

# Summary of Some Major Research Projects In The Agricultural Experiment Station

## **RESEARCH-EXTENSION RURAL DEVELOPMENT**

Title V of the Rural Development Act of 1972 provides for a pilot program to more clearly identify the role of the land grant university in rural development through the use of diverse research and extension resources available at these institutions. The Title V program in North Dakota involves a joint research and extension project directed at State Planning Region VI, a nine-county area of south central North Dakota.

Research in progress through the project includes a study on land-use planning. This study will provide a descriptive analysis of land-use planning, identify land-use policy problems and opportunities and measure the attitudes of people in the region toward land-use planning.

Numerous feasibility studies have been conducted through the Title V program. Most recently completed was a study on the feasibility of a large-scale hog slaughter plant in North Dakota. A project now underway is investigating the investment and operating requirements for small meat plants in rural communities.

A major educational effort of the project has been a course on industrial development offered in cooperation with the North Dakota Business and Industrial Development Department, Farmers Home Administration, Ottertail Power Company and Montana Dakota Utilities.

## **MARKETING IRRIGATION PRODUCTION**

Increasing irrigation in North Dakota presents a completely new set of management and marketing decisions to both irrigators and businessmen. An interdisciplinary project at NDSU to help provide the expertise needed to evaluate these unfamiliar alternatives has been underway for three years and continues to evaluate production alternatives and marketing of irrigation production.

This project involves the departments of agricultural economics, agronomy, soils, animal science and horticulture.

The project has used linear programming to evaluate the optimum combination of resources for model farms in the Garrison Conservancy Dis-

trict. The total effect of the irrigation project will also be assessed to determine the impact on markets for farm products and on the level of economic activity in the project area when the optimum combinations of crop and livestock enterprises have been established. Other market analyses and market feasibility studies for products that show potential for production under irrigation will also be conducted.

Work in the third year of the project concentrated on refining and developing crop and livestock enterprises for the model farm in the southern irrigation area, the LaMoure-Oakes area. Cultural practices for the central area were evaluated, and budgets for irrigated and dryland crops in the Warwick-McVile area were developed. Market projections and analyses for the the southern area have also been made.

Work planned in the coming year consists of additional refinement of the programming model and a more in-depth analysis of the optimum combination of resources in the southern area. Work will continue on the model farm for the central area, along with economic impact and marketing studies.

## **SHEYENNE RIVER BASIN**

Progress continues on a five-year project to identify the costs and benefits of varying pollution control standards and evaluate alternative water and land use management systems in the Sheyenne River Basin. The study focuses on the lower Sheyenne river from Bald Hill Dam, north of Valley City, to the river's mouth on the Red river north of Fargo.

Involved in the project are the departments of agricultural economics, botany, bacteriology, geology and chemistry at NDSU along with the departments of sociology and chemistry at Concordia College.

During the first three years of the study, geologic field analysis and mapping has been done, socio-economic analyses have been conducted, water quality has been analyzed and monitored, relationship of water quality to land use studied and development of a simulation model completed to help evaluate alternative futures for the basin.



Location of water quality sampling sites in the lower Sheyenne river, 1973-74.

Data gathered in this project made possible the analysis of relationships between surface erosion and economic activity in the basin under conditions of varying rainfall and cropping rotations.

### DEVILS LAKE BASIN STUDY

A study to analyze the economy of the Devils Lake Basin and assess the economic impact of alternative plans for water and land management in the basin is in progress in the Department of Agricultural Economics.

The Devils Lake Basin includes numerous streams, some of which interconnect shallow lakes. The flowage finally empties into Devils Lake. Flooding from spring runoff and summer rainstorms results in serious damage to agricultural production in the basin. The Devils Lake Basin is one of the nation's prime waterfowl production areas, so flood reduction plans that would be detrimental to wildlife habitat encounters opposition. The need is for a comprehensive plan for water and land use management that will take into account the interests of all concerned.

Data related to a number of economic dimensions are being collected to provide an overview of economic trends in the region. The future economic structure of the basin will be estimated, and the economic impact of alternative plans for land and water management will be analyzed. The analysis emphasizes the impact on the agriculture and recreation sectors in the basin and takes into

account the trade-offs in land use that arise between agriculture and recreation activities.

Economic costs and benefits of three alternative plans for reducing flood damages in the basin have been estimated and are being refined. The plans included varying levels of structural and nonstructural measures which include both land treatment and wetlands restoration.

### CHECKBOOK IRRIGATION

This past summer, a new method of irrigation scheduling was made available to North Dakota irrigators. This method, "Irrigation Scheduling by the Checkbook Method," was prepared by North Dakota State University Agricultural Engineers Darnell Lundstrom and Dr. Earl Stegman.

The checkbook method allows an irrigator to keep a day-by-day record of crop water use and the water deficit in his soil. Keeping this daily soil moisture record and projecting crop water use over the next few days helps in scheduling irrigations.

The checkbook method requires an irrigator to check daily maximum temperatures. He can then determine daily crop water use by consulting a crop water use table for the crop being grown. Daily crop water use is added to the soil moisture deficit, while irrigation and rainfall is subtracted from this deficit. Good water management means keeping soil moisture deficits at less than 50 per cent.

A soil probe must be used periodically through the irrigation season to check the soil moisture content and update the balance sheet if necessary. During the peak irrigation season, July and August, this update should be done at least every other week.

Instructions for the checkbook method are available in the circular, "Irrigation Scheduling by the Checkbook Method," available from county Extension offices or the Extension Agricultural Engineer at North Dakota State University. Included in the circular are crop water use tables for alfalfa, sunflowers, corn, wheat, pinto beans and sugar beets. Also included are blank soil moisture sheets, water holding capacities of various soils and typical crop root zones for irrigated crops.

### NEW PLANS FOR MACHINE SHEDS & SHOPS

Construction of large machinery storage buildings is increasing on farms. Providing shelter for large, high-investment equipment and machines helps reduce the repairs and keep resale value higher compared to equipment that is allowed to sit outdoors. Protecting tires, wiring, belts, chains, hoppers and other exposed items from the weather saves on repairs and cuts down time when the machine is operating.

Farm shops are used to repair equipment during the off-season. A shop also permits building special equipment when labor is available. Having the tools in one place and indoor space to work reduces the time needed to get a machine going again when it breaks down.

Six new plans for machine sheds and farm shops have been prepared through the Midwest Plan Service. These complete plans can be used to construct a complete facility according to the plan, or assist with planning individual buildings that will be built to suit special needs.

- MW 74146 48' Wide Pole Machine Shed
- MW 74147 60' Wide Pole Machine Shed
- MW 74148 30' Wide Pole Machine Shed
- MW 74150 30' x 40' Shop
- MW 74151 40' x 48' Shop
- MW 74152 40' x 60' Shop

Each of these plans shows pole-frame type construction with clearspan, truss rafters that have plywood, glue-nail joints. A 24'-wide door is included on each machine shed plan. Ideas on shop layout are included. You can order these plans through your County Agricultural Agent, or directly from the Department of Agricultural Engineering, North Dakota State University, Fargo, North Dakota 58102.

### WELDING SCHOOL BEGINS 15TH YEAR

Since its beginning in 1960, the two-day farm welding school sponsored by the North Dakota State Extension Service has continued to flourish. During the past 14 years, the school has taught nearly 3,000 people of many varied occupations throughout North Dakota.

The number of schools ranges from 8 to 18 each year, with a limit of about 24 people per school. Most sessions are conducted from January through March.

The school is open to the public and is arranged through the local county agent's office. Farmers make up the majority of those in attendance, however others enrolled have included implement dealer mechanics, ministers, veterinarians, doctors, vo-ag instructors and plumbers.

S. L. (Seb) Vogel, professor emeritus from North Dakota State University, teaches the school, as he has since its start, through demonstrations, lectures and practice in using the equipment and welding materials. The 12-hour short course has lessons on the basic procedures and techniques in using electric arc welding and oxygen-acetylene welding equipment, stressing the procedures and



Seb Vogel, former Extension agricultural engineer, demonstrates aluminum welding at a county welding school.

electrodes for welding the low-alloy, high-tensile steels now used in the manufacture of farm equipment.

A two-wheel, 4x6-foot enclosed trailer houses all the teaching apparatus Vogel needs. Six AC arc welders of various makes are permanently mounted in the trailer, three on each side. Auxiliary power is necessary for the extra electricity needed to run the welders, and is usually furnished through the cooperation and advice of the local electric power suppliers.

The school supplies all necessary welding electrodes and filler rods, but each person furnishes his own scrap metal for practice welding. If anyone has a minor repair job he wishes to do, this can usually be worked on sometime during the two-day period.

A small enrollment fee covers the cost of electricity and most of the cost of materials.

### **HRSW GENETIC RESEARCH BENEFITS**

Testing hard red spring wheats which have alien cytoplasm is continuing. Screening these materials for potentially beneficial effects of these different cytoplasm on spring wheat's protein, disease resistance and agronomic performance is considered important as possible sources of new previously unexploited genetic diversity.

Recent genetic studies of wheat have indicated that the better pure lines from crosses yield comparably with the F<sub>1</sub> hybrids. Several hybrids were superior in yield when compared to the best pure lines, but several were lower yielding, also. This study did not represent the full diversity of genetic material available in spring wheat, since all parents were well adapted to North Dakota growing conditions. Continued research is necessary to determine if hybrid wheats with adequate hybrid vigor for commercial utilization are possible.

The choice of parents used for hybridization to produce promising new varieties continues to be a major problem in plant breeding and varietal development. Better methods of choosing these promising parents are presently being evaluated. Increased efficiency of knowing the expected performance level of progenies from certain parents would be of great assistance in more efficiently and effectively producing new varieties.

### **WINTER WHEAT RESEARCH**

Insufficient winterhardiness has restricted the acreage of winter wheat in North Dakota. Very few varieties with good winterhardiness have been available to growers in the past, and many of them had other major deficiencies.

Roughrider, released by NDSU in 1975, is an improved variety with good winterhardiness, but even higher winterhardiness would be desirable.

In an attempt to find new sources of winterhardiness, nearly 10,000 wheats from the USDA World Wheat Collection have been grown over the past seven years. Only about 50 appear to be equivalent or superior to our best current varieties for winterhardiness. Most of these are from the USSR. Unfortunately, all 50 have some serious agronomic, disease and/or quality deficiency which makes them unsuitable for commercial production. Hybrids have been between these winterhardy types and our current varieties in an attempt to transfer higher winterhardiness into adapted types. The progeny of these hybrids are being evaluated to find lines with higher winterhardiness and good agronomic, disease and quality characteristics.

A more long-range type of research on winterhardiness is being started this year. Wild wheat relatives, with which wheat will hybridize without sterility, are being crossed with wheat to determine if they can contribute higher winterhardiness.

Present winterhardiness levels, such as found in Roughrider, are adequate for winter wheat production in the southern half of North Dakota when good management practices also are followed. The higher winterhardiness found in wheats from the USDA World Wheat Collection should permit winter wheat production farther north and east. If still higher winterhardiness can be obtained from wild wheat relatives, winter wheat may be grown statewide.

### **DURUM WHEAT IMPROVEMENT**

North Dakota released durum varieties have made up more than 90 per cent of North Dakota and United States production during each of the last 10 years, continuing the dominant position held for many years. When durum production fell to about six million bushels in North Dakota in 1953-54 because of stem rust devastation, the varieties Langdon and Ramsey, released in 1956, brought durum production back to normal levels. New races of stem rust attacked Langdon and Ramsey, which were then replaced by the resistant varieties Wells and Lakota, released in 1960. While Wells today is an important variety in North Dakota and still resistant to stem rust, newer varieties such as Leeds, Ward and Rugby have provided progressively higher stem rust resistance levels.

North Dakota State University and the USDA released their first semidwarf durum variety,



Graduate students and technicians contribute valuable research results to the durum improvement program by taking part in greenhouse evaluation under the direction of Dr. James Quick, right.

Cando, in December, 1975. This release represents research done over a 20-year period. Cando has high grain yield, excellent quality and excellent disease resistance. Cando is the first semidwarf durum to meet the requirements of North Dakota farmers and processors, a significant accomplishment by an already successful variety improvement program. The 1976 agronomic trials confirmed previous high performance levels.

Three new durum varieties, Crosby, Botno and Rugby, were jointly developed and released by the North Dakota Agricultural Experiment Station and the USDA in December, 1973. Together they occupied more than 25 per cent of the 1976 North Dakota acreage. These new varieties possess increased yielding ability over Leeds, and also have a stronger straw, earlier maturity, improved disease resistance and improved spaghetti quality. These varieties join Rolette and Ward released in 1971 and 1972, respectively, to provide North Dakota farmers six new varieties with several major advantages. The most recent five varieties (not including Cando) released since 1971 produced an estimated \$22 million (7.8 million bushels) additional return to North Dakota farmers in 1976, compared to the predicted performance of Leeds and Wells.

The durum wheat breeding program has received a five-year grant from four sectors of the durum industry: the National Macaroni Manufacturers Association, North Dakota farm producers represented by the North Dakota Wheat Commission, the durum wheat millers via the Durum Wheat Institute, and from several exporters, Garnac Grain Co., Inc., International Grain Management Corporation and the Louis Dreyfus Corporation. The grant funds have allowed studies on determination of improved breeding methodology, determination of genetic control of spaghetti color

and evaluation of primary components affecting grain yield.

Increased emphasis has been placed on increasing gluten strength in durums, partly with industry grant funds. Researchers have found that gluten strength is quantitatively inherited with very little dominance. The protein level, between 13 and 17 per cent, is not associated with mixogram rating, but the environment has a large effect on mixogram rating (independent of effect on protein amount). Strong mixing derivatives equal to the high parent can be easily recovered from breeding populations. Also, good bread-making properties are associated with stronger gluten, which may allow the development of a "dual purpose durum."

### NDSU SEEDSTOCKS PROJECT

North Dakota State University has been utilizing the fall season (Aug. 1 - Nov. 10) of California and the winter-spring season (Nov. 12 - May 10) of Arizona to make additional increases of early generation plant breeding materials and new and potential varieties of small grains.

The program has been very successful, but often the seed increases from Arizona, which arrive in North Dakota about May 15-25, are too late for maximum increase.

To hasten the maturity of these southern increases by one month, the Seedstocks Project



Quartz lamps mounted on poles were used to illuminate seed increase plots in Arizona.



Wheat headed out at right shows early maturity due to night interruption, as compared with non-headed plants in the same strip.

undertook an experiment to break the long winter night periods. Long nights induce vegetative growth in most small grain cereals.

Incandescent lights were set above the plot areas and the plots were illuminated for several hours in the middle of the night. This "night-interruption" with a light period creates, in effect, two short dark periods. Short nights or short dark periods induce the reproductive (heading) processes of most small grain cereals.

Several years of experimentation have shown that 10 foot-candles of incandescent light for five hours (9:30 p.m. - 2:30 a.m.) each night for about 85 nights beginning one month after planting will cause the small grain cereals to mature about 30 days earlier. (Ten foot-candles of power light would be about equal to that produced by a 150-watt bulb placed 5 to 7 feet above the growing plants.) The square feet to be covered dictates the number of lamps required to obtain uniform coverage.

Quartz-line 1,500-watt lamps placed 15 to 20 feet above the ground were used to light the plot area. Figure 1 shows how the lights were mounted. Figure 2 shows early heading in the foreground. In the far background, which remained dark, heading has not taken place. This photo shows dramatically the effect of breaking the long dark period.

## BARLEY CYTOGENETICS

Stem and leaf rust resistance was transferred from *H. bulbosum* and (*H. depressum* × *H. compressum*) through interspecific crosses to cultivated barley.

(*H. brachyantherum* × *H. bogdanii*) × *H. vulgare* (4×) crosses produced some plants with pubescence on leaves and stems. The pubescence may provide some resistance to the cereal leaf beetle. In addition, the above cross appears to have transferred some winterhardiness to cultivated barley. This was indicated by one cross with 'Traill' (a spring type) that overwintered at Williston. Other crosses also have shown more vigor following vernalization (freezing temperatures) than 'Nebar,' one of the most winterhardy cultivated barley varieties. Another factor that appears to be present in these crosses is some yellow dwarf resistance which is a very important factor in winter survival.

Interspecific crosses between *Hordeum vulgare* (4×) and an *Elymus* species (probably a haploid out of *Elymus arenarius*) have been produced. Chromosomes of the *Elymus* species pair favorably for the transfer of genetic material from *Elymus* to cultivated barley. Research in the areas of disease and insect resistance, winterhardiness and drought resistance is being conducted with these crosses.

## STUDIES ON MALTING BARLEY VARIETIES

North Dakota has been the leading malting barley producing state for many years, with the upper midwestern states of North Dakota, Minnesota and South Dakota providing a majority of the



Nursery plots at the Langdon Branch Experiment Station contain 1,100 barley breeding lines being evaluated for agronomic characteristics.



Also at Langdon, Dr. Mel Anderson selects for straw strength and disease resistance. Stiffer-strawed barley line is seen at left.

barley used for malting. The six-rowed, white-aleurone varieties have been the most widely grown in this area, with present industry demands approximating 100 million bushels.

Several years ago, breeding two-rowed barley varieties adapted to North Dakota environments was begun. Previous two-rowed varieties from other areas were lower yielding than present six-rowed varieties, because of disease susceptibility, late maturity and lodging. Crosses between adapted, disease resistant six-rowed varieties and unadapted two-rowed varieties have been made. Selection has resulted in two-rowed breeding lines which are high yielding under all North Dakota conditions.

Unlike previous unadapted two-rowed varieties, these breeding lines are earlier in maturity, show high levels of disease resistance, and possess strong straw. Currently, these breeding lines need to be evaluated further for desirable malting quality. At the present time, none of the two-rowed malting barley is produced in this area. All of this barley is now being produced in the western United States or in Canada.

As adapted two-rowed barley varieties become available, the Upper Midwest also can become a significant producer of two-rowed barley that can be used either for malting or feeding purposes.

## CORN RESEARCH IN NORTH DAKOTA

A recent survey of hybrid corn seed producers indicated that 57 per cent of commercial hybrids are produced using one or more parental lines developed by public plant breeding programs. Since private inbred line development programs are essentially non-existent in North Dakota, it is probable that an even larger proportion of public lines are used for producing commercial hybrids for sale in this state.

The corn improvement project at the North Dakota State University Agricultural Experiment Station has contributed 35 inbred lines and numerous male sterile and restorer sublines to the pool of parental lines used by commercial seed producers. The two most recent releases, ND240 and ND241, when tested in eight different hybrid combinations in 1974 and 1975, outyielded adapted commercial hybrids by 15 bushels per acre. At average November corn prices for that period, a single farmer growing 600 acres of the new corn hybrids would have been able to support the entire corn improvement program at NDSU with his increase in earnings.

In addition to developing new parental inbreds, research to identify which inbred combinations produce the most productive hybrids is conducted at various sites in the state. Considering only the 35 North Dakota inbreds, there are 595 possible single crosses, 19,635 possible three-way crosses and 157,080 possible double crosses. Since



Corn breeder Dr. Harold Cross with experimental hybrid grown at the Agronomy Seed Farm, Casselton. Parent lines are released to commercial seedsmen for hybrid seed corn production.

yields of three-way and double crosses can be predicted from the yield estimates of component single crosses, numerous single crosses are yield tested annually in various areas to identify and predict which hybrid combinations are most productive. In 1976 tests under irrigated culture at Oakes, in a group of 45 single cross hybrids, yields ranged from 100 to 216 bushels per acre. Nine experimental hybrids, each involving ND309 and ND408, averaged 188 and 179 bushels per acre, respectively, compared to 166 bushels per acre for 43 adapted commercial hybrids tested under similar conditions.

Tests of commercial corn hybrids are conducted to provide growers and seedsmen with information about hybrid performance in specific growing areas. Assuming that farmers are well informed about corn hybrids marketed by the various seed companies and further that hybrids entered in the corn performance trials are representative of the hybrids available to farmers, then hybrid selection by a farmer lacking specific yield performance information for his growing area should be equivalent to randomly selecting a hybrid from those entered in the corn performance trials. If a farmer selected a high yielding hybrid based on performance in the trials, his hybrid should have outyielding a random selection (the mean of all hybrids in the next year's trial) by an average 3.34 bushels per acre, based on calculations from 10 years of tests at five locations. At November 1974 to 1975 corn prices, this yield advantage would have been worth \$9.15 per acre. The entire cost of the 1975 testing program could have been supported by the additional income of 1,500 acres of the approximately 500,000 acres of corn grown annually in North Dakota.

### **SUNFLOWER PRODUCTION AND PHYSIOLOGY RESEARCH**

Sunflowers have become the major oil crop in North Dakota, with close to 1/2-million acres planted in 1976. Research at NDSU is oriented toward the areas of crop production and physiology. Areas of research include the effect of seed size, dates of planting and plant population on yield and water use efficiency. The role of leaf area in sunflower yield is being studied.

### **HYBRID SUNFLOWERS**

The first hybrid sunflowers produced by cytoplasmic male sterility and genetic fertility restoration were grown in North Dakota in 1972. It was estimated that in 1976 over 80 per cent of the nearly 500,000 acres of sunflowers grown in North Dakota were hybrids.

Since the inception of the USDA - North Dakota Sunflower Improvement Program in 1970, over 25 inbred lines suitable for use in production of high yielding, disease resistant F<sub>1</sub> hybrids have been released to the seed industry. The best of the hybrids have shown a 15 to 30 per cent yield advantage over currently grown open-pollinated varieties, greater uniformity, improved disease resistance, and improved self-compatibility or self-pollination. Most of the hybrids offered by private seed companies involve the use of one or more parent lines developed by USDA and NDSU researchers.

### **DRY EDIBLE BEAN RESEARCH**

Dry edible beans have become a major row crop in North Dakota, with most of the acreage located in the eastern 1/3 of the state. Highest concentration acreage is in the areas of Wyndmere and Hatton, where the lighter soil types coupled with adequate rainfall in a normal year are most conducive to good bean production. Most dry edible bean production is of the pinto type.

In cooperation with branch stations, the Garrison Conservancy District, Campbell Soup Company, and interested growers, considerable effort is being expended for agronomic evaluation of dry beans for increased production in North Dakota. The objectives of these studies are to:

1. Gain information on adaptability and agronomic potential of the various bean types. Variety trials testing both varieties and bean types were conducted at 12 North Dakota locations in



Comparison of adapted (left) and unadapted dry edible beans in field trials at the Oakes Irrigation Site.



1976. Types being evaluated included pinto, Great Northern, Navy and Red Kidney.

2. Select and evaluate experimental lines for possible future production in North Dakota. In all instances, both experimental and name varieties were tested at one or more locations.

3. Conduct research on basic production practices such as planting rates, dates, and row spacings at various sites in North Dakota.

Research at Fargo is also being conducted in hail simulation. Bean growers and hail adjustors often have difficulty in reaching fair mutual agreement relative to losses due to hail. The basic problem is a lack of good information relative to the effect of varying intensities of hail at different stages of growth. Researchers using grant money given to NDSU by the National Crop Insurance Agency and the Crop Research Bureau, are trying to study hail losses due to stand reduction and hail simulation. This information will allow more accurate estimates of hail losses.

### RESEARCH IN MINOR AND NEW CROPS

Research in several crops of limited importance in North Dakota is being conducted at NDSU. Evaluations of established varieties and experimental lines are being conducted in such agronomic crops as millet and winter rye, where acreages are relatively stable and small.

In minor crops such as mustard and safflower where limited production data is available, research on various basic agronomic practices in addition to evaluation of varieties is being conducted. This information will be of value, since growers often have questions concerning these crops.



Safflower in a variety test plot at the Main Station, Fargo.

In addition, new crops are being evaluated for their adaptability and production potential in North Dakota. Crops evaluated in the past include tickbeans, horsebeans, plantago, and chickpeas. Sunflowers was one of the crops evaluated in years past in this project.

### FORAGE MANAGEMENT

Twenty-two years of nitrogen (N) fertilization of an old bromegrass sod at six rates has demonstrated the importance of fertilization as an economical tool by which farmers can increase substantially their average forage production.

Annual fall fertilization at 66 pounds N per acre has doubled and 266 pounds N per acre has more than tripled annual forage production of nonfertilized bromegrass at Fargo, ND. If N sells for 20¢ per pound and bromegrass hay for \$40 per ton (November, 1976 prices), every dollar invested in N fertilization will return \$4.20 worth of forage at 66 pounds N per acre; an excellent buy!

N fertilization increases the crude protein content of bromegrass hay. The crude protein content was increased 0.9 and 6.4 per cent for 66 and 133 pounds N per acre levels, respectively, as compared to nonfertilized bromegrass. A higher protein content and yield of the 66 and 133 pounds N per acre resulted in 216 and 400 per cent greater protein per acre production than nonfertilized bromegrass. Nitrate-nitrogen accumulation was not evident in bromegrass fertilized with less than 133 pounds N per acre.

*In vitro* dry matter digestibility of bromegrass forage was increased during the vegetative stage, was affected little during jointing and heading stages, and was decreased at anthesis by increasing N fertilization level. These data indicate the need to harvest fertilized bromegrass hay at an earlier than normal growth stage to maintain forage digestibility. Acid detergent fiber and cell wall constituents increased with increasing N level at all weekly sampling dates except during the vegetative stage.

The efficiency of N fertilization is determined by the per cent of applied N recovered as crude protein when adjusted for soil N mineralization. Sixty-seven and 83 per cent (a five-year average) of applied N was recovered as crude protein in bromegrass hay fertilized at 66 and 133 pounds N per acre, respectively.

N recovery in bromegrass compares favorably with the 60-70 per cent N recovery typical with small grain fertilization. The yearly efficiency was influenced markedly by the environment, however. Maximum recovery was less than 60 per cent

in dry years and greater than 100 per cent in wet years following dry years. This suggests that a wise management practice on pure grass stands would be to reduce the N level applied following a dry year and increase the N level applied following a wet year assuming near optimum fertilization practices were followed in previous years.

### WEED CONTROL RESEARCH ACTIVITY

Research to reduce the tremendous loss which occurs directly or indirectly from weed infestations is conducted for all major weeds in North Dakota crops.

Concentrated research is in progress to control wild oats, which alone causes approximately \$150 million annual loss in small grain yields. Field experiments are conducted throughout the state to evaluate various herbicides and systems to control wild oats. These experiments are designed to evaluate new and potentially promising herbicides, new methods of applying old herbicides, herbicide combinations, and additives.

The use of additives or combinations of herbicides is to increase the consistency as well as the number of weeds controlled with a single application at minimum cost. The addition of nitrogen fertilizer to barban is an example of an additive presently being researched. Early experimental results have indicated that wild oats control is improved, particularly when plants are growing in soil low in fertility. However, in addition to

improved wild oats control, potential for wheat injury also is increased.

The biology of wild oats is being researched both in the laboratory and in the field. Research on variation among wild oats selections in response to herbicides, in seed dormancy and growth habit, will give information on the potential development of herbicide resistance and future problems. Research is in progress to determine the nature of wild oats seed dormancy and to the possibility of breaking the dormancy with soil-applied chemicals. The ultimate objective is to stimulate all the seeds in the soil to germinate and then control the emerging seedlings with tillage or other systems, thus eradicating the weed seed supply in the soil.

Foxtail infestations in wheat have become another major weed problem in recent years. Field experiments are being conducted at all the Experiment Stations in North Dakota to evaluate several potential preemergence and postemergence herbicides for foxtail control in wheat, barley and oats.

Weeds are the major cause of the low average flax yields in North Dakota. Yields in plots have increased up to 10 bu/A with good weed control compared to the weedy plot, and in some cases even when compared with the yield from plots treated with presently-used postemergence herbicides. Research efforts to improve weed control in flax have been to improve the efficacy of EPTC and several experimental herbicides, preplant soil



Dr. John Nalewaja (left) and Dr. Richard Gorecki, exchange scientist from Poland, observe results of dormancy and wild oat germination experiments.

incorporated, and several postemergence herbicides. Fall herbicide applications are being evaluated as a means to reduce the effect of spring herbicide incorporation on flax seedbed and delayed seeding after EPTC spring applications to reduce flax injury.

Experiments are conducted each year to evaluate registered and near registered herbicides for soybeans, corn, pinto beans and sunflowers to obtain performance information for use in developing the bulletin, "Chemical Weed Control, Guide for Field Crops and Perennial Weeds."

### PERENNIAL WEED CONTROL

The usefulness of glyphosate (Roundup) for leafy spurge control in trees has been established in four years of trials at NDSU. It will be applied at 1 to 1.5 lb/A, and must be applied in the fall after August 15 when the leafy spurge is actively growing. Applications of glyphosate in June and July are not recommended, because less than half of the leafy spurge plants will be controlled when applied too early in the year.

Glyphosate is a postemergence herbicide and is non-selective, so it cannot be used when the farmer has grass or other desirable vegetation that he wants to retain under the trees. Similarly, it cannot be used on pastures or other cropland where desirable plants are growing.

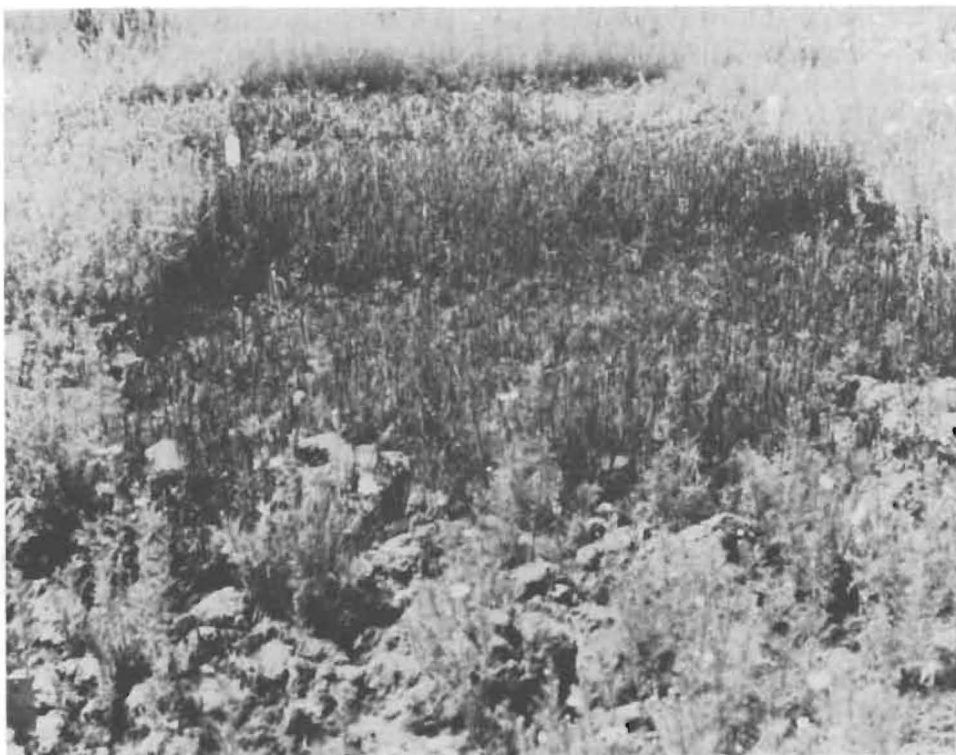
Glyphosate has no activity through the soil, so leafy spurge seedlings will emerge in abundance the following spring because competition from established plants has been eliminated. The seedlings should be controlled with 2,4-D amine at 0.5 lb/A applied during the last two weeks of June. The applicator must keep the glyphosate off the foliage of trees or the green bark of tree seedlings, but the herbicide is not absorbed through the bark of established trees.

### WEED CONTROL IN SUGARBEETS

The goal of the project on weed control in sugarbeets is to eliminate the need for hand labor. Hand labor would not be necessary if mechanical and chemical weed control methods would give adequate weed control. Presently available methods are often inadequate or inconsistent, so hand labor is still used extensively in sugarbeets.

The weed control in sugarbeet project tests candidate herbicides and helps develop them for commercial use. Candidate herbicides are initially tested by field application at several rates in comparison to standard herbicides. When a promising herbicide is identified, further tests are conducted to develop the most effective methods of use for the herbicide in our area.

The conditions under which sugarbeets are grown in the Red River Valley of North Dakota



Results of using glyphosate (Roundup) to control false chamomile around patholes near Mohall, North Dakota.

and Minnesota are different from sugarbeet growing regions in the rest of the world. Herbicide use methods often have to be adapted to fit our conditions. Examples of studies which are done to find the best methods of using a candidate herbicide include: use in combinations with other herbicides, required depth and time of incorporation, optimum sprayer pressure-volume-speed, additives to spray solutions, and the influence of air temperature, soil temperature, soil organic matter, relative humidity, and rainfall on herbicide performance.

### STUDIES IN THE CONTROL OF FALSE CHAMOMILE

False chamomile (*matricaria maritima* L. var. *agrestis* (knof) Wilmott) is a troublesome weed in northern counties of North Dakota, especially in eastern Renville and western Bottineau counties in north central North Dakota.

This winter annual weed has an attractive white flower and is very difficult to control either through the use of chemicals or by cultivation. The spread of the weed has been rapid in the past 10 years and farmers in the infested areas are seeking research information into the control of this pesky weed.

False chamomile was first introduced into North Dakota as an ornamental about 1900. The leaves are sessile and finely divided, terminating in narrow, thread-like segments. Daisy-like flowers are one-half to one inch in diameter and are borne at the ends of the branches. The flowers have yellow centers and white florets in a radiate pattern.

False chamomile likes moist conditions and spreads rapidly in slough and other wet areas. It will also spread rapidly in grain fields. Once established in an area, it is generally found everywhere: trees, road ditches, fences, etc. The plant is very competitive in small grains, especially the winter annual plants. A prolific seed producer, it is known to produce over 190,000 seeds per plant. There is no record of how long the seed will remain dormant. The plants range in height from a few inches to four feet tall.

The North Central Experiment Station staff became involved in research on false chamomile control in 1972 and has continued this research up to the present time. Major emphasis of the research has been through chemical weed control, with applications made in both fall and spring. Previous research is difficult to find, indicating that this weed has not caused economic losses to the extent of creating research of any magnitude.



Bruce Schoenwald, technician at the North Central Branch Station, Minot, shows the extent of the false chamomile problem on a farm near Mohall in an untreated field.

At the present time, cultivation is the only means of control.

Chemical control was the first area of research on this weed carried out by Station staff. This was expanded to include studies in dormancy, use of additives, competition and tillage practices. Most of the research is being conducted in the Mohall area on infested land. The research is in cooperation with Renville county, the Renville County Agricultural Improvement Association, cooperating farmers and the county agent.

Many chemicals have been evaluated, and most of these chemicals have not given adequate control. The popular broadleaf weed chemicals such as 2,4-D, MCPA and bromoxynil are ineffective at rates recommended for use in cereal grains.

False chamomile can be controlled with glyphosate (Roundup) at 16 ounces per acre, paraquat at 16 ounces per acre, and picloram at 4 ounces per acre in non-cropland areas. At these rates the cost per acre is very high and could only be used

for small spot treatments. Research will continue in order to find a more economical chemical or combination of chemicals.

No named chemicals will control the weed in cropland without serious injury to the crop. One experimental chemical, RH-5205, has shown good promise, and control was nearly 100 per cent with no crop injury. Research will continue using this new chemical along with combinations of available chemicals.

One weed competition study was conducted. In it both winter annual and annual plants were present in the plots. Yield of durum was reduced 60 per cent where there were 3.6 false chamomile plants per square foot. Winter annual plants reduced yield more seriously than annual plants alone.

### **WEED CONTROL IMPORTANT IN MINIMUM TILLAGE**

Considerable interest has developed in reduced or no-tillage crop production for North Dakota. However, many problems must be solved before extensive adoption of a production practice can take place.

Weed control becomes extremely important in reduced or no-tillage crop production. Herbicides are the major means of weed control and must be effective. Satisfactory herbicides or herbicide combinations must provide broad spectrum weed control, contact action and residual activity to eliminate weeds throughout the cropping sequence.

Research currently in progress is designed to evaluate herbicides for weed control with reduced tillage and to develop weed control systems for reduced tillage under fallow and continuous crop production.

### **CROSSBREEDING BEEF CATTLE**

Beef cattle crossbreeding research at NDSU was initiated in 1969. The project was developed as a total "conception to consumer" approach to evaluate the reproductive and productive traits of crosses between "new" European breeds, a dairy breed and the conventional British breeds. Traits evaluated include fertility, calving ease, mothering ability, rate and efficiency of gain, carcass quality and composition and characteristics of meat that appeal to the consumer.

The initial project involved mating Charolais, Brown Swiss and Hereford sires to purebred Angus females. The female offspring are then backcrossed to the parent breed, with the heifers



**Russell Danielson, animal scientist, with a group of crossbred heifers in the beef cattle crossbreeding program.**

from this cross then bred to a third breed to serve as the terminal cross. All steers and the terminal cross heifers are fed to slaughter and carcass data accumulated.

Calving difficulty resulting from crosses with larger breeds has been a factor in first calf heifers, but problems have been minimal after first calving.

Adjusted weaning weights show an established trend that crossbreds involving the larger breeds have heavier weights. Difficulty in successfully marketing some breed crosses through the conventional market outlets in North Dakota has been noted, as any advantage in weight is usually offset by a lower price per pound due to lack of uniformity in type and color.

Data on carcass traits indicates a trend toward increased carcass cutability in crosses with Brown Swiss or Charolais, but the increased cutability generally results in a decrease in quality grade.

### **FREE STALL MANAGEMENT OF DAIRY CALVES**

A project has been conducted in the NDSU dairy herd to evaluate the effect of free stall management on dairy calves, especially the question of whether calves in free stalls make a satisfactory growth rate.

Results have shown that Holstein and Brown Swiss heifers kept in free stalls from the age of three months to six or seven months made above normal gains and consumed more than the usually recommended feed levels.

Average daily gains for 110 calves over a four-year period was 2.11 pounds. Average feed consumption per calf per day was 8.5 pounds of alfalfa pellets, 4 pounds of a pelleted grain ration

and about 3 pounds of corn silage. Hay was not used because of the problems it would cause in the liquid waste disposal system.

The researchers hope to follow through with an evaluation of the effects of free stall management on performance later in life.

### **PHOSPHORUS LEVELS FOR SWINE**

NDSU animal scientists have been involved in a study evaluating phosphorus levels in swine rations. The project was initiated because the energy shortage resulted in a high cost for phosphorus, and because recent research has indicated that the phosphorus in barley is relatively available to the pig.

One trial compared supplementing phosphorus at .1 per cent of the ration to .2 per cent added phosphorus with a barley ration. Results showed no difference in either rate of gain or feed conversion. When gilts from this trial were saved for breeding, gilts fed the higher level of phosphorus had breeding problems requiring excessive management. At farrowing, many gilts on the high phosphorus level required assistance, refused to accept their pigs and required treatment to induce milk secretion. Litter weaning weights were reduced in the high phosphorus treatment.

In a second experiment involving growing-finishing pigs, supplementing phosphorus at .1 per cent of the ration compared to no supplemental phosphorus produced no difference in average daily gain or feed conversion.

Research results to date suggest that excessive phosphorus in swine rations may be detrimental, especially for replacement gilts, as well as an unnecessary cost.

### **PROGRESSIVE PNEUMONIA IN SHEEP**

Chronic progressive pneumonia, or "lungers disease," is a contagious virus disease of adult sheep. The disease exists in North Dakota flocks, and losses from the disease are apparently increasing.

A study was initiated at NDSU to determine the genetic basis of resistance to progressive pneumonia or existence of resistance to infection along with the epidemiological and preventive aspects of the disease.

Lambs were selected in an attempt to establish flocks of sheep that were free of the virus causing progressive pneumonia. Lambs were selected from flocks in which "lungers disease" was known to exist. The method was to remove

lambs from ewes immediately at birth, with licking by ewes or suckling by lambs not permitted. The lambs were raised on lamb milk replacer and natural grains and roughages in buildings that had been free of sheep for five to six months and thoroughly cleaned, limed and disinfected.

The general health of ewes in experimental flocks has been excellent. There has been no observation of respiratory disease, coughing, crust-ed eyes or nasal exudate in the isolation flock. In contrast, a rather large percentage of ewes in the parental flocks have contracted progressive pneumonia.

The results indicate that it may be possible to establish sheep flocks that are free from virus pneumonia. Further research is needed to determine if there are breed or individual differences in resistance to progressive pneumonia, and methods to control or eliminate the disease in infected flocks need to be established.

### **CEREAL GRAIN QUALITY**

Most of the work in the Department of Cereal Chemistry and Technology is to assist in the development of high quality cereal grains for North Dakota. Both domestic and foreign users of North Dakota barley, hard red spring (HRS) wheat and durum wheat require that these three cereals have high, uniform quality. This past year, the department tested 5,000 durums, 2,500 barleys, 4,800 HRS and 600 winter wheat samples in various test series for a total of 12,900 new potential varieties evaluated for quality.

The staff of the department assists in providing crop quality information to various foreign markets and trade teams. This past year, the staff participated in a North Dakota State Wheat Commission-sponsored Italian trade team seminar. The 20-person Italian group was presented with a significant amount of information on how NDSU's scientists view durum wheat quality. Trade teams from the following areas also were hosted during the year: Belgium / Luxembourg / Netherlands, Switzerland, Japan, West Germany, Central America and Poland.

Annually, the department conducts a wheat quality survey in cooperation with the North Dakota State Wheat Commission and Extension Service. The 1976 crop of hard red spring and durum wheat was better than expected. Over 91 per cent of the HRS wheat should grade U.S. No. 2 Dark Northern Spring or better, while 77 per cent of the durum wheat should grade U.S. No. 3 Hard Amber Durum or better.

The baking characteristics of the HRS were considered to be very good to excellent. The wheat



Dr. Brendan Donnelly, second from right, discusses pasta quality with Italian trade team members.

milled satisfactorily, produced a flour of high extraction with a good color and low ash. The overall quality of the 1976 durum wheat crop was higher than the 1975 or the five-year (1971-1975) crop quality average. The average test weight for this year's crop was 61.4 pounds per bushel, had little damage and low moisture content. The wheat milled out into a high quality semolina, and when processed produced a spaghetti of good color and cooking quality.

Wheat that moves into the market is a comingling of several crop years, each with different quality traits. A wheat cargo sampling project monitors North Dakota's HRS and durum wheat being shipped from Duluth, Minnesota, and destined for European ports. Wheat that is received in Rotterdam also is monitored for quality. Enroute, North Dakota wheat picks up additional dockage and is reduced in protein content. However, the grade and quality of the processed grain shipped from Duluth changes little in transit to Rotterdam. The results show that our foreign buyers are receiving what they are paying for.

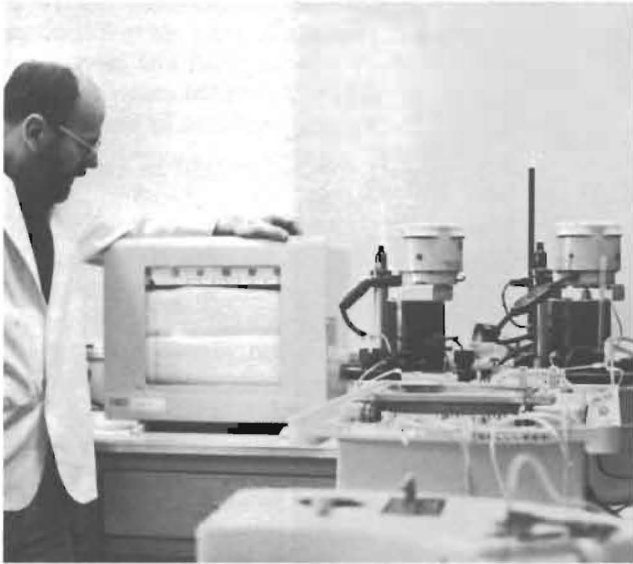
Quality of the 1976 U.S. southwestern grown (Arizona, California and New Mexico) durum wheat was evaluated and the results compared with the average data obtained for the 1975 North Dakota durum wheat crop survey. Quality of the semolina and spaghetti processed from the southwest durum was inferior to that produced in North Dakota. Such deficiencies as relatively low protein levels, low spaghetti color scores and generally

poor cooking quality were the significant features of the products processed from this wheat.

Considerable effort was devoted to the testing of the milling and baking properties of new winter wheats being developed in NDSU's winter wheat breeding program. From this work, the department cooperated in the development of Roughrider, NDSU's first developed winter wheat variety. Also, Cereal Chemistry and Technology cooperated in release of Cando, the first semi-dwarf durum released in North Dakota.

The barley and malt quality testing programs have been critically examined and up-dated. The 1,200 samples analyzed for malt quality represented only 300 to 400 different experimental varieties. The program was streamlined by blending the same variety from the different growth locations and analyzing the blend for malt quality. Statistical analyses showed the blend quality data was equal to the average quality data. This streamlining allows more samples to be analyzed at the same level of equipment usage and staff requirements.

The feasibility of using microwave power during the different stages of malting is being assessed. Supplemental or total use during processing should increase ease of handling and overall quality, based on durum and hard red spring wheat studies conducted the past two years. Total replacement of conventional kilning would result in drying times as short as 2 to 3 hours compared to the present 30 hours. In addition, energy



Laboratory technician Evan Cummings operates the auto-analyzer to determine enzyme activity of malt.

input requirements would be cut dramatically because of the increased efficiency of microwaves.

A number of new test procedures have been developed or are being revised to aid in assessing grain quality. The method for evaluating the cooking properties of durum wheat has been revised. In the study, results showed that protein quality *per se* is not the sole determinant of spaghetti cooking quality, but is primarily a function of protein quality or gluten strength. A new, improved method was developed whereby new wheat cultivars can be screened for the amino acid, lysine. This method will greatly aid in selecting wheats for improved nutritional quality.

An assay for measuring bleaching activity of enzymes in durum wheat was developed. Color measurements of semolina and bleaching activity may prove useful for predicting the amount of color that would be found in pasta made from new cultivars of durum.

An automated fluorescent procedure for measuring malt wort nitrogen is being developed. This will allow the number of samples analyzed per day to be doubled without increasing personnel.

A procedure was developed for isolating and purifying wheat flour pentosans for utilization in baking studies.

A study was completed which established objective methods for bread evaluation including crust color, crumb color, grain and texture.

Development of a physical method for determining barley diastatic power is under way. Preliminary statistical data support the feasibility

of this change in methodology. Such a change would eliminate the need for a purified enzyme and would reduce the cost of the determination considerably.

Baking studies were conducted on pin-milled and air-classified flours to determine if Red River 68, Chris, Era and Pitic 62 could be utilized more efficiently. The flours of the four varieties were classified into high, intermediate and low protein fractions. Bread was made from the high protein fractions while cakes and cookies were made from the lower protein flour. Fractionation did not produce flour that could be utilized better than its current use. The use of flash roasted navy bean flour in baking also is being studied. Preliminary results indicate a considerable difference in response between the untreated and roasted navy bean flour.

Two cooperative studies were conducted with the University of Wisconsin in utilization of protein fractions from oats and the use of brewers spent grains in bread baking. The results appear to be promising in the improvement of the nutritional content of bread.

Carbohydrates are one of the most important ingredients in our food products and contribute greatly to food properties. Studies on pentosans found in pin-milled and air-classified flours have been conducted. Also, the distribution of pentosans in various parts of the wheat kernel has been determined. Although pentosans are a minor con-



Laboratory technician Bruce Johannes prepares micro malts for germination.



stituent in cereal flours, it is believed they play a significant role in bread-making properties.

Starches from various sources are being investigated as to their utilization in food products. The starches from six different legume flours have been characterized. Also, the starches from various tubers, including yam, cassava and arrowroot have been investigated. Use of these starch sources is being studied for producing various specialty breads and developing new food uses.

The use of encapsulation as a technique to reduce cooking losses of vitamins, amino acids and minerals in food products is being investigated. If successful, this technique will improve the nutritional quality of food products to which these ingredients are added.



Dr. Brendan Donnelly operates an experimental spray drier for protein preparation from sunflower seeds.

The presence of phytic acid in food is undesirable from a nutritional standpoint since it chelates minerals and reduces their availability in the diet. The effect of milling and processing durum wheat on the phytic acid content and distribution in the milled products is under study. Variety and location are being used to determine their contribution to phytic acid content and distribution differences.

In the area of Product Development, sunflower meal is currently being used as an animal

feed. The presence of chlorogenic acid has precluded the use of this meal as a source of protein because of the undesirable color chlorogenic acid imparts to the protein isolate. Research is underway in Cereal Chemistry and Technology to devise a process for chlorogenic acid removal from the meal and subsequent use of the meal protein to fortify pasta and bread products.

A new milling procedure was developed to significantly increase the amount of flour that can be extracted from wheat. Baking quality was maintained and some improvement in nutrition was noted while extracting over 80 per cent of the wheat endosperm.

A procedure was developed to extract and purify the proteins of navy and pinto beans for food fortification use. Protein of both legumes was used to fortify the protein of pasta. High protein pasta of improved nutritional quality can be produced (20-23 per cent protein) from beans.

A large research project concerned with the development of a wheat-based food product with improved nutritional value and good consumer acceptance was completed this past year by the Department of Cereal Chemistry and Technology. The project, requiring three years of work, was funded by the National Wheat Institute and the North Dakota State Wheat Commission. Sixteen formulations for high protein (over 20 per cent) pasta were developed. The formulas contained more than 70 per cent durum wheat semolina with various amounts of fat-free soy flour, vital wheat gluten and lactose-free whey protein. One formulation received extensive testing by the Fargo school lunch program and was well received by the students who ate the product. The formula had a protein efficiency ration (PER) of 2.93, compared to 2.50 for casein. Protein contents of the 16 formulations ranged from 20 to 24 per cent.

The same project work developed nine snack food products containing wheat bran, vital wheat gluten, defatted soy flour, corn or durum semolina. Most snack foods are low in protein and nutritional value. In the study, snack food protein was increased more than 260 per cent to about 21 per cent. The PER's were increased from 0.8 to 1.4. By offering new products which can be made from durum wheat, this research should benefit both the farmer and the food processor.

#### WIREWORM CONTROL IN CORN

Several factors prompted the initiation of wireworm control trials in corn. In the late 1960's it became apparent that insecticidal seed treatments used in corn fields where wireworm popula-



Wireworm damage on two check rows with treated corn on either side.

tions were high were not providing adequate control. While such treatments provided some protection to recently planted corn seed, severe injury to the corn in the seedling stage was noted in many fields. This injury occurred because insecticidal seed treatments will not control wireworms attacking the below-ground portion of seedling corn stalks.

Another factor prompting the wireworm investigations was that control of serious wireworm infestations in corn by a preplant broadcast method was expensive. Also, in the early 1970's the Environmental Protection Agency began canceling certain chlorinated hydrocarbons for use in corn for soil insects including wireworms.

A final and important reason to investigate another method of wireworm control was that in 1970 western corn rootworm was discovered to be causing damage for the first time in North Dakota. Thus, it was thought that perhaps planting-time treatments of certain registered and candidate granular organophosphate and carbamate insecticides might provide adequate control of wireworms, as well as corn rootworms, without the need for corn growers to make a separate and costly insecticide application for the one insect or the other.

With these thoughts in mind, wireworm field research was begun in 1970 in southeastern North Dakota near Sheldon. Tests were conducted in subsequent years up to and including 1976. These tests were conducted at field locations near Leonard and McLeod, North Dakota.

The primary method of application involved granular insecticides banded over the row in a 7-inch band. However, in-furrow treatments with insecticides such as Furadan and Counter were also investigated since these insecticides do not pose a hazard insofar as phytotoxicity is concerned. Insecticides tested were evaluated by taking post-treatment stand counts in treatment rows and check rows. In addition, soil samples were taken to record dead or live wireworms.

Insecticides evaluated from 1970 to 1976 included the following: Abbott 47171, Aldrin, Bay SRA 12869, Bay 92114, Baygon, Belt, CGA 12223, Counter, Dotan, Dowco 275, Dyfonate, Furadan, Lorsban, Mocap, Temik and Thimet. As a result of these investigations, entomologists found that Counter, Furadan, Mocap and Thimet provide effective wireworm control. Currently, these insecticides have registration for wireworm control at 1 pound (Furadan at 2-3 pounds) actual per acre banded over the row at planting time. These same insecticides also are registered for control of western corn rootworm at 1 pound actual per acre as a band treatment. Thus the corn grower has the dual advantage of having protection against both wireworms and corn rootworm in a single planting-time treatment.

## TWO SUNFLOWER WEEVILS CAUSE DAMAGE

During the past three years, sunflower research has been directed against two species of weevils, *Cylindrocopturus adspersus* and *Baris strenua*, which have caused economic damage to sunflowers in southeastern North Dakota and western Minnesota. The life history, ecology and control of this weevil complex have been delineated.

Both species are found primarily on sunflowers grown in light sandy soils. Adults of *C. adspersus* are 4 to 5 mm long with dark and white scales that cover the body. *B. strenua* adults are black, and range from 4 to 6 mm long. Both have an elongate snout characteristic of weevils.

Adults emerge during the first week in June to late July. *Baris* adults emerge about two weeks later than *C. adspersus*, and can be found in the field until mid-August. Eggs of both species are laid in the stem tissue of the sunflower plant, and larvae appear during the first week in July. The larval stage causes damage to the sunflower. *C. adspersus* larvae feed upward and downward through the pith. Larvae of *B. strenua* after hatching chew circular tunnels in the cortical cells and endodermis. In addition, *B. strenua* larvae feed on the root system. Simultaneous feeding by larvae

of both species reduces the nutrient uptake and subsequent yield. Heavy infestation by these weevils weakens the stalk, with subsequent lodging prior to harvesting.

Cultural and chemical controls were evaluated against adults and larvae of both weevils. After sunflower harvest, stems were broken by tillage and the overwintering larvae of *C. adspersus* were exposed to harsh climatic conditions. Deep and shallow plowing of the soil reduced the numbers of overwintering larvae of *C. adspersus*. Tillage did not greatly reduce the population level of overwintering larvae of *B. strenua*. This is understandable because this larva forms a protective soil cocoon.

Three insecticides, phosmet, methidathion and endosulfan, were evaluated for control of *C. adspersus*. Control was directed at the reduction of the adult population prior to egg laying. Methidathion (1 L ai/ha) reduced larval infestations by 94.4 per cent, and endosulfan (2 L ai/ha) reduced populations by 77.8 per cent. No significant differences were noted among the insecticides when compared against the check.

This study was conducted by a former graduate student, Pedro Casals-Bustos, as part of his Ph.D. program. Additional studies on the biology and control of these two weevil species will be conducted during the next growing season.

## REAP ENTOMOLOGICAL WORK

At NDSU, the entomological work under the Regional Environmental Assessment Program (REAP) is concentrated in the area south and west of the Missouri river, where land use changes associated with coal and other mineral development, power generation and irrigation are being considered. The principal objective is to obtain base-line data on the organisms present in the area now and to monitor and assess any changes that may occur in association with land use changes. Insects are good indicators of habitats and environmental quality.

Existing records of selected groups of insects deposited in the State Survey and Reference Collection and data available from federal and state insect surveys and Experiment Station projects are being compiled in a format for computer storage and retrieval. This will make the existing data available for ready reference and also pinpoint areas and groups that require more research. Initial work is concentrated on such grasslands insects as grasshoppers and related insects, soil insects and related arthropods, and aquatic insects associated with ponds, lakes, streams and rivers.

Surveys of selected areas in the southwestern part of the state were conducted this past summer. Permanent study sites for intensive sampling of soil arthropods and mosquitoes were set up and monitored and will be continued through next year.

REAP is assembling collections and compiling information on soil invertebrates. Four permanent study sites were selected this year for biweekly sampling from July through the middle of October. Pitfall traps and core samples are located in McKenzie, Slope, Dunn and Hettinger counties.

Two permanent mosquito light trapping stations were set up and monitored from late July through September in Dunn and Stark counties. A total of 20 nightly light trap collections were taken through September 15 for each location. These collections are presently being sorted and identifications being made. Preliminary data indicate that the *Culex tarsalis* mosquito is the predominant species from both areas during this period. Individual one-night collections made with 12-volt portable light traps in Stark, Dunn and Billings counties were taken near suspected mosquito breeding sites. These samples will be sorted and recorded.

General collections of insects were made in the four permanent soil invertebrate study sites on a regular basis. Additional collections were made in conjunction with other sampling programs. These will be the last group to be sorted and identified.

The permanent collecting sites will be sampled on the same schedule starting next spring. Additional collecting will be concentrated on groups and/or locations identified as having minimal data on record.



Removing insects from pit-fall trap as part of the REAP study in southwest North Dakota.



Dr. C. Y. Oseto, Dr. A. W. Anderson and Dr. G. B. Mulkern, entomologists, discuss a variety of insects collected from the REAP study area.

Several areas in Slope and McKenzie counties were extensively surveyed and populations of grasshoppers were assessed.

Most of the material collected in the REAP project is in the process of being sorted and identified or processed for identification. Arrangements have been made for specialists to determine selected taxons.

### EMPHASIS ON DEFENSIVE RESEARCH

The Department of Entomology is currently involved in a number of activities that can best be called "defensive research." This type of activity has as its major focus the preservation of current registrations for insecticides currently recommended and used in North Dakota.

These activities have involved special studies designed and conducted solely to acquire additional data on efficacy, residue degradation and effects on other biological organisms for selected currently registered insecticides. These studies are usually mandated by requests from the Environmental

Protection Agency (EPA) pursuant to their review of existing uses for a particular insecticide.

Departmental personnel have been actively involved in cancellation hearings such as those conducted for aldrin, dieldrin, chlordane and heptachlor. These have involved personal appearances at cancellation hearings, as well as submitting written materials admitted as evidence and presumably used by the hearing judge in assessing the benefits and risks of continued use of an insecticide under review.

Possibly the most visible efforts in the Department's defensive research activities are those which culminate in any emergency use clearance or issuance of a state permit for a given chemical in response to an emergency situation. An example of this effort was the emergency clearance for use of toxaphene on sunflowers to control the painted lady and sunflower beetle in 1973 and 1974.

At this juncture, the EPA's Rebuttable Presumption Against Registration (RPAR) listing contains nine insecticides widely used for insect control in North Dakota. The loss of any of these chemicals will have major impact on North Dakota agriculture. Departmental staff are actively engaged in activities that hopefully will assist in permitting continued use of certain of these insecticides. However, in light of rationale and criteria employed in the review process pursuant to re-registration, it is unlikely that some of these insecticides will continue to be available.

At this time and despite our major efforts to retain use of toxaphene, the future of this insecticide is in serious doubt. What will transpire with the other eight insecticides on the RPAR listing is not known.

### EFFECT OF VARIOUS ROOTSTOCKS ON THE HARALSON APPLE

Rootstocks for apples have long been used for such major factors as hardiness and dwarfing. Other rootstock effects on apple trees have been compatibility, yield, maturity, tree size and shape, growth and structure of the tree.

Five seedling rootstock types were evaluated at the Carrington Irrigation Station for several of the above characteristics. The Haralson apple was used as the scion cultivar. The rootstocks used were seedlings of Dolgo, Columbia, Hopa, Red Manchu and Siberian crabapples.

Compatibility was evaluated by determining the difference between the rootstock and scion circumference above and below the graft and union. Grafts of Haralson on Red Manchu and

Siberian formed the smoothest unions, although all rootstocks were acceptable for use with Haralson.

Maximum growth before fruiting and minimum growth after the onset of fruiting were standards used for selecting the rootstock which produced the optimum-sized Haralson tree. The most desirable size trees were produced on Siberian rootstocks. Rootstocks of Dolgo, Red Manchu and Siberian produced the best tree shape evaluated on the basis of width-to-height ratio. The best tree structure based on the wideness of the angle of attachment of the scaffold branches onto the main trunk was developed by trees grown on Columbia rootstocks. The best annual growth rate was produced on trees grown on Dolgo, Columbia and Siberian rootstocks.

The best fruit yield evaluated on the basis of total yield, yield for each square centimeter of trunk cross sectional area and yield for each cubic meter of canopy volume was produced by trees grown on Dolgo rootstocks. Trees grown on Dolgo rootstocks also produced the largest-sized fruits.

Earlier maturity of fruits, determined by measuring the firmness of fruit and the per cent soluble solids in the fruit juice, was found to be produced on trees grown on Hopa rootstocks. Best fruit color, evaluated on the basis of per cent red color, was observed on fruits from trees grown on Hopa rootstocks.

An overall evaluation of the effects of rootstocks on the performance of Haralson apple trees and fruits suggests that the best seedling rootstocks to date are seedlings of Dolgo.

#### POTATO BREEDING AND DISEASE TESTING

This past year, the Red River Valley Potato Growers Association has presented grant funds to the Departments of Horticulture and Plant Pathology for additional potato research. The purpose is to increase the potato breeding and disease testing program to develop new and more desirable potato cultivars for processing and commercial use. The funds will allow for a 50 per cent increase in the breeding and disease testing program. This will increase the program from growing 40,000 to 65,000 seedlings each year. This increase will allow for increased selection of desirable processing types and for further development of parental materials.

Increased use of potatoes for processing and the need for more desirable types with greater processing qualities was instrumental in instigating this grant. Concurrently with the breeding and

disease testing will be a cultural program that will investigate the growth and reaction of the new stocks to the North Dakota environment.

The program since 1956 has developed eight new cultivars. Among those developed, which now comprise more than half of the potatoes grown in North Dakota, are Norgold Russet, Norland and Norchip. The latter is nationally known for its ideal processing qualities, especially for chips. Bison, a new red-skinned cultivar, was released two years ago and is gaining in popularity as bright red-skinned, smooth cultivar adapted for fresh use and chipping.

#### RESEARCH IN POTATO PRODUCTION

In a crop such as potatoes, many questions arise as to the best ways to produce large yields of high quality potatoes at the lowest possible cost. Some of those questions require extensive research to answer. At the present time effort is being focused particularly on fertility and weed control problems and on causes of hollow heart in potatoes.

One of the most challenging problems in potato production has been the control of hollow heart. Interest in this problem was increased after the introduction of Norgold Russet, which coincid-



Technician Myron Thoreson and Dr. Donald Nelson, horticulturist, determine the incidence of hollow heart in potato tubers.

ed with a two-year period when hollow heart was particularly serious. Many fields were total losses because of the high incidence of hollow heart in tubers. Some others, though harvestable, were much lower in quality.

Causes of hollow heart have not been clearly enough understood to effectively devise control measures. Hollow heart is known to vary with cultivar, cultural practices and weather conditions. Work currently is underway to establish how various cultural practices and weather conditions interact to cause hollow heart in susceptible varieties. Such cultural practices as spacing, planting time and kind of fertilizer applied are known to affect hollow heart, as well as soil moisture level and air temperature. However, it is certain combinations of conditions that favor rapid tuber enlargement and hollow heart rather than any single factor.

### NEW VEGETABLE GROWERS ASSOCIATION

With the assistance of the staff of NDSU's Department of Horticulture, area fruit and vegetable growers banded together to promote the fine produce of the Dakotas and western Minnesota. Their organization is called the Great Plains Produce Association. Originally, it acted to disseminate growing and marketing expertise, and this year added a successful buyers' cooperative program. In this program, members pool their purchase orders for seeds and supplies with a resulting saving in cost and freight, as well as assuring delivery of scarce items.

Plans for 1977 are to initiate a weekly market price letter and to publish "how to grow and market" reports on northern tomatoes and strawberries. A revision of the muskmelon report is in print and available to members.

### BACTERIAL DISEASES OF BEANS

Bacterial diseases are among the most devastating diseases of dry edible beans. In 1976, bacterial blights caused severe losses to commercial and certified bean seed production in North Dakota.

These diseases originate from infected seed and spread rapidly by rainsplash. Chemical sprays are ineffective in North Dakota in limiting spread of the pathogens, and resistant varieties are not available. Crop rotation and blight-free seed (grown in arid western states under row irrigation and tested for blight bacteria) are recommended for control.

Even when western-grown seed has been used, sporadic outbreaks of blight have occurred. The

source of bacteria causing the outbreaks has not been established, but one possibility is that infections came from infected seed. Current tests are not sensitive enough to detect a few infected seeds in a large sample or a few bacteria in lightly infected seeds. Modifications of these tests to increase accuracy and timeliness of results are being evaluated.

Another source of blight bacteria is vegetation which may serve as an alternate host. Native



Plant Pathologist Dr. Jim Vennette studies the survival of air-borne phytopathogens.

vegetation, weeds, and other plants are being collected and assayed for bacteria pathogenic to beans.

Bacterial epidemics may arise from airborne bacterial cells blown to an area from distant infected fields. Rainsplash can cause blight bacteria to become airborne, but infectivity of the airborne cells has not been studied. Experiments are now being made to establish survival of airborne bacteria under various atmospheric conditions. The deposition of bacteria onto bean plants is being studied in wind tunnel experiments.

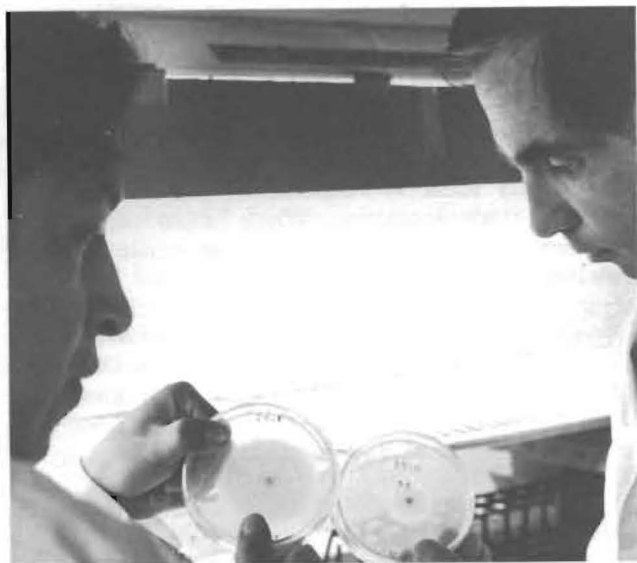
Results of these studies should provide understanding of the epidemiology of the pathogens and thus direct efforts in controlling the diseases through blight-free seed programs.

### BLACK DOT — A "NEW" POTATO DISEASE

In addition to the field research on potato blackleg, seed decay and black scurf, the Department of Plant Pathology has turned its attention

to a "new" disease, black dot. Black dot, caused by the fungus *Colletotrichum atramentarium*, was first observed in one field in the Red River Valley in 1969 and again in a single field in 1972. The disease was not considered to be of particular significance because it was generally thought to be a weak parasite. In the spring of 1976, however, the disease was found on plant residue in many fields from which a potato crop had been harvested in 1975.

A survey was made of the Grand Forks, Thompson, Voss, Grafton and Hoople areas. Disease symptoms were noted and samples were taken to Fargo for isolation. Some 138 diseased plant samples and 29 healthy plant samples were examined. Samples were also obtained from the Stevens Point area of Wisconsin. The varieties Norgold, Kennebec, Red Pontiac and Norchip were included in the survey, and all were observed to be susceptible.



Plant pathology graduate student Victor Otazu, left, and Dr. J. E. Huguélet observe differential growth rates to identify disease species such as black dot and dry rot.

Symptoms of the disease are poor vigor, foliar chlorosis, wilt, early maturity, vascular discoloration and cortical rot. In addition, the literature indicates stolon and tuber infections, but these have not been readily identified here in the Red River Valley. On the stolon, poor growth followed by necrosis occurs, resulting in poor tuber set and/or tuber growth. On the tuber, stem end rot occurs and often a portion of the stolon remains attached to the tuber following harvest. Fungal structures, known as sclerotia, may be found on the stem extending from the seed-piece to above the soil line. Sclerotia may also be seen beneath the cortical region which sloughs off readily on infected stems.

Because the symptoms are similar to those occurring in plants infected with *Fusarium* or *Verticillium* wilt, blackleg or rhizoctonia disease, attempts were made to determine the identity of organisms present in association with the black dot disease.

Percentages of organisms isolated from 138 diseased potato plants and 29 healthy plants was as follows:

Organism Isolated	Plants with symptoms	Healthy appearing plants
<i>Colletotrichum</i>	15.4	20.7
<i>Fusarium</i>	12.8	24.1
<i>Verticillium</i>	0.9	0.0
<i>Colletotrichum</i> plus <i>Fusarium</i>	29.9	3.4
<i>Colletotrichum</i> plus <i>Verticillium</i>	13.7	0.0
<i>Colletotrichum</i> plus <i>Fusarium</i> plus <i>Verticillium</i>	9.4	0.0
<i>Colletotrichum</i> plus <i>Rhizoctonia</i> plus <i>Fusarium</i>	10.3	0.0
Other	6.8	13.8

The one fungus which seemed to be associated with *Colletotrichum* more than any other was *Fusarium* sp. Therefore, both identification procedures for *Fusarium* species and pathogenicity tests were initiated. Several species have been identified, and their ability to infect potato has been found to vary with species and isolates. The same *Fusarium* that we have found associated with dry rot and blackleg was implicated in these tests, and it definitely causes an increase in disease severity when associated with the black dot organism.

Because *Fusarium* causes several potato problems and because it has been found so often, continued research is planned to clarify its position relative to other pathogens such as the blackleg and black dot organisms. At the same time, black dot has been of minor importance, but its alarming increase this year, especially in association with the common diseases caused by *Fusarium*, warrants its continued appraisal and research endeavor.

#### TAKE-ALL, A POTENTIAL THREAT TO IRRIGATED WHEAT IN NORTH DAKOTA

Acreage of irrigated wheat has been increasing in North Dakota. One problem with irrigated wheat is "Take-All," a wheat disease new to North Dakota.

Symptoms of take-all, so called because of its serious effect, are similar to those of common root rot: whiteheads, poor grain filling, shriveled kernels and lodging. Frequently, the plants are stunted with few tillers and can be easily pulled up. Symptoms tend to occur in patches in the field, although in severe cases the patches may spread together to include large irregularly shaped areas.

Although naturally present in prairie soils, take-all is generally not a problem in dryland spring wheat because the soil environment is unfavorable to the causal fungus. When irrigation changes this soil micro-climate, the fungus grows readily, infects wheat roots and causes severe damage.

Following the first appearance of take-all in a field, the disease continues to increase for several seasons, after which time it may decline somewhat. At its worst, take-all may reduce wheat yields by 50 per cent or more. The take-all fungus survives in the soil from year to year mostly in debris, such as old crowns and roots, whether these are buried or not.

Take-all has been a particularly serious problem in irrigated wheat in the Pacific Northwest. Studies there showed that take-all is more likely to develop on irrigated lands formerly in range or dry pasture than on lands in dryland wheat—fallow prior to irrigation. Research will be designed to find out if this is going to be the case in North Dakota as well.

In new irrigation, or on presently irrigated land where take-all is not yet a problem, chances of the disease developing can be minimized by using a crop rotation which includes wheat only once in three or four years. While such a rotation would eventually reduce take-all in fields where it already occurs, a better measure would be to grow several years of irrigated alfalfa before starting the rotation.

Plantings of wheat in take-all infested fields may be partly protected from the worst effects of the disease by using only ammonium sources of nitrogen fertilizer and applying it in the spring, according to research done at Washington State University and the University of Idaho.

North Dakota farmers who have grown irrigated wheat on the same fields for several seasons and who suspect a root-rot problem in such fields may be seeing take-all. To find out, send samples of stubble (including crowns, roots and stem bases) to the Department of Plant Pathology for examination. Take-all is **not** a problem in dryland wheat production in North Dakota, and there is no cause for concern that it may become one.

The department plans to include research on control of take-all in irrigated wheat in its program of root-rot research.

## **SOIL TEST CALIBRATION AND SOIL TESTING**

A soil nutrient test can be defined as a procedure which measures some fraction of the total supply of a nutrient in the soil. To be useful, these tests must be calibrated with the response of crops to the application of fertilizers under field conditions. The fertilizer recommendation that a farmer receives is based on the relationship between the soil test and results of closely controlled fertility experiments.

During the past crop year, small grain fertility trials were conducted by Dr. William Dahnke and Larry Swenson at 18 locations throughout North Dakota. Where possible, the sites of other soils researchers are also used for soil test calibration purposes. The main nutrients worked on were nitrogen, phosphorus, potassium and sulfur. In general, nitrogen is the nutrient most commonly lacking in North Dakota soils and phosphorus is second. Potassium is seldom deficient except on very sandy soils. A response to sulfur has been noted at two locations. When more calibration data on sulfur are obtained, a soil test for this nutrient will be provided.

Each year, use of the Soil Testing Laboratory by farmers has been increasing. For the 1976 crop year, about 53,000 soil samples were analyzed. During the fall of 1976, more than 63,000 soil samples were analyzed for the 1977 crop year.

Amount of nitrate-nitrogen found in cropped fields was much higher this fall than it has been in previous years. This was true especially in the eastern half of North Dakota. The nitrate-nitrogen levels found in some western counties, such as Williams, were similar to those in previous years. For the state as a whole, 21 per cent of the fields tested by farmers had over 100 pounds per acre of nitrate-nitrogen compared to only 11 per cent in this category in 1974.

## **FERTILIZER INVESTIGATIONS ON SMALL GRAIN AND WATER USE EFFICIENCY**

The growth and development of saline seeps in western North Dakota has increased the interest in soil management to increase crop use of soil water. In 1976, fertilizer trials were established in several counties in western North Dakota on fields which had been cropped at least three successive years. This work of Dr. R. P. Schneider





Yield of winter wheat was increased from the zero N fertilizer rate of 15.6 bu/A. on the left to a yield of 39.9 bu/A. from 75 lb N/A. as nitrate to 2 feet deep (77 lb N/A. to 4 ft. deep). This field of winter wheat on the J. Moser farm near Fortuna, ND, was preceded by four consecutive years of recropping to either spring or winter grain. Research was by Dr. R. P. Schneider, Department of Soils.

of the Department of Soils was in cooperation with farmers, county agents, and personnel of the Williston Experiment Station.

Winter wheat, spring wheat or durum were planted in order to determine soil water use, water use efficiency and yields of small grains with appropriate nitrogen (N) applications. If the water, or part of it which would normally move through the soil profile, were used for small grain production, growth of saline seeps could be diminished. This could be accomplished in part by eliminating summer fallow if soil water is adequate to recrop, or increase water use of a crop by fertilizing and increasing yield when nutrient deficiencies limit yield.

Nitrogen applications from two sources, ammonium nitrate (34-0-0) and urea (46-0-0), were broadcast in the spring at several rates of N on winter wheat and broadcast-incorporated on the spring grains. Positive yield responses were obtained at all locations, with maximum yields occurring when 75 pounds of nitrogen per acre were applied, regardless of source. Per cent protein and test weight were N rate-related. Water use efficiency increased dramatically with increased N rates. In the areas where rainfall was very limited, N applications increased the water use efficiency beyond expectations. This work also indicated that under severely dry conditions the capability of small grains to use water was increased by N fertilization.

Additional work was initiated in the fall of 1976 by Schneider, T. H. Krueger, Neil Riveland (Williston Station) and others in relation to stubble management and water use. Nitrogen sources at several rates have been applied directly to standing stubble. Additional spring 1977 applications are planned with emphasis placed on over-winter water storage, water use, N availability and wheat yield.

## PLANT ANALYSIS FOR APPRAISING NUTRIENT STATUS

Plant analysis is a procedure by which the nutritional status of plants is determined by chemically analyzing the whole plant or a plant part for the concentration of one or more nutrient elements.

It is based on the concept that the concentration of a nutrient element in a plant or particular plant part at a specified stage of growth is an integrated expression of all the factors (including soil fertility) that have influenced the nutrient status up to the time the plant sample is taken. The amount of an element in the soil that is available for uptake and support of plant growth and the balance of all available nutrient elements have a direct influence on observed plant composition.

A correct evaluation of soil fertility and nutrient status of crops may require a combination of plant and soil analyses. These analyses are considered complementary because plant analysis gives a picture of nutrient availability up to the time of sampling, while soil analysis gives an indication of the reserves of available plant nutrients in soil.

Before plant analyses will serve the interests of farmers, reliable reference standards must be established. At present, not enough plant analysis data are available to establish reliable nutrient element standards for crops grown in North Dakota. However, research is underway in the Department of Soils by Rick Engel, a graduate student under direction of Dr. Joe C. Zubriski.

A research project on plant analysis was initiated in 1975 with the following objectives: (1) to determine the concentration of selected nutrient elements at several stages of growth in crops produced in North Dakota, (2) to determine interrelationships among plant-nutrient concentration, soil test data, fertilizer treatments, moisture supply, and yield and quality of selected crops in North Dakota, and (3) to appraise plant analysis as a means of diagnosing plant nutrient status. This project is supported by main station funds and grant funds from CENEX. Project leader is Dr. J. C. Zubriski. Drs. J. T. Moraghan, W. C. Dahnke and R. P. Schneider are cooperating on this project. A graduate student, Richard Engel, was assigned to this research project in 1976. He is investigating the effects of fertilizers on nutrient concentration in wheat plants sampled at several stages of growth.

Plant samples will be obtained from fertilizer experimental plots conducted by several staff members of the Department of Soils and by researchers on the Branch Agricultural Experiment

Stations. Hopefully, these experiments will be conducted on most major soil associations of the state.

The data collected so far do not provide sufficient information to establish reliable standards for evaluating sufficiency or deficiency levels of an element. It will take a number of experiments over several years to establish reliable standards for each crop at several stages of growth.

This research should provide information that will be a valuable adjunct to soil tests and field experiments for appraising the nutritional status of crops, for determining the capacity of various soils to provide the nutrient needs of crops, and for improving fertilizer recommendations to soils for common crops of North Dakota.

### ZINC DEFICIENCY IN FLAX RELATED TO "CHLOROTIC DIEBACK"

Crops can differ greatly in their requirements for essential elements, particularly for micronutrients. Flax is a crop which under field conditions sometimes shows severe growth abnormalities.

Dr. J. T. Moraghan had studied under greenhouse conditions one such disease which has been



Influence of zinc fertilizer on the growth of Culbert flax in a zinc-deficient, high phosphorus Red River Valley soil maintained at a temperature of 60° F. The soil in the pot at left received iron but no zinc, while that on the right received iron plus the equivalent of about 8 pounds of zinc sulfate-zinc per acre. Dr. John Moraghan is conducting the research.

referred to as "chlorotic dieback." The disease, which normally occurs in localized parts of fields and is most severe early in the growing season, is

characterized by death or severely retarded meristematic growth of the main stem and premature development of lateral branches from the cotyledonary node. The abnormality was found to be due to zinc deficiency and was very severe at a soil temperature of 45°F, severe at a soil temperature of 60°F, and was not present at a soil temperature of 75°F.

Zinc deficiency is favored by high levels of available soil phosphorus. In the Red River Valley during the past several decades, available phosphorus levels have increased in many soils because of fertilization. Consequently, the likelihood of zinc deficiency occurring in flax and in other crops susceptible to zinc deficiency, such as corn and certain cultivars of edible beans, has also increased.

Work is currently in progress investigating the occurrence of zinc deficiency in flax growing on soils with different extractable phosphorus and zinc levels. Another abnormality in the growth of flax which occurs in the region and which is characterized by a lower leaf scorch syndrome is under investigation. This problem also appears to be nutritional in origin.

### FIELD EVALUATION OF NITROGEN EFFICIENCY UNDER IRRIGATION

With the recent installation of a new mass spectrometer by the Department of Soils in cooperation with Chemistry, Drs. J. T. Moraghan and J. W. Bauder have initiated work at Oakes to take full advantage of the capabilities of the new equipment.

In 1976, a study was undertaken to evaluate the efficacy of nitrogen fertilizer use by irrigated wheat. During first-year studies, isotope-labelled potassium nitrate and ammonium sulfate were applied at varying nitrogen (N) rates to wheat grown *in situ* in undisturbed soil monoliths. Wheat was selected as the study crop due to ease of management. Treatments were established with the intent of (1) determining the contribution of fertilizer N to ground water contamination as affected by fertilizer management, and (2) determining a complete N-balance sheet for wheat under the given study conditions.

The mass spectrometer provides capability to detect isotope concentrations, and hence, when properly used, the difference between naturally-occurring nitrogen and fertilizer-applied nitrogen. This study and others of a similar nature will provide information to promote more efficient fertilizer use in terms of source, rate and time of application of N fertilizer.



Dr. John Moraghan measures isotope concentrations in nitrogen fertilizers with the mass spectrometer.

## ENVIRONMENTAL ACCUMULATION OF PLANT NUTRIENTS

Ongoing and past research under irrigation and dryland management has shown that agriculture in North Dakota contributes to the environmental accumulation of plant nutrients. Both crop and soil management are involved.

However, some recent research within the Department of Soils has been concerned with improving efficiency of resource use and reducing such accumulations. Of particular concern has been the primary plant nutrients nitrogen (N) and phosphorus (P). Research at Oakes has been expanding each year to accommodate increased demands for this type of information.

Unique facilities and instrumentation were fabricated and installed this year by Dr. J. W. Bauder six feet below Dr. J. C. Zubriski's dryland and irrigated corn to continuously collect samples of soil water percolating beyond the effective root zone. Water moving through the soil profile presumably leaching spring-applied N fertilizer was continuously collected before reaching the water table. Periodically, samples are being analyzed to help determine the efficiency of our fertilizer management programs.

The facility, known as "Dr. Bauder's Laboratory," will be in full operation this spring, monitoring four combinations of water-fertilizer management, including dryland. Similar studies are also underway in the greenhouse this winter, using undisturbed soil monoliths. The crop being studied is wheat.

## WATER ANALYSIS AND IRRIGATION FEASIBILITY

An assessment of the suitability of water and soils for irrigation is a function performed in the Department of Soils. Under the direction of Fred Schroer, water samples from test wells are analyzed for concentrations of calcium, magnesium and sodium. Also determined are pH and electrical conductivity (EC), for estimate of total dissolved solids. A calculation is made of SAR (sodium adsorption ratio). Then water and soils data, usually provided by SCS, are combined into recommendations as to the feasibility of irrigation.

Numbers of water samples have increased markedly in the past few years. In the three years 1970, '71 and '72, samples analyzed were five, six, and three, respectively. Since then there has been a striking change. In 1973, there were 42 samples, 1974-94, 1975-107, and in 1976 there were 320 samples.

Not every sample represents a different proposed irrigation system, because sometimes more than one test well will be sampled. However, most samples are for irrigation purposes, and without a doubt, interest and action in developing irrigation systems is moving fast.

The increase in irrigation systems operating on many different soils, and sometimes with marginal quality of water, emphasizes the need for close attention to potential problems developing within the soils. Researchers, farmers, Extension and SCS personnel should be alert for problems needing in-depth research. Schroer has sampled several soils where irrigation installations have been made. Water and soil changes are being monitored over a period of years to detect changes.

## SOIL SURVEYS OF POTENTIALLY IRRIGABLE LANDS

Field survey operations in the Department of Soils on potentially irrigable soils are under the supervision of associate professor Mike Sweeney. The field party tripled its size this year with the addition of Dale Shay as an assistant in soils and Randy Hemb as a research assistant. Hemb is being funded by the State Soil Conservation Com-

mittee as part of their program to support the increase of soil mapping in the state.

With training of new personnel and special sampling for correlation purposes, approximately 25,000 acres were mapped in the Middle Souris and Mouse river irrigation districts in McHenry county. Soil surveying these soils is laborious because of the stratification of sediments in the various landforms that occur in the districts. Identification and location of barriers that restrict the downward movement of water is important in irrigation development in their effect on water tables and drainage.

### **AGRICULTURAL METEOROLOGY AND APPLIED CLIMATOLOGY**

A comprehensive review of research in these areas was presented in the North Dakota Farm Research, September-October, 1976, issue. Dr. J. M. Ramirez and Research Assistants D. D. Nantt and T. J. Method have conducted several field and computer modeling experiments to characterize the air pollution climatology of western North Dakota in view of potential coal development in the area.

Complete records from the many weather stations across the state are kept continually updated and can be made available from the Climatic Data Laboratory, Department of Soils.

Weather and climate information are utilized by many other researchers in interpretations of their crop yield data. Long-term climatic data are also used in formulating interpretations of past changes and expected future trends as related to agricultural production.

### **IDENTIFICATION OF SALINE SEEPS AND MECHANISMS OF THEIR DEVELOPMENT**

Remote sensing imagery of soils affected by saline seeps, such as color infrared photographs and soil thermographs, has been processed and stored on computer tapes by researchers in the Department of Soils.

For "ground truth" calibration of this imagery, 392 observations have been made at regular intervals on a 140-acre field near Dickinson. These include land use, soil moisture, salinity, texture and topography. Statistical comparisons are being made of the remote sensing imagery and corresponding ground observations. Project leader is Dr. L. J. Brun with cooperators Dr. B. K. Worcester and Graduate Research Assistant K. Dalsted.

Color infrared photography and soil thermographs also have been used to visually locate saline seeps in selected areas of 28 square miles in Stark and Hettinger counties. About 85 to 90 per cent of the saline seeps were identified using this method, as compared with ground observations.

Field and laboratory measurements have been made to characterize saline seeps. Types of salts and their distribution have been determined in seep areas. In addition, geophysical techniques of seismology and earth resistivity are being evaluated for their potential as field diagnostic methods. Thin lignite layers are common water conductors to the seep, although textural differences also can form conducting layers.

The mechanisms of saline seep formation are being studied by graduate student Bruce Seelig under the supervision of project leader Dr. B. K. Worcester, Department of Soils. Several geologic conditions have been characterized generally as leading to the growth and development of seeps. Essential conditions are a source of water, either a recharge land area or an upland slough, and stratification of subsurface materials leading to horizontal flow of water and dissolved salt to a point where it is intercepted by the surface. Characteristic vegetation species including kochia, wild barley and others, have been identified and related to degree of salinity and seep development. This has been found to be useful in recognition of seeps, allowing management practices to be applied to restrict or eliminate the seep.



Soil crusting may result from a number of factors, as displayed by Soils Researcher, Dr. Robert Sojka. This soil has been beat into a solid dense crust by the impact of hailstones on the Sinner Bros. farm, Casselton. Such crusting occurring before germination or during early seedling development may severely inhibit stand establishment and crop growth.

## SOIL CRUSTING AND COMPACTION

This past year has seen the initiation of studies intended to investigate the physical aspects of the soil solid phase and soil-atmosphere. Among the problems under investigation by Dr. Robert Sojka and Research Assistant Franklin Arnold, Department of Soils, are soil structural stability, soil crusting, soil compaction and soil strength in relationship to crop performance.

Since soil particle geometry also affects gas exchange, part of our attention is also being directed toward study of the soil atmosphere. Field work is being complemented by related greenhouse studies.

## DEVELOPMENT OF SOILS

Research is being conducted to determine the reason for the existence of forested areas in Benson county in close association with prairie vegetation. Cornie Heidt, graduate student and SCS soil scientist, is working under the direction of Dr. Bruce Worcester, assistant professor of soils.

It appears that the parent material under the forest has a much higher shale content than surrounding prairie areas. This material is more acid and finer textured, producing an environment more suited to trees. Great differences between the soils have resulted as well as differences between the micro-climates associated with the different vegetation. In the forested areas, the temperature is lower and the relative humidity higher. The soil is moister, freezes later and to a shallower depth and thaws earlier.

Soils graduate student and SCS soil scientist, Nord Lunde, working with Dr. Worcester is researching a problem in Emmons county concerned with identifying properties and the source of loess (wind blown silts) as a soil parent material.

Two areas of loess have been mapped in the county. The one in the northern portion apparently received its silts from the Missouri river flood plain. The southern deposit received its loess from sediments of the Missouri river flood plain plus local streams. The properties of these deposits are different, as are the soils developed from them. The deposits become thinner progressing eastward from the river and they also progressively become finer textured. This has significance with respect to land use such as potential irrigation of thicker deposits but not the thinner, finer-textured areas.

## STATEWIDE GENERAL SOIL MAP AND BULLETIN

The General Soil Map of North Dakota published in 1961 is being revised to reflect current knowledge of the soils and changes in terminology.

H. W. Omodt and D. D. Patterson are directing the map work in cooperation with other Department of Soils staff and with a major input by Soil Conservation Service soil scientists.

An updated map will be useful to individuals and groups with interests varying from natural resource planning to classroom teaching, to personal information about the general distribution and extent of North Dakota soils.

Bulletin No. 472, The Major Soils of North Dakota, also is being revised by Patterson and Omodt with input from other Department of Soils personnel. This bulletin will contain soil association descriptions and some general interpretive information to help readers more fully understand the similarities and differences of North Dakota soils.

In addition, plans are underway to update the county general soil maps to conform with terminology used on the state map. County maps provide more detail than the state map and meet the requirements of many users of soils information.

## SOIL AND OVERBURDEN CHARACTERIZATION

Laboratory characterization of the physical and chemical properties of North Dakota soils has been an ongoing effort of the Department of Soils since the early 1950's.

Interpretation of the results of this work has enabled soil scientists to better understand North Dakota soils and to make more reliable predictions of soil behavior in agricultural and other uses. Soil characterization research contributes greatly to the North Dakota soil survey program conducted jointly by the Soil Conservation Service, USDA, and the North Dakota Agricultural Experiment Station.

In recent years, the soils and overburden in areas of known lignite reserves have been given greatest emphasis. Analytical data are essential to develop standards for reclaiming surface-mined lands and to predicting changes in soil productivity and land use after mining.

NDSU soil scientists involved in this work are F. W. Schroer, H. W. Omodt, D. D. Patterson and M. D. Sweeney. Other mined land reclamation work of the Department of Soils is referred to in additional reports.

## MINELAND RECLAMATION

Work was completed this past summer on certain projects of mine spoil reclamation funded primarily by a two-year research grant from the  
tion of excess soluble salts, high sodium or



Water movement study site near Underwood, ND, with insulated tensiometer stack in the foreground with a covered 10x10-foot box for holding water. Terry Brown, Department of Soils, located at Mandan, and W. Freymiller, SCS Soil Scientist, Bismarck, are using an SCS Geedings probe soil sampling unit, with the new UPA-CPA power plant under construction in the far background.

Old West Regional Commission. A brief description of this grant and its objectives was presented in the Sept.-Oct. issue of this bulletin by Dr. Armand Bauer, who served as project coordinator while in the Department of Soils, NDSU.

A final report entitled "Physical, Chemical and Biological Aspects of Mineland Reclamation in Western North Dakota" has been prepared. A few of the important aspects of this report were published in the Nov.-Dec. issue of this bulletin. Additional aspects of this work will be included in future issues of this magazine and in technical journals.

Researchers other than Bauer included Dr. G. W. Gee, presently Department of Soils leader of reclamation research, J. E. Gilley (Agricultural Engineering) and P. E. Nyren (Botany). Some of the recommendations for mineland reclamation that have stemmed from this work are as follows:

1. Reshaped mine spoils should be levelled so as not to exceed 5 per cent slope except where erosion control structures have been provided to limit sediment yields or erosion losses to two tons/acre/year or less.
2. Topsoiling is recommended on all reshaped spoil as specified in the current law. Careful control during segregation of topdressing material is required so that surface materials are not degraded by incorporation of
3. fine textured materials which limit water availability to plants or excessively restrict water movement through these materials. The surface materials should have a hydraulic conductivity of not less than 12 cm/day (4.7 inches/day) to allow for adequate water infiltration rates. Two feet of topdressing material would be most desirable but may not be available. A total of 2.5 feet of topdressing and suitable plant growth medium (as defined in the present state law) appears to be the minimum soil volume necessary for adequate water storage.
3. Where a total of only 2.5 feet of topdressing and suitable plant growth material is applied, the sodium adsorption ratio (SAR) of the underlying spoil material should be less than 20 and the clay content less than 35 per cent by weight in order to provide a suitable subsoil.
4. Topsoiled areas that are not revegetated by fall should be mulched with at least two tons per acre of suitable mulch to minimize erosion losses.
5. Water quality of minesite impoundments should be checked before use for irrigation or as stockwatering ponds to see that the water quality meets recommended standards.

Ongoing reclamation research by the Department of Soils is being conducted in the following areas by Dr. Gee and Terry Brown, research assistant.

1. Runoff from spoils and topsoiled areas at surface mined sites in North Dakota.
2. Water storage at mine sites.
3. Water flow characteristics of disturbed and nondisturbed mine sites.
4. Continuing characterization of overburden properties.

The Department of Soils has been working jointly with the Department of Chemistry on EPA Grant No. R-803727-01-1, "A Cooperative Program to Evaluate Surface and Ground Water Problems Associated with Potential Strip Mine Sites." A cooperative program has been initiated by several colleges and universities in Montana, North Dakota and Wyoming. The purpose of the research is to characterize overburden and water properties at various sites prior to mining. This information will be coupled with post-mining research data from the same sites, and will be incorporated into predictive models.

The soils group at NDSU is concerned with characterization of the overburden materials at a site scheduled for mining near Underwood.

Physical characteristics such as infiltration and water flow at disturbed and undisturbed sites are being evaluated. Also, *in situ* water movement studies have been conducted on five of the major soil types in the area (Fig. 1). Water retention curves are also being developed for disturbed and undisturbed samples using pressure plates extraction techniques.

A plant-water relationships study will be initiated in the spring of 1977 to determine actual evapotranspiration values for a planted crop, characteristic of premined and postmined conditions, and to evaluate the effect of soil structure disturbance on plant-water relationships. A weighing lysimeter which will hold an undisturbed soil monolith will be installed at the site. Also, on-site climatic data are being accumulated.

Overburden materials are being analyzed chemically for pH (below 7 acid, above 7 alkaline), EC (electrical conductivity), SAR (sodium adsorption ratio), CEC (cation exchange capacity),  $\text{HCO}_3$  (di-carbonate) and  $\text{CaCO}_3$  (lime) equivalent. Clay mineralogy is also being studied in cooperation with Dr. M. Klages at Montana State University. NDSU will conduct experiments and tests to determine the extent of  $\text{NH}_4$  fixation by clay minerals.

## IRRIGATION RETURN FLOW AND THE GARRISON DIVERSION UNIT PROJECT

The 1976 research year has seen a considerable amount of attention directed toward irrigation return flow studies by researchers of the Agricultural Experiment Station in connection with the U.S. Bureau of Reclamation (USBR) in North Dakota.

Of major significance has been the Garrison Diversion Unit (GDU) Project, involving approximately 250,000 acres of potentially irrigable soils. Dr. J. W. Bauder of the Department of Soils, Dr. Mary Bromel, Department of Bacteriology, and Howard Olson, superintendent of the Carrington Branch Experiment Station, have been heavily involved in preparing study reports concerning the environmental impacts of the GDU. Particular attention has been given to the potentially adverse effects of GDU irrigation return flow on Canadian water supplies, including the Red and Souris rivers.

During the past year, Dr. Bauder made several trips to Denver where he worked with USBR personnel at their Engineering and Research Center. The major task to be accomplished was an analysis and verification of a multi-phase computer simulation model, being used by the USBR to develop management practices and guidelines for the GDU project. Under the direction of the U.S.-Canadian International Joint Commissions (IJC), the Study Board of IJC recently released its final study report, outlining the predicted effects of the GDU on water quality and making recommendations relative to project management.

Of special significance is the fact that a considerable amount of the research findings by soils researchers at the Oakes Irrigation Farm was used as a basis for adjustments and analysis of the USBR nutrient transport simulation model. Dr. Bauder's involvement with the IJC study group has produced experiences and insights into current irrigation research needs that will be invaluable in the direction and effectiveness of future research in the Department of Soils.

## AFLATOXINS IN CORN SILAGE

Aflatoxins are toxic metabolic products from certain strains of mold. Because they are potent carcinogens, aflatoxins have recently received a great deal of scientific attention. Corn for human consumption is routinely screened for the presence of aflatoxin, and work is also progressing on aflatoxin metabolites in milk.

A project in progress in the Department of Veterinary Science is investigating the incidence

of aflatoxin contamination of corn silage. Silage samples were collected this fall from 19 farms in a three-county area and are being checked for aflatoxin. The data from this work will indicate whether or not aflatoxins in corn silage are a potential animal and human health problem.

### **BLACKLEG AND IBR VACCINATION**

Researchers in the Department of Veterinary Science are working under a contract with the North Dakota Beef Commission to investigate immunological responses of calves from cows that have substantial immunity to blackleg and infectious bovine rhinotracheitis (IBR) at calving.

The primary objective of the research is to determine if the passive immunity the calf receives from its dam will interfere with vaccination responses to either blackleg or IBR. Efforts are also being made to determine the optimum age at which to vaccinate with these two vaccines.

Preliminary results have shown that a single chemical blood test can be used to determine the quantity and quality of passive immunity in the day-old calf resulting from consumption of colostrum milk.

### **COPPER LEVELS IN CATTLE**

Copper was first shown to be a dietary essential in 1928, and is known to function in many growth processes. Copper deficiency may occur when there is insufficient dietary copper or the copper is tied up by molybdenum. In cases of copper deficiency, bone disorders, nervous system problems, poor growth and scours are often observed.

Based primarily on data acquired from diagnostic specimens, it was evident that the copper nutrition of North Dakota cattle should be investigated. A project was developed in the Department of Veterinary Science and is now underway to measure copper levels in cattle. In this investigation, liver and serum samples from North Dakota cattle will be assayed for copper and molybdenum. The data from this investigation will be used in feeding recommendations and in establishing livestock nutrition standards.

### **VETERINARY DIAGNOSTIC LABORATORY**

The Veterinary Diagnostic Laboratory at NDSU is involved in day-to-day evaluation of animal disease, providing diagnostic and laboratory support to practicing veterinarians.

The demand for diagnostic service runs high, as the lab handled over 3,800 cases in 1976. This compares to only 1,631 cases in 1969. The new modern diagnostic facility in the recently constructed Van Es Laboratories building has greatly increased the efficiency of the diagnostic laboratory to accommodate the growing case load.

The NDSU laboratory uses a variety of procedures, including gross and microscopic pathology, bacteriology, serology and toxicology. Procedures used are determined by the pathologist in charge, in consultation with the practicing veterinarian submitting the case.

North Dakota's 90 practicing veterinarians serve the largest area per veterinarian in the United States, so the availability of a modern diagnostic laboratory is an important part of the disease prevention effort in the state's livestock herds.

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(Taylor . . . from page 3)

ing status of the work ethic, the changing sophistication of the inputs and such items as health and safety regulations, pollution controls, and the increasingly complex food and fiber system involving about 17 million people (one U.S. worker in five).

Historically, the aim of the Land Grant Universities' research and education arms has been to ensure that expenditures of public funds on food and agricultural research are one of the soundest investments in the future welfare of mankind that can be made. Given the opportunity, the dedicated workers in these institutions are ready and able to continue to supply the knowledge that North Dakota and the U.S. will need for a bountiful supply of food and agricultural products for the future.

The U.S. population is expected to double within the next 50 years. This increasing population will have to be fed and clothed using cropland acreage not much greater than the amount that has been cultivated since 1930.

Private investments in agricultural research are limited since they cannot capture enough of the benefits created by such investments. Thus, the public sectors must finance and do a large part of the agricultural research, including the dissemination of the results. Among the key institutions in this public research capacity are the Agricultural Experiment Stations and Extension Services of the Land Grant Universities.

With growing competition for both federal and state budget funds, Land Grant Universities

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