

Utah Science

Volume 27 | Number 3

Article 1

9-1966

Utah Science Vol. 27 No. 3, September 1966

Follow this and additional works at: <https://digitalcommons.usu.edu/utscience>

Utah Science is produced by Utah State University Agricultural Experiment Station.

Recommended Citation

(1966) "Utah Science Vol. 27 No. 3, September 1966," *Utah Science*: Vol. 27 : No. 3 , Article 1.
Available at: <https://digitalcommons.usu.edu/utscience/vol27/iss3/1>

This Article is brought to you for free and open access by the Journals at DigitalCommons@USU. It has been accepted for inclusion in Utah Science by an authorized administrator of DigitalCommons@USU. For more information, please contact digitalcommons@usu.edu.



UTAH

SEPTEMBER 1966

Volume 27

Number 3

SCIENCE

AGRICULTURAL EXPERIMENT STATION • UTAH STATE UNIVERSITY • LOGAN





Late summer grain harvests, such as this one at Blue Creek, Utah, have been completed throughout the land. But America, long the land of plenty, is beginning to feel the squeeze exerted by the world's burgeoning population. During 1965, the United States used and exported more wheat than was grown that year. This year, the depletion of our wheat reserves will be even greater.

As the demands for cereal and feed grains increase, the production of Utah's dryland acres will become increasingly important. Production of winter wheat, long the mainstay of Utah dry farms, can be substantially increased by proper use of commercial fertilizers. Experiments conducted by Utah State University scientists since 1942 have shown that dryland soils in Utah are lacking in nitrogen and recent studies show some areas to be deficient in phosphorus.

Fertilizer trials conducted at the Nephi Dryland Station in 1960, 1962, and 1964 yielded data that demonstrated marked increases of winter wheat when phosphorus and nitrogen were drilled in with the seed.

Trials conducted in Box Elder County have shown significant yield increases from nitrogen. Response to phosphorus has been limited to eroded knolls and shallow foothill soils.

Fertilizer is a major tool available to farmers to meet the continuing demand for increased production.

CONTENTS

Station receives new director	87
Range weed can cause deformities	87
What is the Agricultural Experiment Station — editorial, by Director K. W. Hill	88
Farm ponds and plastic liners, by C. W. Lauritzen	90
Destructive animals in Utah fruit orchards, by David R. Walker, J. LaMar Anderson, and Anson B. Call, Jr.	93
Inexpensive methods for measuring soil moisture, by S. A. Taylor....	98
New head appointed for Plant Science Department	103
Nitrogen - carbon dioxide kill insects	103
Maintaining quality in processed fruits, by D. K. Salunkhe, C. Y. Lee, and F. S. Nury	105
Best fruit varieties — for processing, by D. K. Salunkhe	107
Stamping out brucellosis — Western States	109
What about birdsfoot trefoil — upgrading irrigated pastures, by Keith R. Allred	110
Calcium:phosphorus ratios for dairy cows, by George E. Stoddard....	113
Hog cholera can pass to unborn pigs	115
Contributions to research	116
New publications	116

UTAH FARM AND HOME SCIENCE

A quarterly devoted to research in agriculture, land and water resources, home and community life, human nutrition and development, and published by the Agricultural Experiment Station, Utah State University, Logan, Utah.

The magazine will be sent free on request.

To avoid overuse of technical terms, trade names of products or equipment sometimes are used. No endorsement of specific products or firms named is intended, nor is criticism implied of those not mentioned.

Articles and information appearing in Utah Farm and Home Science become public property upon publication. They may be reprinted provided that no endorsement of a specific commercial product or firm is stated or implied in so doing.

Please credit the authors, Utah State University, and Utah Farm and Home Science.

<p>Daryl Chase, President Wynne Thorne, Vice President for Research Utah State University K. W. Hill, Director Agricultural Experiment Station Millard E. Wilde, Editor</p>
--

STATION RECEIVES NEW DIRECTOR

Dr. K. W. Hill was appointed by Utah State University Board of Trustees as Director of the Agricultural Experiment Station, effective July 1, 1966. He succeeds Dr. D. Wynne Thorne who continues as Utah State University Vice President for Research.

Dr. Hill came to Utah State University in 1963, and has served as Associate Director of the Agricultural Experiment Station since that time. He has a broad background as an agricultural scientist and administrator.

He was born in Taber, Alberta, Canada, and received his Bachelor's degree from USU, the M.S. degree from the University of Alberta, and his Ph.D. degree in agronomy and plant physiology from the University of Nebraska.

Dr. Hill is well-known for his work on weed control, crop production, and irrigation. He has published a number of technical and popular articles in the field of plant science and crop production. His doctoral dissertation on the effect of

nitrogen supply on the sucrose percentage of sugar beets led to major changes in the fertilizer practices of sugar beet growers. He is the author of a comprehensive and widely used bulletin entitled "Irrigated Farming in Southern Alberta," and of another definitive bulletin entitled "Soil Drifting Control in the Prairie Provinces."

From 1945 to 1950, Dr. Hill served as agronomist at the Dominion Experimental Station, Lethbridge, Alberta, and in 1951 was transferred to the headquarters of the Canada Department of Agriculture at Ottawa, Ontario, serving as Chief Agronomist, Head of the Field Husbandry Department, and a member of the Program Directorate of the Research Branch of the Canada Department of Agriculture.

Dr. Hill has traveled extensively in North America, Europe and Asia. He served for 3 years as Vice President of the International Commission on Irrigation and Drainage and was in charge of the annual meetings held in Israel in 1962.

In 1952 he served as consulting agronomist to the Royal Commission



DIRECTOR K. W. HILL

on the Saskatchewan River Development. He is a member of a number of professional organizations and has served as board member and officer of several organizations. He is a member of Phi Kappa Phi, Alpha Zeta, Gamma Sigma Delta, Sigma Xi, and the American Association for the Advancement of Science.

Range Weed Can Cause Deformities

Cattle, goats, and sheep should be kept away from false helebore (*Veratrum californicum*), during their breeding season.

Agricultural Research Service scientists at the Animal Disease and Parasite Research Laboratory, Logan, Utah, have found that deformed calves, kids, and lambs may be born if the mother eats this poisonous plant on the 14th day of gestation.

The scientists found that the quantities of poison in this weed vary widely between range areas and also between plants in the same area from year to year. The poisonous chemicals in false helebore are contained in the entire green plant. As the

leaves and stems lose their green color because of maturity, lack of water, or freezing, they also lose the poisons.

False helebore, also called western helebore, wild corn, and skunk cabbage, is a showy perennial that grows in the 11 far western states. The plants range from 3 to 8 feet tall and are usually found in wet seepage areas on mountain ranges above about 5,000 feet elevation.

The plant is relished by sheep, but usually is not eaten by cattle. Some cows apparently taste the plant, however, because deformed calves have been found in areas where this weed grows.

Animals that eat a sublethal dose of the plant show signs of intoxication in about 3 hours. If left undisturbed, they usually make a complete recovery within 3 or 4 hours. A lethal dose usually causes death in 6 to 18 hours.

Eaten before or after the 14th day of gestation, small amounts of the plant may cause death of the fetus without affecting the mother. If eaten on the 14th day, the plant invariably causes head deformities that give the young a "monkey-faced" appearance.

A full-scale article on this research will appear in a subsequent issue of *Utah Farm and Home Science*.

WHAT IS THE AGRICULTURAL EXPERIMENT STATION?

K. W. HILL, Director

The Utah Agricultural Experiment Station was established by the State Legislature in 1888. In common with a number of other states, this action followed the passage of the federal Hatch Act of 1887 which authorized an annual payment of \$15,000 to each state that would establish an agricultural experiment station in connection with a land grant college.

Section 18 of the Act which provided for the Utah Agricultural Experiment Station states: there shall be established an Agricultural Experiment Station to conduct original researches . . ." Subsequent federal and state legislative directives to the Agricultural Experiment Station make it clear that it is our responsibility to seek answers to all of the problems of the agricultural industry, rural living, and the utilization of the state's natural resources of land and water.

Today we are fulfilling this function through the dedicated efforts of 100 staff members who are conducting research on 200 projects. Most of these scientists spend part of their time in research and part in teaching in the various departments of the University. Thus, the Experiment Station has joint appointments in six colleges (Agriculture, Business and Social Sciences, Engineering, Family Life, Natural Resources, and Science) of the University — covering a total of 15 departments. The Experiment Station provides the facilities and the funds for equipment, supplies, labor, travel, etc., and pays the salary of the scientists for the portion of their time devoted to research; the University proper pays them for the time spent in teaching. Each project is covered by an outline which sets forth the need for the work in the state, the objectives, the procedures, and the necessary budget. Two or three project titles will provide some conception of the scope: (1) Changes and social implications of the population composition in Utah. (2) Methodology for determining valuations of water for alternative uses. (3) Insect resistance in alfalfa as related to chemical composition of the plants.

We are trying to maintain a suitable balance in our research between immediate and long-range needs of the state. For example, everyone knows that the fruit growers of the state have suffered serious losses caused by frost in 3 of the last 4 years. We have a project underway entitled "A physiological study of rest and hardness in fruit trees." We hope to learn enough about the internal chemistry and physiology of fruit trees so that we can delay the onset of bloom for a couple of weeks and thus greatly lessen the danger of spring frost damage.

Ranchers will remember that, in the spring of 1964, there were very high death losses among newborn calves — some operators lost 60 percent of their calves. Station veterinarians immediately undertook a study of this new disease and succeeded in identifying a causative virus. Much more work is needed before this virus is fully understood and vaccines or other preventive procedures are available, but progress has been made. These are examples of our immediate, firefighting type of research.

Of equal importance is the more basic, long-range research. Studies on air pollution provide a good example. Our work on fluorine over the past 15 years is well-known and has brought us much acclaim. Utah Agricultural Experiment Station publications are classic in the field; our men have been requested to serve as advisors to foreign governments in the solution of their problems. Realizing that Utah's topography and geography make it very vulnerable to air pollution as industrialization increases, we are now engaged in basic studies to learn the detailed effects of pollutants on the chemistry of plant and animal cells. We expect that this will help us to devise better methods of protection for our plant resources, our domestic and game animals, and our people.

We are studying the hormonal chemistry in the reproduction of sheep. This is especially complex. However, when it is more fully understood it may permit us to raise two lamb crops per year, or at least three crops in two years, and it might well have an important bearing in the solution of the human population explosion.

The financial structure of the Agricultural Experiment Station is somewhat involved. Funds come from three major sources: (1) Appropriations by the State Legislature constitute about 50 percent of the total. (2) Allocations and grants from the federal Department of Agriculture and other federal agencies make up 40 percent. (3) About 10 percent comes from gifts and grants from industrial concerns, both within and without the state. The state appropriation to the Experiment Station appears as a line item in the state budget, but although the Agricultural Experiment Station is an integral part of the University, the funds must be spent and accounted for separately. They cannot be interchanged.

The federal funds are allocated directly to the Experiment Station account and can only be spent to conduct authorized Experiment Station projects. The Director of the Experiment Station is the responsible officer to the federal government for these funds. Each of the fifty states receives an allocation of funds for its Experiment Station according to a formula based on rural population and the number of farms within the state. As indicated above, Utah's federal support nearly equals the funds provided by the state legislature. In most other states, the local legislature provides a much higher proportion of the total operating capital; in California the ratio of state to federal funds is about 14 to 1, in Arizona it is 5 to 1.

The gifts and grants which come to the Sta-

tion from industrial sources are usually earmarked for special research. As an example, the Utah Turkey Marketing Board annually provides several thousand dollars to assist in the financing of our large turkey research program; this research helps to keep our turkey production competitive with that in other states.

The Utah Agricultural Experiment Station has been referred to as the research agency of the state. It has a long record of service. It has helped to ensure that Utah's citizens have the necessities of life, such as food and fiber, as well as some of the more pleasant amenities such as recreation. Without the disease resistant wheat varieties developed by the Station's plant breeders, Utah would not now have a wheat industry, and bread likely would be more expensive. New strains of sheep now in use throughout the state are at least 50 percent more efficient in the production of meat and wool than their progenitors of a few decades ago and these savings have been passed on to the consumer. Scientific studies of recreation have added stability to our hunting, fishing, and water resources and have shown new ways to lure vacationers to Utah to bolster our buoyant tourist industry. Studies on the prevention of water and air pollution are helping to preserve the enviable environment of Utah not only for ourselves, but for generations yet unborn.

This is a brief story of the Utah Agricultural Experiment Station — an integral part of Utah State University and a state research institution in which all citizens have a stake.

USE PESTICIDES SAFELY FOLLOW THE LABEL



PROTECT your FARM with its quality FOOD and FIBER products from the ravages of insects, weeds, diseases and other destructive pests. Guard against hazards resulting from improper use of pesticides.



PROTECT your FORESTS, WILDLIFE, and FISH in the interest of conservation, timber resources, and recreation values so vital to individual well-being and national progress.



PROTECT your HOME and GARDEN where 15 percent of all pesticides purchased are used to help preserve a healthy, attractive, productive environment for work and play.



PROTECT your WATER, SOIL, and AIR—our basic natural resources—from accidental contamination by pesticides or other chemicals on the farm, in the forest, or in the city.

FARM PONDS AND

C. W. LAURITZEN

PLASTIC LINERS

Small reservoirs, whether on rangeland or on a farm, serve many purposes. They lengthen the period over which water is available and regulate flows. Their location, size, and design depend upon their use. In Utah and adjacent states, small reservoirs serve primarily to provide drinking water for livestock. Second to this, reservoirs are used for temporary storage of irrigation water. Others are constructed as recreational facilities and as sources of potable water.

"Small" is a relative term and should be qualified. For the purpose of this article, a small reservoir is an impoundment which has a capacity of 20 acre feet or less. The criteria for location and design are

not greatly different from larger reservoirs, and care should be exercised in the design and construction.

Before construction is started, it should be ascertained that enough water will be available to fill the reservoir. It may be seasonal runoff water from a live stream, a well, or irrigation canal.

The discharge of wells and rights to water in established irrigation systems are usually known. If they are not, they should be determined.

It is more difficult to predict the yield from a drainage area. Many small watersheds in Utah seldom produce runoff and are not reliable water sources. Some record of the

yield from a watershed area is desirable to establish that runoff will provide enough water at the times and in the amounts needed for the projected use.

LOCATION

Assuming that a reliable source of water for storage exists, an irrigation reservoir should be located at the highest elevation to which water can be delivered by gravity or pumping. Generally, however, it will be more economical to locate the reservoir where it can be filled by gravity and to pump water to any land not served by the reservoir.

Stockwater reservoirs are usually located in, or adjacent to, natural

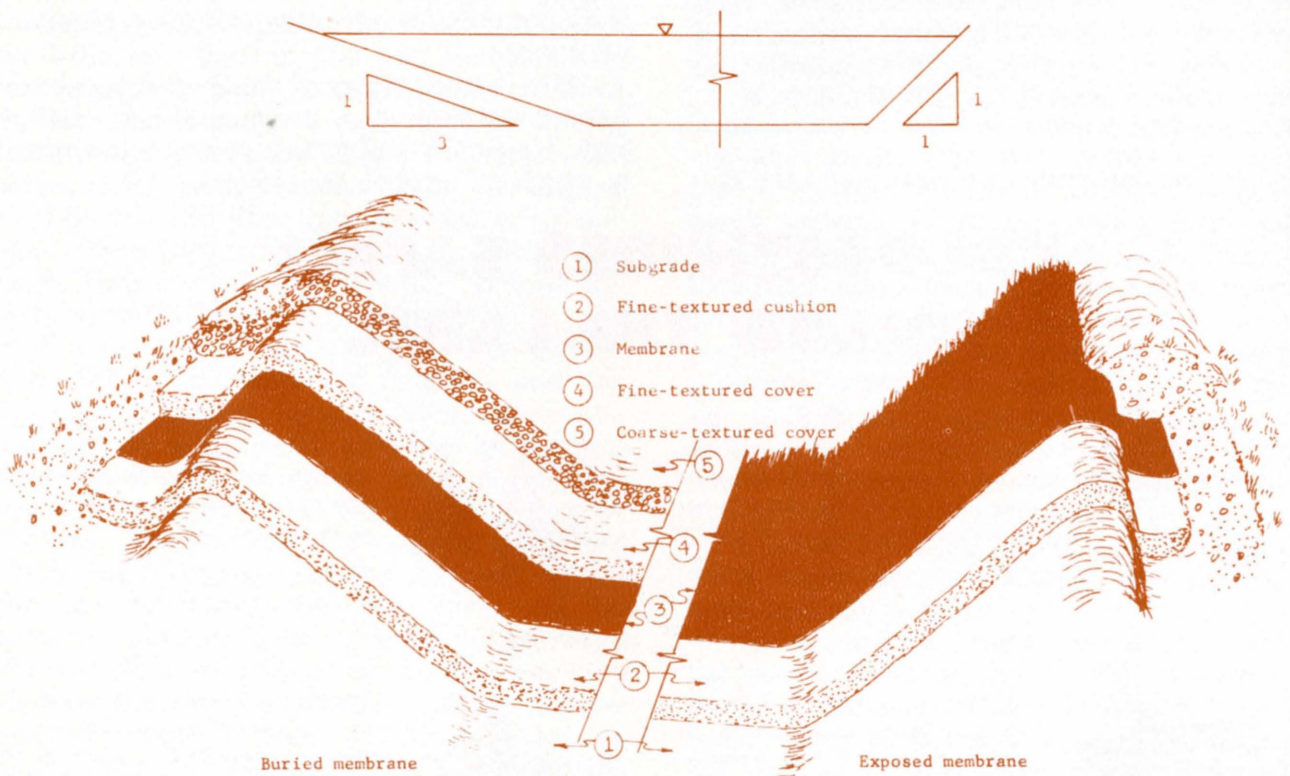


Figure 1. Both vinyl and polyethylene films should be covered as they deteriorate if left exposed to sunlight and weather. Butyl, however, is not harmed by exposure and does not need a covering. This drawing illustrates both types of installation.

drainageways. They should be located in the grazing area. Cows should not have to walk more than 1 mile for a drink of water. If they must go farther, the area in the vicinity of the water will be overgrazed and more distant areas undergrazed.

Reservoirs for recreational use are usually selected because of supporting environment — such as trees and scenic location. It is the combination of natural beauty with a water facility that makes an attractive recreational area. In addition to providing a facility for recreation, water enhances the appeal of the adjoining area.

RESERVOIR DESIGN

The details of design and construction are beyond the scope of this article. *Low Dams*, published by the Material Resources Committee, and *Design of Small Dams*, published by the U.S. Bureau of Reclamation, are excellent references.

Insofar as the smaller reservoirs are concerned, a detailed investigation of foundation material probably is not warranted. However, care should be exercised with earth fills to obtain good compaction and to provide a spillway designed to handle peak flows. Except for inlet and outlet works, small reservoirs are constructed of earth materials. The earth work may involve dikes on all four sides where reservoirs are constructed in flat areas to provide temporary storage for pumped irrigation water, or an earthfill dam to impound water in a natural drainageway, or a combination of these two.

Since the utility of a reservoir depends on its imperviousness, seepage must not be excessive. The earth material used in fills must be selected and placed to assure stable watertight embankments. There are many areas where foundation conditions and material for embankments do not meet this requirement. Where

●

C. W. LAURITZEN is a soil scientist for the Southwest Branch, Soil and Water Conservation Research Division, Agricultural Research Service, U.S. Department of Agriculture, Logan, Utah.



Figure 2. This is a small vinyl-lined stockpond located on a reseeded area near Minersville, Beaver County. Note that it is fenced.

site materials are substandard, better material can be imported (but this is costly), or the reservoir may be lined to make it watertight. Frequently, seepage losses are excessive, after a reservoir is constructed, even though prior study indicated seepage losses would be moderate. In this event, seepage also can be controlled by lining.

FILL FIRST

Actually, it is a good practice to let the reservoir fill once before lining. This will promote settlement of inadequately consolidated material which, upon settlement, could cause failure of the lining. Particularly where membrane linings are used, the reservoir should be so constructed that failure would not occur without a lining, even though leakage is great. Although membrane linings are excellent water barriers, they have little structural strength.

Several materials may be used to line reservoirs. Normally, concrete is too expensive. Where available adjacent to the site, low permeability earth materials — such as clays and bentonites — should be considered. Before earth materials are used, they should be tested to determine their suitability.

Linings make storage feasible at almost any site where water can be collected. In most of Utah, collectible runoff occurs only in early

spring when melting snow combines with precipitation. In some drainageways, this runoff may persist for only a few days. Under these conditions, very little seepage can be tolerated. Losses from evaporation alone will range from 1½ to 3 feet during the 5-month growing season; and seepage losses in unlined reservoirs, even where the better soil materials occur, will be several times this amount. Lining, therefore, will be essential for reservoirs in most areas, and water surface area should be kept as small as possible by making reservoirs as deep as practical.

Unless deposits of clays, gravels, and other earth-lining materials are readily available near the site, plastic films or butyl sheeting can best serve as excellent and economical reservoir linings. They, like earth linings, must be protected with a covering, however. The cover should consist of a 6-inch layer of fine-textured earth, such as sand, topped with a minimum of 6 inches of gravel. To anchor the film and hold it in place on the side slopes, the top edge is buried in a trench on the berm or edge of the structure. Several types of film might be used. Vinyl and polyethylene film have been used extensively and found to be most satisfactory. Vinyl, although more costly, is tougher and easily welded. Both films installed in our test reservoirs at the River Laboratory in Logan have controlled seepage completely

for 14 years and promise to be effective for many more years.

Vinyl film can be purchased in lengths and widths up to 61 feet. It is accordion-folded in two directions and is easily placed by playing it out of the crating from a truck, then spreading it by pulling the leading edge. Two pieces can be joined by heat sealing or solvent welding. In the field, solvent welding is used. To make the weld, the two edges are

lightly brushed with the solvent and immediately pressed together. Only a few minutes are required for the seam to reach full strength. The earth cover is frequently placed with a bucket operated by a crane, dragline, or bulldozer. Where a bulldozer is used, care must be exercised to ensure that there is always a foot or more of fine-textured earth between the tracks and the film. The cover also can be placed on the bot-

tom by excavating with a grader equipped with a conveyor. The earth removed by the grader is transferred to the film as spreading of the film is advanced. When this procedure is followed, the leading edge is held in place, and the folded material repeatedly moved forward, unfolding only the width to be covered.

Normally, polyethylene film is supplied in rolls up to 10 feet and folded to provide a total width of film from 20 to 30 feet. In the field, mastic tape is used to join film. The resulting bond is weak; but if the overlap is liberal (at least 1 foot) and the film is covered, effective seepage control results.

Where cover material is expensive or difficult to obtain, butyl sheeting should be considered. Butyl is highly resistant to degradation and satisfactory for an exposed lining.

A combination of butyl and vinyl, or butyl and polyethylene, with butyl on the side slopes and film on the bottom can be used to reduce cost and the necessity for covering the slopes. Butyl sheeting for lining reservoirs is supplied normally in 10-foot rolls with a center fold, giving a total width of 20 feet. Seams are made with a butyl cement. If the directions of the manufacturer are followed in detail, high-strength joints result.

Figure 1 shows a type of section for both buried and exposed membrane linings. Note that 3:1 side slopes are recommended for buried linings; but, with exposed linings, the side slopes can be 1:1.

All reservoirs — whether lined or unlined — that are accessible to livestock should be fenced, and provision made for delivering water to a trough outside the fenced area. This is essential with lined reservoirs to protect the lining; and, with unlined reservoirs, fencing assures better quality water and more efficient use of water. Connection between the reservoir and trough can be through an underground pipe or through a hose over the bank. In both cases, the trough should be equipped with a float valve to regulate the flow and a line valve to shut it off.



Figure 3. Parks Reservoir near Granite is lined with vinyl. Here, the film is being spread prior to placing the earth cover. The reservoir provides overnight storage of irrigation water.



Figure 4. These strips of 10 mil. polyethylene film canal lining were seamed on the job. The strips were lapped 1 foot and sealed with mastic tape. After seaming, the earth cover was placed and spread.

Destructive animals in Utah fruit orchards

DAVID R. WALKER, J. LAMAR ANDERSON, AND ANSON B. CALL, JR.

Fruit growers are well aware that there are many animals besides insects that cause damage to trees. Others are aware that insects cause wormy and misshapen fruit but few realize the damage that other animals may cause. With a heavy insect infestation the crop may be ruined for that particular year, but the trees will likely leaf out the following year and the grower will have another chance to harvest a crop. Other animals, such as porcupines, rabbits, mice, and gophers, however, may feed on the trunk bark and in many cases girdle and kill the tree. Thus, many years of investment can be eliminated in a few months.

BE PREPARED

Autumn is when the fruit grower must prepare for orchard animal control, because most animal damage occurs during the winter. The small animals feed on other plants during the summer but shift to fruit trees in the winter when other food is scarce or not available. Limited damage may also occur in the summer and spring, however. Fruit growers must know the characteristics of the various animals that attack orchards in order to adequately protect the trees. This article describes the animals which cause the most difficulty, and outlines control measures.

DAVID R. WALKER is a professor in the Department of Plant Science. J. LAMAR ANDERSON is an assistant professor in the Department of Plant Science. ANSON B. CALL, JR., is an associate professor in the Extension Services.

PORCUPINES

Porcupines prefer truck crops and leafy vegetation, but in the winter they turn to forest or orchard trees for their food supply. They generally feed in an orchard near a forested area, usually confining their damage to the first and second rows. Porcupines do not hibernate but remain active even in cold weather and deep snow.

Porcupines chew the bark from the trees and may completely girdle them. This inhibits the translocation of nutrients and eventually kills the trees.

Porcupines do not live in large groups, hence killing a few may solve the problem. They often live in dens located in rock crevices or in pipes under roadways. Porcupines are most active at night and ordinarily sleep in the daytime in their dens or perched in a tree.

They can be controlled by trapping. However, this has not been completely successful because their short legs may spring the traps without catching. A No. 1½ or 2 single spring steel trap is generally used for trapping these animals. The traps are placed in the dens or at the end of the fence line or runway. If the



Figure 1. A younger fruit tree which shows sparse, light green leaves in the spring may be a victim of gophers. The center tree displays typical gopher damage.

trap is chained to a tree, the trap needs to be checked often, because the porcupine may girdle the tree if caught and left for awhile. Spotlights are often used at night to locate the trees where they have been working.

If there is a dense population of porcupines, an electric fence may be used. Using plastic spacers, electric wires are mounted about 8 inches above the ground and 2 inches away from a regular fence. Care must be taken that it is not shorted out by vegetation growing near the fence.

Poison bait is another control method. A mixture of salt and strychnine is placed in the den. Care must be taken to avoid placing the poison mixture in areas where other animals might find it.

GOPHERS

Gophers cause considerable damage in orchards. One block of sweet cherry trees on the University Farm at Pleasant View was so extensively damaged that the trees were removed. Before the trees were pulled out we suspected that virus disease or winter injury had caused the damage, but after we examined the roots it was obvious that gophers had eaten so many of the roots that the trees had died from lack of water and nutrients.

An orchardist should constantly look for new gopher mounds. Close attention to new diggings is essential. After treating the area near the mounds, scatter and level the old mounds so that any new mounds or activity can be detected.

Gophers plug their holes after digging so that they are beyond the reach of birds, snakes, weasels, and other animals which might prey on them. They seldom share their runway system with other gophers except at breeding time. They travel extensively and one gopher may dig as much as 800 feet of runway. Gophers generally cause most of their damage in the early spring and become less active in hot, dry weather.



Figure 2. Mice can quickly girdle young fruit trees and cause extensive damage in an orchard during a single winter.

GOPHER CONTROL

There are a number of ways to control gophers, although the most popular methods are trapping and baiting. Trapping is most effective in or near fresh mounds during the vegetative season. The loose soil is dug away and one trap is placed down in the tunnel on one side of the exit hole and another trap is placed in the runway on the other side. The traps must be chained to a stake above ground so that the animal will not pull the trap farther into the tunnel. The holes may be left open when trapping. Gophers, seeing the light from the hole in the tunnel, will generally return and try to plug the hole and, in the process, be caught.

In baiting, apple or carrot cubes which have been dusted with strychnine (1 ounce per 16 quarts of plant material) are placed in the runway of the tunnel. In addition to placing bait down the main hole, many people have found it profitable to take a sharp probe and wedge it in the ground a few inches away from where the mounds occur to locate the underground runways. Then by

moving the probe back and forth a hole is opened and the bait can be inserted. The hole should be plugged with grass or sod so that the gophers cannot see any light. However, they can easily locate the bait by smell.

TUNNEL MACHINE

A new method of baiting gophers uses a machine which digs tunnels 1 to 6 inches deep, about 3 feet away from the trees. Then poisoned grain is placed in the tunnel. These machine-made tunnels resemble gopher-made tunnels and the gophers' aggressiveness and natural curiosity cause them to investigate. A 100-foot furrow may be treated with $1\frac{1}{4}$ pounds of wheat treated with 3 percent strychnine. Poison grain also can be prepared in a slightly different manner. Use $\frac{1}{2}$ ounce of laundry starch to 3 quarts of water, mix well, bring to a boil and stir constantly until it is free of lumps. Then add 1 pint or 1 quart of corn syrup and $\frac{1}{2}$ ounce of glycerine to the paste. Add 1 ounce of strychnine powder and 1 ounce of baking soda. This mixture is sufficient for 16 quarts of wheat, oats, or corn. No more should be prepared than can be used each day.

If preparing bait is too much trouble, often pre-treated bait is available at the offices of many Extension Agents.

Poisoning with gases or flooding tunnels with water have been used to eradicate gophers, but these two methods have not been as successful as trapping or poisoning.

MICE

Two types of mice can cause extensive damage to orchards, although only the meadow mouse (commonly called the field mouse) is found in Utah orchards. The other type, pine mouse, is found mainly in eastern orchards. The pine mouse digs much deeper in the soil and eats roots at a lower level than does the meadow mouse, which confines itself mostly

to the surface and in shallow covered runways. The mouse problem is extremely serious in many orchards and probably causes more damage than all the other animals discussed in this article.

Most of the mouse damage occurs between late autumn and early spring, when there is deep snow. Therefore, the mouse problem should be carefully studied in late October and November and provision made for control. The orchard should be examined often during the winter to avoid disaster. Mice can work under the snow, so it is necessary to move the snow away from a few trees to observe any mice activity.

Mice are generally much worse in orchards where a cover crop is grown. They prefer moist areas and cover crops provide shade and more moisture than does clean cultivation.

MICE GNAW BARK

Mice gnaw the bark of trees near the soil surface and frequently girdle the trees. Trees may leaf out the following spring with small, yellow leaves, but as the season progresses and water requirements increase they often die. When pale green or yellow leaves occur in the early summer the cause can often be located by removing a few inches of soil away from the trunk and observing if the bark has been gnawed by mice. Growers should walk through their orchards frequently and check for any evidence of mice activity. A few weeks of heavy infestation can completely eliminate an orchard.

The most effective way to control mice is to use a ground spray called "Endrin." This material is relatively new and is quite expensive, but it is the best material available. The cost can be reduced by placing Endrin spray (1 quart of Endrin emulsion per 100 gallons of water) in a 6-foot band on either side of the tree, rather than spraying the complete orchard. Endrin is probably best applied by a hand gun.

Considerable caution should be exercised when using Endrin as it is a highly poisonous material. The

sprayed cover crop or windfall fruits should never be fed to livestock. The material should be applied only after the fruit and cover crop have been harvested. Warning signs should be posted conspicuously around the edge of the orchard; even these do not relieve the orchardist from liability from persons who become ill after eating poisoned fruit.

Every effort should be exercised to avoid skin contact with Endrin, or inhalation of the duster spray mist. This material is about as toxic as parathion or nicotine and is more toxic than TEEP. Operators should avoid spray drift. Soap and water should be available at all times for

removing spray material from the skin.

Breaking up the runways with a disk harrow late in the fall helps to reduce mouse populations. Circular mulching orchard trees, which is considered a good culture practice, furnishes ideal cover for mice, but this can be offset by controlling with poison.

BAITING

The second most important method of controlling mice is by baiting. This has been used successfully for decades but it is time consuming. Poisoned apples, carrots, or grain



Figure 3. Anson B. Call, Jr., points out mouse damage to the trunk base of a larger tree. He shows an oil can used as a bait holder and the dead mouse which resulted.



Figure 4. A close-up of mouse damage, a dead mouse, and the oil can used as a bait container.

are used. One quart of apple or carrot cubes (about $\frac{3}{4}$ " cubes) or a similar weight of grain are placed in a jar, treated with one level teaspoonful of zinc phosphide or strychnine and shaken. This is sufficient for 90 to 100 poisoned baits. Only 1 day's supply should be mixed at a time. The poisoned bait should be placed in the burrows, runways, or mulch around each tree.

A third method of controlling mice in the orchard is by using clean cultivation or by removing sod cover within a 3- or 4-foot radius of the tree trunk. Of course, during a severe winter when food is limited, this may not be effective.

A fourth method of controlling mice is to use a machine called a "Trail Builder." The trail builder has a tube $1\frac{1}{2}$ inches in diameter which travels 1 to 4 inches under the surface and places treated grain in the runway which it makes.

A fifth method which has not been used to any great extent is that of using the anticoagulants Warfarin or Prolin on grain. The mice must eat the treated grain for 5 or 6 consecutive days before it takes effect and causes death from severe internal bleeding.

A sixth method requires individual traps, baited with poisoned grain or poisoned apple or carrot cubes.

Another control method is to wrap the tree trunks with aluminum foil or hardware cloth (wire) to protect them from the rodents. If the wire is used it must be buried 4 to 5 inches deep and extend 20 or more inches above the ground.

DEER

Deer are a problem some years in foothill orchards close to forested areas. During a snowy winter, deer migrate to the valleys to forage and because most of the vegetation is covered with snow they feed heavily on trees and shrubs. They cause two types of injury. One is rubbing their



Figure 5. When cover crops are grown in an orchard, they often harbor large populations of mice. However, the mice can be prevented, to a degree, from damaging the trees if the area immediately around the tree is cleared of vegetation. This photo shows chemical weed control (Amazine).

horns on the limbs and breaking many small spurs off the trees, and the other, which is more injurious, is eating the terminals and the small branches of the trees. Deer damage is much more severe in a young orchard than in older orchards. Deer may completely eliminate a young orchard during a severe winter.

The best control for deer is to place tall fences along the foothills or around individual orchards. The fence should be at least 7 feet tall. Deer are capable of jumping such a fence, although they rarely do so. In Utah, there have been a number of fencing projects by the Board of Big Game Control and the Utah State Department of Fish and Game. These fences are very effective, although they are also very expensive, and unless there are a number of orchards in the area or deer damage has been exceptionally severe in the area they probably are not warranted.

A second type of fencing consists



Figure 6. Where deer are plentiful and orchards are extensive, deer often feed on the trees during the winter. One way to prevent this is the construction of deer fences. This section of deer fence extends across the mouth of Dry Canyon in the vicinity of Logan, Utah.

of placing a small hardware cloth fence completely around the tree for the first few years. This prevents deer, mice, and rabbits from eating the trees. The main disadvantages, of course, are that such a fence is useful only 2 or 3 years because of tree growth and the individual fences are very expensive.

REPELLENTS

Another control measure, not completely acceptable, is the use of repellents. There are several compounds which, when placed on a tree, give off an odor that deer apparently find extremely offensive. Because deer do not like the smell of blood, moistened bone meal and dried blood have been effective when sprinkled on fruit trees. Other repellents include commercial preparations such as Goodrite, Zip, Bac, and Diamond L. These materials should be sprayed on the trees as soon as the deer start moving down from the mountains. A second application may be required.

Arasan also has been used to repel deer and rabbits from trees and ornamental plantings. This chemical is stable in that it acts much like paint and can be applied with a brush or can be diluted with water and applied as a spray. The coating should extend over the tree wherever deer may feed. These repellents do not harm wild life but simply divert them to other foods.

Another method of controlling deer is the use of mechanical scaring devices which range from shotgun blasts to other noise-making devices. These devices may be set to go off at time intervals. Such devices supposedly scare the deer, but deer are not easily driven away in this manner if there is inadequate food in other areas.

Deer may also badly damage some shrubs such as arbor vitae and juniper. The home owner should wrap the trees in either burlap or wire, which has been treated with a repellent, if there are deer in the area.

RABBITS

Rabbits often cause serious damage to orchards if there has been a heavy snow and inadequate food. Rabbits prefer small trees but may work on large trees. Usually, they damage apple orchards more than other fruit orchards if there is a choice available. Sweet cherry orchards have also been extensively damaged by rabbits.

Rabbit damage may be controlled by mechanical or chemical means. Mechanical means such as placing hardware cloth 4 inches under the ground and about 20 inches above ground around the tree is the one that is most used. Some have substituted aluminum foil, which is easier to apply.

Chemicals have not been used extensively, although commercial concerns are continually working with new formulas, hoping to produce a

superior one. A number of chemical formulations are available which have been satisfactory repellents. Probably the cheapest one is made by dissolving 7 pounds of rosin in 1 gallon of ethyl alcohol and then painting the material on the tree. This is inexpensive and is easy to apply. Nicotine sulfate, sold as Black Leaf 40, has been placed in asphalt paint and applied to trees. One gallon of the asphalt paint is mixed with 1 quart of Black Leaf 40. This treatment is effective, although it is rather difficult to apply and is not suitable for ornamental plants. Some orchardists have used $\frac{1}{2}$ teaspoon of 40 percent nicotine sulfate and 1 quart of water, and sprayed this mixture on tree trunks. Spraying is faster and more economical for small plants but not all of the materials will pass through a spray nozzle. Brush application may also be used.



Figure 7. Jesse Zollinger, Logan fruitgrower, demonstrates the use of fine-mesh hardware cloth to protect young trees from mouse and rabbit damage.

Inexpensive methods for

Information on soil moisture is needed and used by many people for a number of different purposes. Each of these purposes might require information about different properties of soil water. Thus, an engineer concerned with designing an irrigation system may need to measure the amount of water in a unit bulk volume of soil. He may need this information at periodic intervals to know how much water is used in a given time.

The irrigator, on the other hand, is not directly interested in the amount of water but he is concerned with its availability to the crop. Moisture in soil differs from other water, primarily because it is held in the soil by forces of retention.

These forces vary widely in their potency, depending upon the kind of soil, the amounts of water involved in and the temperature of the soil-water system and the soluble materials that are present (figure 1). This *retention energy* is a measure of the minimum amount of energy that any given crop must expend to remove a unit volume of water from the soil. Highway engineers, construction engineers, home gardeners, nursery men, and research scientists may be interested in measuring one or both of these two properties of soil water.

SOIL WATER POTENTIAL

The minimum amount of work required to remove water is the same whether it is applied by the plant, by the sun, or by man. For a man to remove the water, he might apply the work in the form of heat, suction through an appropriate membrane or by using a solution and the osmotic pressure effect to draw the

water through a semi-permeable membrane. The energy of retention is expressed in terms of *soil water potential*, which is generally negative

S. A. TAYLOR

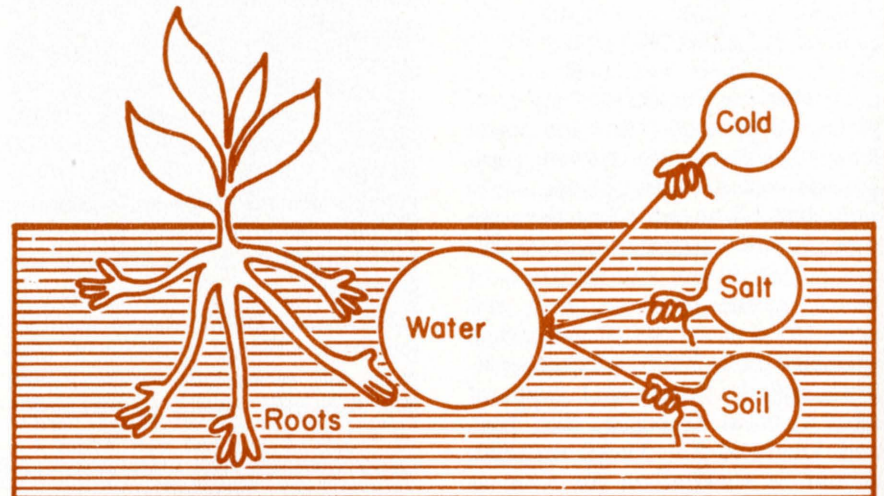


Figure 1. Moisture in soil differs from other water because it is held in the soil by forces of retention. The kind of soil, the amount of water, the temperature, and soluble materials all affect this retention force.

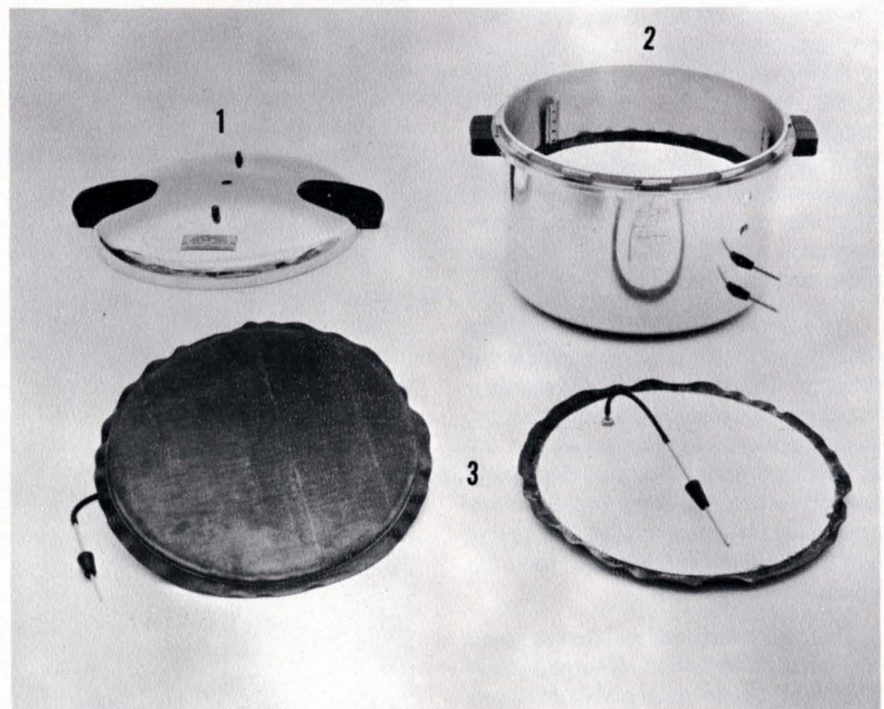


Figure 2. A pressure membrane apparatus: (1) cover, (2) pressure cell, and (3) top and bottom of the membrane.

S. A. TAYLOR is a professor and Head of the Department of Soils and Meteorology.

measuring soil moisture



Figure 3. Using a neutron meter to measure the amount of water in the soil. The probe has been inserted into the tube.

(less than zero) because work must be done to remove water from soil and work (or heat) can be done (or released) when water is added to the soil.

These two properties of soil water, *amount* and *potential*, are most often of interest, but there are other special properties to consider. These special needs are relatively infrequent and uncommon so we shall not discuss the measurement of the other soil water properties here. For those who are interested, a number of these measurements are described and the theoretical basis of the measurements discussed in Utah Agricultural Experiment Station Bulletin 426.

MEASURING AMOUNT

One common but costly method for measuring the *amount* of water in soil is to remove a sample of moist

soil from the field, being careful to prevent evaporation loss. This sample is weighed carefully, then dried in a controlled temperature oven at 105° to 110°C until constant weight is achieved. Then the loss in weight is divided by the dry weight of the sample (minus the weight of the container) and the results expressed as a percentage. The most costly item in this procedure is the labor involved, although the initial cost of the thermostated oven, the balances, the moisture boxes, and the sampling tools may be significant.

The above method is frequently modified by taking a sample of known volume in a specially constructed container. Then the loss of weight upon drying is divided by the bulk volume of the moist sample and the results expressed as a volume percentage. This requires the additional initial cost of the sampler and greater care in taking samples. Consequently, the already high labor cost is increased. Under some conditions, however, these methods are the only ones with sufficient precision to obtain the exact information.

MEASURING POTENTIAL

Only in recent years have methods become available for measuring soil *water potential* in field soils. Prior to that time, the potential was estimated by equilibrating a sample in a sealed vacuum desiccator held at some constant relative vapor pressure of water, then relating the soil water content to the vapor pressure. Later, a pressure membrane apparatus was developed which allowed a sample to come to water content equilibrium across a membrane and inside a cell held at some constant high pressure (figure 2). The pressure was directly related to the water potential.

This equipment allowed scientists to study relations between *amount*

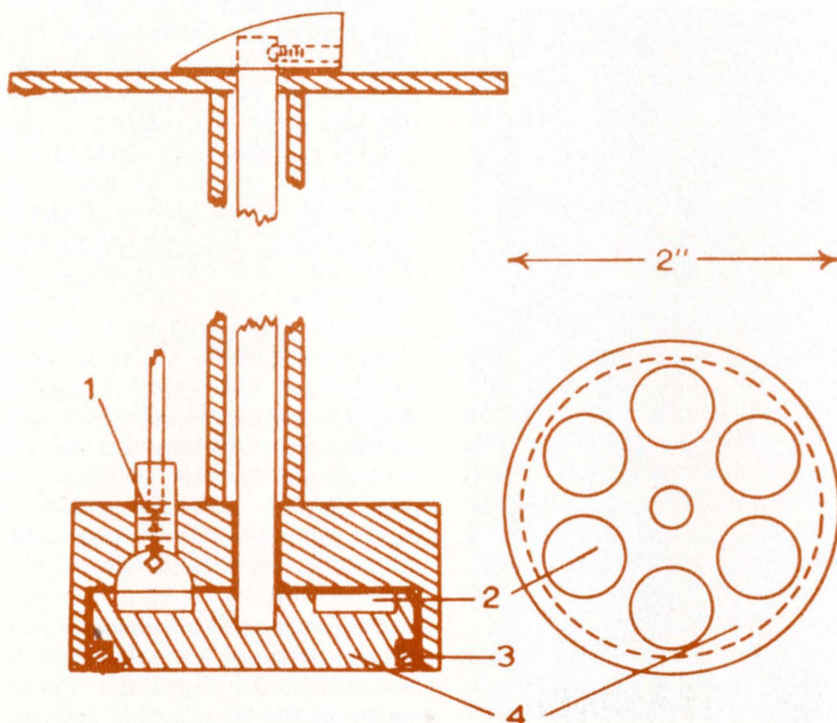


Figure 4. Shallow sample changer for a thermocouple psychrometer. (1) Thermocouple assembly; (2) sample chambers, (3) "O" ring, (4) changer cylinder.

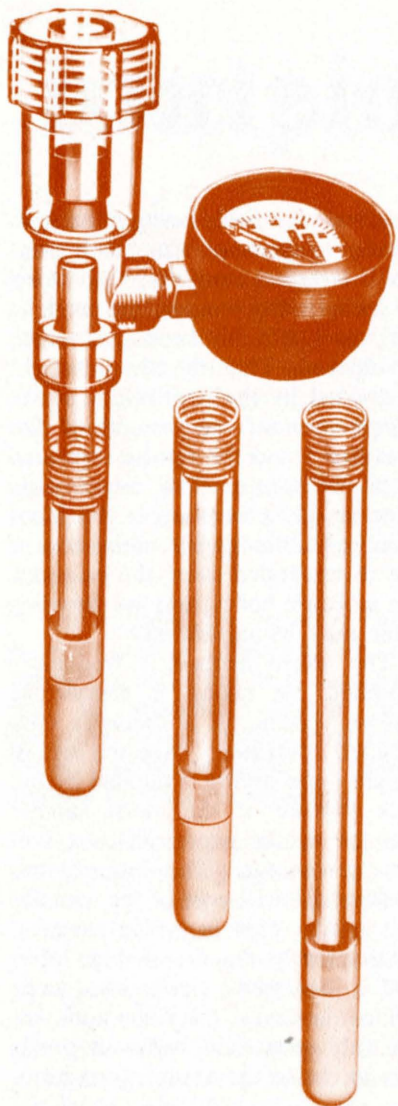


Figure 5. A tensiometer with interchangeable trips of varying lengths.

and *potential* of water in the soil. It was soon found that the relation between these two properties is never constant but depends upon whether the sample is drying from high to low or wetting from low to high moisture contents. This variation is called hysteresis because the relation depends upon the moisture history of the sample.

The relations were also found to vary with soil structure and composition and with the structure and texture of underlying or overlying layers or horizons. Since these factors vary so widely in the field, it was soon found that the *potential* could

not be reliably related to the *amount* of soil water and vice versa. As a result of this poor relation, methods for measuring both amount and potential of soil water have been developed.

LABOR COSTLY

Because labor is the most costly factor in the measurements, great effort has been expended in developing equipment to measure the desired properties of soil water with a minimum of labor. The reduction in labor costs has usually (but not always) been accompanied by increased number of approximations and accompanying loss of precision.

Today the most inexpensive methods measure approximate soil water potential, while the cost of measuring approximate soil water content remains quite high. However, the cost in terms of time and equipment of precisely measuring the water potential is about the same as that for measuring soil water content. Modern methods and equipment require labor that is somewhat more technically trained than was formerly needed. This offers no serious problem, however, since our public schools and technical schools as well as colleges and universities are training students to higher technical proficiency.

GAMMA RAY ABSORPTION

The atomic age has provided a precise but expensive method for measuring water content in laboratory samples by use of gamma ray absorption. This method has application for scientific work but little application for general use. However, a moderately inexpensive way for measuring the amount of water in the soil, providing one wishes to make successive measurements at the same location, has been developed by using neutron equipment.

Although the initial equipment is costly (in excess of \$2,500), the labor required per measurement is reduced so that if enough measurements are made, the cost per meas-

urement is reduced to an economical level. An access tube about $1\frac{5}{8}$ to 2 inches in diameter, depending on the model of instrument being used, is installed in the soil to the desired depth (for cropped soils usually 5 to 6 feet, but for other soils it may be to depths of 20 or 30 feet).

A probe containing a source of high energy neutrons and a counting tube is then inserted to the desired depth in the tube (figure 3). The high energy neutrons are slowed up (moderated) by the hydrogen ions in the water molecules of the soil. The tube detects only the slow (thermal) neutrons, the number of which is proportional to the number of hydrogen ions which in turn is closely related to the volume percentage of water in the soil.

INHERENT ERRORS

Although quicker and generally less expensive, this method has some inherent errors and limitations that make it less precise than the sampling and drying procedure. If the soil has sources of hydrogen ions other than water, such as high amounts of organic matter or high concentrations of some kinds of clay, slight errors may be introduced that will require the determination of a different calibration curve for each soil. If the access tubes do not fit the hole in the soil snugly or if they are left exposed to the direct rays of the sun, errors may be introduced as a result of temperature variations that develop. The high energy neutrons are scattered through a relatively larger volume of soil, the size of which varies with moisture content; consequently, a precise measurement of soil water at a given depth is not possible. For the same reason, measurements near the soil surface are in error. However, if one wishes to know the amount of water in the soil profile or root zone of a crop, the method can be used with confidence.

The cost of making moisture samples, in terms of labor, is about the same as for the first sample at a location as for the sampling and drying procedure. This is because the access hole must be drilled and the

tube installed. For successive measurements in the same access tube at the same location, the cost is reduced to a value from one-third to one-tenth of the cost of the original determination.

The initial cost of the equipment is about four times the original cost of equipment for sampling and drying (about \$2,800 vs. \$700). Hence, if large numbers of determinations are to be made by periodic readings at the same location then the neutron method is inexpensive, but if only one determination is to be made at a location, the method is expensive.

PSYCHROMETERS

The vapor pressure psychrometer (fig. 4) is the most accurate and precise method of measuring soil water potential. It is also the most costly in terms of both time and equipment. The initial equipment requires a means for establishing controlled temperature which is usually a bath, a delicate thermocouple psychrometer that is costly to construct, an amplifier or potentiometer, and a recorder or accurate galvanometer. It also requires special sampling equipment and sample chambers of special design. The minimum initial cost of this equipment is about \$1,200. However, the number of samples that can be measured with the basic equipment is very large so that time still becomes the major item of cost. One man working continuously can analyze about 40 samples per day.

TENSIOMETERS

Instruments called tensiometers (figure 5) can be installed directly in the soil and left. After a few hours the water in the instrument is in equilibrium with the soil water and one can record the water potential directly from the dial or scale of the instrument. Once the instrument has reached equilibrium, determinations can be made by simply observing the reading, which can be done in a few seconds. Thus the time expenditure for successive readings at the same spot becomes very small.

In this case the cost of the instruments becomes a major factor since a separate instrument is needed at each location where readings are to be made. The more expensive and reliable instruments cost as much as \$30 each and range downward in cost to about \$1 for the least expensive.

The error and limitations of tensiometers arise from three sources: (1) The range of potentials is limited to the region from 0 to -80 Joules/kg, which covers in the vicinity of 50 percent of the range of available water for many soils. (2) The instruments may accumulate air within the system and thus give unreliable readings. (3) Thermal effects resulting from exposure may cause anomalous results.

MOISTURE RESISTANCE BLOCKS

To extend the range of potentials that can be observed, moisture resistance blocks are frequently used (figure 6). The blocks consist of two electrodes generally made of stainless steel screen at a fixed distance apart and held there by a por-

ous material. A high grade of gypsum or plaster of paris is the most commonly used material for the block matrix.

The electrical resistance of these blocks is determined by the water content of the block which in turn depends upon the relative attraction or potential of the plaster block and the soil. Water moves along these potential gradients until the attraction (potential) for water is the same in the soil and in the block. Thus the resistance of the block may be related to potential of the water in the soil by use of a calibration curve.

Blocks may be installed in the soil at the desired depths and allowed to come to equilibrium after which the water potential can be determined by simply connecting the leads of the block to a measuring instrument which, for best results, is an alternating current resistance bridge. The alternating current is needed to prevent polarization of the electrodes. The observed resistance is then referred to the appropriate calibration curve to determine the water potential. It is possible to save more time by preparing a special dial that reads

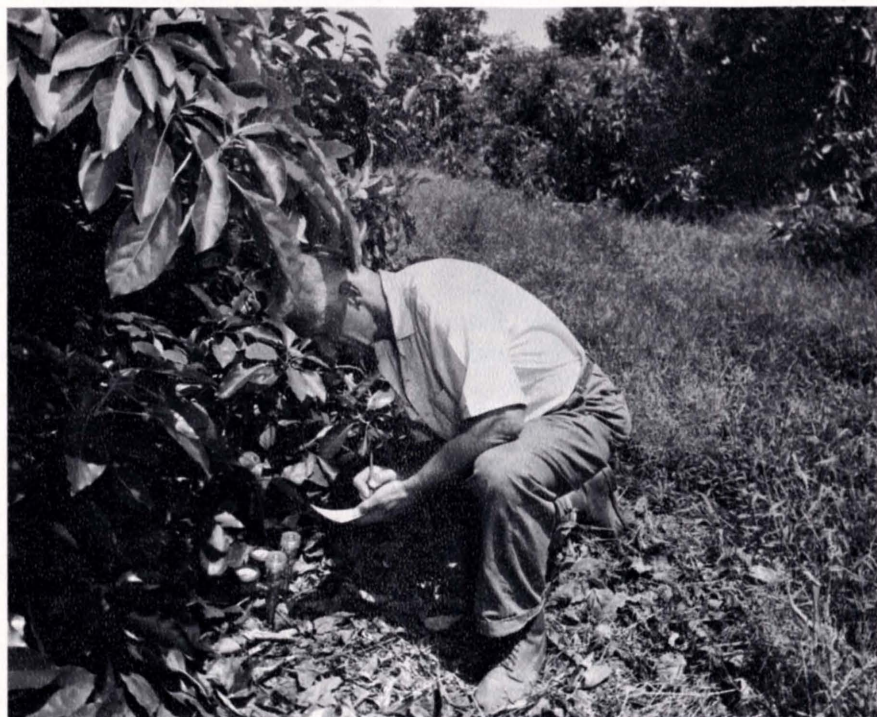


Figure 6. Reading tensiometers installed under avocado trees.
Photo courtesy of Irrrometer Co.

directly in soil water potential to replace the original dial of the instrument.

COST VS. ACCURACY

In terms of time, this method takes about the same as tensiometers, the original cost of the instruments is usually less since a suitable bridge costs between \$100 and \$200 and can be used with a large number of blocks that cost \$2 to \$5 each. Accuracy and precision have been sacrificed to obtain convenience and speed. Thus, the instrument is not as accurate as the vapor pressure psychrometer. It is also less precise than tensiometers and is particularly insensitive in the range of potentials where tensiometers are most effective. Thus tensiometers and blocks complement each other and when used together will cover the entire plant growth range of soil moisture.

Both blocks and tensiometers must be installed and left in place for several hours before they reach equilibrium. To effect maximum economy, they should be left in place and repeated recordings made at the same location.

SOIL PROBE

Often, a quick and simple moisture determination at one location is needed. To do this, an instrument is needed that can be inserted in the soil and a reading taken immediately. To do this, one must again sacrifice a degree of accuracy and precision, but this has been done and suitable instruments are available.

One newly developed instrument consists of a sharp probe with two metal electrodes, one at the point and one back on the wall of the probe. The electrodes are separated by a plastic insulator. The probe is inserted in the soil to the desired depth, a button is pressed and a resistance reading is taken which is related to the soil water content or potential.

Since these instruments do not have the electrodes embedded in a

porous matrix, they do not read water potential but some combination of potential and water content. By properly designing the instrument with switches and internal wiring, it is possible to partially compensate for these errors by setting a selector button for the general soil type. The dial of the bridge may then be divided into different regions, three might be appropriate: indicating high water potential — irrigation not needed; intermediate water potential — apply irrigation water; and low water potential — too low for good crop growth.

SOIL TYPES AND ACCURACY

To obtain readings, the probe must be long enough to reach the desired depth. A soil auger may be used to open a hole in the soil to the desired depth. A partial compensation for salinity may be built into the instrument such that the operator may wet a portion of the soil from a bottle or other source that he has available to him and adjust the instrument dial to record at the calibration point. This compensation is

only approximate and may be more accurate and valid in some soils than others, depending upon the type of salts and clays in the soil.

This equipment is generally inexpensive because it uses a direct current resistance meter rather than an alternating current bridge. Because it uses direct current, the electrodes may be subject to electrical polarization. The seriousness of this error also depends upon the particular soil system to which it is applied.

The method takes much less time than the initial readings with regular blocks or tensiometers but more time than successive readings at one place. The initial cost of all the equipment needed is less than the bridge alone for the block method. It costs as much as two or three of the best type tensiometers.

While this equipment cannot be recommended for situations where accurate information on soil moisture is needed, it certainly is capable of giving a general indication of the water conditions at a particular point in the soil at any given time. Thus it may have use in determining irrigation timing and plant needs for water.

(Continued on page 103)

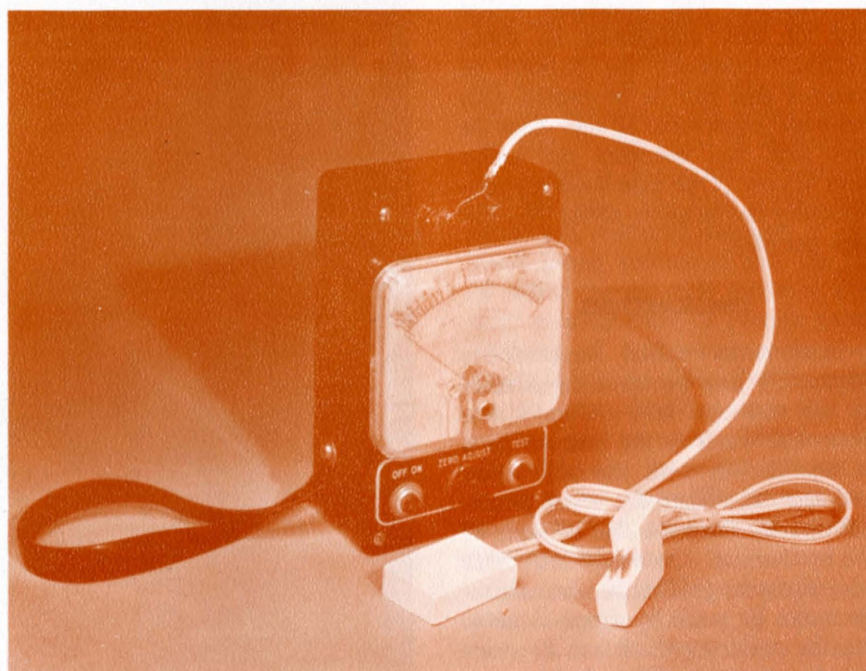


Figure 7. Resistance blocks and meter with a special dial for reading soil water potential directly.

NEW HEAD APPOINTED FOR PLANT SCIENCE DEPARTMENT

Dr. Frank B. Salisbury was appointed as head of the Plant Science Department at Utah State University on June 1, 1966.

Dr. Salisbury was born in Provo, Utah. He obtained B.S. and M.S. degrees from the University of Utah in 1951 and 1952. He received his Ph.D. degree from the California Institute of Technology in 1955.

(Continued from page 102)

SUMMARY

With such a large number of methods available for measuring the amount and potential of soil water, a suitable method can be found for almost any application. The research scientist might use the vapor pressure psychrometers, sampling and drying, or the gamma ray absorption technique. The field worker and both research and commercial producers may wish to use tensiometers, moisture blocks, and the neutron moisture meter. Some producers who do not now measure the soil water may find the direct current probes of considerable aid in helping them to determine when to irrigate and how much water to apply.



Figure 8. Resistance blocks being installed. They remain buried and the water potential can be "read" when the meter is attached.

From 1954 to 1955 he served as assistant professor of botany at Pomona College. He then went to Colorado State University as assistant professor of plant physiology from 1955 to 1961. In 1961 he was appointed as full professor of plant physiology and continued in that capacity until he came to USU.

Dr. Salisbury has published approximately 45 technical papers and popular articles concerning physiological ecology, flowering, and time measurement in plants, space biology, and other topics. Many of his published works deal with life on Mars and exobiology (life on other planets).

He has authored two books: *The Flowering Process*, 1963, Pergamon Press, London, and a science and religion book, *Truth by Reason and by Revelation*, 1965, Deseret Book Co., Salt Lake City, and coauthored a basic botany paperback in a series (Salisbury and R. V. Parke. 1964. *Vascular Plants: Form and Function*. Wadsworth, Belmont, California). At present he is coauthoring a plant physiology textbook to be published in 1967.

Dr. Salisbury spent 1962-63 as a National Science Foundation Post-doctoral Fellow in Tübingen, Germany, and Innsbruck, Austria, at which time he toured all the major controlled environment plant laboratories (phytotrons) in Europe and in Moscow, Russia.

His research at the present time concerns the physiology of flowering (the biological clock) and space biology (response of plants to ultraviolet light and life on Mars) under the support of the National Science Foundation and the National Aeronautical and Space Administration.

He belongs to the American Society of Plant Physiology, Ecological Society of America, American Association for the Advancement of Science (Fellow), Colorado-Wyoming Academy of Science, Sigma Xi, Phi Kappa Phi, and Gamma Sigma Delta.



DR. FRANK B. SALISBURY

NITROGEN CARBON DIOXIDE KILL INSECTS

Two serious pests of stored grain — red flour beetles and Indian-meal moths — died a few hours after being placed in a container in which USDA scientists had created atmospheres of carbon dioxide or nitrogen.

The tests were part of a continuing effort by entomologists of the Agricultural Research Service to develop safe, effective alternatives to fumigating or spraying with conventional chemical pesticides. Carbon dioxide and nitrogen leave no chemical residues on food or other products, and are not generally dangerous to humans. Workers, however, should not enter storage areas treated in this manner until air is restored.

After exposure to all-nitrogen atmospheres in glass jars, red flour beetles lived about 9 hours; larvae of Indian-meal moths lived 21 hours. These insects lived slightly longer — 12 and 24 hours — in an atmosphere of carbon dioxide.

Further tests, scientists believe, are necessary to learn whether the same results are possible in farm and commercial storage structures. For example, air-tight storage structures may not be necessary, as the gases can be continuously released in controlled amounts that maintain an effective concentration.

Maintaining Quality in

Several techniques for maintaining quality in fresh fruit were reported in the June issue of *Utah Science*. In this article we present information about ways to maintain quality in processed fruit.

CANNING

The process of canning requires the transfer of enough heat energy to kill any micro-organisms present in the fruit; at the same time, a desirable product should result. Micro-organisms may come from air, water, soil, and animals. They may be present on the fruit, in ingredients used in the process, and on the equipment used in the processing

plant. The important organisms associated with the fruit are yeasts, molds, and aciduric bacteria which tolerate high concentrations of acid.

Enzymes have a definite effect on fruit products. Enzymes bring about the deterioration of acid foods. A vacuum retards the growth of some organisms and reduces the oxidation of the fruit and the can lining. Tin-coated steel cans have been used in greatest quantities by the commercial canneries. Glass is also used for some fruit products.

PLASTIC "CANNING"

Possibilities of using flexible containers to "can" fruits have been

studied at Utah State University. Certain types of polyethylene packaging films showed a definite potential as a substitute for tin cans. This is especially significant since the cost of tin cans is high for certain products. Peaches, apricots, cherries, and beans were processed in the bags as they normally are processed in tin cans. Several aspects of this research require more thorough investigation, however, before definite conclusions can be reported.

In canning, the greatest loss of nutrients results from the loss of vitamins, particularly the water soluble vitamins. Ascorbic acid (Vitamin C) is water soluble and heat sensitive and its loss may be substantial. The heating of foods changes their physical and chemical qualities. Oxidative browning may occur in foods prior to the inactivation of enzymes.

However, color pigments are also altered upon heating. Thermal degradation of pigments and relative biochemical changes in canned apricots and cherries have recently been investigated at USU.

FREEZING

Technically speaking, freezing is a process that removes heat from a confined space. Freezing shares with canning the advantages over ordinary cold storage by eliminating bacteria and mold spoilage. Also, like canning, freezing produces changes in the texture of the fresh product. Slow rates of freezing produce large ice crystals in the inter- and intracellular tissues of fruits which cause cell wall distortion, separation, and rupturing. These freezing effects are the primary reasons for the textural changes that are noted in thawed fruits. Cryogenic (rapid) freezing in liquid nitrogen minimizes such cell damage.

Research at USU indicates that freezing has some advantages over

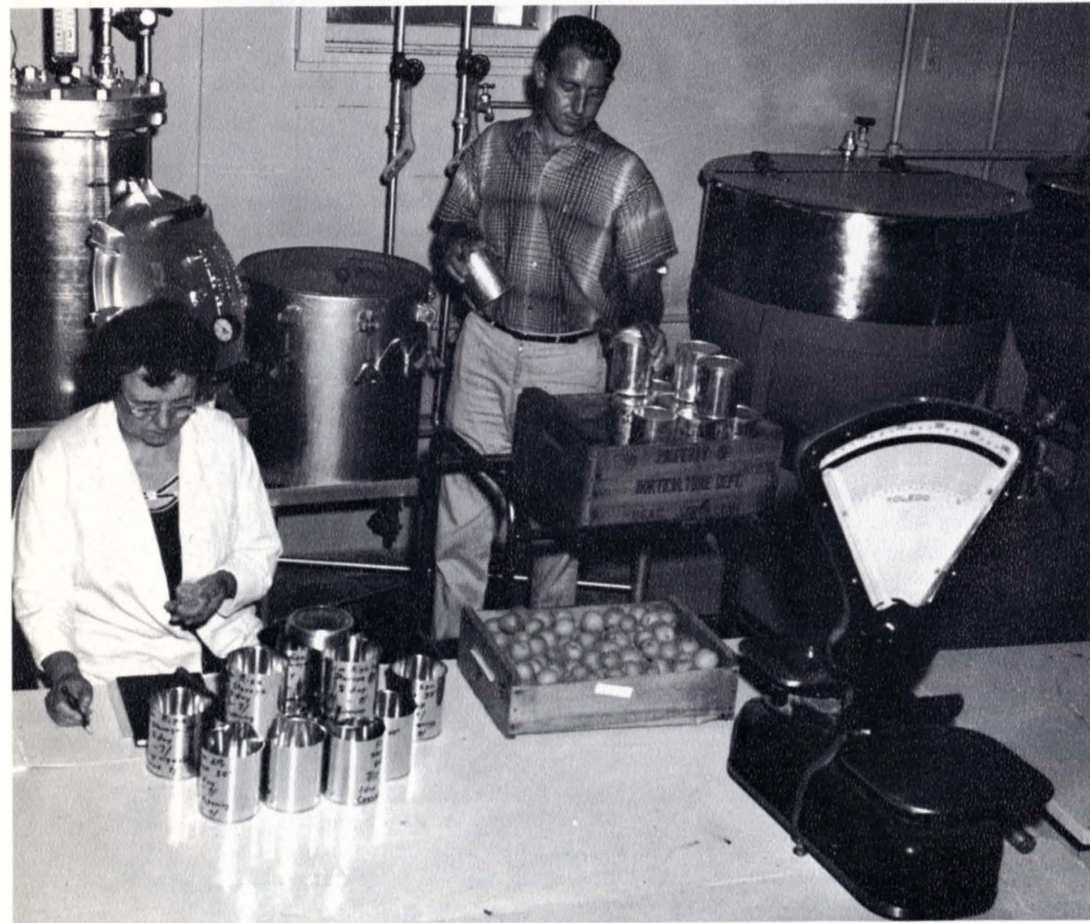


Figure 1. Some essential equipment used in research on canned food products.

Processed Fruit

D. K. SALUNKHE, C. Y. LEE, and F. S. NURY

canning as a way to preserve fruit. For example, the fruit may be picked when ripe for freezing, whereas for canning the fruit must be harvested in the green-mature state. This sometimes makes considerable difference in ultimate flavor.

Commercial freezing of fruit is usually accomplished by indirect contact with the refrigerant. Continuous and stationary multiplate freezers or the blast-type quick freezer have gained acceptance in processing plants. These units correlate well with modern packaging requirements for frozen fruits and are efficient enough to satisfy today's production demands.

Changes which occur in frozen fruits during storage vary from product to product as well as with the type of packaging material. Continuous temperatures of 0°F or lower are desirable to maintain the quality.

JUICES

In recent years, the production of fruit juices has greatly increased in the United States. With the development of large-scale fruit juice canning, considerable attention has been directed to perfecting preservation methods by preservative chemicals. We have examined various fruit juices and found them to be amenable to commercial production. Montmorency sour cherries, Large Early Montgamet apricots, Elberta peaches, and Jonathan apples formed the bases for cherry delight, apricot nectar, peach nectar, and apple juice drinks which were given high quality scores by taste panelists.

Carotene, niacin, and riboflavin are, in general, stable in canned juices. Ascorbic acid and thiamine are lost in appreciable amounts above 50°F. The naturally occurring pigments such as the anthocya-



Figure 2. Applesauce samples during dehydration under vacuum.

nins and tannins undergo changes over time. In the presence of acids, a bright color occurs. Metal ions tend to darken the juice when they react with pigments.

FRESH JUICE TREATMENTS

Recently, extensive studies were conducted on the effects of chemical treatments of apple juice. It was found that apple juice treated with Candicidin, Mycostatin, and Myprozine at 30 ppm was unfermented after 6 weeks' storage at 40°F. Flavor changes were not noticeable. Sorbic acid was effective against yeast growths in apple juices. Vitamin enriched apple juice was also studied.

FRUIT POWDERS

The fruit-juice industry has also

developed convenient and easy-to-handle fruit powders which have more than 85 percent of the original water content removed. The powders thus are economical to transport, store, and handle. Fruit powders can be preserved for extended periods without refrigeration, and they have high quality and nutritive value. The current interest in powdered juice drinks has prompted much investigation in this area. The methods of preparing commercial fruit powders are spray drying, vacuum drying, drum drying, and the more recently developed foam-mat drying. Powdered peaches, apricots, and sour cherries were produced in

D. K. SALUNKHE is a professor of Food Science and Technology in the Department of Plant Science. C. Y. LEE is a graduate assistant in Food Science and Technology. F. S. NURY is a USDA collaborator in Food Science and Technology.

the food processing laboratory at USU in 1962 with the cooperation of Western Utilization Research Laboratory, Albany, California. Recently, powdered apple juice and applesauce were made by the freeze dehydration process. They had a high quality which was comparable to fresh apple juice and applesauce.

The low moisture content and added antioxidants prevent caking, browning, and loss of flavor and nutrients in the fruit powder. Complete dryness may be necessary for satisfactory stability at elevated temperatures during storage. The flavor can be stabilized by eliminating air or incorporating nitrogen or other reducing gases.

LOW CALORIE FRUIT PRODUCTS

It is estimated that more than 40 million Americans are overweight, and either are, or should be, concerned about reducing their weight.

Also, 3 million known diabetics must restrict calorie intake to control their disease. The problems of overweight people and diabetics have fostered a demand for high-quality, low-calorie fruits, fruit syrups, juices, jams, and jellies. This rapidly expanding market for diet foods prompted members of the food science and technology division at USU to conduct pioneering research on the quality of processed fruits and fruit products made with synthetic sweeteners. Comparisons were made of the acceptabilities and quality ratings of canned fruits, jellies, and syrups of selected fruits prepared with several concentrations of sucrose, sorbitol, calcium cyclamate (cyclohexysulfate), and sodium saccharin (O-sulfobenzoic acidimide). The combination cover syrups of 10 percent sucrose and 0.1 percent calcium cyclamate, or 10 percent sucrose and 0.02 percent sodium saccharin were as acceptable as the 40 percent sucrose solution.

Fruits with 0.15 percent calcium cyclamate were preferred to fruits with 0.05 percent sodium saccharin. These syrups did not adversely affect color, pH, or cell structure of the fruits.

DEHYDRATION

Dehydration is one of the oldest known methods of food preservation. The use of solar energy for drying foods to protect them from microbial and fungal attack is still the most widely used method of food preservation. Sun-drying and dehydration (artificial drying) are both used in the preservation of fruit, but sun-drying is unsanitary and dependent on weather and geography. For these reasons, research on dehydration processes has been continuously conducted to find new and improved methods that would yield good quality dried food products.

Research on the dehydration of fruits has been one of the major projects of the food technology program at USU. Extensive investigation has been conducted during the last 3 years. Several varieties of major fruit crops in Utah were dehydrated by sun-drying, conventional hot-air dehydration, dehydrofreezing, and freeze-dehydration methods.

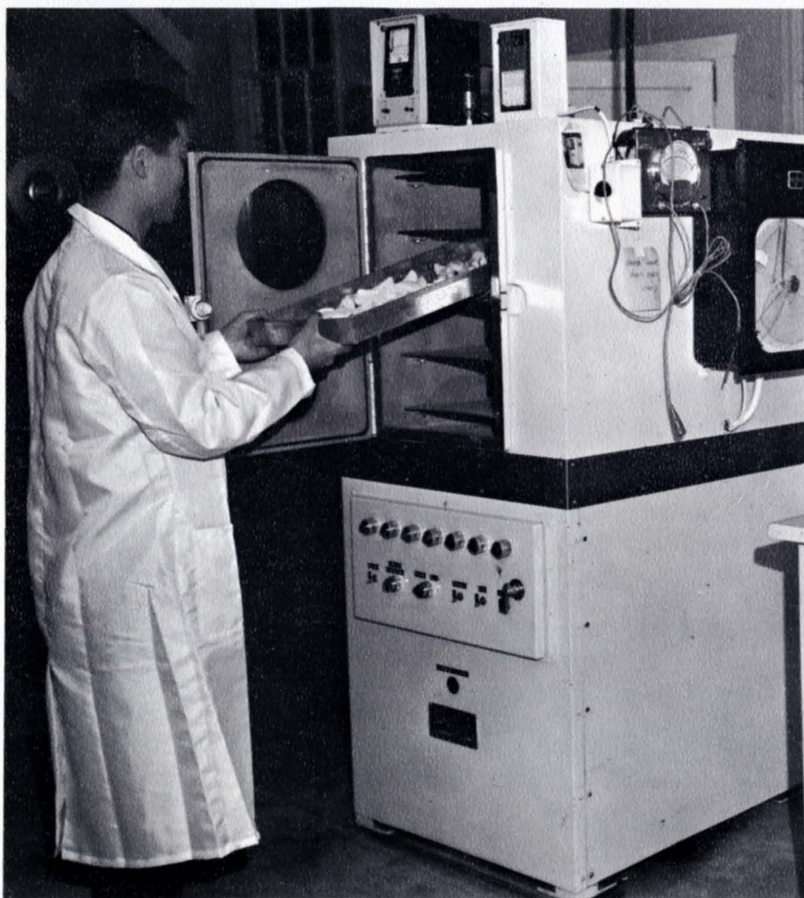


Figure 3. Freeze-dehydration equipment.



Figure 4. This microwave oven was used in dehydration studies.

Effects of each dehydration process on flavor components and fruit texture changes were investigated. The freeze-dehydration process is superior in maintaining good quality of fruits. New techniques for assuring good quality freeze-dehydrated products were developed at USU. Cryogenic freezing and osmotic dehydration treatments prior to freeze-dehydration gave very promising results.

Pioneering research in the microwave dehydration process also is being conducted at USU. When microwave energy is absorbed by a substance (food), the energy is converted to heat. One of the most important advantages of microwave energy is its ability to penetrate and produce instantaneous heat which radiates from within to the outside of the fruit pieces.

Preliminary experiments were conducted on apples to develop a suitable procedure for production of low moisture products. Microwave energy proved suitable for terminal dehydration, that is, after the fresh fruit was preliminarily dehydrated by another method (cabinet dehydration). Specifically, the lowering of moisture from about 20 to 16 percent down to 5 percent was found to be the most suitable range for the use of microwave energy. In some cases, there is a greater retention of nutrients because the microwave process requires a relatively shorter time. The process also minimizes the changes of color and flavor as compared to standard methods. In extensive biochemical and physical characteristics studies now underway at USU, the quality of microwave dehydrated fruit is being compared with that of fruit dehydrated by other processes.

FERMENTED & PICKLED FRUITS

Experiments with pickled fruits also were conducted. Sweet cherries (Bing variety) and peaches (Elberta variety) at firm-ripe maturity were packed in glass jars and were preserved in a sweetened vinegar (ratio: 6 cups vinegar, 4 cups water,

FOR PROCESSING . . .

Best Fruit Varieties

D. K. SALUNKHE

From 1959 to 1963, studies were conducted in the Utah State University food processing laboratories to determine the effects of variety, maturity, and post-harvest storage conditions on the final quality of apricots, cherries, peaches, pears, plums, and strawberries processed by canning and freezing. The quality factors studied included flavor, texture, visual color, soluble solids, acidity, and ascorbic acid (Vitamin C).

APRICOTS

Apricot varieties that yielded good quality canned apricots were Royal, Perfection, Earli Orange, Sun Glo, Moorpark, T101, and Hungarian. New selections that were preferred when canned were Utah A27, Utah A17, Utah A32, Utah 29, Utah A24, and Utah A28. The best varieties when frozen were Moorpark, Hungarian, T101, Perfection, Earli Orange, Sun Glo, and Large Early Montgamet, in that order. New selections that compared favorably with the varieties listed were Utah A17, Utah A32, Utah 29, Utah A24, Utah A28, and Utah A27. The Moorpark variety, although favored by taste panelists, disintegrated when either frozen or canned.

The best quality canned apricots were obtained when the fruit was harvested at the mature-green or firm stages of maturity and then ripened in storage. The final product from such fruit was superior in quality to that obtained from tree-ripened fruit.

3½ cups sugar, and 4 tablespoons of salt). The sweetened vinegar was heated to 190° to 200°F and poured on the fruit. After storage for a month or so the pickles were ready to use. Any condiments, such as cloves, may be added as desired.

Apricots stored at 30° and 40°F gave better results than those stored at other temperatures for comparable time periods. Fruit harvested at the mature-green and firm stages of maturity can be successfully stored for 30 days at these temperatures. The fruit quality is good after such storage, but the weight loss that occurs during storage may be economically significant to processors.

CHERRIES

The Montmorency sour cherry was superior to the other varieties for canning and freezing. The early Richmond variety was of good quality and May Duke and Suda varieties were acceptable.

There is a great deal of seasonal variation in sweet cherries when processed. Varieties that were consistently good when canned include Lambert, Sam, Star, Napoleon, Bing, and Van. The best varieties for freezing are Napoleon, Van, Star, and Black Tartarian. The most promising selections for processing are Utah No. 6 and Utah No. 1.

PEACHES

The standard varieties grown in Utah (Elberta, J. H. Hale, Redhaven, Gleason Early Elberta, and Johnson Early Elberta) all had very good quality when canned, and were acceptable when frozen. The varieties that canned best were Gleason Early Elberta, Red Cap, Sullivan's Early Elberta, Clark-haven, Redhaven, Fertile Hale, Sunhaven, Starking Delicious, Vesper, Redglove, Hale Harrison Brilliant, and Sunhigh. Varieties that were very good

D. K. SALUNKHE is a professor of Food Science and Technology in the Department of Plant Science.

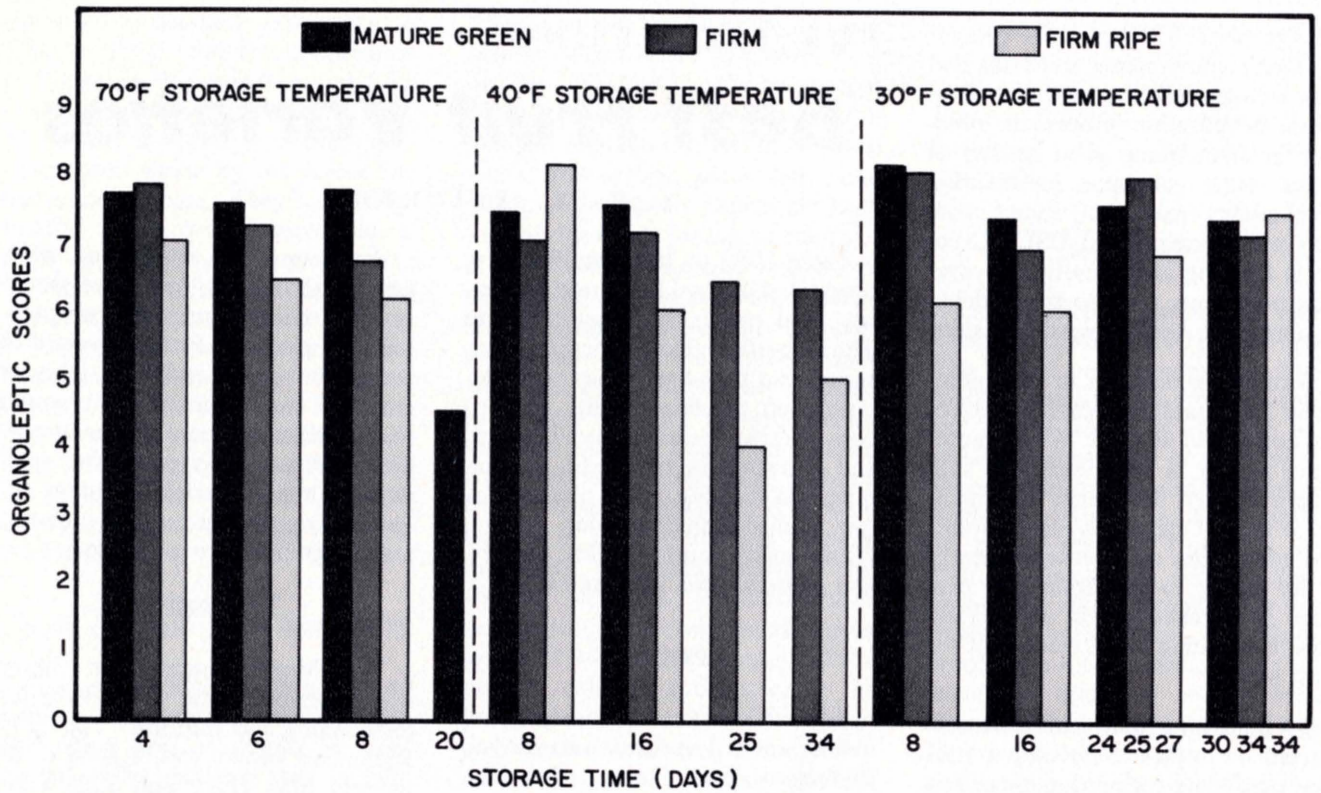


Figure 1. The effect of storage duration and temperature on the flavor of Large Early Montgamet apricots picked at three stages of maturity, 1960.

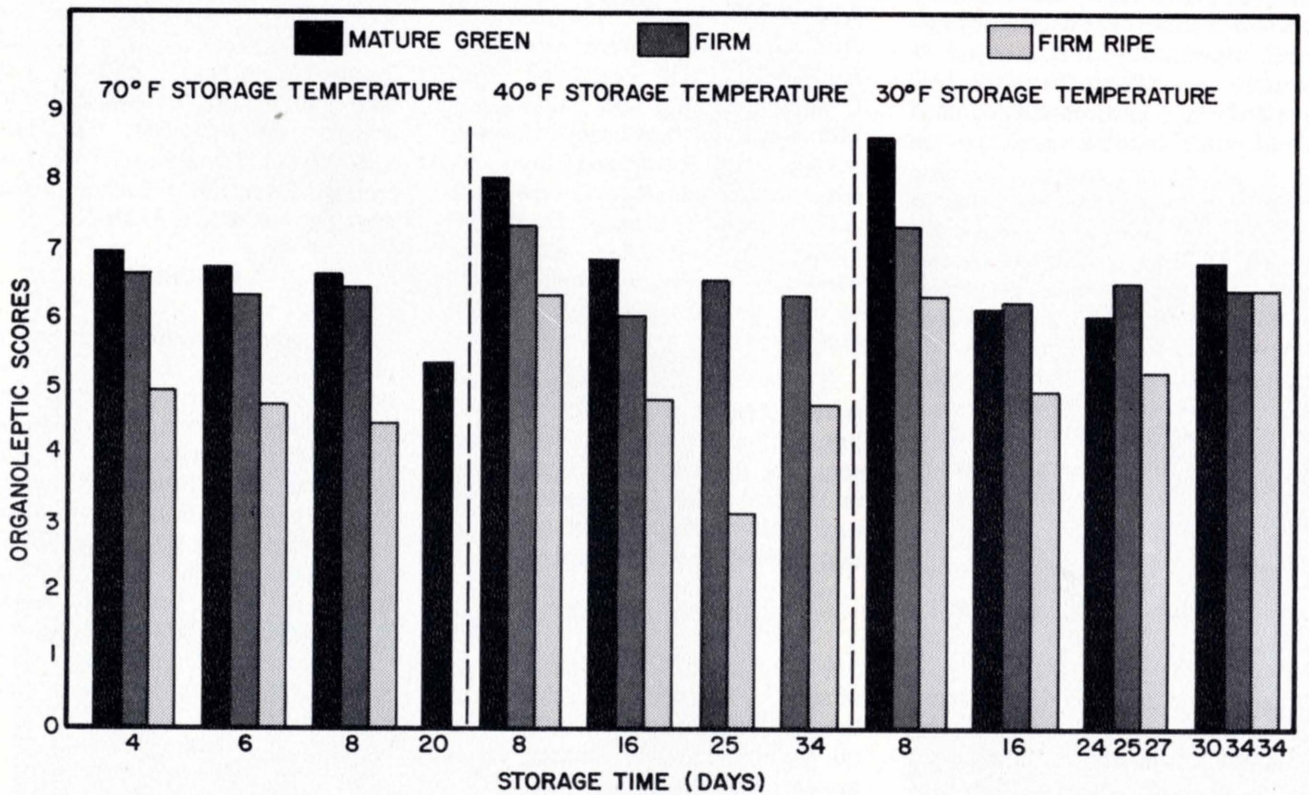


Figure 2. The effect of storage duration and temperature on the texture of Large Early Montgamet apricots, 1960.

for freezing included Summercrest, Sunbright, Sunhaven, Hale Harrison Brilliant, and Red Gold Giant. Redwing, Prairie Sunrise, Cardinal, Erly Red Fre, Keystone, Valigold, Sunbright, Belle of Georgia, and Kimbo are not recommended for canning. The least acceptable frozen peaches were from Redwing, Keystone, and Erly Red Fre varieties. The white varieties are generally less desirable for processing than the yellow varieties.

Canned peaches of the highest quality are obtained when the fruit is harvested at the firm stage of maturity (8-12 pounds pressure — as measured by Magness-Taylor tester) and ripened for several days in storage.

Quality of canned peaches did not vary appreciably after storage at temperatures of 30°, 40°, and 70° F. Peaches to be canned do not keep satisfactorily beyond 2 weeks at 70° F, but will be acceptable even after 30 days' storage at 30° and 40°F, if sorted for quality prior to processing. Weight loss of fresh fruit during storage was very high and increased proportionately with storage time. Peaches stored at 34°F for up to 2 weeks and then ripened at higher temperatures were not adversely affected.

PEARS

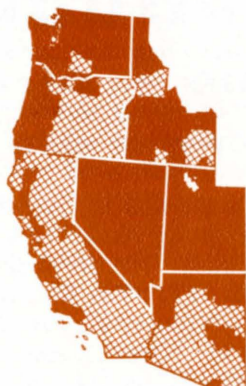
The Bartlett variety remains the best for canning. Other varieties that were good included Max Red Bartlett, Anjou, and Dwarf Bartlett. One selection, P132S52, showed some promise for freezing; however, pears are not recommended for freezing.

Bartlett pears should be harvested at a maturity indicated by 15 to 20 pounds pressure as measured by a Magness-Taylor pressure tester.

Bartlett pears can be successfully kept as long as 9 weeks at 40°F before processing. Pears stored up to 5 weeks at 30°F prior to canning yielded good quality canned fruit. Pears stored at 70°F resulted in a canned product that was of lower quality than those stored at the lower temperatures. Weight loss is high after long periods of storage, especially at 70°F.

WESTERN STATES . . .

STAMPING OUT BRUCELLOSIS



ALL COUNTIES IN NEVADA AND UTAH CERTIFIED-FREE

COUNTY STATUS IN 7 STATES :

- 69% BRUCELLOSIS-FREE
- ▨ 31% MODIFIED CERTIFIED (LESS THAN 1% INFECTION)

Brucellosis, a serious, costly disease of livestock and man, has been eradicated from 7 out of 10 counties in 7 western states.

Two of these states, Utah and Nevada, have eliminated the disease from all their counties to achieve a certified brucellosis-free status. Arizona, California, Idaho, Oregon, and Washington have qualified more than 60 percent of their counties as certified brucellosis-free areas and all the remaining counties are modified certified.

The western states are leading the nation in the cooperative State-Federal effort to stamp out the disease. Nationally, 20.6 percent of the counties are certified free, 68.2 percent are modified certified, and 11.2 percent are noncertified. In this seven state area, 69 percent of the counties are certified free and 31 percent are modified certified.

Aside from Utah and Nevada, 1 midwestern state, Wisconsin, 6 Eastern States, and the Virgin Islands have reached the ultimate goal — a certified brucellosis-free status.

The brucellosis eradication campaign in Utah is being carried out by Dr. Hendrik Versluis, State Veterinarian, and by Dr. J. E. Rasmussen, Federal Veterinarian in charge of USDA's Animal Health Division. Once brucellosis is eradicated from livestock, the only source of infection for man will have been eliminated.

PLUMS

Several varieties of plums are recommended for processing. The best for canning appear to be Santa Rosa, Stanley, Grand Prize, Italian, Giant Cherry, Bradshaw, President, Early Gold, Gold, and Starking Delicious, although many other varieties can be canned successfully. Varieties that are not recommended for canning are Damson, Big McKay Damson, Ozark Premier, and Wickson. Varieties recommended for freezing are Santa Rosa, Red Coat, Wickson, and Starking Delicious. Poor quality frozen plums were obtained from the Sapalta, Yakima, Imperial Gage, Sugar, and Superior varieties.

STRAWBERRIES

Shasta, Pocahontas, Armore, Arch Red, Kasuga, Jerseybelle, Lindalicious, Sparkle, Sure Crop, Cascade, Trumpeter, Wisconsin, Ogallala, Midland, and Midway varieties yielded good quality frozen strawberries. Utah 4-25 and Utah 3-27 selections showed some promise. Strawberries are extremely susceptible to environmental effects and also vary from season to season, so great care must be exercised in selecting the proper variety for any particular area. Varieties that are not recommended, as a result of this study, are Earlidawn and Tennessee Beauty.

What about birdsfoot trefoil?

KEITH R. ALLRED

FIFTH OF SERIES

The most productive irrigated pastures for the western part of the United States contain improved species of both legumes and grasses. A serious problem associated with these pastures is the constant threat of bloat to the grazing animal. This is especially true for pastures containing alfalfa or ladino clover because both species cause bloat. With this bloat factor in mind, it seemed desirable to include a mixture containing a non-bloating legume in the irrigated pasture study. A legume reported to be non-bloating and offering promise of being compatible with the grasses was birdsfoot trefoil. It was included as a component of Mixture 4 along with orchardgrass and smooth brome grass.

This is the fifth in a series of articles reporting results of a 5-year pasture study. The previous articles dealt with: (1) "The Role of Alfalfa," (2) "Grasses Can Be Productive," (3) "Does Ladino Clover Have a Place?" and (4) "Use Alfalfa-Intermediate Wheatgrass Where Water Is Limited." The first article appeared in the June issue, Volume 26, of *Utah Science*, and the other articles have followed in sequence.

The study was conducted at the Greenville Experimental Farm in North Logan, Utah, from 1960 to 1965. The soil is 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 height of 2 inches at each harvest. Nitrogen was applied as ammonium nitrate. The soil was high in potash. To assure that sufficient phosphorus was available to the plants, 100 pounds of phosphate (P_2O_5) per acre were broadcast over the entire experimental area in the springs of 1961 and 1963.

ABOUT BIRDSFOOT TREFOIL

Broadleaf birdsfoot trefoil was used in this study. It is a hardy, long-lived perennial legume that has gained acceptance as a desirable forage species in some of the more humid parts of the United States. Two other species, narrowleaf birdsfoot trefoil and big trefoil, are being used to a much lesser extent. Narrowleaf birdsfoot trefoil does not root as deeply and is less drought tolerant than the broadleaf species. However, narrowleaf has shown more salt tolerance. The big trefoil is best adapted to wet and somewhat poorly drained soils.

Broadleaf birdsfoot trefoil is native to Europe. It is similar to alfalfa in growth habit. It has a branching taproot with stems ascending from the crown to a height of 15-30 inches at maturity. Stems are slender and generally erect. The leaves are made

MANAGEMENT TREATMENTS

Irrigation

- I - 1 4 inches of water every 20 days
- I - 2 3 inches of water every 15 days
- I - 3 2 inches of water every 10 days
- I - 4 1 inch of water every 5 days

Fertilization

- F - 1 Zero pounds of nitrogen per acre
- F - 2 50 pounds of nitrogen per acre
- F - 3 100 pounds of nitrogen per acre (50-pound increments)
- F - 4 200 pounds of nitrogen per acre (50-pound increments)

Clipping Frequency

- C - 1 4 times a season (35-day interval)
- C - 2 5 times a season (28-day interval)

Pasture Mixture

- M - 4 Legume-grass mixture consisting of birdsfoot trefoil, orchardgrass, and smooth brome grass.

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

up of five leaflets, two of which are at the base of each petiole and are sometimes mistaken for stipules. The flowers are born in umbels and are yellow with faint red or orange stripes. Seed pods form at right angles at the end of the flower stalk in the shape of a bird's foot. Seeds are oval to spherical in shape and are about half the size of alfalfa seed. They vary from light to dark brown and may be speckled with dark spots. As the pods mature and become dry they are likely to split open and scatter seeds several feet in all directions.

Birdsfoot trefoil has been described as being "temperamental but versatile." It grows on a wide range of wet or dry soils, persists under fairly intensive grazing conditions, produces excellent quality forage, is non-bloating, and maintains a good stand for many years. Some of the major problems associated with this legume include: seed must be inoculated before being planted, seedlings are slow to develop, stems are weak, lodging is likely unless grown with associated grasses, and it is not competitive when sown with other legumes.

SEEDING AND ESTABLISHMENT

The pasture mixture discussed in this article consisted of Granger broadleaf birdsfoot trefoil (*Lotus corniculatus* L.), commercial orchardgrass (*Dactylis glomerata* L.), and Manchur smooth brome (*Bromus inermis* Leyss). Granger was developed at the Washington State Agricultural Experiment Station. It grows upright, has fine stems, a large percentage of leaves, and grows about two-thirds as tall as alfalfa. Seeding rates in pounds per acre were: birdsfoot trefoil, 5; orchardgrass, 8; and brome, 12. The birdsfoot trefoil seed was inoculated just prior to seeding with a special bacterial culture made for trefoil. At the end of the establishment year (1960), plots seeded to this mixture averaged 30 percent birdsfoot trefoil, 55 percent orchardgrass, and 15 percent brome.

MANAGEMENT RESPONSE

Data on the overall performance of the birdsfoot trefoil-grass mixture throughout a 4-year period as influenced by irrigation frequency and nitrogen fertilization are presented in table 1. Yields of dry forage in tons per acre range from a low of 1.52 to a high of 4.60 (equivalent to 5 tons of hay per acre). High yields were associated with the highest rate of nitrogen fertilization and the most frequent irrigation interval.

At low levels of fertility, the birdsfoot trefoil-grass mixture produced more forage than the all-grass mixture but less than the ladino clover-grass mixture and only about half as much as the alfalfa-grass mixtures. At high levels of nitrogen most of the birdsfoot trefoil disappeared from the mixture. Under these conditions, the forage production was very similar to that of the all-grass mixture and lower than the other legume-grass mixtures that were included in the study.

CLIPPING FREQUENCY

The birdsfoot trefoil-grass mixture showed little difference in response to the frequency of clipping in terms of forage production or amount of

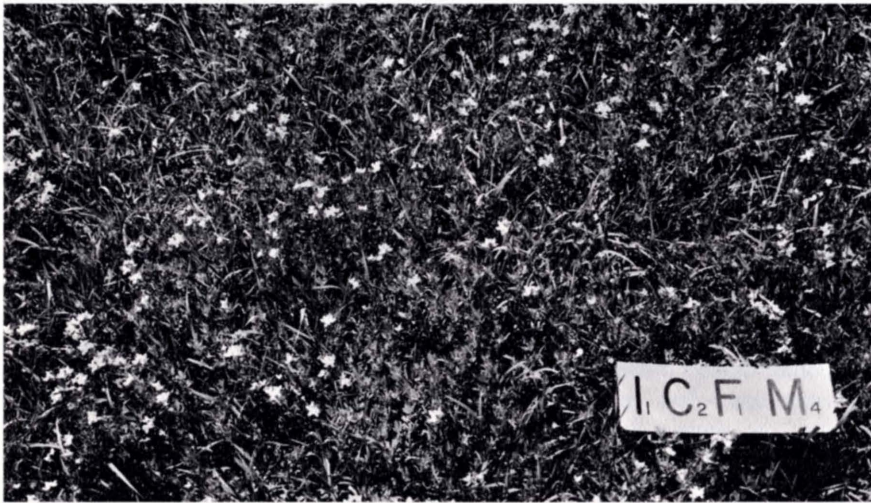


Figure 1a. A fair amount of birdsfoot trefoil was maintained in plots that were irrigated infrequently (I-1) and were not fertilized with nitrogen (F-1), but the forage yield was low.



Figure 1b. Nitrogen fertilization (F-4) greatly increased forage production on the birdsfoot trefoil-grass plots; however, the grasses were stimulated while the birdsfoot trefoil was practically eliminated from the mixture by the end of the third summer.

legume retained in the mixture. The overall forage yields were only 0.2 tons of dry matter larger when harvested four as compared to five times a year. Although this slight increase was consistent during each of the 4 years, it was not large enough to be significant.

Forage harvested from this mixture at 28-day intervals (C-2) averaged 16.5 percent protein as compared to 14.5 percent when harvested at 35-day intervals (C-1).

IRRIGATION FREQUENCY

The frequency of applying water resulted in a change in the amount of dry forage produced but had little effect on either the botanical composition or on the percent protein in the birdsfoot trefoil-grass mixture. Approximately 30 percent birdsfoot trefoil was retained in the plots during the 4 harvest years regardless of the irrigation treatments. The trend was toward a lower protein content when water was applied at frequent intervals. The effect was small, therefore, since forage irrigated at 20 day intervals (I-1) averaged 15.8 percent protein compared to 15.2 when irrigated at 5-day intervals (I-4).

Production of dry forage increased as the interval between irrigations was shortened. When irrigated at 20-, 15-, 10-, and 5-day intervals, the dry matter production was 2.37, 2.71, 2.87, and 3.07 tons per acre, respectively. Although this was a steady increase, the total was not large and may not offset the costs involved in irrigating more frequently.

NITROGEN EFFECT

The amount of nitrogen applied to the plots had a positive effect on the dry matter yields but a negative effect on the amount of birdsfoot trefoil retained in the mixture. Forage yields increased with each 50-pound increment of nitrogen applied. Average yields resulting from the zero, 50, 100, and 200 pounds of nitrogen applied per season over the 4-year period were 2.03, 2.48, 2.71, and 3.81 tons of dry matter per acre,

respectively. An additional yield increase over that from nitrogen was obtained as the interval between irrigations was shortened. Data showing the response at different nitrogen levels and irrigation frequencies are presented in table 1. An average yield of 1.92 tons was obtained when no nitrogen was applied and irrigation was at 20-day intervals. In these plots, birdsfoot trefoil made up approximately 40 percent of the forage. The highest yield of 4.37 tons per acre resulted from the combined treatment of 200 pounds of nitrogen and irrigation at 5-day intervals. These plots were reduced to only 3 percent birdsfoot trefoil by the fourth harvest season. The grasses were responsible for the yield response.

Plots that were not fertilized with nitrogen (F-1) increased in the percent of birdsfoot trefoil in the mixture during the first season and averaged approximately 40 percent legume from the second through the fourth harvest seasons (figure 1a). In contrast to this, plots fertilized with 200 pounds of nitrogen per acre per year (F-4) reduced in the percent of birdsfoot trefoil each season and contained less than 5 percent legume the fourth harvest season (figure 1b). The amount of birdsfoot trefoil in the mixture stayed

near 30 percent for plots fertilized with 50 pounds of nitrogen but gradually decreased to about 25 percent when 100 pounds of nitrogen were applied.

Nitrogen fertilization did not change the protein content of the forage to any great extent. Without nitrogen, the protein content was 16.1 and it was 15.6 for the F-4 treatment.

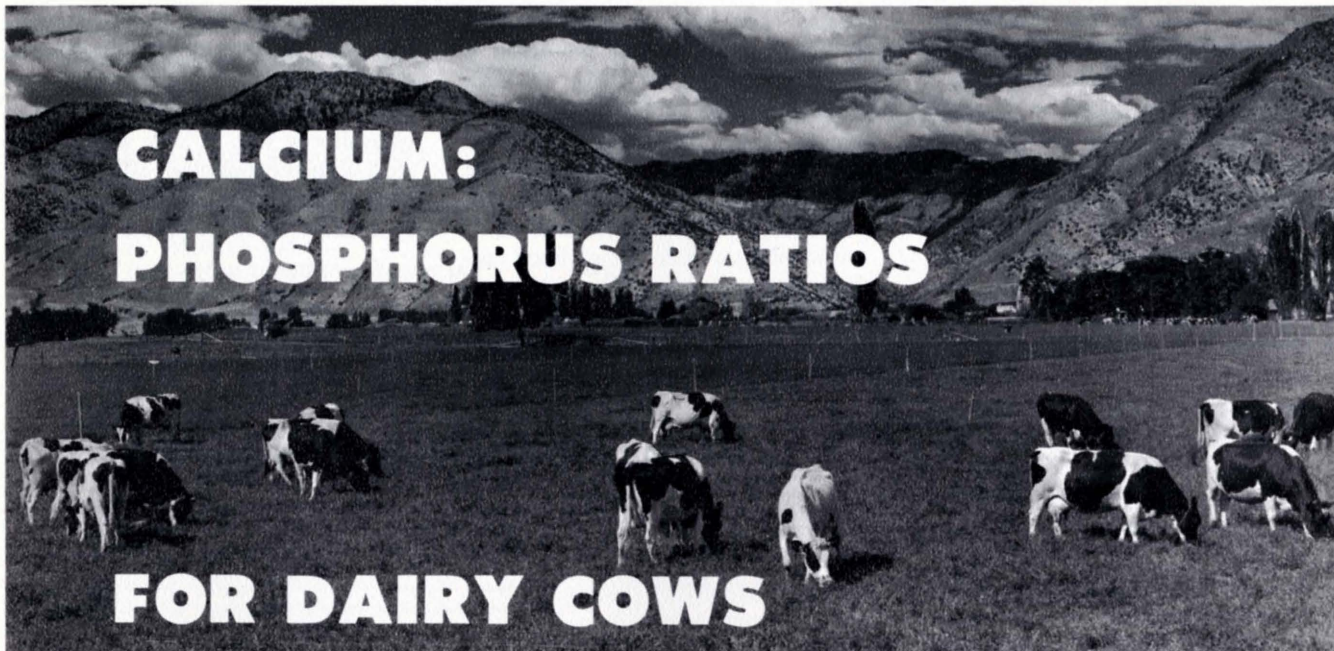
SUMMARY

Broadleaf birdsfoot trefoil is a versatile non-bloating legume that grows on a wide range of wet or dry soils. Nevertheless, it does not seem to be productive enough to be used as a replacement for other legumes such as alfalfa or ladino clover in irrigated pasture mixtures. Some of the most serious weak points of birdsfoot trefoil, observed during this study, include poor seedling vigor, slow and somewhat limited growth, light green color, even though the seed had been properly inoculated just prior to seeding, and the generally low productivity.

The birdsfoot trefoil-grass mixture produced more forage than the all-grass mixture, but considerably less
(Continued on page 116)

Table 1. Yields of dry matter for the birdsfoot trefoil-grass mixture (M-4) as influenced by irrigation and nitrogen fertilization when harvested four times a season (C-1) for four seasons.

Irrigation frequency	Nitrogen fertilization	1961 1962 1963 1964				Average
		Tons per acre				
I-1 20-day	F-1 zero-N	2.31	1.86	1.53	1.97	1.92
	F-2 50-N	2.02	2.25	1.70	2.20	2.04
	F-3 100-N	2.22	2.41	2.07	2.47	2.29
	F-4 200-N	3.39	3.67	3.38	3.89	3.58
I-2 15-day	F-1 zero-N	1.52	1.92	2.17	2.85	2.12
	F-2 50-N	2.36	2.33	2.16	2.83	2.42
	F-3 100-N	2.79	2.52	2.71	2.99	2.75
	F-4 200-N	3.66	3.87	3.81	4.13	3.87
I-3 10-day	F-1 zero-N	1.86	2.29	2.24	2.53	2.23
	F-2 50-N	2.63	2.50	2.29	2.80	2.56
	F-3 100-N	2.78	3.04	3.07	3.15	3.01
	F-4 200-N	4.13	4.33	4.28	4.57	4.33
I-4 5-day	F-1 zero-N	2.50	1.80	1.87	2.27	2.11
	F-2 50-N	2.89	2.37	3.04	3.09	2.85
	F-3 100-N	3.64	3.17	2.90	3.12	3.21
	F-4 200-N	4.36	4.60	4.31	4.21	4.37



Calcium and phosphorus are closely associated with each other in the animal body. In bones and teeth they serve as a structural foundation. In blood they help maintain proper osmotic pressure and in milk they become part of the protein molecules. Besides these and other joint functions, they serve in many other vital roles individually.

The amounts of calcium and phosphorus and their ratio with each other are important factors in body functions. An imbalance may result in certain malfunctions similar to deficiencies, although levels of each may be adequate otherwise. Dietary intake as well as absorption, hormone activity, and excretory patterns may influence the calcium and phosphorus levels in body tissues. This report is concerned with the dietary intake.

FEED CONTENT VARIES

Since calcium and phosphorus are found in about equal amounts in the animal body, it might be logical to assume that the diet should also contain equal amounts of these elements. The amount found in com-

GEORGE E. STODDARD

mon livestock feeds varies, however, and it is sometimes costly to balance the calcium and phosphorus intake. In certain animals, mainly those with single stomachs (pigs, chickens, dogs, man, etc.), the best ratio of calcium to phosphorus is between 1:2 and 2:1. Cattle and sheep have greater tolerance as long as the amounts of the two elements are adequate and there is sufficient vitamin D available. The extent of tolerance for wide ratios of calcium:phosphorus has recently been a topic for considerable discussion.

NRC REQUIREMENTS

The National Research Council, in the past few years, has compiled sets of nutrient requirements for domestic animals. Using their recently revised tables for dairy cattle, several examples of calcium and phosphorus requirements are shown in table 1. Maintenance requirements are based on body weight, and are the same for calcium and phosphorus. For milk production, the calcium requirement is about one-third higher than for phosphorus. The total requirements are in a ratio of 1:1 to

1.4:1 depending on level of production. The fat content of milk does not appreciably affect the calcium and phosphorus requirements for milk production.

The calcium and phosphorus content of typical feeds is shown in table 2. Alfalfa hay and beet pulp have the widest calcium:phosphorus ratio followed closely by molasses. Good phosphorus fertilization of hay fields may increase the phosphorus to more than double that shown in the table and narrow the ratio to below 4:1. Grains and grain by-products and cottonseed meal are comparatively good feed sources of phosphorus and are low in calcium. For this as well as other reasons, such feeds are good supplements to a ration in which alfalfa is the principal forage. Corn silage has a well-balanced calcium:phosphorus ratio and is a good feed with alfalfa hay. A simple home-grain dairy mix is included in the table showing a calcium:phosphorus ratio of 0.6:1 with dicalcium phosphate and 0.3:1 with monosodium phosphate or sodium tripoly phosphate.

TYPICAL RATION

The influence of such a ration on total intake and ratio of calcium:phosphorus is illustrated in table 3.

●
GEORGE E. STODDARD is a professor and Head of the Department of Dairy Science.

A typical ration for the Intermountain West would be 15 kilograms (33 pounds) of alfalfa hay and 5 kilograms (11 pounds) of a grain mix. Calcium in such a ration would be more than adequate (table 1) for a 700 kilogram (1540 pound) cow producing 45 kilograms (99 pounds) of milk. Phosphorus intake would be adequate for only about 22 kilograms (48 pounds) of milk and maintenance of this size cow.

Substitution of a sodium phosphate does not especially change the situation although the ratio is narrowed slightly from a 4.0:1 to 3.6:1. It is quite unlikely that the inclusion of a sodium phosphate would affect production by any measurable amount. Free-choice access to either dicalcium phosphate or a palatable sodium phosphate will usually provide any additional phosphorus needed by the cow.

TOLERANCE

Since the required amounts of calcium and phosphorus are about equal in the NRC tables, one might assume a need to narrow the calcium:phosphorus ratio toward 1:1. However, such tables were designed to show requirements rather than tolerances to variations in rations. If amounts of these two nutrients are adequate to meet the needs, will an excess of calcium interfere with milk production or with the health and well-being of the cow?

Vermont workers reported studies in which the calcium:phosphorus ratio varied from 1:1 to 8:1 and the amounts of these elements included from recommended requirements to eight times these amounts. With growing animals and lactating cows there was no measurable effect of ratio as long as the amounts of each element were adequate. It is noteworthy that the 8:1 ratio is wider than that reported for alfalfa hay in most tables of feed composition.

Studies in Arizona, California, and Europe have shown that a narrow calcium:phosphorus ratio reduces the incidence of milk fever for those cows with past histories of that

disease. The lack of available dietary phosphorus during lactation is also a predisposing factor in milk fever. Vitamin D and parathyroid activity have also been implicated in the complex milk fever syndrome and are closely associated with calcium and phosphorus metabolism.

Phosphorus has long been reported as necessary for reproduction. Although not well documented, conception rate in cows has been low when dietary phosphorus seem-

ed to be inadequate and apparently has been increased by phosphorus supplementation. No reports were found in which the ratio of calcium:phosphorus was in any way associated with reproductive efficiency. If such a relationship exists, it must yet be demonstrated by research studies.

WIDE VARIATION

A recent survey of dairy nutri-

Table 1. Example of calcium and phosphorus requirements

Body Weight Kilograms	500 Kilograms (1100 pounds)		600 Kilograms (1320 pounds)		700 Kilograms (1540 pounds)	
	Grams calcium	Grams phosphorus	Grams calcium	Grams phosphorus	Grams calcium	Grams phosphorus
Maintenance	14	14	16	16	18	18
Production 15 kilograms (33 pounds)	33	24	33	24	33	24
TOTAL	47	38	49	40	51	42
Maintenance	14	14	16	16	18	18
Production 30 kilograms (66 pounds)	72	54	72	54	72	54
TOTAL	86	90	122	90	122	90
Maintenance	14	14	16	16	18	18
Production 45 kilograms (99 pounds)	122	90	122	90	122	90
TOTAL	136	104	138	106	140	108

Table 2. Calcium and phosphorus content of typical dairy feed

	Percent Calcium	Percent Phosphorus	Ratio
Alfalfa hay	1.4	0.2	7.0 :1
Corn silage	0.08	0.06	1.3 :1
Barley	0.08	0.42	0.2 :1
Wheat bran	0.14	1.17	0.12:1
Dried molasses beet pulp	0.56	0.08	7.0 :1
Molasses (beet)	0.16	0.03	5.3 :1
Cottonseed meal (exp.)	0.18	1.15	0.16:1
Dicalcium phosphate	16.0	18.5	0.9 :1
Sodium tripoly phosphate (Ortho)		25.0	
Monosodium phosphate		25.0	
A simple dairy grain mix*			
with dicalcium phosphate	0.33	0.53	0.6 :1
with monosodium or sodium tripoly phosphate	0.17	0.61	0.3 :1

* Mix includes:

Dried Molasses Beet Pulp	19%
Barley	79%
Trace Mineral Salt	1%
Phosphorus Supplement	1%

tionists throughout the United States indicated a wide variation of recommendations on the need for balancing the calcium:phosphorus ratio in dairy rations. Many felt that the ratio should be near 1:1 but did not present evidence (other than for cows with a history of milk fever) that narrowing the ratio would result in higher milk production, better cow health, better breeding efficiency, or any other improvement in performance. Most of them indicated the ratio of typical rations for their area and suggested that this or a narrower ratio would be adequate. Only in cases where nutrient cost of alfalfa forage and grain supplements were similar was it suggested that grain supplements be substituted for alfalfa forage.

In the Intermountain West, alfalfa as hay, haylage, or silage is usually a much more economical source of nutrients than grain supplements. Nutrient costs (energy basis) are similar when grain supplements cost about 1½ times as much per pound as alfalfa hay. For example, \$30 hay is equivalent in cost to \$45 grain. For wilted silage the comparable cost would be \$10 per ton and for 50% moisture haylage, \$17 per ton. A substitution of grain for hay need not be made merely to narrow the calcium:phosphorus ratio. Such

substitutions may be made when prices on comparable energy basis are more favorable to another feed. Corn silage is a good feed and can be substituted for alfalfa hay when economically advantageous but need not be used merely to narrow the calcium:phosphorus ratio.

CALCIUM RARELY NEEDED

Calcium is rarely needed as a supplement unless rations are very low in alfalfa or other legumes. Such might be the case in feedlot operations high in grain and low in forage. In such cases, calcium supplements such as limestone might be added to the diet. In most cases, however, an economical source of phosphorus, such as dicalcium phosphate, is adequate. For cows with milk fever histories, the monosodium phosphates might be helpful, although they are usually more expensive sources of phosphorus.

Phosphorus supplements should be added at the rate of about 1 percent to the grain ration and, in addition, fed free choice in a covered mineral box. For most dairy herds in the Intermountain West, such a phosphorus feeding program is entirely satisfactory nutritionally and economically.

Hog Cholera Can Pass to Unborn Pigs

Hog producers having problems at farrowing time with abortions or with stillborn, weak, or "shaky" pigs should not overlook hog cholera as a possible source of their troubles, USDA scientists say.

Veterinarians of USDA's Agricultural Research Service report that sows exposed to hog cholera virus during pregnancy have, in some instances transmitted the disease to their unborn pigs. These pigs thus carry the virus at birth and may transmit it to other susceptible hogs.

Hog cholera may not be recognized in baby pigs because the usual symptoms and post mortem findings are not present. Often the disease develops slowly — or appears in chronic form. In many cases hog cholera is not detected until it has spread to older susceptible pigs.

Here are some of the things hog producers should notice: (1) Abortions of undetermined cause, stillborn or weak pigs; (2) weak pigs that die soon after birth; (3) "shaky" or "jittery" pigs; (4) any abnormal pigs — blind or hairless, for example; and (5) a high mortality rate from birth to weaning. In the case of farrowings from sows which are immune to hog cholera, trouble may develop slowly with a marked increase about weaning time.

If any of these symptoms occur, hog producers should call their veterinarian at once and advise ARS officials in charge of hog cholera eradication for USDA. Hog cholera is just one of several diseases which can cause these problems, so professional assistance, backed by laboratory tests, is essential in arriving at a diagnosis.

Problems may arise when a bred sow comes in contact either with field strains of hog cholera virus or with modified live virus vaccines. Transmission can occur through vaccinated as well as unvaccinated sows.

(Continued on page 116)

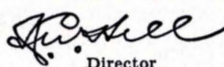
Table 3. Typical calcium and phosphorus intakes with varied alfalfa hay and grain mix in the diet.

Hay intake	5 kilograms (11 pounds)			10 kilograms (22 pounds)			15 kilograms (33 pounds)		
	Ca.in Grams	P.in Grams	Ca/P	Ca.in Grams	P.in Grams	Ca/P	Ca.in Grams	P.in Grams	Ca/P
Grain #1									
5 kilograms	87	37	2.4	157	47	3.4	227	57	4.0
10 kilograms	105	63	1.7	173	73	2.4	243	83	3.0
15 kilograms	120	90	1.3	190	100	1.9	260	110	2.4
Grain #2									
5 kilograms	79	41	1.9	149	51	2.9	219	61	3.6
10 kilograms	87	71	1.2	157	81	0.19	227	91	2.5
15 kilograms	96	102	0.9	166	112	1.5	236	122	1.9

Grain #1: Barley 79 percent; beet pulp 19 percent; trace mineral salt 1 percent; dicalcium phosphate 1 percent.

Grain #2: Same as #1 except monosodium phosphate or sodium tripoly phosphate instead of dicalcium phosphate.

Penalty for private use to
avoid payment of postage \$300
Utah Agricultural Experiment Station
Utah State University
Logan, Utah 84321


Director
Form U. Q. Permit 1142

Lois M. Cox
Ag. Sci. 222
Campus 84321

POSTMASTER: Please return if unclaimed

CONTRIBUTIONS TO RESEARCH

Turkey Marketing Board	\$7,500 for research in turkey diseases
Hoffman LaRoche, Inc.	\$3,000 for turkey research
Velsicol Chemical Corporation	\$100 for weed control experiments
Rayonier Corporation	\$1,000 for study of micro-nutrient elements in soils
Merck and Company	\$4,000 for study of protozoan diseases of livestock
American Chemical Company	\$250 for variety testing of seeds and nuts
Canada Dept. of Agriculture	\$4,000 for compilation of data on livestock feed composition
ESSO Company	\$1,250 for study of canal linings
Climax Molybdenum Company	\$4,340 for study of the function of molybdenum in biological systems
Geigy Chemical Corporation	\$1,000 for weed control studies
	\$1,000 for study of the effect of nutrient elements on fruit quality
Bird's Eye Division	\$1,650 for study of lima bean production and processing

NEW PUBLICATIONS

BULLETIN 460. Employment of mothers and its effect in problem and problem-solving families in northern Utah — 1960-1961, by Carmen D. Fredrickson, Professor Emeritus, Department of Sociology, Social Work, and Anthropology.

Mrs. Fredrickson reports the findings of a study designed to find the effects, if any, of the working mother on juvenile delinquency. This study does not support the contention that delinquency results from the employment of mothers.

SPECIAL REPORT 20. Evaluation of variety, maturity, and storage on the processing quality of Utah-grown fruits, by D. K. Salunkhe, N. S. Schvaneveldt, D. R. Walker, J. L. Anderson, Ethelwyn B. Wilcox, and R. A. Norton. Department of Plant Science.

This special report concerns the effects of variety, maturity, and storage on the quality of certain fruits processed by freezing and canning with a view to the possibilities of expanding the fruit processing industry in Utah. Several varieties of apricots, cherries, peaches, pears, plums, and strawberries are evaluated.

UTAH RESOURCES SERIES 31. Carbohydrate reserves in plants, by C. Wayne Cook. Department of Range Science.

Dr. Cook describes the components of plant carbohydrates, carbohydrate movement in forage plants, and the effect of grazing or cutting on carbohydrate reserves and subsequent growth. A comprehensive bibliography is included.

UTAH RESOURCES SERIES 32. Maximizing incomes from crops on Millard County farms, by Lynn H. Davis and Richard L. Johnson. Department of Agricultural Economics.

The authors, by means of budget tables and linear programming, explain some methods and procedures whereby farm operators in Millard County can increase their incomes.

Pasture Summary (From p. 112)
than the alfalfa-grass mixture at low levels of nitrogen and long irrigation intervals. Forage production was about equal to that of the all-grass mixture, but less than the ladino clover-grass and the alfalfa-grass mixtures with more frequent irrigations and higher rates of nitrogen fertilization.

On the basis of this study, birds-foot trefoil would not be recommended as a component of mixtures for irrigated pastures. It may have a place in a mixture with Kentucky bluegrass on some of the permanent pastures of the west, but it does not appear to be suited as a component of irrigated pastures on the better cultivated land.

Hog Cholera

 (From p. 115)

Producers should therefore take every precaution to isolate bred sows from exposure to hog cholera virus. Sows or gilts should not be vaccinated with modified live virus vaccines during pregnancy, and freshly vaccinated pigs should be kept away from bred sows throughout gestation.

The ARS officials stress that trouble is *not* going to occur with every sow vaccinated or exposed to hog cholera during pregnancy. They point out, however, that the possibility of transmitting hog cholera through the pregnant sow emphasizes the need for disposing of all exposed hogs in eradicating hog cholera.

The incidence of hog cholera is now at an all-time low, according to eradication program officials. During the first 5 months of 1966, there were 58 percent fewer confirmed outbreaks reported to USDA than during the same period a year earlier — 172 versus 411. Officials estimate a drop of between 40 and 50 percent in confirmed outbreaks for the fiscal year ended on June 30, 1966.

The target date for a "hog cholera free" United States is 1972. At the beginning of July 1966, five states had achieved this status and 16 others had advanced to the final two phases of the hog cholera eradication program.