THE KIND of agricultural production of an area and also its profitability is markedly influenced by the available market outlets. Agricultural producers are constantly adjusting their farming operations to changing markets and market demands. In general, however, the adjustments in production lag behind the changes in market outlets. During the past couple of decades the farmers of Utah have been experiencing a gradually changing market for many commodities. This change, from the eastern markets to those of the west coast, has been accelerated by the war and by wartime controls. Following the release of government controls there may be a temporary swing back, but the long time trend is toward the sale of more of Utah's agricultural produce on the California markets.

One of the reasons for the shift to the California market is found in the trend of population in California. The Bureau of the Census estimate of the total population as of July 1, 1944, was 8,747,000. This represents a 41.7 percent increase since July 1, 1935. During the same period the total population of the United States increased only 4.2 percent and of Utah 15.5 percent. (These data do not include U. S. military personnel stationed outside the United States.) This great increase in

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 63, 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 Bemore 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 reseeded 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.
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.
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 Department of Rural Sociology, has just published a bulletin on Utah housing. This article is based on part of the material gathered for this publication.

RADIOS are one of the newer home assets that have come in the wake of electrification. Throughout America electric conveniences are rapidly increasing 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 emancipating 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 convenience, Utah leads the Mountain states, the Pacific states except California, 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 behind Rich 0.2 percent. Many rural Utah counties lag in ownership of radios. 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 percentage. 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 current 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>25.4</td>
</tr>
<tr>
<td>Total for Utah</td>
<td>92.4</td>
<td>90.2</td>
<td>86.2</td>
</tr>
</tbody>
</table>
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)
Symptoms of Peach Mosaic

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, misshapen 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 Elberta variety (Courtey U. S. Dept. Agr. Cir. 427)
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 experiment 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.

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

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**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

...
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 rye 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 predominate. 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 less 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 seventeenth 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 and red clover.

### 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</th>
</tr>
</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</td>
<td>13.71 19.52 33.23</td>
<td>Moderate Perennial</td>
<td>2 yr. to low</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 2 yrs.</td>
<td>2 yr.</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 2 yrs.</td>
<td>2 yr.</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 Perennial</td>
<td>1 yr.</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 2-3 yrs.</td>
<td>2 yr.</td>
</tr>
<tr>
<td>15</td>
<td>Orchard 8, smooth brome 10, alfalfa 3, ladino clover 2 (fig. 3)</td>
<td>8.44 14.14 22.78</td>
<td>Moderate Perennial</td>
<td>2 yr.</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 Perennial</td>
<td>2 yr.</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 Perennial</td>
<td>2 yr.</td>
</tr>
<tr>
<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 Perennial</td>
<td>2 yr.</td>
<td></td>
</tr>
</tbody>
</table>

* To obtain approximate air-dry weights, multiply green weights by .23
By CHARLES J. SORENSON

CATTLE 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 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-eights 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 encapsulated 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 remained lying on the surface. Some of them did each of these three things. How-

Fig. 1. Inside surface of the hide of a yearling Holstein steer killed at Logan, March 1945, containing 209 cattle-grub cysts. Nearly all grubs had each cut a hole through to the surface of the hide. Grubs varied in size from $\frac{3}{16}$ to $\frac{11}{16}$ inches long and from $\frac{3}{16}$ to 7/16 inches in diameter. Their color ranged from milk white to grayish-brown and dark brown

A PRELIMINARY STUDY OF CATTLE GRUBS IN NORTHERN UTAH
higher than in the greenhouse, completed their pupal period in 21 and 24 days, respectively.

One of these two individuals was first to emerge to the fly stage on May 23. The other one was second to reach this stage on May 26. The first fly emerged in the greenhouse on June 2 having spent 34 days in the pupal period.

For the purpose of obtaining some information concerning the length of individual adult life, the flies were kept until death in the same ventilated pint glass jars in which they had spent their pupal periods. The cellucotton was periodically moistened with water. During warm portions of the day these flies were exceedingly restless flying about in the jars attempting to find an avenue of escape. So vigorous were these efforts that they usually broke off portions of their wings. In this confinement the length of life of various flies varied from 2 to 9 days with a mean of 5.57 days.

During April and May, 1945, 44,443 head of dairy and range cattle were treated in Utah for cattle grub control. Two treatments, one month apart, were recommended and usually made with rotenone, either as a dust or spray. Counties of Utah participating in the 1945 cattle-grub control program and number of cattle receiving treatment were the following: (1) Beaver, 1600 head; (2) Box Elder, 5,632 head; (3) Cache, 20,000 head, constituting approximately 80 percent of the cattle owned in the county. Of the total number treated, 15,997 head, mostly dairy animals, received treatment by the dusting method and 4,003 head of range cattle were sprayed. (4) Emery, 400 head; (5) Millard, 100 head; (6) Sanpete, 400 head; (7) Summit, 930 head; (8) Wayne, 55 head; (9) Weber, 12,350 head. Figures for the number of cattle treated in various counties were obtained through the cooperation of the agricultural agent in each county.

PEACH MOSAIC
(Continued from page 6)

berta, J. H. Hale, Rio-Oso Gem and others affected with mosaic may exhibit misshapen or what is commonly called bumpy fruit (fig. 5, A and B). This bumpiness may appear in the form of round, raised areas or islands of surface tissue surrounded by depressions, or as various types of irregular bumps and depressions, or as ridges, which frequently are more pronounced along the suture. The symptoms appearing on the green fruit become more marked as the season advances. Mosaic-affected fruit thus may be severely dwarfed, exhibiting a marked contrast in size and shape to normal fruit. Mosaic-diseased fruit may ripen as much as several days to a week or more later than normal fruits and the texture is coarse and the flavor inferior.

Transmission and Spread of the Mosiac 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 definitely 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.

There is no evidence to show that peach mosaic can be 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
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 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 Montgamet apricot exhibited mosaic symptoms. However, all these trees so inoculated, whether expressing symptoms or not, were shown to carry the virus, which could be reincoculated into healthy Elberta 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 growers 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 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 trees or orchards.

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</th>
<th>1938</th>
<th>1941</th>
<th>1944</th>
<th>1935</th>
<th>1938</th>
<th>1941</th>
<th>1944</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cases</td>
<td>cases</td>
<td>cases</td>
<td>cases</td>
<td>percent</td>
<td>percent</td>
<td>percent</td>
<td>percent</td>
</tr>
<tr>
<td>California</td>
<td>14,260</td>
<td>15,445</td>
<td>17,781</td>
<td>20,120</td>
<td>87.4</td>
<td>84.5</td>
<td>81.9</td>
<td>68.7</td>
</tr>
<tr>
<td>Utah</td>
<td>223</td>
<td>204</td>
<td>1,192</td>
<td>3,438</td>
<td>1.4</td>
<td>1.1</td>
<td>5.5</td>
<td>11.7</td>
</tr>
<tr>
<td>Northwest states*</td>
<td>1,759</td>
<td>1,895</td>
<td>1,788</td>
<td>3,372</td>
<td>10.8</td>
<td>10.4</td>
<td>8.2</td>
<td>11.5</td>
</tr>
<tr>
<td>Other western states*</td>
<td>35</td>
<td>32</td>
<td>153</td>
<td>163</td>
<td>.2</td>
<td>.2</td>
<td>.8</td>
<td>.6</td>
</tr>
<tr>
<td>Midwestern states</td>
<td>20</td>
<td>685</td>
<td>564</td>
<td>2,064</td>
<td>.1</td>
<td>3.7</td>
<td>2.6</td>
<td>7.1</td>
</tr>
<tr>
<td>Southern states</td>
<td>11</td>
<td>13</td>
<td>227</td>
<td>117</td>
<td>.1</td>
<td>.1</td>
<td>1.0</td>
<td>.4</td>
</tr>
<tr>
<td>Total</td>
<td>16,310</td>
<td>18,274</td>
<td>21,705</td>
<td>29,274</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

* Oregon, Washington and Idaho

† Montana, Wyoming, Colorado, New Mexico, Arizona, and Nevada

**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>166</td>
<td></td>
</tr>
<tr>
<td>1936</td>
<td>1,082</td>
<td>1,080</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>2,924</td>
<td>2,476</td>
</tr>
</tbody>
</table>

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

† Washington County.

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 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 trees or orchards.

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.

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 3.5 percent. The proportion from Utah increased from 3 to 4 percent of the total. The proportion from the southern and eastern states also increased.

Butter

Butter is another commodity that Utah is in an excellent position to place on the California markets. While Utah butter has been sold there for a number of years it constitutes a small proportion of the total butter on the market. In 1935 the receipts from Utah amounted to just 1.0 percent of the total receipts (table 2). In 1938 Utah furnished 1.8 percent of the total which was the largest proportion during any of the selected years. The three Pacific northwestern states, and the midwestern states were the most important sources outside California with the northwestern states being most important except for the war year 1944. In 1944 the midwestern states and the southern states together provided approximately half of the butter received on these two markets. The elimination of wartime controls and activities will no doubt cause a return to a condition more like 1941, but even then there should be a good opportunity for increasing the sale of Utah butter in these markets.

Cheese

The total volume of cheese received on the Los Angeles and San Francisco 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-fat 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.

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>1935</th>
<th>1938</th>
<th>1941</th>
<th>1944</th>
</tr>
</thead>
<tbody>
<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>Southern states</td>
<td>10,257</td>
<td>4,202</td>
<td>12,287</td>
<td>31,612</td>
</tr>
<tr>
<td>Other states</td>
<td>127</td>
<td>143</td>
<td>143</td>
<td>2</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>1935</th>
<th>1938</th>
<th>1941</th>
<th>1944</th>
</tr>
</thead>
<tbody>
<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>1,026</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>Southern states</td>
<td>115</td>
<td>433</td>
<td>391</td>
<td>148</td>
</tr>
<tr>
<td>Eastern states</td>
<td>115</td>
<td>433</td>
<td>391</td>
<td>148</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>

NEW PUBLICATIONS


This bulletin reviews the history and status of the cherry rootstock problem in Utah and the United States and reports 14 years' results from a sweet cherry rootstock 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 morello as a rootstock for sweet cherries.


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 non-farm 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.
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 more efficient seed setting may be assured in the areas where the wild bee populations are low and seem to have a near future.

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

A general rearrangement in the Veterinary Science Department has brought Dr. M. L. Miner, formerly in charge of the Provo Veterinary Laboratory, to Logan as acting head of the Department. J. Newell Allred has been hired to take over the work at the Provo Laboratory. Dr. Allred took his A. B. degree at the Arizona State Teachers College and his D. V. M. from Colorado State College. He did veterinary work in Ogden before joining the Station staff.

A new and interesting turkey blood samples for pullorum disease is in charge of Professor Harold Nielson. The work this year is being done in St. George in connection with Dixie College.

The new division of Soils, Fertilizers and Irrigation of the U. S. Bureau of Plant Industry, Soils and Agricultural Engineering is represented on the campus by Dr. Omer J. Kelley and Dr. James L. Haddock. These men will conduct experiments in crop rotations and soil treatments in order to evaluate the present condition as to soil fertility and to devise improved soil management practices.

Dr. Kelley comes to Logan from the guar-yule research project at Salinas, California, and Dr. Haddock from Washington State College at Pullman.

Dan F. Trussell, of the Soil Conservation Service and in charge of soil conservation surveys in Utah, has been transferred to Logan to work cooperatively with the Station on the soil survey in the state. He will work with Dr. D. S. Jennings and LeMoyne Wilson of the Station staff.

Mr. Trussell is a graduate of the University of California and did soil survey work for that institution. He has been stationed in Salt Lake City for the past six years with the Soil Conservation Service.

THE FUNCTIONS OF ORGANIC MATTER IN THE SOIL

By J. E. GREAVES

THAT there is a relationship between the organic matter of the soil and its productivity has been recognized for centuries. Virgin soils are highly productive and they decrease in productivity as they are cultivated and there is a corresponding decrease in their organic content. Both factors decrease rapidly at first and as time goes on they decrease 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 material 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-
ency to stick together and when applied to a loose sandy soil may improve its tilth. Excessive quantities of fresh organic manures may loosen some soils excessively and in this way be injurious.

(4) Organic matter absorbs large volumes of water and hence increases a soil's water holding capacity. It also makes drainage possible. Water when applied to a soil containing abundant organic material readily distributes itself throughout the soil whereas the same soil devoid of organic material does not manifest this property to an appreciable extent.

(5) 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.

(6) 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 decomposes considerably more plant food than it carries. The fresh organic materials and not the old decayed materials are of greater value in this respect.

(7) 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.

(8) Loose soils, low in organic matter 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 which 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.