grain scarcities are leading to —

MEAT AND MILK FROM FORAGE
MEAT AND MILK FROM FORAGE

By the most conservative estimates, 460 million people are threatened with starvation today. Ten million will probably die this year, mostly children under five years of age. Secretary Kissinger has said that the United States, as a major producer known for its productivity and tradition of advanced technology, must take a major lead in fostering solutions.

One solution is to find a cheaper way of producing meat and milk – that is, without a large consumption by livestock of grain which humans can eat. This issue of Utah Science explores the way we can produce meat and milk from forage, how we can produce better and more plentiful forage, and what the economic outlook is for farmers and ranchers in the West.

TABLE OF CONTENTS

Forages for Livestock Production ................................................. 3
R. Dean Plowman

Square Pegs in Round Holes? Cattle on Traditional Sheep Range .......................... 5
John C. Malechek and Arthur D. Smith

Utah’s Rangeland Development Program — Research and Theory to Application .......... 8
Frank E. (Fee) Busby

Beef from Rangelands — A glance at the future .................................. 11
John P. Workman

New Grasses for Western Rangeland ............................................. 15
K. H. Asay

Forage Fattened Cattle — A new look at an old practice ............................. 19
Clair R. ACord

To Convert Forage to Milk, You Need Cow and Land Efficiency ......................... 21
M. J. Anderson, G.E. Stoddard, and R.C. Lamb

High Quality Hay for Dairy Cattle ................................................. 23
M.J. Anderson

First — Get the Seeds .................................................................... 26
P.F. Torchio and F.D. Parker

Alfalfa Insects .............................................................................. 30
Donald W. Davis

Alfalfa Nematodes ........................................................................ 33
W.F. Campbell and G.D. Griffin

Crime in the Onion Patch ............................................................... 40
W.F. Campbell and W.P. Nye

Index, Volume 35 ......................................................................... 36

Cover photo by M.J. Anderson

UTAH SCIENCE

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UTAH SCIENCE
FORAGES FOR LIVESTOCK PRODUCTION

R. Dean Plowman

Will we have an animal-producing agriculture in the future? If so, how will it operate? Recent pessimism about the world's ability to feed itself has generated urgent questions about the manner in which food is produced to meet world needs. Those who predict a diminishing role for animals point to their relative inefficiency in converting calories and protein to human food, and they emphasize competition between humans and animals for nutrients, particularly in the case of cereal grains.

The arguments presented suggest that modern husbandry methods, which use large amounts of cereal grains in meat, milk, and egg production, make these grains unjustifiably unavailable to people who need them.

Such arguments tend to underestimate or overlook the extent to which animals can produce human food nutrients from land crops, materials and/or wastes that are unsuitable for any other productive use. The ruminants (sheep and cattle are prime examples) rank high in this capacity to use coarse, fibrous, bulky materials as food. If it were not for the unique digestive process of the ruminants, millions of acres of rangelands would go largely unused in the production of human food—a waste that is hardly consistent with the world's critically increasing need for food. The transformation of forage-held carbohydrates and proteins into edible meat and milk would be prohibitively costly to duplicate by any other means.

Historically, milk and milk products have been an important part of the diet of most United States citizens. Their nutritional value is widely acknowledged. They are the only natural food that contains all of the essential amino acids necessary for proper growth and development (Table 1), providing in addition many of the important vitamins in today's average American diet.

Beef is the other main source of protein in the American diet (Table 2), supplying large amounts of other important elements.

It is truly lamentable, therefore, that today's livestock industry is in serious trouble. Dairymen are going out of business at an alarming rate. Since 1960, our dairy cow population has decreased by 35 percent. Between 1960 and 1970, however, rapid increases in production per cow nearly offset the decrease in numbers, and thus our national needs were met. But last year, though we produced approximately 115 billion pounds of milk, we were...
Genetic and other research should be able to develop a means by which animals can utilize grasses, legumes, and other forages as a higher proportion of their diet and still produce at a satisfactory level.

Table 1. Milk and milk products

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<th>% Provided In Average American Diet</th>
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<tr>
<td>Protein</td>
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<td>Food Energy</td>
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<td>Fat</td>
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<tr>
<td>Calcium</td>
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<td>Phosphorus</td>
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Table 2. Beef

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<th>% Provided In Average American Diet</th>
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<tbody>
<tr>
<td>Protein</td>
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<tr>
<td>Total Energy</td>
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<td>Fat</td>
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Table 3. All meat and dairy products

<table>
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<th>% Provided In Average American Diet</th>
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<tbody>
<tr>
<td>Protein</td>
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<td>Calories</td>
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4 billion pounds behind the 1970 production. Last year also marked the first time since records began to be kept that production per cow decreased. If this trend continues, we can't possibly meet the milk and milk/products requirements of the country as estimated for 1980.

Beef producers are also going out of business. Current prices paid for feeder calves, fat cattle, and breeding stock are low. Prices received by growers are well below their costs of production. Cattlemen are dispersing their herds as soon as they can find a market for them. The only way to stop this trend is reduce the cattlemen's costs of production or pay him higher prices for his product.

A partial solution to the long-term dilemma of high feed costs for ruminant animals and projected shortages of grain needed for human consumption is to promote greater animal dependence on nutrients from high quality forage. Forages now provide about 60 percent to 65 percent of the nutrients fed to dairy cattle. The percentage is much higher for beef cattle and sheep. It could go higher still in all these instances. Genetic and other research should be able to develop a means by which the animals can utilize these grasses, legumes, and other forages as a higher proportion of their diet and still produce at a satisfactory level. New varieties of forages and/or new ways of using forages and by-products must be developed to optimize profits for the livestock producer. The potential for improving their yields as well as their utilization, and therefore the livestock returns from these crops, is great and obviously worth achieving. The efficiency of forage production has suffered the past 10 years as research effort devoted to them decreased and was thinly spread over numerous species of grasses and legumes.

The developing research effort to improve forages for livestock will require much new technology as well as more effective use of what is available. Technology is required to: (1) breed improved, higher yielding, more adaptable, and more nutritious grasses, legumes, and other forage crops; (2) upgrade land, water, and cultural management and animal management on grasslands; (3) revise methods of harvesting and conserving forages to reduce losses and maintain acceptability and nutritive value; and (4) increase consumption, digestibility, and utilization of the nutrients for greater animal production.

An attainable research goal for 1985 is to have livestock depending on forage for 10-20 percent more of their total energy than they do at present. The challenges are obvious — the imaginative solutions are being discovered within the agricultural research community.

R. Dean Plowman is Area Director, ARS, USDA, Logan, Utah.
Square Pegs in Round Holes?

Cattle on Traditional Sheep Range

John C. Malechek and Arthur D. Smith

Present market trends and forecasts of experts point to a major shift from sheep to cattle ranching over much of the west. Spurred on by the unfavorable economics of sheep production over the past 30 years, this shift will be augmented by the recent emphasis on forage-finishing cattle in the face of high grain prices.

Professional land managers are now asking the question: “What are the environmental impacts of grazing cattle on rangelands long ago determined to be the most suitable for sheep?” Of greatest concern here are the arid ranges in the western and southern part of the state that produce most of their forage crop in the form of shrubs or browse plants. Historically, these ranges have been used primarily during the winter by sheep when there is little potential for harming the dormant plants. These sheep are usually moved (some flocks over hundreds of miles) to higher elevation rangelands for the summer grazing season.

The emerging problem is that cattle operations are generally not as mobile as sheep operations and the opportunity for migration to high elevation summer range is not as great. More and more cattle, therefore, are likely to find themselves on desert shrub ranges all year long. Work conducted by the Range Science Department at USU in past years suggests that late spring and summer grazing is potentially harmful to the physiological processes of palatable desert shrubs. (1) Although specific and detailed research is not available, particularly for the summer season, it’s certain that changes in the use of these traditional winter ranges must be accompanied by carefully planned grazing systems if deterioration is to be avoided.

Cattle on arid ranges

Under future conditions when more demand will be placed on all kinds of rangeland for beef production, caution and only the best technical information available will ensure efficient production without undesirable changes to rangeland plant productivity. By the same token, efficient production will result by using only the animal most adapted to the particular range environment.

Beef cattle breeding and development have been directed primarily toward an animal that performs well on a ration high in cereal grain concentrates.
The rugged and legendary longhorn may offer potentials for crossing on our conventional beef breeds.

water, alternatively hot and cold temperatures, and rough terrain. We may be entering an era of increased demand for range-fed beef with a "Cadillac" animal when in fact we need one designed along the lines of a "Jeep." This is a question that has yet to be faced by a cattle industry still vibrating from shocks of a major about-face in its system of beef production.

Fortunately, we do have a limited amount of information from forward-looking ranchers and researchers who long ago realized the importance of environmental adaptability in range beef animals. For example, work done by scientists at New Mexico State University (2) suggests that cattle with some Zebu in their bloodlines (Santa Gertrudis in this case) tend to walk farther and eat coarser plants that Herefords on the same range. Other work has shown the higher tolerance to heat and water stress imparted by the Zebu breeding.

A practical example is the crossing of Africander, Hereford, Angus, and Santa Gertrudis breeds by the Bard-Kirkland Ranch in west-central Arizona. There, nine major points are used in selecting animals well adapted to the rough Arizona range conditions (3):

1. Well-structured feet and legs to handle rough country
2. Ability to utilize shrubs as forage
3. A slightly longer head, reputed to be indicative of gaining ability
4. High fertility
5. Ease of calving
6. Motherability
7. Heat tolerance
8. Insect resistance
9. Beef conformation

Similar opportunities for improving beef cattle adaptability exist on ranches here in Utah, and such programs should be aided and directed through appropriate research findings.

What about exotics?

Any discussion of meat production from arid rangelands sooner or later turns to the question of such exotic species as the eland, goat, camel, and even more rare and mysterious species. When one considers the relative inefficiencies in harvest and management of such species, however, to say nothing of the major shift in human diets and preferences that large-scale production of such animals would necessitate, their extensive use is probably decades into the future.

Recent news releases have made much over the potentials of one of our own native "wild" animals in this regard — the American Bison. While crosses of this animal on domestic cattle (called the "Beefalo") are reputed to grow rapidly and produce a highly desirable carcass that contains more protein than beef (4), such claims are presently unfounded scientifically. Recent research in Colorado (5) has shown, however, that the pure American buffalo is apparently more efficient in digesting poor quality roughage than is the domestic cow. Future range cattle with some bison breeding in their bloodlines might well impart desired traits necessary for rangeland conditions.

Another rather exotic bovine often mentioned in discussions of animal adaptability is the longhorn. Legendary as a rugged animal well...
suited to the vagaries of climate and poor forage conditions on range-lands, this animal may also offer potentials for crossing on our conventional beef breeds.

The foregoing is largely "brain-storming." It points to a couple of valid needs, however — the need for better understanding of the impacts of cattle on our fragile desert ecosystems not previously grazed by cattle and the need for a beef animal well adapted to growth and production on a diet of range forage. Presently we can only make educated guesses about such important questions as the correct levels of forage utilization, seasonal impacts, and stocking rates for cattle on arid shrub ranges. Information is sorely needed by both the professional land manager and the stockman.

Utah State University has recently been at the forefront in development of an international program for sheep improvement (see Utah Science, June 1974). A center for the study of sheep and goats is presently located on campus.

Perhaps a similar broad-front approach aimed at other kinds of livestock is in order.

**Literature Cited**


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Utah's Rangeland Development Program: Research and Theory to Application

Frank E. (Fee) Busby

Approximately 86 percent of Utah's 52 million acres of land is rangeland. Utah's deserts, mountains, scenic canyons, foothill areas, grasslands, pinyon-juniper woodlands, sagebrush areas, mountain meadows, and salt desert shrublands are all classified as range. Forests generally have herbaceous vegetation growing beneath the trees, and that vegetation is often managed as range. But what are the common characteristics of all these diverse land types that make them range?

First, all of these areas produce grassy, herbaceous, or shrubby vegetation that can be eaten by wild or domestic animals. Except for the time that they might feed off a farmer's haystack, our deer and elk herds are totally dependent upon rangeland for their food and cover. The same is true for most of our smaller game and nongame birds and animals. Utah's multimillion dollar beef and sheep industries are largely dependent on range production, using rangelands to supply most of the needed forage. The dairy industry does not extensively utilize rangelands.

Second, rangelands are usually not subjected to intensive agronomic manipulation practices such as regular cultivation, irrigation, fertilization, and mechanical harvest of the forage crop. Range management is based on the ecological characteristics of the land area. Ideally, proper range management results in the sustained yield of the products a manager desires without large inputs of energy and materials.

Importance of Rangeland to Utah

Utah's rangelands are used by many people for many purposes. The conservation, improvement, and management of rangelands for present and future use is vitally important to the tourist seeking scenery or open space; the recreationist seeking an enjoyable outdoor experience; the urban resident demanding a high quality water supply; the person interested in a healthy, viable wildlife population; the consumer desiring an economical diet that includes red meat products; and the rural family and community depending on livestock grazing for their livelihood and economic stability. Fortunately, under proper management these multiple uses and values are compatible.

Despite their importance — and while considerable improvement has been made in recent years — Utah's rangelands remain one of the most neglected and underdeveloped resources. Past grazing use — carried out before adequate knowledge about the range environment was available — caused a
Range improvement is one of the best ways that rural development can be accomplished in Utah.

deterioration of many ranges. Originally diversified plant communities have been replaced by less desirable, nearly pure stands of such species as sagebrush, halogeton, pinyon-juniper, wyethia, or cheat grass. This situation has resulted in accelerated soil erosion, sedimentation, and unstable plant communities. These depleted ranges have less value for all uses of man and grazing animals than lands that have been developed to their potential.

Range specialists and research findings have found that proper range development and management practices can economically correct these conditions and increase plants desirable for livestock forage, wildlife habitat, and watershed protection as much as 2 to 10 times on some of our poorer ranges. Range improvement is one of the best ways that rural development can be accomplished in Utah.

Production from Utah’s rangelands accounted for over 125 million dollars of livestock products in 1974. If the multiplier effect of agricultural production is considered, our rangelands contributed $350 to $500 million of economic activity to the State. If these ranges were developed to their potential, livestock production from them could easily be doubled. Utah’s economy could use that kind of “shot-in-the-arm.” In addition, all other rangeland uses and values would benefit.

Reduction of livestock numbers and adoption of proper management practices has generally stopped the deterioration of Utah’s rangelands. Depleted ranges, however, particularly in the arid and semi-arid areas of Utah, improve very slowly when “properly managed.” If the full potential of goods and services is to be produced from rangelands, improvement practices must be combined with proper management practices. Improvement practices which are successful when properly planned and applied include control of undesirable brush species, range seeding, fertilization, water development, fencing, and water spreading. Livestock management practices can result in better livestock distribution, better nutrition, and increased reproduction rates.

Utah’s Rangeland Development Program

Utah’s Rangeland Development Committee was established by Utah’s Agricultural Development Council (Utah State Department of Agriculture) in January 1973. Committee membership includes representatives of the agencies and organizations most concerned with the development and management of the state’s range resource. Forest Service, Bureau of Land Management, Soil Conservation Service, Agriculture Stabilization and Conservation Service, Farmers Home Administration, Intermountain Forest and Range Experiment Station, Utah Cattlemen’s Association, Utah Woolgrowers, Multi-County Planning Districts, Utah Wildlife Federation, Utah Agriculture Land Owners Association, Utah Association of Soil Conservation Districts, Utah Department of Agriculture, Utah Division of Wildlife Resources, Utah Division of State Lands, Utah Division of Indian Affairs, and USU Extension. The purposes of the Committee are to:

1. Develop and maintain in a current status a Rangeland Development Program for Utah. This Program would identify major uses and values of Utah’s range resource, establish goals to meet its future demands and describe what is needed to accomplish these goals.

2. Improve awareness of the general public of the importance of rangelands to our state’s economy,
and of the increased potential that can be realized from the multiple use of our ranges.

3. Coordinate range management, wildlife management, administration, technical assistance, education, and research programs among the various agencies, organizations, and individuals concerned with the proper management of Utah's rangelands.

4. Stimulate range, watershed, and wildlife improvement programs by working with land owners and administrators to set goals for private, state, and federal land improvement projects and assist where possible in supporting and strengthening these organizations by gaining public endorsement and needed finances.

Immediate priorities of the Committee are 1) establishment of a state-supported loan fund to assist ranchers in developing their private lands, 2) increased funding for Federal and State Agency range development programs, and 3) expansion of education programs. Development and achievement of a "State Rangeland Development Plan" is a major long-term priority.

**Research to Application: Ranch Management**

One of the programs being conducted by Utah State University as part of the State Range Development Program is the "Demonstration Ranch Program." This project is funded by the Four Corners Regional Commission. Several small areas exist in Utah where range specialists have demonstrated successful range improvement practices. A few ranchers have utilized these management practices in developing their ranches; however, many ranchers still ask if the improvements are worth the time and money required to implement and maintain them.

The purpose of the Demonstration Ranch Program is to demonstrate and document the environmental and economic impact of range and livestock development on the total ranch operation. The program involves 1) working with a rancher in inventorying his resources and identifying his management objectives, 2) determining what range or livestock problems
are presently preventing him from achieving his objectives, 3) aiding the rancher and concerned agencies in developing a plan to solve these problems, and 4) providing any technical or financial assistance available to implement the plan. When completed, the ranch studied and the accumulated environmental and economic data will be used to demonstrate to other ranchers and the public the value of range development.

The Demonstration Ranch Program stresses cooperative effort between the rancher and all concerned agencies. Rather than the rancher working under three management plans (one each for his Bureau of Land Management and Forest Service allotments, plus his private ranch plan), the Program hopes to promote the cooperative development of one. This does not mean that an agency loses its identity or has its responsibility weakened, but it does mean that all range planners working with a rancher are aware of what each other is doing. This cooperative effort should improve the management plans and strengthen public relations between the agencies and the ranchers.

The Demonstration Ranch Program also stresses that the best animal management may be the best range management. Ranchers are assisted in solving range livestock health, reproduction, and nutritional problems. Any assistance that can improve the efficiency of the livestock management program usually speeds the range management and improvement program.

Utah’s rangeland is a valuable resource to every one of the state's citizens. These lands produce many useful products, and they have the potential to produce much more. Utah’s Rangeland Development Program hopes to encourage this development by applying the many management guidelines that have been developed by years of range research.

Frank E. (Fee) Busby is Extension Range Specialist in the Department of Range Science, College of Natural Resources, USU, and Executive Secretary of Utah’s Rangeland Development Committee, Utah State Department of Agriculture.

BEEF FROM RANGELANDS

A glance at the future

John P. Workman

In the past 15 months weaner calf prices have been cut in half due to the slump in the market for fat cattle and processed beef. The inflation-caused loss in real United States per capita income combined with beef import restrictions in Europe and Japan has caused beef demand to level off. Due to high feed grain prices fewer cattle are being placed on feed and supplies of choice grain-fed cattle are dwindling. The price of fat cattle however, has remained low since the beef market is currently glutted with nonfed steers and heifers plus an alarming number of breeding stock. Cattle feeders have suffered large losses during the past year. On fat cattle marketed last August, for example, beef feeders in the Intermountain area lost $89 per 1061 lb steer and $46 per 894 lb heifer. The resulting cautious attitude of cattle feeders leaves the current crop of feeder calves without buyers.

The current cutback in cattle feeding operations along with premature slaughter of breeding stock promises a future shortage in choice fed beef as well as general reduction in beef production. Thus it appears that cattle ranchers who somehow...
manage to weather the current market crisis will find themselves in a much more favorable position within two to three years. If beef import restriction in western Europe and Japan are relaxed, an improvement in the financial position of United States cattle ranchers will be virtually assured.

The manner in which these cattle are prepared for market may be changed considerably, however, with rangeland becoming increasingly important.

**Importance of Range Forage**

Clearly, the only means of producing significant amounts of human food from rangelands is through the use of grazing animals—particularly ruminants which have the ability to synthesize edible protein from range-produced roughage. Due to the obvious inefficiencies involved in managing and harvesting wild ruminants, it appears that domestic cattle, sheep, and goats will continue to be used, in the foreseeable future as the primary method of converting the renewable range forage resource into food for man.

Rangeland in the 48 adjacent states totals 1.026 billion acres or 54 percent of the total 48 state land area. Along with 175 million acres of forest land (9 percent of the total), these two categories of land comprise over 1.2 billion acres. During 1970, 835 million acres of this land was grazed by domestic livestock. Forage production totaled 213 million animal unit months (AUMs) or the yearlong feed requirement for more than 17 million cows, the equivalent of 40 percent of the 1970 beef cow population.

Of the 213 million AUMs produced in 1970, only 14 percent came from federal land, the bulk of range forage being produced by

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Figure 1. Eight to six percent of the total range forage is produced from nonfederal private and state owned rangelands.

Figure 2. Although providing only 14 percent of the range forage produced in the 48 adjacent states, federal ranges are crucial to the yearlong operation of many western ranches.
lands held in private and state ownership. However, this 14 percent is crucial to the yearlong operation of many livestock enterprises in the eleven western states. Grazing of federal land serves to alleviate seasonal forage bottlenecks which occur due to shortages of other livestock feeds such as hay, improved pasture, and crop aftermath.

Rangelands and the Future

A growing world population promises an increasing scarcity of feed grains. The resulting rise in feed grain price will trigger an increased demand for all forages (range, hay, improved pasture, and silage) as less expensive livestock feed alternatives. Unfortunately, there will almost certainly be a simultaneous decrease in nonrange forage supplies. With the higher prices for feed grains and plant protein, much of the nation’s best forage lands will be shifted into the production of grains and soybeans. Even marginal cropland, which at one time was viewed hopefully as a badly needed source of forage, will continue to be taken out of the permanent grass cover encouraged by the Soil Bank Program and returned to wheat production.

These decreases in supplies of nonrange forage will correspond to a time of increased world demand for red meat due to world population growth and growing affluence of developing nations. All aspects of the current situation appear to point to a tremendous increase in the demand for range forage and an ever growing importance of the contribution of this renewable resource to meat production.

Another important aspect of rangeland forage production might be its contribution toward solving our current twin problems of fossil fuel shortages and the balance of payment deficit. Range livestock production is highly efficient in terms of fossil fuel usage (production of one pound of meat from rangelands requires about one half as much fossil fuel as a pound of meat produced from harvested feeds). Future sale of livestock products on the international market might help enable us to purchase our energy needs from foreign nations.

Changes Proposed for Beef Grades

Grass-fed beef is already appearing on the consumer market. If current USDA beef quality grading procedures are retained, the shift from grain-fed to grass-fed beef will result in very little “prime” beef being marketed, a sharp decrease in “choice” beef, and a significant increase in beef grading “good” and “standard.”

Nebraska Livestock Specialist Dave Hendricks has called for a revision of beef grading criteria because from 5 to 7 times more feed energy is required to produce a pound of fat than a pound of lean meat and today’s consumers seem to prefer the pound of lean. A special work group composed of personnel from six agencies within the USDA also recently recommended changing USDA meat quality grades to better reflect both consumer preference and nutritional value of forage-fed and range-fed beef.

If slaughter weights of cattle remain unchanged, grass-fed beef will mean that much of the beef purchased by consumers will come from older animals since grass fattening is a much slower process than grain finishing. Another possibility, however, is a shift toward consumption of “baby beef” from lighter cattle which might leave unchanged or even reduce the age of cattle at the time of slaughter.

Clearly, the only means of producing significant amounts of human food from rangelands is through the use of grazing animals.
Beef to Become More Expensive

Future beef consumers will almost certainly find red meats more expensive relative to other products than at present. Although grass-fed beef will cost less to produce than grain-fed, the number of animals produced annually will be considerably reduced. Not only will most nonrange forage lands have been allocated to grain and soybean production, but about one million acres per year of agricultural land (including rangeland) will likely continue to be lost to other uses such as highways, airports, and home sites. Substitution of fattening steers and heifers for brood cows on rangelands will cause a further decrease in the number of cattle produced annually. This twin decrease in forage and cattle production may well push beef prices to levels beyond the reach of much of the world's population.

What About Utah?

It appears safe to predict that Utah range cattle operators can anticipate considerably higher prices for weaner calves, stockers, and grass fat animals in the not too distant future. Rangeland prices, also, will undoubtedly continue to rise rapidly due to increased land demand for both beef production and nonlivestock purposes such as recreation and homesite development. Increased land prices will place stockmen under growing pressure to increase per-acre production by intensifying capital, labor, and management inputs on their fixed land base. Various range improvements such as brush control and reseeding will then become more economically attractive.

Future Utah range cattle operations will differ considerably from those of today. Shifting from a cow-calf to a cow-calf-yearling setup and selling spring stockers to summer grass fattening operators will require a considerable decrease in brood herd size since it will be necessary to make room for the increased yearling cattle while staying within the fall, winter, and spring carrying capacity constraints. Necessary reduction in brood cow numbers will be even more severe for stockmen shifting from a cow-calf operation to a combined cow-calf-yearling and summer grass fattening phase. Fortunately, in either case, less than one cow animal unit (AU) must be given up to gain a yearling AU since the per-AU energy requirement for lactating cows exceeds that of fattening yearlings.

Substitution on rangelands of the grass fattening phase for traditional feeder calf production will also have important national implications. Since the average age of cattle grazing rangelands will be higher and the average animal larger in size, total number of animals produced will be less adding further impetus for decreased cattle production in the United States.

Information Needed

There is general agreement that marketing of beef directly from rangelands will become increasingly important in the future. However, little information is currently available to guide range cattle operators in the transition from the traditional cow-calf setup to one of a variety of options involving combined cow-calf and range yearling feeder operations. Also, despite wide recognition of a necessary reduction in breeding stock to make room for an expanded yearling herd, data indicating the extent of this reduction is lacking.

A new Utah Agricultural Experiment Station research project in the Department of Range Science hopes to supply the missing information to aid in cattle ranch decision making. Using a large Juab County cow-calf operation as a case study, the relationship between increased yearlings and cow herd reductions will be established. Next, the optimum herd composition and optimum age of cattle at the time of marketing will be determined by linear programming analysis of inventory and budget data for four representative sizes of Utah cattle ranches. The analysis will then be expanded to project the likely impact on total beef production in the state of Utah which will aid in predictions concerning future availability of beef for consumers.

John P. Workman is Assistant Professor and Acting Head of the Department of Range Science, College of Natural Resources, USU.

Pat Neal says:

It's natural to think it can't happen to you. But a stroke makes no distinction...suddenly it strikes! Therapy can return most stroke victims to life's mainstream and many of them count on Easter Seals' help. Can Easter Seals count on you?

UTAH SCIENCE
NEW GRASSES FOR WESTERN RANGELAND

K. H. Asay

As the costs of feed grains continue to increase and cultivated land previously used for forage production is diverted to other crops, more demand will be placed on the rangeland of the Intermountain West for beef and other livestock. The productivity of this vast resource must be significantly and economically increased to meet this challenge and one way is to seed with adapted grass species.

The USDA Agricultural Research Service has recently initiated a range grass breeding program — a relatively neglected area of research — in cooperation with Utah State University to produce new and promising varieties for range seeding.

Genetic Variation

Heritable variation is not only essential for plant populations to naturally adapt to environmental changes, but it also forms the basis of plant breeding. Fortunately, wide variation occurs between and within most species. The role of the plant breeder is to accumulate as much genetic variability as possible and then to manipulate that variation into plants more useful to man.

Many of our plant species were introduced from foreign countries — wheat from Asia, sorghum from Africa, soybeans from China, and dandelions from Eurasia. Extensive collections must be made from these centers of origin to provide adequate genetic variability for a breeding program. Crested wheatgrass (Agropyron cristatum) originated in Asia; therefore we are assembling a broad genetic base of this species from the Asian countries. Other species such as bluebunch wheatgrass (Agropyron
spicatum) and basin wildrye (Elymus cinereus) are native to the American continent and a major portion of the genetic diversity must be obtained from domestic sources.

Large populations of each species will be established in source nurseries and thoroughly evaluated. Selected lines will be progeny tested to determine their true genetic potential — the outward appearance or performance of a plant is not always a reliable indication of the type of offspring it will produce. Parental lines with the best progeny performance will then be combined using a series of crosses to produce the first group of experimental strains. These strains will then be tested under actual range conditions at several locations to determine which will be released for public use.

**Interspecific Hybrids**

If the genetic variation within species is inadequate, we must look for it in a related species. Interspecific and intergeneric crosses have been used successfully to transfer disease resistance from one species to another in tomatoes, tobacco, and wheat. Such crosses have also been used to develop new species with characteristics of both parents although results have not always been equal to expectations. For example, Karpechenko was optimistic concerning his new species Rahpanobrassica produced by crossing a radish and a cabbage. Although the new plant may have had some desirable qualities, it had the root of a cabbage and the top of a radish. Many other attempts to develop new species have been equally disappointing; however, some successes have been recorded.

Several research programs are in progress to develop useful varieties from an intergeneric hybrid between wheat and rye (Triticale). Several researchers have succeeded in crossing tall fescue with annual and perennial ryegrass. Buckner et al. (2) have developed an experimental strain (Kenhy) from this cross. Although this potential variety is still being evaluated, they appear to have combined many of the nutritional attributes of ryegrass with the vigor of tall fescue.

Sterility problems due to chromosomal and genetic imbalance are quite common in such hybrids. This is not a severe problem in a grass that can be established with vegetative propagation; however, production of viable seed is an essential quality of most range grasses. Various means have been employed to correct these sterility problems: (1) selecting for fertility for several generations after the initial cross, (2) backcrossing to one of the parents, and (3) doubling the chromosome number of the sterile hybrid by treatment with the drug colchicine. The latter method often improves chromosome pairing during meiosis resulting in the production of balanced gametes (Figure 1).

The world’s most extensive collection of the Agropyron, Elymus, and Hordeum grasses has been assembled at Logan. Over 100 interspecific and intergeneric hybrids have been produced and populations with a unique combination of characters have been developed by chromosome doubling and selection (3,4). We are testing these hybrids on range sites in Utah, Idaho and North Dakota and the most promising will be included in the breeding program.

It may surprise some that quackgrass (A. repens) is a parent in three of the four more promising hybrids. This species is so aggressive that it has been classified as a noxious weed; however, it makes a valuable genetic contribution in certain hybrid combinations.
brid combinations. The cross between quackgrass and bluebunch wheatgrass looks particularly good. Characteristics of both parental species are represented in the hybrid population suggesting at least two possible approaches. One is to combine the drought tolerance and other range attributes of bluebunch wheatgrass with the spreading habit and general aggressiveness of quackgrass. Such a combination would be particularly valuable in range reclamation programs where soil stabilization is a major problem. Another approach would be to produce a type similar to quackgrass but less aggressive and with improved forage quality. The objective would be a variety that could be used with irrigation or in areas with more precipitation. Selection would be for types that are adapted for use in a mixture with a legume such as alfalfa.

Problem Sites

Because of the energy crisis, acreages disturbed by surface mining operations are increasing at an alarming rate. This not only lowers the productivity of the range but the quality of water derived from affected watersheds is also threatened. Grass and other forage species used to revegetate such areas are often confronted with unusual environmental conditions. The organic matter content and fertility of the soil used in fill areas is generally low and soil physical properties are often unfavorable for plant growth. A grass variety developed for these sites must also establish and persist under drought, excess soil salinity, unfavorable soil pH, and extreme temperatures.

We are cooperating with the Intermountain Forest and Range Experiment Station to develop varieties for reclamation of mine spoils. A complex of wildrye (Elymus) species that includes basin wildrye (E. cinereus), beardless wildrye (E. triticoides), and salina wildrye (E. salina) is of particular interest. In general, these species are tolerant to adverse conditions such as drought and excess soil salinity, but often lack the combination of other characters needed. For example, beardless wildrye has many of the desired vegetative traits but lacks good seed quality. Basin wildrye has better seed quality but lacks the aggressiveness of its close relative beardless wildrye. Some hybrids between these two species have been produced and there are indications that a more concentrated breeding effort would yield a new population with a combination of the seed and vegetative qualities of each. The genetic diversity generated in other phases of the breeding program will also be evaluated for possible use on disturbed sites.

Stand Establishment

One of our major objectives is to develop grass varieties with greater seedling vigor, substantially reducing the incidents of range reseeding failures. Soil fertility, soil moisture, temperature, and relative humidity will therefore be controlled in growth chambers to induce varying degrees of stress in our grass breeding program. The final testing will be done in the field under actual range conditions; however, thousands of lines will be screened during the winter months prior to the establishment of more expensive field trials.

Fairway crested wheatgrass is commonly used to stabilize roadbanks along highways and for other turf purposes where soil moisture is limited. Although Fairway has many vegetative characteristics desired for turf, it is a diploid with small seeds and relatively poor seedling vigor. Most other crested wheatgrasses are tetraploids with larger seeds and better seedling vigor; however, they are adapted for forage production rather than turf. Several accessions
of tetraploid crested wheatgrass were recently collected in Iran from areas generally subjected to over-grazing. Closer observations at Logan have revealed that many of these lines are finer textured, have a shorter growth habit and are much more rhizomatous than common tetraploid types (Figure 2). Selections from these accessions will form the basis of a breeding effort to develop varieties of tetraploid crested wheatgrass specifically for soil stabilization and turf.

Forage Quality

Since the economic benefits of an improved range grass variety is measured in terms of livestock performance, we must be concerned with the complex plant-animal interaction associated with nutritional value of forage. The necessity of evaluating several hundred small samples of forage during each breeding cycle makes this particularly troublesome. Large animal trials can be used to appraise the quality of a small number of experimental strains at the end of each cycle, but require too much forage to be useful during the earlier stages of the program. A miniature cow has not yet been developed; however, some promising laboratory procedures are now available to predict animal performance of relatively small forage samples (5,6). Probably the most useful to the grass breeder is the two-stage in vitro digestibility procedure. Here a small forage sample is fermented in rumen fluid that has been collected from fistulated animals. In vitro results have been closely correlated with those obtained from large animal trials and the procedure will be used in our grass breeding program.

One of our major objectives is to develop grass varieties with greater seedling vigor.

Literature Cited


K. H. Asay is Plant Geneticist, ARS, USDA, Logan, Utah
forage-fattened cattle—a new look at an old practice

Clair R. Acord

Putting the final pounds on cattle by feeding them vast quantities of grain didn't become popular until the 1940s. Now it looks as if we'll have to revert to the older method of using mostly (if not solely) forage to grow and fatten beef animals. The national economy, as well as humanitarian considerations, demand that more grain be used to directly feed people, with less being converted into meat. The shift is going to require a re-education of both consumers and cattle producers in this country.

Consumers will have to learn how to appreciate the advantages of meat that carries relatively little fat and therefore grades "Good" instead of "Choice." The producers will have to learn how to optimize combinations of range forage, pastures, and minimal grain.

Neither group seems to have many options other than to adapt to changing conditions. The cattle producers are going bankrupt as their costs skyrocket while returns per animal decline. At the same time, consumers continue to pay premium prices at their supermarkets for "USDA Choice beef." If too many cattle producers are forced to abandon their business, consumers could find themselves confronted with even higher prices for a far less available supply of meat.

Forage-fattening instead of grain-fattening cattle obviously won't solve all the complex economic problems inherent in raising and marketing beef—but it is a step in the right direction.

Alternatives

Utah cattle producers will have an unusually wide choice of alternatives in producing "grass-fed" or "forage-fed" beef.

1. Run the cows and calves on regular summer range. From July through December offer the calves for sale on a grass-fed or milk-fed basis. This alternative would limit options for heifer selection for replacements if all calves were sold. But moving the calves early could conserve feed and possibly help improve the ultimate carrying capacity of some sections of a given range.

2. As in number 1, run cows and calves on summer range. Then in the fall, wean the calves and winter on strictly forage such as alfalfa hay and/or corn silage. If corn silage was fed alone, a protein supplement should be added. This program could put about 1 1/4 to 1 1/2 pounds per day on each calf from weaning to spring sale.

This process also allows good selection of heifers for replacements. Non-replacement calves could be sold for pasturing or feedlot finishing.

3. Utilize range for summering

Utah cattle producers have an unusually wide choice of alternatives in producing "grass-fed" or "forage-fed" beef.
Long-yearling calves taken off pasture produce palatable and nutritious meat which merely requires slower cooking and some added liquid.

the calves that had been held in alternative 2, and then offer them for sale as “grass-fed” cattle in the fall.

4. Develop an improved irrigated pasture for calves in one of Utah’s valleys. Experience over 15 years suggests that such pastures can produce excellent results. For example, a straight grass pasture such as smooth brome or orchard grass or a combination of the two will produce approximately, 650 to 750 pounds of beef per acre under Utah growing conditions. This assumes the pasture is properly fertilized, irrigated, and used in a rotation system whereby the cattle do not graze one section more than four or five consecutive days.

When a combination of alfalfa and a grass such as smooth brome and/or orchard grass are used for a pasture, then approximately 750-900 pounds of beef can be produced per acre. With a legume added to the pasture mix, however, either the liquid-molasses with poloxalene will have to be used as a top dressing or poloxalene will have to be mixed and fed with one or two pounds of grain per day to control bloat.

When cattle are pastured on straight alfalfa, gains of 1300 to 1800 pounds of beef can be obtained per acre. But again, poloxalene must be used to control bloat, with the added costs involved.

To be effective, each of these pasturing programs must be on a rotation basis, with the cattle grazing a section for four or five days and not returning to the same section before 25 days.

Long-yearling calves taken off these pastures should weigh 750-850 pounds. Taken off pasture in late September or early October, these calves are prime candidates for a feedlot; however, many of them could be killed right off the pasture and would grade “USDA Good.” The resultant meat sold over the counter to the consumer would be palatable and nutritious and merely require slower cooking than “USDA Choice” grade cuts and some addition of liquid.

5. Wean calves and winter them on forage (alfalfa hay and/or corn silage) before pasturing on improved pastures with four to five pounds of grain added to each calf’s daily intake while on the summer pasture. For example, feeding four pounds of grain daily to each calf on pasture for 150 days would mean 600 pounds of grain per animal for the summer at a cost of approximately $40 per animal. Such a process increases the carrying capacity of a pasture by one to two animals per acre depending upon management and the kind of pasture. Also, the calves produced would easily grade “USDA Good” and some would reach “USDA Choice.”

6. Summer calves on pasture as in alternative 5, then put the calves in the feedlot and finish to low choice on a high-concentrate grain ration. Experience indicates that of heifers held for 60 to 70 days in the feedlot, nearly one-half will grade “USDA Choice.”

7. Follow the sixth alternative, except that when the calves go into the feedlot give them pelleted alfalfa (free-choice) plus four or five pounds of pelleted grain per day. Calves consume more alfalfa in a pellet than in a long or chopped form and weight gains should therefore be optimized to a point at which the calves would be “USDA Good” with a few “USDA Choice.”

Which alternative is best depends on relative prices of feed and other costs and individual circumstances. Certainly the consumer’s interest in having each producer make the best possible choice is becoming increasingly apparent. Optimizing the uses made of Utah’s forage might even someday displace the Pro Super Bowl as a prime topic of conversation at meatless dinner tables throughout the state.

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Give a hoot! Don’t pollute.
To Convert Forage to Milk, You Need Cow and Land Efficiency

M. J. Anderson, G. E. Stoddard, and R. C. Lamb

Animals differ in the efficiency with which they convert their feeds into human foods (Table 1). Obviously, many classes of livestock are low in efficiency, and often use feed that could be consumed directly by people. However, ruminant animals can produce food for humans by utilizing forage crops from land which cannot grow food directly. The production of milk is the most efficient method of producing foods from animals in this way.

The dairy cow’s efficiency can be illustrated another way, too. For example, the average production of wheat in the United States is less than one ton per acre. Hay production approaches 3 tons per acre and corn silage production averages more than 4 tons per acre. With a 25 percent efficiency of converting feed energy to milk we produce about the same amount of human food per acre from milk as from wheat. The nutritional value of milk in the human diet is further incentive to devise ways to keep dairy cows as productive as possible.

The percent of forage and concentrates consumed by different classes of animals is presented in Table 2. Beef cattle, sheep, and dairy cows could take an even greater proportion of their diets from forages. However, reducing the concentrates fed to dairy cattle does lower productivity per animal. For example, dairy cows on all-forage rations produce only about 70 percent as much milk as when they are fed the average amount of concentrates.

The Options

This does not equate with being caught between a rock and a hard spot, though. Both the individual dairyman and the country as a whole have viable options to ease the inevitable adjustment period. The dairyman’s possibilities are discussed in the article in this issue, “High Quality Hay for Dairy Cattle.” Some national and state concerns are considered below. The production of major grains and the United States production of grains, hay, and corn silage are summarized in Table 3. Some of the land producing hay and corn silage could be diverted to grain production. But even good land will not produce satisfactory yields of grain indefinitely unless soil fertility is maintained. As commercial fertilizers become increasingly scarce, alfalfa in crop rotational system and manure from livestock enterprises could be important factors in main-

Land use planning is needed to determine which lands are best suited for grains for humans and which are best for forage production.
Land use planning is needed to determine which lands are best suited for grains for humans and which are best for forage production. Of the forage lands, which should be used for dairy cows and which for beef cattle or sheep? Which forages should be harvested and which grazed? Should dairy replacement animals be raised in less agriculturally productive areas where they can graze forage?

An accelerated research effort is needed to increase the quality and quantity of forage (grasses, legumes, corn silage), particularly what is grown on lower class land. New and improved plant varieties and better crop management practices are needed. An improved quality of forage could permit cows to maintain high levels of production with minimal amounts of grains and other concentrates. Cows will need to be selected for their ability to do well on primarily forage. A greater rise of by-product feeds, i.e., new feeds from waste materials, should be explored. Accurate evaluation of forage quality would provide for more equitable marketing of forages to dairymen and allow better balancing of rations.

Milk and forage production are major agricultural commodities in Utah. Dairying, with farm sales of milk and surplus dairy animals amounting to over $80 million annually (25 percent of the total farm cash receipts in the state), rivals beef cattle as the leading source of farm income in Utah. Although most corn silage and 75 percent of the hay is fed on the farm where it is produced, the value of harvested hay and corn silage for both dairy and beef animals is also equal to about 25 percent of the cash farm income in the state.

In recent years dairy and beef cattle have both increased in importance to the agricultural income of Utah as compared to other livestock and cash crops. For example, total milk production in Utah has increased 13 percent since 1960, while nationally milk production has declined 6 percent. Projections for the state see continued increases in livestock production. Such growth must be accompanied by increased emphasis on forage production, evaluation and use, with a view to optimizing the productivity of Utah’s diverse landscape.

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G. E. Stoddard is Professor and Head of the Department of Dairy Science, College of Agriculture, USU.

R. C. Lamb is Associate Professor in the Department of Dairy Science and Federal Collaborator, ARS, USDA, Logan, Utah.
HIGH QUALITY HAY FOR DAIRY CATTLE

M. J. Anderson

Utah research indicates that changes in dairy feeding programs should be pre-examined carefully. Simply reducing nutrient intake from grain may not be the best way to reduce the cost of producing milk. Increasing forage quality might be far better than looking for cheap feeds. High quality hay may cost slightly more than low quality, but the better per cow production and/or reduction in grain feeding should more than offset the cost difference.

Choice and fair quality hays vary drastically in feeding value, but relatively little in price. The choice hay will be high in digestibility, essential nutrients, and palatability. Therefore, in purchasing hay the dairyman should buy the highest quality he can find. The dairyman who raises his own hay should take proper steps to insure that it is high quality.

To obtain hay of the highest possible quality, alfalfa should be harvested at early maturity, preferably in the bud or early bloom stage, and windrowed during or immediately after mowing. The use of a conditioner will speed drying time, lessen leaf loss and give a more palatable hay. Quality is also enhanced when the hay is allowed to dry thoroughly and then baled while the dew is still on. Ideally, no storm will occur during harvesting, although rain will not seriously affect digestibility or protein content if the leaves are saved. Thus, if palatability remains high, rained-on hay can grade high in quality, although yield and vitamin A will be reduced.

You can recognize high quality hay by its minimum number of blossoms, and its fresh clean smell with no hint of mildew or mold. Stems should be soft and pliable to insure palatability. A bright green color indicates the hay was harvested during good weather. Ideally the leaves are still attached to the stems. The presence of early-cut grasses and even some weeds (if palatable) will not downgrade hay quality, but contamination with weeds, dirt, chemicals, or other substances that are unpalatable or harmful means poor quality.

The same principles apply to high quality hay-crop silage. The only basic difference between high quality hay crop silage and hay are their preferred moisture contents when harvested and their requirements for storage. The most efficient production of hay crop silage occurs when the forage is harvested when it has between 65 and 70 percent moisture. A higher moisture level will cause seepage losses and excessive fermentation losses. Usually such silage will have a foul odor and be unpalatable to the animals. Less than ideal moisture will cause difficulty in packing and consider-
able oxygen may remain. The presence of oxygen will allow the silage to heat and result in a decrease in the digestibility of energy and protein, and the vitamin A activity will be destroyed.

**Milk Production from Hay**

The importance of hay quality can be illustrated from a study conducted at Utah State University with first-crop alfalfa hay. Hay was cut on different dates starting about May 25 and continuing into July. These dates covered both earlier and later dates than hay is normally harvested in northern Utah. Highest yields and top quality are usually obtained in the Logan area when first-crop hay is harvested around June 10 to 15.

The USU study covered a 3-year period and all hay was harvested in excellent condition. From 4 to 6 harvests were taken in each of the three years. Ranger alfalfa was used in two years. Lahontan and Dupuits alfalfa were used the third year. All the hays were stored under cover until fed. Prior to feeding, the hays were chopped to minimize the animals' opportunity to select mainly leaves.

Each hay was fed to a minimum of four sheep to determine digestibility and relative intake. (Digestibility trials with sheep produce results fairly comparable to those obtained with cattle, and sheep are less costly to use.) The digestibility results were similar for the three years. The cutting dates, estimated stages of maturity and digestion coefficients are presented in Table 1.

From these data it was calculated that the digestibility of dry matter dropped 0.29 percentage units for each day that the harvest was delayed. Thus, in three weeks, there would be a drop of 5.8 percentage units. Corresponding decreases in protein digestibility were 0.20 percentage units per day of delay.

The data were then used in a theoretical situation to determine the level of milk production that might be expected if the hays had been fed as the only feed to dairy cattle (Table 2). In a practical situa-

The data were then used in a theoretical situation to determine the level of milk production that might be expected if the hays had been fed as the only feed to dairy cattle (Table 2). In a practical situa-

<table>
<thead>
<tr>
<th>Date</th>
<th>Stage of Maturity</th>
<th>Digestion Coefficients</th>
<th>Protein Content (%)</th>
<th>Daily dry matter intake lbs/100 lbs BW**</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 31</td>
<td>vegetative</td>
<td>65.9</td>
<td>74.7</td>
<td>21.4</td>
</tr>
<tr>
<td>June 5</td>
<td>early bud</td>
<td>64.4</td>
<td>73.6</td>
<td>20.3</td>
</tr>
<tr>
<td>June 10</td>
<td>bud</td>
<td>63.0</td>
<td>72.5</td>
<td>19.3</td>
</tr>
<tr>
<td>June 15</td>
<td>early bloom</td>
<td>61.6</td>
<td>71.4</td>
<td>18.3</td>
</tr>
<tr>
<td>June 20</td>
<td>¼ bloom</td>
<td>60.1</td>
<td>70.3</td>
<td>17.2</td>
</tr>
<tr>
<td>June 25</td>
<td>½ bloom</td>
<td>58.7</td>
<td>69.2</td>
<td>16.2</td>
</tr>
<tr>
<td>June 30</td>
<td>full bloom</td>
<td>57.3</td>
<td>68.1</td>
<td>15.2</td>
</tr>
</tbody>
</table>

* Protein content expressed on 100% dry matter basis
** BW equals body weight

<table>
<thead>
<tr>
<th>Date</th>
<th>Intake of Dig. energy (Mcal)</th>
<th>Milk productions (lbs)</th>
<th>Hay intake (lbs)</th>
<th>Cost hay/ton $</th>
<th>Cost hay/cow/day $</th>
<th>Value of milk above hay costs $</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 31</td>
<td>57.3</td>
<td>52.2</td>
<td>43.8</td>
<td>53</td>
<td>1.16</td>
<td>2.76</td>
</tr>
<tr>
<td>June 5</td>
<td>54.8</td>
<td>48.6</td>
<td>43.0</td>
<td>52</td>
<td>1.12</td>
<td>2.53</td>
</tr>
<tr>
<td>June 10</td>
<td>52.3</td>
<td>44.8</td>
<td>42.0</td>
<td>51</td>
<td>1.07</td>
<td>2.29</td>
</tr>
<tr>
<td>June 15</td>
<td>50.0</td>
<td>41.5</td>
<td>41.1</td>
<td>50</td>
<td>1.03</td>
<td>2.08</td>
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<tr>
<td>June 20</td>
<td>47.7</td>
<td>38.0</td>
<td>40.3</td>
<td>49</td>
<td>.99</td>
<td>1.86</td>
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<tr>
<td>June 25</td>
<td>45.5</td>
<td>34.8</td>
<td>39.4</td>
<td>43</td>
<td>.95</td>
<td>1.66</td>
</tr>
<tr>
<td>June 30</td>
<td>43.3</td>
<td>31.6</td>
<td>38.5</td>
<td>47</td>
<td>.90</td>
<td>1.47</td>
</tr>
</tbody>
</table>

* Table based on assumption that only hay is fed to a 1430 lb. cow

Suggestions for producing high quality alfalfa hay. The same principles apply if forage is purchased:

1. Select a long-lived, high yielding variety of alfalfa that is adaptable to the area. A vigorous stand of alfalfa will help control weeds and insects and will be more uniform in quality.
2. Cut at an early stage of maturity, preferably in the bud or early bloom stage.
3. Use a swather-conditioner for cutting. The swather eliminates an extra operation of handling the hay and the conditioner speeds drying time.
4. Allow the hay to dry thoroughly then bale while it carries dew whenever possible.
5. Avoid damage from rain when possible but do not delay harvest very long because of possible storms.
6. Minimize the time between cutting and harvesting as much as possible.
7. After the hay is baled, remove it from the field as soon as possible. Do not leave it in the field unless it must dry to prevent spoiling. Then treat for weevil if necessary, irrigate, etc. to encourage regrowth of the following crop.
8. Manage the hay crop to provide optimum growth of desirable forage species.
9. Feed the forage in a scientific manner (See boxed suggestions).
10. Avoid wasting forage.
11. Store the hay on a dry, well-drained area and cover the top to prevent bottom and top spoilage.

Under which the hay is grown and harvested. In addition, feeding, breeding, and management practices would influence both level of production and efficiency of feed utilization and thereby cause economic differences. Our results, however, do reflect highly probable trends. Thus, the value of feeding high quality hay cannot be over-emphasized.

**Table 3.** Guide for feeding grain to dairy cows based on 1430 pound cow producing 3.5 percent milk.

<table>
<thead>
<tr>
<th>Quality of Hay</th>
<th>Good</th>
<th>Fair</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE* (milk) Mcal/Kg</td>
<td>1.26</td>
<td>1.17</td>
</tr>
<tr>
<td>TDN** (%)</td>
<td>57.5</td>
<td>55.0</td>
</tr>
<tr>
<td>Cutting date</td>
<td>May 31</td>
<td>June 10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Milk Production (lbs/day)</th>
<th>Energy Requirement (M cal)</th>
<th>Grain Feeding Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14.4</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>17.5</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>20.7</td>
<td>0</td>
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<tr>
<td>30</td>
<td>23.8</td>
<td>1</td>
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<tr>
<td>40</td>
<td>26.9</td>
<td>6</td>
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<td>50</td>
<td>30.1</td>
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<td>60</td>
<td>33.2</td>
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<td>70</td>
<td>36.3</td>
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<tr>
<td>80</td>
<td>39.4</td>
<td>26</td>
</tr>
<tr>
<td>90</td>
<td>42.6</td>
<td>31</td>
</tr>
<tr>
<td>100</td>
<td>45.7</td>
<td>At least 40% of the ration Dry Matter should come from forage.</td>
</tr>
</tbody>
</table>

*SNE = net energy
**TDN = total digestible nutrients.

Suggestions for feeding forages to dairy cows:
1. Feed the best forages to those animals that will benefit most. Calves, and high producing cows especially need high quality feeds.
2. Do not waste feed. Feed frequently, and only the amount of feed that will be consumed between feedings.
3. Consider the quality of feeds. With high quality feed, less grain is required for the same level of production (Table 3). If a particular hay needs supplementation, e.g. protein or vitamin A, provide the supplement.
4. Consider the production potential of the cows. Feed liberally those cows with high productive potential. Cut the feed on low producers (Table 3).
5. Especially feed liberally during each cow’s peak production period.
6. Experiment with your situation. If an increase of pounds in grain feeding increases milk production...
more than 1 pound the increased grain feeding will be justified. The reverse can be true.

7. If corn silage is fed, determine if extra protein is required. Good corn silage has about the same energy content as high quality hay. Thus the grain feeding level can be reduced slightly when corn silage is fed liberally. Corn silage should not provide more than two-thirds of the forage dry matter.

First Get the Seeds

P. F. Torchio and F. D. Parker

Alfalfa, queen of the forage crops, occupies 41 percent of Utah's cultivated land. And every one of those 460,000 acres was started from seed — seed that has been consistently difficult to produce. Obviously, as our meat and milk supplies come to depend more on forage-fed and less on grain-fed animals, alfalfa is likely to become an increasingly popular crop. If, that is, potential growers can get enough seed.

Of the 63 million acres planted to alfalfa throughout the United States, only an average of 380,000 are harvested for seed each year and yet, the United States is the world's largest producer and exporter of alfalfa seed. Unfortunately, seed yields characteristically and capriciously vary from 50 to 1500 lbs/acre. That means that even the best informed, most careful alfalfa seed producers often lose their gamble with nature.

For the past 50 years, scientists have been trying to better the odds for the growers in their annual game-of-chance with nature's phenomena. So far, the studies have mainly demonstrated that many factors (alone or in combination) can reduce seed yields. The most important include pest insects, faulty irrigation schedules, poor weed control, soil types and mineral content, adverse climate, age of the alfalfa stand, and varietal differences in plant physiology. The studies also proved, however, that even if alfalfa was grown under ideal climatic and soil conditions and with successful weed and pest controls, seed yields would increase little unless pollination requirements were satisfied.

In fact, lack of pollination can be (and usually is) the single most important factor that limits alfalfa seed production in the United States. And since bees are the primary pollinators for alfalfa, the research done by scientists at the USDA Bee Laboratory on the USU campus has long been of direct interest to alfalfa producers. Now it looks as if all of us who like to regularly include meat in our diet have a less direct but no less urgent interest in that research.

The Pollinators and Their Work

When pollinators visit alfalfa flowers to collect nectar (located at the base of the corolla, Figure 1) and pollen, they force open the flower as they enter, thus "tripping" the flower (Figures 1 and 2). Invariably, the bee (or occasionally a wasp or beetle) is positioned above the keel during tripping so that the sexual column (stamens and stigma) strikes its body and dusts it with pollen. At the same time, the protective layer on the apical tip of the stigma is ruptured and pollen is transferred to its sticky surface, thus effecting pollination.

More than 100 species of bees have been recorded as seen on alfalfa in North America and most of these do trip the flowers (and thereby pollinate them) as they collect pollen and nectar. Unfortunately, the densities of these bees in natural populations are usually low in alfalfa seed producing areas. As a consequence, they have not been considered important pollinating agents. Three species of bees, however, are presently managed in the United States for alfalfa pollination. All three [the honey bee, Apis mellifera L.; the alkali bee, Nomia melanderi Ckll.; and the alfalfa leaf-
cutting bee, *Megachile pacifica* (Panzer) occur, have been studied and are used in Utah.

**The Honey Bee**

Because of its honey-production, this bee was first introduced into North America soon after white settlers began planting crops. As a pollinator of alfalfa, however, it has proved less than satisfactory. Research by state and federal scientists in Utah and other areas of the United States has shown that the field force of any honey bee colony is composed of nectar collectors and pollen collectors. To the despair of alfalfa seed producers, apparently both types of worker bees dislike being slapped by the stigma and stamens of the alfalfa flower. Nectar collecting honey bees do sometimes accidentally trip alfalfa flowers and the rate of such tripping is correlated with latitudes in North America. The reasons for this correlation are obscure; but in Utah, Nevada, and the central Great Plains, the average rate of tripping of alfalfa blooms by nectar-collecting honey bees is 1 percent. In Canada, however, the average tripping rate is only 0.0-0.2 percent. By contrast, in southern California the rate is 2-3 percent. Research has translated these percentages into seed yield potentials which indicate that less than 1 percent tripping does not produce high yielding

**Figure 1.** Front view of an untripped alfalfa flower with sexual column hidden from view.

**Figure 2.** Front view of a tripped alfalfa flower with sexual column exposed and facing standard petal.

As a pollinator of alfalfa, the honey bee has proved less than satisfactory.
crops. At a 1 percent tripping rate, however, 500 lbs. of alfalfa seed/acre can be realized if nectar collecting honey bees are evenly distributed across the crop at a density of 5-10 bees/sq. yd. Unfortunately, this density can only be figured when unusually large numbers of honey bee colonies are available. At the California 2-3 percent tripping rates, effective pollination can be realized when the density is 2-5 bees/sq. yd.

The number of pollen-collecting honey bees found in alfalfa seed fields also varies in a North-South pattern within North America (0.0 percent of bees in Canada to well over 50 percent of bees in southern California and Arizona). Reasons for this variation are also obscure, but it is abundantly clear that honey bee pollination of alfalfa is ineffective in Canada and the northern United States, marginal in mid-states such as Utah, and satisfactory in the southwestern states.

The Alkali Bee

The alkali bee (Figure 3) is nearly equal in size to the honey bee worker; but unlike that species, it is a gregarious, ground nesting, non-social species that is native to the western United States. This species, with its distinctive yellowish to greenish-yellow color bands on the abdomen, was first recognized as a potential pollinator of alfalfa in Utah during the late 1940s. In the early 1950s a few growers in states adjacent to Utah were noticing numbers of alkali bees tripping flowers in their alfalfa seed fields. By 1957, some progressive growers were trying to improve the existing nesting sites of these bees. Then, state and federal researchers in Utah, Oregon, Idaho, and Washington initiated studies of the alkali bee and generated guidelines for its management.

Later it was learned that cores of soil containing live alkali bee larvae could be successfully transported hundreds and thousands of miles. Nesting sites were thus artificially established throughout the years. Methods have recently been devised by which live adult alkali bees can be transported and established on new nesting surfaces, eliminating the time consuming and expensive procedure of transporting cores of soil containing larvae. The new method of transfer also avoids the possibility of introducing pest organisms from the soil and cells into new areas.

Alkali bees have an innate ability to pollinate alfalfa flowers. Every flower is tripped that is visited by an alkali bee of either sex (there is no specialized worker caste as in honey bees), regardless of the bee's pollen or nectar collecting habits. During nesting, each female can trip 12 flowers in a minute and she needs up to 45 minutes to collect one load of pollen. Since an average of 11 pollen loads are required to provide each cell and a maximum of 25 cells are constructed per bee, each female can trip at least 25,000 flowers in a lifetime. Over the same time period the males will also be tripping some flowers as they seek enough food to sustain themselves. It would seem that alfalfa seed growers fortunate enough to have alkali bees available have a good chance to consistently produce maximum seed yields.

And they do unless they encounter natural enemies of the alkali bees, which can sometimes seriously reduce a bee population at a particular nesting site. The most important threat to alkali bees, however, exclusive of insecticides, is rain during the nesting season. Once nesting is established, almost any measurable precipitation, even a short-lived downpour, will allow water to seep into nesting sites and
cause spoilage of partially provisioned cells as well as of cells containing eggs or growing larvae. In addition, rain at nesting time will drown many females within their nests, cause surviving bees to desert established nesting sites, and supersaturate neighboring soil surfaces to make them unavailable as new nesting sites. As a result, alkali bees in any alfalfa seed producing area can be (and have been) nearly eradicated by one midseason thunderstorm. This can cut what had been a maximum alfalfa pollination throughout a decade to virtually zero. These and other factors have caused the use of alkali bees for pollinating alfalfa crops in Utah and other western states to drop during the last 10 years. To some extent, they have been replaced by alfalfa leafcutting bees.

The Alfalfa Leafcutting Bee

The alfalfa leafcutting bee (Figure 4) is native to Eurasia, and was accidentally introduced on the East Coast of the United States during the 1930s. Collection records indicate that the species slowly migrated westward across the continent while its total numbers remained low. Some time during the early 1950s, however, the bees crossed the Rocky Mountains and their population increased markedly in the arid western states. The value of the species as an alfalfa pollinator was recognized by 1958 (in contrast to native leafcutting bees, it strongly prefers alfalfa) and investigations on its management were initiated soon afterwards at USU’s USDA Bee Laboratory and elsewhere. Growers, primarily in the Northwest, heeded a number of published research reports, and in 1960 began providing the nesting holes these bees need. Commercial use of the bees began in 1961. By 1965 alfalfa leafcutting bees had replaced alkali bees as principal pollinators of alfalfa in many western areas.

While management of the alfalfa leafcutting bee varies somewhat from region to region to meet local requirements, adherence to certain easily applied principles allows a grower to readily optimize their efficiency. Nesting materials used and available for commercial use include: (1) drilled boards, (2) paper soda straws, (3) grooved polystyrene wafers, and (4) grooved wood. Drilled boards are the most popular, and each contains approximately 2,000 holes with each 7/32" in diameter and 2 3/4" deep. The nesting materials are placed within shelters and located around the edges of alfalfa fields where they remain until nesting is completed. The nest units are then transferred to cooled rooms to both conserve space and guard against parasites and predators. By holding the temperature at 80-85°F in the spring, growers can correlate bee emergence with alfalfa bloom. A number of growers maintain their nesting shelters on trailers for easy transfer in order to assure effective pollination of large or disjunct alfalfa fields.

The sex ratio of newly emerging alfalfa leafcutting bees is usually 2 males per female and, under some circumstances, it can reach 3 males per female. Because males visit flowers only to feed themselves, at least twice as many bees (5,000/acre) must be released in any alfalfa seed field as would be required if the sex ratio was one to one. This species is highly gregarious, however, and large numbers of individuals will nest in a small space (field nesting shelters.)

Alfalfa leafcutting bees forage most efficiently at relatively high temperatures on sunny, windless days. Females do not normally fly as far as either of the bee species discussed above, even on ideal days, but each female can trip up to 16 alfalfa flowers a minute and she will visit an average of 200 flowers per pollen load. Since 15-18 pollen loads are required to provision one cell and one cell is likely to be constructed per day over the average 20-day working life of a female, the popularity of this species as a pollinator of alfalfa is easy to understand.

The main deterrent to using these bees for alfalfa pollination in the United States is their vulnerability to parasites and predators. Over the years, 30 or more native pest organisms have adapted to this introduced pollinator species, and the viability of the alfalfa leafcutting bee industry is now threatened in localized areas. Fortunately, several
methods for controlling these pests have been tested recently and found successful. By incorporating these control techniques into their management programs, seed producers can substantially reduce their parasite and predator problems.

**Potentials for Other Pollinators**

In 1972, 378,100 acres of alfalfa seed were harvested in the United States. Only 48 percent of this acreage was grown west of the Rocky Mountains, but it produced 85 percent of the crop (average of 480 lbs. acre). The midwest planted 52 percent of the total acreage and produced only 15 percent of the crop (average 90 lbs. acre). Growers in the western region of the United States are thus producing about ⅓ of the 1500 lb. potential maximum yield while Midwestern growers are producing minimal quantities of seed.

Since lack of pollination is the most frequently identified cause of low seed yields, scientists may well intensify their pollination research aimed at increasing the effective pollinators species that could be managed in the western and midwestern states. Studies of alfalfa pollinators in their native Eurasian habitats would seem to have a strong potential for producing reasonably quick insights.

Candidate bee species that demonstrate the greatest promise for successful establishment in North America could then be imported, tested, and either rejected or brought into use. A simultaneous effort could be made to study native pollinator species in western and midwestern regions of the United States to determine which of them can be managed for pollination of alfalfa and related crops. Such a program would supplement ongoing research to study native pollinator species in western and midwestern regions of the United States to determine which of them can be managed for pollination of alfalfa and related crops.

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**ALFALFA INSECTS**

*Donald W. Davis*

The ability of alfalfa to sustain some insect damage with very little loss of yield, plus the many limitations placed on insecticide use on forage crops, makes alfalfa an ideal crop for biological control, integrated control, and control through cultural practices. Growers should not rely strictly on pesticides.

Alfalfa supports a wide variety of insects besides those that destroy alfalfa: pollinators, insect predators and parasites, and insects that use the alfalfa fields as favorable habitat but have little or no effect on the crop. Because of its perennial growth habits, alfalfa serves as a natural nursery for insects, some quite beneficial, which may later leave the field and migrate to neighboring crops. This means that any actions taken to control insects in alfalfa or even just cutting the crop and forcing migration will have direct effects on surrounding crops.

Optimum management of alfalfa acreage demands attention to all organisms since they interact with one another. This complex of interrelationships can be illustrated by a specific example. Insect pests living in the soil (such as the clover root curculio) and nematodes (parasite worms) attack and injure healthy plants. Alfalfa wilt, a disease, enters alfalfa plants through injuries. Once a stand has been weakened by insects, nematodes, and diseases, it can no longer effectively compete with the inevitable weeds — and production is lost.

The insect-plant interrelationships also have to be considered when pesticides are used. Virtually any pesticide application activates a series of events that affects more than just the target pest species. Often the events upset a balance existing among populations and thus encourage previously minor pests to explode into major problems.

Pesticide use on forage crops is more restricted than that on most other crops because much is fed to dairy cattle and pesticides can find their way into the butterfat of milk. The length of time that pesticides can be found in milk following feeding on treated forage can vary from a few hours with some of the organic phosphate insecticides to a year or more with DDT or dieldrin. The safe use of pesticides and strict adherence to label instructions are important on all crops, but are most important on forage being fed to dairy animals.

When discussing alfalfa insects, there is a need to distinguish those
affecting seed production from those affecting the vegetative growth. In the western United States alfalfa is grown for both seed and forage. Those insects affecting the foliage are important to both industries, while those affecting seed production are not of direct interest to the forage producer.

**Common Alfalfa Insect Pests**

Defoliators usually cause spectacular damage to alfalfa fields, stripping foliage from plants and destroying shoot growth (Table 1). Although grasshoppers and caterpillars are serious pests, by far the most serious defoliator in Utah is the alfalfa weevil. At least 75 percent of the insecticide applications made on forage alfalfa in Utah are to control the alfalfa weevil. In the Great Basin area, the weevil spends the winter as an adult, then lays its eggs in alfalfa stems from late April through June. It has only one generation per year. Much of the entomological research in intermountain states is directed toward the control of this pest.

Caterpillars are present in alfalfa fields every year. Unless growers can collect at least 2-3 per sweep in insect net samples it is unnecessary for them to spray for control.

Sucking insects and mites can also cause serious damage, the most troublesome of these being the aphids. Leafhoppers are serious alfalfa pests in the Midwest, but in Utah they are of concern primarily as carriers of disease pathogens. Mites and thrips can damage alfalfa, but rarely is control recommended in Utah.

**Table 1. Common insect pests in Utah alfalfa fields.**

<table>
<thead>
<tr>
<th>Type</th>
<th>Extent of damage in Utah</th>
<th>Season of damage</th>
<th>Main controls currently in use</th>
<th>Controls being developed</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLANT DEFOLIATORS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa weevil</td>
<td>most serious alfalfa pest, $3-5 million damage annually</td>
<td>late May and June</td>
<td>Insecticides, three possible timings</td>
<td>Cultural practices, new parasites, prediction methods</td>
</tr>
<tr>
<td>Caterpillars (3 common species)</td>
<td>erratic, about 1-2% loss of production</td>
<td>mid summer</td>
<td>Special controls, seldom required</td>
<td>Disease pathogens</td>
</tr>
<tr>
<td>Grasshoppers</td>
<td>serious next to uncultivated land</td>
<td>July-Sept</td>
<td>Barrier treatments around field margin</td>
<td>—</td>
</tr>
<tr>
<td>SUCK PLANT JUICES</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pea aphid</td>
<td>very common, often not serious</td>
<td>May-June</td>
<td>Usually handled by weevil sprays</td>
<td>Resistant varieties</td>
</tr>
<tr>
<td>Spotted alfalfa aphid</td>
<td>erratic, can be serious in southern Utah</td>
<td>July-Sept</td>
<td>Resistant varieties, some areas may require insecticides</td>
<td>Resistant varieties, preservation of predators</td>
</tr>
<tr>
<td>ROOT FEEDERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clover root curculio</td>
<td>very common, damage hard to evaluate</td>
<td>May-July</td>
<td>Crop rotation</td>
<td>Resistant varieties</td>
</tr>
<tr>
<td>SEED PESTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lygus bugs</td>
<td>about 40-50% seed losses in unsprayed fields</td>
<td>damage near bloom period</td>
<td>Insecticides, mainly pre-bloom clean up</td>
<td>Cultural practices, new parasites, selective insecticides</td>
</tr>
<tr>
<td>Seed chalcid</td>
<td>about 12% seed loss</td>
<td>damage right after seed is set</td>
<td>Crop management</td>
<td>—</td>
</tr>
</tbody>
</table>

Many predators feed on pea aphids, then migrate to other crops or remain to feed on other pests in the alfalfa field. The spotted alfalfa aphid is primarily a warm climate insect with annual flights into Utah alfalfa fields from the south. When pea aphid predators are allowed to survive, they often control the spotted alfalfa aphid when it arrives during July or August. Chemical controls can be applied, but the spotted alfalfa aphid has developed a resistance to many insecticides. Inasmuch as the aphid problem in Utah is primarily one of reinfestation; it is impossible to predict what insecticide resistances will occur because the origin is not the same each year.

Insects feeding on alfalfa roots are very common and often highly injurious. The clover root curculio is
the most serious of the insect pests, but nematodes and disease are often more important. Control of soil pests is difficult. Any chemical capable of giving a long term control, will also result in objectionable residues on the forage. Alfalfa varieties are available with resistance to nematodes and certain diseases, but not to the clover root curculio.

Insects affecting seed production (lygus bugs and seed chalcids) are difficult to control chemically because they attack the crop during bloom. Any applications of pesticides at that time may do more harm than good by destroying pollinators, wiping out bee colonies and reducing seed set to extremely low levels due to lack of pollination.

Lygus bugs feed on flowers and developing seeds of many plants. When lygus bugs attack blossoms there is a severe blossom drop with little seed set. When they attack newly set seed, the seed shrivels and will not germinate. One major source of lygus bugs comes from alfalfa hay fields which are usually cut about the time the first flowers appear in neighboring alfalfa seed fields — at a time when the more effective insecticides cannot be used on seed fields. Frequent sampling with an insect net should be done to determine whether lygus bug numbers are reaching injurious levels. If any insecticide treatments are required during bloom, materials should be selected which are relatively safe for bees.

Seed chalcids spend the winter as larvae inside alfalfa seeds then build up during the summer on a combination of volunteer plants with off season bloom and first and second crop seed grown in the same area. The only recommended controls involve either the synchronization of alfalfa bloom in an area to break the sequence of generations, or the destruction of waste seed infested with chalcids.

**Alfalfa Insect Studies at Utah State University**

Insect studies at Utah State University are oriented toward species that affect forage. This emphasis is expected to continue for as long as the economy continues to depend so heavily on the livestock industry, which in turn depends on alfalfa and range forage. Unfortunately, results from this kind of research cannot be readily transferred from area to area and in our case must be conducted under conditions encountered in Utah. Problems vary drastically depending on geography, alfalfa variety, age of alfalfa stand, and both long and short term climatic factors.

Alfalfa insect studies have taken two major thrusts in Utah: pest management and pollination. Scientists trying to find ways to manage alfalfa pests want to integrate all available control methods into an ecologically acceptable approach that is both effective and economically practical. They think in terms of using biological and chemical controls, developing plant resistance to pests, and modifying cultural practices to hinder insect development. Simultaneously, they must be careful not to harm beneficial predators and pollinators but rather to improve the value of those beneficial insects already present and develop and introduce new ones.

Future USU research relating to alfalfa pests will continue to emphasize management as the most promising way to achieve control. Most entomologists agree that this approach currently offers the best chances for success. At present, two diseases of the alfalfa weevil are being studied. If we can learn to induce these diseases into weevil populations, we will have a new

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The most serious defoliator in Utah is the alfalfa weevil.
Pea aphids on alfalfa tool to aid in biological control. An effort is also being made to establish three new parasites of the alfalfa weevil in Utah. Utah is a participant in a national research project aimed toward predicting alfalfa insect populations early enough in the season to allow flexibility in applying solutions before the pests get out of hand.

**General Recommendations for Pest Control on Alfalfa**

1. The recommendation of specific chemicals for alfalfa insect control should be obtained from the county agricultural agents and other sources of information at the local level. There are too many variations in pest problems and available insecticides to make recommendations here.

2. Alfalfa growers should make full use of cultural practices, resistant varieties, and biological control methods. Many pest management procedures are available which can reduce the reliance on insecticides.

3. Fully effective pest control demands an understanding of the problems as they exist in a given field at a given time. Every field should be examined several times a season and an insect net used to sample both beneficial and pest insect populations. On hay fields the most critical period for the alfalfa weevil is during May and June. On seed alfalfa, in addition to the weevil, careful attention is needed during the bloom period to determine lygus bug numbers.

4. The necessary time interval between application of insecticides and harvest is of prime importance. This makes strict adherence to instructions on insecticide labels very necessary. Once alfalfa is baled or put in storage, the pesticide residues will not continue to disappear at the same rate as they did in the field.

With intelligent pest management, high quality alfalfa can be produced free of dangerous pesticide residues. This management, together with proper irrigation, fertilization, selection of varieties, and weed control, will make possible substantially increased yields. Alfalfa, already our most valuable forage crop, can then assume an even more important role in helping solve the world food problem.

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**Alfalfa Nematodes**

**W. F. Campbell and G. D. Griffin**

Protein malnutrition is second only to shortages in total food supply among problems facing the nations of the world. Fortified and processed leaf proteins may help to satisfy this protein shortage. Alfalfa is considered the most economical source of leaf-protein among all presently grown crops. Unfortu-
nately, this prodigious crop suffers combined average annual losses from diseases, insects, and nematodes amounting to about 40 percent of the national alfalfa production. Nematodes alone may destroy one-half to three-fourths of an alfalfa crop. Heaviest losses usually occur in fields which have been allowed to remain growing for over 5 years or those which have been replanted immediately following an old stand. The average annual losses in alfalfa to nematodes in terms of dollars is over $2,000,000 in Utah and exceeds $86,000,000 in the United States as a whole.

Three species of nematodes are found in Utah on alfalfa. They are the alfalfa stem nematode, *Ditylenchus dipsaci*, the northern root-knot nematode, *Meloidogyne hapla*, and the southern root-knot nematode, *Meloidogyne incognita*. These are not to be confused with the sugarbeet nematode, *Heterodera schachtii*, which is not pathogenic on alfalfa.

**Alfalfa Stem Nematode**

*D. dipsaci* is a microscopic, slender, roundworm about 1.0 mm (1/25 inch) long and 0.03 mm (1/950 inch) wide. The body tapers at both ends, but not nearly as much at the anterior end. Nematodes live as parasites within the tissue of alfalfa plants, multiply rapidly, and young larvae resemble the adults. Nematodes have a well-developed sensory and behavior system that enables them to seek out specific parts of plants.

This nematode is the most important and one of the most serious pathogens attacking alfalfa. It is found throughout alfalfa-producing areas of Utah and it is particularly important in irrigated areas where waste water is used. *D. dipsaci* is of less importance in dry farm areas where damage is usually minimal since the nematode is spread mainly by water.

*D. dipsaci* overwinters in succulent alfalfa tissue under a snow cover, in the crown of the plant, and as eggs in the soil. Damage is usually confined to the first cutting during cool, humid weather, although there is continual feeding of the nematode in the crown tissue. Nematodes infect the growing crown buds beneath the soil and are carried up with the growing alfalfa stem. Young infected stems become enlarged and discolored, the nodes swell, and the internodes shorten (Figure 1). Growing stems may succumb to the infection or overcome the swelling and make what appears to be a normal growth, except that a stem necrosis varies in severity, depending on the climate.

Nematode infections are usually first noticed in low-lying areas of the field where water tends to collect. After the alfalfa has been killed by the nematodes, weeds and other disease organisms readily invade. These areas gradually increase in size each year as more of the alfalfa plants die. In addition, we have observed scattered infected plants with a condition known as stem-nematode-induced white flagging. Affected leaves and stems exhibit partial to complete loss of normal green pigmentation, while maintaining nearly the same size and shape. We have only observed this condition after the first cutting when moisture conditions and temperatures are high.

Numbers of stems within a crown become less each year, and whole stands of susceptible varieties may degenerate in as few as 2-3 years when conditions favor the nematode. Its presence also enhances the infection and importance of bacterial wilt.

Nematodes in the stems are removed with the first cutting, but then are carried into the irrigation system. Crown buds are infected 1 to 2 inches beneath the soil and there is little danger of infection in late cuttings, unless alfalfa is cut when the soil is wet — the nematode must have a water medium by which it reaches the plant tissue.

Resistance is the major source of control, and varieties such as Lahontan and Washoe have been developed (Figure 2). Breeders are also developing new varieties for areas with different climates. One should consult his extension specialist on the variety of alfalfa to plant in his area.

Growers should not cut alfalfa when the ground is wet or muddy in order to avoid infection of the next cutting. Stubble should not be burned in the spring in order to avoid new crown bud initiation and greater nematode infection. Fall burning has shown promise in lessening the nematode infection.

The feasibility of using systemic nematicides is being studied. Nematicides are not only excessively costly and difficult to use on alfalfa, however, but they are also a potential environmental pollution hazard and require frequent applications. For these reasons it is important to use nematode resistant alfalfas in irrigation alfalfa producing areas.

**Root-knot Nematode**

The larvae and adults of root-knot nematodes differ in size and shape. Larvae are approximately 0.4 mm long, while the females are oval in shape, approximately the size of the head of a pin. Males are cylindrical and about 1.2 mm long.

The northern root-knot nematode is not as important a problem as the alfalfa stem nematode, since it is not as widely distributed. The southern root-knot nematode is even more confined in distribution, and is found only in Utah's Dixie.
Unlike the stem nematode, the root-knot nematode infects and parasitizes the roots of plants and characteristically galls the roots (Figure 3). Young seedlings may die because of a heavy infection, however, even though the roots fail to show galling. Alfalfa is usually not as susceptible to root-knot nematodes as it is to stem nematodes. Root-knot nematodes enhance the infections and symptoms of bacterial and fungal disease; however, that may be as devastating as the stem nematode.

Resistance is the only method of control. Resistance has been found in “Vernal” alfalfa selections, but resistant commercial varieties are not yet available to the grower. Root-knot nematodes can be controlled also with soil fumigation. This is expensive, however, and not economically feasible.

**Nature of Resistance**

Resistance is a characteristic of the alfalfa plant. However, various environmental factors such as temperature, soil type, host nutrition, age of the plant and previous cropping history may alter the expression of resistance. Temperature affects the rate of penetration and reproduction of both *Ditylenchus* and *Meloidogyne* in alfalfa. For example, optimum temperatures for invasion and reproduction of *D. dipsaci* in alfalfa are 15 to 20°C. Reproduction can occur over a wide temperature range, 5 to 30°C, however, and, in the stem-nematode-resistant variety Lahontan, resistance is apparently lost at about 25 to 30°C.

Soil type may affect the plant parasitic relationship. In heavy soils the alfalfa stem nematode populations tend to stabilize at about 50 nematodes per 500 grams of soil, whereas in light soils the population may fall to less than ten nematodes per 500 grams of soil.
This is different for root-knot nematodes which favor light, sandy soils. Under controlled environment studies we have found no relationship between severity of host response and numbers of invading nematodes. Since one organism can do as much ultimate damage to a plant as several, the resistance apparently has to be absolute to be effective.

Nutrients such as K+ and Ca++ thought to be associated with resistance to both stem and root-knot nematodes. These elements may form enzymes resistant complexes with polygalacturonates in the middle lamellae. Using light and electron microscopic cytochemical techniques, however, we have been unable to demonstrate any change in the middle lamellae of resistant Lahontan or susceptible Ranger following stem nematode inoculation. Older plants appear to be more resistant to both stem and root-knot nematode attacks than do young seedlings. Also previous cropping may be a factor in selecting out more pathogenic strains of nematode species.

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UTAH SCIENCE

Index for Volume 35, 1974

Author Index

Barker, Philip A.
Syrup production from canyon maple. 35(1):13-15
The spectacular canyon maple. 35(1):7-10

Barnes, Barry
The blue grouse in northern Utah. 35(2):43-46

Batty, J. Clair.
Agricultural wastes and energy — some problems and potentials. 35(2):66-70

Bleak, A.T.

Bond, Larry K.
What to look for in a lease. 35(3):101-102

Box, Thadis
Utah and the nation's needs. 35(4):119-122

Bylund, Bruce H.
A public poll on land use planning. 35(3):93-98

Cottam, Walter P.
Some uncommon people and some uncommon plants. 35(1):10-12

Davis, Donald W.
Unsprayed fruit trees — how much of a problem to commercial orchards? 35(2):56-57

Dewey, Wade G.
Cardon and Hansel — new smut resistant winter wheat varieties. 35(2):53-55

Foste, W.C.
An international approach for improving Utah's sheep. 35(2):47-51

Gardner, B. Delworth
Land use legislation: peddling uphill backwards. 35(3):75-78

Geertsen, H. Reed
A public poll on land use planning. 35(3):93-98

Giunta, Bruce C.
Shrubs for restoration of depleted ranges and disturbed areas. 35(1):28-33

Hancock, "H" K.
Land values in Utah's canyon country. 35(3):81-85

Hansen, Garth R.
Assessing feed quality. 35(2):58-61

Harris, Lorin E.
Assessing feed quality. 35(2):58-61

Hoagland, John F.
Wilderness fishing: a study in recreational land use. 35(3):99-100

Holmgren, Arthur H.
Shrubs in Utah and the intermountain region. 35(1):3-4

Hunt, John D.
Utah's tourism and recreation potential. 35(4):126-132

Johnson, Ralph M.
The importance of basic research. 35(4):122-125

Keller, Wesley

Kennedy, James J.
Wilderness fishing: a study in recreational land use. 35(3):99-100

Leone, N. C.
Veterinary medicine helps humans. 35(2):62-65

Lewis, W. Cris
A critical look at land use planning. 35(3):90-92

Low, Jessop B.
The blue grouse in northern Utah. 35(2):43-46

Malechek, John C.
Range cow behavior and energy conservation. 35(3):103-104

Matthews, Doyle J.
Food for consumers — a living for producers. 35(4):107-108.

McArthur, E. Durant.
Shrubs for restoration of depleted ranges and disturbed areas. 35(1):28-33

McKell, C.M.
In Utah — planning at the local level. 35(3):81-85.

Middlebrooks, E.J.
Ag research in the College of Engineering. 35(4):115-116

Plummer, Perry A.
Oldman woodworm to stabilize disturbed areas. 35(1):26-27
Shrubs for restoration of depleted ranges and disturbed areas. 35(1):28-33

Salunkhe, D.K.
Syrup production from canyon maple. 35(1):13-15

Smith, Benton M.
Range cow behavior and energy conservation. 35(3):103-104

Snow, Phyllis R.
Family awareness. 35(4):117-118.
Spillett, J.J.
An international approach for improving Utah's sheep. 35(2):47-52

Stutz, Howard C.
Rapid evolution in western shrubs. 35(1):16-20

Thorne, D. Wynne
Goals for Utah agriculture. 35(4):109-114

Van Epps, Gordon
Shrub seed production — a potential enterprise. 35(1):21-23

West, Neil E.
Shrublands of Utah. 35(1):4-6

Weber, David
The blue grouse in northern Utah. 35(2):43-46

Willard, E. Earl.
Rangeland shrub regrowth — bane or benefit? 35(1):34-36

Wiseman, Clark
Rezoning by auction — a new approach to land use decisions. 35(3):86-89

Subject Index

Agriculture
Wastes and energy 35(2):66-70
Goals for consumers 35(4):109-114
Research in College of Engineering 35(4):115-116
New sweet cherry 35(2):72
Research covers Utah 35(4):133

Family
Family awareness 35(4):117-118

Feed
Assessing quality 35(2):62-65

Fruit Trees
Unsprayed fruit trees 35(2):56-57

Land Use
Legislation 35(3):75-78
In Utah 35(3):79-80
Canyon country 35(3):81-85
Rezoning by auction 35(3):86-89
A critical look 35(3):90-92
A public poll 35(3):93-96
Wilderness fishing 35(3):99-100
What to look for in a lease 35(3):101-102

Livestock
An international approach 35(2):47-52
Range cow behavior 35(3):103-104

Natural Resources
Utah and the nation's needs 35(4):119-121
Utah's tourism and recreation 35(4):126-132

Plants
Shrublands of Utah 35(1):3-4
Shrublands of Utah 35(1):4-6
Canyon maple 35(1):7-9
Some uncommon plants 35(1):10-12
Syrup production 35(1):13-16
Rapid evolution 35(1):16-20
Shrub seed 35(1):21-33
Kochia prostrata 35(1):24-25
Oldman wood worm 35(1):26-27
Shrubs for restoration 35(1):28-33
Rangeland shrub 35(1):34-36
Effects of ultraviolet radiation 35(2):52

Research
The importance of basic research 35(4):122-125
Wynne Thorne Award 35(1):37
Veterinary Medicine
Veterinary medicine helps humans 35(2):62-65
Wheat
Cardon and Hansel 35(2):53-55
Wildlife
The blue grouse 35(2):43-46

MARCH 1975

THE ONION PATCH

Continued from page 40
water from some plants. All plots were irrigated twice before bloom. Thereafter, only half of the plots were irrigated each week. After water had been withheld from the dry plots for 3 weeks, their soil moisture tensions were higher than could be measured by tensiometers.

Appearance and disposition of assaulted plants: Your Honor, to again save the Court's time we submit Table 2 and Figures 1 and 2 as evidence. Fertilizers alone or in combination had no effect on the number of umbels per plant. However, N alone and N and P together significantly reduced plant survival, seed yield, and all components of yield. While the fertilizers significantly reduced most of the components of yield, a high soil moisture tended to reduce such negative effects. Seed yield, the end product, and the components of yield followed closely the trend in plant survival as affected by fertilizers times moisture relationships.

Normally, excess N fosters lush vegetative growth and delays maturity. The scientists did not notice any delay in maturity in this case, but they did notice a difference in leaf coloration between control, N, P and NP treatments (Figures 1 and 2). The ratings were based on plants with dark green, light green, yellow, partly dried and totally dried leaves. The positive effects of the fertilizer treatments in maintaining green leaves were evident from leafburn ratings taken just prior to withholding irrigation. Let the record show that the ratings of leaf burn were evaluated 2 weeks after discontinuing irrigation and the differences were pronounced (P > 0.05) between no-fertilizer and fertilized plots and between low and high moisture plots (Figures 1 and 2). The plots receiving low moisture
and no fertilizer had greater leaf
burn than did the plots given high
moisture plus N or P treatments.

Your Honor, normally, N in the
presence of P favorably affects the
various components of seed yield.
The method of fertilizer application
used by the accused in their exper­
iment did not take into account the
combined effects of the 2 fertilizers.
The fertilizers did not significantly
influence the number of umbels per
plant, but they did significantly af­
fect plant survival and the other
components of yield. Fortunately,
sufficient soil moisture offset the
negative effects of over­
fertilization.

The delayed emergence (3
weeks after planting), the highly
significant reduction in plant sur­
ival, and the low magnitude of
bolting and flowering were proba­
bly caused by direct injury to the
developing roots because of their
close proximity to the fertilizer and
the large amounts of fertilizer ap­
plied. Your Honor, injury symp­
toms might have been even more
notable, but for the low salt con­
tent of the soil (average EC < 0.5),
and the high quality of irrigation
water (rated class 1A).

Let the record show that fertilizer
placed close to seeds or plants may
increase the osmotic pressure of the
soil solution and injure the plants.
Hence, any fertilizer with a high salt
index must be used with great care.
The salt indices of the ammonium
sulfate and of triple superphosphate
used by the accused were 69 and
10.0, respectively.

It is charged therefore your
Honor, that these USU scientists did
willfully and with forethought
maliciously torment the innocent
onions in the onion patch.

| Table 1. Onion inbreds, moisture and fertilizer levels used during the two years of field testing. |
|---|---|---|
| Inbreds | Moisture | Fertilizer |
| | 1970 | 1971 |
| B2149A | Low | none |
| | (2 irrigations at early growth) | N at 150 lbs N/A |
| B2264A | | P at 200 lbs P2O5/A |
| B2267A | High | N and P together at these rates |
| B5546A | | (Irrigated weekly) |
| MSU-611C | | |
| B12115-2C | | |

| Table 2. Criteria evaluated and the effects of fertilizer and moisture on these criteria. |
|---|---|---|---|---|
| Components of Yield | Moisture | Effects of Fertilizer | N | P | N + P |
| | Low | High | | | |
| Plants per row that survived and bolted | ** | ** | ** | — | ** |
| No. umbels per plant | — | — | — | — | — |
| No. flowers per umbel | — | — | — | — | — |
| Percentage fertilized flower | * | * | * | — | * |
| No. seeds per fertilized flower | * | * | * | — | * |
| Leaf burn | * | * | * | — | * |
| Seed burn | * | * | * | — | * |

* Treatments were significantly different 95% level.
** Treatments were significantly different at 99% probability level.
Court Judgement

You have heard the charge; how do you scientists plead?

Your Honor, we plead guilty to the charges, but we believe that the value of what we learned to anyone growing onions (*Allium cepa* L.) for seed should be taken into consideration before you pronounce the sentence. Such growers can enhance their probable success by:

1. Testing the soil before planting. Do NOT apply additional fertilizer to fields that test adequate for fertilizer requirements for crop production.

2. If the onions are following a crop that has already had a generous application of fertilizers, no further fertilization is needed.

3. If fertilizers are necessary (even in light applications), then considerably more water is needed to reduce the osmotic stress on the plants.

4. Continuing irrigations through the critical times of flowering and seed setting when temperatures are apt to be in the high 90s.

The accused, having pled guilty to the charges, were thereby sentenced to extensive research in other areas.

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Figure 1. Experimental onion plot subjected to nitrogen plus phosphorous fertilizer and no irrigation. Note the reduction in plant density and the burnt leaves.

Figure 2. Experimental onion plot with no fertilizer and irrigated. Note only a slight burning of the leaves.
W. F. Campbell and W. P. Nye

Hear Ye! Hear Ye! The Court of Scientific Process is now in session. The case before the court involves alleged assault by USU research scientists on peacefully flowering onion plants that were doing their thing, namely producing seed.

Let the record show that to get a high seed yield from almost any plant, you have to work with complicated interrelationships among plant characteristics and environmental factors. And a hybrid onion seed production program is even more complicated than average. The need to use male-sterile plants introduces additional factors to worry about: the male-fertile (pollen parent) and male-sterile (seed parent) plants must flower simultaneously and pollen has to be transferred artificially from the male-fertile plants to the male-sterile ones.

Moreover, in hybrid seed production many of the basic factors depend upon time-related events that must occur in proper sequence. Let the record further show that with prices for onion seed expected to soar this spring ($30 to $40 a pound or higher) potential returns can justify the time and effort required to avoid a partial or complete loss of seed yield.

That the suffering perpetrated on the onions by the scientists may not go in vain, we would like to read into the record as the case is heard a few notes from their journals and logs which describe the effects of fertilizer and moisture levels on onion seed yield.

Charge: Aggravated assault and attempted murder. Victims — onion bulbs planted in soil (Millville silt loam) that previously tested adequate with respect to fertilizer requirements for crop production. Victims in some communities (experimental plots) were slowly poisoned by extra fertilizer, while other communities were deprived of water and thus condemned to a slow death.

Assailant and Modus Operandi: Your Honor, to save the court time we submit Table 1 as evidence.

The aforementioned scientists deliberately and willfully withheld

Let the record show that prices for onion seed are expected to soar this spring ($30 to $40 a pound or higher).