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Breeding Alfalfa for Pest Resistance
A Message from the Vice Chancellor

One of the reasons for establishing the Institute of Agriculture and Natural Resources was to provide a vehicle for the coordination of agricultural, natural resource and related programs within the University of Nebraska.

Many of the Institute’s programs cross departmental lines, and many are interdisciplinary.

The Institute, and its major components—the College of Agriculture and School of Technical Agriculture at Curtis, the Agricultural Experiment Station, the Cooperative Extension Service, the Conservation and Survey Division, the Water Resources Center, and International Programs—have the same basic mission of teaching, research, and extension.

Each of the Institute’s components has its own specific mission within the IANR framework.

The Conservation and Survey Division, for instance, was originally established by the legislature in 1921 for the specific purpose of surveying the soil, forest, water and geological resources of Nebraska.

All of these functions have been performed by the division, operating strongly from a geological base of expertise. In recent years, its activities have been most prevalent in the mapping of soil types by county (in cooperation with the U.S. Soil Conservation Service), and in investigating the status and availability of our mineral resources such as coal, sand, limestone, oil and gas.

New methods for collecting resource-related data, such as satellite imagery collected at the Remote Sensing Center, are being used to compile land-use maps, and maps showing the location of all center-pivot irrigation systems in the state.

The Conservation and Survey Division, like the other components of the Institute of Agriculture and Natural Resources, exists to serve the people of Nebraska.

M. A. Massengale

Farm, Ranch and Home

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On the cover:

Pests, such as these pea aphids, can cause millions of dollars of damage to alfalfa each year. One of the best ways to control pests and diseases is to breed alfalfa for better resistance. This is one goal of the continuing alfalfa breeding program of the Nebraska Station-USDA-ARS. See page 12. (Photo by Dick Dodds)
Needling Makes Beef More Tender

By W. C. Schwartz and R. W. Mandigo

The tenderness of meat is very important to the consumer. The possible increase of beef fed little or no grain has stimulated considerable interest in mechanical tenderization.

Research at Loeffel Meat Laboratory has shown that penetrating beef with needles of a mechanical tenderizer can make beef more tender. A mechanical needle tenderizing machine was used to determine if needle penetration would make beef inside rounds more tender by severing some of the muscle fibers.

Forty U.S.D.A. Choice and forty U.S.D.A. Good grade boneless inside rounds were passed through a chamber where stainless steel needles were pushed into the meat (Figure 1). The conveyor carrying the meat into the chamber was adjusted for three different speeds. The slower conveyor speed results in more needle penetration (Continued on page 4).

Penetrating beef with needles is one way to give the consumer tender meat.
Needles...

dle punctures in the meat because the needle assembly continues at a consistent rate. One inch (2.54 cm) steaks were cut from the center of the boneless rounds and analyzed for chemical and physical properties.

Tenderness and chemical effects of needle penetrations are given in Table 1. The mechanically treated beef rounds were more tender than the untreated rounds, but increasing the number of needle penetrations did not further increase tenderness. Mechanical tenderization did not change the moisture or fat content.

Results of the cooking tests are in Table 2. Although thaw and cooking loss showed decreased values with increased needle punctures, the values were not statistically different. Cooking time did decrease with increased tenderization, probably because of increased heat penetration during cooking caused by the punctures.

Round steaks processed in this manner appeared normal. The tiny holes left by the needles did not distract from the appearance of the steaks. Many customers were unaware the steaks they purchased were treated until they were shown the tiny needle marks as they returned to buy more steaks. Moisture loss was the same for the treated and untreated steaks, but a decrease in cooking time was noted. This information contradicts those who expect needle tenderization to increase moisture, fat and total cooking losses because of the increased exposure of meat surface area to heat caused by penetrating the cut with needles.

Assuring beef tenderness with mechanical needle penetrations is one acceptable method of assuring tender beef for the consumer. Tenderness may be a problem in beef animals not fed much grain. Through the use of mechanical tenderization, this type of beef may become a more acceptable product. "Needling" your beef can make it tender!

**Detecting Herbicide Carryover in Soil**

By T. L. Lavy and D. W. Hoffman

The past three dry summers in Nebraska have caused many more herbicide carryover problems than usual. Water plays a key role in the breakdown of herbicides in the soil. There are several reasons why in dry years herbicides show more carryover. In dry years:

- herbicides are bound (adsorbed) more tightly to the soil
- less herbicide is lost into the air by volatilization
- the lowered number of soil microorganisms in a dry soil results in less microbial breakdown of herbicide
- hydrolysis and other nonbiological chemical breakdown reactions occur more slowly
- less herbicide leaching and runoff occurs
- decreased plant uptake of herbicide occurs since less water is taken up by the growing plants.

Plants compete for water, sunlight and nutrients in the soil. While searching for more sensitive tools to detect herbicide carryover in soil, weed researchers found that plants also compete for herbicides in the soil. When two soybeans were planted in the greenhouse in a pot of soil containing approximately 1 pound (454 g) soil and 0.8 lb/ft² (0.4 ppm) atrazine, both soybeans soon died because of the atrazine in the soil. When 10 soybeans were planted into pots containing the same amount of atrazine-treated soil, all plants grew normally during the 28-day growing period and none appeared to be injured by the atrazine.

To further investigate the possibility that plants were competing for the atrazine, an experiment using three sizes of pots was set up. Three soybean plants per pot were grown in pots containing approximately ½, 1 or 2 pounds (227, 454, or 908 g) Sharpburg silty clay loam soil treated with atrazine at a rate of 1 lb/ft² (0.5 ppm).

Because all soil in each pot was treated with atrazine at 1 lb/ft², the 2-pound pot contained four times as much atrazine as the small pot and

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W. C. SCHWARTZ is group leader for product development, R. W. MANDIGO is professor of Animal Science and Food Science and Technology.
twice as much atrazine as the 1-pound pot. As shown in Figure 1, after 28 days, plants grown in ½ pound of soil were only slightly injured. Plants in 1 pound of soil were damaged badly and plants grown in 2 pounds of soil were dead. These results indicate that the ratio of soil volume to plant seeding rate is important when we are trying to detect trace levels of herbicide residue in soil.

Figure 2 contrasts the sensitivity of oats to atrazine residues in field soil when two sizes of pots of soil were used to grow the plants. The small pots contain 1 pound of soil while the larger pots contain approximately 14 pounds of soil. This larger volume of soil is more comparable to field conditions.

Twenty oats were planted into each pot. Where injury occurred, plants growing in larger pots (more soil for each plant) were always damaged more. This study illustrates that if a sample of soil is brought in from the field and tested using a small amount of soil, a different answer may be obtained depending primarily on the size of the soil sample and not necessarily on the concentration of the herbicide residue in the soil sample.

These findings are helping us explain why crops grown in the field are sometimes injured by herbicide carryover and yet when soil samples are taken from the same field and assayed for herbicide carryover using 1 pound of soil, no carryover can be detected. Where higher amounts of the herbicide have carried over, planting a sensitive crop into a small pot is adequate. Where low levels of herbicide residues are suspected, increasing the amount of soil available for each plant will increase the sensitivity of the test. To increase our ability to detect herbicide carryover (in the greenhouse or your living room) ideally, a plant should have as much soil available to it as the root system occupies in the field.

What is the explanation for this apparent competition for the herbicide? Since less than 3 per cent of the applied herbicide is commonly taken up by plants in the field, plant population has not been considered to be a major factor in herbicide performance. However, the amount of herbicide in the available fraction of the soil complex plays a major role in determining the amount which will be taken up by growing plants.

The available fraction, which may amount to as little as 3 per cent of the total applied, is commonly divided among the following methods of dissipation: a) volatility; b) leaching; c) microbial tie up; d) chemical reactions; e) and plant uptake. Thus in soils high in clay or organic matter content, where a large percentage of the herbicides is in the adsorbed state, competition for the available fraction occurs. For some herbicides the amount and rate of herbicide which is eventually released from the "non-available" soil fraction plays an important role in herbicide performance in the field.

A field experiment was designed to test the relationship between soil volume and plant numbers which was shown in the greenhouse. Atrazine was sprayed at a rate of 2 lb/ai (1 ppm) onto the surface of a Sharpsburg silt loam. Three weeks later soybeans were planted into the treated field at two planting rates. In one area the beans were planted at the rate of one soybean per 100 cm² while in another area six soybeans were planted in a similar 100 cm² area.

The photos in Figure 3 show that soybeans planted at the low seeding rate were killed readily, while soybeans, when planted closer to each other, were not damaged nearly as much. Thus, the concept of plants competing for atrazine has been shown both in the laboratory and in the field.

Figure 3 shows that several plants growing near each other tend to "protect" each other initially from the herbicide, however, no yield data were collected since these plants were harvested before maturity. However, if herbicides have carried over, or are suspected, planting a more tolerant crop would probably be a better practice than increasing the planting rate in dryland agriculture.

Results from these studies also provide a practical application to weed control. If dense weed stands are anticipated in the field it may be necessary to slightly increase herbicide application rates for optimum weed control.□

T. L. Lavy is professor of Agronomy. D. W. Hoffman is a graduate research assistant.
Direct from-the-farm marketing has been around since colonial days. Today, from-the-farm and on-the-farm marketing can be a profitable outlet for the farmer's produce. Shorter working hours, more leisure time and consumers' greater mobility have contributed to the increased popularity of these types of selling.

A farm's most valuable property could well be its frontage on a free-access highway. Some farmers are taking advantage of this frontage by operating roadside markets. Other farmers located near cities and on improved roads have the opportunity to develop a pick-your-own fruit or vegetable market.

Over the years the fruit and vegetable industry has become more specialized and mechanized with individual grower operations becoming larger. This type of production encourages lower prices of horticulture crops.

However, large producers abandon some of the excellent quality varieties for one reason or another and this offers opportunities to the small growers. With a few acres and a lot of desire he can produce a variety of crops and market them through a roadside market or as a pick-your-own operation. With either method he could increase his income by marketing his own produce.
In Nebraska seasonal roadside markets have been the main method of selling vegetable produce off the farm. Methods vary from selling from the back of a pickup truck to use of well designed permanent structures. They are found throughout the state. Pick-your-own marketing hasn't developed yet in Nebraska but has real potential.

Each marketing system has its own characteristics. A roadside market is exactly as the name implies: a market at the side of the road. It differs from the corner supermarket by selling primarily fresh fruit and vegetables. Other specialty items sometimes are sold, usually as novelties.

Near Highway

The market can be located on the same farm as the vegetables are produced or it could be some distance away. It is nearly always located on a well-traveled road or highway. The roadside market requires the operator to grow, pick and sell his vegetable produce.

The pick-your-own marketing method requires the consumer to travel to the orchard or vegetable farm and pick the produce himself from the farmers' fields. The advantage to the consumer is his assurance of fresh, high-quality produce at reasonable prices. The farmer can also realize higher profits by eliminating the costs of labor. In the eastern section of the United States and Canada many consumers and producers use the pick-your-own method.

Pick-your-own marketing is not new, either. Pick-your-own had its beginning in the 1930s and 1940s as a result of several factors. One grower was forced to try customer harvest when poor prices in city markets resulted in losses on his sales. More than once, pick-your-own strawberries were advertised out of desperation when immigrant pickers failed to arrive on schedule. One grower started pick-your-own as a novel idea because people coming to his market stand asked to pick their own berries. He let them and discovered that the method had some advantages.

The pick-your-own marketing system has advantages and disadvantages. First the customer has to travel to the farmers' fields. This requires the farm to be near a highly populated area.

The farmer needs to grow produce that is in demand by the consumer as well as profitable for himself. Because the consumer picks the produce himself, the farmer needs to advertise so the produce is harvested just when it is ripe. And he has to be able to get along with the public.

Both urban and rural people enjoy harvesting their own fruits and vegetables from a commercial field. They enjoy fresh, field-ripened fruits and vegetables. Some like the lower prices, and others just enjoy the recreation and the experience of the farm atmosphere. Whatever the reason, more and more people are doing it every year.

First in 1920s

One of the first in commercial pick-your-own was William Thompson of Summers, Wisconsin, who planted cherries for U-pick in the early 1920s. Gradually through the 1950s more and more growers in the midwest tried selling part or all their berry or other fruit crops on a pick-your-own basis. More growers in the 1960s and early 1970s began to plan for pick-your-own, and today they are buying farm locations for the express purpose of growing fruits and vegetables for direct sale to the customer.

In 1970 a survey of pick-your-own strawberry customers was conducted in southern Illinois. It was found that 64 per cent of the customers lived within 25 miles of the farm. Another 23 per cent would travel up to 50 miles one way to pick the strawberries. Forty-six per cent of the customers picked between 10 to 30 quarts per visit. Of all the strawberries picked, freezing (62 per cent) was the principle use followed by fresh use (28 per cent) and preserves (10 per cent). This suggests that people pick their own fruits and vegetables or buy from roadside markets to supplement their food fare with reasonably priced produce that can be bought in large quantities.

Any vegetable with general acceptance can be potentially marketed through pick-your-own and roadside markets. Vegetables grown for pick-your-own today are tomatoes, green beans, sweet corn, cabbage and peas. This doesn't mean other vegetables can't be used. Vegetables such as green peppers, asparagus, cauliflower and melons may become future top sellers.

Success Depends

Almost any vegetable or fruit can be marketed through a roadside market. Roadside or pick-your-own marketing is like any other small business. The success or failure of the business will depend on many factors. To identify these factors an analysis of the marketing potential and customers' wants is needed. Questions relating to advertising, levels of production, pricing, services offered and even what to plant should be considered. A survey prior to planting will answer questions and reduce uncertainty in the business venture.

A factor that seems to be very important in roadside and pick-your-own marketing is family involvement. A market is usually successful if it is a family operation with members of the family directly involved. The family involvement and the personal touch seem to be the keys to success.

The opportunities in roadside markets and pick-your-own vegetables or fruits in Nebraska are great. The climate of Nebraska is good for vegetable production. Tree fruit in the southeast region of the state was once a major crop. These facts, plus the interest in vegetables and fruit marketing, could develop another industry in Nebraska.

Donald E. Janssen is extension horticulture assistant. Donald H. Steinegger is extension horticulturist.
Many Uses Found
For Geologic Maps

By R. R. Burchett and
J. B. Swinehart

Nebraska geologists have had rocks on their minds ever since the late 1850s. At first, it was to satisfy a basic scientific curiosity. In later years, however, geologic studies have also been directed towards a better understanding and management of our natural resources.

An important tool of geologists for summarizing and communicating their data has been the geologic map. In 1963 a project was started by the Nebraska Geological Survey, in cooperation with the U.S. Geological Survey, to prepare regional geologic maps of the bedrock surface in Nebraska.

What is a bedrock geologic map? Bedrock is a general term for consolidated or solid rock exposed at the land’s surface or, as is the usual case in Nebraska, buried by soil and other unconsolidated surficial material (glacial material, loess and sand hills).

A geologic bedrock map shows where different rock units are with surficial material removed. A topographic map, which shows the arrangement of the land surface by using contour lines of equal elevation, is usually the base for the geologic map.

In areas of Nebraska where many surficial materials are present, their thickness is shown by the use of contour lines (Figure 1). Surface exposures of the bedrock can also be shown on the map. A columnar section, giving information on the important physical characteristics, thickness and age of each mapped geologic unit accompanies each map.

How is a bedrock geologic map prepared? Two basic kinds of infor-
mation are necessary. The first is information about the surface or outcrop exposures. Geologists from our staff study exposures of bedrock in the field. The contacts between the different geologic units are located and followed across the countryside where possible. Aerial photographs and topographic maps are used to record the locations of outcrops and geologic contacts.

The field geologists also describe, measure the thickness and collect samples of the mapped rock units.

Subsurface data is the second kind of information needed to construct a geologic bedrock map. The Conservation and Survey Division uses its own drilling rigs to determine the depths to and the character of the bedrock. This subsurface and surface data—along with data from thousands of other drill holes made in search of water, minerals and fuels, as well as published and unpublished maps, and field notes from the files of the division—are then transferred to a topographic map.

Why So Important

Why is a bedrock geologic map important? Bedrock geologic maps and cross-sections prepared from them are important sources of information for a wide variety of users. They may be used to interpret the geologic features and history of an area. They also are useful to determine the depth to or location of rock or mineral deposits, such as limestone, shale or sand and gravel.

The bedrock geologic maps are helpful in foundation studies for building sites, roads and bridges and as an aid in locating and managing groundwater supplies. All in all, a bedrock geologic map is a basic tool for planning and managing the development of Nebraska’s natural resources.

Base maps for the current mapping program are the U.S. Geological Survey 1° × 2° topographic quadrangle maps, scale 1:250,000 (approximately ¼ inch equals one mile). There are 13 of these quadrangles that cover Nebraska, as shown in Figure 2. The Lincoln–Nebraska City, Grand Island, and Fremont–Omaha bedrock geologic maps have been published and are available from the Conservation and Survey Division.

The price of each sheet is $1 per copy, plus tax. Make checks and money orders payable to University of Nebraska. Address orders to:

Conservation and Survey Division
113 Nebraska Hall
University of Nebraska
Lincoln, Nebraska 68588

Geologic mapping has been completed on the Sioux City Quadrangle and has been sent to the U.S. Geological Survey in Denver for final review and drafting. Field mapping will continue this summer in several areas of the state.

R. R. Burchett and J. B. Swinehart are research geologists, Nebraska Geological Survey, Conservation and Survey Division.

Figure 3. Geologists of the Conservation and Survey Division measure and describe bedrock outcrops in western Nebraska.

Figure 4. A bedrock outcrop in western Nebraska, better known as Courthouse Rock, shows a contact between two rock units.
By Warren W. Sahs

The University of Nebraska Institute of Agriculture and Natural Resources looks to the future with confidence and anticipation. Nebraska, a leading agricultural state, recognized early the importance of basic science in agriculture.

A majority of past advances in utilizing farm products and by-products came from research aimed at discovering the basic properties of agricultural commodities. This type of research endeavor will be continued in the future with emphasis on improved and more efficient nutrition for humans, through interdisciplinary team approaches.

Screening of national and worldwide sources of wheat germ plasm is a program seeking to increase the genetic potential for increased protein in wheat. The Lancota variety with increased protein is in production, and has proven to be as much as two percentage points ahead of hard red winter varieties now being grown. The protein is of good quality and the milling and baking characteristics are good.

Current experimental hard red winter wheat varieties now being tested indicate genetic variability is contributing protein increases of five percentage points over present varieties. Most important, these increases of over 15 per cent protein are not associated with differences in amino acids. All the additional protein in Atlas 66 derivatives and most of the Nap Hal protein is in the endosperm, which is transferred directly into white flour during milling. Another advantage is that high nitrogen fertilizer application rates are not necessary for these selections to exhibit their protein superiority.

Winter hardiness must be present for widespread acceptance. Disease resistance is very important before germ plasm is disseminated for worldwide use.

An important adjunct to this program is the search for associative symbiotic nitrogen fixation microorganisms. Collection of soil and wheat plant samples from Nebraska and the U.S. locations are being tested, isolation of the microorganisms will be carried out, and the analysis of roots for the sites of the nitrogen fixing microorganisms will be accomplished.

Historically, alfalfa has been a major crop in Nebraska, a crop which capitalizes on the fertile soils and the subirrigated stream valleys and irrigated lands. Commercial dehydrated alfalfa plants moved in after World War II and Nebraska is one of the nation’s leaders in the dehydration industry.

Nebraska scientists have been working on an alternate method of pressing the freshly cut alfalfa. Approximately half the water is removed as a green fluid and ends up as a “residue alfalfa” that would require much less natural gas to be dried. This end product would be from 13 to 15 per cent protein, a very logical roughage source for animals.

Centrifugation of the green fluid results in the removal of the chloroplasts forming a “pigmented residue,” an excellent poultry feed supplement.

The golden color “clarified press fluid” resulting from centrifugation can be treated with an acid and heated to 75°C, which yields an “alfalfa protein concentrate.” APC is a tan-white powder which is 75 per cent protein, stable, easy to store and transport, and very high in nutritional quality. The protein efficiency ratio (PER) is 2.8 when compared to milk protein casein (PER of 2.5).

The use of APC is still experimental in the U.S., but many developing nations — as well as several developed nations — are making plans to use APC as a food protein source.

The restructured meat area, involving beef, pork and lamb products, has been extensively researched at UN-L’s Loeffel Meat Laboratory. A full array of main dish entree items, sandwich food items, and fast food service meal meat items has been developed in the concept. A fresh pork process, a cured and smoked product line, as well as beef and lamb products, have been developed.

Nebraska has been a leader in research on mechanical deboning methods for turkey and fowl meat. The products were combined with flour through a co-extrusion process, resulting in better flavor and improved nutritional value. Present work stresses interdisciplinary efforts utilizing plant by-products, i.e. alfalfa leaf protein, cull dry beans, and grain alcohol fermentation by-products. This is an additional human food protein concentrate for
possible export to developing nations.

Extensive trials using certain volatile fatty acids for the preservation and storage of the whole kernel, high moisture corn were successful in the early 1970s. This timely research helped lessen the impact of crucial supplies and more costly fuel for farm grain dryers in subsequent years.

Rumesin, a cattle feed additive, improves feed utilization in ruminants by increasing energy utilization from rumen fertilization. Its mode of action is consistent with our need to conserve energy.

Nebraska is exploiting underutilized plant by-products as an energy source for cattle rations. Over 25 million tons (22.5 million tonnes) of crop residues are annually produced in Nebraska. Chemical treatment of crop residue using sodium and calcium hydroxide increases corn and sorghum stalk residue digestibility to approximately that of corn silage.

Researchers also have evaluated the protein value of such products as textured vegetable protein and breakfast cereal. Vitamin/amine acid/protein relationships of peanut butter have been investigated. Results show peanuts are an excellent source of protein and niacin for high energy value. In 1975 Nebraska scientists reported on the dietary value of millet grain, triticale grain, and soybeans (Soy-TVP), a meat-analog produced from extruded defatted soybean meal.

Considerable controversy exists as to whether or not highly saturated animal fat contributes to the onset of atherosclerosis in man. It is the aim of animal agriculture to produce a product that is not only nutritious, but also healthful for mankind. Experiment stations have established ways to produce meat which is high in the so-called "polyunsaturated" fatty acids. Feed a pig a diet high in plant oils, and a polyunsaturated fat will be deposited in the muscle. People like pork chops. They may or may not care for a lean "pork patty" to which a possibly less-flavorful plant oil has been added.

Producing a T-bone steak that is well marbled and also high in polyunsaturates is a difficult problem. By treating plant oils with formaldehyde before they are fed to beef cattle, the fat is protected by the formaldehyde from microbial fermentation in the rumen. The polyunsaturated fat passes into the small intestine unchanged where it is digested, absorbed and deposited as a polyunsaturated fatty acid within the T-bone steak.

Through the use of enzymes, food products and/or manufacturing processes are improved with better quality and efficiency of operation. Enzymes change and improve flavor, extend shelf life and aid in modifying milk solids into partially digested foods.

A University agronomist has discovered a mode of action by which herbicides kill plants. This discovery yielded laboratory procedures that permit rapid and accurate identification of chemicals which kill weeds. A spinoff has stressed the importance of surfactant specificity for testing the effectiveness of herbicides.

Numerous chemical companies cooperate with the Institute striving for superior plant performance. With 90 per cent of Nebraska's cultivated crops treated annually with herbicides and 50 per cent treated with insecticides, surveys indicate all herbicides are needed, but only 50 per cent of the insecticides are actually needed. Recent close drilled soybean and no-tillage research has resulted in greater yields, elimination or reduction in tillage and a reduction in herbicide rates. Minimum tillage, a technical alternative for reducing fuel expenditures of cropping systems, is a proven system wherein all spring cultural practices are combined into one operation using herbicides as a weed control measure.

Eco-fallow is a scheme for the semi-arid, fallow cropping regions where compatible crop rotations are used with no-tillage, substituting chemical weed control for mechanical.

Production of raw agricultural commodities ranks third in energy consumption after the steel and petroleum refining industries. Nebraska excels in the production of corn, wheat, soybeans, sorghum, and oat crops, the most energy efficient producers, or conversely, those using the least cultural energy. Through interdisciplinary efforts supported by public and private industry funding, we intend to intensify research on the genetic and biochemical components of specific crop varieties and the environmental interactions where they are grown, resulting in more efficient use of agricultural materials and by-products.

The Nebraska Agricultural Experiment Station has a distinguished record in improving the yield of energy per acre. In the future, our added objective will be to improve identifiable nutrient yields per acre. With rapid and accurate means of measuring nutrient content of foods at hand, the future will bring more genetic, environmental and biochemical manipulations. This will result in specific genetic expression and metabolic regulation in plant and animal performance. These are being developed on a broad spectrum, and also need to be converted to a more narrow spectrum, resulting in a refinement of selection for specific desired nutritional improvements in adapted cultivars and animal species. These accomplishments will increase the amount of food and its nutritional value for the ultimate consumer.

In conclusion, the race is on. The world needs more and better human nutritive food supplies, to be produced as efficiently as possible using less energy. Economics will in the end dictate the substitution of use alternatives. The Nebraska Agricultural Experiment Station is in the midst of this situation and is in the forefront. From an international standpoint, the United States is and will be the fulcrum in the balance of payments, based upon the availability of knowledge and raw materials for suitable diets, which in turn means it will continue to be a world power.

The Nebraska Agricultural Experiment Station appreciates past support and cooperation, and will seek Nebraskans' support in the future. □

Warren W. Sahs is assistant director of the Agricultural Experiment Station.
Photographs show various insects and diseases which afflict alfalfa.

**Resistant Alfalfa Varieties**

*By W. R. Kehr, J. E. Watkins, G. R. Manglitz, and R. L. Ogden*

Alfalfa is susceptible to many diseases which may limit growth and production. Alfalfa is attacked by at least four important nematode species; however, none are presently known in Nebraska. Abiotic diseases may limit production, through winter injury, frost, heaving and unfavorable environments. An almost limitless number of insects can be found on alfalfa. A few of these insects are serious pests. One of the best ways to control these is to breed alfalfa for improved pest resistance.

The cooperative Nebraska Station-USDA-ARS alfalfa breeding program is a continuing program initiated about 50 years ago.

The alfalfa breeding program has several objectives: (1) to develop varieties with combined pest resistance for two or more diseases, or diseases and two or more insects, along with high forage and seed yield, and forage quality; (2) to develop breeding methods, including determination of the mode of the inheritance of important traits; and (3) to conduct recurrent selection programs for resistance to pests of great importance.

Disease-resistant, insect-resistant, and multiple pest-resistant varieties or populations are being compared in the field with susceptible materials, with and without chemical controls, to measure the value of resistance.

Diseases of major concern, such as bacterial wilt, anthracnose, common leafspot and Phytophthora root rot are receiving the most attention. The nematode research is directed toward control of the stem nematode, the most threatening species. Other diseases with more limited work include: spring and summer blackstem, downy mildew, Phythium root rot, Stemphylium leafspot, yellow leaf blotch and alfalfa mosaic. Research on manmade epidemics and interactions of diseases with insects is pursued as needed. Insects of most concern are the alfalfa weevil, pea aphid, spotted alfalfa aphid and potato leafhopper.

Team approaches are a vital part of the program. The cooperation is informal, people working with people who have the appropriate expertise to deal with specific problems.

Resistance screening procedures are available for anthracnose, bacterial wilt, bacterial leafspot, summer blackstem, common leafspot, downy mildew, Fusarium root rot and wilt, Leptosphaerulina leafspot, spring blackstem, Phytophthora root rot, Stemphylium leafspot, yellow leafblotch, stem and northern root-knot nematodes.

These diseases and nematodes are of greatest concern or potential concern. Screening procedures are also available for pea aphids, spotted alfalfa aphids, potato leafhopper and alfalfa weevil. Fortunately, most procedures involve seedlings. Improvement in screening procedures is in progress with other diseases and insects. Breeding methods are available to combine disease and insect resistance with other traits and to
Sought By Researchers

select for multiple pest resistance. Research is in progress on improved breeding methods.

Levels of disease resistance adequate for economic protection are available for anthracnose, bacterial wilt, common leafspot, downy mildew, Phytophthora root rot, rust and stem nematode. Adequate levels of resistance to the pea aphid and spotted alfalfa aphid are available.

Moderate resistance (of the tolerance type) is available for the alfalfa weevil. Moderate resistance to potato leafhopper yellowing is also available. Field, laboratory and greenhouse data have proved the value of disease and insect resistance to stand establishment, forage yield and quality, and persistence. Improved levels of resistance are being developed for other diseases and insects.

Since 1956, all ARS-Experiment Station jointly-released varieties have multiple pest resistance against one or more diseases or insects. The Nebraska-USDA-ARS program released 'Dawson' in 1967; other germplasm has recently been released and a new variety is in the process of being released. Additional releases are planned.

Variety development is the product of research most easily recognized by farmers and ranchers.

Diseases cause an estimated annual loss of 24 per cent of the forage and 9 per cent of the seed yield of alfalfa. Each year, these losses cost U. S. growers more than $395 million (1972). Losses from nematodes are 3 to 5 per cent of the national production, worth about $86 million annually (1972). Annual losses from insects amount to about $260 million (1972) or about 15 per cent of the crop. At 1975 prices, each 1 per cent yield loss is worth $40 million.

Diseases and insects reduce establishment, yield, forage quality and persistence; increase damage from environmental stresses; and decrease efficiency of water and nutrient use. Breeding for resistance is the most practical and economical means of controlling most alfalfa diseases, insects and nematodes. Disease, insect and nematode resistant varieties with high levels of resistance have controlled specific pests, reducing the need for chemical control with its potential pollution and other biological problems.

Anthracnose and Phytophthora root rot resistance in varieties and advances in stem nematode screening procedures are recent outstanding accomplishments. It is difficult to assess values of the following: (1) variety release, because seed of brands or blends may be of unidentified origin; (2) germplasm releases, because of indirect, delayed, and probably unidentified uses; (3) development of resistance screening procedures; and (4) the international value of varieties, germplasm releases and breeding methodology.

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"Nebraska—the Good Life" may be an impossible dream for the Nebraska teenager who has a baby. Suddenly, 90 per cent of her life's script is written for her. Her choices are few, and most of them aren't good.

Pregnancy and childbearing among teenagers is a growing concern in the United States. Statistics indicate that unwanted teenage pregnancies in America are epidemic.

Overall rates of childbearing among teenagers have fallen, but the decline has not been as great as that for older women. The difference means that, proportionately, more children are born to teenagers—up from 13 per cent in 1965 to about 14.5 per cent in 1975.

Are these teenage mothers married? A study by the Department of Human Development and the Family, Lancaster County Welfare and Lincoln Planned Parenthood has shown that illegitimacy among teenagers varies markedly with age.
The younger the mother, the more likely she is not married when the baby is conceived and born.

Because of changing social values, pregnant teenagers are not pressured to marry as much as they used to be. There were 571 out-of-wedlock births to teenage mothers in 1965, 1,003 such births in 1970, and 1,101 in 1975.

Carol Epp, school nurse at Lincoln High School, says pregnant girls and young mothers are assimilated into the school population, and apparently there is no social stigma. However, many births to teenagers occur within marriage, though a significant proportion of babies may be conceived outside of marriage.

What are the prospects for a last- ing marriage after a teenage pregnancy? We know that the younger a girl is when she's married, the more likely she will be divorced. The younger both parents are, the more likely they are emotionally immature. Neither parent is prepared to assume the role of mother or father.

Many young parents have unrealistic expectations for their children. They expect a child to behave in ways only an older child can. Teenage parents often are not tolerant of crying, illness, or other demands put upon them by their babies.

In addition to emotional immaturity, teenage parents generally have a limited education. The majority of the 90 girls studied had dropped out of school during the tenth grade or after completing that grade. Pregnancy and motherhood may be major reasons for the girls leaving school, according to Helen Weber, Supervisor of Health Services of Lincoln Public Schools and President of Nebraska Nurses Association.

Exact information is impossible, however, for after a girl becomes 16 she is not required by law to give the reason for dropping out of school. Some girls in Nebraska drop out of school and then become pregnant, but this is not the usual case.

Title IX of the Educational Amendments makes it illegal for schools receiving federal funds to exclude any girl because of pregnancy. However, the demands and expense of child care make it difficult for girls with babies to stay in school. A girl whose mother helped take care of the baby was less apt to be absent from school or to eventually drop out. Some schools may be planning such special programs as child care for pregnant girls or young mothers, but most high schools across Nebraska, and especially those in rural areas, can't provide them.

The young father also often has a limited education. If he drops out of school to work, he usually finds himself in a low-paying job with no prospects for a better one.

For a mother who does not marry the father of her child, the social consequences are equally dim. More of them keep their babies rather than give them up for adoption. For instance, in the last two years only one girl at Lincoln High School has given up her baby for adoption. Keeping the baby limits the probability of completing school and becoming economically independent.

In fact, many teenage mothers rely upon their immediate families for financial assistance. During March 1977, about 90 teenage mothers received public assistance in Lancaster County.

The average amount of public assistance for that month was $314. One mother received $2,208 that month. This amount included hospitalization and other medical expenses. The lowest amount of public money received by a teenage parent was $52. Food stamps are not included in these amounts, so public assistance would actually be greater for many of these teenage mothers.

Teenage parenthood poses a challenge for adequate child care if the mother goes back to work or back to school. Her social life is restricted and disappointing. Her prospects for successful marriage later are diminished. Teenage childbearing not only has adverse social consequences, the health consequences may also be bad. The younger the teenage mother, the more likely it is that she will experience a miscarriage, that her baby will be stillborn, that it will die soon after birth, or that it will be born prematurely or with a serious physical or mental handicap.

Low birth weight is characteristic of infants born to teenage mothers. Physical immaturity and poor nutrition of the teenage mother are contributors to low birth weight. Babies with low birth weights are more apt to die from various medical conditions than are babies of normal weight. Low-weight babies who survive are more likely to suffer from birth defects which may have lasting consequences, according to Richard Rumbolz, Eastern Nebraska Field Representative, March of Dimes.

Nationwide, the death rate in childbirth is greater for younger teenage mothers than for mothers in their 20s. Nebraska's childbirth death rate at all ages is lower than the national average. In 1975 Nebraska listed five childbirth deaths. The ages of the women were 18, 19, 22, 26 and 34. Early childbearing is associated with an increasing number of babies and a shorter period of time between deliveries. This may add higher risks to the lives and health of a young mother and her baby.

Accidents are a significant cause of childhood deaths regardless of the parents' age. The present study is incomplete regarding accidents, but one study found that the childhood death rate from ages one to four is 41 per cent above average among children born to adolescent mothers. The figure declines rapidly as the age of the mother increases. The implication is that many teenagers are too immature to provide adequate care and supervision for their children.

Children of teenage parents may not do as well in school as children of older parents. This may be caused by poorer supervision, emotional deprivation, poor nutrition, inadequate medical care or lack of finances.

(Continued on page 16)

<table>
<thead>
<tr>
<th>Table 1. Nebraska births by adolescent mothers according to age.</th>
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<tbody>
<tr>
<td>Age of mother</td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>12-13</td>
</tr>
<tr>
<td>14-15</td>
</tr>
<tr>
<td>16-17</td>
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<tr>
<td>18-19</td>
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<td></td>
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</tbody>
</table>
Other serious problems may be child neglect and child abuse. Pressures of teenagers’ parenthood result in many frustrations. Many teenagers can’t handle it. Suicide attempts are significantly higher among teenage mothers than among teenagers of the same age without children.

All births to adolescent mothers do not lead to these problems, just as waiting until the 20s will not guarantee a risk-free pregnancy. Some young parents and their children are healthy and adjust successfully. But teenage parenthood does pose increased risks.

Why should Nebraskans be concerned about teenage parenthood? Research shows that numbers of births to teenagers are increasing. Research shows there are increased social and medical risks for teenage parents and their babies. Research shows that other members of the extended family are affected. Research shows that teenage parenthood costs the taxpayers money.

What can Nebraskans do? To some teenagers the answer is simply sexual abstinence. For others with more permissive values, the solution is the use of contraception. For an increasing number of persons, interruption of pregnancy by therapeutic abortion is a solution. Another alternative is for the mother and father to marry, to have the child and to try to care for it. For others, adoption may be an alternative. For others, not marrying but keeping the child is possible.

Nebraskans have a variety of beliefs and values, so not everyone will agree on solutions. Complete agreement, in fact, may not be so critical. If individuals and groups, as parents, teenagers, physicians, counselors and community leaders, can work on the problems in ways that seem best to them, perhaps the problems can at least be reduced.

But for efforts to be effective, one fact must be recognized; teenage pregnancy usually closes the door to the Good Life in Nebraska.

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BARBARA CHESSER is associate professor, department of Human Development and Family.
fatal. Cattle and sheep usually become infected by contact with infected swine. Dogs, cats and other animals often become infected by eating carcasses of dead PRV-infected pigs. Humans appear to be highly resistant to the infection, however.

PRV infection can be confused with diseases caused by other agents, so laboratory diagnostic procedures are required to definitely diagnose pseudorabies. Diagnosis of an active PRV infection usually is based on a combination of laboratory tests. The tests include isolation of virus, fluorescent antibody (FA) technique, histopathology and serology.

PRV is a herpesvirus (Herpes suis). A characteristic feature of herpesviruses is their ability to remain alive but dormant within a host without producing any signs of disease. The presence of the virus is not continuously evident. This type of infection is called latent. Certain forms of stress (weaning, farrowing, transporting) can make the virus multiply and cause shedding of PRV from latently-infected animals. Introducing a latently-infected animal into a clean herd can start an outbreak of pseudorabies.

The fear of introducing a normal-appearing PRV carrier into an infection-free herd or area has created a demand for extensive testing of animals before they are shipped or introduced into a herd.

Eliminating potential carrier animals by testing is a way to minimize the spread of infection.

A blood test performed at specialized laboratories is used to screen for animals infected with PRV. The blood test is based on the principle of demonstration of antibodies against PRV in the animal's blood serum. When an animal has a demonstrable concentration of serum antibodies, it is said to have a "titer" for PRV antibodies. A measurable antibody titer develops about one week after virus infection occurs.

The blood serum test used to detect serum antibody titers is known as the serum neutralization test or
"SN test." A positive SN test for PRV (PRV antibody titer) is considered proof that an animal has been infected with PRV. Consequently the SN positive animal is a potential shedder or carrier of PRV infection. A negative test (absence of PRV antibody titer) generally means an animal has not been infected with PRV. The SN test is currently the only practical test for screening animals latently infected with PRV.

The Veterinary Diagnostic Center at the University of Nebraska–Lincoln conducted the PRV SN test on 3,028 serum samples during the first three months of 1977. Over half these samples were received and tested in March. The 3,028 samples were derived from 144 individual Nebraska swine herds located in 44 Nebraska counties (Figure 1). Eleven of the 144 herds (7.6 per cent) had one or more animals that were positive in the SN test. The 11 herds containing SN positive animals were located in 11 different Nebraska counties (Figure 2).

The actual pseudorabies virus has been isolated and specifically identified in the UN–L Veterinary Diagnostic Center from active disease outbreaks in swine, cattle, sheep, goats, cats and dogs in Nebraska. The animals involved were from 15 different Nebraska livestock production units located in eight counties (Figure 3). Isolation of virus is the most accurate method for confirming a PRV infection.

Because of the relatively limited number of herds that have been tested to date, it is conceivable that this data does not reflect the total incidence or distribution of pseudorabies in Nebraska. This information pertains only to those cases handled by the Veterinary Diagnostic Center. The results of out-of-state laboratory tests of Nebraska livestock are not included. In addition, some PRV outbreaks involving Nebraska livestock are not reported to the laboratory.

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Technicians Susan Barrett, left, and Susan Mills are involved in testing for pseudorabies at the Nebraska Veterinary Diagnostic Center.

Figure 3. Distribution by county of Nebraska swine herds from which pseudorabies virus has been isolated. First Quarter 1977. (Number indicates number of herds per county.)
Northeast Station Compares—

Corn or Grain Sorghum?

By Russell S. Moomaw and August F. Dreier

The ratio of dryland corn to grain sorghum acreage in Nebraska changes drastically from the East to the Northeast Cropping Districts. In 1975 dryland corn acres in Northeast Nebraska exceeded grain sorghum 22 to 1. In the East District, however, the ratio between the two crops was only 1.4 to 1 acre (Figure 1.) Certain counties in the Northeast District produce more grain sorghum than others, but corn production still leads grain sorghum by a wide margin in all counties. The question of which is a better crop for the farmer remains unanswered, however.

We decided to compare dryland corn and grain sorghum production at the University of Nebraska Northeast Station, Concord, from 1971 to 1975. Both crops were planted in 30-inch (76 cm) rows using the Buffalo till-plant system. The soil type was a Moody silty clay loam. Fertilizer was applied uniformly to both crops to annually supply about 110–36–0 lb/A (123–40–0 kg/ha) of nitrogen and phosphate. Band application of herbicide at planting time plus cultivation provided good weed control in both crops.

Both corn and grain sorghum were grown in side-by-side field strips, duplicated three times, and machine harvested. We developed three crop sequences in the study: 1) corn after corn; 2) corn after sorghum; and 3) sorghum after corn. Corn was planted at the rate of 16,400 to 17,400 seed/A (40,500 to 43,000 seed/ha) while 3.5 to 4.0 lb/A (4 to 5 kg/ha) of grain sorghum was planted. An adapted mid-season variety of both crops was selected for planting. Because popular corn and grain sorghum varieties change, we changed varieties once over the five-year period.

A wide variety of weather conditions occurred over the five-year span of this experiment. Rainfall and temperature during July and August have the most effect on yield of dryland corn and sorghum. Figure 2 shows crop yield and rainfall data, and Figure 3 shows crop yield and temperature data. Crop yield data are from the corn after corn and sorghum after corn field strips.

Over these years, grain sorghum was superior to corn in 1971 and 1974. Corn out-yielded sorghum in 1972 and 1975; and neither crop was superior to the other in 1973.

Year 1974 was an interesting one in which to compare corn and grain sorghum. July 1974 was 2.7 inches (68 mm) below normal in rainfall and 4.9°F (2.7°C) above normal in temperature. August was 4.3°F (2.4°C) below normal, which slowed development of a subtropical plant such as grain sorghum.

Then an extremely early killing frost on September 3 stopped sorghum growth so the yield advantage over corn was not as much as might have been expected in such a dry year.

Our yield results in 1975 also need some explanation. Because a wet June was combined with cool temperatures, sorghum seedling emergence was poor. We replanted the sorghum about mid-June. Sorghum crop prospects looked promising compared with corn because of below-normal summer rainfall and above-normal temperatures. But a killing frost September 12, about three weeks ahead of normal, dropped sorghum yield well below that of corn.

In other experiments at the Northeast Station in 1975, sorghum which did not require replanting yielded more than corn. Average yield over the five-year period 1971 to 1975 was 84 bu/A (5268 kg/ha) for corn and 78 bu/A (4892 kg/ha) for grain sorghum.

Grain sorghum is often thought to be "hard on the land" but our yield data in Table 1 do not show this. Corn yield was slightly higher where (Continued on page 20)

Table 1. Yield data.

<table>
<thead>
<tr>
<th>Crop sequence</th>
<th>1972</th>
<th>1973</th>
<th>1974</th>
<th>1975</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>bu/A</td>
<td>bu/A</td>
<td>bu/A</td>
<td>bu/A</td>
<td>bu/A</td>
</tr>
<tr>
<td></td>
<td>(kg/ha)</td>
<td>(kg/ha)</td>
<td>(kg/ha)</td>
<td>(kg/ha)</td>
<td>(kg/ha)</td>
</tr>
<tr>
<td>Corn after corn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>126.8 (7933)</td>
<td>99.0 (6209)</td>
<td>14.0 (878)</td>
<td>91.2 (5720)</td>
<td>82.8 (5193)</td>
<td></td>
</tr>
<tr>
<td>Corn after sorghum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>130.9 (8210)</td>
<td>103.1 (6466)</td>
<td>34.2 (2145)</td>
<td>89.2 (5595)</td>
<td>89.4 (5607)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Harvested dryland acre ratio in 1975 between corn and grain sorghum in selected counties and the northeast and east cropping districts.
Corn or Sorghum...

corn was grown following sorghum than on the continuous corn plots in three of four years. The only large difference was in 1974, however, and we think this was due to severe corn rootworm damage on the corn-after-corn plots.

Corn roots were dug from all plots of the two crop rotations in 1974 and were scored for corn rootworm damage. Corn rootworm damage was much more severe with continuous corn. Each year of the experiment we applied a corn rootworm insecticide uniformly to all corn plots in the experimental area, regardless of the previous crop.

To follow soil moisture and nutrient changes, we soil sampled all plots to five feet (1.5 m) at the end of the first year, and again four years later. Soil pH, organic matter, phosphorus, and potassium levels declined over the four years but residual nitrate remained constant. Only with the nutrient phosphorus was there an indication that sorghum in the rotation (two years sorghum, two years corn) caused a greater decline than with continuous corn. Phosphorus levels in the test area were in the very high range so we could not measure possible yield difference caused by grain sorghum either using more or tying up available soil phosphorus.

Soil moisture levels were not greatly influenced by the crop grown. There was an indication that grain sorghum left more soil moisture in the 1 to 3 foot (0.3 to 0.9 m) level of the soil profile than did corn.

Cost of producing grain sorghum in our experiment was lower than for corn, ranging from $4 to $9/A ($9.88 to $22.23/ha) or less, depending on the year. Grain sorghum seed cost was about $3/A ($7.41/ha) less than for corn. Insecticide costs were less for grain sorghum but they varied yearly according to insect infestations on the two crops. Fertilizer, herbicide and machine costs were equal.

Using Nebraska Agricultural Statistics, grain sorghum in the Northeast Cropping District was discounted from 11 to 16 per cent below corn in 1971 through 1974.

The price discount for grain sorghum in comparison to corn has recently narrowed. However, a 10 per cent discount for sorghum represents a real advantage for corn if the average yield potential of the two crops is similar.

1. Under the environmental conditions of our experiment, average corn yield was 6 bu/A (376 kg/ha) higher than for grain sorghum over the years 1971 through 1975. Both corn and grain sorghum excelled in certain years of the test period when conditions favored them.

2. Experimental results and field observation suggest that relatively cool August temperatures may be a major reason why grain sorghum was not more competitive with corn in Northeast Nebraska. Development of new sorghum varieties with greater cold tolerance both in early and late summer may be a practical solution.

3. Grain sorghum did not appear to be injurious to the soil in a continuous corn rotation. A grain sorghum rotation was of significant benefit in 1974 when corn rootworm damage was moderately severe with continuous corn.

4. Lower production cost for grain sorghum was more than offset by lower market value of grain sorghum compared with corn. Grain sorghum must have a greater yield potential or a lower risk factor for it to be economically competitive with corn in view of prevailing price discounts.

**Russell S. Mooaw** is district extension specialist (crops), August F. Dreier is extension agronomist (crop varieties).
Don't Fool.... cooperate with MOTHER NATURE

By P. T. Nordquist and G. A. Wicks

Farming in Nebraska is hazardous business. Over the years thousands of farmers have gone broke; many times because mother nature didn't cooperate by supplying a timely rain.

We have a tendency to think of a timely rain as one that comes just when the crop needs it, but in reality timely moisture may come several months before it is needed by the crop. It's timely as long as the moisture is available to the crop when needed.

The long term average moisture pattern in Nebraska forms a nice curve. January moisture is the lowest for any month of the year. Monthly amounts increase through June and then begin to decline through December. This pattern is the same across Nebraska, but the amounts per month are lowest in the northwest. Moisture increases to the southeast corner of the state. The long term pattern is consistent but the yearly and month-to-month variations can be substantial.

In Nebraska, mother nature limits our crop season to the warm summer months, usually May through September for most active crop growth, thus leaving seven months with little or no crop growth. If we follow winter wheat with a crop planted the next spring we may have as many as 10 months between harvesting one crop and planting the next.

Often, the timely moisture we need for crops comes before planting. The failure may not be that timely moisture didn't come, but that we failed to store it in the "bank" for use when the crops become stressed. The moisture stress period is usually June for winter wheat and July and August for corn and sorghum.

We have an excellent bank for moisture storage: the top 6 feet (1.9 m) of soil. The amount of moisture the bank can hold varies a great deal, but all soils will hold some. For example, sands and gravels hold much less than heavier clay soils. Sandy soils will store from ½ to 1 inch (1.3-2.5 cm) of moisture per foot, depending on the clay and organic matter content.

Medium textured soils, such as those in the valley around North Platte, can store from 1½ to more than 2 inches (3.8-5.1 cm) per foot. Heavier soils in eastern Nebraska can hold more than 2 inches (5.1 cm) per foot. A six-foot (1.9 m) soil profile, which is what we normally consider the maximum root zone of most crops, has the capacity to store several timely rains. It's our job to cooperate with mother nature by helping store as much moisture as

(Continued on page 22)
Nature ...

we can in the soil for use when the crop needs it.

We begin by helping mother nature make her deposits in the bank. The bank can only take deposits so fast, so we must leave the soil in a condition in which maximum water intake is possible. Any excess precipitation must be able to run off with a minimum of soil erosion.

The best way to accomplish this is to leave as much crop residue standing on the surface as possible. This helps in five ways: (1) by slowing the velocity of the raindrops before they hit the soil surface; (2) by reducing soil compaction, allowing moisture to enter the soil faster; (3) by slowing the rate of runoff, allowing more time for water to enter the bank; (4) catching drifting snow; and (5) reducing the soil temperature and surface evaporation in our growing crops.

To see how important snow trapping is, take a look at the road ditches after a spell of good Nebraska winter. Look at the amount of snow and also the amount of soil in that snow from fields with standing crop residue and those where the residue has been destroyed. Some years trapped snow can contribute several inches of extra moisture.

Once we put moisture in the bank it is essential that we keep it there until it is needed by the crop. Plants fall into two classes: the bank-rob­bing weeds or the bank-borrowing crop in need of moisture. Weeds are the most notorious bank robbers. After wheat harvest a good crop of weeds in a stubble field can rob more than 3 inches (7.6 cm) of moisture in a month or less. That’s equal to 2 to 3 timely rains. During the fall and spring, volunteer winter wheat and winter annual weeds also can be robbers, wasting 2 to 3 inches (2.5-7.6 cm) of moisture—again equal to a couple of timely rains.

We generally consider tillage a moisture-saving operation because we destroy many weeds, but it also can be a robber because the soil may quickly lose moisture to the depth of tillage. Recent studies indicate the drying effect of tillage may be several inches deeper than the depth of tillage. It therefore is advis­able to till no deeper than necessary to destroy the weeds. Deep tillage does little good and will result in an additional withdrawal from the bank. Chemical control of the weeds has proven very valuable for weed control without disturbing the soil or destroying the surface residue.

Just how big is the moisture bank we mention? How much can we de­posit before it is filled to about 6 feet, which is considered the maximum rooting depth for most of our crops? With medium-textured soil at North Platte we can store about 1.5 to 2.0 inches (3.5-5.1 cm) per foot for a total of 9 to 12 inches (22.9-40.1 cm) in the top 6 feet (1.9 m). Each acre inch saved is about 27,000 gallons (102,000 l) of water.

Save Moisture

If 9 inches (22.9 cm) were saved, some 243,000 gallons (923,400 l) per acre would be banked. That’s a lot of water available to hedge against missing those timely rains in June, July and August. Providing 9 inches (22.9 cm) of water by irri­gation would mean pumping a 1,000-gallon well for about 4.05 hours per acre. On a section of 640 acres it would require running a 1,000-gal­lon well for 108 days of 24 hours each. It is obvious we need to make a real effort to save the moisture mother nature deposits, regardless of whether we have irrigation capability or not. It is even more true if we must rely completely on precipita­tion for our crops.

Because of the erratic pattern mother nature uses to make deposits we won’t always accumulate 9 to 12 inches (22.9-30.1 cm) between har­vest and planting the next crop, but whatever she deposits can be used later for those timely rains we need nearly every year.

How much moisture do we need to produce a crop? Research data from North Platte indicate about 9 to 10 inches (22.9-25.4 cm) are needed to produce the vegetative growth of a dryland corn or sorghum crop. Any moisture above this amount is available for grain production. Each additional inch can be worth up to 10 bushels of grain per acre (630 kg/ha).

You may recall 1974 was a drought year for most of Nebraska. From May 1 through September 30 we received only 7.56 inches (19.2 cm) of moisture at North Platte. That wasn’t enough to produce any grain without plants withdrawing some moisture from the bank. We still had average dryland corn and sorghum yields of about 70 bushels per acre (4400 kg/ha). The reason was the timely rain mother nature deposited in the bank between wheat harvest and planting time. Those deposits occurred in July of 1973 when she deposited 2.95 inches (7.5 cm), Sep­tember when 5.02 inches (12.7 cm) were added and in October when 1.35 inches (3.4 cm) were received. An additional 3.08 inches (7.8 cm) more came in April 1974. That’s a total of nearly 12.5 inches (31.7 cm).

Lesser amounts also came during the other months but were so small most of the moisture evaporated from the soil surface before it could be deposited deep enough in the bank to be saved. Surface evapora­tion also claimed some of the 12.5 inches (31.7 cm), but we still saved enough to fill the soil profile to a depth of 6 feet by planting time. Those 9 or more (22.9 cm) inches combined with the 7.56 inches (19.2 cm) were enough to grow 70 bushels per acre (4400 kg/ha) corn and sor­ghum. If we had failed to control the weeds in the wheat stubble, the weeds would have cost us most or all of the 2.95 inches (7.5 cm) of July moisture. Those weeds combined with volunteer wheat and winter an­nual weeds would have wasted most or all of the September deposits, leaving little in the bank to be used by the next crop.

How the crop makes withdrawals from the bank varies considerably. A growing crop of corn or sorghum may consume up to 0.3 inch (0.7 cm) of moisture per day at some­what more if it’s hot, dry and windy, so a timely rain of an inch in the top foot of the soil profile in July or Au­gust won’t last too many days.

That same inch of moisture depos­ited in the 4th, 5th or 6th foot is much more difficult for the crop to withdraw. The deeper the moisture the more time is needed for with­drawal by the plants. For this reason
plants are stressed and wilted during warm afternoons, but during cool evenings and nights the crop continues to make withdrawals and by morning has returned to good conditions. It therefore can survive considerably longer on an inch of deeply stored moisture than from an equal amount of moisture in the top foot of soil.

Why could we produce crops in 1974 and 1975 under moisture conditions similar or worse than in the "dirty thirties"? Probably the most important factor is that through the use of improved technology we have learned over the years to cooperate with mother nature to conserve and make the best use of the moisture, residue, and other environmental conditions she provides.

In addition we have far superior corn and sorghum hybrids compared to the open pollinated varieties used in the thirties. We also have learned to use fertilizer to feed the crops and thus make better use of the available water.

Better cultural and chemical control for weeds, as well as improved equipment for seeding a crop when moisture conditions are less than ideal, have all helped to increase crop yields. Many of these improvements are a direct result of research in Nebraska and many other states by a whole host of scientists in industry and experiment stations.

Much still needs to be done to avoid risks of soil erosion by wind and water. Improved technology and soil management are still needed in Nebraska. No bare soil should be left exposed to mother nature's savage elements. No matter how good the moisture supply may be, exposed soils are subject to wind erosion when mother nature decides its time for a good blow.

We can't predict what the future holds very accurately, but if we learn to manage what mother nature does supply we can reduce some of the risks of Nebraska agriculture and possibly avoid those disastrous crop failures that have been so prevalent in Nebraska's past.\[P. T. NORDQUIST is associate professor and G. A. WICKS is professor of Agronomy. Both are at the University of Nebraska-Lincoln North Platte Station, North Platte, Nebraska.\]

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**Sulfur Can Boost Corn Yields on Sandy Soils**

By G. W. Rehm and R. C. Sorensen

The importance of sulfur for crop production in Nebraska was first recognized in 1952 when applying this essential nutrient to sandy soils increased the yields of both corn and alfalfa.

When the need for sulfur was discovered, ordinary superphosphate (0-20-0) was the major fertilizer source of this nutrient. Powdered gypsum could be purchased, but it was difficult to spread.

Several new fertilizers containing sulfur have appeared on the market since those early days. Yet, experiments were not conducted to evaluate the effects of these new products on crop production. In addition, very little research had been directed to determining the best rate of sulfur to use for crop production on the sandy soils in Nebraska.

The rapid development of sprinkler irrigation on sandy soils, as well as the marketing of new sources of sulfur has prompted a new look. Studies were started in both Pierce and Holt Counties in 1973 and were continued through 1975. Different sites, selected to represent the soils in the area, were used each year in both counties. In addition, the sources and rates of sulfur applied were varied from year to year.

At all sites, the sulfur fertilizers, as well as adequate phosphorus, potassium and zinc, were disked in before corn planting. Adequate rates of nitrogen were used at all sites and recommended insecticides and herbicides were used by the farmers who planted the corn.

The early research with sulfur produced recommendations that sulfur should be used for crop production on all sandy soils. The application of sulfur, however, did not increase corn yields on all the sandy sites selected for the study (see Table 3). Use of sulfur produced a substantial increase in yields at all sites selected in Pierce County. The corn at the Holt County sites, on the other hand, did not respond to sulfur fertilization.

In Pierce County, differences in corn growth produced by the use of sulfur could be seen early in the growing season. The appearance of corn plants deficient in sulfur is quite similar to the appearance of corn plants deficient in nitrogen. Sulfur-deficient corn plants, in general, have a yellow color with distinctive striping in the leaves.

It's important to point out that corn plants which are deficient in nitrogen may also show these same symptoms. It is easy to confuse these deficiency symptoms. In many corn fields on sandy soils, the yellow corn is caused by a deficiency of both nitrogen and sulfur.

Throughout the study, all sulfur sources had an equal effect on increasing corn production at the responsive sites in Pierce County (see Table 1). Although yields produced by the application of the elemental S + bentonite products were somewhat lower than yields produced by other products in both 1973 and 1974, statistical analysis of the data showed that these yield differences were due to the natural variation in the field rather than the treatment applied. The differences in yields from the three sulfur sources used in 1975 are also due to natural variation in the field.

High rates of sulfur fertilizers are not needed for high yields. The application of 10 lb. sulfur per acre produced the largest yield increases in both 1974 and 1975 (see Table 4). In 1974, 20 lb. sulfur per acre produced slightly higher yields than 10 lb. sulfur per acre but rates higher than 10 lb. per acre did not produce additional increases in yield in 1975.

Approximately 95 per cent of the total amount of soil sulfur is in the organic matter. It's logical, then, to consider the organic matter content of soils in making sulfur recommendations. Since plants take up sulfur

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Sulfur... in the sulfate (SO\textsubscript{4}) form, the sulfate-sulfur (SO\textsubscript{4} - S) content of the soil must also be considered. These properties for the soils at the experimental sites are listed in Table 5.

The soils in Pierce County had a much lower organic matter content than the Holt County soils. The

| Table 1. Effect of sources of sulfur on irrigated corn yields on sandy soils in Pierce County. |
|-----------------|-----------------|-----------------|-----------------|
| Sulfur Source   | 1973            | 1974            | 1975            |
|                  | S/acre of #2 corn | S/acre of #2 corn | S/acre of #2 corn |
| None            | 163             | 143             | 112             |
| Granular gypsum | 186             | 170             | 129             |
| Elemental S + bentonite | 176         | 161             | 132             |
| Ammonium sulfate | 182           | —               | —               |
| Potassium-magnesium sulfate | 186       | 168             | —               |
| Fortified gypsum* | —             | —               | 134             |

*Fortified gypsum is a sulfur source consisting of 50% elemental S and 50% gypsum.

|
| Table 2. Sulfur recommendations for corn on sandy soils. |
|-----------------|-----------------|-----------------|
| SO\textsubscript{4} – S Content (0-8 in.) | Organic Matter Content (0-8 in.) |
| ppm              |                  |                 |
| 0 to 5           | 15 lb. S/A in a starter* | 15 lb. S/A in a starter* |
|                  | or               | or              |
| 6 to 8           | 25 lb. S/acre broadcast | 25 lb. S/acre broadcast |
| more than 8      | none             | none            |

*If the irrigation water contains more than 6 ppm SO\textsubscript{4} – S, no broadcast sulfur will be needed and use of sulfur in a starter fertilizer would be recommended.

| Table 3. Effect of sulfur on yield of irrigated corn on sandy soils. |
|-----------------|-----------------|-----------------|
| Treatment       | Year            | Yield           |
| S               | 1973            | 163             |
| S               | 1973            | 183             |
| S               | 1974            | 143             |
| S               | 1975            | 112             |
| S               | 1976            | 132             |
| S               | 1977            | 165             |
| S               | 1978            | 187             |
| S               | 1979            | 138             |
| S               | 1980            | 175             |
| S               | 1981            | 132             |

SO\textsubscript{4} – S content was also higher in the Holt County soils. The results of this study show that these two soil properties are important. Corn grown on soils with a low organic matter content and a low amount of SO\textsubscript{4} – S responded to application of sulfur. By contrast, corn grown on soils with a high organic matter content and a relatively high amount of SO\textsubscript{4} – S did not respond to use of sulfur.

By using the information gathered in this study, it is now possible to make more detailed sulfur recommendations for corn on the sandy soils of Nebraska. These recommendations take into consideration the organic matter content of the soil as well as the amount of SO\textsubscript{4} – S extracted from the soil by calcium phosphate (see Table 2).

The sulfur content of the irrigation water must not be ignored when making sulfur recommendations for irrigated corn on sandy soils. Some irrigation water contains enough sulfur to meet the requirements of an irrigated corn crop. In these situations, sulfur fertilizers may not be needed. Water from many wells in the Sandhills and bordering areas, on the other hand, contains only a small amount of sulfur. For these situations, sulfur fertilizers increase corn yields where soil sulfur is low.

It's also important to point out that the recommendations listed in Table 2 are for sandy soils only. All studies conducted up to this time have shown that sulfur will not increase the yield of corn grown on non-sandy soils. Thus this nutrient does not need to be applied for corn production in all of Nebraska. When the need for this essential nutrient is indicated by soil testing procedures, the application of sulfur fertilizers will produce healthy increases in corn yields on the sandy soils of Nebraska.

Research results of the Nebraska Agricultural Experiment Station are available to anyone regardless of race, color, religion, sex, or national origin.

| Table 4. Effect of rate of applied sulfur on yield of irrigated corn in Pierce County. |
|-----------------|-----------------|-----------------|
| Rate of Sulfur Applied | Year | Yield           |
| lb/acre         | 1974            | S/acre of #2 corn |
| 0              | 143             | 112             |
| 10             | 163             | 130             |
| 20             | 170             | 132             |
| 30             | 167             | 133             |
| 40             | —               | 133             |

| Table 5. The organic matter content and SO\textsubscript{4} – S content of soils at the experimental sites. |
|-----------------|-----------------|-----------------|
| County          | Year            | S/O SO\textsubscript{4} – S |
|                  |                 | Content | ppm |
| Pierce           | 1973            | .89     | 4.7* |
| Holt             | 1973            | 1.40    | 5.6  |
| Pierce           | 1974            | .97     | 3.8  |
| Holt             | 1974            | 3.77    | 12.1 |
| Pierce           | 1975            | .85     | 2.7  |
| Holt             | 1975            | 2.15    | 7.9  |

*SO\textsubscript{4} – S is extracted by a calcium phosphate procedure.

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