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UTAH SCIENCE

UTAH AGRICULTURAL EXPERIMENT STATION SPRING 1985 VOLUME 46 NUMBER 1

Conservation Tillage in Utah

SPRING 1985 VOLUME 46 NUMBER 1

UTAH SCIENCE

UTAH AGRICULTURAL EXPERIMENT STATION

NEW APPOINTMENTS

Utah Agricultural Experiment Station

Kurt W. Gutknecht, the Experiment Station Editor, holds BS and MS degrees in agricultural journalism from the University of Wisconsin-Madison. He was previously an editor with the Louisiana Agricultural Experiment Station, and the College of Agricultural and Life Sciences, University of Wisconsin-Madison.

Jane McCullough is the Head of the Home Economics & Consumer Education Department. She received a PhD from Michigan State in Family Ecology, an MS degree from USU in Household Economics and Management, and a BS degree from USU in Home Economics Education. Her current research project is "Time, Sequencing and Coordinating of Household Production and Paid Work." She worked at CSRS (Cooperative State Research Service) as a Home Economist for one year.

Brian L. Pitcher is the Head of the Sociology, Social Work & Anthropology Department. He received a PhD in Sociology from the University of Arizona, and MS and BS degrees in Sociology from Brigham Young University. His area of current research is social psychology, social change, and quantitative methods.

R. Dean Plowman was named Head of the Animal, Dairy & Veterinary Sciences Department. He received his PhD in Animal Genetics from the University of Minnesota, an MS degree in Animal Husbandry, and a BS degree in Dairy Sciences from USU. He is the former USDA/ARS Area Director.

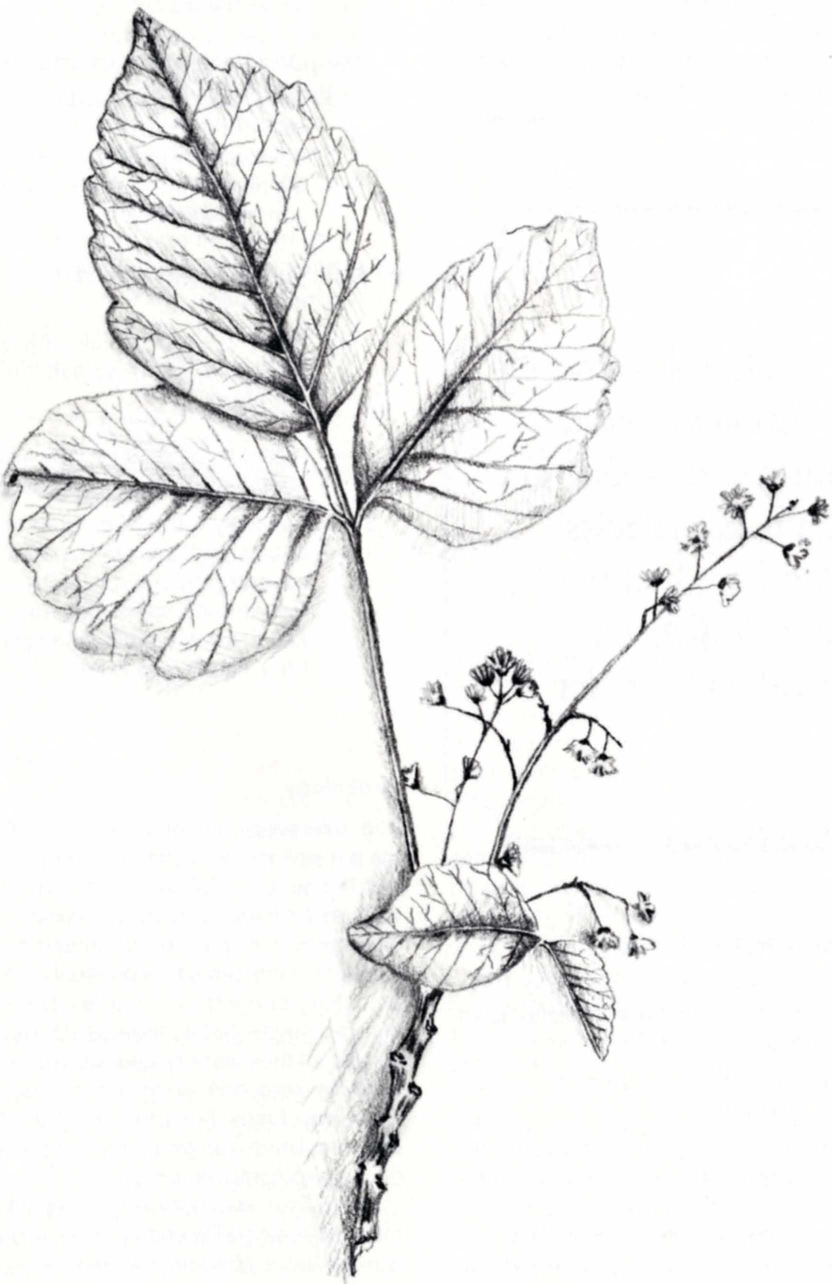
Richard J. Shaw, Director of the Intermountain Herbarium and Professor of Botany, guides and sets policy for the collection of 187,000 specimens of plants. He is currently writing a flora of northern Utah with Dr. Mary Barkworth. His main research areas are plant geography and alpine ecosystems.

Donald V. Sisson, Head of the Applied Statistics Department, received his PhD from Iowa State University in Entomology, and MS and BS degrees in Biology from Gustavus Adolphus College in St. Paul, Minnesota. His specialty is experimental design for agricultural purposes.

Bonita W. Wyse is the Acting Dean for the College of Family Life and professor of Nutrition and Food Sciences and Director of the Medical Dietetics Program, Department of Nutrition and Food Sciences. She has a continuing interest in communicating nutrition information to the public, and has conducted research in that area.

POISON POISON POISON-IVY IN UTAH

R. J. SHAW and M. C. WILLIAMS



The fisherman pushed his way through the thick vegetation along the canyon stream to reach the trout hole. He noticed the maple, birch, and hawthorne in the area but—unfortunately—did not notice a semi-shrubby plant resembling a vine. Only later did he attribute the itching and blisters to poison-ivy.

Poison-ivy and poison-oaks, members of the cashew family (Anacardiaceae), are found from coast to coast. The full economic significance of the painful dermatitis which these plants cause is impossible to assess, but Klingman et al. (1983) reported that poison-ivy and poison-oak cause almost two million cases of skin poisoning each year in the continental United States and are the greatest single cause of Worker's Compensation claims. These statistics suggest Utahns suffer considerable economic losses and personal misery due to the poison-ivy—poison-oak complex.

Utah's poison-ivy, the most northerly ranging species in the family Anacardiaceae, extends from east of the Cascade Mountains in Washington and Oregon to the east coast and north into Canada. At least eight species have been described. The taxonomy of the poison-ivy—poison-oak complex was not clarified until 1971 when William T. Gillis published a comprehensive monograph on the genus, *Toxicodendron.* Unfortunately, many plant manuals still continue to use such binomials as *Rhus radicans* and *Toxicodendron radicans* for Rydberg's poison-ivy in Utah.

Present Distribution

Five herbaria in Utah and one herbarium in another state were surveyed to learn the distribution of *Toxicodendron rydbergii* in Utah. It soon became apparent that while many botanists say they have seen the plant in many locations, few have made pressed specimens, perhaps to avoid the unpleasant dermatitis. Even so, enough specimens have been deposited in the herbaria to indicate its distribution and ecological preferences over the past 100 years.

Seventeen of the state's 29 counties have or have had populations of poison-ivy since 1875. Poison-ivy seems to prefer canyons and disturbed sites, especially along irrigation canals and road sides. In Logan Canyon for instance, 10 populations were located on the south-facing slope within 50 feet of Highway 89 over a distance of four miles. A similar pattern was observed in Box Elder Canyon east of Brigham City. Associated plant species included big tooth maple, river birch, hawthorne, and red osier dogwood. In Box Elder Canyon, however, poison-ivy located in full sun at the mouth of the canyon was four feet high and was not associated with any major tree or shrub, an indication of the species' wide ecological range.

Conditions Favor Poison-Ivy Spread

Gillis concluded that poison-ivy occupied many habitats, including floodplains, river terraces, talus, railroad rights-of-way, and other disturbed sites. He also noted that it responds favorably to disturbance and becomes more abundant following fire.

T. rydbergii reproduces by rhizomes. The many stems which appear on a single site may be from one or several plants. Many birds like its light yellow fruits and may drop seeds at the base of trees, telephone poles, and fence rows. Bears, rabbits, and mule deer have also been observed browsing poison-ivy.

Poison-ivy's method of reproduction, seed dispersal by mammals and birds combined with more environmental disturbance, seem to indicate that poison-ivy will continue to occupy new sites.

Utah's Poison-Ivy Has Distinct Features

Utah's poison-ivy is distinct from all other taxa. It is never more than about four feet high and, unlike its eastern relatives, cannot become a true vine because it does not produce aerial roots. The leaf petioles always lack hairs and are usually quite long. The three leaflets are very broad and nearly circular. Leaflets are 2½ to 6 inches long; sun leaves are the larger leaves. Most plants have three leaves although some produce additional leaflets. The fruiting inflorescence is much more compact and tightly clustered than its relatives. The fruits tend to be larger and lighter in color.

The western poison-oak in California, Oregon, and Washington (*Toxicodendron diversilobum*) is a related plant that may be confused with Utah poison-ivy. It will take the form of a vine, a shrub, or, rarely, a tree. Its fruits always have minute hairs.

"Utah's poison-ivy is distinct from all other taxa—four feet high, leaf petioles lack hair, and the three leaflets are broad and circular."

Poison-Ivy Myths Abound

Few plants have been the subject of so many myths that have been handed down for generations.

- Myth: Everyone is sensitive to poison-ivy.

  Fact: Only about half of the population is sensitive. Those who are sensitive may find sensitivity increases through repeated exposure and may decrease if a person is not exposed for several years or as one ages. It is best, however, to simply avoid the plant.

- Myth: Poison-ivy emits volatile compounds that produce dermatitis through the air. No physical contact is required for poisoning.

  Fact: The poison is not volatile. Physical contact with the poison or a contaminated object is required for dermatitis.

- Myth: Only living plants are poisonous.

  Fact: Dead plants can also be poisonous. Sensitive persons have developed dermatitis after handling herbarium specimens of poison ivy more than 100 years old.

- Myth: Running sores spread the dermatitis.

  Fact: Running sores contain only body fluids and will not spread the dermatitis.

- Myth: Eating a leaf of poison ivy will confer immunity to poisoning.

  Fact: Immunity will not be conferred. Eating the leaves or fruit may severely affect the mucous membranes, alimentary canal, and the entire gastrointestinal tract. Death may result.

Toxicology

The toxic properties of poison-ivy in America are well known from Indian legends and the accounts of early colonists. The early settlers and their descendants could not explain how poison-ivy caused dermatitis but concocted some unusual—and potentially dangerous—"cures." The substances suggested as therapeutic were as bizarre as they were numerous: morphine, bromine, kerosene, gunpowder, aqua regia, strychnine, buttermilk, cream, and marshmallows—or the consumption of a pint of photographer's hypo!

The poison was not identified until the mid-1950s when Dawson (1956) isolated 3-*n*-pentadecylcatechol, a clear or slightly milky oil found in the resin ducts in the phloem of the plant. The poison occurs in four forms, each varying slightly in the degree of saturation of the sidechain. All forms are toxic to sensitive individuals. The poison occurs throughout the plant except for the pollen.

Since the poison occurs in ducts within the plant, the plant must be damaged in some way (breaking, crushing, insects) to expose the poison ducts before the poison can be transmitted (Kingsbury 1964). A person cannot be poisoned by brushing against an undamaged leaf or twig. The poisonous liquid in a damaged plant may reach the surface and form a black gummy substance after a few hours. Either the liquid or black gum are toxic and may cause dermatitis.

The poison can also be transmitted through secondary objects contaminated with the poison. Tools, pets, clothing, and sports equipment are common objects which may damage plants and become contaminated. In a recent case, boys developed severe dermatitis after contact with a contaminated football.

While the toxic compound in poison-ivy does not volatilize if the plant is burned, the poisonous oils which stick to dust and ash in the smoke can cause dermatitis if these particles contact the skin.

Treatment

The poison reacts quickly with the skin proteins but symptoms may appear as soon as three or four hours after exposure to several days later, depending upon the person's sensitivity. The dermatitis may be confined to red and itchy skin or in severe cases may be manifested in blisters and running sores.

The toxic compound must be removed almost at once from sensitive individuals to prevent a rash. Wash the exposed area with large amounts of cold water. Warm water may let the oil penetrate more deeply into the skin. Remove contaminated clothes and, if possible, place them in a plastic bag. Contaminated clothing should be washed two or three times with soap and water.

Also wash other objects that might have become contaminated (door handles, steering wheels, tools, sports equipment, pets, etc.) with several changes of soap and water.

No medicines can completely prevent the rash from poison-ivy. If a rash develops, consult a doctor at once. New steroid gels usually stop the rash, reduce discomfort, and hasten recovery. These should be applied at the first symptoms of rash, but should not be continued beyond 72 hours. If the poisoning is severe, i.e., extends over 25 percent of the body, or severely affects the face or genitals, the physician may prefer to administer the steroids in a more potent form, either by injection or pills.

Control of Poison-Ivy

Poison-ivy plants can be grubbed or pulled out, a tactic which may be necessary when the ivy clings to trees or is found among valuable ornamentals. (Only those who are not sensitive to poison-ivy should do this.) Remove the rootstalk completely to prevent resprouting. Cut vines and roots in segments and place them in plastic bags for disposal. Thoroughly wash tools to remove the poison.

Several herbicides are registered for control of poison-ivy. The herbicide selected should be registered for the site and not harm desirable plants adjacent to the poison-ivy. Also consider a herbicide's cost and whether it has a soil residual. Retreatment may be necessary the following year. Always read and follow carefully the directions for application on the label of the herbicide container.

Three herbicides are recommended for control of poison-ivy: amitrole (3-amino-*s*-triazole), glyphosate [N-(phosphonomethyl)glycine], and ammonium sulfamate (AMS).[1]

Amitrole can be purchased as a water-soluble powder or a liquid to be mixed with water before spraying. Amitrole is also sold in aerosol cans, but these are practical only if a few plants are to be treated. Amitrole persists in the soil and should not be used where food crops will be raised within the next year nor where livestock graze. The herbicide kills other plants, so treat only poison-ivy. Apply to the foliage of the poison-ivy when the plants are fully leafed and actively growing.

Glyphosate should be applied to the foliage of poison-ivy in late summer after the fruit has formed. Glyphosate kills or severely injures most plants and should be used carefully. The herbicide is translocated throughout the plant and kills both foliage and roots. Glyphosate does not act through the soil and has a very short residual so a treated area can be reseeded shortly after spraying. Glyphosate is sold as a liquid to be mixed with water.

Ammonium sulfamate is effective when applied as a drenching spray to foliage of poison-ivy. This nonselective herbicide will kill other plants. Thoroughly clean equipment to remove corrosive ammonium sulfamate.

[1]Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or Utah State University and does not imply its approval to the exclusion of other products that also may be suitable.

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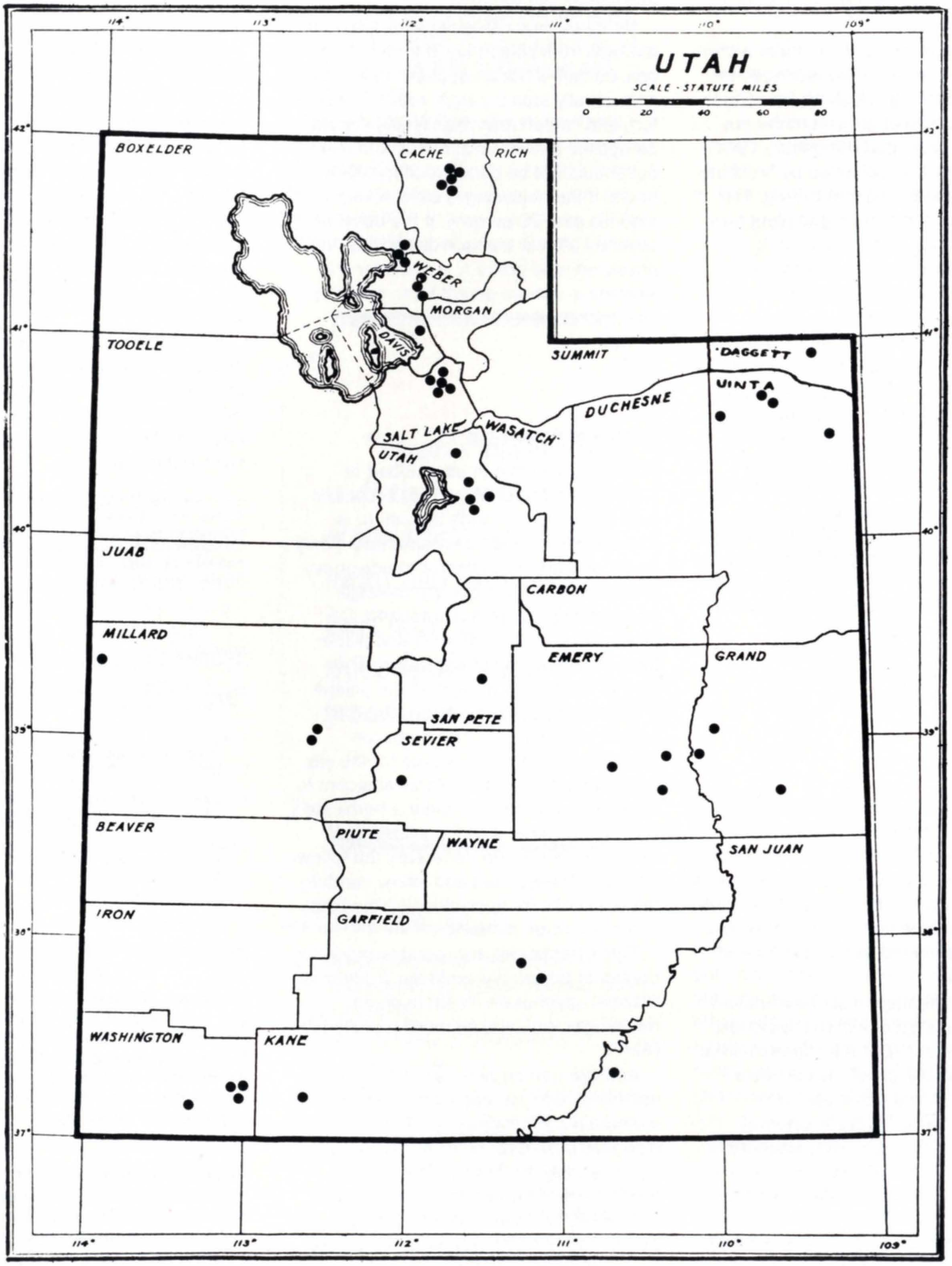
ABOUT THE AUTHORS

M. Coburn Williams, Research Plant Physiologist, is on the staff of the Poisonous Plant Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, and of the Biology Department, Utah State University. Dr. Williams conducts research on the biochemistry and physiology of poisonous range weeds.

Richard J. Shaw, Director of Intermountain Herbarium and Professor of Botany. As Director he guides and sets policy for the collection of 187,000 specimens of plants. He is currently writing a flora of northern Utah with Dr. Mary Barkworth. His main research areas are plant geography and alpine ecosystems.



• Distribution of *Toxicodendron rydbergii* in Utah

Captions:

Clockwise from top:

1) *Toxicodendron rydbergii* spring plant with the previous year's fruit;

2) Toxicodendron rydbergii fruit;

3) Close-up of *Toxicodendron rydbergii* fruits;

4) Poison-ivy dermatitis on a leg;

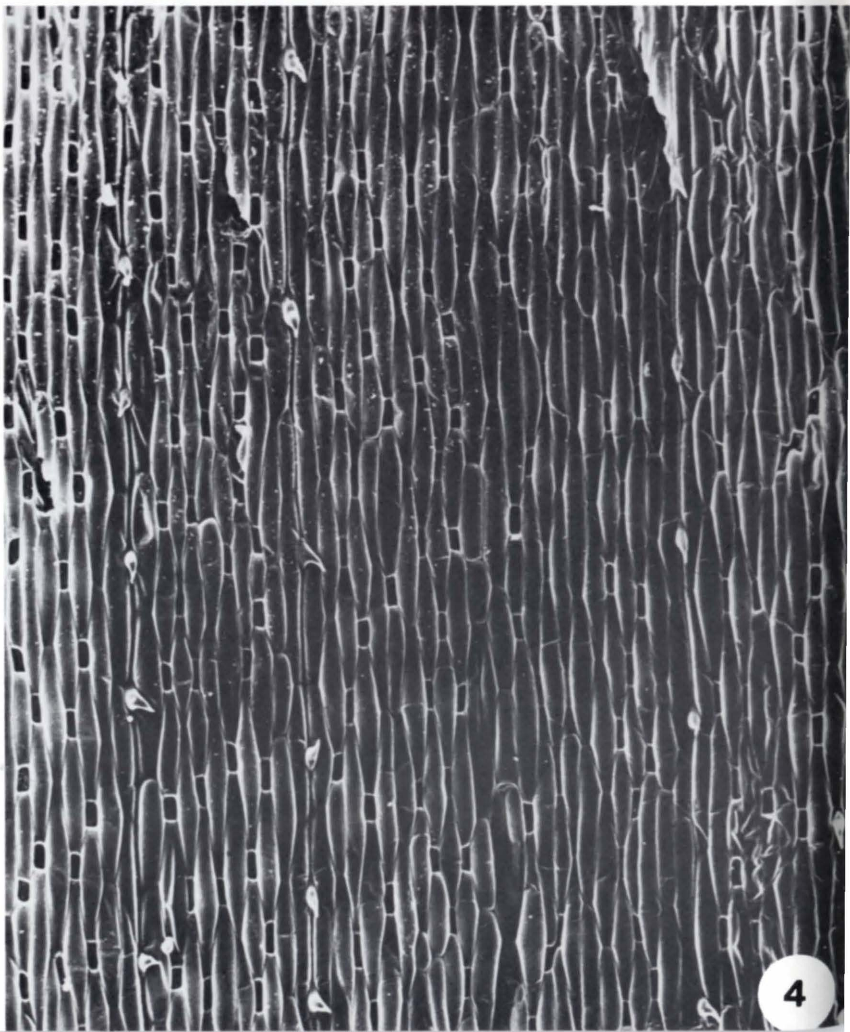
5) Close-up of lesions;

6) *Parthenocissus* (Virginia creeper), a poison-ivy look-alike;

7) *Toxicodendron rydbergii* as it appears in September

Photos by Richard J. Shaw

Photos #4 and #5 by Robert Morris



CAPTION

The young nymphs shown in Figure 2 might be hindered or injured by the long trichomes on some grasses, such as those on bluebunch wheatgrass (Figure 3). Note the lack of trichomes on leaves from grasses such as smooth bromegrass, or chardgrass, and reed canarygrass shown (Figure 4).

Photos by W. F. Campbell

TRICHOMES
A Potenial Defense Against Grass Bugs

W. F. CAMPBELL and Y. H. LING

Figure 1. *Labops* feeding on a grass leaf.

In western North America, approximately 6 million hectares (ha) (15 million acres) of rangelands have been seeded to introduced wheatgrasses and related plants. Tolerance to drought, temperature, and salinity means wheatgrass is well adapted to many localities in western North America. Wheatgrasses lengthen the grazing season and supplement native vegetation.

The wheatgrass monoculture, however, has also encouraged large populations of destructive insects, the most important of which are the black grass bugs. These bugs weaken or kill grass plants and lower the palatability and productivity of infested grasses. Black grass bugs have been found on ranges in Montana, Nevada, Oregon, Utah, and Wyoming. They will feed on native grasses, but prefer monocultures of wheatgrasses.

Insects may reduce forage production on western ranges by as much as 30 percent or more annually. Developing cultivars resistant to insects is a practical and economical strategy for crops with relatively low cash value, crops such as range grasses.

Resistance to insect attack may result from physical properties of the plant, such as trichomes (pubescence), thickened epidermis, a fibrous cuticle, a spiney surface, presence or absence of small cavities or crevices on the surface, and hardness of the plant tissue. Trichomes, which extend from the epidermis or aerial tissue of plants, vary widely in structure, function, and distribution over plant parts. They have been used extensively in taxonomy and help plants defend themselves against herbivorous insects.

A computer literature search revealed that trichomes are associated with resistance to insects in at least 18 plant genera, including most major crops. Increased numbers of trichomes on wheat cultivars was related to better resistance to cereal leaf beetle attack. Additional research with alfalfa, cotton, potato, snapbean, sorghum, tomato, and wheat has shown that trichome length was of equal or greater importance than trichome density. There was, however, no information on the relationships between leaf trichomes and insect resistance in range grasses.

Scanning electron microscopy (SEM) was used to determine whether trichome length and density on the leaves of range grasses affected the feeding and mobility of black grass bug nymphs. Scanning micrographs can be enlarged and have better clarity than images produced by light microscopy. Moreover, SEM has a depth of field several times greater than a light microscope. Cultivars and/or hybrids of several range grass genera *Agropyron, Bromus, Dactylis, Elymus, Elytrigia, Leymus, Pascopyrum, Phalaris, Poa, and Pseudoroegneria* were exposed to varying numbers of blass grass bugs in the laboratory, greenhouse, and field.

The piercing sucking mouth parts let black grass bugs puncture the plant cell walls, inject digestive enzymes into the leaf cells, and extract the liquid cell contents. Removal of the cell's photosynthetic material causes irregular yellow or white spots on the leaf surface. Black grass bugs damage both native and introduced grasses, but many more of these insects are found in the introduced grasses. We found no correlation between the stage of plant development and the stage of black grass bug instar development.

An average of 117 black grass bugs were collected per sweep of the net during field preference tests. The ratio of adults to nymphs was approximately 3:1. Bluebunch, standard and fairway crested, intermediate and western wheatgrasses, and quackgrass were very susceptible to the bugs (Table 1).

Plant pubescence did not affect the feeding behavior of adult bugs. RS hybrid lines differed in their susceptibility. Altai and basin wildrye were susceptible to the bugs; Russian wildrye was more resistant. Field-grown Kentucky blue grass varied in its susceptibility to the bugs, a finding contrary to the laboratory and greenhouse findings. Orchardgrass, reed canarygrass, and smooth bromegrass were very resistant to the black grass bugs whether plants were grown in the laboratory, greenhouse or field.

Smooth bromegrass, which had a smooth leaf surface, had an average of 6 percent damage per plant, while damage on intermediate wheatgrass, which had long, dense soft hairs, averaged 52 percent.

The laboratory preference test and SEM study of leaf morphology involving only species of wheatgrasses seemed to support the hypothesis that the larger and thicker leaf trichomes would inhibit nymphs' feeding behavior and impair their movement. Trichome length and density of some species were positively correlated with feeding behavior (Table 1). The long trichomes of grasses such as bluebunch wheatgrass could hinder the mobility of the young nymphs and possibly injure their soft and tender bodies.

Leaves of smooth bromegrass, orchardgrass, and reed canarygrass, however, had few trichomes, yet plants of these genera were rarely damaged or fed upon by any stage of black grass bugs. These results suggest that chemical factors may influence the food preference of nymphs. Chemical characterization of the genetic diversity in range grasses with pyrolysis-mass spectrometry indicates that palatability may affect black grass bugs' attraction to grasses.

Prior to World War II, plant breeders and entomologists cooperated to develop improved plant cultivars resistant to insect pests. This resistance was often based on oviposition nonpreference, interference with young insects' migration on the leaves, and palatability. Since World War II, however, agriculture has evolved toward intensively farmed monocultures, away from traditional methods of pest control to an almost complete dependence on pesticides. Since the late 1960s and early 1970s, there has been a shift toward an integrated system of pest control and more cooperation between plant breeders and entomologists. The integrated system of pest control combines cultural, chemical, and biological control methods to suppress pest numbers below crop damaging levels. Development of resistant plant cultivars can be the foundation for an integrated control system.

Insect-resistant grasses may serve as foundation for an integrated system of pest control.

Chemical control of black grass bugs is not economically feasible because of the relatively high application costs on the large areas of low-value land. A far more practical method of controlling range pests is to reseed with insect-resistant grasses.

- Pest control through resistance is cumulative and economical, and requires no "extra" direct expenditure by farmers and ranchers.
- Resistance may apply to several pest species.
- Resistant cultivars reduce the vigor and number of insect pests, making them more vulnerable to natural enemies and other control methods. A low level of plant resistance, may, in combination with natural enemies, effectively control a pest when either single method would not be effective. Resistance also deters reinfestation once an insect has been brought under control.
- Resistant cultivars reduce the risk that chemical residues will enter the food chain or the environment; the method also conserves energy.
- Incorporating resistant cultivars in a control program protects the insects' natural enemies and the environment.

The USDA/ARS grass breeding program at USU has a long history of developing grasses for the harsh environments of western North America. The genetic diversity in the breeding populations of important range grasses will enable selection for resistance to the black grass bug. Farmers and ranchers should consider using these new cultivars when reseeding areas where grass bug infestations might be a problem.

ABOUT THE AUTHORS

William F. Campbell is a professor of Agronomy with the Plant Science Department, USU. His training has been in agronomy, plant physiology, radiation botany, and cytology, with extensive experience in electron microscopy. His research interests include cytochemical, physiological, and ultrastructural responses of plants to environmental stresses.

Yun-Hwa (Gloria) Ling is a former graduate student in the Plant Science Department. She is currently a graduate student at Northwestern University.

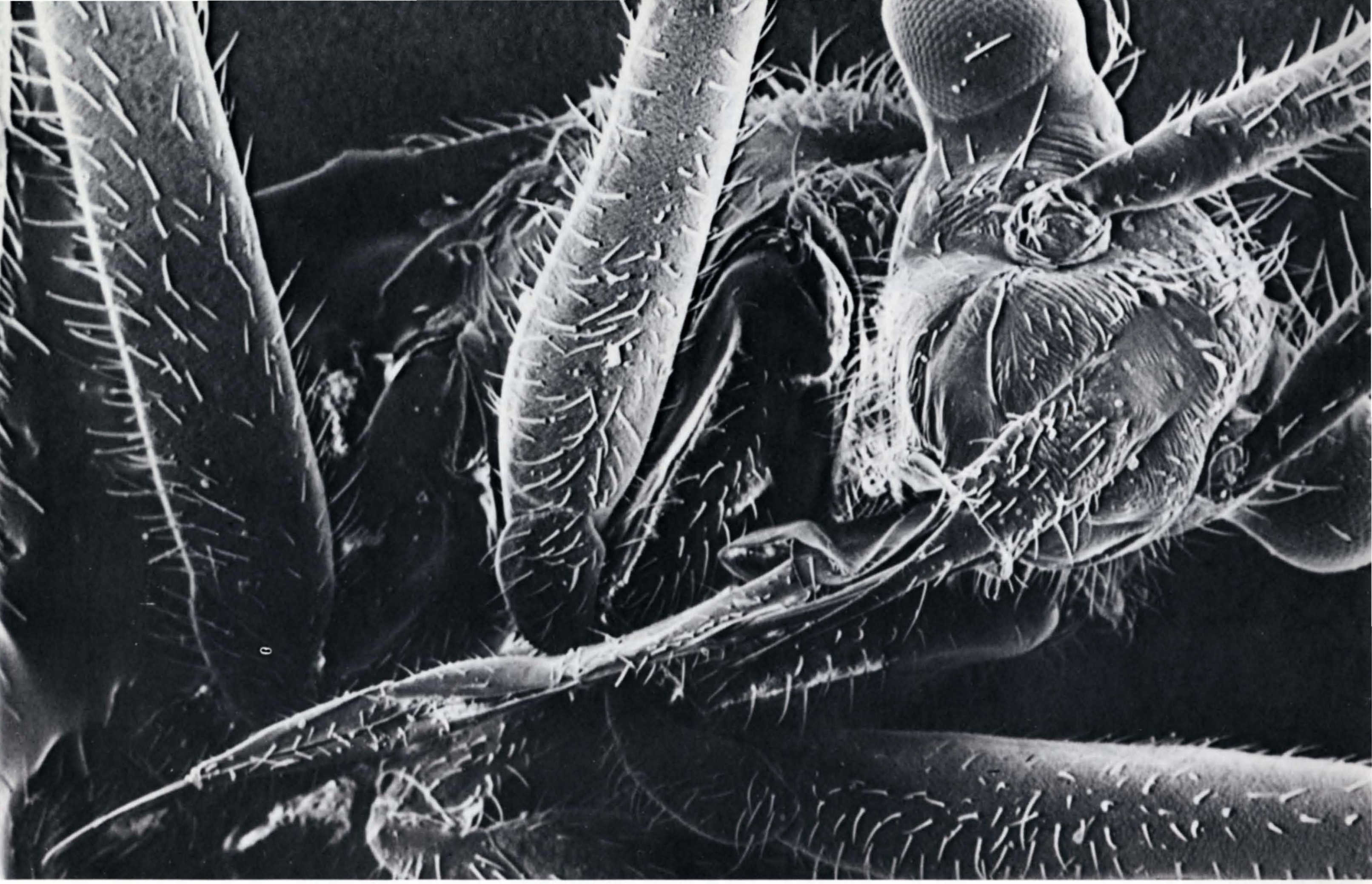


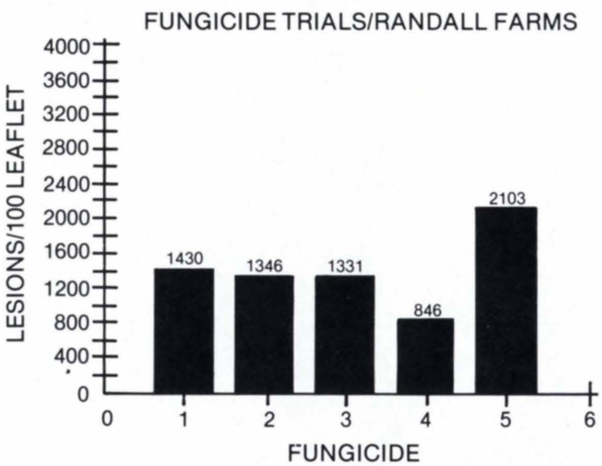
Figure 5. A scanning electron micrograph of a black grass bug showing the piercing mouth parts of the insect.

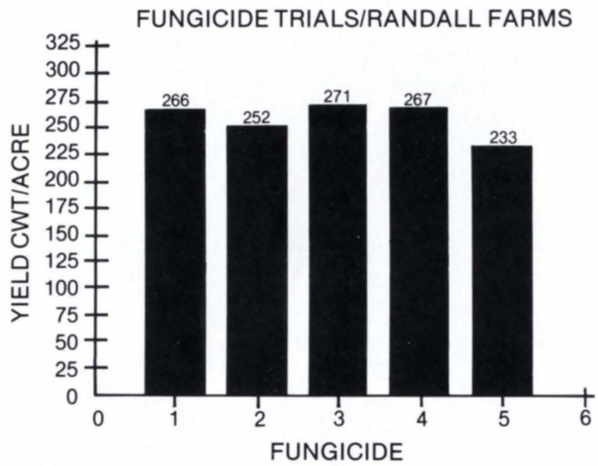
TABLE 1. The scientific and common names and the average susceptability of different grasses exposed to *Labops*.

Scientific Name	Common Name	Percent Damage/Plant x̄	±	SE
Agropyron cristatum (L.) Gaertn.	'fairway' crested wheatgrass	49.3		3.3
Agropyron cristatum (L.) Gaertn. R-line (Iran)	'fairway' crested wheatgrass	44.5		3.4
Agropyron desertorium (Fish. ex Link) Schult. var summit	'standard' crested wheatgrass	57.1		2.3
Agropyron desertorium (Fish. ex Link) Schult. var Nordan	'standard' crested wheatgrass	48.0		2.7
Bromus inermis Leyss.	smooth bromegrasss	6.0		1.4
Dactylis glomerata L.	orchardgrass	3.0		0.8
Elymus junceus (Fisch) var. bozoisky	Russian wildrye	19.5		2.1
Elymus junceus (Fisch) var. vinall	Russian wildrye	19.4		1.3
Elytrigia repens (L.) Nevski (Local collection)	quackgrass	52.3		2.6
Elytrigia repens (L.) Nevski (green-genetic marker)	quackgrass	32.5		1.6
Elytrigia intermedia (Host) Nevski var. oahe	intermediate wheatgrass	42.5		2.4
Elytrigia intermedia (Host) Nevski var. intermedium	intermediate wheatgrass	52.0		1.3
Leymus angustus (Trin. ex Ledeb) Pikger	altai wildrye	53.3		2.4
Leymus cinereus (Scribn. & Merr.) Love	basin wildrye	44.0		1.6
Phalaris arundinaçeae L.	reed canarygrass	4.3		0.8
Pascopyrum smithii (Rydb.) Love	western wheatgrass	41.5		1.7
Poa pratensis L. (P-1)	Kentucky bluegrass	9.8		1.7
Poa pratensis L. (P-3)	Kentucky bluegrass	30.8		1.9
Pseudoroegneria spicata (Pursh) Love PI 28314	bluebunch wheatgrass	58.6		1.5
Pseudoroegneria spicata (Pursh) Love PI 285273	bluebunch wheatgrass	46.5		1.4
Elytrigia repens × *Pseudoroegneria spicata* (RS-2)	RS hybrid	63.5		2.0
Elytrigia repens × *Pseudoroegneria spicata* (RS-2)	RS hybrid	31.5		0.9
RS NL 12-75	RS hybrid	26.1		1.6
RS NL 32-35	RS hybrid	39.4		1.5
RS NL 35-37	RS hybrid	43.1		1.4
RS NL 38-37	RS hybrid	33.9		2.3
RS NL 56-6	RS hybrid	57.0		2.2
RS NL 96	RS hybrid	27.9		1.5
Elytrigia repens × *Agropyron desertorum*	RD hybrid	62.1		3.0
Elytrigia repens × *Agropyron cristatum*	RC hybrid	43.2		2.6

POTATOES

Graphs 1 and 2

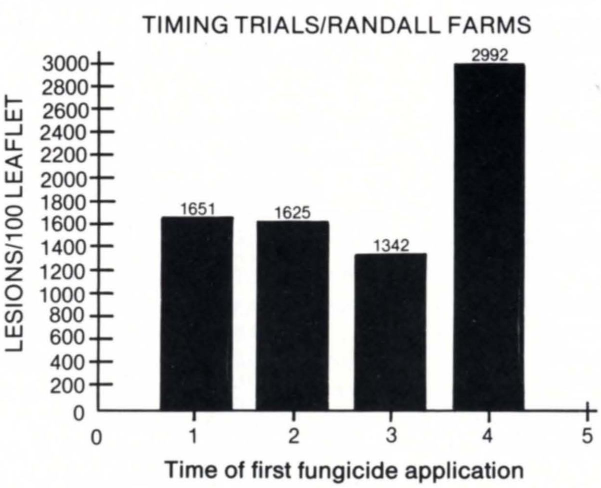


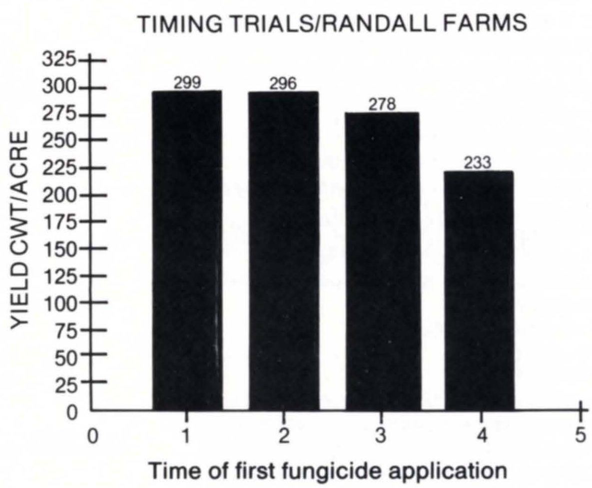


Lower legend for graphs 1 and 2 is 1) Bravo,® 2) Difolitan,® 3) DuTer,® 4) Manzate,® 5) Control (no fungicide applied)

Manzate® effectively controlled early blight (see graphs above), and was also the least expensive fungicide of those tested. As the graphs below show, fungicide applied at the first sign of blight lesions apparently controlled early blight as well as when fungicides were applied earlier (just before the rows closed). These findings also promise to reduce the costs of controlling early blight. Data are from trials conducted at Randall Farms, Enterprise, Utah.

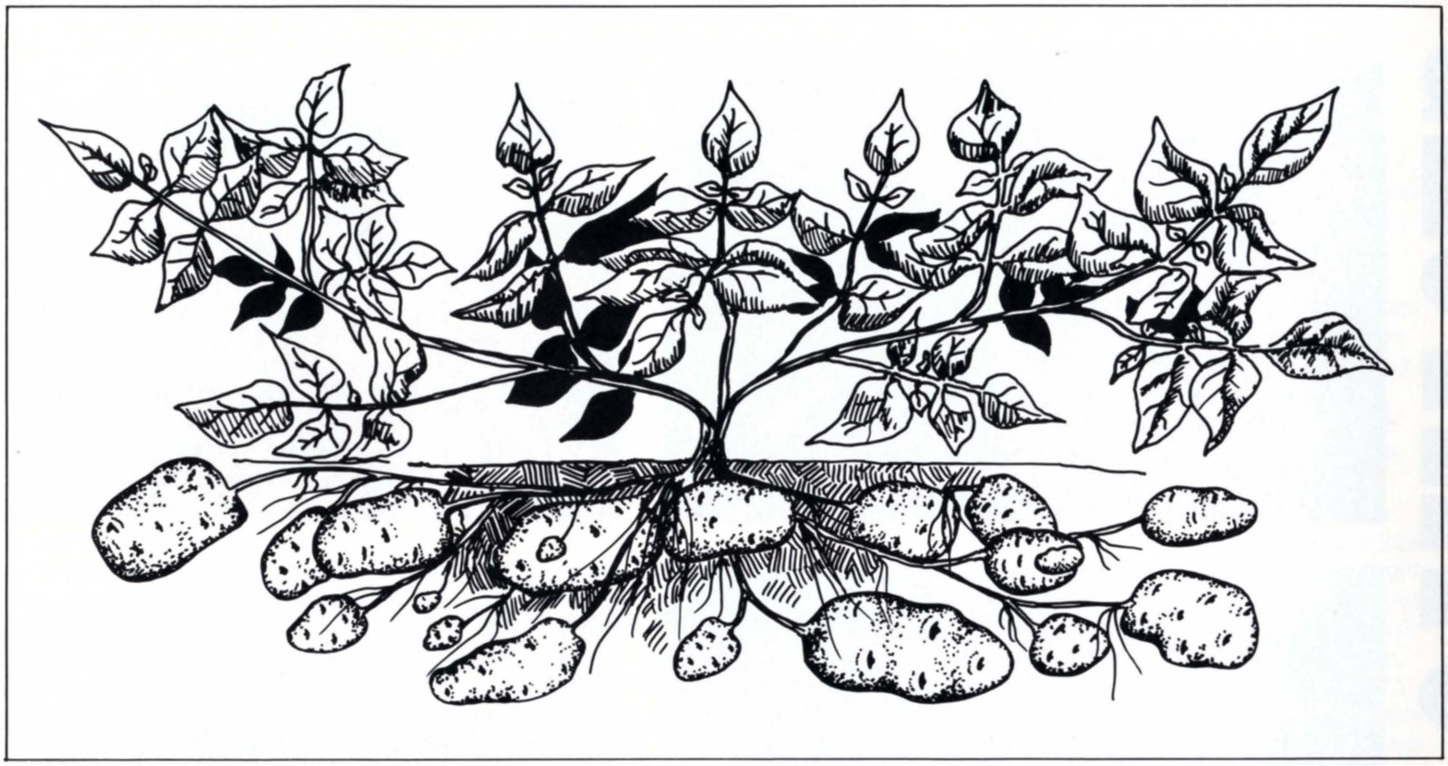
Graphs 3 and 4





The lower legend for graphs 3 and 4: 1) Just before rows closed, 2) Appearance of first lesions, 3) Lower one-third of plant covered with lesions, 4) Control (no fungicide applied)

integrated pest management for POTATOES



T. W. HELMS and J. L. BUSHNELL

In 1982, 1,305,000 cwt. of potatoes worth $5,220,000 were harvested from 5,800 acres in southern Utah. Processors on the west coast purchase most of the potatoes for potato chips; the remainder are for the fresh market and seed.

The USU Plant Science Department started a 160-acre research project in Millard County in 1982 to help producers improve their management skills. In 1983, the USU Cooperative Extension Service expanded the project to 1,000 acres in Millard County and 160 acres in Washington County, and eventually also included 2,000 acres in the Escalante Valley of Washington and Iron Counties and 1,200 acres in Millard County.

The Integrated Pest Management (I.P.M.) potato project has three major objectives.

1. Reduce costs through timely irrigation and proper fertilization.
2. Improve potato quality and yields by scheduling irrigation, monitoring fertility levels in plants and soil, and monitoring and controlling weeds, insects, and diseases.
3. Conduct potato-related research in cooperation with USU Plant Science Department.

Irrigation Scheduling and Fertility Management

Irrigation is probably the aspect of potato production that requires the most management. Adequate soil moisture is required for early emergence, throughout the growing season, and at harvest to facilitate potato harvest. Adequate moisture may even help suppress diseases such as scab caused by the bacterium *Streptomyces scabies* and Verticillium wilt.

Potatoes may require as much as 0.34 inch of water per day during the peak of the growing season, so irrigation is essential for maximum production. Many producers do not know when moisture levels are adequate and often apply too much water, thus significantly increasing production costs. Irrigating only when necessary can also reduce fertilizer loss due to leaching and thus result in the maximum use of fertilizer.

Neutron probes were used during the study to determine irrigation schedules. The number of access tubes for the neutron probes depended on field size and

POTATOES

Captions: Photos by Terry Helms

1) Uncontrolled plant diseases in this field caused extensive production losses.
2) Potato fields near Enterprise, Utah. The center pivot irrigation systems in the photograph cover approximately 2,000 acres.
3) A close-up of early blight lesions.
4) Two conidia (oblong objects in the center of the photograph) of *Alternaria solani Sorauer* which cause early blight.
5) A field of potatoes at row closing.
6) Potatoes in the foreground were not treated with fungicide and are more severely defoliated than the treated potatoes in the background.
7) A helicopter applying fungicide to control early blight.

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soil variability. Soil moisture levels were monitored at depths of 9 inches and 18 inches. The individual readings were then averaged and plotted on a graph.

Irrigation began when the average moisture level at a soil depth of 9 inches was 65 percent of field capacity. The moisture levels at a depth of 18 inches determined how much water should be applied. The maximum recommended amount of water was applied when the soil moisture at 18 inches approaches 70 percent of field capacity. This meant that the maximum irrigation rate on a sandy soil was an 8-hour set with side rolls and handlines, or 30 to 40 hours in a pivot rotation. On clay soils, the maximum set length was 11 hours, or a pivot rotation of about 70 hours. The last irrigation of the season began when the average moisture level at a depth of 9 inches reached 50 percent of field capacity.

Growers have indicated that scheduling reduced irrigation costs by about one-third, primarily because less electricity was required to pump water. One grower said his irrigation costs decreased from $8,000 to $5,000 annually. Irrigation scheduling also decreased fertilizer costs by about one-fourth.

Soil tests were taken in the spring or fall prior to planting. During the growing season, weekly petiole samples determined nutrient levels in plants; any deficiencies were corrected through foliar feeding. Proper foliar fertilization increased potato yields 25 to 40 cwt. per acre.

Controlling Pests

Pest management reduces competition from weeds, insects, and diseases. Weeds were sprayed with selective pre-plant, pre-emergence and, in some cases, post-emergence herbicides. Cultivation also helped control weeds. Insects in Utah potatoes are generally not a problem, but they occasionally must be controlled with a systemic insecticide applied at planting or by airplane during the the summer.

During the potato I.P.M. project, the fields were visited three times a week to observe and identify pest problems. Control measures were recommended when damage threatened to exceed the acceptable economic threshold levels. There were relatively few insect-related problems in the potatoes.

"Controlling early blight extended the growing season for three weeks and increased average yields."

Better Methods to Control Early Blight

Research to help growers control early blight of potatoes started during the summer of 1984. Early blight, which is caused by the pathogen *Alternaria solani,* has killed potato vines as early as mid-August and can dramatically reduce yields. Different fungicides were evaluated to determine how well each fungicide controlled the pathogen, the relative cost of control, and the best time to begin spraying.

Bravo,® Difolatan,® DuTer,® and Manzate® fungicides were evaluated during 1984 on 12 randomly selected plots. Plots were first sprayed at the first sign of lesions; the fungicide was then applied every 7 days until August 15th. Fungicide effectiveness was determined by the number of lesions per 100 leaflets randomly selected from the top, middle, and bottom of plants. Subsequent potato yields and fungicide costs were also evaluated.

There were significantly fewer lesions following application of Manzate® or Bravo® than with DuTer® or Difolatan®. There were no significant differences in yields among the fungicides, but there were substantial differences in fungicide costs per acre: Manzate® cost about $4.00; Bravo® cost about $7.00; Difolatan,® $11.00; and DuTer,® $13.00. Considering the effectiveness of control and cost, Manzate® gave the best control.

A similar experiment determined whether the best time to start applying fungicides was just before the rows closed, at the sign of the first lesions, or when the lower one-third of the plant was covered with lesions. All plots were then sprayed with Bravo® at 7-day intervals. Based on the number of lesions and yields, initial results indicate that it is best to start spraying at the first sign of blight lesions, and to spray again every 7 to 10 days.

During July and until the last week of August, potatoes are "bulking" (increasing in size). Early blight had previously stopped potato growth by August 15, a time when potatoes were doubling in size about every week. Controlling early blight in effect extended the growing season for 3 weeks and increased average yields by about 75 cwt. per acre. The increase in yield varied considerably, from about 25 cwt. per acre on some fields to more than 150 cwt. on others. The average increase in yield increased returns by more than $400 per acre, far offsetting the cost of controlling early blight. Frost damage may occur if the growing season is extended too long and harvest is delayed, but that has not yet been a problem.

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Terry W. Helms received his BS degree in plant science at USU and has begun work on his MS degree in plant science. He is currently a consulting agronomist for Stukenholtz Consulting, Twin Falls, Idaho.

Jim Bushnell received a PhD in plant science at Ohio State University. He is an assistant professor in the Plant Science Department at USU and an Extension Agronomist.

LIMITING EROSION ON FROZEN

C. A. LACEY and A. R. SOUTHARD

To control erosion caused by runoff over frozen ground and minimize water runoff in northern Utah, the Soil Conservation Service (SCS) offers a cost-share program to design and install level terraces. Although some research (4,9) shows that properly designed terraces effectively reduce soil erosion, there are indications that these terraces may not effectively control runoff over frozen ground.

The need to control runoff under these conditions was demonstrated in a watershed area northwest of Clarkston, Utah, when 9.9 inches of rain fell on frozen ground January 8 through 14 and February 14 through 20, 1980.[1] Excessive soil erosion resulted even on terraced fields. The effectiveness of terraces and other soil and water management practices under these conditions were studied on 1,458 ha (3,600 acres) in northern Utah, 2.4 km (1.5 miles) northwest of Clarkston. The average annual precipitation in this area is 400 to 500 mm (16-20 inches), most of which falls as snow between December and March. The elevation ranges from 1,585 m to 1,798 m (5,200-5,600 ft). Slopes range from 6 to 16 percent.

The soils in the study are the Avon, Nebeker, and Henricks series and are classified as follows:

Avon—fine montmorillonitic, mesic, calcic pachic Argixerolls.

Nebeker—fine montmorillonitic, mesic, pachic Argixerolls (10).

Henricks—fine-silty, mixed mesic, pachic Argixerolls.

The soil loss tolerance is 3 tons for Avon and Nebeker soils and 5 tons for Henricks soils (11).

Some dryland farms in the area have terraces. Designed and constructed according to SCS specifications, older terraces were installed in 1975; newer ones were installed in the fall of 1979.

[1]Rainfall measurements taken by Andrew Heggie, Clarkston, Utah.

To determine differences in soil erosion, 56 plots were selected on various fields. Size of plots in terraced fields varied according to terrace width while plots on nonterraced fields were 61 m × 67 m (200 ft × 220 ft).

Plots represented several cropping practices and systems: fall grain (drilled up and down the slope), and fallow land (chisel plowed on the contour or with the slope, no-till, and planted to alfalfa or grass). The variety of farming practices made it possible to directly compare soil loss between terraced and nonterraced fields on 11 paired plots. The remaining 34 plots were used to study other conservation practices.

Rill and gully erosion were measured on each plot. The Aultin Rill Erosion Equation (2) was used to estimate rill erosion. Gully erosion was measured by the direct volume method.

More Erosion on Some Terraces

Contrary to what might have been expected, soil movement on terraced fields was greater than on nonterraced fields (Table 1) perhaps because most of the terraced plots were relatively new and had not yet been compacted by farm machinery and natural settling. These new terraces were more susceptible to piping and soil movement.

Some of the new terraces which crossed drainageways that had been backfilled, shaped, and graded were susceptible to overland flow. Erosion was most severe in these areas. It is likely that erosion would have been reduced if the new terraces had time to settle.

Substantially less soil moved on grass plots than on fallow plots and drilled grain plots. No-till techniques and chisel plowing on the contour were equally effective in controlling erosion on fallow plots. More soil eroded on fallow plots that had been chiseled with the slope. Erosion on alfalfa fields was appreciably less than on drilled grain plots and plots that had been chiseled up and down the slope. These results are consistent with other research (1,4) and clearly indicate the importance of effective land-treatment practices.

Note that the mean soil loss on alfalfa plots (2.5 tons/acre) is within the soil loss tolerance for all three soil types while the 11 tons/acre loss on tilled fallow plots, even no-till plots and plots chiseled on the contour, exceeded the soil loss tolerance for these soils (Table 2).

Evidently, much of the erosion occurred because rain fell on frozen soil. Previous investigations (6) show that runoff over frozen ground has occurred in northern Utah. Although it is difficult to determine how often to expect runoff over frozen ground (7), land managers in the Clarkston area say the climatic conditions that enable this to happen may occur every three to five years.

Management Implications

Our study has several implications for land management in the study area.

- Terrace design and construction may have to be altered when used as a conservation practice in the Clarkston, Utah, area.
- Terraces are more effective when used with grass waterways. Conservationists must stress the value of contour strip-cropping, a practice that may reduce erosion by 50 to 90 percent (12).
- Marginal cropland should be planted to a grass or grass-legumes. This may be difficult to achieve. Although other research (1,3,5,8) has shown that perennial grasses and legumes are effective in reducing erosion, conservationists report that it is often difficult to convince farmers to grow grass instead of grain.
- No-till and chisel plowing on the contour are sound management practices on fallow ground.
- Fallow land should not be chisel plowed up and down the slope.

Conclusions

The excessive soil erosion in northern Utah in 1980 clearly indicates the need to

GROUND IN NORTHERN UTAH

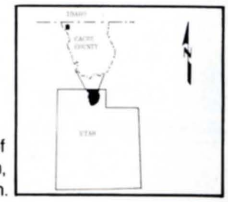

Figure 1. Location of study area near Clarkston, Cache County, Utah.

reevaluate some current conservation practices. SCS technical assistance and cost-share programs provide valuable assistance. It is necessary, however, to constantly evaluate recommended conservation practices and change them to reflect current research findings and experience.

The results of this study confirm the validity of advice offered more than 30 years ago: "Terraces should always be supplemented with the best possible cropping practices because terraces in themselves do not improve soil fertility and used alone fail to hold soil adequately."[2]

[2]United States Department of Agriculture Soil Conservation Service, 1954. A Manual on Conservation of Soil and Water. Agriculture Handbook, No. 61, p. 80.

TABLE 1. Soil movement on terraced and nonterraced fields.*

Land Use	Terraced	Nonterraced
	Tons/Acre	
Alfalfa	45	9
Fallow, chisel on contours	42	12
Fallow, chisel up and down slope	78	44
Fallow, no-till	8	13

*Eleven paired plots (22 observations).

TABLE 2. Soil movement by land use.

Land Use	Number of plots observed	Soil movement tons/acre
Grass	4	none
Alfalfa	13	2.5
Fallow, no-till	4	11.0
Fallow, contour chisel	5	11.0
Drilled grain	12	58.0
Fallow, chisel up and down slope	3	58.0

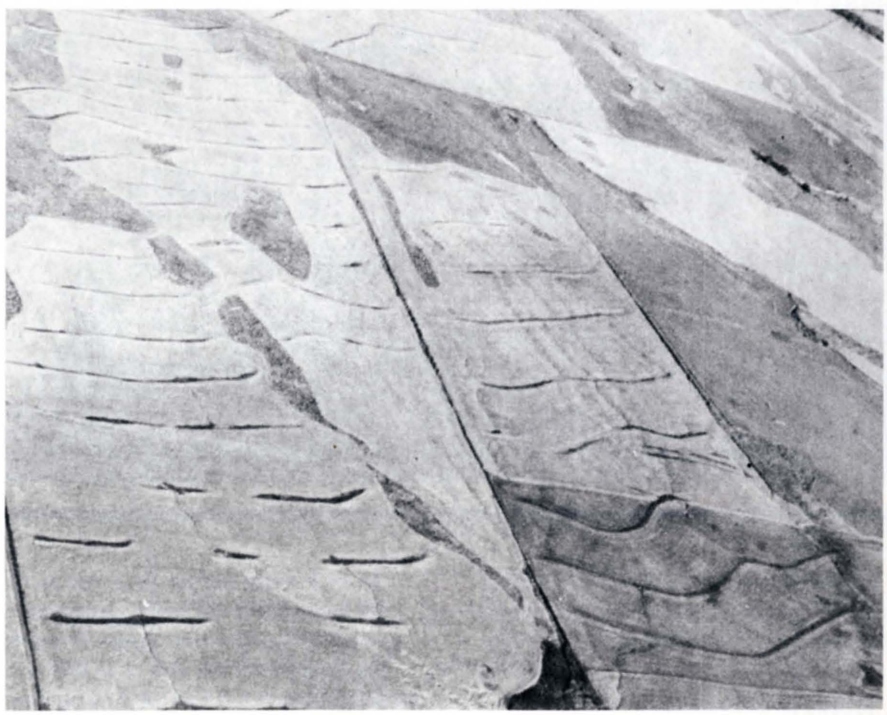

Figure 2. An aerial view of the study area. Vertical lines between contour strips are the ditches formed by erosion.

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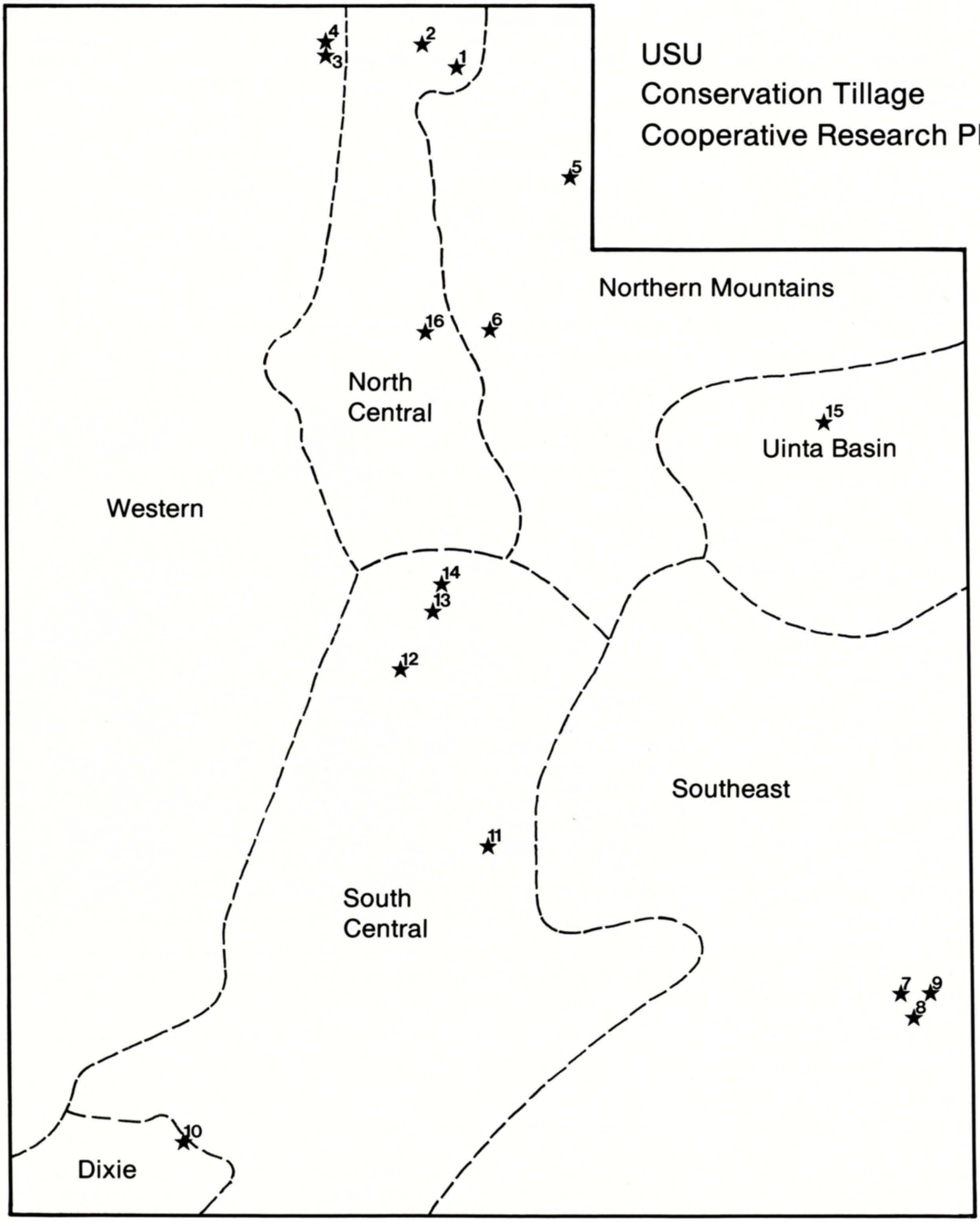

See pages 22 and 23 for more information.

Some American Indians practiced minimum tillage (and even placed fertilizer for maximum utilization by plants) when they planted maize in a hole with fish. In fact, conventional tillage didn't even appear until the moldboard plow was invented to break dense virgin sod.

There was a resurgance of interest in conservation tillage during the 1960s, primarily in the Midwest, although USU had at least an indirect role in rekindling interest. Asael E. Palmer, a Utahn who studied under the late J. A. Widstoe, noted soil scientist and president of the Agricultural College of Utah, wrote a booklet describing events during the dust-bowl era of the 1930s, a chronicle that helped spur interest in current conservation tillage techniques.

Most farmers practice some form of conservation tillage when they limit the number of tillage operations and leave crop residue on the soil surface for as long as possible. In general, conservation tillage often refers to any crop residues left on the surface to control soil erosion and increase water retention, but more precise definitions have been developed.

A conservation tillage and planting system is now defined as one that retains at least 30 percent of the crop residue on the soil surface after planting.

In no-till or slot planting, the soil is not disturbed before planting; seeds are planted in a narrow seedbed approximately 1-3 inches wide. Ridge-till involves tilling about one-third of the soil surface at planting with sweeps or row cleaners; seeds are planted on ridges that are usually 4-6 inches higher than the middle of the rows.

Strip-till is similar to ridge-till except rows are not ridged. In a mulch-till system, ground is tilled before planting but at least 30 percent of the crop residue remains on the soil surface.

A reduced-till system may utilize these conservation tillage techniques, but less than 30 percent of the crop residue is left on the surface after planting.

A 1983 survey by the Soil Conservation Service indicated that about 14,000 acres in Utah were in no-till, 54,000 acres were in mulch-till, and 6,000 acres were in reduced tillage. — ***The Editor***

Conservation in Utah

Equipment is a key factor in conservation tillage. USU researchers have modified conventional drills (top photo), which promises to dramatically reduce equipment costs. Among the drills now available are a Tye® drill (note the cutting colters), a Haybuster® no-till drill, and a Yielder® drill, shown here fitted with anhydrous ammonia tanks.

Utah farmers aren't about to abandon tillage completely, in spite of this "no-till" symbol, but they may decide not to use moldboard plows on some land in order to curb soil erosion, which gouged out these ditches on fields near Cache Junction.

Researchers with the Utah Agricultural Experiment Station stress that conservation tillage is not simply less tillage, but a sophisticated system of management. USU scientists use a device to measure absorbed and reflected soil radiation to determine evaporation, information essential in making the optimum use of conservation tillage techniques.

Tillage

Photographs by Jim Bushnell, Jack Evans, and Phil Rasmussen.

One of the first experiments with conservation tillage in Utah was conducted on this weed-choked pasture north of Logan. An excellent stand of alfalfa resulted on herbicide-treated sod.

Weed control is essential, as is shown in the difference between the two plots in a field of oats (top photo). Conservation tillage techniques often require different weed-control strategies than conventional tillage to make sure that crops, such as wheat planted in an old stand of alfalfa or in stubble, don't have to compete with weeds for water, nutrients, and sunlight.

Conservation tillage may have gotten off to a relatively slow start in Utah, but it has caught on quickly...perhaps even too quickly.

Researchers with the USU Agricultural Experiment Station and specialists with the USU Extension Service are convinced that conservation tillage has several advantages, including the potential to increase yields, curb soil erosion, renovate steep and stoney land for forage production, and reduce production costs. It might even enable continuous cropping of dryland wheat in certain select areas. But the experts also warn that minimum tillage requires maximum management and is no panacea for many farm problems.

Researchers temper their optimism for another reason: they are still determining which crop varieties, tillage techniques, and equipment are best suited to Utah conditions. Glowing reports about conservation tillage from other regions may mislead some Utah farmers into starting on too large a scale.

"Farmers should remember that we have gathered information about conventional tillage for more than 120 years, but have only 4 years' data on conservation tillage," says Philip Rasmussen, Experiment Station soil scientist who is studying dryland conservation tillage techniques. The Experiment Station, Extension Service, farmers, and several state and federal agencies are cooperating to erase any information deficit.

Conservation tillage isn't a new concept, although there's some confusion about definitions (see accompanying article).

The Experiment Station's involvement had a relatively low-key beginning in 1978 when weed scientist John Evans, who is studying chemical fallow systems, borrowed a no-till drill from Ricks College in Idaho and planted alfalfa on a stoney, weed-choked pasture in North Logan. Part of the pasture had been sprayed with a herbicide and part had been conventionally tilled. Evans wanted to know whether the conservation tillage techniques touted elsewhere would work in Utah.

They did.

"One week after planting, we had a fantastic stand of alfalfa on the plot that had been sprayed and planted. Burning off weeds with an herbicide and planting in sod cut planting costs," Evans says. The planting technique also improved stands and reduced the likelihood that the field would have to be replanted. Yields from the two plots were also similar.

Conservation tillage research during the next few years had to be sandwiched between researchers' other tasks, but continued favorable results coupled with a rapid escalation in farmer interest prompted the Experiment Station to bolster its commitment to conservation tillage research.

Conservation tillage may not work in every situation, but it's obviously here to stay. That's good news in a state where cropland and water are relatively scarce resources.

Weed Control

Weed control is an integral part of conservation tillage. Farmers who haven't licked their weed problems with conventional tillage will probably still have weed problems—albeit different weed problems—with conservation tillage, Evans says. But many more herbicides are available today than 10 or even 5 years ago, and more are being developed. Although conservation tillage increases reliance on herbicides, herbicide costs are often offset by other savings.

Proper use of herbicides is always important, but it takes on additional importance in conservation tillage. Glyphosate (Roundup®) has become one of the most popular herbicides, in part because it kills quackgrass, a particularly troublesome weed whose roots are dispersed by tillage. Extension agronomist Jim Bushnell, who is studying conservation tillage on irrigated crops, says Roundup® must be translocated to roots, so farmers should wait long enough after application before planting to monitor the effectiveness of kill but not so long that broadleaf weeds get started. Roundup® is applied differently than some other herbicides. It is important to apply it with limited amounts of water (1 quart of Roundup® per acre requires no more than 10 gallons of water). Coverage is also improved by adding .05 percent v/v surfactant.

Evans stresses the importance of selecting the correct herbicide mix for the weed problem in a chemical fallow system. A "weed problem" shouldn't deter anyone from trying conservation tillage, he adds, but don't expect a single herbicide application to solve weed problems caused by mismanagement of conventional tillage systems.

Selecting Varieties

Varieties that do well under conventional tillage may not always be those best suited to conservation tillage. Rasmussen notes that crop residues lower the soil temperature in the spring by about 2°C. Conservation tillage also tends to make soils wetter in the spring, conditions which could favor molds, fungi and other pathogens that overwinter on straw.

With four varieties of winter wheat, yields have been higher with conventional tillage, probably because an infestation of snowmold which overwintered on straw reduced yields with conservation tillage. Rasmussen says varieties more resistant to snowmold are slowly becoming available.

There are indications that the right varieties and absence of disease problems means conservation tillage can increase dryland wheat yields by 5-10 bushels per acre. Much of that increase can be attributed to the retention of an additional inch or two of moisture, but better fertilizer placement may also help.

Bushnell says varietal selection is particularly important with small grains which must germinate quickly and push through surface residues. Conservation tillage is likely to increase the demand for salt- and moisture-tolerant alfalfa varieties since farmers can plant where conventional tillage may bring salts to the surface. "Farmers are getting excellent stands of alfalfa where they normally wouldn't have been able to plant alfalfa," Bushnell says, including stoney ground where it is impossible to use a moldboard plow.

Alfalfa varieties should be resistant to phytophthora root rot and stem nematodes in both conventional and conservation tillage systems.

Equipment

Several years ago, many of the conventional drills developed elsewhere simply couldn't handle no-till residue. That situation is changing, but equipment specialist Keith Hatch is determining whether Utah farmers might be able to cut costs by modifying conventional drills for conservation tillage.

Modification could save thousands of dollars, and would be particularly useful for part-time farmers. One top-of-the-line no-till drill costs about $150,000 and requires a similarly priced tractor. That rig is beyond the financial reach of most farmers in Utah. An opener assembly can be added to a conventional drill at a cost of about $500 per row.

Hatch is also evaluating other drills, including three with disc openers and about 20-30 types with hoe openers.

"The configuration and location of the press wheel is extremely important to insure good soil contact with the seed," Hatch says. Dryland wheat may emerge well but later die due to dessication caused by poor seed-soil contact. Disc openers are less likely than hoe openers to be damaged by stones since discs tend to roll over stones and similar obstructions. Hatch says disc openers apparently enable better control of planting depth. He and other members of the USU Department of Agricultural Education are also determining horsepower required by various tillage operations, and how horsepower measured elsewhere is related to conditions in Utah.

Bushnell has used several types of drills that have performed "satisfactorily" under Utah conditions, although some lack desirable features, particularly the ability to control planting depth and fertilizer placement. "The ultimate drill for all situations and crops that is moderately priced hasn't been invented yet," he says.

Bushnell offers a thumbnail description of the drills he has worked with: the disc-type Haybuster (it can be adjusted for conservation or conventional tillage, starter fertilizer can be put with or 2 inches below seed, and it's relatively easy to adjust and control planting depth); the Tye drill (it doesn't place fertilizer below the seed, but incorporates it in with a fluted colter, and the planting disc offers limited depth control); the Marliss drill (a shoe-type drill more prone to damage by stones; fields should be tilled at least once before the drill is used); and the John Deere power-till drill (1500 series) (tungsten clip-ons are available for colters with six slots, PTO-powered colters are particularly well suited to planting in sod).

Bushnell also notes that some Soil Conservation Service (SCS) districts have purchased drills with assistance from the Utah Department of Agriculture. Loans and other assistance is available to farmers in some areas to lease SCS equipment or hire custom planting. Contact your local SCS office or ASCS office for details.

Moisture

One to two inches of soil moisture is lost when soil is plowed and/or disced extensively. This is moisture that could improve seed germination and plant growth. The additional moisture retained by conservation tillage techniques might even make it possible to occasionally grow wheat continuously in some dryland areas.

Rasmussen says dry and wet years tend to occur several years in a row (Utah has been in a "wet" cycle). During a "wet" cycle, the additional moisture saved by conservation tillage might eliminate the need for a fallow period. At best, conventional fallow systems capture only about 30 percent of the available moisture.

Continuous cropping probably won't be possible in many moisture-short areas, and trying to raise wheat continuously during a "dry" cycle might result in two successive crop failures whereas letting land lie fallow might let farmers get at least one crop.

"Although the data suggest annual cropping may be reasonably successful in the 'high' rainfall areas of Utah, we are concerned that many farmers are gambling on annual cropping in areas of limited rainfall. Annual cropping can be successful during the current 'wet' weather pattern, but could be disastrous during drier cycles," Rasmussen warns.

Rasmussen has developed two computer programs, an instructional program which illustrates how moisture affects wheat yields, and another which shows how soil moisture levels are affected by crop residues and other factors. These programs are the forerunners of one now being developed that will tell farmers when the odds favor continuous cropping.

Fertilizer Placement

Conservation tillage has renewed interest in the effects of fertilizer placement.

"In my opinion, some of our methods of applying fertilizer really played into the hands of weeds. Essentially, we fertilized weeds as much as the crop," Evans says. Some of the new drills can place fertilizer where crops—not weeds—derive the most benefit. Better fertilizer placement may also allow application of starter fertilizers at rates previously thought to "burn" the seed.

"There's every indication that fertilizer placement is critical," Rasmussen says. Kansas researchers have stated that higher yields might result from better starter fertilizer placement, not only because nutrients are more accessible to crops, but because phosphate might help the plant "pump in" nitrogen and other nutrients.

Proper phosphate placement is particularly important when the soil isn't "mixed" by tillage following fertilizer application. "Shanking-in nitrogen reduces volatization. There's also apparently an additive effect when nitrogen and phosphate are applied in the same band," Rasmussen explains.

Farmers' Support Essential

Innovative farmers have been instrumental in encouraging conservation tillage research; most enthusiastically endorse the system, and many have donated land for research plots. Farmers may at first be startled at the bedraggled appearance of fields that lack the smooth uniformity of tilled land. "But once a farmer has tried 5 acres, he usually is convinced," Bushnell adds.

Extension specialists estimate that using no-till techniques in sod to establish alfalfa costs about $9.00 less per acre than conventional tillage, assuming that herbicide costs $20 per acre. Savings are higher if a less-expensive herbicide can be used.

Farmers report a host of other advantages, including timely planting, faster planting, the ability to plant steep and bottom land, and more efficient use of seed and fertilizer.

"So far, two types of farmers have tended to adopt conservation tillage. The early adopters are good managers who seem to be able to do it right and make it profitable. Now, more part-time farmers are becoming interested, often because they want to get planting over with," Rasmussen says. He is concerned that many of these latter farmers might not realize that conservation tillage requires top-notch management.

Research Taps Techniques' Full Potential

Research concerning a variety of conservation tillage techniques continues at the Experiment Station (see accompanying map for a complete listing of projects and demonstration plots). So, in spite of the information deficits and risks involved in changing production practices, most researchers and Extension specialists are excited by the opportunities offered by conservation tillage.

"To me, the benefits far outweigh the risks, even if we haven't yet found out enough to get all of the 'bugs' from the system. It certainly has interested farmers. Done properly, it appears that yields are at least equal to conventional tillage," says Bushnell.

"At one time, I thought no-till would gradually phase in, but I'm now convinced that it will rush in. I hope we can stay ahead of unforseen circumstances that might give the program a black eye," Evans adds.

1984-85 USU Conservation Tillage Cooperative Research Plots

Cache County

[1]**Site:** USU Greenville Experiment Farm
Description: Comparison of microclimate and water use in conventional tillage and conservation tillage under irrigation
Cooperators: Phillip Rasmussen, John Hanks, UDOA, Monsanto, Chevron Fertilizers, Velsicol
Status: Chem-treated fall 1983. Planted to spring wheat in May 1984. Different irrigation rates studied.

[2]**Site:** Norman Ravesten Farm, Clarkston, Utah
Description: No-till fertilizer interactions, renovation of white knolls and tests of varieties
Cooperators: Philip Rasmussen, UDOA, Chevron Fertilizers, and TVA (Fertilizer Div.), Conservation Districts, USDA-SCS
Status: Planted in fall 1984. Additional studies continuing.

Box Elder County

[3]**Site:** USU Blue Creek Experiment Farm
Description: Comparison of water conservation, snow retention, erosion and run-off of eight different combinations of chem-fallow, conventional fallow, conservation tillage and conventional tillage
Cooperators: Philip Rasmussen, Ray Cartee, Chevron Fertilizers, Monsanto, Inc., Velsicol Chem. Inc., Western Seeds and UDOA
Status: Initiated in fall 1984, ongoing for 6 years.

[4]**Site:** Ken Clark Farm
Description: Comparison of chem-fallow treatments
Cooperators: John Evans, Bob Gunnell, USDA-SCS, Philip Rasmussen (planting), UDOA
Status: Initiated in fall 1984.

Rich County

[5]**Site:** Several landowners
Description: Pasture renovation with alfalfa and grasses
Cooperators: Jim Bushnell, John Barnard (county agent), Monsanto, Chevron Fertilizers, UDOA, USDA-SCS, and Conservation Districts
Status: 1984 plots.

Summit County

[6]**Site:** Gilmore Ranch, Silver Creek Junction
Description: Three alfalfa varieties research/demonstration
Cooperators: Philip Rasmussen, Jim Bushnell, Monsanto, Chevron Fertilizers, UDOA, USDA-SCS, and Conservation Districts
Status: Planted in 1984.

San Juan County

[7]**Site:** Tye Lewis Farm
Description: Comparison of chem-fallow treatments
Cooperators: John Evans, Bob Gunnell, USDA-SCS, Philip Rasmussen (planting), UDOA
Status: Initiated in fall 1984

[8]**Site:** Spencer Frost Farm
Description: Conservation tillage, fertilizer, and variety interactions
Cooperators: Philip Rasmussen, Jim Bushnell, Terry Tindall, UDOA, USDA-SCS, UDOA, Conservation Districts, Monsanto, Velsicol, Chevron Fertilizers, and TVA
Status: Planted in fall 1984.

[9]**Site:** Byron Peterson Farm
Description: Conservation tillage, fertilizer, and varitey interactions
Cooperators: Philip Rasmussen, Jim Bushnell, Terry Tindall, UDOS, USDA-SCS, UDOA, Conservation Districts, Monsanto, Velsicol, Chevron Fertilizers, and TVA
Status: Planted in fall 1984.

Washington County

[10]**Site:** Kolob Bench
Description: No-till spring wheat/alfalfa
Cooperators: UDOA, Brent Glendhill (county agent), Jim Bushnell, Philip Rasmussen, Chevron Fertilizers
Status: Planted in May 1984.

Wayne and Piute Counties

[11]**Site:** Over 14 landowner plots
Description: No-till pasture renovation and variety trials
Cooperators: Jim Bushnell, Verl Bagley (county agent), Monsanto, Chevron Fertilizers, UDOA, USDA-SCS, and Conservation Districts

Millard and Juab Counties

[12]**Site:** Five sites on Monroe and Probert Farms
Description: No-till pasture renovation and oat trials
Cooperators: Robert Newhall (USDA-SCS), Jim Bushnell, Philip Rasmussen, Monsanto, Chevron Fertilizers, Velsicol, Inc., UDOA, and Conservation Districts

Juab County

13
Site: Ross Harper Farm (cooperative conservation tillage plots established with John Evans in 1979)
Description: Chem-fallow comparisons, water use research, variety and fertilizer interactions
Status: Six experiments in 1984.

14
Site: USU Nephi Experiment Farm
Description: Study of fertilizer water-use interactions under conservation tillage
Cooperators: Philip Rasmussen, Ray Cartee, Terry Tindall, Monsanto, Chevron Fertilizers and UDOA
Status: Planted fall 1984.

15
Duschesne County
Site: Roosevelt, Utah
Description: Study of different fertilizer carriers on conservation tillage with varieties
Cooperators: conservation districts, Terryl Heilman (USDA-SCS), Terry Tindall, Jim Bushnell, UDOA and Chevron Fertilizers
Status: Planted fall 1984.

16
Salt Lake County
Site: Dale Bateman Farm
Description: Study of winter and spring barleys under irrigation and conservation tillage
Cooperators: Philip Rasmussen, Monsanto, Chevron Fertilizers, UDOA, and Conservation Districts
Status: Planted fall 1984.

The Promises (and Pitfalls) of Conservation Tillage

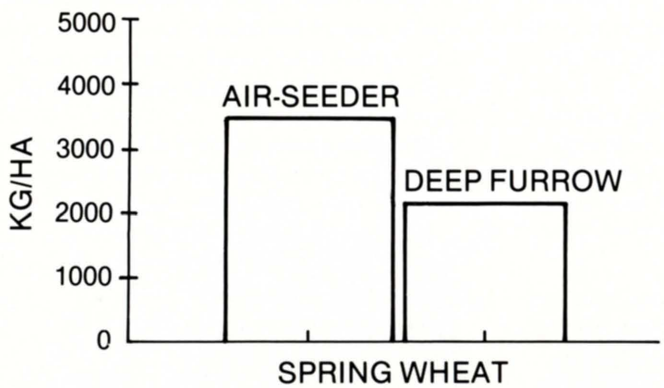

Figure 1.

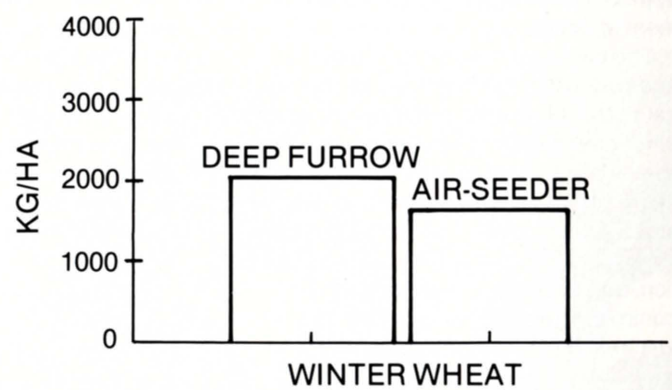

Figure 2.

There are risks, as well as advantages with conservation tillage, as shown by the wheat yields from experimental plots in Box Elder County during 1982. Spring wheat (Komar) yields were higher with conservation tillage (air seeder) than with conventional tillage (deep furrow). Winter wheat (Weston) yields were lower, probably due to an infestation of snowmold that overwintered on crop residues.

TABLE 1. Alfalfa hay yields with conventional tillage and no-till (North Logan, Utah).

	(Tons/Acre)*			
	No Tillage		Conventional Tillage	
Year	First Cutting	Second Cutting	First Cutting	Second Cutting
1980	2.0	2.1	1.9	2.2
1981	2.6	2.4	2.3	2.3
1982	2.4	2.2	2.5	2.2
1983	2.4	2.0	2.5	2.3
1984	2.2	2.1	2.3	2.0

*Third cuttings were possible in some years; data not included because yields varied with date of first killing frost.

ABOUT THE AUTHOR

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INTEGRATED PEST Management:

New Ways to Manage Aphids and Other Alfalfa Pests

D. W. DAVIS

Research concerning insects related to forage crops at Utah State University has concerned pollination, problems on range grasses, alfalfa weevil population management, and aphid problems in alfalfa. During the past 5 years, interest in the aphid problems has increased, partially due to the accidental introduction of new alfalfa aphid species, but also due to a better understanding of the diverse approaches to integrated pest management of aphids.

The concept of integrated pest management (IPM) has emerged as the logical approach to pest control in alfalfa and other crop systems. New ideas are constantly being incorporated as the system evolves. IPM involves a variety of control strategies, depending on the area, season, organisms, the economics of crop production, and the impact of pests and their controls. Knowledge of pest populations ensures that control practices are used only when needed.

The lygus bug is the key insect problem in seed alfalfa. The major adverse side effect of insecticide use has been killing of pollinators. In forage alfalfa, the key insect problem in the intermountain region is the alfalfa weevil. The major pesticide-related concerns are residues at harvest time. Cutting alfalfa for forage means there are 3 or 4 distinct population cycles of insects in the fields during a season. Harvesting alfalfa for forage also affects disease, nematode, and weed problems. There are fewer, less dramatic disruptions when seed alfalfa is harvested.

Key pest problems may be insect, weed, nematode, or disease. There are seldom more than about four major pest problems in any given crop system in an area. Primary cultural (including resistant varieties), biological, and chemical control methods must cope with these key problems.

Secondary pest problems are common, but these pests do not always cause economic damage. The chemical and cultural practices used to control primary pests and to manage the crop are often instrumental in causing secondary problems. For example, many aphid problems in alfalfa become serious only after insecticides used to control primary pests have destroyed too many beneficial predators. Secondary pests may then become as injurious as primary pests.

Finally, minor pest problems occasionally cause damage. Many insects and diseases require rather specific long-term conditions before they are of any concern. These conditions may occur once every 10 years or so.

IPM must be adapted to specific areas and reflect agronomic practices, e.g. the different programs for seed and forage alfalfa. Problems in Washington, County, Utah, differ from those in most other regions of the state. Pest problems can vary within a short distance. There are, for example, major differences in insect problems in the center of Cache Valley and those encountered on the east bench due to temperatures, soil types, moisture levels, and irrigation practices.

Aphids

There are three species of alfalfa aphids of economic importance in Utah. **The pea aphid** is found in all parts of Utah and affects alfalfa primarily during May and June. Warm weather, long days, and a variety of predators and parasites usually decrease the populations by mid-summer. The pea aphid, under Utah conditions, is rarely a serious pest, in spite of the large numbers. Most alfalfa varieties grown in Utah suffer minimum damage, so chemical control is rarely necessary. Occasionally, pea aphids will cause alfalfa plants to yellow and leaves will drop from the lower portions of the plants. This yellowing shows up shortly before the first cutting for forage and in Utah is commonly associated with stress due to excess spring moisture. Injured plants to be used as forage should be harvested rather than using insecticides. The materials used to control lygus bugs on seed alfalfa usually control the pea aphids.

The blue alfalfa aphid is closely related to the pea aphid. It is a recent introduction into the United States, and has been in Utah for about 9 years. The season of activity is about the same as the pea aphid, but only the southern half of the state is infested. The most serious damage occurs in Washington, Beaver, and Iron Counties. Even rather low infestations will stunt alfalfa and seriously reduce yields. Insecticides applied after the alfalfa has been stunted will kill the aphids. Aphid control alone, however, will not necessarily stimulate plant regrowth. Applying insecticides before plants appear to be stunted will allow the alfalfa to resume growth immediately. Stunted alfalfa must be cut following the insecticide treatment to stimulate regrowth.

The spotted alfalfa aphid was introduced into the United States about 1953 and is basically a hot weather species. Most damage in Utah occurs during July and August (except in Washington County). While it has been collected in most parts of Utah, it tends to cause less damage as in northern areas of the state. Only a few examples have been reported north of Nephi that required treatments.

Captions:

Clockwise from top:

1) Spotted alfalfa aphids (one is giving birth).
2) Close-up of a pea aphid.
3) Parasitized pea aphids. Note their swollen bodies.
4) Injured alfalfa due to blue alfalfa aphids. Note the short internodes on alfalfa.
5) Spotted alfalfa aphids on an alfalfa leaf.
6) Alfalfa injured by spotted alfalfa aphids is stunted and off-color.
7) A typical pea aphid colony on alfalfa.

1

2

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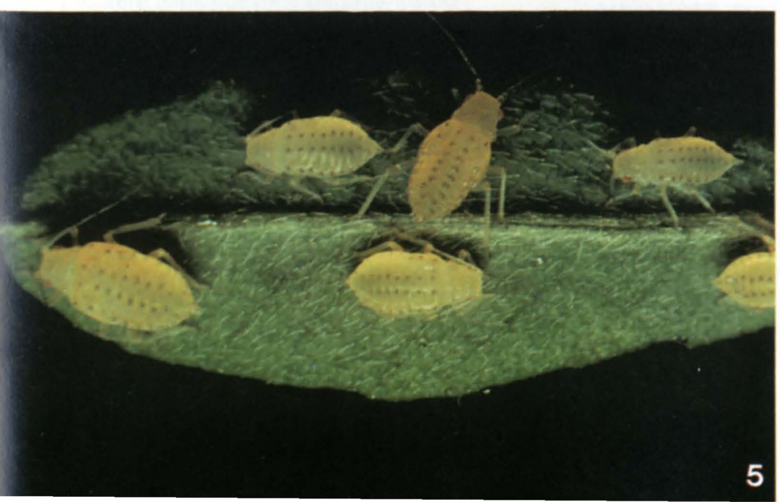

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The toxin that spotted alfalfa aphids inject will kill young susceptible alfalfa plants. An early symptom is vein clearing. Plants become covered with extremely large amounts of honeydew, which in turn results in sooty mold growth. This species of aphid rapidly becomes resistant to insecticides.

Basic IPM Practices

Always plant the varieties or cultivars best suited to a region to utilize their tolerance and/or resistance to pests commonly found in the area. More varieties are being developed by both public agencies and commercial producers. Resistant varieties have been particularly successful against the spotted alfalfa aphid, the pea aphid, the stem nematode, and bacterial wilt.

Resistant varieties may be the only way to suppress spotted aphids and obtain high alfalfa yields in areas where the pest is likely to cause damage. Most insecticides once used to control the spotted alfalfa aphid have now failed. The most effective insecticide (Thiodan) is limited to seed alfalfa.

Pea aphids seldom cause enough damage in the Great Basin states to warrant planting varieties resistant to this pest. Varieties with some resistance may be of some value but resistance should not be the prime consideration when selecting alfalfa varieties for Utah plantings.

Some types of non-dormant alfalfa are resistant to the blue alfalfa aphid, but so far none of the fully dormant commercial varieties show much resistance. It appears that resistant varieties will eventually be the best way to control this insect.

Many of the beneficial predators and parasites that feed on pest insects in alfalfa fields also attack aphids. Left undisturbed, these beneficial insects commonly keep aphid numbers below injurious levels. Unfortunately, insecticides required to control insects such as alfalfa weevils and lygus bugs usually kill predators. Cutting practices often disrupt predators more than prey. Predators develop in seasonal cycles. Populations increase in the spring as they prey on pea aphids and blue alfalfa aphids, and there are enough by mid-season to suppress many of the late-season pests such as lygus bugs and spotted alfalfa aphids. Thus, anything that reduces the number of predators in the spring (or even during the previous season) will tend to increase the number of late-season pests.

It is important to protect pollinators when seed alfalfa blooms. This is also important in forage alfalfa that contains dandelions. Since flowering weeds in alfalfa fields are major sources of nectar, especially early in the season, weed control can thus reduce bee losses.

All actions in an IPM program are based on needs. Do not apply pesticides on a routine or calendar basis. Monitoring insect populations enables the use of diverse preventive techniques and can eliminate unnecessary spray applications. Control should also be based on weather data and on a detailed knowledge of pest patterns within an area.

Use and Selection of Insecticides

1. Pesticides used during certain periods have a greater impact than during other times. Insecticides should be carefully selected, timed, and applied to avoid problems.
   - Pollinators are commonly killed when either alfalfa or weeds within or adjacent to the alfalfa field are in bloom. Some problem insecticides can kill bees when they have been applied as many as 10-14 days before bloom. Occasionally, bees may also visit alfalfa to collect aphid honeydew. Leafcutting bees may use alfalfa leaves from treated fields to construct nests. For these reasons, do not apply troublesome insecticides when plants in the field are in bloom or when bee colonies are in or near the field.
   - The number of predators in alfalfa fields usually increases rapidly during May, shortly before the first cutting, and in pre-bloom seed alfalfa. These early-season predator populations can frequently control late-season pests. Insecticides that destroy predators in May or June may allow populations of late-season pests such as the spotted alfalfa aphid to increase to damaging levels.
   - There are strict laws concerning pesticide residues on forage crops to prevent contamination of dairy products. Residues can persist for a very long time in hay. Be sure to observe the proper interval from application to harvest. Few insecticides can be applied within 10 days of harvest. Observe these precautions when feeding screenings and other residue from seed alfalfa.
2. It is not easy to select insecticides for an alfalfa IPM system. Almost all insecticides have some adverse effects on beneficial insects under certain conditions. The benefits of an insecticide application must always be weighed against their effects on beneficial insects.
   - Long-lived, broad-spectrum insecticides generally cause the most problems. Materials such as Furadan and Sevin do not control mites and are only partially effective against aphids but are lethal to most predators, parasites, and pollinators. Broad-spectrum insecticides may be used under certain conditions (e.g. very early in the season or on the stubble following harvest), but not when beneficial insect activity is high.
   - Short-lived materials can often effectively control pests while preserving beneficial insects. The extremely short-lived materials such as Phosdrin and Dibrom can be applied in the evenings after bees

quit visiting flowers. Materials such as methyl parathion, Lannate, and malathion will kill the active stages of predators and parasites, but their eggs and pupae often survive so the population rapidly rebounds.

- Most systemic insecticides, such as Systox, Metasystox R, and Supracide, have little effect on predators after the insecticide is taken into the plant tissue. Pollinators may also be protected, but some systemics such as dimethoate can appear in the nectar or pollen and kill bees.

- A few insecticides are highly or partially selective. Use these materials whenever possible. *Bacillus thuringiensis* (a bacterial insecticide) will kill caterpillars only. Dylox kills caterpillars and lygus bugs with minimal harm to honey bees. Supracide and Imidan are not extremely selective but are not nearly as detrimental to ladybird beetles and damsel bugs (predators) as some materials commonly used to control alfalfa weevils. The miticide Comite used alone will not harm most beneficial insects but can become toxic to bees when combined with some other materials.

- Dosages are important in an IPM program. For example, Furadan can be applied from 4 to 12 oz. of active ingredient per acre. At 4 oz., it has a rather short residual life, does not control aphids, but adequately controls alfalfa weevil larvae. At the lower rates, many predators will survive especially damsel bugs. Applications of 12 oz. kill almost all insects and prolong the insecticide's residual life. The 4 to 6 oz. rates are compatible with some pest management systems; the 8 to 12 oz. rates are not readily adaptable.

- Unnecessary insecticide applications often cause more problems than they solve. For example, insecticides are not recommended to control thrips in forage alfalfa or to control seed chalcids in seed alfalfa because control is questionable while damage to predators and pollinators can be extensive. Control of lygus bugs after seed set is usually unnecessary and very detrimental to predators that feed on lygus bugs. Unfortunately, insecticide applications are commonly based on habit, calendar dates, or actions taken by neighbors, not on actual needs. Applying insecticides in this manner can be very detrimental to an IPM program.

- Early-season pea aphids do relatively little harm to alfalfa in Utah and serve as a source of food for the major predators that can control more serious pests, such as the spotted alfalfa aphid, later in the season. When selecting insecticides to be used during May and June, consider the insecticide's impact on beneficial predators, both direct effects (the elimination of predators) and indirect effects (elimination of predators' food sources).

The Use of Cultural Practices in IPM

1. As discussed earlier, use the available resistant alfalfa varieties.
2. Alfalfa weevils can usually be kept below economic injury levels by harvesting alfalfa slightly early, before extensive injury occurs. This tactic will eliminate the most common insecticide applications on forage alfalfa. If the alfalfa weevil must be controlled by insecticides, apply short-lived insecticides before harvest or apply treatments to alfalfa stubble.
3. Strip-cutting or alternate harvesting of blocks of alfalfa has been very effective in helping predators survive. The adult predators can move among unharvested blocks in pursuit of prey; alfalfa weevils and aphids do not move as readily. This method is effective but has not been widely accepted because it requires more effort by growers.
4. A very complicated ecological interaction exists between adjacent crop systems. For example, lygus bugs will migrate to an adjacent field of seed alfalfa when forage alfalfa is cut. Lygus bugs do not seriously affect forage quality but can seriously damage many types of seed production, including alfalfa. The common practice of staggering alfalfa seed production within an area favors the alfalfa seed chalcid, while synchronizing production can result in effective control. Both pest and beneficial insects commonly develop in uncultivated areas near crops. There are many other examples of similar crop interactions.

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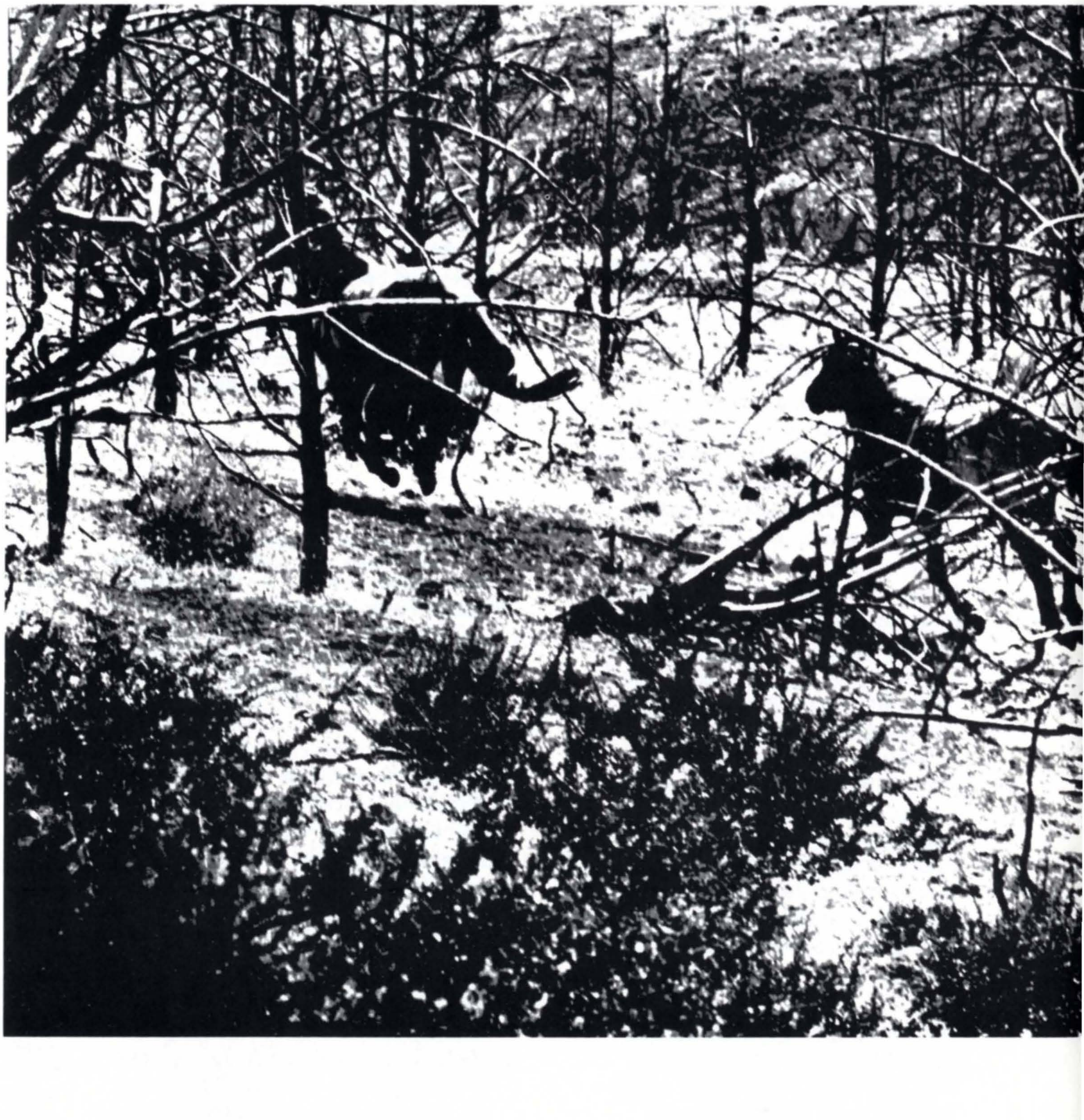
Donald W. Davis is professor in the Department of Biology. His research with the Agricultural Experiment Station concerns integrated pest management programs to control alfalfa insects. The entomologist also studies the life history and control of orchard insects.

PARADOXES and PROBLEMS

in the Horse Industry



J. McArthur

The horse industry in the United States is characterized by some revealing contrasts and paradoxes. Generally, thousands of horse owners have not placed much emphasis on lobbying to promote their interests. But another segment of this country's horse industry, those who view themselves as protectors of wild horses, have effectively conveyed their views, mustered public support for their concerns, and translated that support into legislation.

This has, in turn, spawned other paradoxes. Most of the expenses for programs designed to "protect" wild horses are paid by the government. And even as the number of grade horses has declined, the government is, in effect, raising more of them. Trends seem to indicate that wild horses are in no danger of extinction and that many wild horses removed from the open range will not be adopted but will be cared for by the government until they die. Ironically, these horses are neither wild nor a source of much enjoyment for those who originally sought to protect them.

Number of Registered Quarter Horses Increase

In 1974, it's estimated that 37,367 people owned 132,743 horses in Utah, an average of 3.55 horses per owner. About 30 percent of these horses, or 39,399 head, were registered.(1)

The number of registered Quarter Horses reported in Utah increased from 17,149 in 1973 to 39,337 in 1983, an increase of 129 percent.

As shown in Table 1, a similar increase occurred in the United States during this period. The 11.7 percent annual increase in the number of registered Quarter Horses in Utah (numbers have increased by 11.7 percent in the United States) exceeds the rate of increase in the number of grade (non-registered) horses.

Many lower quality grade horses (and even some higher quality grade horses) have been sold for slaughter, drastically reducing the number of grade horses. This shift in the relative popularity of different types of horses is evident in a decline in the number of grade sales and increase in the number of registered sales. These factors mean that the increase in the number of registered Quarter Horses has not resulted in a similar increase in the total horse population.

In 1983, 150,995 active members in the American Quarter Horse Association registered 168,349 new horses, 11.4 percent of the total horse population. There were about 2,000,000 registered Quarter Horses reported in 1983. The American Quarter Horse Association is this country's largest livestock breed association.

As shown in Table 2, those belonging to dairy and beef cattle breed associations register many more animals per active member than horse owners, although it must be noted that it costs more to produce and manage a horse than other livestock. Thus, horses and their use have a proportionately larger economic impact per animal.

The dairy, beef and sheep owners have strong breed and industry associations that help owners lobby, advertise, and protect their industry. Most of these livestock owners are fully or partially employed in agriculture.

In comparison, the horse owners apparently have a hard time maintaining their breed associations and have relatively little impact on a state basis as an organized industry. These horse owners are employed in a variety of occupations. About the only thing they have in common is their ownership of horses.

Lobbying for Wild Horses

Wild horse fanciers, on the other hand, have well organized groups that lobby nationally to promote their views. For example, one individual, the late Velma Johnston, better known as "Wild Horse Annie," was instrumental in getting Public Law 86-234 passed on September 8, 1959, a law which made it a crime to chase wild horses from a motorized conveyance.

When the law was passed, there were about 20,000 wild horses in the Western states. Over the next 10 years, wild horses could be chased only from horseback. As a result, mainly the weaker, older, and very young horses were captured.

Wild horse numbers remained relatively stable over the next 12 years so most ranchers did not have to contend with large herds of wild horses nor did they appear to be in danger of extinction. Taxpayers were saved the expenses involved in controlling wild horses.

Then a fourth-grade teacher in Oregon told her class about the wild horse slaughter that occurred several years before, prompting students to start a "pencil war" for the preservation of the wild horse, a letter-writing campaign that garnered the support of Wild Horse Annie, the Humane Society, and the Sierra Club, among others.

An Eastern lawyer, Pearl Twine (who admitted that she had little insight into the problem of the wild horse) was the president and founder of the "Wild Horse Protective Organization" who drafted the Hatfield-Jackson Bill which was passed as Public Law 92-195 on December 15, 1971.

A 1972 fact sheet released by the U.S. Department of Interior stated that "BLM estimates that there are some 17,000 wild horses on public domain lands in the Western States. Of these, approximately 7,000 may be branded or privately owned."

Ranchers were given time to round up all privately owned horses. Yet, by 1974, the BLM estimated that there were more than 45,000 wild horses. Most of the "increase" was attributed to BLM's original low estimate.

An Increasingly Expensive Program

Between 1959 and 1972, taxpayers incurred no expenses for wild horse management. In fiscal year 1973, BLM was appropriated $400,000 for wild horse and burro management. By 1983, this had increased to $4,877,000 for BLM and $570,000 for the Forest Service. These figures include costs associated with management plans, animal and habitat inventories, removal and disposition of excess animals, and program administration. Actual expenditures each year have far exceeded amounts allocated for wild horse and burro management.

Most wild horses are found on land administered by the BLM. Fewer than 5 percent of the wild horses are found on land administered by the Forest Service.

Once a realistic population goal was developed in 1974, some horses were removed. The estimated population increased from 45,207 in 1974 to 57,202 in 1978. More wild horses were removed and by 1982 the population had been reduced by 10,000 head. Numbers quickly increased again to 50,385 even when many had been removed in 1982 and 1983.

Wild burros are also a problem in Arizona, California, and Nevada, where it's estimated that there are 10,000 head. These animals are not included in Table 4, although that does not mean they are less of a problem in some states than wild horses.

The Act of 1971 provided that "where the secretary determines...that an overpopulation exists on a given area of the public land and that action is necessary to remove excess animals, he shall immediately remove excess animals."

The act says that old, sick or lame animals should be destroyed in the most humane manner possible. Next, the remaining excess animals are made available for private adoption by qualified individuals exists. Finally, any remaining excess animals which have not been adopted should be destroyed in the most humane and cost-efficient manner possible.

TABLE 1. Total number of registered Quarter Horses in eight western states and the United States.

Area	1973 Head	1983 Head	Increase Percent
Idaho	16,215	40,788	151
Wyoming	15,802	38,141	141
Montana	27,201	63,642	134
Utah	17,149	39,337	129
Colorado	40,109	75,049	87
New Mexico	25,765	46,625	81
Nevada	8,118	14,240	75
Arizona	21,005	36,060	72
U.S. 50 States	931,112	1,916,792	106

Source: 1984 Annual Report of American Quarter Horse Association.

TABLE 2. Number of active members and registered animals by breed association (1983)

	Active Members Number	Registered in 1983 Head	Head/ Member
Horses			
Quarter Horses	150,995	168,346	1.1
Other registered breeds	64,406	67,540	1.1
Total	215,401	237,766	1.1
Ponies	3,125	1,880	.6
Dairy Cattle			
Holstein	28,383	425,385	15.0
Other registered breeds	6,954	110,905	16.0
Total	35,337	536,290	15.2
Beef Cattle			
Angus	26,619	195,267	7.3
Hereford	20,000	151,220	7.6
Polled Hereford	15,997	129,517	8.1
Other registered breeds	42,357	315,563	7.4
Total	104,973	791,567	7.5
Sheep			
Suffolk			
American Society	3,500	23,189	6.6
National Association	9,750	58,994	6.0
Other registered breeds	7,300	54,714	7.5
Total	20,550	136,897	6.7

Source: National Society of Livestock Record Association 1983-1984 Annual Report.

Adoption Fails to keep Pace

In fiscal years 1982 and 1983, BLM and the Forest Service removed a total of 16,892 animals from public lands and placed 12,425 animals in private care through adoption. Of the 4,467 animals removed but not adopted, approximately 1,300 were old, sick or lame and were destroyed. About 500 died during or following capture. The remaining 2,600 were awaiting adoption in feedlots at the end of fiscal year 1983.[2]

In total, approximately 37,900 wild horses have been adopted to date. USU researchers are now determining the fate of the ownership or disposition of those that have been adopted to date.

The adoption fee first established in 1982 was $200 per horse and $75 per burro, plus transportation charges from the distribution facility to the adoption center. On March 3, 1983, the fee was reduced to $125 per horse in an attempt to increase adoptions.

The estimated cost of rounding up and capturing wild horses was $600 per animal in 1983.[2] It was also estimated that it cost the BLM about $2.00 daily to maintain each animal,[2] or about $730 per year.

In October 1974, Congress authorized $17,000,000 to capture and maintain 17,000 wild horses. These horses will be available for adoption, but few will probably be adopted considering the current low prices and demand for domestic horses.

Few would fail to find excitement in watching a wild stallion and mares. Many believe that we should preserve wild horses and burros for others to enjoy. But perhaps it is time to ask how many people will drive to the open country and ride horseback just to see some wild horses, an endeavor which is often expensive, tiresome, and time-consuming. Circumstances indicate that it may be time to re-evaluate the wild horse problem particularly when taxpayers must pay $17,000,000 to catch and maintain horses; many of these horses will be cared for (at a cost of $730 annually per horse) until they die.

TABLE 3. Allocated and actual expenditures for management of wild horses and burros (1972-1983).

Fiscal Year	U.S. Forest Service	Bureau of Land Management
1972	0	0
1973	$200,000*	$ 400,000
1974	200,000*	687,000
1975	200,000*	1,314,000
1976	200,000*	1,272,000
1977	200,000*	2,679,000
1978	200,000*	4,025,000
1979	435,000	4,250,000
1980	450,000	4,582,000
1981	400,000	5,704,000
1982	310,000	5,418,000
1983	570,000	4,877,000

*Estimate by U.S. Forest Service.

Source: Administration of the Wild Free-Roaming Horse and burro Act, 5th Report to Congress, June 1984, USDI and USDA.

TABLE 4. Population estimates by state for wild horses on BLM and national forest lands.

State	1972	1974	1976	1978	1980	1982	1984
Arizona	115	122	112	73	133	180	122
California	265	3,828	5,267	4,081	4,294	4,326	4,602
Colorado	456	500	1,035	990	1,229	650	675
Idaho	257	534	879	1,200	942	887	814
Montana	264	333	266	308	240	208	161
Nevada	8,684	21,174	23,563	32,842	32,211	27,189	30,132
New Mexico	7	7,757	6,699	490	306	250	284
Oregon	2,925	5,480	7,788	4,265	3,683	3,755	1,683
Utah	658	1,045	1,893	2,253	1,835	1,404	1,683
Wyoming	3,245	4,434	8,833	9,700	10,448	9,000	7,959
Subtotals							
BLM		42,666	53,310	54,030	52,374	44,930	48,998
Nat'l Forest		2,541	3,025	3,172	2,947	2,894	1,387
Total	16,878	45,207	56,335	57,202	55,321	47,824	50,385

*Major reductions are due to capture and removal from range.

Source: Administration of the Wild Free-Roaming Horse and Burro Act, 5th Report to Congress, June 1984, USDI and USDA.

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ADOLESCENT

This article presents trends in and consequences of teen pregnancy, and discusses ways of preventing or reducing associated problems.

The problems associated with adolescent pregnancy are related to several controversial topics, including teenage sexual activity, contraception, abortion, and the rights of children versus those of parents. Even the demographic facts about teen pregnancy have created controversy; some analysts claim teenage pregnancies are an "epidemic" while others claim the problem is a "statistical hoax."

RATES AND TRENDS IN UTAH AND THE UNITED STATES

Utah's teen fertility rates have been among the highest in the nation (Utah Department of Health, 1983). Table 1 shows that teen fertility in Utah increased during the 1970s while national rates declined. Factors such as race, marital status, and the distinction between pregnancy and fertility must also be considered, however.

Comparisons between Utah and the United States are most accurately made with national statistics for whites only due to Utah's relatively small (about 5 percent) nonwhite population. Table 1 shows that this adjustment increases the disparity between state and national rates.

Marital status must also be taken into account. The data in Table 1 do not indicate whether teens are married. Because Utahns' average age at first marriage is nearly a year less than the national average, childbearing teens in Utah are more likely to be married. Unfortunately, there is no completely satisfactory way to compare data according to marital status. Subtracting marital births allows a comparison of nonmarital (or illegitimate) births among teens, but many teens marry only because pregnancy is discovered. (One study of the dates of marriage and first birth concluded that 60 percent of first births to teenagers in Utah were the result of premarital conceptions.) Low rates of nonmarital teen fertility in Utah partly reflect Utah teenagers' increased tendency to marry after pregnancy is discovered.

An alternative method of examining adolescent pregnancies is to divide teen pregnancies into two age groups: 18- and 19-year olds (many of whom have graduates from high school and might choose to marry and become parents), and 15- to 17-year-old teens (most of whom are still in high school and would be far less likely to choose to marry and have children).

It is also important to distinguish between pregnancy and fertility. In the past, the number of births to teenagers (fertility) was often used as an indicator of teen pregnancy because the vast majority of teen pregnancies resulted in live births, especially before abortion was legalized in 1973. Today, however, increased abortion rates mean fertility data alone are not an adequate measure of teen pregnancy. Subsequent data in this paper will include both live births (fertility) and induced abortions as major components of teenage pregnancy.

Tables 2 and 3 both show similar patterns of mid- and late-teen pregnancy, abortion, and fertility. Teen fertility is higher in Utah than the United States. Teen fertility in both age groups has increased modestly in Utah while national rates have changed little since the mid 1970s. Teen abortion rates are between two and three times higher in the United States than in Utah although teen abortion has increased substantially in both the state and nation. Utah's teen pregnancy rates (combining childbirth and abortion) are slightly lower than national rates.

Teen pregnancy has increased in the United States but childbearing has been relatively stable or declined slightly since the mid 1970s. Teen pregnancy rates continue to be higher in Utah than in the United States, a difference largely attributed to the difference in abortion rates. About one-half of pregnancies among 15- to 17-year-old teens in the United States ended in abortion during 1980; 40 percent of pregnancies were aborted among 18-and 19-year-olds. Fewer than one in five teen pregnancies in Utah in 1980 were terminated by abortion (19 percent among 15-17 year olds, and 15 percent among 18- and 19-year olds).

It has been estimated that about half the unmarried female teens in the United States in 1979 had experienced sexual intercourse, a dramatic increase from 27 percent in 1971 (Zelnick and Kantner, 1980). A survey of 12 Utah high schools in 1981 found that 21 percent of the females and 24 percent of the males reported having experienced sexual intercourse (Miller et al., 1981). A relatively small proportion of teenagers in the United States use contraception but contraception use is increasing (Zelnick and Kantner, 1980). There are no comparable data on contraception use for Utah.

Even though the sexual activity of Utah teenagers appears much lower than U.S. teens, their pregnancy rates are only slightly lower than national levels, even among the younger 15- to 17-year-old teens who are not likely to be married when they conceive. Although there are no data to support or refute this speculation, contraception is probably less accessible to and less utilized by Utah teens, so that a higher proportion of their sexual experiences result in pregnancy. Compared to national trends, Utah teenagers abort fewer pregnancies and bear more children.

EFFECTS OF EARLY CHILDBEARING

Consequences for Children

Babies born to young mothers are more likely to be underdeveloped at birth and are more prone to develop serious health problems. Birth defects have also been reported to be more common among infants born to teen mothers. Infants born to teen mothers in Utah are almost twice as likely to have low birth weights (under 2,500 grams) compared to infants of mothers 25- to 34-years-old (Utah Department of Health, 1983) Death rates for infants born to teen mothers are much higher than for infants of mothers in their prime childbearing years; newborn death

PREGNANCY AND CHILDBEARING

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rates for teen mothers in Utah are almost double those of mothers in prime childbearing years (Utah Department of Health, 1983). The younger pregnant women are the more likely they are to terminate their pregnancies by abortion.

Several studies have also reported relationships between mother's age and the child's later physical health and social and cognitive development (Baldwin and Cain, 1980). Infants born to teen mothers have somewhat lower I.Q. scores, less favorable social and emotional development, and poorer health up to 7 years of age. Data from other studies suggest that teen mothers are less aware of normal child development, more likely to use physical punishment, and more likely to exhibit poor mothering behaviors that some have linked to higher risk of child abuse and neglect (Elster, et al., 1983; Roosa et al., 1982).

The initial health risks for infants of teen mothers appear to be largely due to poor maternal nutrition and poor prenatal care, not due to the mother's biological immaturity (Baldwin and Cain, 1980). The later health, social, and cognitive deficits of children born to young mothers are probably the result of the mother's social, educational, and financial disadvantages. Whatever the cause, the implications for children are still the same: a child of a teen mother is less likely to survive the first year of life, and is more likely to experience continued health problems, and have social and cognitive disadvantages. In general, the younger the mother, the more likely her child will be affected.

Consequences for Teen Parents

Obstetrical complications such as toxemia, anemia, and prolonged labor are more common among teen mothers than women in their twenties. Given similar quality prenatal care, however, the relationship between age and obstetrical complications disappears except for the youngest teens who are biologically immature (Roosa, et al., 1982). While older teens who have good prenatal care experience minimal health risks due to childbearing, they still experience the social and economic effects associated with an early first birth.

Young mothers are more likely to have unwanted and illegitimate children. About half of teen mothers interviewed soon after birth of their first child said they wished the child would have been born later or not at all; three years later, over three-quarters of the same mothers expressed this regret (Baldwin and Cain, 1980). Even after the first child was in first grade, women who had been teen mothers were more likely than older mothers to report those negative feelings. Another study found that early first birth was linked to a decrease in a mother's sense of personal efficacy (McLaughlin and Micklin, 1983). Teen mothers are much less likely to complete high school, or go on for further education, and are more likely to hold jobs with low pay and prestige which offer little job satisfaction (Card and Wise, 1978). Many teen mothers must decide whether to marry while dealing with the emotional pressures associated with pregnancy.

The potential negative psychological, social and economic consequences for a young father depend on whether he marries the mother, and the degree to which he supports and rears the child. Early family formation usually forces males into the labor force. Young fathers are more likely to earn higher salaries than their peers, but a decade later hold jobs at lower pay and prestige than their classmates who did not begin families so young (Card and Wise, 1978).

Those who marry young are more likely to express regrets about their marriage; marital dissolution rates increase as the age of marriage partners decreases. One recent study (Teachman, 1983) estimated that only 56 percent of the marriages of white women who marry before the age of 16 will last 15 years, compared with about 90 percent of those who marry between the ages of 20 to 24. Marriage before the age of 16 and a premarital birth increased marriage dissolution rates by 453 percent.

Consequences for Grandparents

Grandparents—especially grandmothers—are usually affected by teen childbearing. A large majority of single teen mothers live with their parents, usually for several years (Zelnick, et al., 1981). Teen parents often rely on their parents for financial help and child care. The emotional and psychological costs to grandparents are probably important but are not well documented. Grandparents who may be starting to have the freedom and resources to pursue their own interests may have to help care for dependent children and grandchildren, an unexpected and unwelcome turn of events.

Consequences for Society

Teen childbearing has several adverse consequences for society if infants are disadvantaged and teen parents do not achieve their educational, occupational, and financial potential. Society loses their potential contributions to the economy and the tax base, and there are direct public sector costs such as Aid to Families with Dependent Children (AFDC), Medicaid, food stamps and foster care. In 1975, it's estimated that $8.55 billion was spent in government programs for AFDC households in which a teenage mother had borne her first child (Baldwin, 1982).

REDUCING TEEN PARENTHOOD

Pregnancies and childbearing at young ages will no doubt continue. Even though some teen parents successfully overcome the problems associated with early family formation, most would have fared better if they had delayed parenthood.

Sexual Abstinence

Since 1978, the federal Office of Adolescent Pregnancy Programs (OAPP) has provided care services for adolescent parents and their children in an attempt to mitigate the negative consequences of teen parenthood. Passage of the Adolescent Family Life Bill in 1981 gave OAPP a legislative mandate to prevent early pregnancy as well. National prevention demonstration projects try to reach adolescents before they become sexually active. This legislation (dubbed the "Chastity Bill") focuses on premarital sexual abstinence, family involvement, and adoption. The effectiveness of legislation to reduce teen sexual activity will not be known for several years.

Sex education in the public schools is still a controversial topic, but the data clearly show that most parents do *not* take an active role in deliberately teaching their children about sex. When they do, however, parents seek to prevent or postpone early sexual behavior (Miller, et al., 1981). Perhaps if parents, churches, schools, and other community agencies cooperated in conveying information and values about sex, these efforts would be more effective in preventing early sexual activity, pregnancy, and parenthood.

Contraception

Both private and federally sponsored agencies have provided contraception to sexually active teens. Research suggests that making contraceptives available to teens does not encourage early sexual activity. Few teens use contraception in their first sexual experiences and most teens who visit family planning clinics for contraception are already sexually active (Zelnick et al., 1981). It is not known whether sexually active teens are more promiscuous when contraception is available. There appears, however, to be little empirical basis for the presumed relationship between contraceptive availability and the beginning of teen sexual activity.

Those who believe in premarital sexual abstinence sometimes oppose contraception for teens. Even though sexual abstinence is the surest way to prevent teen pregnancy and its related problems, discouraging teens who choose to remain sexually active from using contraception does not solve the problem.

Abortion

Abortion was legalized in the United States in 1973 and more Americans now accept abortion in principle. Still, many strongly oppose it. Teenagers account for about one-third of all abortions performed in the United States; even though parents must be notified and give their consent. Although nearly half of pregnant teenagers end their pregnancies by abortion, Americans are deeply divided over whether abortion is an answer to the problems of unwanted teen pregnancies.

> "Utah's teen fertility rates have been among the highest in the nation."

Adoption

Adoption does not prevent teen pregnancy, but can prevent some of the negative consequences associated with early parenthood. Most teen parents are at least ambivalent about parenthood, and many are not ready to care for a child. Adoptive parents want to have a child and are usually carefully screened. The 1981 Adolescent Family Life Bill sought to "promote adoption as an alternative for adolescent parents." Legalized abortion and a reduced stigma toward unmarried parents meant that less than 5 percent of unmarried teen parents released their babies for adoption in 1976; nearly two-thirds did so in the mid-1960s.

More pregnant teens, especially younger teens, might consider adoption if it were more actively promoted as an alternative. Except for older teens already seriously committed to their relationship, research suggests that it is often a mistake for young teenagers to marry because of pregnancy. Sometimes the mother and/or grandparents decide to raise the child. As Nye and Lamberts (1980, 16) wrote: "Although adoption may be best for the baby, the school age parents, and every one else, it is frequently a difficult decision of the young mother... even if she is convinced that the child should be adopted, she sometimes experiences pressure to keep the child from school friends or even occasionally from the grandparents or the father."

REFLECTIONS AND CONCLUSIONS

Teen sexual activity and pregnancy are increasing in the United States even though teen childbearing rates have declined and are remaining fairly stable, largely because of increasing abortion. Teens in Utah are less likely to be sexually active than teens elsewhere, but Utah teens are probably less likely to use contraception. As a result, teen pregnancy rates in Utah are close to the national level and, like the national trend, are increasing. Utah teens are definitely less likely to terminate pregnancy by abortion, so a higher percentage of teens in Utah, even those 15-, 16-, and 17-years-old, have children.

These trends in adolescent pregnancy are cause for concern. Babies deserve to be born healthy and have good care; adolescents should have the opportunities to develop to their full potentials; grandparents prefer that their children are capable of rearing healthy, happy children, and others are concerned about the economic costs of adolescent childbearing.

Efforts to encourage sexual abstinence can and probably should take place through families, churches, schools, and other community agencies. Parental involvement is important in these programs. Contraception is not very effective in preventing teen pregnancy since most teen sexual behavior is unplanned; still, it seems irrational to deny contraception to sexually active teens. Abortion has reduced teen fertility nationally, but is much less common in Utah. Few teen mothers relinquish their babies for adoption even though adoption can be a viable alternative.

It appears that increasing numbers of pregnant Utah teenagers will either marry and/or to raise children with the help of their parents. Some of these fragile family beginnings will succeed, but many will fail to provide a nurturing, healthy environment for the parents and the children. Teen pregnancies are associated with increased costs to grandparents and to society because young parents are less

TABLE 1. Teen-age fertility rates,[1] 15-to-19 years of age: Utah and United States, 1970-1980.

Year	Utah	United States: All Races	United States: Whites Only
1980	65	53	45
1979	64	52	44
1978	62	52	43
1977	61	53	44
1976	57	53	44
1975	56	56	46
1974	55	58	48
1973	56	59	49
1972	56	62	51
1971	55	65	54
1970	57	68	57
Percent Change 1970-1980	+14%	−22%	−21%

[1]Fertility rate is the number of live births per 1,000 15- to 19-year-olds.
[2]Adapted from Table 2, Utah Department of Health (1980) updated with 1980 census based revisions from Tables B1 and B2, Utah Department of Health, 1983, and Table 4, *Monthly Vital Statistics Report*, Vol. 31, No. 8, Supplement, November 30, 1982.

TABLE 2. Pregnancy data for white females, ages 15-to-17, in Utah and the United States, 1975-1981.[1]

	Fertility Rate[2]		Abortion Rate[3]		Pregnancy Rate[4]	
Year	Utah	U.S.	Utah	U.S.	Utah	U.S.
1981	34.8	N/A	7.7	N/A	42.5	N/A
1980	36.5	25.2	8.6	24.8	45.1	50.0
1979	34.9	24.7	8.0	23.4	42.9	48.1
1978	34.3	24.9	6.0	22.8	40.3	47.7
1977	35.5	26.1	6.1	18.7	41.6	44.8
1976	32.5	26.3	6.4	18.0	38.9	44.3
1975	31.3	28.0	5.3	18.1	36.6	46.1
Percent Change 1975-80	+17%	−10%	+62%	+37%	+23%	+8%

[1]Data taken from Tables 4 and 5 of *Teenage Pregnancy in Utah 1975-1981*, Utah Department of Health, August 1983.
[2]The number of live births per 1,000 15- to 17-year-olds.
[3]The number of abortions per 1,000 15- to 17-year-olds.
[4]The addition of fertility and abortion rates provides an estimate of the number of pregnancies (not including spontaneous abortions).
N/A = Not Available.

TABLE 3. Pregnancy data for white females, ages 18-to-19, in Utah and the United States, 1975-1981.[1]

	Fertility Rate[2]		Abortion Rate[3]		Pregnancy Rate[4]	
Year	Utah	U.S.	Utah	U.S.	Utah	U.S.
1981	106.4	N/A	18.9	N/A	125.3	N/A
1980	100.4	72.1	17.8	51.7	118.2	123.8
1979	102.8	71.0	17.9	49.5	120.7	120.5
1978	100.3	69.4	16.0	49.2	116.3	118.6
1977	96.7	70.5	17.3	40.5	114.0	111.0
1976	90.7	70.2	13.9	36.4	104.6	106.6
1975	90.1	73.9	14.1	32.4	104.2	106.3
Percent Change 1975-80	+11%	−2%	+26%	+60%	+13%	+16%

[1]Data taken from Tables 6 and 7 of *Teenage Pregnancy in Utah 1975-1981*, Utah Department of Health, August 1983.
[2]The number of live births per 1,000 18- to 19-year-olds.
[3]The number of abortions per 1,000 18- to 19-year-olds.
[4]The addition of fertility and abortion rates provides an estimate of the number of pregnancies (not including spontaneous abortions).
N/A = Not Available.

likely to be able to support themselves or reach their full potential. Solutions to the problems associated with adolescent pregnancy will require more emphasis on prevention and an increased tolerance of different values.

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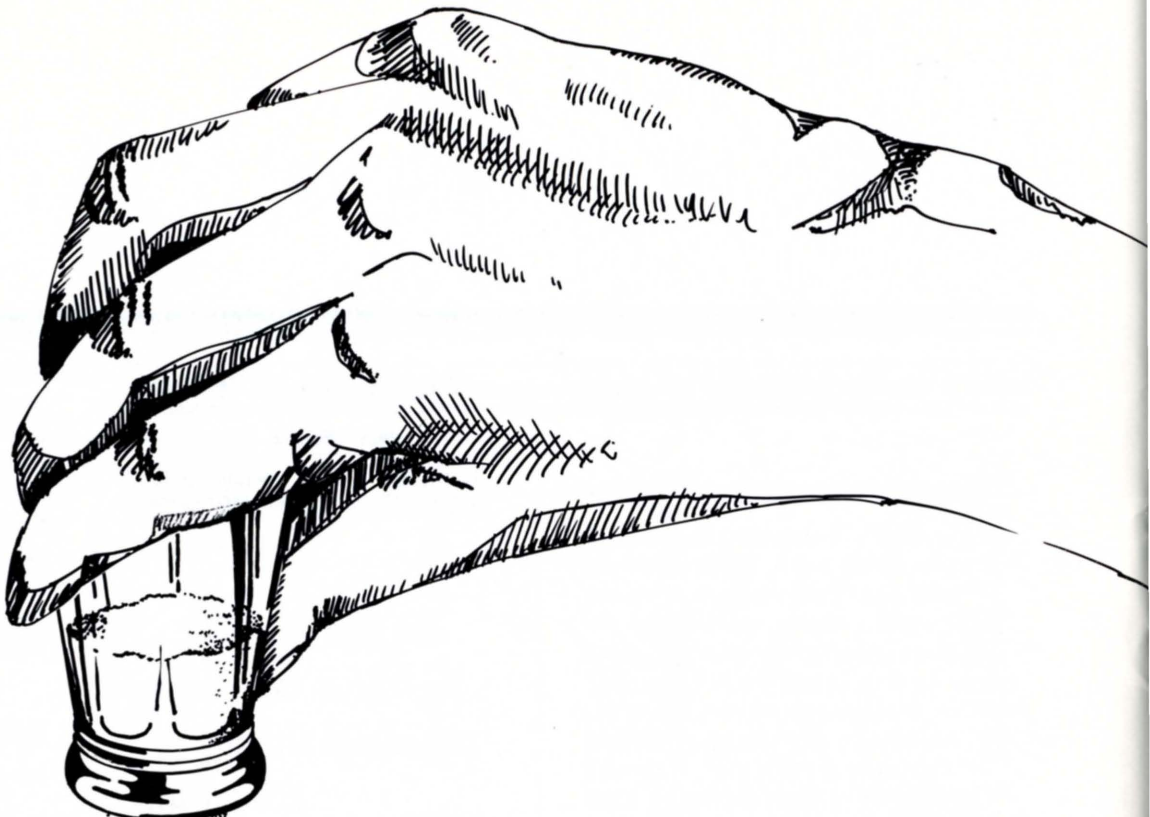

he SEARCH for Salt-Tolerant Alfalfa/*Rhizobium*

In the late 1950s, Bernstein and Hayward (1958) estimated that some salt or sodium (Na) had accumulated in as much as 30 percent of the irrigated land in the United States. This area has increased since then as more marginal land has been put into production and lower quality waters have been used.

In Utah, approximately 4.5 million hectares (ha) (slightly more than 11 million acres) or about 21 percent of the state's land is saline. Salt-affected lands are found in 17 western states where most of

the irrigated land in the United States is located. Levels of salinity harmful to plant growth occur on approximately 4×10^8 ha (9.9×10^8 acres), approximately 40 percent of the potentially arable land in the world. Soils of semi-arid to arid regions already contain relatively large amounts of salt due to high evaporation rates. Dissolved solids in irrigation water further increase salinity.

Many think of chloride salts, particularly sodium chloride, when they refer to salinity. Salinity, however, can also be due to sulfates, and bicarbonates of sodium, calcium, magnesium and potassium.

Fortunately, there are several ways to reduce the potentially damaging effects of salt accumulation in agricultural soils. A common and highly successful procedure to reclaim salt-affected soils involves leaching large volumes of water through soil profiles to reduce the concentration of salt. Some chemicals can accelerate the movement of salt and water. Improving drainage can facilitate salt leaching.

Although these procedures have been used to maintain large areas of land in agricultural production for hundreds of years, productivity could be further increased if crop plants were better able to tolerate high levels of salt. Advances in physiology, genetic engineering, and tissue culture have shown this might be possible in some crop plants and nitrogen-fixing bacteria. Salt-tolerant crops would make agricultural production possible on millions of acres by using brackish and saline waters for irrigation.

Many researchers have studied the effects of soil salinity on plant growth. There is a great deal of information on how soil salinity affects interrelationships between legumes (*Fabeaceae*) and *Rhizobium* bacteria, but limited attention has been given to locating salt-tolerant legumes and rhizobia. Leguminous crops will directly or indirectly provide more dietary protein for millions of people because, as many believe, the existing worldwide dietary protein shortage is due to a shortage of nitrogen available for protein synthesis. Legumes inoculated with appropriate *Rhizobium* can fix atmospheric nitrogen into an available form without large amounts of expensive nitrogen fertilizer. Residual nitrogen can be used by companion or succeeding crops.

Bacteria of the genus *Rhizobium* in root nodules synthesize nitrogenase, the enzyme that catalyzes biological nitrogen fixation. It has been estimated that the world's legumes, which include beans and peas, fix 35 million metric tons of atmospheric N_2 annually. At present prices, this nitrogen is worth over $8 billion.

Alfalfa, *Medicago sativa* L., one of the most widely grown legumes, provides forage for animals and increases soil fertility with the aid of effective strains of *Rhizobium mililoti* L. Alfalfa's ability to fix nitrogen, however, is affected by the strains of bacteria and environmental factors such as salinity. These factors limit where alfalfa can be established and reduce growth, yield and nitrogen fixation.

Compatible *Rhizobium* for salt-tolerant alfalfas, must be identified to fully utilize alfalfa's ability to fix nitrogen in soils that are marginally saline. For example, examination of plants from two alfalfa fields within 2.4 kilometers (km) of the south shore of the Great Salt Lake failed to show any live nitrogen-fixing bacteria or even root nodules. Since samples were taken late in the growing season and plants were entering winter dormancy, the bacteria may also have been dormant. We were unable, however, to locate any residual nodules on numerous excavated plants.

USU scientists are studying alfalfas from droughty and saline areas around the world which have been collected by plant breeders in the intermountain west. Over 25 cultivars, germplasm releases, and/or breeding lines of alfalfa have been identified that germinated and survived without injury at an electrical conductivity (EC) of 20 decisiemens per meter (1 dS/m = 640 mg/L = 11 mM sodium chloride) at 25°C. A few alfalfa lines survived at 28 dS/m.

USU scientists also want to identify salt-tolerant *Rhizobium* that are infective and effective with salt-tolerant alfalfa germplasm. Extensive efforts to acquire salt-tolerant *Rhizobium meliloti* bacteria have been hampered by lack of information on salt tolerance in rhizobia. Collections from various bacterial laboratories* in the United States have been obtained that grew on plants from many semi-arid and arid regions of the world. Samples were also collected from the Great Basin area and from dry regions in an attempt to determine whether drought-tolerant bacteria are also more tolerant to salt. Thus far, more than 90 accessions have been collected and more than 10 strains of *Rhizobium meliloti* have been identified that grew at an EC of 56 dS/m—approximately equal to 3.5 percent salt (sea water). Some of these strains even grew at 64 dS/m. Some rhizobial strains grew slowly in saline conditions while others grew rapidly. Experiments will determine if the rate of growth is related to *Rhizobiuim's* ability to tolerate salinity, drought and temperature stresses. Bacteria will then be tested for infectiveness and effectiveness with the salt-tolerant alfalfas.

Snakes, deer flies, and mosquitoes have been encountered in the search for the elusive salt-tolerant *Rhizobium*. Locating even one salt-tolerant bacterium compatible with salt-tolerant alfalfa will be a significant step toward converting more atmospheric nitrogen into a form usable by plants.

*The Cell Culture and Nitrogen Fixation Laboratory, Beltsville, Maryland; The Nitragin Company, Inc., Milwaukee, Wisconsin; The Nitrogen Fixation Company—Urbana Laboratories, Urbana, Illinois; and CepPril Industries, Inc., Manteca, California.

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