Bees are objects of both fear and fascination for many people, especially when they are swarming.

Swarming is the natural tendency of bees. It is nature's way of providing for the survival of the species and usually occurs when conditions are favorable for the survival of both the parent colony and the new swarm. The old queen takes flight and a number of workers follow her.

Swarming bees will cluster on almost any imaginable object. Trees, bushes, fenceposts, cars, mail boxes, and house walls are only a few of the places from which swarms have been taken.

The values set on swarms in this verse is based on the length of time it takes a swarm to become strong enough to store a surplus of honey or at least a winter's supply.

If you wish to capture a swarm on a bush or tree within easy distance of the ground, your problems are relatively few. The best way to capture it is to cut the branch gently on which the bees are clustered and carry it carefully to the hive. Lay it down on the ground right up against the entrance, and with a stick brush a few of the bees into the entrance. As soon as a few bees find the hive, they will enter and signal the rest to follow.

A swarm of bees in May
Is worth a load of hay.
A swarm of bees in June
Is worth a silver spoon.
A swarm of bees in July
Isn't worth a fly.
— Anon. —

CONTENTS

Use alfalfa-intermediate wheatgrass where water is limited — up-grading irrigated pastures, by Keith R. Allred .................................. 47
New canal sealer clings to concrete .................................................. 51
Insecticides in animals — their storage and interactions, by Joseph C. Street ................................................................. 52
USDA developing leaf harvester to strip alfalfa ..................................... 54
Pruning bearing trees and rejuvenating old trees, by David R. Walker, J. LaMar Anderson, and Anson B. Call, Jr. ......................... 55
Bees fed pathogens ........................................................................ 58
Native browse and broadleaf herb seed production — on cultivated land, by Gordon A. Van Epps .................................................. 59
Maintaining quality in fresh product, by D. K. Salunkhe, L. E. Olson, B. N. Wankier, and Kazuo Chachin ................................. 62
Fertilizing winter wheat in Utah, by Rex F. Nielson and Gordon A. Van Epps ................................................................. 68
Black light lures insects to sterilant ..................................................... 71
Resource development on the Bolivian Altiplano, by J. Clark Ballard, Darrell H. Mathews, Devere R. McAllister, and N. Keith Roberts ................................................................. 72
Water for Utah — by plan or by accident, by B. Delworth Gardner .... 78
Farm flocks pay off, by Russell R. Keetch ........................................... 82
Contributions to research ................................................................. 83
New publications ........................................................................... 84
Sugar osmosis — new method for drying fruits ................................... 84

UTAH FARM AND HOME SCIENCE

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Daryl Chase, President
Utah State University

Wynne Thorne, Director and Vice President for Research

K. W. Hill, Associate Director

Millard E. Wilde, Editor
Agricultural Experiment Station
UP-GRADING IRRIGATED PASTURES . . .

Use alfalfa - intermediate wheatgrass where water is limited

KEITH R. ALLRED

The acreage of land used for improved pastures in Utah and the Intermountain West has been increasing the past few years. Nevertheless, there is still a need for additional high-producing pastures. Part of this need can be filled by using land that is suitable for pasture production but is limited as to the availability of water during part or all of the growing season.

Most of the forage species being recommended for irrigated pastures do best under conditions where there is a plentiful supply of water. Some of these species do poorly when water becomes limiting. New combinations of compatible forage species that have a high production potential coupled with drought resistance need to be developed. Alfalfa-intermediate wheatgrass is a mixture with the potential to do a good job in areas with limited supplies of water.

This is the fourth in a series of articles reporting results of a 5-year pasture study (figure 1). The previous articles dealt with: (1) "The Role of Alfalfa," (2) "Grass Can Be Productive," and (3) "Does Ladino Clover Have a Place?" They appeared in the June, September, and December issues, respectively, of Utah Science, Volume 26, 1965. This article discusses the value of a pasture mixture that is suitable for use on good land where irrigation water is limited during part of the growing season.

The study was conducted at the Greenville Experimental Farm in North Logan, Utah, from 1960 to 1965. The soil was a Millville silt loam. Design of the experiment and management treatments imposed on the pasture mixtures were described in detail in the first article and are, therefore, only briefly outlined here.

The plots were all sprinkler irrigated. Forage was clipped to a 2-inch height at each harvest. Nitrogen was applied in the form of ammonium nitrate. The soil was high in potash. To assure that sufficient phosphorus was available to the plants, 100 pounds of phosphate (P₂O₅) per acre were broadcast over the entire experimental area in the springs of 1961 and 1963.

INTERMEDIATE WHEATGRASS

Intermediate wheatgrass is a perennial sod-forming grass that was introduced into the United States by the Department of Agriculture from the Soviet Union. It has been tested under a variety of soil and climatic conditions and shows great promise for use as a pasture and forage grass.

This grass develops a vigorous root system, grows erect and produces a heavy growth of basal leaves. The plants begin growth in early spring and, if left ungrazed, often attain a height of 3 to 4 feet by midsummer. The plant spreads by means of underground stems (rhizomes).

Intermediate wheatgrass has good seedling vigor and therefore can be established using reasonable seeding rates. It is slower to form a full sod than is smooth bromegrass. Intermediate is more drought resistant than smooth bromegrass but is less hardy and less drought resistant.

<table>
<thead>
<tr>
<th>MANAGEMENT TREATMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
</tr>
<tr>
<td>I-1</td>
</tr>
<tr>
<td>I-2</td>
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<tr>
<td>I-3</td>
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<tr>
<td>I-4</td>
</tr>
<tr>
<td>Fertilization</td>
</tr>
<tr>
<td>F-1</td>
</tr>
<tr>
<td>F-2</td>
</tr>
<tr>
<td>F-3</td>
</tr>
<tr>
<td>F-4</td>
</tr>
<tr>
<td>Clipping frequency</td>
</tr>
<tr>
<td>C-1</td>
</tr>
<tr>
<td>C-2</td>
</tr>
<tr>
<td>Pasture mixture</td>
</tr>
<tr>
<td>M-5</td>
</tr>
</tbody>
</table>

KEITH R. ALLRED is an associate professor in the Department of Plant Science.

FOR JUNE 1966
than crested wheatgrass. It has been shown to be productive in the Intermountain region as a range grass on sites averaging more than 14 inches of precipitation per year.

When sown in mixtures on irrigated land, intermediate wheatgrass is very compatible with alfalfa. Plant growth is vigorous and the leafy foliage is relished by most classes of livestock.

We used the Greenar variety of intermediate wheatgrass in this study. It was developed from plants introduced from Russia in 1932. It is dark green in color, has broad leaves, is late maturing, and provides high forage production.

MANAGEMENT RESPONSE

The pasture mixture to be discussed in this article consisted of Ranger alfalfa (Medicago sativa L.) and Greenar intermediate wheatgrass (Agropyron intermedium). Seeding rates in pounds per acre were: alfalfa, 3; and intermediate wheatgrass, 15. At the end of the establishment year (1960), plots seeded to this mixture contained approximately 65 percent alfalfa and 35 percent intermediate wheatgrass.

Of the six pasture mixtures included in this study, the alfalfa-intermediate wheatgrass mixture was the most productive the first harvest year. It was also on a par with the other two alfalfa mixtures during the second, third, and fourth harvest years (figure 2). Its highest forage yield was 6.77 tons of dry matter per acre, obtained in 1961. This would be equivalent to 8 tons of hay per acre. It was obtained from two separate treatment combinations: harvesting four times (C-1), irrigating at 15-day intervals (I-2), no nitrogen fertilization (F-1); and four harvests per season (C-1), irrigating at 5-day intervals (I-4), and fertilization with 100 pounds of nitrogen per acre (F-3). It was notable, however, that on plots that were harvested four times during the season the lowest yield obtained was still a good 5.4 tons per acre and most of the treatment combinations resulted in yields of more than 6 tons of dry forage per acre.

The yield dropped off during the second, third, and fourth harvest years. This was a common trend in all mixtures containing alfalfa. Nevertheless, yields obtained from this as well as other alfalfa mixtures were still higher than yields from the other mixtures. The lowest yield from the alfalfa-intermediate wheatgrass during any of the four years was in 1964 under the treatment combination of: five harvests per season (C-2), irrigation at 10-day intervals (I-3), and no fertilization (F-1). Production from this combination was 2.54 tons of dry matter per acre.

IRRIGATION FREQUENCY

Depth of the root system is an important factor related to the water requirement of plants. Semi-deep and deep-rooted plants may require about the same amount of water during the growing season as shallow-rooted plants to maintain top forage production. However, they are capable of going longer periods between irrigations because of their ability to obtain available moisture from a greater depth and volume of soil.

Alfalfa is deep rooted and intermediate wheatgrass has a moderately deep root system. There was very little influence on the amount of forage produced by the alfalfa-intermediate wheatgrass mixture by the frequency of irrigation (table 1). During the first harvest year, more forage was produced by the mixture when irrigated at 5-day than 20-day intervals. This trend was reversed the third harvest season and there were no differences during the second and fourth harvest seasons. Therefore, on the...
basis of the 4-year averages, the alfalfa-intermediate wheatgrass mixture produced approximately the same amount of forage regardless of frequency of irrigation. This was very much in contrast to the ladino clover-grass and the all-grass mixtures. Frequency of irrigation was one of the main factors contributing to high yields of these mixtures.

Frequency of irrigation did not have an influence on the ratio of legume to grass that was maintained in the pasture plots during 4 years (figure 3). Although the alfalfa percentage in the mixture changed from 65 percent in 1961 to 40 percent in 1964, the change was very similar each year for the four frequencies of irrigation. This helps point up that alfalfa and intermediate wheatgrass respond similarly to applications of water and are compatible so far as their water requirements are concerned. One species does not become dominant over the other when long intervals between irrigation turns become necessary. Also, they both can withstand fairly long intervals between irrigations without a corresponding reduction in yield.

**Table 1.** Dry matter production for the alfalfa-intermediate wheatgrass mixture as influenced by irrigation regime

<table>
<thead>
<tr>
<th>Irrigation frequency</th>
<th>1961</th>
<th>1962</th>
<th>1963</th>
<th>1964</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-1 20 day</td>
<td>5.22</td>
<td>4.07</td>
<td>4.02</td>
<td>3.38</td>
<td>4.17</td>
</tr>
<tr>
<td>I-2 15-day</td>
<td>5.85</td>
<td>4.36</td>
<td>4.00</td>
<td>3.57</td>
<td>4.45</td>
</tr>
<tr>
<td>I-3 10-day</td>
<td>5.48</td>
<td>4.17</td>
<td>3.74</td>
<td>3.47</td>
<td>4.22</td>
</tr>
<tr>
<td>I-4 5-day</td>
<td>6.10</td>
<td>4.14</td>
<td>3.65</td>
<td>3.43</td>
<td>4.33</td>
</tr>
</tbody>
</table>

**Table 2.** Dry matter production for the alfalfa-intermediate wheatgrass mixture as influenced by frequency of clipping

<table>
<thead>
<tr>
<th>Clipping frequency</th>
<th>1961</th>
<th>1962</th>
<th>1963</th>
<th>1964</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-1 35-day interval</td>
<td>6.13</td>
<td>4.91</td>
<td>4.41</td>
<td>3.79</td>
<td>4.81</td>
</tr>
<tr>
<td>C-2 28-day interval</td>
<td>5.20</td>
<td>3.47</td>
<td>3.30</td>
<td>3.14</td>
<td>3.78</td>
</tr>
</tbody>
</table>

**EFFECT OF CLIPPING**

Both forage species in this mixture, alfalfa and intermediate wheatgrass, are subject to severe damage by frequent clipping or grazing. They depend on the maintenance of good food reserves in the roots and crowns for top forage production. Frequent harvesting depletes these food reserves and reduces plant vigor.

The seriousness of frequent clipping on the reduction of dry matter can be seen from the data presented in table 2. Plots harvested five times per season average 1 ton less dry matter than those harvested four times. Most of the yield reduction took place as a result of harvesting at 28-day intervals the first year. Between the first and second seasons the forage yield decreased 1.7 tons or 33 percent. It continued to decrease the following years but at a much reduced rate.

Plots harvested four times produced more than 6 tons of dry matter the first year. This was an excellent yield but was not maintained, as forage production decreased each season throughout the experimental period. This would suggest that harvesting at 35-day intervals (4 harvests per season) was too frequent and that a longer interval between cuttings would have resulted in higher and more uniform forage production. Although this experiment does not provide the information, data from alfalfa hay experiments and from other pasture studies involving the alfalfa-intermediate wheatgrass mixture show that near-maximum forage yields are obtained in most parts of Utah when plots are harvested three times per season.

One problem that developed with the alfalfa-intermediate wheatgrass mixture was the invasion of weeds. Dandelions appeared in some plots of the mixture during the second harvest season and the amount of

Figure 2. Alfalfa and intermediate wheatgrass make a fairly easy pasture mixture to establish. This legume and grass combination provides one of the most productive mixtures for good land where irrigation water is limited during part of the growing season. It also does well where there is adequate water. The above photo shows the alfalfa-intermediate mixture in comparison with mixture 1.
weeds in the plots increased each year thereafter (figures 3 and 4). This was the only mixture of the six that had any significant weed invasion during the 5-year experiment. On plots harvested five times per season, weeds accounted for about 20 percent of the harvested dry matter in 1964 at the frequent irrigation interval and at low rates of nitrogen fertilization.

### Table 3. Dry matter production for the alfalfa-intermediate wheatgrass mixture as influenced by nitrogen fertilization

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>F-1 Zero-N</td>
<td>5.73</td>
<td>3.81</td>
<td>3.58</td>
<td>3.10</td>
<td>4.06</td>
</tr>
<tr>
<td>F-2 50-N</td>
<td>5.53</td>
<td>4.06</td>
<td>3.71</td>
<td>3.32</td>
<td>4.16</td>
</tr>
<tr>
<td>F-3 100-N</td>
<td>5.63</td>
<td>4.23</td>
<td>3.92</td>
<td>3.55</td>
<td>4.33</td>
</tr>
<tr>
<td>F-4 200-N</td>
<td>5.77</td>
<td>4.65</td>
<td>4.21</td>
<td>3.89</td>
<td>4.63</td>
</tr>
</tbody>
</table>

**EFFECT OF NITROGEN**

Alfalfa is one of the most efficient nitrogen-fixing forage legumes available for irrigated pastures. Actually, it is a symbiotic relationship between alfalfa and the bacteria that inhabit the roots of alfalfa that makes it possible to fix nitrogen from the soil air in a form that can be utilized by the forage plants.

Data presented in table 3 indicate the dry matter production for the alfalfa-intermediate wheatgrass mixture as influenced by nitrogen fertilization. During the first harvest season there was no difference in forage yields regardless of the fertilization treatments. Small responses were obtained by adding 50, 100, and 200 pounds of nitrogen per acre during the second, third and fourth harvest years. However, they were not large enough to begin to pay for the cost and application of the fertilizer. Averaging over the 4 years, applications of 50, 100, and 200 pounds of nitrogen per acre only increased forage production 0.1, 0.27, and 0.57 tons per acre, respectively. This helps point out why it is uneconomical to apply nitrogen fertilizer to pastures where healthy legumes make up 40 percent or more of the sward.

The application of the various nitrogen treatments did not change the amount of forage produced by alfalfa. On plots harvested four times per season, nitrogen fertilization had very little influence on the amount of forage produced by the intermediate wheatgrass. Nitrogen fertilization at the rate of 200 pounds per acre did increase the production of intermediate wheatgrass during the third and fourth harvest years on plots harvested five times per season but had little influence at the lower rates.
RECOMMENDATIONS

Along with the demand for an increasing amount of irrigated pasture has come the need for improved pastures that can be successfully grown on land where irrigation water is limited during part or all of the growing season. To meet this need, research has been done on a series of pasture mixtures. The alfalfa-intermediate wheatgrass mixture is one that has proven to be adapted to situations of this type. To obtain maximum production from this mixture under conditions of limited water, the following recommendations should be followed.

* Prepare a good seedbed and plant shallow, not to exceed a depth of ½ inch.
* Plant ½ to 2 pounds of alfalfa seed with 12-15 pounds of intermediate wheatgrass. On soils where alfalfa is well adapted, a ½- or 1-pound seeding rate of alfalfa may provide a better legume-grass balance than higher rates.
* Irrigate to fill the soil profile to its capacity in the fall or spring when water is available.
* Irrigate at 10- to 15-day intervals during periods when water is available, applying approximately 2½ to 3 inches of water per irrigation. When water becomes limited, irrigate frequently enough to keep the plants alive and healthy.
* The establishment year is a critical period for the new pasture. Clip during midsummer to remove weed growth. Delay grazing until late fall. Early grazing may result in the up-rooting of plants that are not fully established.
* On the established pasture, delay grazing until alfalfa reaches the late-bud to early-bloom stage of maturity. This will minimize bloat and maximize forage production as compared to earlier grazings.
* Use a rotation grazing system that will provide a 40-day minimum recovery period.
* Graze a restricted area intensively for a short time, then change to a new area.
* Maintain the soil at a high level of fertility and give special attention to supplying adequate phosphorus to meet the needs of the growing plants.
* In most of Utah and the Intermountain area the alfalfa-intermediate wheatgrass mixture will reach the recommended grazing stage two and possibly three times during a growing season. Under some conditions more frequent grazing may be necessary; however, it should be kept in mind that the more frequently this mixture is grazed, the less productive it will be and the sooner it will be necessary to plow and reseed the pasture.

New Canal Sealer Clings to Concrete

A crack sealer and an efficient method for applying it to weather-cracked concrete irrigation canals have been developed by U.S. Department of Agriculture water conservation scientists.

Hundreds of billions of gallons of valuable — and scarce — irrigation water are lost through cracks in concrete-lined canals that supply western farmers with water.

The newly-developed sealer, a mixture of asphalt, butyl latex and asbestos fiber, can be sprayed on the cracks with high-pressure pumps and nozzles.

Previous asphalt-base sealers could be easily peeled from concrete because the bonds were mechanical. Concrete has a negative-charged surface, so the researchers added positive-charged agents to their formulation, forcing the sealer and concrete to form an electrochemical bond.

The high-pressure (400 to 500 pounds per square inch) water jet cleaning, without tack coat, was the most satisfactory method of preparing the cracks for sealing. It blasted the soil out of the cracks and removed all silt and algae around their edges. Fine silt-covered cracks that might otherwise have been missed were quickly and easily traced with the water jet.

Sealer sprayed directly on the clean, wet concrete at 1,500 pounds per-square-inch pressure produced a superior bond. After 1 year, there were no bonding failures and the sealer could not be scraped from the concrete with a knife.

For efficiency, the scientists said three men are required for the new method of treating cracks. One man jets the cracks, another sprays on the sealer, and the third drives a truck laden with pumps and water supply along the canal. Eight hundred feet of cracks, requiring about 10 gallons of sealer, can be treated in 1 hour.
INSECTICIDES IN ANIMALS—Their Storage and Interactions

Since their introduction in 1943, the chlorinated hydrocarbon insecticides (such as DDT, dieldrin, heptachlor, and lindane) have had a remarkably successful history in controlling many of man’s worst insect enemies. From the beginning, however, the tendency of these insecticides to concentrate and be stored in the body fat of animals and humans has been of concern to public health officers. Periodic surveys during the past 10 years have clearly shown that the general human population carries traces of DDT and other insecticides in the body fat. As more and more such evidence was obtained, the question of the long-term, or ultimate, hazards to individuals due to such insecticide burdens in the body became increasingly urgent. A major factor in that sense of urgency has been the realization that soils, water, and foods are also extensively contaminated with traces of many of these insecticides.

Precisely what happens to insecticides like DDT and dieldrin when they are ingested by animals is not yet completely known, but it is certain that such compounds are subject to complex, overlapping biochemical and physiological processes. Furthermore, animals and man commonly encounter traces of several insecticides mingled together in foods and water. Under these conditions the bodily processing of the chemicals becomes even more complex.

INSECTICIDE INTERACTIONS

A research group in the Animal Science Department of Utah State University has been particularly interested in the possibility that the normal processing of one insecticide compound within an animal body might be altered by treating the animal simultaneously with other insecticides. An elaborate experiment was conducted to test combinations of DDT, methoxychlor, and dieldrin for possible combined effects in the rat. We expected to be able to identify any such interactions by altered storage patterns of the insecticides in the body fat. The insecticides were added to a commercial rat diet using three dosage levels of each so that, in all, 27 possible combinations of compounds and dosages were prepared. Groups of rats were

<table>
<thead>
<tr>
<th>Treatment duration</th>
<th>Dieldrin in tissue lipid ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>16.1</td>
</tr>
<tr>
<td>b</td>
<td>1.5</td>
</tr>
<tr>
<td>c</td>
<td>6.1</td>
</tr>
<tr>
<td>d</td>
<td>1.8</td>
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<tr>
<td>e</td>
<td>20.6</td>
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<tr>
<td>f</td>
<td>6.4</td>
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<tr>
<td>g</td>
<td>11.7</td>
</tr>
<tr>
<td>h</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Figures 1. Effects of time and duration of DDT administration on the storage of dieldrin in rat adipose tissue. All DDT treatments caused highly significant reductions in dieldrin storage. The DDT effect persisted for at least 3 weeks after ceasing DDT treatment, but was definitely weakened (compare a, b, and c). DDT treatment for the final 3 weeks of a 6-week dieldrin exposure was as effective as dieldrin given continuously (b and d). Pretreatment with DDT for 3 weeks was effective throughout the following 6 weeks of dieldrin exposure (e and f). Administering DDT after the dieldrin treatment was highly effective in reducing residual dieldrin in fat (compare g and h). These results give indications of the potential value of the interaction effect in preventive or therapeutic treatment of individuals undergoing insecticide exposure.

JOSEPH C. STREET is an associate professor in the Department of Animal Science.

JOSEPH C. STREET
fed the treated diets for 10 weeks. They were then killed and their abdominal fat tissue analyzed for its content of insecticides.

**DDT VS. DIELDRIN**

The results showed that DDT had a striking effect on the storage of dieldrin. DDT, added to the diet at 50 ppm, cut dieldrin storage to about 10 percent of that in rats not given DDT. Dieldrin, in turn, caused an increased storage of DDT, although the effect was less pronounced and only observed with the highest dosage levels of dieldrin and DDT tested. Methoxychlor neither influenced the storage of the other compounds nor was influenced by either of them.

We conclude that the fate of one ingested chlorinated hydrocarbon insecticide may be greatly altered by another. This discovery will undoubtedly have considerable influence in reorienting man's view of the ultimate hazard of chlorinated hydrocarbon insecticides in his environment. Perhaps the ubiquitous traces of DDT, generally thought undesirable in the environment, may actually be of some benefit if, in its presence, storage of an insecticide like dieldrin is minimized. Such speculative thinking must wait for confirmation, however, until we gain a full understanding of the interaction effect.

In follow-up studies, DDT administration also proved effective in reducing the storage of dieldrin in the body fat of swine, sheep, and probably of trout. When DDT was tested in combination with heptachlor the resulting heptachlor epoxide storage was markedly reduced, thus indicating that DDT's interaction effect may operate with many other chlorinated hydrocarbon insecticides. We also found that pretreating rats with DDT would reduce the storage of subsequently administered dieldrin. Similarly, rats treated with DDT following heavy exposure to dieldrin would clear dieldrin from the body fat more quickly than otherwise (figure 1).

This interaction effect of DDT may offer a means of countering some insecticide problems of various segments of agriculture. The dairy industry, for example, has had costly difficulties with excessive insecticide residues in milk and other dairy products. Traces of dieldrin and heptachlor epoxide in alfalfa hay have necessitated the dumping of much milk, the sacrifice of many dairy cows, and near panic on the affected farms since health officials do not permit marketing of dairy foods containing detectable traces of those compounds. This particular problem has been important in Utah during the past few years.

In theory, DDT could be used to lessen the storage of dieldrin or heptachlor in dairy cows. In reality, however, the resulting DDT level would make milk unmarketable.

**DRUG INSECTICIDE INTERACTIONS**

Other chemicals, however, might have the same ability as DDT to alter insecticide storage, but with the advantage of being less toxic and objectionable. Pharmacologists have recently established that DDT speeds the destruction of various drugs in rats. Rats treated with DDT metabolize drugs and eliminate the breakdown products at a faster rate than non-treated rats. It seemed likely that the effect of DDT...
on insecticide storage could be operating through the same mechanism. Moreover, since a diverse group of drugs also stimulates drug metabolism, we felt it likely that such drugs might similarly stimulate dieldrin metabolism and reduce its storage in animals. We have completed tests in rats using six sedatives of the barbiturate family, two fever-suppressing drugs, and an oral antidiabetic. Each drug did cause a significant reduction in dieldrin storage. Their effectiveness varied somewhat, with some of the barbiturates (common phenobarbital, for example) producing the greatest degree of response. None of the drugs was as potent as DDT, however, in reducing the amount of dieldrin stored.

CONCEPT VALID

We have thus confirmed the validity of a new concept about the fate in animals of a major class of pesticides, the chlorinated hydrocarbon insecticides. Much more study is needed before we can delineate the total significance of these findings. An intriguing possibility is that effective drugs may be developed which could be safely used to reduce insecticide storage in animals and man. Such agents might also be used in treatment of individuals who become overexposed to insecticides and other poisonous chemicals. However the implications of our completed and contemplated research transcend merely the better understanding of the fate in animals of a class of insecticidal compounds. Its more significant value lies in the probability that the principles discovered may be applicable to the toxicology of many other chemical pollutants already present in, or being introduced into, our environment.

The research reported here was supported, in part, by USDA regional research funds and by USPHS grants EE-00543 and GM-1179.

USDA DEVELOPING LEAF HARVESTER TO STRIP ALFALFA

Conventional alfalfa harvesting methods often waste leaves—the most valuable portion of the plant. Now, United States Department of Agriculture scientists are developing a machine that strips and collects alfalfa leaves from a standing crop, leaving the stems undamaged to grow new foliage.

Although leaf regrowth studies are still preliminary, findings indicate it may be possible to strip the leaves twice, then harvest the stems as roughage. If so, the new harvest method may greatly increase the value of the crop. The leaves would make a high-protein, low-fiber feed ideally suited to processing into meal or pellets, and the stems would make a useful roughage.

The tractor-drawn unit, a modified version of a commercial hay crusher, is equipped with a windrow pick-up attachment from a combine, which serves as a feeding device to position the plants properly for stripping.

The stripping mechanism consists of 2 modified crusher rolls—a 12-inch upper roll of smooth steel and an 8-inch lower roll of rubber. Spacing between the rolls and speed of rotation of the rolls can be set to control the amount of stems and thus control the quality of the stripped leaf product. The experimental harvester collects up to 90 percent of the leaves.

Figure 3. The author is operating a chromatograph fractionating device for the purpose of isolating new metabolites of the insecticide, DDT, obtained from the feces of rats.
Pruning bearing trees and rejuvenating old trees

In the last issue of Utah Science there was an article on training non-bearing trees to provide a strong bearing tree. This article is a continuation of the series and discusses the pruning of bearing trees.

Annual pruning provides for the maximum quantity of top grade fruit and maintains tree height at a proper level for economical management. Good pruning practices will increase the size and color of the fruit and keep the fruiting wood young and vigorous. It also assists in controlling insects and diseases because it opens up the tree and allows better spray penetration.

THEORY CHANGE

The extent or degree of pruning each year depends upon many factors: age, species, variety, existing framework, condition of the bark and wood, and soil fertility.

Years ago, growers would plant their apple trees 40 feet by 40 feet apart, but now it is common for them to plant the trees 20 feet by 20 feet. In fact, many growers are planting semi-dwarf apple trees and placing them even closer. Earlier, the idea was to develop very large trees. This theory has changed completely, and growers are now concerned with planting trees much closer and pruning them so that most of the fruit can be picked from the ground and only 8-foot ladders need be used. Smaller trees reduce the amount of hand labor for thinning and picking. They also provide better spray penetration in the tops and more sunlight reaches the lower branches.

Pruning reduces the number of growing points and produces a tree with less total growth. This is referred to as a dwarfing process. Pruning also invigorates the remaining limbs. There is less competition among the remaining limbs. They are able to grow better, thus producing better quality and often more fruit than if the tree were not pruned.

GENERAL TERMS

In general terms, pruning is a matter of thinning out the dead, diseased, broken, closely parallel, and crossing-over limbs. Cuts should be made where other lateral branches are growing and not in the middle of the limb. Always cut back to the next lateral limb or the buds just behind a "stubbing cut" will develop long shoots which do not form fruiting wood. Root suckers should be cut off each year.

The extent of pruning varies for the different types of trees. As an example, sweet cherry, pear and many apple trees produce mostly on spurs, which often grow just a fraction of an inch each year. Peaches, apricots, and sour cherries, on the other hand, produce their fruit on shoots which may grow 1 or 2 feet each year. All of the fruit trees produce their fruit only on the wood produced the preceding year, but the species fruiting on spurs do not require nearly as much pruning as those fruiting on shoots. The orchardist is well aware that a 4- or 5-inch growth on a spur tree may be 7 to 10 years old and that the spur will produce fruit. These small pieces of growth are very important and must not be broken off at the time of picking. This is one of the reasons growers provide ladders and do not want the pickers to climb the trees.

PRUNING CHERRIES

Sweet cherry trees do not require much pruning, although it is well to spend 1 or 2 minutes to check each tree once a year. You can observe bark disorders, splitting crotches, diseased wood or other problems much easier in the early spring before the leaves start to grow. The main problem with sweet cherry trees is developing a large capacity tree near the ground. These trees tend to grow tall before producing much fruiting wood. A discussion as to how to keep the bearing wood close to the ground was given in the last article. Cherry trees become very tall if not pruned regularly and maintained at 18 to 20 feet. If the trees have been allowed to grow tall and it is difficult for pickers to reach the fruit, sometimes growers

FOR JUNE 1966

55
make large cuts at the time of harvest and the fruit is picked from the limbs after they have fallen.

**PRUNING PEARS**

Pears also require very little pruning once they start bearing. Mostly, it is a matter of thinning out a few limbs or removing a few broken ones unless the bacterial disease, fire blight, is in the orchard. This disease is the limiting factor in pear production and will kill the tree if it is able to spread from the limbs to the trunk. Infected bark turns black and growers should prune out all infected wood by cutting 4 to 6 inches lower than the discolored wood. The infected wood must be removed regardless of how the tree looks after removal, otherwise the blight will spread. The disease usually first appears soon after bloom time and continues to spread until the infected wood is removed. We recommend that orchardists walk through their pear orchard every 2 weeks and break off all young shoots that are infected. The shoots are broken off by hand, where possible, to keep from spreading it by using shears. Some disinfect their shears after each cut in a mercuric chloride solution so they can use the tools. It is essential for successful pear production that infected wood be removed as soon as it is noticed. Excessive pruning or heavy fertilization of pears is not recommended since it stimulates the young succulent growth which is more susceptible to fire blight.

**PRUNING APPLES**

A new method for pruning most apple varieties, called the "mold and hold" system, has received a lot of attention. As the name implies, after proper training, it is a matter of keeping the tree at the desired height and thinned out well for maximum production. This system utilizes the principle of developing fruiting wood close to the ground by converting water sprouts and small shoots, which previously were eliminated, into spurs. This results in the development of apples near the trunk on scaffold limbs. This is done by leaving 3 or 4 inches of the water sprout the first year and continuing each year to leave another 2 or 3 inches on the shoots until they develop spurs. This may take 3 or 4 years, but once a spur has formed it will continue to fruit. Of course, if the water sprouts are closer together than 3 or 4 inches then some thinning out is needed.

A common practice in the past was to remove many of the branches in the center of the tree and depend on the fruit forming on the outer periphery, which usually meant a large tree. Now, if the top center area is opened up there is adequate sunlight for quality fruit in the lower center portion of the tree. This lower hanging fruit doesn't require as much ladder work.

If an apple tree becomes much more than 18 to 20 feet high, it should be lowered for increased efficiency. Likewise, if limbs become long and narrow, or bend downwards, they should be removed or at least shortened to invigorate them. If the limbs become too thick and form a matted area, small sized and poor quality fruit will develop. Thinning out is needed to allow adequate sunlight and spray penetration. Limbs should not be allowed to touch each other nor to grow closely parallel.

As the trees become older, more thin wood develops. This necessitates more pruning to keep the tree physiologically young.

**PRUNING PEACHES**

There is probably more controversy about the proper method of pruning peach trees than the other fruit trees. Some growers choose to remove more wood than others. A number of experiments have been performed on peach pruning. The studies generally show that the less pruning you do the more fruit you will harvest, although it does not have the size and quality of fruit produced from trees more heavily pruned. On the other hand, a tree pruned excessively will bear much less fruit, which usually is delayed in its ripening even though it is much larger. The main problem in peach culture is to adjust fertilizer and pruning practices to return the most dollars per acre. If your market is stores which sell just a few pounds of premium peaches at a time, you

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**Figure 1.** This peach tree has far too many limbs for efficient production. When it is in full leaf, sunlight or spray cannot penetrate to its center.
should prune differently than if the market is housewives who buy a few bushels for home canning.

An 8-year extensive peach pruning study was conducted by Utah State University personnel. During this period, they studied the effects of pruning treatments ranging from removing only dead, diseased and broken branches to a severe type of pruning in which they removed 50 to 75 percent of all wood and headed the remaining wood back 4 or 6 inches.

The pruning method which produced the most marketable fruit (fruit 2 1/4 inches in diameter or more), was thinning out. This method involves the removal of weak wood, and about one-third to one-half of the new wood, with the scaffold branches headed to outside laterals at about 9 feet in the air.

The most desirable fruiting wood for peaches is new wood 12 to 18 inches long. Wood longer than this usually has very few fruit buds, while wood shorter than this is usually weak and also has few fruit buds. Small, dead twigs indicate insufficient pruning in past years. Peach trees have the habit of growing the fruiting wood further and further away from the trunk. Once the tree has the desired height and spread it is necessary to practice renewal pruning. New limbs are allowed to develop from the scaffold branches which in a couple of years will replace the older limbs. In this manner young fruiting wood can be maintained.

The main points about peach pruning are to keep the tree well thinned out, develop good fruiting wood as described above, and keep the tree 8 to 9 feet tall. Some prefer smaller trees but it reduces the production.

Pruning peach trees in this manner provides vigorous shoots for production and is the cheapest and best answer to peach thinning.

**REJUVENATING OLD TREES**

Older trees, particularly apple trees, which have not been pruned for a number of years and have been abandoned, may often be revitalized and brought back into productivity. This can be done by a rather severe pruning and extra fertilizer. The pruning usually involves very heavy thinning out so that plenty of light can penetrate.

**LOWERING TREES**

When trees become taller than desired they can be lowered effectively by cutting the top back to a lateral limb at the height desired. Cutting back to a lateral limb prevents the growth of water sprouts which shoot directly into the air. This results in as tall or even taller trees. Whenever a limb is not cut near a lateral a stub is left and the shoots develop directly under the cut.

**TIME OF YEAR**

The optimum time to prune trees in areas having cold winter temperatures is in the dormant season, preferably during early spring just before the flowers and leaves appear. Pruning becomes a dwarfing process if it is done while the leaves are on the tree instead of during the dormant season. This does not present a problem for the homeowner or small fruit grower, but it does for a large acreage. To estimate when to start pruning, determine how much time is actually needed to prune the orchard, then, as a safety margin, allow several more days for poor weather and breakdown of power equipment.

In Utah, pruning is delayed until spring because the trees are more susceptible to below freezing temperatures after they are pruned. Pruning stimulates trees in some way which may be injurious. This stimulation occurs less with older trees than with younger ones and some types of trees are more susceptible than others. In general, one should start pruning his older apple or sour cherry trees first, then pears, sweet cherries, apricots and finally peaches. There are numerous reports of pruned peach trees which have suffered winter injury while non-pruned trees grown under similar conditions were not injured.

If winter damage is evident, it is better to prune late in the spring and remove much less wood. In some cases with apples, or other trees not requiring a large amount of pruning, do not prune that year at all. If as much wood as possible is left the maximum number of leaves will grow. The leaves produce carbohydrates and contribute to the growth and repair of the tree. A heavy pruning after the tree has been injured, on the other hand, may result in death of the tree.

Figure 2. The same tree after correct pruning. Notice how the tree has been opened up. Another advantage is the added ease of picking.
HEALING OF CUTS

The sun acts as an efficient disinfectant for wounds. The orchardist does not paint or cover over the cuts he makes. Callousing occurs rapidly and generally the cut does not become infected. In fact, painting over cuts is sometimes more harmful than leaving them open. Microorganisms are sheltered from the sun by the paint. If paint is used it should not have a lead base or the paint itself may be injurious to the tree. If a large cut is made and it appears desirable to cover the area, commercial preparations are available. A dressing of eight parts resin and three parts raw linseed oil may be warmed and applied as paint. The wound will heal faster if the dressing is applied a week after pruning. Annual applications of the dressing may be needed for a few years. An inexpensive disinfectant is powdered bordeaux mixture which may be spread on the cut.

Power pruners and saws are often used in large orchards thus allowing a person to cut much faster and not be fatigued as much as with hand loppers. Pruning platforms on a wagon with "kick boards" which are moved into the trees are sometimes used instead of ladders. Power lifts have been adapted to hoist pruners into trees. The lifts are not used by many growers as yet, because they are still in the experimental stage. In addition, they are expensive with only one man pruning per lift.

Brush should be removed shortly after pruning. If brush is allowed to remain in the orchard, insects and disease organisms increase on the dead wood and then spread to the trees. Grass also grows up between the branches making it more difficult to remove the brush later in the summer. Orchard operations such as fertilizing, thinning, irrigating and harvesting also are more difficult when the brush is not removed.

The brush can be removed in a number of ways. Some growers place forks on the front of a tractor and push the limbs out or drag the limbs away with a spring tooth harrow.

Bees Fed Pathogens

Some insect diseases offer promise as effective biological control agents. To learn the effects on beneficial insects of disease organisms used against insect pests, scientists of the Agricultural Research Service are conducting tests with honeybees fed various insect pathogens.

Bees were selected for testing because of their economic importance and because as social insects they are particularly susceptible to some diseases.

It is also possible, the scientists say, that an organism that does not visibly affect individual bees may harm the colony. They want to learn, for example, whether certain pathogens affect honey or wax production, or the queen's egg laying, without killing the bees or harming them in other ways.
Based on the type of vegetation cover, approximately 86 percent of the land area in Utah is classed as range land. Major areas in the surrounding states also consist largely of range land. Stock-edible shrubs and herbs are an important resource throughout most of this vast area. In many areas, however, the range has been depleted of the more palatable shrubs and herbs. One of the major problems facing stockmen, the Bureau of Land Management and range land owners is how to reclaim these depleted ranges. To bring back these forage plants, seed sources must be developed because indigenous plants are too scattered, seasonal in seed production, and hand gathering the seed is expensive.

Range managers and stockmen know that a diversified diet made up of browse and herbs is better than either alone. On winter ranges, when grasses are low in protein and high in energy, browse plants help furnish the needed protein to supply a more balanced diet. In areas of heavy snow, browse with vegetative portions above the snow blanket may furnish the only feed.

**ADDITIONAL GRAZING**

Additional grazing on our private, State and Federal winter and spring range lands can be supported by improving the palatable shrub and herb plant cover, which will provide thicker growth for more animals and at the same time furnish a better season distribution of nutritious forage. This, in turn, might extend the grazing period.

**FOR JUNE 1966**

GORDON A. VAN EPPS

Another aspect of this overall need for restoring some of our native shrubs and herbs is the demand for forage by game animals. This need is particularly acute on many of the foothill winter ranges.

During the past 10 years or more the Intermountain Forest and Range Experiment Station in cooperation with the Utah State Fish and Game Department has been studying ways and means for restoring game ranges. Because of the rising need for seed from several species, we are experimenting to explore the feasibility of producing them on dry and irrigated farm land. At present, nearly all seeds are collected from scattered indigenous stands at various locations. This makes the seed costs expensive. Some years an abundant seed yield is produced while few seeds are formed during other years. This is due mainly to climatic conditions, insects, and other unknown factors. The lack of seed along with the cost of gathering are major factors in prohibiting its use for restoring native ranges to their potential productivity.

**SPECIES STUDIED**

Five species are being used in these studies and they show marked promise. There are three shrubs and two broadleaf herbs. The shrubs are antelope bitterbrush (*Purshia tridentata*), fourwing saltbush (*Atriplex canescens*), and winterfat or white sage (*Europia lanata*). The broadleaf herbs are arrowleaf balsamroot (*Balsamorhiza sagittata*) and Utah sweetvetch (*Hedysarum*).
boreal var. Utahense). They are in very limited use because adequate seed sources are not available. Consequently, they have been entered into trial plantings to determine their merit as seed producers on cultivated lands.

Actually, the value of these species as quality forage producers has been known for a long time, but their potential in the artificial rehabilitation of ranges is comparatively recent. This is attributed to the many difficulties which have been encountered. There have been problems in the seed source, harvesting cost, germination, and establishment.

POSSIBLE CROP

The possibility of growing one or more of these species for seed production as a profitable new crop on our dry and irrigated farms warrants exploration. These were indigenous on many of our lands which are now dry farms and irrigated fields. Consequently, we know they have the inherent attributes for adaptation. We are now investigating how to best grow and manage them. First-year results show real promise for the future with all these species.

Successful spring plantings in single rows have been made with all five species at the Nephi Field Station and with transplants of the five species under irrigation at Snow Field Station.

Antelope bitterbrush is one of the more important native deciduous shrubs for game food as well as cattle and sheep browse. It grows primarily in foothill ranges throughout Utah and the other Western States. One of the first field plantings of antelope bitterbrush is of particular interest because of the response from seed sources and treatments.

In these first year trials, seed from three sources of bitterbrush was subjected to four treatments prior to making a field planting on the Nephi Dryland Field Station. The seed was furnished by the Great Basin Experimental Area of the Intermountain Forest and Range Experiment Station. Seeds came from three strikingly different forms growing in Sanpete County. One source was from a low foothill area east of Mt. Pleasant, another from a slightly higher range east of Fountain Green, and the third from a still higher range in Ephraim Canyon. Plants from Ephraim Canyon are a low spreading type reaching a height of 2 to 3 feet. New plants have been formed vegetatively through natural layering of the branches. The Mt. Pleasant plants are of a semi-tree type growing 12 feet high. There may be one to several main stems. The bitterbrush in the Fountain Green area is intermediate between the other two. Plants may grow to a height of 6 feet.

The seed was cleaned to a purity of 90 percent. Germination for all lots exceeded 85 percent. The seeds from Ephraim Canyon and Fountain Green were from the 1963 seed crop and those from Mt. Pleasant were harvested in 1964.

SEED TREATED

The seeds were given four treatments. Three treatments consisted of the following: half of the seeds from each of the three seed sources were treated with a 3 percent solution of thiourea for 4 to 5 minutes and then dried. Half of the untreated seeds and half of those treated were stratified by placing them between wet paper towels. These were then wrapped individually in plastic and placed in a refrigerator for 10 days, at a temperature of 32° to 34°F. The remaining half of the untreated seeds were left to be planted dry. On March 23, 1965, the seeds were planted by hand in single rows, in the bottom of shallow furrows, covered with soil, and lightly compacted. A high rate
of seeding was used with a count kept by row of the seeds planted. The land was in wheat stubble and the soil contained excellent moisture. Several good storms followed the planting. Hand hoeing kept other plants from competing within the experimental area.

Monthly precipitation during first-year growing season was: March (.75); April (1.43); May (1.84); June (.40); July (1.57); August (.86); September (2.35); October (0); November (1.49) for a total of 10.69 inches. Distribution of moisture during this period was more uniform than normal. The 62-year average during this same 9-month period was 9.61 inches. The mean average monthly temperature during the germination and main emerging periods was 36°F in March and 48°F in April. There were at least 20 days following the planting when the minimum temperatures dropped to freezing or lower.

PLANTING RESULTS

The seedlings started emerging on April 20. Most of them were through by April 27. A few new seedlings emerged following each storm during May and early June, but most of these did not survive the summer.

A count was made of the individual live seedlings of bitterbrush on June 2 and November 22, 1965, to compare the effect of the four seed treatments on seed from each of the three sources. The results were similar but tremendous differences in germination were noted between the treatments. The percent of plant survival from the planted seed is shown in table 1.

The poorest results came from the untreated seed. We expected this, as the weather had not been cold long enough to break the natural dormancy of the seed. Next ranking were the moist-cold and thiourea treatments. Seedling percentages were not significant between the cold and thiourea treatments, though there was a slight trend in favor of the chemical. The combination treatment where the seeds were first treated with thiourea and then subjected to the moist-cold condition more than doubled the number of seedlings in the other treatments. The early planting along with the cold temperatures which followed no doubt had a supplemental effect to the cold and thiourea treatments in helping to break dormancy.

We were surprised to find substantially better survival rates for the layering form of bitterbrush from Ephraim Canyon and especially its superior establishment from the combination treatment.

Perhaps fall may prove to be the proper time for establishing one or more of these species because of seed dormancy and the longer time the seed is subjected to moist soil conditions. There may be times when spring plantings are essential for better weed control, rotting of seed when overwintered in the soil, or seed removal by rodents or birds. Both planting times need to be explored under different soil and climatic conditions.

The two small plantings of bitterbrush and fourwing saltbush established from transplants at the Snow Field Station in Ephraim produced excellent first year growth in heavy clay-loam soils under limited irrigation. Evidently, both are sensitive to water because some plants died where they received too much water at the bottom of the rows.

Results from these exploratory trials show several things. The dormancy of bitterbrush seed can be broken for spring plantings on cultivated cropland. The distinct difference in response seems to prove early spring plantings can provide satisfactory stands. The other four species were all established by early direct seeding on the dryland soils at the Nephi Field Station. Transplants of all five species made good first-year growth under limited irrigation at the Snow Field Station.

For future experiments, large field plantings of these three shrubs and two broadleaf herbs were made during the fall of 1965 at the Nephi Dryland Field Station and the Snow Field Station.

Table 1. Percent Antelope Bitterbrush seedling survival at late spring and fall dates from a field planting made March 23, 1965.

<table>
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<th>Seed Source</th>
<th>Seed Treatments</th>
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<th>Thiourea</th>
<th>Cold + Thiourea</th>
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<td>Cold + Thiourea</td>
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<td>Average</td>
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<td></td>
<td>Cold</td>
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EDITOR'S NOTE

In accordance with Federal regulations, we are revising the mail list of Utah Farm and Home Science. A post card was enclosed in the March issue.

Please return it if you wish to continue receiving the magazine. Don't forget your zip code.
Maintaining Quality

(This is the first article in a series on the quality of fresh and processed fruits and vegetables.)

American consumers are increasingly fastidious about the foods they buy. They no longer accept tired looking “fresh” produce as the inevitable price they must pay for living away from the farm. Progressive producers of fruits and vegetables who cater to these critical consumers can command top prices for their merchandise. The higher profits more than justify the costs associated with using the methods science has developed to prolong the quality of fresh produce.

The most important fruit crops produced in Utah include peaches, apricots, apples, and sweet cherries. Of these, apples are the most durable, but even apples require certain storage and transportation conditions to maintain high quality. They must be stored around 32 °F and over 85 percent relative humidity. The other Utah fruits are relatively perishable and need additional careful attention if they are to satisfy the modern housewife.

With some fruits, a grower can affect his marketing potential by the variety he chooses. For example, Chinese (Large Early Montgamet) apricots store better than the Moorpark variety. The Marshall and Robinson varieties of strawberries bruise more easily than do Shasta, Miss Utah, and Kasuga varieties. To retain maximum flavor and quality in storage and during transportation, the fruit should be harvested at the firm-but-ripe stage. If the fruit is harvested before it reaches this maturity, it does not develop proper color, flavor, texture, and certain vitamins. However, if harvested beyond this stage of maturity, the fruit bruises easily and deteriorates faster during storage and transportation.

CONTROLLED ATMOSPHERE STORAGE

Fruits and vegetables continue to respire after they are harvested. In normal respiration, oxygen is consumed while carbon dioxide, water, and heat (energy) are released. Post-harvest respiration can result in a number of objectionable changes such as loss of sugars, color, and flavor.

The respiration of stored produce can be slowed by low temperatures and a controlled atmosphere. In a controlled atmosphere, the concentration of oxygen (O₂) around the stored produce is decreased artificially while the concentration of carbon dioxide (CO₂) is increased. Too much CO₂, however, can trigger anaerobic respiration which produces objectionable end products and hastens deterioration. The recommended relative concentrations of CO₂ and O₂ depend upon the specific fruits and fruit varieties.

In general, controlled atmosphere storage can add 4 to 8 months of refrigerated life to most fruits. Furthermore, fruits removed from controlled atmosphere storage remain in good condition 5 to 20 times longer than comparable fruits removed from conventional cold storage. This indicates a residual effect of controlled atmosphere storage.

The Tectrol Division of Whirlpool Corporation has revolutionized controlled atmosphere storage by developing a way to burn natural gas to form and maintain the desired concentrations of carbon dioxide and oxygen.

Figure 1. Controlled atmosphere storage for fruits has been revolutionized by an apparatus which burns natural or propane gas to form and maintain the desired concentrations of carbon dioxide and oxygen.
in Fresh Produce

B. N. WANKIER, and KAZUO CHACHIN

or propane gas and maintain precisely the desired concentrations of CO₂ and O₂. Many thousands of bushels of apples and other fruits are held every year throughout the country in this kind of controlled atmosphere storage under the supervision of Whirlpool Corporation engineers. At Utah State University we are using one of these units to study the metabolic changes and flavor chemistry that characterize apples, peaches, apricots, cherries, and pears. This research is in progress on grants from the Tectrol Division of Whirlpool Corporation.

PRE-HARVEST CHEMICAL SPRAYS

Chemicals, such as Mycostatin, Captan, Phaltan, Difolatan and Daconil 2787, have been applied to cherries, apricots, and peaches with a knapsack-type sprayer while the fruits were still on the tree. Applications were made 1 to 2 weeks before harvest. The results showed that these chemicals controlled the mold growth in the storage of these fruits whereas the control lots became moldy. Difolatan not only inhibited the mold growth, but also retarded the onset of senescence, that phase of plant growth that extends from full plant maturity to actual death.

PRECOOLING FRUITS

Precooling refers to the rapid removal of heat from fruits prior to shipment or storage. The more quickly the field heat is removed after harvest, the longer the product can be maintained in marketable condition. The cooling can be accomplished by a blast of cold air, immersion in ice or cold water, or by applying a vacuum. Any of these treatments can delay the ripening process, reduce the rate of respiration, and retard the evolution of ethylene, thus lengthening the storage life of the produce.

During the summer months in Utah, temperatures often rise above 80° and 90°F while the relative humidity is 10 to 15 percent. Hence, a precooling treatment that supplies water is most effective since the water will help offset any tendency to shrivel. The ideal duration for hydro-cooling processes depends upon water temperature, fruit temperature, size of fruit, amount of ice, amount of water, water flow, and heat transfer characteristics of the fruits.

Hydro-cooling techniques can be used in packaging sheds and by the road-stand industry to extend the marketable life of fresh produce.

POST-HARVEST TREATMENTS WITH FUNGICIDES AND ANTIMUGHAL ANTIBIOTICS

In Utah, certain fungi take a heavy toll of stored fruits. Research has been conducted and is in progress at USU in cooperation with several pharmaceutical companies on the use of antifungals to prevent fungal growth on fruits and control metabolic changes in the fruits.

![Figure 2. Instruments sensitive to concentrations of certain gases are used to monitor the concentration of carbon dioxide and oxygen in controlled atmosphere storage experiments.](image1)

![Figure 3. Certain fungi cause a high rate of spoilage in stored fruit. Research has shown that fruit treated while in the hydro-cooler with certain anti-fungal chemicals and hormones before storage will remain in good condition weeks longer.](image2)
Some of the most promising chemicals are: Dowicide A, DHA-S, Captan, Difolatan, Myprozine, and Mycostatin in minute concentrations of 100 to 1,000 parts per million (ppm). In our laboratories these chemicals have been used as dips, sprays, and in conjunction with hydro-cooling and flexible packaging.

Some of these antifungal chemicals (Captan, Botran, and sorbic acid) have been cleared for certain concentrations by the Food and Drug Administration for use in foods. Considerably more experimental work has to be done, however, before any of these chemicals can be recommended for routine applications to fruit intended for human consumption. Secondary aminobutane effectively controls Penicillium decay of cherries. This volatile fungicide is very effective at 500 to 1,000 ppm level. Sorbic acid (1,000 ppm) and Mycostatin (500 ppm) controlled yeast fermentation in apple juice.

HORMONE TREATMENTS

N6 Benzyl adenine and 6 Fururyl aminopurine are being investigated in our laboratories as hormone-type senescence inhibitors. These chemicals extend post harvest storage life of fruits and green-picked vegetables. These hormones inhibit respiration, and help delay the breaking down of chlorophyll and proteins in fruits and vegetables. Leafy vegetables, green calyx of strawberies, and pedicels of sweet cherries remained relatively fresh more than 25 days when they were treated at harvest time with 10 to 20 ppm of these chemicals.

RADIATION PRESERVATION

For more than ten years, USU has conducted extensive research in preparation of food by ionizing radiation. Gamma and beta rays can destroy or delay the growth of certain bacteria and fungi without generating much heat. The process also retards ripening and treated fruits can be stored satisfactorily for longer than usual periods. Promising results have been noted at USU on the extension of the refrigerated life of peaches, sweet cherries, and strawberries, and on sprout inhibition in onions, carrots, and potatoes. This research is continuing with our goal being a substantial extension of shelf life and the maintenance of high quality.

PACKAGING TECHNIQUES

Today, packaging fruits for distant markets or delayed markets generally involves the use of polyethylene, saran, and mylar films. These films create, in effect, a modified atmosphere of increased CO2 and decreased O2 around the fruit. Such packaging also serves to increase the relative humidity in the

Figure 4. Lambert cherries in Mylar 50 film bag (photographed 60 days after storage at 32°F, 90 percent relative humidity). A. hydro-cooled with Mycostatin (400 ppm). B. control.

Figure 5. Effect of Mycostatin and packaging treatment on fungal growth of Lambert cherries (photographed 60 days after storage at 32°F, 90 percent relative humidity). 1. hydro-cooled with Mycostatin (400 ppm) and packaged in Mylar 50 film. 2. control in Mylar 50 film. 3. control in wooden box.

64 UTAH FARM AND HOME SCIENCE
containers and thus cuts losses by shriveling.

The success of flexible packaging of fresh fruits depends upon the permeability of films to CO₂ and water vapor. If a film is impervious to gases, the eventual anaerobic respiration of the packaged fruits will cause serious deterioration. Impervious films promote the heavy accumulation of moisture in the container and foster profuse mold and fungal growth on the fruit. Our research has shown that certain mylar films and perforated polyethylene films hold promise.

GOAL

Fruits and vegetables that stay fresh (in looks and in taste) and remain highly nutritious all the way from a field in Utah to a market in New York is the end goal of much USU food technology research. Attaining that goal will help both consumer and producer.

Hydro-cooling with antifungal chemicals and then careful packaging in consumer-size units are proven steps toward that goal. Pre- and post-harvest treatments with various chemicals have shown promise, but more research is necessary. The potentials for radiation preservation are just beginning to be fully tested. Storage in a controlled atmosphere under low temperatures and treatment with antifungal and/or senescence inhibiting chemicals can definitely prolong the life of fresh produce.

Figure 6. Lambert cherries in wooden box (photographed 60 days after storage at 32°F, 90 percent relative humidity).

Figure 7. Lambert cherries in polyethylene B film bag (photographed 60 days after storage at 32°F, 90 percent relative humidity).

Figure 8. Gamma and beta rays can destroy or delay the growth of certain molds and bacteria. This radiation apparatus under 20 feet of water is used to treat specimens of fruits and vegetables.
REPRODUCTIVE PERFORMANCE
OF DAIRY COWS
ON AN ALL FORAGE RATION

R. C. LAMB, C. H. MICKELSEN, AND L. L. PERKES

One of the prime concerns of breeders of registered dairy cattle is whether the seed stock which they are developing today and which may still be influencing dairy herds for 10, 15, or even 25 years, will be able to meet the feeding and management programs of the future. To answer some of the basic questions needed to help breeders with this perplexing problem, USDA scientists are working in cooperation with the Department of Dairy Science at Utah State University on a long-range study of the relationship between genetics and environment in dairy cattle. Currently, they are studying the performance of cows on rations ranging from all forage to high concentrate-low forage. These cows are daughters of sires selected from various lines of breeding within the Holstein breed and proven in different areas of the world under many varied management and feeding systems.

SIRE INFLUENCE

Daughters of the first group of sires were divided at random into two groups at the time of first calving. One-half of the daughters of each sire were fed a standard ration consisting of all of the high quality alfalfa hay each cow would eat plus a concentrate ration fed at the rate of 1 pound for each 3.5 pounds of 4 percent fat-corrected milk produced. This concentrate ration consisted of 79 percent barley, 19 percent molasses dried beet pulp, 1 percent trace mineral salt, and 1 percent dicalcium phosphate. The other one-half of the daughters of each sire received only alfalfa hay and mineral supplement, but were allowed all they would consume. All other management was held constant for the two groups of daughters.

The main objective of this research was to study the efficiency with which the cows on the different rations converted their feed into milk, and particularly to determine if efficiency of feed is a heritable characteristic in dairy cattle. A summary of these results will be published in a later report.

Since normal reproduction is tied closely to sustained milk production over a number of years, it became important early in the study to see if the different rations had any influence on the reproductive performance of cows in the study. Whether or not sires had any influence on the reproductive performance of their daughters was also observed.

Data for 120 daughters of 8 Holstein sires were available for this study. Two cows, one on each ration but by different sires, did not conceive again within 1 year after first calving and were excluded from the remainder of the study. All other cows were either held for a second calving or diagnosed as pregnant prior to the end of their first lactation.

EFFECT OF RATION

Table 1 shows the effect of ration on several measures of reproductive performance. The average age at first calving was approximately 26 months and only differed by 2 days for the two rations. It was not expected that this measure would be different for the two rations since the heifers had been treated the same up to this point. Although the average number of days from freshening to first heat was the same for the two rations, there was considerable variation among cows, ranging from 9 to 190 days. The cows on the all-forage ration were more variable in the number of days from freshening to first heat period.

Cows on the all-forage ration averaged 8 days longer from freshening to first breeding and 7 days longer from freshening to conception. These differences were not statistically significant. However, the number of heat periods exhibited prior to first breeding was 1.7 for the all-hay group and 1.3 for the cows on the standard ration. This difference was statistically significant, in other words, not occurring by chance.

No differences in fertility were evident between the two groups of cows as they both required an average of 1.5 services per conception. As shown in table 2, approximately two-thirds of the cows on each ration settled on the first service, nearly 90 percent in the first two services, and more than 95 percent in the first three services,
Table 1. Effect of ration on reproductive performance

<table>
<thead>
<tr>
<th>Measures</th>
<th>Ration</th>
<th>All hay</th>
<th>Standard</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>57</td>
<td>61</td>
</tr>
<tr>
<td>Number of cows</td>
<td>799</td>
<td>797</td>
<td></td>
</tr>
<tr>
<td>Age at first calving in days</td>
<td>51</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>Days fresh to first heat</td>
<td>107</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>Days fresh to first breeding</td>
<td>129</td>
<td>122</td>
<td></td>
</tr>
<tr>
<td>Days open</td>
<td>1.7</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Number of services</td>
<td>1.5</td>
<td>1.5</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Number and percentage of cows settled per service

<table>
<thead>
<tr>
<th>Number of services</th>
<th>All hay</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>1</td>
<td>36</td>
<td>63</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6 or more</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 3. Number of heat periods without breeding past 69 days post calving

<table>
<thead>
<tr>
<th>Ration</th>
<th>All hay</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of days</td>
<td>Number</td>
<td></td>
</tr>
<tr>
<td>70-74</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>75-79</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>80-89</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>90 or more</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>9</td>
</tr>
</tbody>
</table>

with very little difference between the two groups.

BREEDING CYCLE

Cows were to be bred on the first normal heat period occurring after 69 days following calving. Table 1 shows that the average number of days from freshening to first breeding was 99 and 107 days for the two rations. Table 3 shows, at least partially, why this difference occurred.

Nine cows out of 61 (14 percent) on the standard ration were not bred back on the first heat period after 69 days following calving. For seven of the nine cows the heat period on which breeding was missed came within 79 days following calving. On the other hand, 21 of the 57 cows on all-forage ration (37 percent) were not bred back on the first heat period after 69 days following calving.

The reason for this difference in the percentage of cows not being bred back as scheduled was indirectly due to ration. The difference between the two groups of cows in the number of days from freshening to first service, number of days open, and number of heat periods prior to first breeding, was caused by an unintentional difference in management. By 60 days following calving many of the cows on the all-forage ration had milked down and became extremely thin. When these extremely thin cows exhibited symptoms of heat just shortly after 69 days following calving, the herdsman had a tendency not to breed them until the following heat period in order to allow them a longer dry period following their lactation, hoping they would thus be back in a more normal condition for their second lactation. Since the cows on the standard ration were in better condition 69 days following calving, there was less of a tendency to skip an extra heat period with these cows.

THIN COWS

Careful study of the data showed that while the cows on the two rations followed a similar pattern in returning to normal estrus cycles following parturition, some cows on the all-forage diet stopped exhibiting symptoms of estrus as they became extremely thin, which was about the time they should have first been rebred. These cows generally did not return to heat for an extended period of time, thus delaying breeding even further. Fewer cows on the all-forage ration were bred back in less than 90 days, and four times as many went 150 days or more before breeding.

The influence of sire on reproductive performance of his daughters is summarized in table 4.

There was considerable difference between sire groups in the number of services required for conception for the first gestation, ranging from 1.5 to 3.3 services per conception. Much less variation existed among sire groups in number of services for conception for the second gestation, ranging from 1.3 to 1.9. Daughters of two sires, namely B and G, exhibited considerable difficulty in settling as heifers but were better than average breeders following first calving. The use of poor quality semen during 1961 when daughters of these two sires were first being bred as heifers, i.e., the influence of service sire, accounts for much of this difference. After 1961, all service sires were used equally, as near as possible, on daughters of previous sires so that effect of service sire should be limited in the data on breedings for the second gestation.

RESULTS

Results of this study would indicate that sires have little influence on the reproductive performance of their daughters. Likewise, an all-forage ration does not appear to be

(continued on page 68)
Fertilizing Winter Wheat in Utah

REX F. NIELSON and GORDON A. VAN EPPS

Figure 1. The effect of nitrogen fertilizer can be seen plainly in the darker green strip to the left.

Production of winter wheat on the drylands of Utah is limited primarily by moisture. When moisture is favorable, many areas respond to nitrogen. Fertilizer effects on winter wheat have been studied extensively since 1942. Studies conducted during the 1940's, when rainfall was above normal, showed that broadcast applications of nitrogen increased the yields of wheat significantly. Trials conducted in the 1950's indicated that yield responses to nitrogen fertilizer occurred in about 30 percent of the trials. Precipitation during this period was generally below normal.

Fertilizers used in tests prior to 1960 were applied broadcast with the exception of anhydrous ammonia. Trials with anhydrous ammonia showed that placed fertilizer was more effective in increasing yields than broadcast treatments. Nitrogen broadcast on drylands is ineffective unless it is applied in the fall or early enough in the spring for precipitation to move the nitrogen into the root zone early in the growing season.

NEPHI TRIALS

A 1957 trial at the Nephi Dryland Station resulted in the first data showing that a broadcast nitrogen-phosphorous treatment increased the yield of wheat more than nitrogen alone. Similar results were

REPRODUCTIVE PERFORMANCE OF DAIRY COWS

Table 4. Influence of sire on reproductive performance of his daughters

<table>
<thead>
<tr>
<th>Sires</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of daughters</td>
<td>15</td>
<td>11</td>
<td>9</td>
<td>16</td>
<td>11</td>
<td>20</td>
<td>19</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Number of services — first gestation</td>
<td>1.9</td>
<td>3.3</td>
<td>1.7</td>
<td>1.5</td>
<td>1.5</td>
<td>1.7</td>
<td>2.3</td>
<td>1.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Age at first calving in days</td>
<td>804</td>
<td>812</td>
<td>792</td>
<td>801</td>
<td>770</td>
<td>794</td>
<td>807</td>
<td>786</td>
<td>798</td>
</tr>
<tr>
<td>Days fresh to first heat</td>
<td>60</td>
<td>40</td>
<td>33</td>
<td>48</td>
<td>68</td>
<td>46</td>
<td>47</td>
<td>62</td>
<td>51</td>
</tr>
<tr>
<td>Days fresh to first breeding</td>
<td>103</td>
<td>88</td>
<td>101</td>
<td>106</td>
<td>98</td>
<td>102</td>
<td>100</td>
<td>117</td>
<td>103</td>
</tr>
<tr>
<td>Days open</td>
<td>114</td>
<td>101</td>
<td>125</td>
<td>138</td>
<td>130</td>
<td>124</td>
<td>113</td>
<td>152</td>
<td>125</td>
</tr>
<tr>
<td>Number of heat periods without breeding</td>
<td>1.1</td>
<td>1.6</td>
<td>2.6</td>
<td>1.5</td>
<td>1.0</td>
<td>1.6</td>
<td>1.4</td>
<td>1.3</td>
<td>1.5</td>
</tr>
<tr>
<td>Number of services — second gestation</td>
<td>1.3</td>
<td>1.5</td>
<td>1.6</td>
<td>1.6</td>
<td>1.9</td>
<td>1.5</td>
<td>1.3</td>
<td>1.7</td>
<td>1.5</td>
</tr>
</tbody>
</table>

(continued from page 67)

detrimental to the reproductive performance of dairy cows. However, two problems did arise with cows on the all-forage ration. When these cows producing heavily they became extremely thin, necessitating a delay in breeding to get them back in normal condition for the following lactation. This same extremely thin condition apparently restricted estrus in some cases, beginning at about 80 days following calving and continuing until at least 150 days following calving. Therefore, if breeding was delayed for these cows it was of necessity delayed for an extended period of time. In cases where these thin cows were bred back as scheduled, at first heat after 69 days following calving, they settled normally but were still out of condition at the subsequent calving.

1960 FARM AND HOME SCIENCE
measured from tests conducted in 1958, 1959 and 1960 (figure 2).

In 1960, at Nephi, fertilizer (nitrogen and phosphorous) was drilled with the seed at planting. Separate seed and fertilizer boxes were rigged so that both the seed and the fertilizer dropped down a common tube and were placed closely together by the single-disc drill. We expected the placement of phosphorus to cause more efficient fertilizer utilization than broadcast applications.

Results from this study showed that drilling was much more effective than broadcasting. Data showing the affect of various rates of 16-20-0 placed with the seed are listed in figure 3. Yields were increased from 3 to 5 bushels per acre. The results from a 1962 trial at Nephi, which involved nitrogen and phosphorus placed with the seed at the time of planting, both singly and in combinations, are listed in figure 4. The higher yields from the NP treatment is evident in this test.

The 1963 dryland winter wheat trials were a failure and no yield data were obtained. To determine effect upon yield, a study was conducted in 1964 using different ratios and rates of nitrogen and phosphorus. Data from this trial (figure 5) are inconclusive; however, the 16-20-0 material appears to be as good or better than other NP treatments.

**BOX ELDER TRIALS**

A series of fertilizer trials, involving placement of fertilizer with the seed, were established in Box Elder County the last week of September 1963. The seed and fertilizer were planted in good moisture and the seedlings emerged within 10 days of planting. Wheat in the fertilized plots emerged more slowly than wheat in the check plots. This delay appeared to be in direct proportion to the amount of fertilizer applied. However, it was of short duration and one week after emergence, no difference could be observed. Wheat treated with nitrogen fertilizer was delayed more than that treated with ammonium phosphate or phosphorus alone. Stand counts made of a large number of plots showed no evidence that fertilizer treatment had any measurable effect on the total number of plants established. The tests were inconclusive because severe snow mold caused differential stands and erratic yields.

Data collected from a test harvested in 1965 at the Bluecreek Experimental Farm are listed in figure 6. These data show a significant linear response to nitrogen. Phosphorus had little measurable affect on yields.

**SOIL TESTS**

Soils have been analyzed for...
available phosphorus from all sites where trials have been conducted. These soils are all relatively high. The values ranged from 29 to 33 pounds per acre P (bicarbonate soluble) at Nephi to 18 to 64 pounds available P in Box Elder County. Soil tests appear to be of little value in predicting whether or not a dryland site will respond to added phosphorus. We need additional information before we can predict, from soil tests, the phosphorus needs of dryland winter wheat in Utah.

It has been suggested that the response to phosphorus was actually a sulfur response, since some phosphate fertilizers carry an appreciable amount of sulfur. For 25 years, a number of trials have included ammonium sulfate and ammonium nitrate as treatments. Without exception, the ammonium nitrate treatments have either been equal to or better than the ammonium sulfate treatments. If a sulfur deficiency were to exist, it should have become evident during this testing period.

The protein content of the wheat was measured in all of the studies to date. Protein is usually higher in wheat receiving additional nitrogen. When wheat yields are low, particularly during years with limited precipitation, nitrogen may not increase protein content under all situations.

RECOMMENDATIONS

The benefits from fertilizer applied to dryland winter wheat are affected by a number of factors, the most important one being moisture. We suggest that, where used, fertilizer be placed with the seed at time of planting. When fertilizer is applied with the seed, the cost of application is reduced to a minimum and it is readily available to the growing seed. Some trials have shown a response to phosphorus. Low rates applied with the seed were effective in increasing wheat yields.

The amount and kind of fertilizer to be applied with the seed will depend on soil moisture reserve and whether or not phosphorus is needed. If phosphorus is needed, 15 to 35 pounds of available nitrogen and 10 to 20 pounds of P₂O₅ (5-15 lbs P) should be applied. If nitrogen alone is used, the rate can be increased to as high as 40 pounds N per acre.

If it is not possible to apply fertilizer with the seed in the fall, then the situation should be appraised in early spring. If good stands are obtained and moisture prospects are favorable, 30 to 50 pounds of nitrogen should be applied broadcast. This application should be made as early as mid-February or as late as mid-April, depending upon weather conditions. Since rainfall prospects decrease as late spring
approaches, we recommend early application. The widespread use of bulk spreaders makes it possible to treat large acreages on frozen soil early in the spring. Aerial application has worked effectively and may be advantageous when fields can not be treated with ground rigs.

![Graph](image)

**Figure 6.** The influence of nitrogen and several nitrogen phosphorus ratios on the yield of winter wheat at Bluecreek in 1965. The fertilizer was drilled with the seed.

## CONCLUSIONS

1. A nitrogen deficiency exists on essentially all of the areas producing dryland winter wheat in Utah. This deficiency tends to be exaggerated during years of favorable moisture.

2. Some dryland soils respond more favorably to a nitrogen-phosphorus application than to nitrogen alone. These differences have been more pronounced in the Nephi area than in Box Elder County.

3. To date, little correlation appears between soil tests for phosphorus and response to phosphorus by winter wheat.

4. Placement of fertilizer with the seed at time of planting has produced yields either equal to or better than those obtained from broadcast applications.

5. Response to fertilizers appears to be more pronounced in years when wheat emerges in the fall. When emergence does not occur until mid-winter or early spring, fertilizer response is less striking.

6. When broadcast applications of nitrogen are made in the spring, treatment should occur early in order that nitrogen will be moved into the soil by spring storms.

7. Response of winter wheat to phosphorus applied broadcast is less than that placed with the seed.

8. Fertilizer placed with the seed at time of planting may result in a slight germination delay. To date, no trials have shown that fertilizer placed with the seed has reduced stands or yields with rates up to 50 pounds of nitrogen per acre.

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**Black Light Lures Insects To Sterilant**

Scientists have reduced reproduction of cabbage loopers 90 percent in preliminary field cage tests by using blacklight lamps to lure the insects into contact with a chemical that sterilized males.

The cabbage looper is a destructive pest of several valuable crops, and occurs throughout the United States.

Results of preliminary trials with blacklight lamps and chemo-sterilant were so encouraging that scientists of the Agricultural Research Service are considering the possibility of field tests, if safe procedures can be developed. Recent tests at Riverside, California, were conducted in screen cages set up in cabbage fields.

Using light to lure insects into contact with chemosterilant is only one version of the sterility principle of insect control. The great potential of this principle was demonstrated in a campaign 5 years ago that eradicated screwworms from the southeastern United States. In this campaign, millions of insects were reared in a laboratory, sterilized by exposure to radiation, and released. Sterile males released outnumbered fertile native males by such an overwhelming ratio that reproduction stopped, and the entire population disappeared.

Chemosterilizing insects in the native population rather than in the laboratory potentially is more efficient and the expense of rearing, sterilizing, and distributing insects is unnecessary.

Lamps used in the California tests lured both male and female cabbage looper adults. At the dosages tested, the chemosterilant completely sterilized males and was highly effective against females but did not completely sterilize them. Ideally, both sexes should be completely sterilized.
Bolivia is a relatively poor country as measured by almost any standards. Yet, it has agricultural resources (land, labor, capital, and management) with considerable economic potentials that are largely undeveloped. Farmers are struggling with the problems that have dominated Bolivian agriculture since the agrarian reform in 1952. The citizens of Utah through Utah State University have the privilege of assisting Bolivian farmers solve some of these problems. This mutual effort will result in agriculture on the Bolivian Altiplano entering an era of more rapid economic development — if a few production and marketing problems can be solved. Optimism prevails among the Utah State University team members from USAID because the Bolivian farmers (campesinos) generally seem eager to attain a better life.

THE ALTIPLANO

The Bolivian Altiplano is a high plane lying between east and west ranges of mountains in the great Andean complex. Peaks in the mountains surrounding the plane reach altitudes of 23,000 feet. The plain, about one-third of Bolivia's land area, varies from 10,000 feet elevation in the lower areas to 16,000 feet on the mountain sides. Lake Titicaca, at 12,500 feet elevation, is at the northern end of the Bolivian part of the plain. The mountain ranges close in southern Bolivia to form the southern boundaries of the plain. Great salt flats and a salt lake are located in the central and southern sections.

The whole Altiplano has a wet season from December to March and a dry season from May to October. In the south, however, even the wet season is relatively dry. Rainfall increases to the north, with the wettest area being around Lake Titicaca. Although some small areas are irrigated, there is a water shortage throughout most of the Altiplano which becomes more severe as one moves south.

SOME PROBLEMS

Because of the altitude, frost can occur at any time during the year. Night temperatures are generally cold. If the sun shines, day temperatures can be uncomfortably warm. However, most days are cool. The surrounding mountains contain minerals (tin, silver and others) which have been the major export products for Bolivia. They also contain extensive veins of soluble salts that wash down into the Altiplano when the streams are flowing. This is especially true of the southern and central parts.

Because of the frost, water shortages, and soil salts, cropping alternatives are restricted to hardy varieties of potatoes (many varieties), barley, quinoa (a crop related to the common pig weed), broad (horse) beans, and in more favorably endowed areas, small plots of alfalfa. Except for small quantities of barley, none of these crops appear to have the potential of becoming large commercial or export crops. They are mostly grown for family use, although some vegetables grown around Lake Titicaca reach the La Paz markets.

Grasses, small shrubs, and cactus provide cover for much of the Altiplano. This vegetation has been grazed by sheep since the early Spanish period more than 300 years ago. Llamas and alpacas ranged the Altiplano even before the Incan period. Because of overgrazing, the more desirable native forage species disappeared long ago. However, there is a potential for improved...
on the Bolivian Altiplano

forage production. In irrigated areas, alfalfa and pasture grasses show promise as supplements to seasonal range forages.

Altiplano land resources lend themselves to a range livestock economy. Such a pattern of use has existed historically. The elements have forced the pattern. Range livestock products also present the best possibilities for developing into important commercial products both for the domestic and foreign markets.

LABOR RESOURCE

About two-thirds of Bolivia's 4 million people live on the Altiplano. The majority of them are subsistence farmers. As a result, they make little contribution to the Bolivian economy. However, there is an awakening among the campesinos which is encouraging to those who recognize them as the source of Bolivia's future economic development.

Considering the history of the campesino, his development is taking place very rapidly. Before the agrarian reform in 1952, the Indian population was largely attached to land owned by a privileged class of landlords. For the right to farm a small parcel of the hacienda for their own needs, the Indian and his family worked for the landlord 3 or 4 days a week. He could not own land. Thus, he and his family were attached to the land and landlord as serfs. The Indians had no rights except to work and receive a subsistence living in return.

After the agrarian reform in 1952, the control of the large landlords was broken. Indians were permitted to own land and use it as they wished. In many cases the old landlords were completely dispossessed; in others, they retained a small portion of their once large holdings. The Indians became small farmers. They also assumed control of the livestock on the old hacienda and mixed them with their own small herds.

Because the Indians were forced to think and act only as forced labor for centuries, the land reform produced a class of labor-oriented small farmers. They knew how to plant, cultivate, and harvest for their own use; they knew how to herd livestock; and they knew how to work with their families, ox, stick plough, and clod-breaking mallet. They did not know how to use the machinery, the improved breeds of livestock, nor other production inputs left by the former landlords at the time of the reform. Thus, the campesinos were a poor quality agricultural labor force, before the reform. The only thing that really changed after the reform was that the laborers became land owners. The quality of labor did not change immediately.

ALTIPLANO MANAGEMENT

Before 1952, the agricultural management function on the Bolivian Altiplano centered in the hands of relatively few people. The landlord and his chief overseers made the decisions. In some cases, haciendas were well managed. Improved breeds of sheep, cattle, and horses, as well as improved varieties of forage crops, including alfalfa, existed on hacienda lands before the reform.
The campesinos did not share in management even on the plots of land and the small livestock herds operated for their own use. In reality they did not own the plots nor the animals, and most of their time was devoted to producing for the landlord. Making management decisions was beyond their realm of activity. Most of the management force was lost with the coming of the agrarian reform.

The deep-seated desire on the part of the campesinos to own land, suppressed for centuries, was realized through the agrarian reform. However, the problem of economic land use was not considered seriously by many of the new landowners for several years. Even today, many campesinos think in terms of planting, cultivating, herding, and harvesting for family needs only. As a result, the majority of sheep, llama, and alpaca are not sheared regularly, and only a small part of the crop production reaches a commercial market.

NEW AWARENESS

Yet, the increase in managerial awareness among campesinos is the most encouraging result of the agrarian reform. As it increases, other problems, such as marketing, farm size, production per unit of land or breeding stock, and capital deficiencies, will be solved.

Evidence that this awareness is increasing is found in many ways and places. Campesinos around the few experiment stations watch the research being conducted with real anticipation. Agricultural extension schools are attended by campesino families eager to learn new practices. The feeling that hoarding wool on the backs of their animals is not very satisfying is obvious as enthusiastic participation in wool preparation and marketing training schools increases.

The management unit is the family. A big question in many a campesino mind is: Where can I find out how to manage my resources better? There is no lack of intelligence among the campesinos, but they are trying to change the agricultural practices of centuries in 2 decades. Each new management technique discovered by a campesino requires almost the same vision and skill usually associated with inventors.

If the management resource continues to develop in the future at the same rate as it has in the 14 years since the agrarian reform, the economic, political, and social complexion of Bolivia will change for the better in a relatively short period. The great surprise to astute Bolivian observers is not that so little has happened to Altiplano agriculture during the 14 years since the reform, but that so much has happened during that period to transform serfs into a managerial class. The future of Bolivia rests with this awakening.

CAPITAL RESOURCES

Two problems exist with respect to capital on the Altiplano. First, are the campesinos accumulating...
capital and, are they using what they have for improved management practices? Second, is external capital available to the campesinos for intermediate and long-term investments?

One of the first impacts of the reform was the rapid deterioration in the quality of livestock. The old landlords often prided themselves in the quality of livestock that they possessed. After the reform, the campesinos split up the sheep, llama, and alpaca herds and used them only for family use. The larger improved animals were often eaten. The improved strains were not kept pure. They were crossed with the smaller, low producing "criollo" or "scrub" types. It was not long until the improved breeds all but disappeared. Also, many of the plantings of improved forage crops were destroyed, and the land was planted to the traditional subsistence crops of potatoes, quinoa, barley, and broadbeans. Machinery was left to corrode and disappear. Old haciendas fell in disrepair — some were burned as a result of uncontrolled zeal during the early days of the reform. Obviously, in the first instances, capital assets decreased considerably. The campesino felt little need for capital assets beyond his small acreage (1 or 2 tillable acres), an ox, a traditional stick plough, a one-room adobe house, a few animals, and a "handful" of seeds for his next crop. He was going to get part of the more fertile land owned by the old landlord which would raise his subsistence standard of living to a level never dreamed of before the reform.

**PROGRESS IS NOTED**

However, land ownership and a manager attitude tend to make men aware of the world outside of their own small sphere. They begin to expect more out of life than a subsistence living. Also, they begin to look at the resources at their disposal in a different light and wonder about their potential. They sit up and take notice when they see in a demonstration that a sheep need not produce only 1.5 pounds of wool a year, but that one of an improved breed can produce 10 pounds a year. They see that the better type sheep can produce lambs weighing 60-80 pounds in a year instead of lambs which average 20-30 pounds such as their present herds produce. It doesn't take long for an intelligent man to realize that he can produce as much wool and meat with one good sheep as he does with four to six "criollo" sheep.

He also observes through demonstrations, experiments, and innovating neighbors that some plants,
properly managed, produce 10 or more times as much forage as those he has traditionally grown. After he and his family think through a crude farm budget, the results begin to excite him. He first dreams of increased production, then some simple consumption goods, then the need for increased income; and his expectations take a leap that drives him to make the managerial decisions necessary to satisfy those expectations.

Evidence is mounting that this mental process is culminating in capital accumulation among campesinos. Of course, by United States standards, capital assets on campesino farms are few indeed, but in relation to what they were before the reform the accumulation is significant. The most obvious changes are found in communities with improved animals, alfalfa seedings, transistor radios, houses with metal roofs, factory-made clothes, two-story homes (one room above another), bicycles, plastic rain protectors, dipping vats for animals, and many other items. Also, some communities are investing in tractors, and some land sales are taking place which means larger operating farm units.

Capital sources external to the campesino are still deficient but increasing. Interest rates are relatively high—a minimum of 12 percent and often much higher. An agricultural bank partly supported from U.S. funds makes production and intermediate loans for improvement under certain conditions. One evidence that campesino management awareness is growing is the increasing demand for credit to make improvements. Of course, for a rapid change in the agricultural economy, capital must so increase that it is not the limiting resource.

**USU TEAM PROGRAM**

Three types of problems face the USU Team in Bolivia.

*First*, production practices are not in use where physical and economic feasibility are obvious and knowledge concerning them is available. Some examples include shearing and wool preparation, resource requirements, and management practices for growing some varieties of alfalfa, and methods of controlling some livestock parasites. Gaining accept-
ance of these practices is generally accomplished through extension education demonstrations which convince campesinos of physical and economic feasibility.

Second, there are problems where knowledge of solution is incomplete as far as physical and economic feasibility are concerned. In some cases, the necessary knowledge can be acquired through experimentation. Some problems in this category are: (1) How can the very low reproduction (50 percent or less) for Altiplano livestock be increased? (2) How will introduced range forage plants react to Altiplano conditions? (3) How will improved breeds of sheep, llama, and alpaca react to Altiplano conditions? (4) What methods will control some diseases and parasites in plants and animals found on the Altiplano? Both physical and economic feasibility can be established by controlled experimentation. Programs designed to solve these problems take longer than those in the first problem group. After experimental research has determined the feasibility of a solution, then the knowledge must be extended to campesinos through demonstrations and education programs.

Third, there are problems requiring solutions which do not lend themselves to experimental control nor is knowledge certain enough at present for demonstration programs. Some of these problems are: (1) What kind of marketing system will best serve the needs of the Bolivian situation? (2) What kind of government policy will be most effective in developing Altiplano resources? (3) What kind of extension program will disseminate knowledge most adequately and rapidly? (4) What forage and livestock varieties should be selected for further study on the Altiplano? Solutions to these and many other problems depend upon the imagination and training of specialists making the decisions. The solutions require knowledge of the general principles of the disciplines involved

(continued on page 84)
WATER
FOR
UTAH
BY PLAN
or
by
accident

B. DELWORTH GARDNER

When California took the initiative in establishing a state water plan for developing and utilizing her water resources, she played without a trump suit. She did not have a meaningful set of economic goals on which to base criteria that would aid the planners in optimizing water use and development in the state. As a result, California’s plan may never fulfill itself satisfactorily.

In a very real sense, California’s mistakes in this regard are Utah’s gain. Utah now can play her cards more judiciously than did her neighbor on the coast. If she is willing to learn from experience, Utah may be able to develop a state water plan that will serve as a model for other states.

Figure 1. Snow fields high in Utah’s mountains furnish most of the water used within the state. Optimal use and development of these “snow banked” waters are major problems facing Utah.

DISCUSSION

This article presents a discussion and evaluation of alternative goals that the state should consider in water planning. The best interests of the state of Utah require the development of a water plan. Judged by any criterion, but especially in terms of human welfare, water is a crucial commodity in Utah. It is “consumed” in a variety of ways by individual households, it is used as a productive input by many kinds of business enterprises, it limits types and areas of agricultural production and it is an indispensable ingredient in almost every outdoor recreational activity. As these and other demands for water rise sharply over time, water is becoming increasingly scarce. The productivity of Utah’s economy and the aesthetic quality of life within her borders will be determined to a great extent by how wisely water resources are conserved, developed and allocated. Such wisdom depends upon thoughtful progressive planning.

Acknowledging the critical im-
portance of water in the state, however, does not equate with knowing precisely what the state ought to be trying to accomplish with a water plan. What kinds of considerations are important and how are they to be weighed and ranked as the plan evolves? How can these considerations be translated into explicit goals? Answers to such questions must precede consideration of the means or policies that should be implemented in the plan itself.

WATER LAW ECONOMICS

Existing water law reflects, explicitly or implicitly, certain underlying economic concepts. These concepts may have been useful years ago—it is less clear that they are useful today. Most of the western states, including Utah, subscribe to the doctrine of prior appropriation as the basis of water law. Under this doctrine, water can be appropriated legally when it is to be used for some "beneficial" purpose. What constitutes specific "beneficial use," however, is poorly defined except as interpreted by the courts and the state officials charged with administering the law. Sometimes, generally accepted broad categories of beneficial uses are ranked in order of priority when water is in short supply. In most states, domestic (household) use tops the priority list. Agricultural uses generally come next with industrial and recreational uses following.

Listing domestic consumption first and then production of food and fiber suggests that those uses which meet human needs most directly are most beneficial. This is a questionable proposition, especially in a dynamic industrial economy. At the time it was established, such an ordering might have reflected social welfare evaluations quite accurately, but conditions change and rigid priority lists are soon outdated. These outdated priorities are at the heart of the water allocation problems now plaguing Utah and other western states. Many of the new uses for water that have arisen in recent years have considerable promise for enhancing welfare. The existing legal and institutional framework and the priorities of beneficial use, however, tend to impede or prohibit transfers to new uses—no matter how valuable and conducive to social welfare.

GOALS DEFINED

The legislature authorized state water planning in 1963 but the enabling legislation provides no indication of desirable planning goals. In the most recent edition of the Utah Code (Section Water and Irrigation, Chapter 178, subtitle Developing a State Water Plan) nothing is said about acceptable general goals or water planning nor about specific goals appropriate to a state water plan. An appropriation to the Water and Power Board is authorized "for initiating and conducting water resources investigations . . . required relative to developing an overall state water plan under the provisions of the Utah Water and Power Board Act of 1947 . . ." Section 73-9-1 of Chapter 4, title 73 Utah Code Annotated 1953 contains the Utah Water and Power Board Act of 1947 and states that the policy of the state is "to obtain from water in Utah the highest

Figure 2. Most of the water from the Deer Creek Reservoir, 17 miles upstream from Provo, Utah, goes for urban and industrial uses. If expensive reclamation projects such as this one, which has been an economic blessing to Utah, are viewed on a purely dollar-and-cents basis, larger shares of water should be turned to urban and industrial use.
duty for domestic uses and irrigation of lands in Utah within the terms of interstate compacts or otherwise.” The statement “to obtain . . . the highest duty” is subject to varied interpretations. Apparently this has never been interpreted to mean the highest duty in the sense that a tariff or charge might be levied on water users since domestic and agricultural users are mentioned specifically and it has never been state policy to maximize charges for these uses. Perhaps “duty” is meant to imply “utility” or “best use”, but this is far from clear.

The 1947 Water and Power Board Act also contains the statement: “1) That by construction of projects based upon sound engineering, the water within the various counties of the state of Utah can be saved from waste and increased in efficiency of beneficial use by 25 percent to 100 percent.” This statement suggests that efficiency in use is an important goal and that a considerable disparity exists between present efficiency in use and attainable efficiency.

Perhaps the most pointed statement by the legislature concerning goals for state water planning is the following from the 1947 Act: “3) That water as the property of the public should be so managed by the public that it can be put to the highest use for public benefit.” This statement by the legislature suggests that Utah’s water policy is to follow a “highest use” goal implying that water allocation should be so carried out as to maximize the value of the water itself. In addition, the welfare of the entire public apparently is to be evaluated in appraising the desirability of development and allocation decisions. The statement of the goal is clear enough —how to make the goal practically operational by finding ways to express “public welfare” remains a critical problem.

**PUBLIC WELFARE**

“Public welfare” is at best a nebulous concept. Welfare is a state of well-being and therefore is subjective and psychological. It has intangible as well as tangible components with aesthetic as well as physical overtones. Moreover, the public is composed of numerous individuals, some of whom gain and some of whom lose by any specific policy. How do you aggregate these individual welfare positions to get an indication of public welfare? Interpersonal differences in preferences and in income levels, and the fact that the well-being of one individual is often dependent on the relative well-being of his peers, further frustrates attempts to define public welfare. It is seldom possible to simply add up the welfare levels of individuals and accurately arrive at a statement of public welfare. In addition, welfare is very difficult to measure empirically. What units of measurement can you use? Despite the difficulties, it is possible to identify some considerations that are closely associated with welfare.

**ECONOMIC EFFICIENCY**

Economic efficiency in resource use is obviously a crucial consideration in trying to maximize social welfare. Every family group is concerned about its living standards and living standards rise when economic efficiency is achieved. In fact, economic efficiency is maximized when resources are used in such a way as to maximize the production of goods and services. As related to water allocation, efficiency is realized when water is used in those areas and uses where the greatest production of goods and services results. Efficient water development requires that a given amount of water be supplied in the least costly fashion. Efficiency assures that the most valuable sources of water will be tapped first and that water development will occur only if benefits exceed costs.

One reason why economic efficiency is so important is because it is pervasive. That is, all family units are interested in efficiency since through it their living standards are increased. Another peculiarity that should be noted about efficiency is that it tends to be more dominant in the long-run than in the short. Efficiency considerations might suggest that water should be used in

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Figure 3. Agriculture has historically claimed the greatest share of Utah’s water. If our state is to advance in population and industrialization, a larger share of this “agricultural” water will have to be diverted to the more “economic” uses of industry and cities.
other uses and areas but more dramatic goals, which seem to be politically expedient, may prevent water from being moved. Over the long-run, however, economic forces are inexorable in pushing toward an economic equilibrium. The relentless pressure of efficiency considerations tends to eventually overcome all conflicting factors. By contrast, given political goals are ascendant and strong only sporadically.

SOCIAL JUSTICE

Efficiency is not the only goal in water planning, another might be called "social justice". This often seems to be the overriding concern of the multiple use policies that have been in vogue for natural resource planners. Making use of resources by a large population and over a wide geographic area assures that resource use might be very attractive from a political point of view. At the same time, however, maximizing might require that the resource be used for one purpose and by only a few of the most efficient users.

When a state plans for the future use of its water resources it may be able to affect a more equal income (wealth) distribution among uses and users. Concern is currently increasing at all levels of government about the need to provide disadvantaged people with more equal income opportunities. Federal and state governments are assuming more responsibility for the welfare of individual families, geographic areas, and occupational groups which are not sharing the fruits of economic progress. This is the rationale for progressive taxation, social security, medicare, public education and many other welfare programs. Alleviation of poverty or prevention of social stress that results from uprooting families from their traditional homes might well be a desirable goal of those creating the state's water plan. This could be a reasonable goal even if efficiency requirements were violated.

Of course, planning that aims to achieve a more equitable distribution of income will not always conflict with economic efficiency. It may be consistent with the goal of efficiency to subsidize families and industries in the short-run until they acquire productive efficiency to compete effectively over the long-run. But more often the antithesis is true. People are disadvantaged economically because society does not value highly their income producing resources, at least not in the places where those resources are being used. Low earnings mean that society wants resources to move to new uses or to new locations. This is the essence of economic efficiency.

TENURE PROTECTION

Finally, in water planning the matter of tenure protection always warrants consideration. Under the appropriative laws of Utah and the other western states, each state grants "rights" to use water in perpetuity for certain purposes. If the state wants the water to be productively employed over long periods, these rights must be protected from expropriation (condemnation) without due process and fair compensation.

This protection need not conflict with concepts of economic efficiency. Tenure security helps assure that water will be put to uses of maximum productivity and will be conserved so that it can also yield maximum benefits in the future. But guaranteed protection to inefficient users that happen to file for applications first, in time can impede efficiencies if transfers to more valuable new uses and users are prevented by the rights structure of allocation. By seeing to it that the state water plan encourages the maintenance of a market in water rights, the state can contribute to tenure security. Thus, if the owner of a right can be compensated by selling the right in the market place or alternatively if the courts are asked to determine "just" compensation if the right is condemned, then right owners are protected from wealth losses due to loss of water right. But how about others who are affected? Downstream users can be adversely affected by upstream polluters, for example. How are these losses to be evaluated? Are these indirect losers to be compensated or will negative indirect effects simply preclude transfer? Much depends upon the interpretation given to individual situations and to the specific state's water law by the courts and the state's administrative officers. Clearly, if a state water plan is considered a tool to be used primarily to protect the interests (legal and economic) of all individual water users, then tenure protection and economic efficiency goals might easily be in conflict.

WHO SETS GOALS

This discussion of goals should not be considered definitive. We have mentioned economic efficiency, social justice, equitable income distribution, and tenure protection as relevant planning goals. Others may be important to other people, but enough has been said to emphasize the importance of goals in water planning. The Legislature, the Water and Power Board, the State Engineer, the courts, and finally the people themselves all have important roles to play in deciding what the goals should be. Only if goals are made explicit and an attempt is made to critically evaluate them, establish weights and priorities, and resolve goal conflicts can Utah expect to maximize the welfare of her citizens through state water planning.
Livestock men at Utah State University together with County Extension Agents feel justified in urging an increase in the number of farm sheep flocks in this area. They all are sure that farm flocks can increase the annual farm income.

We have evidence that with good care, management, and nutrition, sheep will continue as a profitable enterprise. Farm flocks are usually associated as a supplement to other agricultural endeavors or as a replacement for small dairy or other livestock on small farms.

Part-time farmers consider sheep production as an important enterprise. Flock management can become a popular activity for older people receiving Social Security or other retirement checks and those who want to ease away from heavy work and obtain freedom from the "tie-down" daily chores of the dairy.

As evidence of farm flock returns, County Extension Agent, Ray Thatcher of Morgan County wrote this letter:

"Last spring we suggested to Mr. W. V. Shaw that he wean his early lambs and put them on a fattening ration rather than turn them out on the range with the ewes. We also asked Mr. Shaw for the privilege of

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RUSSELL R. KEETCH

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getting gross income figures from the project. Here they are:

Started lambing February 15 and finished March 10th.
Lambs marketed 150 per cent (1\(\frac{1}{2}\) lambs per ewe).
Two-thirds were fats and one-third were feeders.
Average weight of fats — 106.5 pounds; Feeders — 78 pounds.
Average wool per ewe — 13 pounds.
Price of wool per pound net 51.8 cents.
Total returns per ewe $41.38.
This is equal to $206.90 per range cow. (Five ewes are considered equal to one cow.)

Producing early lambs from older range ewes makes an ideal project for a small farm where the owners have off-the-farm jobs and only a limited amount of time available for farm operations. The returns can be high for the time spent. A lot of the harvesting of forages can be done by the sheep. In many instances, it may be possible for the operator to arrange his vacation time to take care of the sheep during the lambing season.

Farm sheep provide 2 pay days each year; one from sale of wool, the other from sale of lambs. Good managers have sometime been able to pay for original cost of breeding stock in 1 year from the sale of wool and lambs.

Sheep are not difficult to handle nor do they require much in the way of sheds and equipment. They do respond to good management and proper feeding just as other livestock. Farm sheep require little labor during the busy summer months.

Farm flocks make good productive use of small waste areas and land not suited for cultivation. It is best, however, to avoid wet pasture area. The size of farm flocks is usually determined by the amount of pasture land suited for grazing or the type of enterprise.

Two distinct types of farm flock enterprises are found throughout Utah: (1) The enterprise that specializes in production of early market lambs and (2) those in which the ewes are bred to lamb later; the lambs being marketed about the same time as range lambs. These lambs are fattened on grass. Sheep are the only domestic animal species that will fatten to a prime grade on grass. However, higher profits are obtained and more sheep can be handled in an enterprise if the ewes are bred for early lambing. When the lambs are weaned under this type of enterprise they should be left on their regular creep rations until...
they reach a market weight of 95 to 100 pounds. Only breeding ewes are turned on pasture, where they require very little attention until late in the summer. They should not be totally neglected, but should be frequently checked for parasites, fly strikes and moved onto new pasture areas, when necessary, for fresh feed. Sheep are very good at cleaning up weedy areas and can utilize forage from waste lands that are not suited to cultivation. Fencing with net wire is needed.

Early-lamb operators usually sell all the lambs. They then buy their ewe replacements. A good source of replacements from range operators is older range sheep. With farm feeds these ewes can be productive for another 3 years and will produce more lambs than the younger ewes. Usually they will not shear as much wool and the wool quality will probably not be as good.

Sheep can be wintered on alfalfa hay until just before lambing. From then until weaning time they need ½ to 1 pound of grain daily. Whole or chopped grain has the same nutritional value, but if some of the ewes are old and have unsound teeth, chopped feed is best.

High daily weight gains are an important key to economic production. Producers have found that they can get more gain per pound of feed when lambs are young.

It is not unusual to have lambs gain .80 pound per day from birth until weaning under good feed and management conditions. Therefore, they can be ready for market (100 pounds per lamb) in 112 days.

Lambs finished on pasture under the second enterprise usually gain about .30 pound per day and require about 270 days to reach market weight.

Both types of enterprises are needed in our state. Depending upon feed and pasture resources, each flock owner will need to decide for himself which type is best suited for his farm.

Figure 2. Farm sheep provide two pay days each year; one from sale of wool and the other from sale of lambs. Old range ewes can be used for breeding stock. The original cost can often be repayed in 1 year.

Figure 3. Putting early lambs on fattening rations gives high returns for the time spent. A typical farm flock in Morgan County returned $41.38 per ewe.

CONTRIBUTIONS TO RESEARCH

January 1, to April 1, 1966

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<tr>
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<th>Amount</th>
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avoid payment of postage $300
Utah State University
Agricultural Experiment Station
Logan, Utah

Wynne Thorne
Director
Form U. Q. Permit 1142

POSTMASTER: Please return if unclaimed

NEW PUBLICATIONS

The authors grew seed crops of Early Perfection peas from 1955 to 1961, inclusive. They found that high seed yields were definitely associated with either medium or high moisture levels although high moisture levels delayed maturity.

This is a companion to Bulletin 457, Age and sex population projections of Utah Counties. It gives a detailed account of how the figures in Bulletin 457 were obtained. This is a technical and detailed description of population projection methods.

This circular has been revised and contains the latest recommendations for using nitrogen, phosphorus, and potassium on Utah soils.

Dr. Christensen gives a history of the conditions in the Utah dairy industry which brought about the Federal Milk Marketing Order. He discusses the effects of the Order since it was established.

The authors have written a brief but comprehensive history of the Provo River Project, one of the first reclamation projects where most of the impounded waters went to urban and industrial uses.

Utah Resources Series 30. Maximizing incomes from Circle Valley farms, Piute County, Utah, by Lynn H. Davis. Department of Agricultural Economics.
This publication provides information to farm operators in the Circleville- Kingston-Junction area about the optimum combinations of crops and livestock. Budget charts and an explanation of linear programming are included.

RESOURCE DEVELOPMENT IN BOLIVIA

(continued from page 77)
and the imagination to apply them to the Bolivian situation. Many solutions are hypothetical until proven practical in the real Bolivian world. In some cases only one chance for an ideal solution is given because of the institutional labyrinth that builds up with the implementation of a program. Utah ranchers know how hard it is to change a land policy once it has been established.

USU, the citizens of Utah, and especially the team of specialists directly involved in the Bolivian USAID experience should receive considerable satisfaction from being able to make a contribution to the economic development of Bolivia. For, Utah grows as places around the world like Bolivia grow and develop.

Sugar Osmosis
New Method for Drying Fruits

Producing high-quality dehydrated fruit at a reasonable cost may be possible with a new sugar process being studied by Agricultural Research Service scientists.
The process involves covering cut fruits with dry sugar or sirup, which removes 60 to 70 percent of their moisture — or half their weight. Then, they are drained and dried further under vacuum or in air. With absorption of moisture, the dry sugar becomes sirup.

Research has not only produced a new product but has shown that ordinary sugar, or sucrose, prevents most cut fruits from turning brown. Films of sugar also reduce losses of natural volatile flavors. These findings could stimulate widespread use of sugar as a fruit-drying agent.

Besides their potential as commercial dried fruits, these products are attractive for eating out of hand and for use in breakfast cereals. This is because they have a lower acidity and slightly slower rate of absorption of liquid, as compared with other dried foods.