Changes In The Economic Position Of Agriculture

By W. PRESTON THOMAS

THE Korean War and threat of a world war has accelerated inflation, increased prices, and created changes in demands and in production programs. During such inflationary periods there is always a strong demand for raw products. Hence the demand for agricultural products in 1951 will be favorable. Prices and incomes received by farmers will undoubtedly be substantially higher than they were in 1949 or the first half of 1950. Resulting from the increased prices and the expected larger agricultural production for 1951, cash receipts will likely be increased about 10 percent. During this inflationary period, production and living costs will increase and there will be difficulties in obtaining farm supplies and needed labor.

During 1951 production costs are not likely to increase at the same rate as prices received for farm products. It is estimated that the net farm income for 1951 will be about 15 percent above the level of 1950, resulting from the favorable relationship between prices received and cost of production. Farm living costs will also be higher but the real income of the farm operator and his family should be improved over that of the past two years, but will be below the peak of 1947-48.

The large demand for agricultural products will be supported by full employment of industrial workers, high wages, increased national income, military demands for food and fiber, and the improvement of the foreign market resulting from a significant improvement in available dollars in foreign countries.

Inflationary Trends

The federal fiscal policy has been drastically changed by the defense program since the outbreak of the Korean War. Large additional appropriations for defense purposes have been authorized, and for the coming year federal expenditures will be greatly increased. The increase of defense expenditures directs the resources of the country into production for defense purposes rather than for the production of civilian goods. Increased federal appropriations, which put more money into circulation, and the reduction of civilian goods available are inflationary pressures. These pressures can only result in higher prices. Control of prices may decrease the rate, but controls will not remove the cause or pressure on prices. The basic difficulty is that incomes are rising at a time when sup-

(Continued on page 18)
Radioactive Elements In Agricultural Research

Joseph Woolley, laboratory assistant, and Dr. F. B. Wann determine the radioiron content of plant ash samples. The sample is placed in the lead shield containing the Geiger tube (center) and the radioactivity is automatically recorded by the counters.

Preparing radioiron solutions for experimental work requires handling by "remote control" behind thick shields of lead brick. Progress of the treatment is observed by means of a mirror on the side.

Radiations from radiophosphorus are not as penetrating as those from radioiron. Here Dr. Biddulph is pipetting the radioactive liquid behind a lucite screen.

Taylor Cottle, laboratory assistant, and Dr. Biddulph inject rat with radiophosphorus to study the role of phosphorus in metabolism. (For story see page 4)
IT IS highly desirable to know the weight of steers at various periods during the fattening process so that the rations can be evaluated, rate of gain calculated, or show ring classification determined. Frequently suitable scales on which to weigh animals are not readily available to many Utah farmers. It would be useful to these farmers if some simple but reasonably accurate means of estimating weight based on body measurements could be devised.

In an effort to develop a suitable formula for estimating weight for steers of the beef type common to Utah, various measurements were taken on 258 steers that were exhibited at the Ogden and Salt Lake Junior Livestock shows. It was apparent that as steers grow, develop, and fatten they become taller and longer, the width and depth of body increases, and the circumference around the chest and paunch becomes larger. However, considerable variation existed among the steers of the same weight for the various measurements. Also, some measurements could be taken with more apparent accuracy than others. The one single measurement that was highly accurate and yet easily taken was the heart girth.

A suggested equation based on heart girth alone for Utah beef steers is: Live weight = 1.04 \[27.5758 \text{(heart girth in inches)} - 1049.67\].

The calculated live weight values for steers of certain heart girth measurements would be as follows:

<table>
<thead>
<tr>
<th>Heart Girth (inches)</th>
<th>Calculated Live Weight (pounds)</th>
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In taking the heart girth measurement the animal should be standing with all four legs squarely under the body and with the head up in a normal position. The tape should be passed around the body just back of the shoulders at the smallest circumference and pulled up snugly.

The formula is thought to be accurate within the range from which it was developed and for similar steers. This means that it can be applied to steers of good and choice condition and that have heart girth measurements within the range of 63 to 80 inches. It will, obviously, not be applicable to steers smaller or larger in heart girth than the range specified.

**VALUE OF BODY MEASUREMENTS FOR ESTIMATING WEIGHT AND CONDITION IN STEERS**

By JAMES A. BENNETT

In an effort to develop a suitable formula for estimating weight for steers of the beef type common to Utah, various measurements were taken on 258 steers that were exhibited at the Ogden and Salt Lake Junior Livestock shows. It was apparent that as steers grow, develop, and fatten they become taller and longer, the width and depth of body increases, and the circumference around the chest and paunch becomes larger. However, considerable variation existed among the steers of the same weight for the various measurements. Also, some measurements could be taken with more apparent accuracy than others. The one single measurement that was highly accurate and yet easily taken was the heart girth.

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**Estimating Condition**

The measurement data indicated that as a young steer grows and fattens he becomes larger in all respects but since the increase in size is not equal for all body measurements, it was thought that a means of estimating condition, or degree of finish, might be developed from the measurements. Height at withers is known to be a measurement of skeletal size and is only slightly influenced by environment over a short period of time such as during the fattening period. Heart girth, paunch girth, and weight on the other hand increase rapidly with deposition of flesh and are strongly influenced by the level of nutrition. Experimental results indicate that the dressing percentage is a reliable index of the amount of fat an animal's body contains. An equation for estimating dressing percentage including weight, in pounds, and height at withers, heart girth, and paunch girth in centimeters, was therefore developed and is as follows:

\[
\text{Dressing percent} = 44.08 - 0.0029(\text{weight}) - 0.1155(\text{height}) + 0.2658(\text{heart girth}) - 0.0801(\text{paunch girth})
\]

This equation, though not highly accurate, provides an indirect means of estimating degree of fatness, or condition, in steers. It is definitely limited in its application for comparison purposes, however, to steers that have the same amount of "fill."
THE use of radioactive elements in agricultural research, both with plants and animals has many possibilities for the discovery of life processes heretofore unknown. That certain elements were needed in plant and animal nutrition has been known for some time. But the exact function of these elements in the life processes of the plant or animal has not been definitely known. For example, it has been known for many years that iron is required for the production of the normal green color in plants. More recently it has been established that zinc, manganese, boron, copper, and molybdenum are essential for the nutrition of plants. But the exact function of these elements is not known completely; however, in the absence of any one of them, plants show symptoms of malnutrition.

All chemical elements may have two or more forms known as isotopes. If one of these is made radioactive it is then referred to as a radioisotope. These radioisotopes have the same chemical properties as ordinary elements; they are apparently absorbed, translocated, and utilized by plants just as readily as non-radioactive elements. But the radioisotopes give off radiation which can be detected by a Geiger counter so that their movement into and throughout a plant can be traced by analyzing various plant tissues with the counter. In this way it is possible to detect the presence of radioisotopes in the plant tissues and, it is hoped, within the cell itself. By breaking cells down into their various constituents and analyzing these with the counter it may be possible to determine the exact location of the functioning element and thus establish some reason for its need. This is the approach that is being used by the Utah Station in connection with the study of the problem of iron chlorosis. If the actual location and function of iron in plant cell metabolism can be determined, an intelligent basis for a permanent correction of the chlorotic condition may be found.

Another problem that is being attacked at the Utah Station by the use of radioisotopes is the availability and utilization of phosphates by plants. By applying radiophosphorus to the soil it is possible to determine the effect of various soil conditions on its availability as well as the absorption and translocation of this element by the plant.

The Station is also studying the influence of radioactive isotopes on reproduction in animals. Phosphorus is important in the normal metabolic processes of living tissue, and is a normal constituent of the proteins of the cell nucleus. Since male sperm cells (spermatozoa) are composed predominantly of nuclear material, these cells are ideal for studying the role of phosphorus in metabolism. Studies are being made on the utilization of radioactive phosphorus and the factors influencing the use of this element in the normal metabolism of these cells. Laboratory animals have been injected with the radioactive phosphorus and it has been found that their spermatozoa become radioactive. Whether such spermatozoa are capable of fertilizing viable ova will be determined in future studies.

These studies are under the direction of Dr. D. W. Thorne of the Agronomy Department, Dr. F. B. Wann of the Botany Department, and Dr. Clyde Biddulph of the Physiology Department.

A grant of $10,000 from the Atomic Energy Commission supplements regular Station funds on these projects and has made it possible to provide some of the special equipment needed for this type of research and for the employment of research assistants.

This is expensive research because of the special precautions that must be taken to guard scientists and others from the radiations of the radioactive materials. Special laboratories lined with lead have been constructed to confine the radiations to limited areas. A large amount of new equipment has been purchased to begin this new type of research.

The research with radioactive elements is cooperative with the U. S. Department of Agriculture and the Atomic Energy Commission.

Radioactive Elements In Agricultural Research

Laboratory assistants, Michael Marcour and Joseph Woodley prepare samples of plant ash for the determination of radioactive iron. Portions of the ash solution are evaporated in small flat dishes which are then placed under Geiger tubes for counting. The plant work is a cooperative project between the Departments of Agronomy and Botany. Dr. D. W. Thorne and Dr. F. B. Wann are the leaders.
Legume-Grass Mixtures For Hay

By R. J. EVANS

When farmers plant pastures in Utah they usually use mixtures containing one or more grasses and one or more legumes. The advantages of such mixtures over pure species in pastures are well known, and have caused farmers to wonder if it would not be advantageous to use grass-legume mixtures for hay, also, rather than using one pure species such as alfalfa or red clover.

In experiments conducted at the Greenville Farm in North Logan from 1943 to 1946, hay yields were not increased by seeding perennial forage grasses with alfalfa. A mixture of red clover and late timothy, however, gave higher forage yields than red clover grown alone or in association with smooth brome or orchard grass.

How the Tests Were Made

These experiments were conducted on a deep, fertile, well-drained soil classed as Millville clay loam that is well-suited to the production of alfalfa, red clover, and the forage grasses that were tested.

Superphosphate fertilizer was applied at the rate of 200 pounds per acre and worked into the soil during seedbed preparation. There were 10 treatments—both alfalfa and red clover were seeded alone and in mixtures with smooth bromegrass, with orchard grass, and with late timothy; red clover was also seeded with early timothy.

The alfalfa and clover were seeded with a drill at the rate of 8 pounds per acre. The grasses were broadcasted by hand and raked in with garden rakes. Late timothy was seeded at two rates—5 and 10 pounds per acre. Early timothy, orchard grass, and smooth bromegrass were seeded at the rate of 5, 10, and 8 pounds per acre, respectively.

Ranger alfalfa and Cumberland red clover were the legume varieties used.

In harvesting, a 5 foot strip was cut lengthwise through the middle of the plots, weighed green, and sampled at the time of harvesting, for dry weight determinations. The samples were reweighed after being dried to around 15 percent moisture. All plots were cut at the same time, with the alfalfa and clover being used as the index of the best stage for harvesting.

(Continued on page 19)
A Program For Control Of Virus Diseases Of Stone Fruits

By B. L. RICHARDS

THE virus diseases in Utah orchards taken as a group constitute a serious, if not the most serious, threat to profitable stone fruit production in Utah. These diseases reduce yields, lower the quality of the fruit and, since virus-affected trees do not recover, the viruses accumulate in the orchards and gradually cause orchard degeneration and ultimately orchard destruction. The ultimate objective of all research studies on these virus diseases now under way at the Utah Agricultural Experiment Station is their

DR. B. L. RICHARDS is head of the Department of Botany and Plant Pathology and did the original research in Utah on virus diseases of stone fruits.

When infected with the western x virus both sweet and sour cherries growing on mazzard or other sweet cherry rootstocks produce reliable diagnostic symptoms in the fruit only. The virus therefore cannot be detected in trees in their pre-fruiting stages or in the older bearing trees when ripening or ripened fruits are not present on the tree. Therefore only by indexing can the virus be detected in trees when diseased fruits are absent. Young Napoleon on mahaleb rootstock provides a most reliable index tree as such young trees will rapidly die when inoculated with the western x virus (fig. 2). Spread of the western x virus may be disastrously rapid from apparently healthy but virus-infected trees (fig. 3)
control. On the other hand, effective control is made possible only through an understanding of the disease to be controlled. The importance of the relationship of control practices to basic knowledge concerning the diseases has never been more clearly established than in the fight against the stone fruit viruses. Not only must research workers discover the facts about diseases as a basis for working out control procedures but orchardists and nurserymen must become aware of the nature and the potential destructiveness of these diseases before a control program can be effectively initiated and properly executed.

Present Status of Our Knowledge of Virus Diseases of Stone Fruits in Utah

While there can be no definite assurance that all the virus diseases in Utah orchards have been discovered, 26 virus and virus-like diseases have been recognized and described; 6 in peach, 10 in sweet cherry, 6 in sour cherry, and 3 in prunes. These are as follows:

In peach
- Western x decline
- Ring spot
- Asteroid spot
- Dixie rusty mottle
- Peach mosaic
- Leaf mottle

In sweet cherry
- Western x wilt & decline
- Western x little cherry
- Necrotic ring spot
- Yellows (without symptoms)
- Necrotic rusty mottle
- Dixie rusty mottle
- Utah mild rusty mottle
- Leaf crinkle
- Deep suture
- Rugose mosaic

In sour cherry
- Western x wilt & decline
- Western x little cherry
- Sour cherry yellows
- Ring spot
- Necrotic rusty mottle
- Dixie rusty mottle

In prune
- Prune dwarf
- Leaf mottle
- Leaf spot

Development of specific controls suited to each type of disease. On the other hand, there are general practices which, if effectively applied, will decrease losses greatly.

The Basic Nature of Viruses as Related to Diseases and to Disease Control Practices

A few facts must be understood about the nature of stone fruit viruses and their relation to trees which they invade and in which they induce disease. These facts provide the foundation of a control program. First: The virus particles responsible for disease are exceedingly small; they become so intimately associated with the living protoplasm that they cannot be separated from it, especially under
field conditions. Infected plants are seldom killed outright by the virus. They do not recover and there are no cures. For this reason infected trees

Fig. 6. (Above) Necrotic ring spot symptoms on sweet cherry leaves. The tattered condition results from the dropping out of necrotic areas. The leaf on the right is normal

Fig. 7. (Left) Four-year-old Elberta peach tree one year after inoculating with ring spot virus. The inoculated branch on the left was killed during the winter following infection. Bark cankers are developing on the trunk and are extending upward on the other main branches

The ring spot virus group is comprised of a number of related viruses which vary greatly in their effect on any one host plant. Some forms of the virus are extremely severe. Others are so mild as to be imperceptible even in the most susceptible host plants. Indexing becomes the only means of detecting the various forms of this virus in a wide range of hosts. Peach and sour cherry are most generally employed as index hosts for different forms of ring spot virus

Fig. 8. (Below) Symptoms in Montmorency leaves produced by sour cherry yellows virus. Sweet cherries and probably many other stone fruits are symptomless carriers of the sour cherry yellows virus. In Utah sour cherry varieties provide the only reliable index hosts known
Basic Operations Essential for Effective Control of Stone Fruit Virus Diseases in Utah

Virus diseases are seldom completely eradicated. Even partial control must be justified either from the immediate economical advantage to the grower or from the long range social viewpoint in which the prevention of spreading to other regions with subsequent losses is involved.

Disease control is a complex problem involving a number of practices, all of which might be costly. Each of the 26 different virus diseases in Utah presents different problems in control. Any effective control program must include the following 5 elements:

First, a continuation and intensification of our research program. Effective control is contingent upon a thorough knowledge concerning all the diseases involved. If there are other diseases not yet recognized these must be found. Research must be continued to discover all of the basic facts regarding each disease—its host range, economic importance, insect vector, and such other relationships as may be necessary to perfect control operations.

Second, a further perfection and extension of efforts and machinery to prevent the introduction of virus diseases into the state. Achievement toward this end will demand a mutual understanding of common problems and the effective cooperation of workers in the various states. Effectiveness of this cooperation again will depend upon the effectiveness of the research on stone fruit virus diseases in each state. The threat of such destructive diseases as the albino of cherry in Oregon, the little cherry in British Columbia, or the yellowbud mosaic of peach in California cannot be ignored.

Third, a well organized clean-up or removal program. The fact that plants do not recover from virus infections and the further fact that each infected plant provides a reservoir of infective material make a removal program imperative. Even though a virus spreads slowly, or not at all, it may still be necessary to remove diseased trees.

Fourth, an effective search and indexing program for procurement of virus-free budwood and rootstocks from our present supply of reliable varieties of stone fruits. Virus diseases are so generally distributed in the state that our present available virus-free budwood sources are critically limited and are rapidly disappearing. While our knowledge is at present somewhat incomplete, it should be put at the service of the nurserymen and producers to prevent the use of virus-infected budwood and understocks which result invariably in the further spread of disease. This type of service will involve rather extensive and costly indexing procedures. However, control programs are effective only if replacements can be made from reliable virus-free stocks.

Fifth, the production of reliable virus-free budwood and understocks for nurserymen and growers. A budwood production service of the type demanded could be accomplished in two ways:

(1) By setting up of budwood mother-tree blocks within privately owned nurseries with a continuing indexing and certification service provided jointly by the Utah Agricultural Experiment Station and Utah State Board of Agriculture.

(Continued on page 12)
The growth and yields of agricultural crops depend on the moisture available during the growing season. Studies in recent years have shown that it requires work to remove water from the soil. The rate of growth of plants is related to the amount of work they must do to remove a unit amount of moisture from the soil. However, the relationship between the quantity of water in the soil and the growth rate of plants is indirect rather than direct.

DR. STERLING A. TAYLOR joined the staff about a year and a half ago as a soil physicist. He is a former student of USAC and received his Ph.D. degree at Cornell University.

At the Utah Agricultural Experiment Station research work is being done to establish some of the fundamental relationships between the amount of water in the soil, its movement, its availability to plants, and their response to moisture held in the soil by various forces. These studies will eventually lead to a knowledge that will permit a more efficient utilization of water to allow the maximum production with the limited water supply available in Utah.

Forces Holding Water in Soil are Important

The ease with which water in the vicinity of roots can enter the plant is related to the forces that are holding the water in the soil. More work is required to move a unit of water into the plant root if the forces holding it are large than if they are small. These forces are greater in soils that have many small particles such as clays, clay loams, and silty clay loams, than in soils with fewer particles such as sandy loams and sands.

It has long been known that the accumulative surface area of all the particles in a fine textured soil is greater than in a soil made up of coarser particles. This total particle surface affects markedly the movement and availability of moisture in the soil. Experiments have shown that more work is required to remove a unit of water from a soil containing a large particle surface than from one having a smaller particle surface even though both soils may contain the same percentage of water. Likewise it has been shown that if water is retained in these two soils such that the same amount of work is required to remove a unit of water, the soil with the greatest particle surface will contain a higher percentage of water (fig. 1).

Soil Moisture Stress Composed of Two Types of Forces

The force per unit area with which water is held in the soil is called soil moisture stress. Research workers at the U. S. Regional Salinity and Rubidoux Laboratories, Riverside, California, have shown that the total stress is made up of two types of forces, called soil moisture tension and osmotic pressure. The former is connected with the surface of contact between soil, water, and air. The latter depends directly upon the content of soluble materials in the soil, and is of increasing importance in soils of progressively higher salt content. In soils of low salt content the osmotic pressure effect is small and moisture tension is responsible for the major part of soil moisture stress.

Available Range of Soil Moisture

Having free internal drainage, water applied to the surface of the soil will move rapidly into the drier soil beneath under the force of gravity, until
the soil moisture tension reaches about \( \frac{1}{2} \) atmosphere (approximately 5 pounds per square inch pull on the soil moisture) after which the movement of water as a liquid is slow. Further drying out is attributable largely to evaporation and plant use. When soil is in this condition it is said to be in the range of field capacity. If drainage is impeded the moisture will move out of the soil slowly. Pore spaces will become filled with water and most plants suffer from insufficient ventilation (aeration) of the roots. After moisture in the soil has been removed by growing plants or by evaporation to a condition where the tension is near 15 atmospheres (approximately 220 pounds per square inch) growing plants can no longer extract water from the soil sufficiently fast to support growth and the plants wilt and remain so until more water is supplied from another source. These relationships are shown in fig. 1.

When irrigation water is applied it is desirable to apply sufficient to bring the soil moisture in the root zone of the growing crop to approximately field capacity. If more water is applied it will be lost in drainage, or it may cause a high water table or water logging. If less water is applied the plant will be under unnecessary stress to get the water and growth will be somewhat retarded.

The amount of water that any soil will hold at any given moisture tension depends upon the texture and structure of the soil. It can be seen from fig. 1 that a clay loam soil (curve 1) will hold about 18 pounds of water per 100 pounds of soil if the tension is near the permanent wilting point; it will hold about 38 pounds, if the tension is near field capacity, which means that 20 pounds of water per 100 pounds of soil is available to the growing plant. Hence if the soil moisture were near the wilting point, and if the dry soil weighs 75 pounds per cubic foot in its natural condition, and if the root zone extends to two feet, the maximum amount of water that can be used in the soil is 5.8 acre inches per acre. The irrigation water applied should not then exceed this amount. By the same reasoning it can be seen that a loam soil (curve 2, fig. 1) will hold about 5 pounds of water per 100 pounds of soil near permanent wilting and 21 pounds near field capacity with 16 pounds available to plant growth. Under the same conditions as above this means that an irrigation applying 4.6 inches of water would be maximum. A fine sandy loam soil (curve 3, fig. 1) will hold 5 pounds of water per 100 pounds of dry soil near permanent wilting and 14 pounds near field capacity with 9 pounds being the available water-holding capacity. An irrigation of 2.6 acre inches per acre would then be appropriate for this soil if the same conditions prevailed as in the first soil.

Soils containing high salt have been found to hold more water at both field capacity and permanent wilting point, but the range of available water is generally smaller consequently saline soils will need more frequent but lighter irrigation than corresponding non-saline soils.

**Plant Growth Better at Medium Low Moisture Tensions**

In experiments conducted by the Utah Agricultural Experiment Station devices such as those shown in fig. 2 (Continued on page 17)
**pH And Its Relation To Soil Fertility**

By D. W. THORNE

S**oil fads** are becoming nearly as common as health fads and they are just about as unreliable. The latest has to do with pH. What is pH? Literally, pH means the potential hydrogen ions. Practically, pH is an expression of the degree of acidity or alkalinity of any substance. Insofar as soils are concerned, the meaning of the pH range is illustrated in fig. 1.

Most Utah soils fall in the range of pH 6.5 to 8.5. Soils of humid regions are generally in the acid range and almost never are higher than 7.

pH Preferences of Plants

Nearly all books about soils are written for farmers in the East working with acid soils. Such books give considerable space and include lists of the important crop plants with the pH range to which each is adapted. If these ratings are taken seriously, apparently only a half dozen or so different crops will grow in our limy soils. According to these lists strawberies or even corn and tomatoes will not grow on most Utah soils and wheat and barley will not grow well in much of our area.

Some people seem to have just discovered these textbook discussions written for “acid soil” farmers and are now telling us that all or nearly all of our soils must be acidified.

Do the acid soils of the East produce higher crop yields than western soils? No. Average yields there are no higher than 50% of the yields obtained in much of our area.

Could we get higher yields if we acidified our alkaline soils? In some cases of excessive alkalinity we could, but experiments do not indicate any higher yields from putting sulfur or acids on our normal well-drained soils.

pH Itself Means Little

Probably the reason we hear so much about pH is that it is so easy to determine. No training or experience is required. Large differences in pH values of soil can be obtained by using a soil testing laboratory to find the facts about soils. Let this laboratory test your soil before investing in some acidulation scheme.

Actually, many soils in Utah could not be accurately altered in pH for less than $5,000 to $10,000 an acre. It is hardly worth it.

**CONTROL OF VIRUS DISEASES**

(Continued from page 9)

(2) By the establishment of an isolated nursery plot of adequate proportions to be operated under the direct supervision of trained research personnel. Under such supervision stocks of reliable virus-free fruit trees could be built up to serve generally the needs of both growers and nurserymen throughout the state. In such a program nurserymen might have their own nursery block established from source material selected by the nurserymen but indexed and protected from exploitation. Such a program would become a basic state service involving the Experiment Station, the State Board of Agriculture, and reliable and interested nurserymen, possibly representing the state nursery association. Steps toward such a service would involve:

First, the location and procurement of an isolation plot in an area suitable for stone fruit production.

Second, the setting up of an effective indexing program preferably in the virus disease division of the Farmington Substation.

Indexing procedures for determining the presence or the absence of viruses in trees are technical, drawn out, and costly. The procedures are forced into the control program by the existence of latent viruses and symptomless virus carriers. The four virus groups for which indexing must be done—western x, ring spot, rusty mottle, and yellows—are the most dangerous to the stone fruit industry in the state. The effect of these viruses on certain index hosts are shown in fig. 1 to 10. Symptomless carriers for each of these groups of viruses must be indexed.

**Farm and Home Science**
Will Sulfur Improve Soils

By J. P. THORNE

Will sulfur improve soils? Many farmers have asked this question and for good reason. Articles and advertisements expounding the benefits of additions of sulfur and sulfur compounds to the soil have appeared frequently and persistently in popular farm literature. Reportedly, the added sulfur improves soil reaction by lowering the pH; it is an essential nutrient element; it has an insecticidal effect on harmful soil life, like nematode and cutworms, yet stimulates the growth of organisms that make available plant foods in the soil. According to some promoters these sulfureous materials will do just about all that needs to be done except to plant and harvest the crop.

Of course, sulfur cannot do all that is claimed for it, and, on most soils of Utah, sulfur will not produce any of these benefits. A number of experiments conducted by the Utah Agricultural Experiment Station over a period of years show there is no need for sulfur as a fertilizer in this state. This means that on all soils where trials were conducted the soil itself contained enough sulfur to furnish all plant requirements for this element. Many irrigation waters also add sulfate to the soil. One specific use of sulfur has been found—certain alkali soil conditions can be corrected by the use of sulfur, gypsum, or some of the other sulfur compounds. Whenever abnormal alkalinity of a soil is caused by absorbed sodium in the clay fraction, sulfur may be used to correct this trouble.

Actually, the sulfur acts indirectly. In order to change a "sodium" soil to a normal soil, it is necessary to remove the sodium from the clay and to replace it with calcium. Sulfur, when oxidized in the soil, forms acid, which reacts with soil lime to form soluble calcium. This dissolved calcium then replaces the sodium in the clay. This reaction results in a soil of lower alkalinity and of better tilth and permeability to water than the original sodium soil.

To obtain such a soil improvement from sulfur requires that the soil contain lime. Many sodium soils do contain lime but some do not. Sulfur would not be effective in reclaiming a soil without lime. However, rather than to add lime, gypsum—which is calcium sulfate—can be used instead of sulfur. In fact, gypsum might be a cheaper amendment in the first place.

If the soil does not contain an abnormal amount of exchangeable sodium—and most cultivated soils do not—no benefit from sulfur can be expected.

How, then, can one tell whether or not his soil is affected with sodium? The only sure way is to have a sample of soil analyzed. Yet there are some typical characteristics of "sodium" soil that may be identified by examination in the field. Frequently, such soil appears as bad spots in otherwise fairly productive fields. These spots are often called "slick spots" because of their slick surface when wet. They are impervious to water and hard when dry. Crops do not grow well, if at all, on these spots. Again, rather large areas may be affected by sodium, but usually the soil itself has the same puddled, impervious character as found inslick spots.

Correction of a high sodium condition through the use of soil amendments may or may not be economically feasible. Soil tests can furnish data which in most cases make it possible to determine the feasibility of a given project. Such data also show whether sulfur can be used or whether gypsum would be more effective.

These tests are of such a nature that they cannot be made in the field. Several different tests must be made; for example, conductivity, water soluble sodium, total sodium, base exchange capacity, and lime. Measurement of pH alone is not sufficient. Tests of this kind are made available to farmers by the Soil Testing Laboratory at the Utah State Agricultural College. A small charge is made to cover part of the cost of analysis, but charges are in general much less than the cost of a bag of fertilizer or soil amendment.

"Slick spots" in alfalfa field near Spanish Fork, Utah

JAMES P. THORNE is in charge of the Soils Laboratory at USAC, maintained cooperatively by the Soil Conservation Service and the College.
Drainage Problems Follow Irrigation

Drainage Must Be Effective if Irrigated Areas Are to Continue to Be Productive

By WARREN W. RASMUSSEN

The need for adequate drainage of irrigated land in the West should be generally recognized. Irrigation and drainage are inseparable; lands long irrigated must also be drained either naturally or by artificial means. In irrigation practice it is impractical to apply just the proper quantity of irrigation water to supply the needs of the crops without getting some excess. In fact, some excess is often necessary to insure the continued productivity of irrigated land, to flush the root zone, and leach soluble salts. Thus in irrigated regions drainage may be defined as “the removal of excess water and soluble salts from the surface and the subsurface of soils.” If an area is to remain productive it is imperative that the quantity of salts removed by drainage should equal or exceed the quantity brought into the area in the irrigation water.

Waterlogging and the attendant effects of salinity and alkali constitute the gravest threat to the continued productivity and prosperity of our irrigated regions. The solution of drainage problems is of paramount importance if irrigation agriculture is to be perpetuated. These problems are both vexatious and complex and offer a challenge to the energies and ingenuity of those intimately associated with them: the farmer, the engineer, the soil scientist, and the agricultural economist.

Extensive areas of some of the most fertile soils in the West have been abandoned because of inadequate drainage. It has been estimated that the productive capacity of the 21,000,000 acres now irrigated in the 17 western states may have been reduced as much as 20 percent by waterlogging and attendant factors. Losses in crop production from these causes may exceed $100,000,000 annually.

Drainage Problems in Utah

Drainage problems in Utah are similarly acute, if slightly less impressive than the problems in the entire West. In the state where irrigation has been practiced for only slightly more than 100 years, abandonment of irrigated lands and declining productivity have proceeded at an alarming rate.

As early as 1900 the need for drainage was
apparent in many sections of the state. The U. S. Department of Agriculture initiated drainage investigations in Utah in 1904. The following year the Utah Legislature enacted a law to support "investigations and use of irrigation water and the reclamation of alkali lands"; the research to be conducted by the Utah Agricultural Experiment Station. This was the beginning of long and intensive research that has since been conducted by the Utah Station, a pioneer in the field of irrigation and drainage research.

Soon after the turn of the century the urgent need for drainage in Utah resulted in the enactment of the Drainage District Law and the organization of drainage districts.

The Progress of Drainage in Utah

From the beginning in the early 1900's drainage construction has proceeded at varying rates; continuing activity at times and then slackening as favorable or unfavorable economic periods developed. Drainage work increased rapidly during and immediately following the first World War when high prices gave impetus to the desire for increased production. During this period many drainage districts were formed and drains were installed to serve about 150,000 acres. Of this area about 100,000 acres was successfully drained. Active drainage work continued until about 1930 when a decided slackening occurred, primarily the result of the financial depression and the decrease in drainage requirements as a result of the prolonged drought of the early 1930's. Other factors contributing were the lack of interest on the part of landowners because of failure of many of the drainage enterprises and the solution of drainage problems in some areas. Drainage activities declined rapidly from the beginning of the depression up until the end of World War II. The rise in farm prices and the demand for greater production have resulted in increased demands for drainage since then to the present time. Drainage needs have increased as a result of the use of more water and the bringing into production of new lands.

Present Problems

The present problems in drainage are largely organizational and social. There appears to be an unfortunate lack of interest in some areas in future drainage undertakings. Drainage construction and maintenance have halted in many localities. One factor involved in this lack of drainage activity may be that people are learning to live with the problem, since with the prevailing high prices even inadequately drained lands have produced profitable returns. Other factors may be disappointment in the results of past drainage ventures and dissension and disunity in organized districts. Cooperation in large area drainage projects seems to be declining, with current activities being carried on only by individuals and small groups.

Recently a field study was made in an effort to determine the status of drainage in Cache County, Utah. In a survey of a number of farm drainage systems the chief factors considered were the effectiveness of the systems and the relative costs and value of drainage to the farm.

The costs of drainage installations vary widely because of type of soil, type of drain, methods of construction, and other factors. Their effectiveness is based largely on crop responses and increased production. These factors may often be affected by conditions other than improved drainage, such as favorable weather conditions and crop and soil management practices. The results from drainage systems may not be fully evident for many years without making a careful study of the lowering of the water table and the leaching of alkali salts. The total benefits are then dependent upon the yield and quality of the crop and the prevailing price.

Drainage Survey

Four farms on which representative drainage systems have been installed were selected for detailed study. Two of the farms were located entirely within organized drainage districts. The other two have individual drainage systems financed and constructed by the farmers. The combinations of circumstances revealed by the Cache County survey may be typical of the drainage problem in many sections of Utah and the West.
**Farm A** consists of 120 acres of land and lies within an organized drainage district. The farm had been highly productive until about 1910 when waterlogging and alkali accumulations became noticeable, crop yields declined, and the farm became largely unproductive. The drainage district was organized and main open drains constructed in 1926. This gave some relief but it was not adequate, only about one-third of the farm being suitable for general crops. Productivity of the farm declined until in 1938 the land was largely out of production and supported only "salt grass" and "fox tail" pasture of little value.

In 1946 the owner installed more than a mile of tile drain. The tile was placed with a tile-laying machine at a total cost of $0.46 per linear foot including the tile. Concrete tongue and groove 6-inch tile in 3-foot lengths was installed, using graded pea gravel envelopes at all joints. Relief was immediate; the water table was rapidly lowered over most of the farm. In 1947, the first year after draining, oats were grown on most of the drained area. Growth was spotty but vastly improved over previous years. Since then the productivity has rapidly improved. In 1949 most general crops were grown; sugar beets yielded 22 tons per acre and the other crops all produced substantial yields. According to the farmer the farm produced "more in 1949 than in the previous 10 to 15 years put together." The increased production has already repaid the cost of the drainage system.

**Farm B** consisting of 120 acres lies in another drainage district. The land had been highly productive until about 1925 when waterlogging and alkali became evident. After the construction of the large open drains in the area, the drainage activities of the district were largely discontinued. Little attention was given to drain maintenance. The open drain did not provide adequate relief for all the area and the productivity of the land declined. From about 1920 the land of the farm was practically out of production. Previous to draining the land the present owner purchased a 40-acre field without a water right for $179 in back taxes, another 40 acres for $1800, and in 1946 he purchased a third 40 acres for $2000. In 1946 tile drains were installed on the better 80 acres with a tile-laying machine at a cost of $0.46 per linear foot including the tile and the gravel envelope at the joints. The total cost amounted to approximately $80.00 per acre.

The drainage was effective, and productivity rapidly increased. The following year profitable yields were produced on much of the farm and in 1948 and 1949 all general crops gave substantial yields.

The owner reported that the increased production had amply repaid all the drainage costs. The land now is valued in excess of $400 per acre.

**Farm C** consisting of 170 acres was largely non-arable at the time the owner bought the land. The small area cultivated was seriously affected by a high water table and alkali. The soil is heavy and of varying textures and permeability. Previous to draining the land supported only a poor quality pasture. Only about 5 acres were capable of being farmed. The land "failed to pay the taxes for nine years previous to draining."

In 1935 two open drains were constructed in one area but the drainage was largely ineffective. In 1937 more than 15,000 feet of tile drain was installed on 111 acres. The first drains failed to lower the water table adequately, and additional lines had to be added. The owner admitted that he spent more money than was thought justified at the time. The land cost him $2500 and the drainage system more than $4000. Since then the land has repaid the drainage cost many times. In 1947 the owner refused an offer of $26,000 for the farm.

**Farm D** consists of about 110 acres. It lies in an area in which drainage is a serious problem. Much of the area had never been farmed when the present owner bought the land. The soils of the area are heavy clay loam with a clay hard pan at about 5 feet. Most of the land had a high water table and alkali conditions previous to drainage.

The drainage system was begun in 1930 when large open main drains were installed. Lateral tile drains were constructed from 1930 to 1936. The tile drains were largely constructed by hand by members of the family. It is estimated that the total cost of such drains, including the tile, was about $0.30 per linear foot.

Drainage facilities are being continued and drains are constantly cleaned and maintained. The farm is now highly productive, the result of drainage and careful management.

**Problems and Progress of Drainage Enterprises**

The problems and progress of drainage enterprises in the state were discussed in conference with one of the leading drainage engineers and contractors. He reviewed the progress in drainage equipment and design and discussed the major problems associated with farm land drainage. A summary of his comments follows:

1. Drainage districts are largely inefficient because of financial difficulties; bonds are not readily acceptable, means of collecting revenues are ineffective.

2. Drainage is now being accomplished largely by individuals or small groups.

3. Drainage failures usually result from (1) poorly designed and poorly constructed drainage systems, (2) inadequate maintenance, (3) careless handling of irrigation water resulting in "wash ins" into tile lines, and (4) over-irrigation and poor soil management practices which reduce the effectiveness of drainage systems.

The conclusions based on the writer's surveys and discussions with drainage leaders reflect in general the opinion of people most conversant with the drainage problem in the state. These conclusions are:

1. That present drainage organizations are not providing adequate drainage in many areas.

2. That drainage should be on an area-wide basis. It is generally recognized that the need for drainage is caused by irrigation, and since irrigation on any part of any area may contribute to the need for drainage it is felt that all in an area should be responsible for drainage.

3. That the need for adequate effective organization in drainage is essential. Such organizations should have

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*Farm and Home Science*
adequate power to collect sufficient revenue for drainage operation and should have authority to control factors such as unsound irrigation practices that are contributing to drainage needs.

4. That all drainage enterprises should have adequate competent professional services and advice on organizing, planning, and construction of drainage facilities and in the operation and maintenance of the drainage system.

5. That economical long-time capital financing, either public or private, is essential to drainage undertakings to provide a reasonable assurance that such projects will have a chance to "pay out."

6. That good farm management is especially important to improve the physical condition of the soil as an aid in drainage and to repay the added cost of the drainage system.

**Present Needs**

Admittedly there is much to be learned concerning the planning and construction of drainage systems and the management of drainage enterprises. Technical "know how" has come a long way in recent years. But there are still many indications of need for further effort.

Recent developments in methods and equipment for the construction of open and tile drains have done much to reduce the cost and improve the efficiency of such drains. New methods and techniques for use in making drainage investigations, such as means of determining the permeability of the soil, source and quantity of excess water, and means of plotting the flow of excess water in the soil have helped to take the guess work out of the location and placement of both open and tile drains. The development and improvement of equipment for cleaning and maintenance of drainage facilities have done much to reduce the cost of such operations.

The development of new equipment and materials for lining irrigation canals and ditches is helping to reduce the costs of such projects and to encourage lining programs. This is helping to reduce conveyance losses and to reduce the need for drainage in many areas. Lining costs are still excessive and prohibit the utilization of lining in many instances. The development of means of reducing the cost of canal lining is vitally needed.

Unsound irrigation practices are probably the greatest single factor contributing to the need for drainage in many irrigated regions. The present irrigation efficiency in much of Utah is about 25 to 50 percent; the additional 50 to 75 percent is lost through runoff and deep percolation and results in greatly increasing the need for drainage.

The adoption of sound irrigation methods, the utilization of improved water measurement and control structures, and the improvement of irrigation efficiencies by proper land preparation for irrigation, such as land leveling, coupled with adequate irrigation supervision, would do much to reduce drainage needs.

Perhaps the greatest need is in the organization and management of drainage institutions. The development of an organization capable of effectively dealing with the many complex problems associated with drainage is vitally needed. A drainage organization to manage drainage affairs adequately should have some control over unsound irrigation practices, so any effective solution to the problem may require the consolidation of irrigation and drainage enterprises.

**FORCES HOLDING WATER IN SOIL**

(Continued from page 11)

are now being used for measuring the soil moisture tension and availability of water to plants growing in the field. With the use of such devices it has been found that on the College Experiment Farm with soils of high fertility, best crop yields are obtained for alfalfa, sugar beets and potatoes, if the moisture tension is kept between 1/3 atmospheres and about 1 or 2 atmospheres. On these treatments irrigation water is applied when the average moisture tension in the root zone reaches about 1 atmosphere and only sufficient water is applied to bring the soil in that zone to field capacity. This soil is represented by curve 2, fig. 1. The amount of water needed is often about ½ acre inch per acre at a single application, with irrigations occurring on potatoes and sugar beets about every 2 to 5 days during the summer. Larger but less frequent irrigations are required for established alfalfa because of its deep root system.
ECONOMIC POSITION OF AGRICULTURE

(Continued from page 1)

plies of goods for civilians are being reduced. The general price level is high at the present time when compared to long-time trends and undoubtedly will go higher.

Price Increases

From June to November 1950, wholesale prices increased about 9 percent and farm prices in the United States rose about 12 percent (table 1). The index of Utah farm prices for November 1950 was 253 as compared to 224 for 1949 and 254 for the same month in 1948. It was thought that the peak in farm prices had been reached in 1948 and a leveling off of prices during 1949 was the beginning of the downward trend for the post-war period. However, the outbreak of war in Korea and the intense pressure to place the country on a war basis resulted in the return to war demands with increased prices. Prices paid in Utah for meat animals are 287 percent above the 1939 level, as compared to prices paid for crops of 124 percent for the same period (table 2).

The prices paid to Utah producers in November 1950, the percentage change since 1939, and the purchasing power or parity for various commodities show wide variations (table 2). The index of beef cattle prices in November was 427 with a parity of 164; lamb price index 369, parity 141; hogs price index 217, parity 83. Parity price for butterfat for processing was 78, wheat 89, barley 75, potatoes 72, and hay 106.

Increased Farm Income

With the outlook for increased prices for 1951 and with a favorable year for crops and livestock production, Utah farm income will likely be increased from about 160 million dollars during recent years to about 180 million. A farm income for Utah of 180 million dollars will give an average gross income per farm of about $7,000. If this farm income is realized, it will be the highest income in the history of the state. The gross income per farm in 1951 will be seven times what it was in 1932.

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Unit</th>
<th>Nov. 15, 1920</th>
<th>Nov. 15, 1932</th>
<th>Nov. 15, 1939</th>
<th>Nov. 15, 1950</th>
<th>Parity 1910-14</th>
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<tr>
<td>Livestock:</td>
<td></td>
<td></td>
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<tr>
<td>Beef cattle</td>
<td>cwt.</td>
<td>7.00</td>
<td>118</td>
<td>3.35</td>
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<tr>
<td>Butterfat*</td>
<td>lb.</td>
<td>0.54</td>
<td>153</td>
<td>0.23</td>
<td>65</td>
<td>0.35</td>
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<tr>
<td>Hogs</td>
<td>cwt.</td>
<td>12.50</td>
<td>117</td>
<td>3.75</td>
<td>52</td>
<td>7.30</td>
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<tr>
<td>Total livestock</td>
<td></td>
<td>142</td>
<td>59</td>
<td>96</td>
<td>262</td>
<td>100</td>
</tr>
<tr>
<td>Crops:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>bu.</td>
<td>1.61</td>
<td>207</td>
<td>0.38</td>
<td>49</td>
<td>0.71</td>
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<tr>
<td>Barley</td>
<td>bu.</td>
<td>1.00</td>
<td>176</td>
<td>0.61</td>
<td>55</td>
<td>0.45</td>
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<tr>
<td>Potatoes</td>
<td>bu.</td>
<td>0.92</td>
<td>149</td>
<td>0.28</td>
<td>45</td>
<td>0.58</td>
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<tr>
<td>Hay</td>
<td>ton</td>
<td>12.60</td>
<td>155</td>
<td>6.40</td>
<td>79</td>
<td>9.20</td>
</tr>
<tr>
<td>Total crops</td>
<td></td>
<td>175</td>
<td>66</td>
<td>92</td>
<td>221</td>
<td>85</td>
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Table 1. Index of farm and non-farm prices and industrial wages for various periods, 1920-1950 (1910-14 = 100, 1935-39 = 100)

<table>
<thead>
<tr>
<th></th>
<th>Base period</th>
<th>Nov. 15, 1920</th>
<th>Nov. 15, 1932</th>
<th>Nov. 15, 1939</th>
<th>Nov. 15, 1949</th>
<th>Nov. 15, 1950</th>
</tr>
</thead>
<tbody>
<tr>
<td>Utah farm income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>all commodities</td>
<td>1910-14</td>
<td>165</td>
<td>66</td>
<td>106</td>
<td>241</td>
<td>263</td>
</tr>
<tr>
<td></td>
<td>1935-39</td>
<td>153</td>
<td>61</td>
<td>98</td>
<td>224</td>
<td>244</td>
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<td>U. S. farm income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>all commodities</td>
<td>1910-14</td>
<td>169</td>
<td>54</td>
<td>97</td>
<td>237</td>
<td>247</td>
</tr>
<tr>
<td></td>
<td>1935-39</td>
<td>158</td>
<td>62</td>
<td>92</td>
<td>218</td>
<td>231</td>
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<tr>
<td>U. S. prices paid by farmers for commodities*</td>
<td>1910-14</td>
<td>206</td>
<td>110</td>
<td>122</td>
<td>245</td>
<td>255</td>
</tr>
<tr>
<td></td>
<td>1935-39</td>
<td>158*</td>
<td>94</td>
<td>98</td>
<td>187</td>
<td>204</td>
</tr>
<tr>
<td>U. S. wholesale prices of commodities</td>
<td>1935-39</td>
<td>193*</td>
<td>80</td>
<td>98</td>
<td>188</td>
<td>195</td>
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<tr>
<td>Factory payrolls</td>
<td></td>
<td>1910-14</td>
<td>227*</td>
<td>220*</td>
<td>459</td>
<td>505</td>
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<tr>
<td></td>
<td>1935-39</td>
<td>108*</td>
<td>105*</td>
<td>232</td>
<td>240</td>
<td>244</td>
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</tbody>
</table>

*Figures for 1948 on include commodities, interest, taxes, and wage rates
†Yearly index
‡Index figure for September 1950

Table 2. Prices paid producers in Utah for farm products for various periods, 1920-1950 (Price 1935-39 = 100, Parity 1910-14 = 100)

The effect of the inflation on agriculture in the long run, however, is not likely to be so favorable. Individual farmers will temporarily benefit from inflation and increased prices, but the farm economy as well as the economy of the country may be injured. Rapid advance in agricultural prices will result in excessive land values. Farm land will generally be purchased by young farmers who will incur heavy indebtedness in obtaining ownership. Although there is no indication of decline in prices in the near future, a sharp decline is probable at some future time. When the decline comes, prices of farm products will drop more rapidly than costs and farmers again will find themselves in a position of selling farm products at low prices and paying relatively higher prices for goods and services.

1951 Program For Utah Farmers

The 1951 program for Utah farmers should be full production with emphasis on efficiency and at lowest costs possible. Although the outlook for this year is for relatively high prices for most farm products, there will probably be a wide variation in prices of various commodities. The prospect for higher prices does not justify production at any cost, but rather a production of commodities that will give a net profit to the operator.
Labor Scarcity

The defense program will reduce the efficiency and supply of farm labor through drafting of farm boys. Agricultural labor will be both scarce and high priced. Labor requirements for each farm enterprise as well as the farm as a whole, and availability of supply should be carefully analyzed in planning the farm program. It is a time when modern farm machinery and family labor should be fully utilized. Like farm labor, farm supplies used in production will also be scarce and high priced. For protection it is a good time to buy for future needs. Control of needed feed supplies is also good business. Prices of feed grains and forage are relatively low compared to meat prices; hence, a liberal feeding program of livestock will pay.

A realistic appraisal is needed to guard against the assumption that the recent change in prices and demand are evidences that the postwar adjustments have been made and that a new economic era with a stable high price level is permanent. The present economic situation is a continuation of World War II and the world peace is still to be worked out with the necessary readjustments which will have to be made on a normal national and international basis. Agriculture is always vulnerable when severe adjustments or changes in production, demand, and price become necessary.

During this period of shifts to production for defense resulting in changes in availability of goods for domestic and foreign markets, there will probably be a wide variation in prices of various farm commodities and in economic positions of some farm enterprises and agriculture in different areas. Prices for certain products where increased production is needed to meet war demands will likely increase above present levels while other products that are adversely affected by the war situation may decline. The present economic situation in this country and in the world is in such a position that major changes may take place that will greatly change or affect the economy of the country. Under such conditions farmers should be cautious and plan programs on the basis of a war economy. With the economic uncertainty during this inflationary period or the immediate future, it is the time to produce to the limit, to sell, and to pay off indebtedness.

GRASS-LEGUME MIXTURES

(Continued from page 5)

Alfalfa Yields Equal or Exceed Mixtures

In 1944, the year following seeding, yield differences were not statistically significant (table 1). In 1945, one mixture (alfalfa and orchard grass) gave a significantly higher total annual yield than alfalfa alone. In 1946, however, the situation reversed itself, and alfalfa alone had a highly significant yield advantage over the alfalfa and orchard grass mixture.

The 3 year averages show that alfalfa alone yielded about the same as the alfalfa-grass mixtures.

All alfalfa combinations outyielded all combinations of clover and grasses in 1945 and 1946 and over the 3 year period.

In all 3 years the red clover and late timothy (10 pounds per acre) mixture gave higher yields than red clover alone. The yield difference was highly significant in 1946, significant for the 3 year averages, and approached significance in 1945.

The clover was practically all dead by the time the third crop was harvested in 1946.

Grass-Legume Mixtures Have Their Place

The results of these experiments show that there is little difference in yield when alfalfa is grown alone, or in combination with smooth bromegrass, timothy, or orchard grass, under conditions such as exist at the Greenville Farm at North Logan. It is probable that this holds true whenever alfalfa is well-adapted in the state.

This should not be interpreted to mean that there is no place in Utah for grass-legume mixtures for hay. There are extensive areas of sloping land in our valleys. It is important that such land be protected against erosion. On such land under irrigation, a mixture of alfalfa and smooth bromegrass provides a much better protective cover than does alfalfa alone and should be more extensively planted. This mixture may also be used on dry farm slopes when the precipitation is sufficient to grow these plants, and under more adverse precipitation conditions alfalfa-grass mixtures may well be seeded in strips where runoff water tends to accumulate.

Alfalfa does poorly on soils with high water tables; if the water table is within three feet of the surface, it is generally safer to grow red clover.

Table 1. Yields of forage from paired plantings and pure species seeded in 1943

<table>
<thead>
<tr>
<th>Crop plants</th>
<th>Yield per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1944</td>
</tr>
<tr>
<td>Red clover</td>
<td>5.0</td>
</tr>
<tr>
<td>Clover + early timothy</td>
<td>4.5</td>
</tr>
<tr>
<td>Clover + late timothy*</td>
<td>4.8</td>
</tr>
<tr>
<td>Clover + late timothy**</td>
<td>5.4</td>
</tr>
<tr>
<td>Clover + orchard grass</td>
<td>4.7</td>
</tr>
<tr>
<td>Clover + smooth brome</td>
<td>3.9</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>4.7</td>
</tr>
<tr>
<td>Alfalfa + timothy</td>
<td>4.8</td>
</tr>
<tr>
<td>Alfalfa + orchard grass</td>
<td>4.5</td>
</tr>
<tr>
<td>Alfalfa + smooth brome</td>
<td>4.8</td>
</tr>
<tr>
<td>Average</td>
<td>4.71</td>
</tr>
</tbody>
</table>

*10 pounds per acre
** 5 pounds per acre

F values | L. S. D. at .05  at .01
---------|------------------
1944 yields—NS |
1945 yields—13.75** | .819 | 1.089 |
1946 yields—79.37** | .695 | .924 |
Three year average—36.75** | .503 | .669 |
than to try to grow alfalfa. Utah has thousands of acres of such land, which could be used more effectively than at present by growing red clover mixed with timothy or some other grass.

The wide range of conditions existing in Utah requires a variety of forage plants. On the good, well-drained irrigated land, alfalfa can't be surpassed for hay. There are some situations, however, to which alfalfa is not well adapted, and where this is the case the use of red clover and grass-legume mixtures may be warranted and should be more thoroughly investigated.

FORCES HOLDING WATER IN SOIL

(Continued from page 17)

If moisture tension is kept lower than this value excessive water may be present and conditions of poor aeration and water logging might reduce crop growth. This is particularly true if soils are not as well drained as those on the college farm. If tension is allowed to get much higher than this range plants wilt for part of the day and growth is retarded. The amount of retardation in growth increases as soil moisture tension increases until growth ceases entirely when the tension has reached about 15 atmospheres.

Moisture Tension Devices Used in Other Research

In addition to indicating when irrigation water should be applied and something about how much water should be applied at any one time, these tension devices are being used to show movement of moisture into and through the soil. Samples of undisturbed soil have been taken in the field and brought to the laboratory where water was applied to the surface. The movement of water in the core samples was studied by means of moisture indicating devices. The amount of water required to moisten the soil to various depths has been determined. The rate of entry of water into the soil and its speed of transmission have been measured. Observations have also been made on the amount of movement that occurs after the application has ceased. Studies of this kind are used to get basic information on the amount of water required by a soil at various stages of drying out. They also are useful in indicating how rapidly soils will take up water. This makes it possible to make more efficient use of water in the field. To be of most value these studies must be confirmed by carefully controlled field experiments. This is being done.

The use of tensiometers to study the movement of water from irrigation furrows is shown by fig. 4. These studies when used in conjunction with laboratory work will, when completed, provide the information necessary to determine such things as the rate water should be applied to a soil and the best spacing of irrigation furrows on different soils and for different crops. This will make it possible to keep soil moisture tensions in the desirable range for plant growth without excess water loss from run-off and deep percolation.

CONTRIBUTIONS TO RESEARCH

November 15, 1950 to February 15, 1951

$50,000 for breeding improvement of Ramboillet sheep and for studies in the nutritional requirements of plants and animals... Utah Division, Kennecott Copper Company

$2,000 for studies on the value of dehydrated alfalfa for range sheep... American Dehydrators Association

$500 for the study of the effect of cultural and harvesting methods, and varieties on the yield and quality of vegetables... Utah Canning Crops Association

$500 for the study listed above... Utah Canners Association

1 case of eggs of meat type chickens for use in experimental breeding studies... Christie Poultry Farms, Kingston, New Hampshire