A Market for Utah Farm Products
Increase in Population in West Coast Area Opens New Market Opportunities

By GEORGE T. BLANCH

California population was not entirely the result of wartime activities, as there has been a consistent and steady increase for many years. During the decade 1925 to 1935 the increase amounted to 30.5 percent and from 1915 to 1925, 57.3 percent. Students familiar with these movements expect the population to continue to increase relatively rapidly during the coming decades. At the present time the California population is equal to the combined population of the other 10 western states.

While agricultural production in California also increased during these periods, it has not kept pace with the population increases. This is particularly true of certain products such as meat animals, most livestock products, feed grains, late potatoes, and canning vegetables except tomatoes. The production of these products is considerably less than the consumption, with the result that the deficiency must be made up by shipments from other areas. Because of differences in the time of maturity of certain crops and other factors that give rise to trade, California also imports considerable quantities of certain products that it also exports. These imports are often drawn from areas of considerable distance.

Transportation Facilities

By reason of distance and also transportation facilities, Utah is in an excellent position to dispose of much of its produce on the California market. Direct rail lines connect Utah with both San Francisco and Los Angeles, as do also transcontinental highways. While freight charges are not exactly proportional to distance, the closer distances do usually have lower freight costs as well as some other advantages such as saving of time, less spoilage of produce, and easier contacts between buyer and seller. Except possibly for eastern Oregon, Utah is closer to both the Los Angeles and San Francisco markets than any other major source of supply outside California itself. In the past Oregon, Washington, and Idaho have been the most important out-of-state sources of supply for California and are likely to so continue. However, Utah is in a favorable position to compete on these markets.

Market Outlook for Eggs

The outstanding example of change in the outlet of a Utah product is that of eggs. For the years 1935, 1938, 1941, and 1944 the Utah egg shipments to California amounted to 2.4, 2.0, 9.5, and 89.4 percent, respectively, of the total out-of-state shipments. For the same years the percentage of the out-of-state shipments that went to New York were 93.6, 94.3, 89.2 and 6.3, respectively. In other words, in 1941 approximately 90 percent of Utah's egg shipments went to New York, while in 1944 approximately 90 percent went to California. This almost unprecedented

(Continued on page 13)
THE Department of Animal Husbandry plays a vital role in Utah's agriculture since Utah is primarily a livestock state. The functions of this department are to train students in the science and practical phases of animal industry and through research and extension activity to aid in the solution of the numerous problems vitally concerned in handling our nearly $60,000,000 worth of livestock not including dairy cattle and poultry.

Facilities for teaching animal husbandry to college students have been improved and enlarged in recent years. Livestock are maintained to meet the needs of student instruction and to carry on an extensive research program. The department has for this purpose two outstanding herds of beef cattle, maintains five breeds of sheep, a herd of swine and horses.

Recently established laboratories for work in animal nutrition and animal breeding have greatly improved the facilities for research work in these fields. The importance of laboratory research in animal industry cannot be over-emphasized. This has been well demonstrated by the results obtained in the wool laboratory which has been operating for several years and is equipped to do technical and practical wool work.

An extensive program in range sheep production and management research is under way in the Cedar City area as part of the Experiment Station program at the Branch Agricultural College. In this program over 800 ewes are maintained under careful control and are operated as a ranch unit with summer and winter grazing lands, and the Valley Farm to serve as headquarters for the entire operation and to supply supplemental feeds and spring and fall grazing.

The extension program in sheep production has been active and successful. The main projects are sheep selection and culling, wool grading and scouring, preparation of wool for market, and 4-H club activity.

Two experiments with beef cattle are active at the present time. One of these involves a breeding program with approximately 100 beef heifers; one group being bred as yearlings and the other group as two-year-olds. These cattle are ranged in Logan Canyon.

Another experiment with beef cattle in cooperation with the Soil Conservation Service, the Forest Service and the Bureau of Plant Industry, Soils and Agricultural Engineering, is in progress on abandoned dry farm land at Bonneville in Tooele County. This experiment utilizes twenty-seven one-hundred acre pastures which have been seeded to crested wheatgrass. Within the pastures, nine grazing treatments, duplicated three times, are being utilized to determine the correct way to graze in that area on resowed land. When fully under way liveweight gains of approximately 700 cattle along with grass measurements will be available to measure the effects of the various treatments.

Range sheep and cattle production requires information on the nutritive value of range forage and correct grazing methods. Research on these important problems in the intermountain west is being organized in cooperation with the Range Management Department and the Veterinary Science Department of the College. This program is being partially financed by a $20,000 grant from Swift and Company.

Livestock improvement in the state has been given special attention through the extension program and regular departmental activities. Special emphasis has been placed on improved stock and better management methods.

Department of Animal Husbandry

(1) Dr. Louis L. Madsen became head of the Department on July 1 of this year. Before returning to Utah he served as a National Research Fellow at Columbia University, was on the staff of the Agricultural Experiment Station at the Michigan State College and for the last eight years was nutritionist for the Bureau of Animal Industry, U. S. Department of Agriculture. (2) Alma C. Esplin is professor of Animal Husbandry and extension animal husbandman. He is a recognized authority in the fields of sheep production under western range conditions and in wool technology. (3) George R. Henderson is professor of Animal Husbandry and extension animal husbandman. He has gained an enviable reputation as a judge of livestock, particularly beef cattle and horses, and is aiding materially in the beef and general livestock improvement program in the state. (4) Dr. Lorin E. Harris, associate professor, is a product of Utah State and the University of Illinois. He came to Utah from Cornell University and is continuing work in the nutrition of farm animals and laboratory phases of animal nutrition. (5) Dr. T. Donald Bell is associate professor and is stationed at the Branch Agricultural College as chairman, Division of Agriculture. His major responsibility has been in connection with the range livestock research program. (6) James A. Bennett, assistant professor, a recent addition to the faculty, comes to Utah State after several years experience in range livestock breeding and management at the Swift Current Experiment Station in Saskatchewan, Canada. His responsibilities will be in connection with teaching and with the improvement of farm animals through breeding. Mr. Bennett is a graduate of Utah State.
Factors Affecting Alfalfa Seed Setting and Production in Utah

By JOHN W. CARLSON

Lygus Infestation and Damage

The harmful effects of lygus bugs in the production of alfalfa seed were first shown by investigations conducted at the Uinta Basin Alfalfa Seed Experimental Farm more than fifteen years ago. Since that time, attempts have been made to find or develop effective control for these insects, but without success until the new insecticide DDT became available less than two years ago. It appears from preliminary results on the use of this insecticide, as reported in the September issue of Farm and Home Science, that effective control of lygus-infestation— in the practical production of alfalfa seed seems assured.

The average production of 60 naturally infested plants was shown in experimental trials to be 41 pounds of seed to the acre, as compared with 123 pounds for 60 similar plants of the same genotype when dusted with an insecticide that gave only partial control of the infestation. It appears also that alfalfa when heavily infested with lygus bugs may be less attractive to pollinating insects. Present evidence seems to suggest a possible antagonism or incompatibility between the habits of lygus bugs and the pollinating insects that visit alfalfa flowers in search of pollen and nectar. Lygus infestation seems thus to have the effect of reducing greatly the efficiency of seed setting in alfalfa through making the flowers less attractive to the tripping and pollinating insects.

The Breed and Variety of Alfalfa

The average yield of 60 vegetatively propagated plants of a poor seeding strain of alfalfa was found to be 37 pounds of seed per acre, as compared with 441 pounds for 60 similar plants of a high seeding type. The difference is attributable largely to differences in the heredity of the strains, since the plants of both types were grown adjacent to each other and were given equal opportunity for pollination by visiting bees. The breeding and improvement of alfalfa for seed production as well as forage production is at present being given the attention of research workers at various state and federal stations.

The aim is to find types that are highly attractive to the pollinating insects, since cross pollination results in seed of superior value because of its hybrid nature.

Cultural Practices, Water Relationships and Soil Conditions

With virgin soils and possibly a greater abundance of wild bees under pioneering conditions, profitable crops of alfalfa seed were formerly produced successfully without dependence upon any prescribed field practices. The native flora seemed at that time also to harbor fewer harmful insects, such as lygus bugs. More exacting requirements must now be met in the successful production of alfalfa seed. Lygus infestation in particular appears to be a limiting factor in Utah and other western states, although its control seems assured through the use of DDT and (Continued on page 15)

Fig. 1. The type of cage used to exclude pollinating insects from the alfalfa plants

Dr. John W. Carlson, associate agronomist with the Division of Forage Crops and Diseases, U. S. Bureau of Plant Industry, Soils and Agricultural Engineering, writes another article summing up the status of the work on alfalfa seed production. Other articles on this subject appeared in the September issue.

for December 1945
RURAL RICH COUNTY SETS THE PACE FOR THE
COUNTIES OF UTAH IN HOME RADIOS

By JOSEPH A. GEDDES

Dr. Joseph A. Geddes, head of the Depart-
ment of Rural Sociology, has just published a
bulletin on Utah housing. This article is
based on part of the material gathered for
this publication.

Radio is one of the newer home
assets that have come in the wake
of electrification. Throughout America
electric conveniences are rapidly in-
creasing in number and in usefulness.
Fortunately for the people of Utah,
mountain rivers and streams provide
favorable conditions that encourage the
development of power resources. The
larger mountain power sites have not
yet been developed, but progress has
been made. Where electric energy can
be produced cheaply and at nearby
water power sites, home conveniences
multiply in number. Culinary water
conveniences and electric conveniences
are having much to do with the rapid
advances now being made in emanci-
pating the housewife from drudgery.

Utah, with 92.4 percent of all homes
with radios, stands well up among the
states in possession of this convenience.
Seven states outrank Utah. These are:
Massachusetts (96.2%), Rhode Island
(95.7%), Connecticut (95.7%), New
York, (95.5%), New Jersey (95.5%),
Michigan (93.4%), and California
(92.9%). Pennsylvania and Utah are
tied at 92.4 percent. The state with the
fewest radios is Mississippi with 39.9
percent. Thus with respect to this con-
venience, Utah leads the Mountain
states, the Pacific states except Califor-
nia, the Plains states, the Southern
states, the Mississippi Valley states, and
the Great Lakes states.

Rich County, a small rural Utah
county with a population density of 2
per square mile and a total population
of only 2,028 (1940), tops all Utah
counties.

Salt Lake, an urban county, falls be-
hind Rich 0.2 percent. Many rural
Utah counties lag in ownership of ra-
dios. San Juan is conspicuously low
with 42.8 percent. And yet in 1930 the
state average was only 41.1 percent or
slightly less than San Juan’s 1940 per-
cent. Non-white households in Utah
with 48.8 percent with radios, also fall
far behind white households which
average 93.0 percent.

Unlike many modern movements, the
radio invites people to stay at home
rather than to leave it for recreation
and entertainment. In spite of excessive
use for advertising, time is found for
musical, educational, dramatic and cur-
rent informational programs which even
people of wealth could not have a few
years ago. To rural people and to rural
family life the radio is a major aid to
improved living.

* * *

“The greatest events of an age are
its best thoughts. It is the nature of
thought to find its way into action.”
—Bovee.

Table 1. Home radios in (1) Rich County, (2) Salt Lake County, (3) San Juan County, and (4) the average for Utah

<table>
<thead>
<tr>
<th>Area</th>
<th>All</th>
<th>Rural non-farm</th>
<th>Rural farm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rich County</td>
<td>95.5</td>
<td>95.4</td>
<td>95.7</td>
</tr>
<tr>
<td>Salt Lake County</td>
<td>95.3</td>
<td>94.0</td>
<td>94.0</td>
</tr>
<tr>
<td>San Juan County</td>
<td>42.8</td>
<td>72.2</td>
<td>75.4</td>
</tr>
<tr>
<td>Total for Utah</td>
<td>92.4</td>
<td>90.2</td>
<td>86.2</td>
</tr>
</tbody>
</table>

Since joining the Station staff in 1922
Professor Tingey has done outstanding
work in the development of smut resist-
ant wheats. When the wheat industry
of northern Utah and southern Idaho
was threatened with extinction because
of loose smut Professor Tingey devel-
oped Relief wheat, released in 1933, which
was resistant to most forms of smut
found in the area. Since that time, in
cooperation with R. W. Woodward of
the Division of Forage Crops and Dis-
eases, U. S. Department of Plant In-
dustry, Soils and Agricultural Engineer-
ing, he has developed two other varie-
ties, Cache and Wasatch, both superior
to Relief. Cache is a hard red wheat
similar to Relief but beardless. Its
beardlessness makes it easier to maintain
pure stands while Relief becomes con-
taminated with other bearded varieties
and loses its smut resistance. The new
variety Wasatch is more resistant to
smut disease than any other known
commercial variety.

Professor Tingey has also done work
on the control of perennial weeds,
especially whitetop and morning-glory.
He will devote a major part of his time
to this work in the future. He will
experiment with the new chemicals and
with cultivation and other methods in
the control of weeds.
PEACH MOSAIC IN UTAH

By B. L. RICHARDS and ARTHUR S. RHOADS

Occurrence and Economic Importance of Peach Mosaic in Utah

Peach mosaic, a highly contagious virus disease of the peach and related stone fruits, constitutes a serious threat to peach growers in Utah. The disease invariably has resulted in extensive tree losses in all the various states where it has occurred. Peach mosaic first attracted the attention of officials almost simultaneously in Texas and western Colorado, and somewhat later was found in varying concentration in southern California, Utah, Oklahoma, Arizona and New Mexico. It subsequently has been found to occur in Old Mexico along the United States border and as far south as Chihuahua. The origin of the disease is not known.

This is the third of a series of articles on virus diseases of stone fruits prepared for Farm and Home Science by Dr. B. L. Richards, head of the Department of Botany and Plant Pathology, and Dr. Arthur S. Rhoads of the U. S. Bureau of Plant Industry, Soils and Agricultural Engineering. Dr. Rhoads, who was formerly connected with the Plant Disease Survey, is now with the Division of Forest Pathology with headquarters at Portland, Oregon.

Fig. 1. Breaking petal color (Early Wheeler variety) caused by peach mosaic. A., B. and C. from diseased trees selected to show variety in color patterns. D. normal flower (Courtesy U. S. Dept. Agr. Cir. 427)

Fig. 2. A. Elberta peach twig showing small deformed leaves and retarded foliation in the spring caused by peach mosaic. B. Normal Elberta twig (Courtesy U. S. Dept. Agr. Cir. 427)
Fig. 3. Showing variety of peach mosaic patterns in peach leaves from nursery tree resulting from artificial inoculation. All leaves show distortion resulting from disease (Courtesy U. S. Dept. Agr. Cir. 427)

Fig. 4. A. Rosette effect of foliage owing to shortening of internodes and excess branching from diseased twigs. Tree showed severe mosaic symptoms preceding spring. Photographed in early August. B. Limb from center group shown in A with leaves removed to expose whorl of twigs resulting from current season's growth. Elberta variety (Courtesy U. S. Dept. Agr. Cir. 427)

Fig. 5. A. Bumpiness in Elberta fruit induced by peach mosaic virus. B. Normal fruit from healthy Elberta tree (Courtesy U. S. Dept. Agr. Cir. 427)

Peach trees affected with mosaic present a variety of symptoms that vary with the season, with the variety of peach affected, and with the strain or form of virus involved. The principal symptoms may be classed into 5 general groups according to the season of the year and the part of the tree in which they develop. These are (1) color breaking in blossom petals, (2) retarding of foliage development, (3) mottling and deformity of leaves, (4) abnormal twig development, and (5) deformity of fruit. Individual trees, in various stages of development of the disease, may exhibit one or more of these groups of symptoms and there is a wide variation among varieties in the severity and type of symptoms expressed.

Blossom Symptoms: In certain varieties of peach, particularly those with large highly colored flowers and in the nectarine, the first symptoms of mosaic in the spring can be detected by the modification of color in the petals of the flower. These symptoms are exhibited as a breaking of the normally solid pink color resulting in striking patterns of great variety (fig. 1). Also in some instances petals of affected flowers become crinkled, missshapen and sometimes severely dwarfed.

Leaf Symptoms: Leaves of mosaic-infected trees are characterized by being small, narrow, crinkled, irregular in outline, and definitely mottled with light-yellow and dark-green mosaic patterns (figs. 2 and 3). In a single leaf or in different leaves, the yellowish discoloration may vary in size from tiny point-like flecks to variously shaped spots or blotches or to irregular, more or less crooked streaks. These markings often coalesce so as to involve a large part or all of the leaf surface (fig. 3, C and D). In young leaves which are heavily diseased the mottling appears close to the midrib. Severely affected mosaic leaves may be shed early. Leaves less severely affected may remain on the tree and exhibit characteristic mosaic symptoms until late in the season. On the other hand, as the season advances, the mosaic patterns frequently become less distinct and by midsummer they may be so modified that the affected trees show little if any evidence of the disease.

Twig Symptoms: Trees that have been heavily diseased for more than one year tend to produce abnormal twig symptoms. Instead of elongating normally, the internodes of diseased twigs are shortened with a greater thickness in proportion to length. This condition is accompanied by a greater tendency to branching than is found in normal twigs (fig. 4, A and B). The new growth on heavily diseased trees rarely attains more than 4 to 8 inches during the growing season, whereas that of a normal tree may attain 12 to 18 inches. Clusters or whorls of twigs sometimes grow from the tips of diseased twigs of the previous season (fig. 4, B).

Fruit Symptoms: Varieties such as El-

(Continued on page 12)
The relative palatability of the different clovers and grasses was determined by observing the cows of the dairy experimental herd as they grazed the various mixtures. The cows were allowed free access and had equal opportunity to graze the different mixtures that were randomized throughout the 5-acre field.

**Pasture Studies Indicate Possibilities of More Productive Grass and Legume Mixtures for Irrigated Land**

By WESLEY KELLER, GEORGE Q. BATEMAN and J. ELMO PACKER

REALIZING the need for experimental work with pasture mixtures a study was begun on the Dairy Experimental Farm 3 years ago. In addition to the authors, B. H. Crandall, D. F. McAlister and Harry F. Goodloe participated the first season. The present report is a summary of 2 years’ data now available. Objective of the study was to design and evaluate a number of pasture mixtures for highly productive land under a system of rotation grazing with good dairy herd management.

Pastures on the fertile, well drained, irrigated lands of Utah are usually planted to a combination of species known as the standard mixture no. 1. Modifications of this mixture, as well as quite different species combinations, have also been recommended to the farmers of Utah but so far as the present writers are aware none of these mixtures have been advocated as a result of their superiority in experimental tests conducted in this state. Recommendations in Utah appear to have been based on those of other experimental stations, possibly modified somewhat by local experience.

For this study high quality seed was obtained from reliable commercial sources. The seedings were made in a five acre field. The various mixtures were sown in April 1943 by broadcasting. Barley was drilled as a nurse crop at the rate of 60 pounds per acre, and yielded 80 bushels per acre. The plots were grazed lightly in the fall of 1943. During 1944 and again in 1945 the plots were grazed 3 times (May, July, and September) and just prior to each grazing quantitative yield data were obtained by harvesting a strip through each plot with a mowing machine and weighing the fresh green forage. The milking herd grazed the plots as long as forage was adequate to maintain milk production at the expected level after which dry stock were turned in. During grazing the various mixtures were rated for palatability and immediately after each grazing period the entire field was mowed and the clipped forage which had not been grazed off was raked up and removed.

**SOME SUGGESTIONS FOR ESTABLISHING A PASTURE ON IRRIGATED LAND**

1. Obtain only high quality seed. Only certified ladino clover is sure to be ladino. It costs more but is worth it.
2. Plant early in the spring on a firm, well prepared and well fertilized seedbed.
3. Use a cereal nurse crop preferably barley to control weeds. Plant not to exceed 50 lbs. per acre.
4. Place the pasture seed in the upper half inch of soil. Generally a cultipacker will help to firm the soil after seeding. Remember that a too loose seedbed is the most common cause of poor pasture stands.
5. Irrigate at regular intervals while the nurse crop is growing, and again as soon as it is removed. Irrigate to meet the requirements of the pasture mixture rather than the nurse crop.

Dr. Wesley Keller is geneticist with the Division of Forage Crops and Diseases, U. S. Bureau of Plant Industry, Soils, and Agricultural Engineering stationed on the Logan Campus, and working with grasses. George Q. Bateman is agent for the U. S. Bureau of Dairy Industry and superintendent of the Dairy Experimental Farm where the pasture research is in progress. J. Elmo Packer is a research assistant in dairy husbandry on the Station staff.

for December 1945
One phase consisted of the study of 36 mixtures in plots 25 feet square, replicated 6 times. Obviously only the highlights of the study can be reported here. In this series the standard mix was relatively unproductive, occupying twenty-first place in 1944 and twenty-fourth place in 1945. The composition and yields of the standard mix and 8 high yielding mixtures are presented in table 1. The appearance of 7 of these mixtures before and after the September 1945 grazing, reflecting yield and the degree of utilization is shown in figures 1 to 7.

The three highest yielding mixtures in table 1 all contain red clover, a species which is particularly valuable for its contribution to yield the first grazing season.

High yielding mixtures contained either brome, orchard or tall fescue.

Fig. 1. Mixture no. 22. Orchard, smooth brome, tall fescue, and tall meadow oat grass with alfalfa, red and ladino clover gave an abundance of forage but was only moderately grazed. Owing to the fact that alfalfa and red clover were not over-abundant and that they appear to be average in palatability, the unpalatability of this mixture is probably mainly owing to the tall fescue. The removal of tall fescue from the mixture or its replacement by Reed canary grass requires further investigation.

Fig. 2. Mixture no. 36. Orchard and red clover. Red clover was less abundant the second year in all mixtures in which it was planted. Red clover was observed to be less palatable than ladino, white alsike, or strawberry clover. Plots of red clover with orchard, or of red clover with smooth brome were not grazed as readily or to the same degree as were the plots in which ladino replaced red clover. The first year when red clover was most abundant during two different grazings, the blossoms were still on the red clover when plots of ladino with orchard or brome had been grazed to the ground.

Fig. 3. Mixture no. 5. Plots of tall fescue with ladino made a luxuriant growth but the forage was unacceptable to the grazing herd, indicating the unpalatability of tall fescue. This grass was not satisfactorily grazed in any mixture in which it occurred. On the basis of this study we do not feel justified in recommending tall fescue in irrigated pasture mixtures.

Fig. 4. Mixture no. 27. Alfalfa with brome. The plots of alfalfa with brome and alfalfa with orchard were much the same in ap-
with red clover, ladino clover or alfalfa as the legume. Combinations of these species were also highly productive. In contrast, if either Kentucky blue, meadow fescue, meadow foxtail or perennial rye was the predominant grass, or if strawberry clover or any of several sources of ordinary white clover was the predominant legume, or any of these species in combination, yields were relatively low. The data obtained to date indicate that on fertile land and with rotation grazing, Kentucky blue and white clover yield only about half as much forage as other mixtures.

Ladino clover appears to be the most desirable perennial legume for rotation pastures. It is highly palatable, recovers quickly after grazing, and appears to be aggressive enough to maintain itself in mixtures with such species as brome and orchard. The plot shown

pearance. There was little observable difference in the way in which they were grazed. In all cases there was a significant amount of alfalfa stems left after the brome and orchard had been grazed to the ground

Fig. 5. Mixture no. 11. Plots of brome with ladino were among the first to be grazed. One to three hours after the herd began to graze, a significant amount of forage of this mixture had been consumed while some other mixtures showed no evidence of having been grazed at all

Fig. 6. Mixture no. 8. Orchard with ladino was well utilized. However, parts of the stems of orchard were not grazed if the plants were in head when the cattle were turned into the pasture. Orchard is not quite as palatable as brome

Fig. 7. Standard mixture no. 1 was not utilized to the same degree or as readily grazed as mixtures of ladino with brome or orchard. The perennial rye in this mixture probably lowers its palatability

Fig. 8. Ladino with meadow fescue. In this mixture ladino made up a high percentage of the forage, meadow fescue contributing very little. This was one of the first mixtures to be grazed to the ground. The high palatability of ladino clover is shown by the degree to which it has been grazed

Fig. 9. The low yield of perennial rye is indicated by the height against the board and its unpalatability by the high percentage left after grazing. Furthermore, in this study legumes did not establish as satisfactorily when planted with perennial rye as when planted with the more desirable grasses. For these reasons we recommended that perennial rye be left out of pasture mixtures
in figure 8 was originally a mixture of ladino clover and meadow fescue. As figure 8 indicates, it is now nearly a pure stand of ladino. The high palatability of ladino is clearly evident in the complete utilization made of it by the milking herd. Every mixture which had ladino as the predominant legume yielded more forage than standard mixture no. 1. Ladino is clearly more productive than ordinary white clover. In another series of plots designed to compare a large number of sources of different species, ladino exceeded white clover by 70 percent the first season and by 30 percent the second season.

Smooth brome and orchard have consistently contributed to high yields. Orchard recovers after grazing faster than any other desirable grass. Orchard is less palatable than brome but the difference is not great in early stages of growth. Grazed prior to heading, orchard has always been fully utilized by the milking herd.

Perennial ryegrass has regularly been a component of pasture mixtures. Our experience with this species has been disappointing. It is not adapted to simple mixtures. Where perennial ryegrass is the predominant grass it provides such intense competition in the seeding stage that associated legumes are likely to be eliminated. Figure 9 shows a mixture in which perennial rye predominates. It is low in yield and definitely unpalatable.

**Palatability of Mixtures**

The mixtures listed in table 1 require consideration from the standpoint of length of life and palatability. Mixtures 34 and 36 have no doubt given their highest yields and red clover will thin out rapidly. Likewise, in mixture 27 alfalfa will probably not persist beyond about 3 years. Mixtures 22, 5, 15, 11, 8 and standard mixture no. 1 will apparently persist a considerable number of years if properly managed.

When species differing in palatability occur in a mixture, it appears that the palatability of the mixture is more or less limited by the least palatable species. For example, all mixtures containing tall fescue or perennial rye grass were shown to be the least palatable. When these two grasses and other relatively unpalatable species were only partially utilized (figs. 3, 4, and 9) it was necessary to move the herd to a fresh pasture in order to maintain milk production at a high level. It was noted that when the palatable species (figs. 5, 6, and 8) such as ladino clover, smooth brome, and orchard grass were grazed out, milk production started to decline. The work so far indicates that a pasture mixture may produce an abundance of forage but if it is made up of unpalatable species, cows will not graze enough to maintain milk production at the highest level. Both red clover and alfalfa are definitely less palatable than ladino clover. Mixture 22 is low in palatability largely because of tall fescue and to a lesser extent because of alfalfa and red clover. Tall meadow oat, which occurs in mixture 22 has been observed to be high in palatability. Further experience with this species will be necessary before we can appraise its contribution to total yield.

One side of the field was adjacent to a spring and was designated as a wet area. A series of 25 mixtures was located here in plots 13 x 16 feet, replicated 3 times. Under these conditions the standard mixture no. 1 occupied seventh place in 1944 and thirteenth place in 1945. The outstanding species in this series was red canary grass which was found to be palatable although it was not exceptional in yield the first season. During 1945 it yielded well in association with orchard.

(Continued on page 15)

**Table 1. Yield, palatability, and anticipated longevity of 8 pasture mixtures compared with the standard mixture no. 1**

<table>
<thead>
<tr>
<th>Mix no.</th>
<th>Species and pounds of seed used per acre</th>
<th>Green weight yields in tons per acre*</th>
<th>Relative palatability rating</th>
<th>Longevity no. used per acre</th>
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</thead>
<tbody>
<tr>
<td>22</td>
<td>Smooth brome 4, orchard 3, tall meadow oat 4, tall fescue 4, alfalfa 3, ladino clover 2, red clover 2 (fig. 1)</td>
<td>13.71 19.52 33.23</td>
<td>Moderate</td>
<td>Perennial</td>
</tr>
<tr>
<td>34</td>
<td>Smooth brome 20, red clover 5 (very similar to fig. 2)</td>
<td>13.91 16.40 30.31</td>
<td>Moderate</td>
<td>2 yrs.</td>
</tr>
<tr>
<td>36</td>
<td>Orchard 16, red clover 5 (fig. 2)</td>
<td>11.81 14.83 26.63</td>
<td>Moderate</td>
<td>2 yrs.</td>
</tr>
<tr>
<td>5</td>
<td>Tall fescue 16, ladino clover 4 (fig 3)</td>
<td>8.70 14.46 23.16</td>
<td>Low</td>
<td>Perennial</td>
</tr>
<tr>
<td>27</td>
<td>Smooth brome 20, alfalfa 5 (fig. 4)</td>
<td>8.02 14.86 22.88</td>
<td>Moderate</td>
<td>2-3 yrs.</td>
</tr>
<tr>
<td>15</td>
<td>Orchard 8, smooth brome 10, alfalfa 3, ladino clover 2 (Approx. between figs. 2 and 5)</td>
<td>8.44 14.14 22.78</td>
<td>Moderate</td>
<td>Perennial</td>
</tr>
<tr>
<td>11</td>
<td>Smooth brome 20, ladino clover 4 (fig. 5)</td>
<td>8.06 13.77 21.83</td>
<td>High</td>
<td>Perennial</td>
</tr>
<tr>
<td>8</td>
<td>Orchard 16, ladino clover 4 (fig. 6)</td>
<td>8.27 13.04 21.31</td>
<td>High</td>
<td>Perennial</td>
</tr>
<tr>
<td>6</td>
<td>Standard Smooth brome 4, orchard 3, perennial mixture rye 3, meadow fescue 4, Kentucky blue 4, alsike clover 2, Idaho grown white clover 3 (fig. 7)</td>
<td>6.77 8.43 15.19</td>
<td>Moderate</td>
<td>Perennial</td>
</tr>
</tbody>
</table>

* To obtain approximate air-dry weights, multiply green weights by .23
ATTLE grubs and heel or bomb flies which develop from them, cause serious losses in the cattle industry of the entire country. Principal losses result from (1) reduced milk flow in dairy cows, (2) failure to gain weight normally in fattening cattle, (3) loss of leather and devaluation of hides because of holes cut in them by the grubs, (4) injury and occasional death of cattle because of their running to escape from the attacks of egg-laying flies, (5) damage to fences by “stamping” cattle, (6) strayed and lost cattle resulting from being chased by flies.

If cattle grubs were effectively controlled, the cattle industry and the general public of Utah would be saved from losses running into several millions of dollars annually.

During February, March, April and May, 1945, limited opportunity was afforded the writer to do some survey work on the distribution of cattle grubs in the northern half of the state. Grub-infested cattle were found in all areas visited. The percentage of cattle infested and the number of grubs harbored by individual animals varied considerably in different localities as did also the stage of development of the grubs. Reports received from county agents and cattle men indicate that cattle-grub infestation in Utah is state wide.

Through the cooperation of Dr. Oscar Wennergren, Logan City meat inspector, a short-yearling Holstein heifer, heavily infested with cattle grubs, was made available on April 9, for study of the natural emergence of grubs, length of the pupal period, identity of species involved, length of adult life, and other phases of the biology of cattle grubs.

During the period of observation (April 9 to June 1) a canvas belt or jacket was designed, fitted and made to cover the heifer’s body between the front and hind legs, extending completely around it with an overlap and strap fasteners on one side. With the jacket in place around the middle of the animal, it covered nearly all of the jacket in place around the middle of the animal, it covered nearly all of the

grub cysts, and upon their natural emergence, the grubs were held within the jacket which had extra space in the lower part, without being crushed or otherwise injured.

On April 10, before any emergence had taken place, 72 grub cysts were counted on the back of this heifer. These cysts extended along the back from the region above the withers posteriorly to beyond the hip joints and ventrad on to the ribs.

The first cattle grub to emerge from the back of the heifer was captured in the jacket on April 11. This proved to be the larva of the bomb fly, Hypoderma bovis De G.

Forty-five grubs were caught in the canvas jacket following their natural emergence. They were jet black in color, averaging approximately seven-eighths inch long and one-half inch in diameter at the thickest point of the body. All 45 grubs pupated. The outward form of these pupae was definite within 24 hours after larval emergence. Three grubs, already protruding approximately one-fourth inch through the animal’s hide, were squeezed out and put in ventilated glass jars for pupation, but died without pupating.

A few grub cysts were not covered by the jacket, and were therefore not caught by it but were killed before emergence either by the heifer herself, or by the observer. Whenever the jacket was loosened to make examination for emerged grubs, the heifer licked and scraped her back most vigorously with tongue and teeth, displaying intense irritation resulting from the grubs encapsuled therein. In this activity she was able to extract from her back grubs that were ready, or nearly ready, to emerge. In order to observe what might be the result of licking and digging with her teeth, this activity was permitted for a moment on two or three occasions at intervals of a few days. In this manner several grubs were dislodged and killed by the animal.

Grubs emerged from the back of the heifer at intervals of a few days from April 11 to May 29, a period of 48 days. Immediately after emergence, half of the grubs were put in flower pots nearly full of soil with a bit of chaff or other litter over part of the soil surface. The grubs were laid on the surface soil and had a choice as to whether or not they dug down into the soil, crawled under the chaff or remain lying on the surface. Some of them did each of these three things. How-

Charles J. Sorenson, associate research professor of Entomology, has been on the Station staff since 1914. Professor Sorenson’s main interest during recent years has been with the control of alfalfa seed insects. The work on the cattle grubs was made during the time he was extension entomologist while Dr. G. F. Knowlton was on leave with the army.

for December 1945
Peach mosaic affects and spreads naturally from diseased to healthy trees in the orchard and from orchard to orchard in infected areas. Inspection records in orchards have shown that this spread in the orchard may approximate 100 percent in a single year. From data presented in table 1, it is also apparent that new cases of mosaic occur, despite the persistent eradication and destruction of diseased trees each year. It is commonly and no doubt correctly assumed that insects are responsible for such rapid and natural spread.

There is no evidence to show that peach mosaic can spread by juice inoculations, mechanical contact, irrigation water, or other cultural practices except by propagation methods, which involve budding and grafting. Experimental work in Texas has failed to show that the disease is transmitted by seed or by pollen.

Susceptibility to the Peach mosaic virus

The peach mosaic virus affects and spreads naturally to all varieties of peach. Although varieties differ greatly in severity of symptom expression, none are known to be immune. All peach varieties infected with peach mosaic appear to exhibit similar symptoms.

Transmission and Spread of the Mosaic Virus

Various investigators have demonstrated repeatedly that when healthy peach trees are budded or grafted with tissue from mosaic diseased trees, such healthy trees become diseased and exhibit characteristic symptoms of peach mosaic. It is thus apparent that this disease can be spread by man from tree to tree, from orchard to orchard, or from one locality to another through ordinary propagation methods. It is also definitively established that mosaic spreads naturally from diseased to healthy trees in the orchard and from orchard to orchard in infected areas. Inspection records in orchards have shown that this spread in the orchard may approximate 100 percent in a single year. From data presented in table 1, it is also apparent that new cases of mosaic occur, despite the persistent eradication and destruction of diseased trees each year. It is commonly and no doubt correctly assumed that insects are responsible for such rapid and natural spread.

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Susceptibility to the peach mosaic virus

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in spring. However, with the passing of these spring or early symptoms, the appearance of the tree will vary with different varieties. Susceptibility to the disease does not appear to be influenced either by age or vigor of tree or by soil type.

**Hosts of the Virus and their Relation to Control in the Peach**

The persistent development of peach mosaic in certain areas despite the systematic removal of diseased trees over a period of years has suggested that *Prunus* types other than the peach may harbor the virus without expressing typical or in fact any symptoms of the disease. Cochran and Hutchins, working in California, found that when healthy almond, apricot, plum, and prune nursery trees were inoculated with buds taken from peach trees affected with the peach-mosaic virus, the virus remained in the tree but no symptoms developed in the inoculated plants. Bodine and Durrell, working in Colorado, found that when trees of almond, apricot, Royal Duke cherry, Hungarian prune, and plum were infected by the peach-mosaic virus through bud inoculations only the Hungarian prune and Montgomer apricot exhibited mosaic symptoms. However, all these trees so inoculated, whether expressing symptoms or not, were shown to carry the virus, which could be reinculcated into healthy Alberta peach trees.

In Utah the Pottawattamie plum which commonly grows wild in the vicinity of peach orchards in the Moab section, has been found by Cochran to carry the peach-mosaic virus and is probably spread as readily from the Pottawattamie plum to peach as from peach to peach. This fact provides the basic reason as to why eradication measures applied so successfully in other regions of the state have failed to control mosaic in the peach in the Moab area. The Pottawattamie plum must be destroyed in the Moab district before control of the virus in the peach can be attained.

**MARKET FOR FARM PRODUCTS**

*Continued from page 1*

change in market outlet resulted at least in part from wartime controls of transportation and marketing, and there may be some question about Utah eggs continuing to be shipped to that market after all controls are removed. However, there is good reason to believe that Utah can continue to market a large volume of eggs in the Los Angeles and San Francisco areas.

In table 1 are shown the total egg receipts by area of origin for the two major California markets for 1935, 1938, 1941, and 1944. These data show that before the war a considerable quantity of eggs was received from areas much farther away than Utah. While some of the eggs from the Midwest and the South may have been of poor quality and used in various kinds of manufacturing, the quality of eggs from the Northwest is generally comparable with eggs from Utah.

Prior to 1940 the receipts from Utah amounted to only slightly more than 1 percent of the total, whereas the receipts from the three northwestern states made up more than 10 percent. However in 1944 Utah shipped more eggs into these two markets than the three states combined. This is the best large out-of-state market available to

### Table 1. Trees removed on account of peach mosaic since discovery of the disease in Utah to date*

<table>
<thead>
<tr>
<th>Year</th>
<th>Total for state</th>
<th>Total for Grand Co.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1935</td>
<td>16†</td>
<td></td>
</tr>
<tr>
<td>1936</td>
<td>1082</td>
<td>1080</td>
</tr>
<tr>
<td>1937</td>
<td>172</td>
<td>171</td>
</tr>
<tr>
<td>1938</td>
<td>108</td>
<td>65</td>
</tr>
<tr>
<td>1939</td>
<td>514</td>
<td>184</td>
</tr>
<tr>
<td>1940</td>
<td>125</td>
<td>101</td>
</tr>
<tr>
<td>1941</td>
<td>145</td>
<td>134</td>
</tr>
<tr>
<td>1942</td>
<td>137</td>
<td>136</td>
</tr>
<tr>
<td>1943</td>
<td>140</td>
<td>139</td>
</tr>
<tr>
<td>1944</td>
<td>243</td>
<td>240</td>
</tr>
<tr>
<td>1945</td>
<td>242</td>
<td>226</td>
</tr>
<tr>
<td>Total</td>
<td>2924</td>
<td>2476</td>
</tr>
</tbody>
</table>

† The data for this table was kindly furnished by Earl Hutchins, supervising inspector of the Utah State Department of Agriculture.

† Washington County.

The persistent development of peach mosaic since discovery of the disease in Utah to date*

When such a contagious disease as peach mosaic is involved, control calls for prompt and drastic action, and even considerable fortitude upon the part of the growers involved. Growers are often called upon to sustain heavy losses for their safety and that of the industry as a whole. To attempt to deal with such an insidious disease by mild and lenient measures is futile and may lead to the majority of the trees in an orchard, or in an entire peach growing area, becoming infected in the course of a few years. Once a tree becomes infected, even though but the mildest symptoms are expressed, that tree until removed continues to constitute a source of infective material for adjacent healthy trees in the orchard.

The infective principle or virus causing peach mosaic is deep-seated and is distributed throughout all the living tissues of the tree. There is no known way to combat the disease other than by the prompt destruction of the affected tree or trees.

Since the peach-mosaic virus is not known to live in any but living tree parts and does not exist in the soil from which a diseased tree has been removed, it is considered safe to replant. It should be borne in mind, however, that replanted trees can become infected by spread of the virus from other diseased trees, including symptomless carriers, that may be present in the neighborhood.

### Table 1. Total receipts of eggs by area of origin at Los Angeles and San Francisco for selected years

<table>
<thead>
<tr>
<th>Area of origin</th>
<th>1935 cases</th>
<th>1935 percent</th>
<th>1938 cases</th>
<th>1938 percent</th>
<th>1941 cases</th>
<th>1941 percent</th>
<th>1944 cases</th>
<th>1944 percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>14,260</td>
<td>.845</td>
<td>17,781</td>
<td>81.9</td>
<td>20,120</td>
<td>87.4</td>
<td>23,128</td>
<td>88.5</td>
</tr>
<tr>
<td>Utah</td>
<td>225</td>
<td>1.1</td>
<td>1,192</td>
<td>5.5</td>
<td>3,458</td>
<td>14.4</td>
<td>3,438</td>
<td>11.7</td>
</tr>
<tr>
<td>Other western states*</td>
<td>35</td>
<td>.2</td>
<td>153</td>
<td>.6</td>
<td>163</td>
<td>.6</td>
<td>2,064</td>
<td>7.1</td>
</tr>
<tr>
<td>Midwest states</td>
<td>20</td>
<td>0.3</td>
<td>564</td>
<td>2.6</td>
<td>2,064</td>
<td>7.1</td>
<td>2,064</td>
<td>7.1</td>
</tr>
<tr>
<td>Southern states</td>
<td>11</td>
<td>0.1</td>
<td>227</td>
<td>1.0</td>
<td>1,192</td>
<td>5.5</td>
<td>1,192</td>
<td>5.5</td>
</tr>
<tr>
<td>Total</td>
<td>16,310</td>
<td>100.0</td>
<td>21,705</td>
<td>100.0</td>
<td>29,274</td>
<td>100.0</td>
<td>29,274</td>
<td>100.0</td>
</tr>
</tbody>
</table>

* Oregon, Washington and Idaho
† Montana, Wyoming, Colorado, New Mexico, Arizona, and Nevada

For December 1945
Utah poultrymen and it will probably be to their advantage to continue to use it.

The California markets also offer an excellent outlet for poultry. During 1944 more than 64 million pounds of dressed poultry were received at the Los Angeles and San Francisco markets in addition to quantities of live poultry. Of the dressed poultry 46 percent originated in California, 4.0 percent in Utah, 5.5 percent from the 3 northwestern states, 1 percent from the 6 other western states, 36 percent from midwestern states, and 7.0 percent from the southern and eastern states. In 1935 the total receipts were only 22,642,000 pounds, in 1938, 22,731,000, and in 1941, 34,318,000 pounds. The 1944 receipts were no doubt abnormally large because of the military activities. The most significant changes in the origin of the poultry supply between 1935 and 1944 were that the proportion from the midwestern states nearly doubled, while that from the three northwestern states decreased from 30.6 percent to 5.5 percent. The proportion from Utah increased from 3 to 4 percent of the total. The proportion from the southern and eastern states also increased.

**Bul. 319. Cherry rootstocks, by Francis M. Coe. Department of Horticulture. 44 p.**

This bulletin reviews the history and status of the cherry rootstocks problem in Utah and the United States and reports 14 years' results from a sweet cherry rootstocks test orchard on open porous soil at Farmington, Utah. On this soil the mahaleb stock proved to be much superior to either mazzard or Stockton morelo as a rootstock for sweet cherries.

**Bul. 321. Utah housing in its group and community aspects, by Joseph A. Geddes and Carmen C. Fredrickson. Department of Rural Sociology. 90 p.**

This bulletin discusses housing and home conveniences in the state as a whole and in four rural communities in northern Utah. In these communities the various farm groups are compared with respect to housing and home conveniences with nonfarm groups.

Either of these publications may be obtained free by addressing a card to the Utah Agricultural Experiment Station, giving number and series of the publication desired.

**NEW PUBLICATIONS**

**Table 2. Total receipts of butter by area of origin at Los Angeles and San Francisco for selected years**

<table>
<thead>
<tr>
<th>Area of origin</th>
<th>Total receipts 1935</th>
<th>Total receipts 1938</th>
<th>Total receipts 1941</th>
<th>Total receipts 1944</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,000 pounds</td>
<td>1,000 pounds</td>
<td>1,000 pounds</td>
<td>1,000 pounds</td>
</tr>
<tr>
<td>California</td>
<td>32,783</td>
<td>38,961</td>
<td>38,013</td>
<td>16,514</td>
</tr>
<tr>
<td>Utah</td>
<td>733</td>
<td>1,012</td>
<td>1,654</td>
<td>964</td>
</tr>
<tr>
<td>Northwestern states</td>
<td>26,838</td>
<td>29,710</td>
<td>31,077</td>
<td>22,240</td>
</tr>
<tr>
<td>Other western states</td>
<td>2,417</td>
<td>4,435</td>
<td>6,250</td>
<td>3,519</td>
</tr>
<tr>
<td>Midwestern states</td>
<td>10,237</td>
<td>4,202</td>
<td>12,287</td>
<td>31,612</td>
</tr>
<tr>
<td>Southern states</td>
<td>842</td>
<td>2,663</td>
<td>3,585</td>
<td>10,216</td>
</tr>
<tr>
<td>Other</td>
<td>127</td>
<td></td>
<td></td>
<td>143</td>
</tr>
<tr>
<td>Total</td>
<td>73,997</td>
<td>80,983</td>
<td>92,866</td>
<td>85,208</td>
</tr>
</tbody>
</table>

**Table 3. Total receipts of cheese by area of origin at Los Angeles and San Francisco for selected years**

<table>
<thead>
<tr>
<th>Area of origin</th>
<th>Total receipts 1935</th>
<th>Total receipts 1938</th>
<th>Total receipts 1941</th>
<th>Total receipts 1944</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,000 pounds</td>
<td>1,000 pounds</td>
<td>1,000 pounds</td>
<td>1,000 pounds</td>
</tr>
<tr>
<td>California</td>
<td>5,382</td>
<td>4,817</td>
<td>5,068</td>
<td>4,911</td>
</tr>
<tr>
<td>Utah</td>
<td>779</td>
<td>734</td>
<td>524</td>
<td>430</td>
</tr>
<tr>
<td>Northwestern states</td>
<td>14,302</td>
<td>17,919</td>
<td>20,397</td>
<td>10,616</td>
</tr>
<tr>
<td>Other western states</td>
<td>115</td>
<td>433</td>
<td>391</td>
<td>148</td>
</tr>
<tr>
<td>Midwestern states</td>
<td>4,838</td>
<td>7,110</td>
<td>7,154</td>
<td>10,341</td>
</tr>
<tr>
<td>Southern states</td>
<td>24</td>
<td>615</td>
<td>1,562</td>
<td>4,007</td>
</tr>
<tr>
<td>Eastern states</td>
<td>399</td>
<td>407</td>
<td>473</td>
<td>410</td>
</tr>
<tr>
<td>Total</td>
<td>25,839</td>
<td>32,227</td>
<td>35,569</td>
<td>30,863</td>
</tr>
</tbody>
</table>

markets is between a third and a half as large as the receipts of butter (table 3). The amount ranged from 25,839,- 000 pounds in 1935 to 35,569,000 in 1941. California contributed relatively less cheese than butter, and the midwestern and the northwestern states contributed relatively more. Except for 1944, Oregon, Washington, and Idaho furnished more than half of the cheese on these two markets. Utah's contribution amounted to 3.0 percent in 1935 and to 1.4 percent in 1944.

California markets also obtain a large part of their pork, beef, lamb and mutton supplies from the same general areas from which the livestock products are drawn. The western states ship grass-fatt cattle and lambs to the California markets as well as a large part of the feed-lot finished animals. They also supply feeder stock for the feed lots of California. However, the numbers of slaughter animals from the western states are not adequate so fat animals from the Midwest also find their way to the coast. In addition large numbers of hogs and hog products are shipped westward from the Corn Belt.

In the markets of California, Utah has an almost unlimited outlet for all kinds of livestock and livestock products. Those markets will also take large quantities of feed grains, late potatoes, and canned vegetables except tomatoes. Also because of different seasons of maturity considerable quantities of fresh fruits and vegetables can be sold there. Apparently the only essential limitation to the volume of our sales in that area is the capacity of Utah farms and ranches to produce the kind and quality of products wanted.
PASTURE STUDIES
(Continued from page 10)

...tion with ladino, alsike or strawberr...y clover. Reed canary was not included in the mixtures previously discussed but in still another series, under similar conditions, it appeared very promising.

On the basis of 2-years’ experimental data from a fertile field at the Dairy Experimental Farm grazed rather heavily three times each season, mixtures 15, 11, and 8 were superior to the standard mix in yield and mixtures 11 and 8 were also superior in palatability. There is reason, though not experimental evidence, to believe that the addition of red clover to these mixtures would increase the yield considerably during the first 2 years. Mixture 22 exceeded mixture 15 by 5 tons per acre each season. It is clear that dropping tall fescue from mixture 22 would greatly improve its palatability. What effect this would have on total yield is not known.

Experimental evaluation of pasture mixtures is something new at the Utah Station. The work is just beginning. There is urgent need for more investigation in this field. Many additional species combinations have possibilities. We need to know more about such mixtures as 22 with tall fescue dropped or replaced by reed canary, both with and without alfalfa.

If further results follow present trends it appears obvious that recommendations for pasture mixtures in Utah will be drastically revised in the near future.

ALFALFA SEED PRODUCTION
(Continued from page 3)

other insecticides. An increased knowledge of the importance and value of honeybees as pollinators of alfalfa bids fair also to become the means whereby in the areas where the wild bee populations are low and seem to have decreased more slowly and are intimately associated with the microbiological processes of the soil. Hence any permanent system of agriculture must maintain the organic matter of the soil.

The functions of this organic matter are eight fold:

1. Organic matter in its various stages of decay gives to soil its dark brown or black color. The absorption of heat and consequently the temperature of a soil depends to a marked degree upon its color. The microbiological activity of the soil is a function of its temperature which in turn is a function of its productivity.

2. The decay of fresh organic matter in the soil generates heat. This at times may be sufficient to increase the temperature of the soil. Albrecht calculated that an acre of the better corn belt soils in Iowa produces each hour, owing to the decomposition of organic material, sufficient heat to convert 17 pounds of water into steam at 100 pounds pressure.

3. Organic matter changes the structure of the soil. When added to a light or clay soil it tends to spread the particles thus causing the soil to increase in volume. This increases the pore space and hence the quantity of oxygen entering, and in this manner aerobic microbial activities are increased. Partly decayed organic materials have a tend-
organic manures may loosen some soils' tilth. Excessive quantities of fresh organic material readily distributes appreciable extent. It does not manifest this property to an appreciable extent.

Organic matter is the great reservoir in which is held the nitrogen of the soil and considerable of the phosphorus and potassium. The plant residues which reach the soil carry nitrogen, phosphorus, and potassium in organic forms. As bacteria decompose the organic matter they liberate plant nutrients. Moreover, as the minerals are rendered soluble they are taken up by other plants or built over into other compounds by bacteria. Hence these essential elements are constantly passing from the soluble to the insoluble and back again. Were this not the case even greater quantities of plant food would be leached from the soil. The speed with which this transformation occurs depends upon the organic matter of the soil.

As the organic materials of the soil decay there are produced various acids which react with insoluble plant nutrients and render them available. Many economic systems of permanent soil fertility are based on the following: Plant nutrients are added to the soil in cheap forms or those already in the soil in an insoluble form are rendered available as needed by keeping the soil well supplied with plant residues and organic manure. A ton of manure is worth far more than its nitrogen, phosphorus and potassium. It may render available as it decays considerably more plant food than it carries. The fresh organic materials and not the old decayed materials are of greater value in this respect.

The heterotrophic microorganisms of the soil require organic carbon for growth and metabolic activities. They may use it for building material, energy, or as accessory growth substances but in most cases the kind and quantity of organic material in the medium are the factors governing their activities.

Loose soils, low in organic material are readily eroded by wind and water. Organic material enables the surface to absorb and retain more of the water. It also has a granulating effect upon the soil reducing the tendency to run together, hence keeps the soil open so there is less runoff and less erosion.

The increase in nitrogen resulting from a readily available supply of organic material is appreciable in some soils. Greaves and Nelson found that one acre foot of the Greenville unirrigated fallow soil which had received yearly for eleven years 5 tons of barnyard manure gained 486 pounds of nitrogen or 44 pounds per acre annually over that supplied in the manure. In a second experiment, Greaves and Bracken found that a soil to which various plant residues had been added and kept in a greenhouse under optimum conditions for 10 years gained from 6 to 18 pounds of nitrogen per acre annually. In still a third test extending over a period of 19 years, made on a soil naturally devoid of Azotobacter, bacteria which live free in the soil and make atmospheric nitrogen so it can be used by plants, but inoculated with these organisms and variously treated with organic manures, Greaves and Jones found an annual gain of from 27 to 38 pounds of nitrogen per acre. Each of these soils carried an abundant supply of all the essential plant nutrients except nitrogen, which was low. The soils were supplied with organic material and contained an abundant supply of calcium, magnesium carbonate, and phosphorus. Those which were kept in the greenhouse had an optimum temperature throughout the year. Hence it appears that soils with an optimum supply of limestone and carrying an abundance of available plant nutrients except nitrogen when supplied with a good source of organic matter may gain annually from 6 to 44 pounds of nitrogen owing to nonsymbiotic nitrogen-fixing microorganisms.

Soil microorganisms also play another part which is of special importance in our western soils which are often high in insoluble phosphorus. The microorganisms may either directly render the phosphorus of the soil more soluble or they may build it over into their bodies. The phosphorus, on the death of the organism, would be returned to the soil in a readily available form. Fifty percent of the nitrogen of Azotobacter is changed within six weeks, so it can be used by plants and there is every reason for believing that the phosphorus would be liberated just as readily.

Moreover, many soil organisms produce nitrous, nitric, sulfuric, formic, acetic, lactic, butyric, and other acids, the quantity and kind of each depending upon the specific organisms and upon the substance on which they are acting. These all come in contact with insoluble substances which may be rendered soluble. They have a high solvent power for the insoluble phosphates. The resulting salts of calcium would be further attacked by bacteria with the formation of calcium carbonate.

Whether these processes give rise to an increase in the water-soluble plant food of the soil depends upon the composition of the soil and whether the products of the breaking down process exceed the products of the building up reactions. However, we must not lose sight of the fact that, although many of the organic phosphorus constituents produced by the action of bacteria may not be soluble in pure water, they may be more available to the living plant than are the constituents from which they were at first derived. Moreover, there is abundant literature showing that the addition of organic matter to the soil often increases the phosphorus of the plants grown upon the soil.

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