<td></td>
<td>Range Management</td>
<td>Investigations in range land economics</td>
</tr>
<tr>
<td></td>
<td>Agricultural Economics, Agronomy and Soils, Irrigation and Drainage</td>
<td>A study of agricultural resources of Utah and their utilization</td>
</tr>
<tr>
<td></td>
<td>Agronomy and Soils</td>
<td>Forage crop improvement</td>
</tr>
<tr>
<td></td>
<td>Agronomy and Soils</td>
<td>Breeding and improvement of range and pasture grasses and reseeding investigations</td>
</tr>
<tr>
<td>Regional Salinity Laboratory, Riverside, California</td>
<td>Experiment Station</td>
<td>To study the relationships of salinity of irrigation water, and of soil conditions to plant growth and related factors involved in permanently successful irrigated agriculture</td>
</tr>
<tr>
<td>Regional Sheep Breeding Laboratory, Dubois, Idaho</td>
<td>Animal Husbandry</td>
<td>To improve sheep for western ranges through the application of breeding methods</td>
</tr>
<tr>
<td>Resettlement Administration</td>
<td>Agronomy and Soils</td>
<td>To make soil and land classification maps of Utah to aid in land planning projects</td>
</tr>
<tr>
<td></td>
<td>Agricultural Economics, Agronomy and Soils, Irrigation and Drainage</td>
<td>A study of agricultural resources of Utah and their utilization</td>
</tr>
<tr>
<td>Soil Conservation Service</td>
<td>Agronomy and Soils</td>
<td>To make soil and land classification maps of Utah to aid in land planning projects</td>
</tr>
<tr>
<td>Federal agency cooperating</td>
<td>Station department cooperating</td>
<td>Nature of problem under investigation</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Weather Bureau</td>
<td>Irrigation and Drainage</td>
<td>Study of snow cover with reference to forecasting the supply of irrigation water</td>
</tr>
<tr>
<td>Western Regional Research Laboratory</td>
<td>Experiment Station</td>
<td>To find new uses and new and extended outlets for fruits (other than apples) and vegetables, Irish potatoes, wheat and alfalfa</td>
</tr>
<tr>
<td>U. S. Department of the Interior Bureau of Reclamation</td>
<td>Agricultural Economics, Irrigation and Drainage, Agronomy and Soils Range Management</td>
<td>A study of Utah's agricultural resources and their development</td>
</tr>
<tr>
<td>National Park Service</td>
<td>Irrigation and Drainage</td>
<td>Study of snow cover with reference to forecasting the supply of irrigation water</td>
</tr>
<tr>
<td>U. S. Works Progress Administration</td>
<td>Agricultural Economics</td>
<td>Investigation of farm mortgages and reasons for foreclosures and transfers</td>
</tr>
</tbody>
</table>
## COOPERATION WITH STATE AND PRIVATE AGENCIES

In addition to the cooperative agreements with the federal government, the Station cooperates with various state and private agencies in the investigation of fundamental problems. These cooperative agencies and the type of investigation undertaken are presented in Table 3.

**Table 3. Cooperative investigations conducted jointly by agencies other than federal and the Utah Agricultural Experiment Station during the biennium ending June 30, 1940**

<table>
<thead>
<tr>
<th>Non-federal agency cooperating</th>
<th>Station department cooperating</th>
<th>Nature of problem under investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>State of Utah</td>
<td>Experiment Station</td>
<td>Investigation of the Colorado River—Great Basin project</td>
</tr>
<tr>
<td>State Department of Agriculture</td>
<td>Botany and Plant Pathology</td>
<td>To survey peach-growing areas of Utah for peach mosaic so that diseased trees can be eradicated in an effort to stamp out the disease</td>
</tr>
<tr>
<td></td>
<td>Agronomy and Soils</td>
<td>To provide a working basis for a statewide weed eradication campaign</td>
</tr>
<tr>
<td>Various counties Extension Service</td>
<td>Experiment Station</td>
<td>A committee organized for the purpose of correlating the study of agricultural problems throughout the state</td>
</tr>
<tr>
<td>State Department of Agriculture</td>
<td>Irrigation and Drainage</td>
<td>To study water-application efficiencies and their relation to irrigation and water use</td>
</tr>
<tr>
<td>State Engineer</td>
<td>Irrigation and Drainage</td>
<td>To obtain fundamental information with respect to pump operation, costs and discharge from ground-water areas and water use that will aid in obtaining more efficient use of ground-water resources</td>
</tr>
<tr>
<td>State Engineer</td>
<td>Irrigation and Drainage</td>
<td>To make annual snow surveys of precipitation on and runoff from the various watersheds in Utah and report the information gathered</td>
</tr>
<tr>
<td>State Water Storage Commission</td>
<td>Agronomy and Soils</td>
<td>To make soil surveys and land classification maps of Utah to aid in land use planning studies</td>
</tr>
<tr>
<td>State Planning Board</td>
<td>Agronomy and Soils</td>
<td>To make a study of the agricultural resources of Utah and their utilization</td>
</tr>
<tr>
<td>State Water Storage Commission</td>
<td>Agriculture Economics</td>
<td>To outline methods to be used in the state W. P. A. weed eradication project and check on results</td>
</tr>
<tr>
<td>Non-federal agency cooperating</td>
<td>Station department cooperating</td>
<td>Nature of problem under investigation</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Utah Poultry Producers'</td>
<td>Poultry Husbandry</td>
<td>To study better methods in turkey production and marketing</td>
</tr>
<tr>
<td>Cooperative Association</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State Bee-Keepers'</td>
<td>Experiment Station</td>
<td>To study effect on bees of spraying crops with poison insecticides and to</td>
</tr>
<tr>
<td>Association</td>
<td></td>
<td>devise methods to lessen the danger of bee poisoning</td>
</tr>
<tr>
<td>Seed Improvement Association</td>
<td>Botany and Plant Pathology</td>
<td>To determine the disease content of seed potatoes grown or offered for sale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>in the state and to perfect such diagnostic technique as will aid in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>decreasing degeneration diseases in potato seed stock</td>
</tr>
<tr>
<td>Utah Ice and Storage Co.</td>
<td>Horticulture</td>
<td>To lay the foundations for the development of a fruit and vegetable freezing</td>
</tr>
<tr>
<td>Rocky Mountain Packing</td>
<td>Vegetable Crops</td>
<td>industry in Utah which will provide an additional outlet for fruits and</td>
</tr>
<tr>
<td>Corporation</td>
<td>Dairy Manufacturing</td>
<td>vegetables</td>
</tr>
<tr>
<td>American Can Company</td>
<td>Home Economics</td>
<td></td>
</tr>
<tr>
<td>Amalgamated Sugar Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 commercial ice cream factories</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utah Canners Association</td>
<td>Vegetable Crops</td>
<td>To study effects of fertilizer application and legume seed inoculation on</td>
</tr>
<tr>
<td>American Can Company</td>
<td>Agronomy and Soils</td>
<td>the yield and quality of canning crops</td>
</tr>
<tr>
<td>Anaconda Sales Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td>American Potash Institute</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitragin Company</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Irrigation Companies of Utah,</td>
<td>Irrigation and Drainage</td>
<td>To survey lands irrigated by Provo River and its tributaries and classify</td>
</tr>
<tr>
<td>Utah, Wasatch and Summit</td>
<td></td>
<td>all lands, both irrigated and nonirrigated</td>
</tr>
<tr>
<td>Counties</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utah Power &amp; Light Co.</td>
<td>Animal Husbandry</td>
<td>To determine the suitability of various types of electrical equipment for</td>
</tr>
<tr>
<td></td>
<td>Dairy Husbandry</td>
<td>use under ordinary farm conditions</td>
</tr>
<tr>
<td></td>
<td>Horticulture</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poultry Husbandry</td>
<td></td>
</tr>
</tbody>
</table>
NEW INVESTIGATIONS SUGGESTED

With the increased complexity of agriculture in Utah there is an added demand on the resources of the Station. Sound land utilization, efficient disease and insect control, economic soil conservation, range rehabilitation, better adapted fruit and vegetable crops are all dependant upon constructive research. As these problems expand in scope there is an ever increasing demand for new investigations.

During the current biennium requests for the investigation of many new problems were received. These included appeals for investigations of the bee losses in recent years, for the control of potato diseases and pests, for soil and irrigation surveys, for better fruit and vegetable marketing methods, for more hardy fruit trees that will withstand the cold winters of the higher valleys, for improved grazing practices, for better livestock management practices to increase lamb and calf crops.

IMPROVED RESEARCH FACILITIES NEEDED

In order that the research program may in some way be commensurate with the magnitude of the agricultural problems requiring investigation more adequate research facilities should be provided. The present research staff should be supplemented in a number of places. More and better equipment is needed in many laboratories. More land for experimental research involving soil conservation, land use, fertility, crop improvement, disease control, irrigation and other problems where soils must be used is indispensable.

At present the Experiment Station rents 140 acres of land. It is a questionable procedure to continue long-time fundamental experiments on leased land, which may be withdrawn by the lessor. Heavy losses may occur in breaking the continuity of crop and soil experiments.

It is recommended that a ten-year land purchase program be developed in which necessary experimental land may be purchased and partly financed with funds now used for land rentals.

Funds not adequate to meet needs

These needs cannot all be met with the present inadequate funds granted to the Station.

Nearly two thirds of the funds used in the pursuit of research in agriculture in Utah are supplied by the federal government. This does not include salaries or expenses of federal employees on the campus, which
come directly from Washington, but only money appropriated directly to the Station through four federal acts, the Adams Act, the Hatch Act, the Purnell Act and the Bankhead-Jones Act. Less than 25 percent of the money used for experimental purposes comes from direct state appropriation (fig. 57). Only as the state realizes the value of research to agricultural progress and thereby financial success and appropriates money adequate for the needs of the program can the Station keep abreast of the many problems facing the agriculture of the state, and thereby find solutions which will help make a prosperous agriculture and free and contented rural peoples.

![Fig. 57. Source of funds used for agricultural research](image-url)
PERSONNEL

Staff

Peterson, Elmer George, B.S., A.M., PhD. ........................................ President
Walker, Rudger H., B.S., M.S., PhD. ................................................. Director
Peterson, William, B.S. ......................................................... Co-operator, Director, Agricultural Extension Service
Berntson, Russell E. ................................................................. Secretary-Treasurer
Burgoyne, David A., B.S., M.S. ..................................................... Executive Secretary
Harrison, Gladys L., A.B., Cert. Lib. ............................................. Bulletin Editor
Hardy, LaRue H. ................................................................. Stenographer-Treasurer
Johnson, Laura, B.S. ................................................................. Stenographer

Research Professors

Alder, Byron, B.S. ................................................................. Poultry Husbandry
Caine, George Ballif, B.S., M.S. ................................................ Dairy Husbandry
Clayton, Christine B., B.S., M.S. ........................................ Co-operator, Home Economics
Clyde, George Dewey, B.S., M.S. .............................................. Irrigation and Drainage
Dunn, Paul M., B.S., M.S. ......................................................... Co-operator, Forestry
Evans, Robert J., B.S., PhD. ...................................................... Agronomy
Gardner, Willard, B.S., M.S., PhD. ............................................ Physics
Geddes, Joseph Arch, B.S., M.S., PhD. ......................................... Rural Sociology
Greaves, Joseph Eames, B.S., M.S., PhD. .................................... Bacteriology and Biochemistry
Henderson, William Williams, B.S., M.A., PhD. .......................... Entomology
Hill, Reuben Lorenzo, B.S., PhD. ............................................... Chemistry
Israelsen, Orson Winso, B.S., M.S., PhD. .................................... Irrigation and Drainage
*Madsen, David Edward, D.V.M. ............................................... Animal Pathology
Phillips, Ralph W., B.S., M.A., PhD. ........................................ Animal Husbandry
Richards, Bert Lorin, B.S., M.S., PhD. ....................................... Botany and Plant Pathology
Stoddart, Laurence A., B.S., M.S., PhD. ...................................... Range Management
Thomas, W. Preston, B.S., M.S., PhD. ........................................ Agricultural Economics
Walker, Rudger H., B.S., M.S., PhD. ............................................ Agronomy

Research Associate Professors

Bracken, Aaron F., B.S., M.S. ..................................................... Agronomy
Brown, Almeda Perry, B.S., M.A. ............................................. Home Economics
*Blanch, George T., B.S., M.S. ................................................... Agricultural Economics
Coe, Francis M., B.S., M.S. ........................................................ Horticulture
Esplin, Alma C., B.S. ............................................................... Animal Husbandry
Hirst, Charles Terry, B.S., M.S. ................................................ Chemistry
Jennings, David Stout, B.S., PhD. ............................................. Agronomy
Knowlton, George F., B.S., M.S., PhD. ........................................ Entomology
Maguire, Bassett, B.S., PhD. .................................................... Co-operator, Botany and Plant Pathology
Morris, Arthur J., B.S., M.S. .................................................. Co-operator, Dairy Manufacturing
*Pittman, Don Warren, B.S., M.S. ........................................... Agronomy
Pollard, Leonard H., B.S., M.S., PhD. ...................................... Vegetable Crops
Sorensen, Charles J., B.S., M.S. ................................................ Entomology
Stark, Arvil R., B.S., M.S., PhD. ............................................. Horticulture
Stevens, Kenneth R., B.S., M.S., PhD. ...................................... Bacteriology
Thorne, D. Wynne, B.S., M.S., PhD. ........................................ Agronomy
Tingey, Delmar Clive, B.S., M.A. ............................................. Agronomy
Wann, Frank B., A.B., PhD. ................................................... Botany and Plant Pathology

Research Assistant Professors
Bateman, George Q., B.S. ...................................................... Dairy Husbandry
Binns, Wayne, D.V.M. .......................................................... Animal Pathology
Carpenter, George Alvin, B.S., M.S. ....................................... Agricultural Economics
Cutler, Harold H., B.S., M.S. .................................................. Agricultural Economics
Madsen, Milton A., B.S., M.S. ................................................ Animal Husbandry
Rasmussen, Russell A., B.S., M.S., PhD. ................................. Animal Husbandry
Sargent, David L., B.S., M.S. .................................................. Agronomy
Smith, Arthur D., B.S., M.S. .................................................. Co-operator, Range Management
Symons, Joseph N., B.S., M.S. ................................................ Rural Sociology
Wilson, LeMoyne, B.S., M.S. ................................................ Agronomy

Research Assistants
Broadbent, Dee A., B.S., M.S. ............................................... Agricultural Economics
Christenson, John, B.S., M.S. ................................................ Animal Husbandry
Christiansen, Roy M., B.S. .................................................... Botany and Plant Pathology
Daly, Rex F., B.S., M.S. ........................................................ Agricultural Economics
Huefner, Paul, B.S. ............................................................... Agricultural Economics
Jones, Louis W., B.S., M.S. ..................................................... Bacteriology
Peterson, Howard B., B.A., M.A., PhD. ................................. Agronomy

Research Fellows
Clark, John W., B.S. .............................................................. Agronomy
McAllister, Devere, B.S. ....................................................... Agronomy
Norris, Jonathan J., B.S. ....................................................... Range Management
Rasmussen, Lowell, B.S. ....................................................... Agronomy
Richards, Grant S., B.S. ........................................................ Animal Husbandry
Wallace, Melbourne D., B.S. ................................................ Vegetable Crops and Soils

*On leave of absence
United States Department of Agriculture Collaborators

Bailey, Reed W., B.S., M.S. .............................................. Forest Service
Bartholomew, O. F., B.S., M.S. ........................................... Bureau of Dairy Industry
Bateman, George Q., B.S. .................................................. Bureau of Plant Industry
Blood, H. Loran, B.S., PhD. .............................................. Bureau of Plant Industry
Carlson, John W., B.S., M.S., PhD. ..................................... Bureau of Plant Industry
Christiansen, Roy M., B.S. ................................................ Bureau of Plant Industry
Dorst, Howard E., B.S., M.A. ............................................. Bureau of Entomology and Plant Quarantine
Jackson, R. Scott, A.B. .................................................... Bureau of Animal Industry
Keller, Wesley, B.S., M.S., PhD. ......................................... Bureau of Plant Industry
Krull, Wendell Henry, A.B., M.S., PhD. ................................. Bureau of Animal Industry
McAlister, Dean F., B.S., PhD. ............................................ Bureau of Plant Industry
Maughan, J. Howard, B.S., M.S. .......................................... Bureau of Agricultural Economics
Nielsen, Harold M., B.S., M.S. ............................................ Bureau of Animal Industry
Shapovalov, Michael, B.A., M.S. ......................................... Bureau of Plant Industry
Stewart, Clyde E., B.S. ..................................................... Bureau of Agricultural Economics
Stewart, George, B.S., M.S., PhD. ....................................... Forest Service
Walker, Dilworth, B.S., M.A., PhD. ..................................... Bureau of Agricultural Economics
Woodward, Rollo W., B.S., M.S. .......................................... Bureau of Plant Industry

Resignations from the Staff

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>William E. Carroll</td>
<td>Research professor of animal husbandry</td>
<td>September 1938</td>
</tr>
<tr>
<td>Elmo D. Hardy</td>
<td>Research fellow in entomology</td>
<td>September 1938</td>
</tr>
<tr>
<td>Donna Barton Bell</td>
<td>Stenographer</td>
<td>November 1938</td>
</tr>
<tr>
<td>Bliss Crandall</td>
<td>Research fellow in agronomy</td>
<td>June 1939</td>
</tr>
<tr>
<td>Wallace R. Hanson</td>
<td>Research fellow in range management</td>
<td>June 1939</td>
</tr>
<tr>
<td>Edna Cardon Taylor</td>
<td>Stenographer</td>
<td>June 1939</td>
</tr>
<tr>
<td>Everett H. Larson</td>
<td>Research assistant professor of irrigation and drainage</td>
<td>July 1939</td>
</tr>
<tr>
<td>Sadie O. Morris</td>
<td>Cooperator, home economics</td>
<td>September 1939</td>
</tr>
<tr>
<td>Harry H. Smith</td>
<td>Research associate professor of animal husbandry</td>
<td>January 1940</td>
</tr>
<tr>
<td>E. M. Dieffenbach</td>
<td>Collaborator, U. S. Bureau of agricultural engineering and chemistry</td>
<td>June 1940</td>
</tr>
<tr>
<td>Wayne E. Domingo</td>
<td>Research fellow in agronomy</td>
<td>June 1940</td>
</tr>
<tr>
<td>Naomi R. Domingo</td>
<td>Stenographer</td>
<td>June 1940</td>
</tr>
<tr>
<td>Walter U. Fuhriman</td>
<td>Research associate professor agricultural economics</td>
<td>July 1940</td>
</tr>
<tr>
<td>Ariel A. Anderson</td>
<td>Research assistant professor of bacteriology and biochemistry</td>
<td>July 1940</td>
</tr>
<tr>
<td>Name</td>
<td>Position</td>
<td>Date</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Eldon M. Stock</td>
<td>Research assistant professor of irrigation and drainage</td>
<td>July 1940</td>
</tr>
<tr>
<td>Ianthus Wright</td>
<td>Research assistant professor of agricultural economics</td>
<td>July 1940</td>
</tr>
<tr>
<td>Wade H. Westmoreland</td>
<td>Collaborator, U. S. Bureau of Animal Industry</td>
<td>July 1940</td>
</tr>
</tbody>
</table>

### Appointments to the Staff

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dee Broadbent</td>
<td>Research assistant professor of agricultural economics</td>
<td>July 1938</td>
</tr>
<tr>
<td>Ariel A. Anderson</td>
<td>Research assistant professor of bacteriology and biochemistry</td>
<td>July 1938</td>
</tr>
<tr>
<td>Bliss Crandall</td>
<td>Research fellow in agronomy</td>
<td>July 1938</td>
</tr>
<tr>
<td>Wallace R. Hanson</td>
<td>Research fellow in range management</td>
<td>July 1938</td>
</tr>
<tr>
<td>Wayne E. Domingo</td>
<td>Research fellow in agronomy</td>
<td>July 1938</td>
</tr>
<tr>
<td>Elmo D. Hardy</td>
<td>Research fellow in entomology</td>
<td>July 1938</td>
</tr>
<tr>
<td>James Perry Thorne</td>
<td>Research fellow in agronomy</td>
<td>July 1938</td>
</tr>
<tr>
<td>Edna Cardon Taylor</td>
<td>Stenographer</td>
<td>August 1938</td>
</tr>
<tr>
<td>Naomi R. Domingo</td>
<td>Stenographer</td>
<td>November 1938</td>
</tr>
<tr>
<td>Leonard H. Pollard</td>
<td>Research associate professor of vegetable crops</td>
<td>June 1939</td>
</tr>
<tr>
<td>Arvil L. Stark</td>
<td>Research associate professor of horticulture</td>
<td>July 1939</td>
</tr>
<tr>
<td>Devere McAllister</td>
<td>Research fellow in agronomy</td>
<td>July 1939</td>
</tr>
<tr>
<td>Arthur J. Morris</td>
<td>Cooperator, dairy manufacturing</td>
<td>July 1939</td>
</tr>
<tr>
<td>Dilworth Walker</td>
<td>Collaborator, U. S. Bureau of agricultural economics</td>
<td>September 1939</td>
</tr>
<tr>
<td>D. Wynne Thorne</td>
<td>Research associate professor of agronomy</td>
<td>September 1939</td>
</tr>
<tr>
<td>Wade H. Westmoreland</td>
<td>Collaborator, U. S. Bureau of animal industry</td>
<td>September 1939</td>
</tr>
<tr>
<td>Clyde E. Stewart</td>
<td>Collaborator, U. S. Bureau of agricultural economics</td>
<td>October 1939</td>
</tr>
<tr>
<td>LaRue H. Hardy</td>
<td>Stenographer</td>
<td>October 1939</td>
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<tr>
<td>Ralph W. Phillips</td>
<td>Research professor of animal husbandry</td>
<td>November 1939</td>
</tr>
<tr>
<td>Russell A. Rasmussen</td>
<td>Research assistant professor of animal husbandry</td>
<td>February 1940</td>
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<tr>
<td>Paul Huefner</td>
<td>Collaborator, U. S. Bureau of agricultural economics</td>
<td>February 1940</td>
</tr>
</tbody>
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Leaves of Absence

D. C. Tingey, associate professor of agronomy, was on leave of absence during the year 1938-39, which time he spent studying toward an advanced degree at the University of Minnesota.

R. W. Woodward, Division of Cereal Crops and Diseases, U. S. Bureau of Plant Industry, also spent the winter term of 1938-39 studying at the same institution.

Dr. W. P. Thomas, head of the Department of agricultural economics, studied during the year 1938-39 at Cornell University where he completed work for his PhD. degree.

Dr. Wesley Keller and Dr. John Carlson of the Division of Forage Crops and Diseases, Bureau of Plant Industry, also completed work for the doctorate degree in the spring of 1939 at the University of Wisconsin.

Dr. Kenneth R. Stevens, research associate professor of bacteriology and biochemistry, spent the biennium on leave in Tahiti.

Dr. J. A. Geddes, research professor of rural sociology, visited educational institutions throughout the east during the spring of 1939.

Dr. W. U. Fuhriman was granted a six months' leave the spring of 1940 to work for the U. S. Bureau of Agricultural Economics.

Professor H. H. Cutler spent the summer of 1939 at Iowa State College.
Dr. Alma L. Wilson

Dr. Alma L. Wilson, head of the department of horticulture, died October 30, 1938, as a result of an arm injury received at the Davis Experimental farm the year previous. Dr. Wilson received his B.S. degree from the Utah State Agricultural College in 1916. After graduation he was employed as extension plant pathologist for the U. S. Department of Agriculture and county agricultural agent for Morgan County. In 1920 he was appointed superintendent of the Experiment Station farm in Davis County, a position he held at the time of his death.

In 1938 he entered Cornell University where he received his PhD. in 1931. The same year he returned to the College and in 1932 was made head of the Horticulture Department. His most outstanding work was in the development of the Utah strains of the Yellow and White Sweet Spanish onion.