Summary of Some Major Research Projects In The Agricultural Experiment Station

Coal Research Project (3332)

The prospect of extensive coal development in North Dakota poses many questions to public decision makers and to all citizens of the state. Some important questions include the effect of coal development on employment opportunities for North Dakota residents and the effect of development-induced population growth on business, governmental units, and the way of life in affected communities. A project to evaluate these socioeconomic effects of coal development is underway and involves researchers from the Department of Agricultural Economics and the Department of Sociology.

Coal development may create many new jobs. For example, a 1,000 megawatt electric generating plant and its associated mine would result in up to 1,000 temporary construction jobs and nearly 500 permanent jobs in plant and mine operation. But just as important as how many jobs there will be is the question of who will get the jobs. Will North Dakota residents be able to qualify for the jobs or will they be filled by migrants?

Surveys of the state's present coal mine and power plant work force and the construction work force involved in building two new electric generating plants provide some insights into this question. The present coal mine and power plant work force is made up primarily of North Dakotans. Prior to being hired by their present employer, more than half of the workers lived in the county where the plant or mine is located, about one-third moved to their new job from another North Dakota county, and less than one in six moved to the area from another state.

On the other hand, preliminary results from the survey of power plant contruction workers indicate that only half of these workers are North Dakotans with the remainder coming from out of state. The prospect of rapid growth in the state's coal industry indicates that expanded vocational education and training programs could help prepare the state's workers for industry jobs.

Construction of coal gasification plants or large electric generating facilities can be expected to have a substantial effect on nearby communities and their people. A case study of the effect of the Anti-Ballistic Missile (ABM) project in northeastern North Dakota indicated that providing housing and public services for the new workers and their families was a major challenge for the community. Communities affected by coal development will be better able to cope with rapid growth if they have accurate advance projections of the likely timing and extent of population increase. Work is now underway to provide such projections for communities in Dunn, Mercer and McLean counties.

Sunflower Processing

North Dakota is the leading state in the production of oilseed sunflowers and several community groups have requested information concerning the feasibility of a plant for processing this commodity within the state. A preliminary investigation of the feasibility of constructing a high oil sunflower processing plant in North Dakota completed by the Department of Agricultural Economics was encouraging enough that local communities requested a more complete and rigorous study.

Project funding from the Experiment Station, the Economic Development Administration (a federal agency), and other state and local entities was completed in June, 1974. Research work was started with a number of agricultural economics staff members and vegetable oil industry personnel participating in the study. Several agricultural and non-agricultural staff members have provided consulting services. The project has been completed and the results are to be submitted for EDA's approval.

Objective of the research was to determine both the feasibility of establishing a processing plant in the state and its impact on the state's employment and income. Achieving this objective requires analysis of sunflower production in terms of existing and potential production patterns related to processing requirements.

Investment requirements and operating costs for processing plants of different sizes were estimated to reveal the most efficient size plant compatible with estimated production, market, and transportation factors. Domestic and foreign markets for sunflowers and end products were analyzed within the study framework. Transportation costs to assemble raw products and distribute end products for alternative production densities were integrated with the other phases of this research.

Consolidation of these research results will determine the economic feasibility of sunflower oil

processing in the state under different economic conditions. Projecting benefits on employment and income levels in locally affected areas of the state should also prove helpful to decision makers.

North Dakota Resources Inventory, Information Management and Monitoring System (RIMS)

Comprehensive land use planning and good resource management requires immediate access to many types of reliable information. North Dakota is undergoing rapid change, one important fact being that lignite needed for energy underlies land used for food production. Problems facing North Dakota citizens are many and complex, and necessitate the creation of a computerized resource information system.

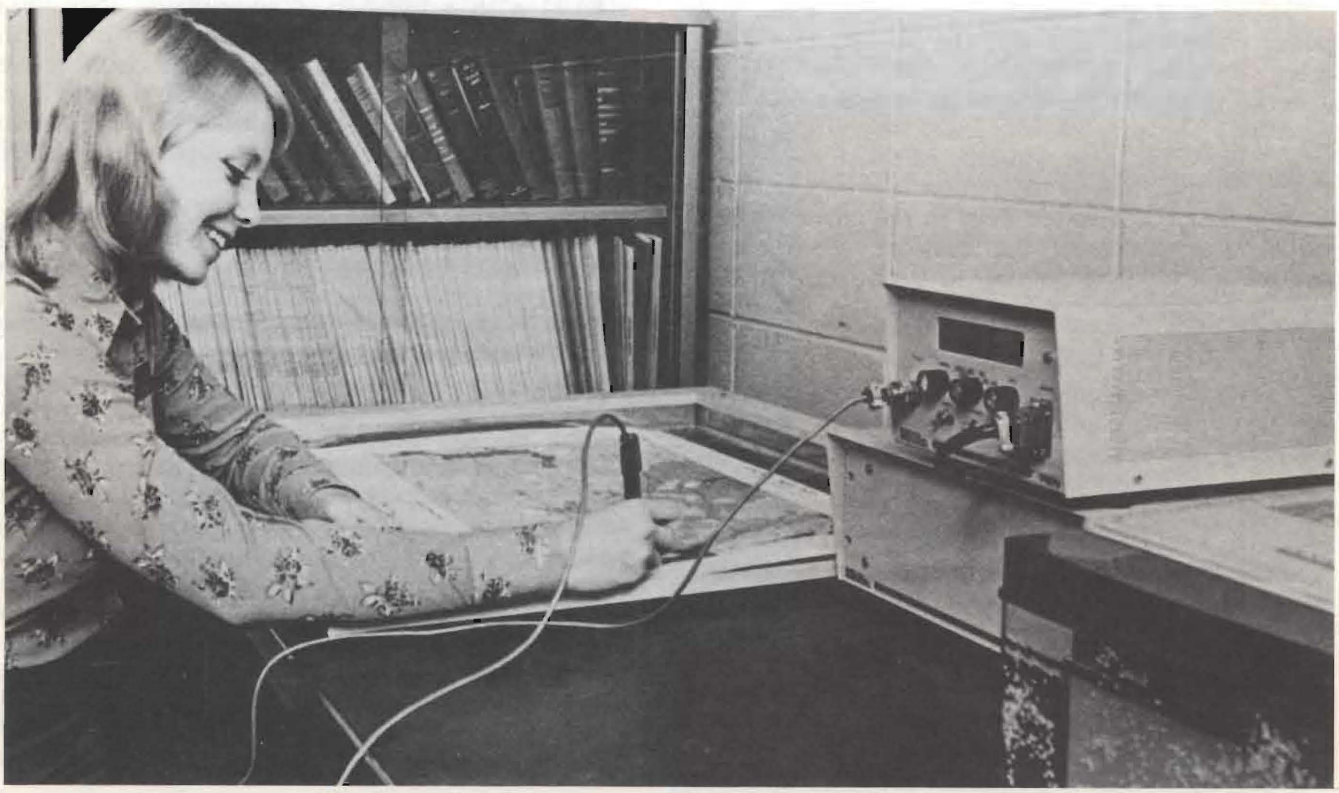
A computerized data system will allow users to manipulate and analyze large volumes of resource information in their planning and management roles. The computerized information system can be viewed as a tool to identify, inventory, classify and analyze available data with speed and accuracy not previously possible.

Development of a computerized information system will allow better information flow by providing immediate access to current and accurate information to solve detailed and complicated problems. It will permit better scientific management of North Dakota resources by providing information for predictive estimates to "what if" questions and help the many individual users gain access to greater computing power than would be available to any one user. The system will save time and money by allowing many people immediate access to expensively obtained data and eliminate duplication of expensive equipment, and allow rapid examination of different kinds of information on television-type terminals and the selective printing of needed information.

Information currently available in the North Dakota Agricultural Experiment Station will be the first data entered into the data bank. This will include climatological data, soils information from both published and unpublished data, census data, land use, crop and livestock statistics, transportation systems, historical sites, cultural features, government and critical environmental areas.

The North Dakota Resources Inventory, Information Management and Monitoring System (RIMS) consists of a set of techniques for recording, storing, processing, recalling and displaying information from a resource inventory. Recording involves the transformation of data from maps and tables to a form acceptable for storage. One method of obtaining information from maps is by a machine called a digitizer. The digitizer converts lines on maps to numbers and records the locations of these lines on paper tape.

The long range goal of RIMS is to provide as complete an inventory as possible of information



Dawn Hamlin, data processing analyst, traces lines on a map with a stylus which transfers coordinates to a punched tape for computer analysis and for reproducing the maps on a computer plotter as a part of the RIMS project.

useful to resource decision makers. Additional research and data collection will be required to meet user needs.

This information can be used to study problems of state, regional and county concerns, such as land use planning, regional energy development assessments, power plant and transmission tower settings, strip mining, and mined land reclamation.

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 use of the diverse research and extension resources available at these institutions. Specifically, universities are requested to provide research aimed at development, assist in the practical application of knowledge in support of rural development, and coordinate project activities to on-going rural development programs.

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.

The major thrust of the North Dakota Title V project is to complement existing programs and cooperate with other agencies involved in rural development activity to provide local communities with a more complete program of development assistance.

One specific objective of the program is to help community and business leaders identify opportunities for economic activity through business and industrial development. Several feasibility studies have been conducted on such potential industries as an alfalfa pelleting plant, a flax fiber processing plant, a portable seed cleaning unit and a large scale cooperative hog farrowing system.

Other specific goals include assisting local citizens through the social action process to achieve community goals, identify land-use problems and analyze alternative methods and procedures for land-use planning.

Wind Generators

Energy problems actual or otherwise have come to our attention in many different ways. The one sure thing is that they are not likely to get better.

Windpower has been suggested as a potential source of energy to supplement some of our depletable energy sources such as oil, gas and coal.

Wind has a lot of power. It can blow down trees and buildings, and move tremendous amounts of soil. It has a lot of energy. The average wind velocity in North Dakota is about 15 miles per hour. The power available is proportional to the projected area of the impellor or rotor and the cube of the wind velocity. With a 40 per cent overall efficiency, a windmill impellor which is six feet in diameter would produce about 200 watts with a 15-mile wind. This is equivalent to less than a one-quarter horsepower motor. It is the amount of heat required for about 10 square feet in an electrically heated building.

A wind generator can supplement regular electric energy for space and water heating in a home or barn.

Available wind energy can be increased by increasing the diameter of the impellor projected area. Most of us have seen pictures of the "Dutch" type of windmill which used diameters of 30 feet or more. Additional energy can be obtained by increasing the elevation above ground, about a 12.5 per cent increase as a tower doubles in height. Both progressively increase the cost of installation.

The other problem is that the wind doesn't blow consistently. Variations of from 0 to 100 miles per hour or more can be expected. When pumping water, there must be a water storage to carry over for periods of no wind. But what do you do when milking the cows — wait until the wind blows? You could use a battery, but this is not very efficient and it also has a short life and is expensive to replace.

Actually, what might be feasible is to have hundreds or even thousands of these windmills all over the country all tied together electrically. The wind is always blowing somewhere and maybe this would do the job.

At the present cost of electricity it doesn't seem feasible to replace a $40.00 electric motor with a $1,800.00 windmill or wind generator. But who knows what the cost of electricity will be 10 years from now?

Another possibility is windmill power for just specific jobs. For example, a hot water tempering tank could be installed ahead of the regular water heater and this tempering tank could be heated with the wind generator when the wind blows. When the wind was not blowing, the water would be heated in the usual manner.

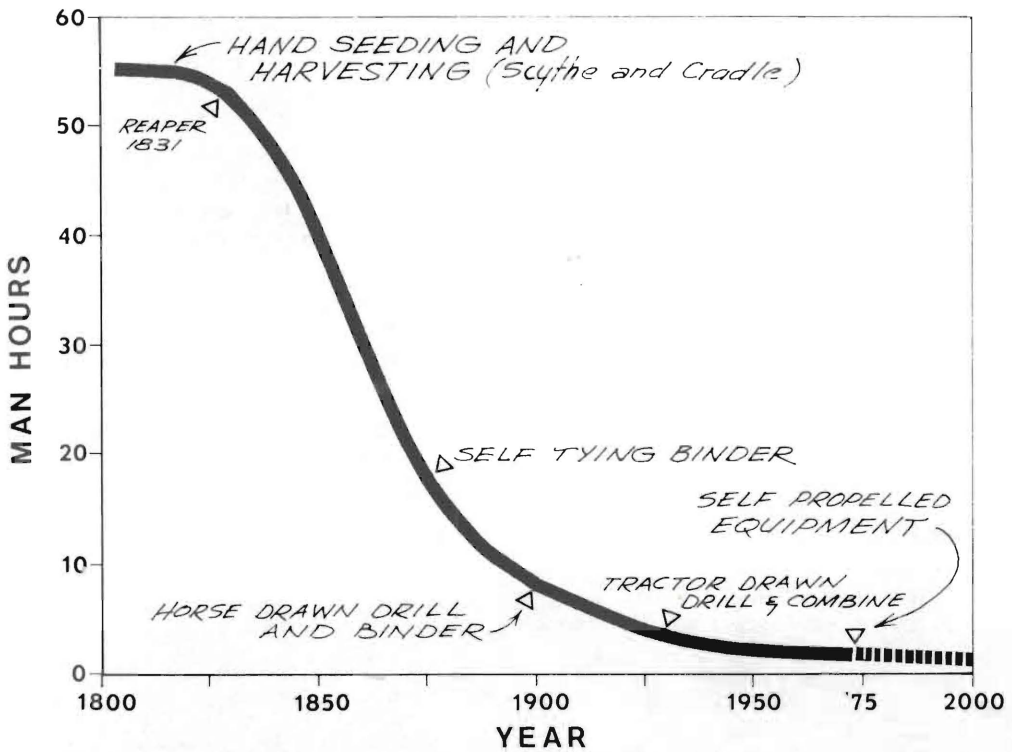
Man Power, Horse Power, Tractor Power

Two hundred years ago, man was the main source of power to produce food and fibre. The farmer of that time was compelled to produce food and clothing with little more than his bare hands. To prepare the seedbed he used the spade, or a crude plow pulled by an ox or a horse. His grain crop was sowed by hand from a sack tied around his neck. A crude harrow was used to cover the seed. Harvesting was done with a scythe and cradle. The bundles were tied by hand, threshing was done with a flail, and the straw and grain were separated by a winnowing process which took advantage of nature's breezes. The farmer's wife and children were often seen working at his side.

His house was built of rough logs and thatched with straw. On the inside it had a minimum of comforts. Candles were used for light. Heat was supplied by a fireplace which was also used for preparing meals and baking bread. Necessity dictated how the family would spend its time, because the essential task was to produce enough to eat and enough to wear. There was little time for recreation.

During these pioneer days, much labor required to produce crops. For example, the labor required to produce wheat was about 55 man-hours per acre. With the beginning of mechanization of agriculture in the early 1800's, this situation began to change rapidly. Many machines operated by horses were developed beginning about 1820. These included the revolving rake, a grass cutting machine, the reaper, the threshing machine and combine, the steel plow and many others. Horse power was replacing man power, and a reduction in the man hours required to produce food and fibre was immediately noticed.

In 1850 the man-hours required to produce an acre of wheat had dropped to 40 (see figure). Horse-drawn equipment continued to have a significant effect on the labor requirements for farming operations. In 1900 the man-hours required per acre for wheat had dropped to about 9. Of course, the steam engine had a part in this. It was first used as stationary power on the farm in about 1860, and later became popular for some field chores such as plowing as well as a dependable source of power for operating threshing machines.



MAN HOURS TO PRODUCE AN ACRE OF WHEAT
(Great Plains Area)

solid waste from the cable scrapers is a single-chain barn cleaner.

Temperature control is maintained in the building through the winter, but higher summer temperatures in the building fluctuate with outside air temperatures. During July and August, drinking water intake rates were higher than for April, May and June. Drainage from the building, however, was reduced during the warm summer months as compared with the early spring period of March, April and May.

Total solids in the liquid that drained from the pit ranged from 12,000 to 25,000 parts-per-million. Total solids in filtrate from vacuum filter tests ranged from 36,500 to 55,000 parts-per-million. The data suggest that the liquid drained from a sloping floor will pick up less solid matter from the fecal waste than when the feces are mixed into a slurry and the liquid drawn off by use of a vacuum filter.

Liquid wastes collected in the holding pond may be disposed of by irrigation equipment. Data were collected for six months to evaluate the potential for disposing of livestock liquid waste in North Dakota by evaporation. Lake evaporation equals rainfall along a line that passes through Minnesota, Wisconsin, Iowa, Missouri, Arkansas, Oklahoma and east Texas. States east of this line receive more rainfall than is evaporated from open lakes, and so there is no potential for using evaporation in this area. West of this line, evaporation exceeds rainfall by from 10 inches to 60 inches. In these areas there is a potential for evaporation of liquid wastes.

Data taken on evaporation rates from a pond that receives the drained liquid from the pit under the slatted floor of the beef barn indicate that the rate of evaporation from the pond is about the same as from an open lake in North Dakota.

Solid manure comes from the cross conveyor at about 80 per cent moisture. This indicates that about a third of the total water in the manure is removed mechanically by this system.

Several alternatives might be considered for storing the solid waste taken from the system. It has been successfully stored in above-ground bunker storage. Successfully stacking the manure would require a conveying device that would operate in freezing temperatures. Manure stored in bunker-type storages is suitable for field spreading, and can be loaded with a front-end loader on a tractor and spread with conventional solid manure spreading equipment.

A series of tests made to determine the heating value of beef cattle manure indicates that the average heat value of the manure was 6,286 BTU per pound of dry matter. Marks Handbook gives an average high heat value of 8,300 BTU per pound for moisture- and resin-free wood, and an average high heat value of nearly 7,000 BTU per pound for North Dakota lignite coal.

One high value use being made of manure is to include it in the rations for livestock feed. Tests indicate that the average digestibility of the ration used for the cattle was 63.5 per cent when calculated by a "summative equation." Use of the equation of fecal material indicates it contained 22.5 per cent digestible dry matter.

A major source of pollution from livestock is the runoff that is generated from feedlots during rainstorms and spring thaws. One effective method of controlling this runoff is to house the animals under a roof.

The method of management that has been presented here provides an efficient way to remove manure from the building. Pollution is kept to a minimum since no clean water is added to the system. Free liquid waste appears to make up about one-third of the total weight of the liquid in animal manure. Liquid waste disposed of by evaporation reduces the handling problems associated with manure management. When fecal waste is removed from the building at 80 per cent moisture, it can be handled with conventional manure handling equipment. Much dewatering is accomplished by this system, and because of this dehydration becomes more feasible. Moisture removal from the fecal waste helps to control odors, reduces the bulk of material that must be handled and puts it into a form that is more readily acceptable for utilization.

Supplementary Solar Heat Grain Drying

A solar collector was installed on an existing heated air bin dryer located on the Lester and Richard Ockert farm near Cathay, North Dakota.

The plastic solar heat collector connected to the grain dryer on the Ockert farm.

This collector was connected in series with the air intake of the existing grain dryer fan.

The solar collector used was of a triangular cross-section about eight feet wide at the bottom, about three feet high and 100 feet long.

The bottom of the collector was black plastic, while the top was a translucent reinforced plastic.

A recorder was installed to take temperatures at various parts in the system.

Manometers for measuring before and after air pressures were installed.

Analysis of data collected is not complete, but initial findings are summarized in the table below.

Date started	Hours of drying	Average temperature rise of air through collector	Average outside air temperature
Aug. 28	17	11.59°	73°
Sept. 1	32	7.30°	50°
Sept. 3	24	6.40°	52°
Sept. 7	17	7.00°	67.5°
Sept. 12	21	3.70°	44.4°
Sept. 13	22	2.70°	74.7°
Oct. 20*	20	1.80°	45.7°

*drying sunflowers

Preliminary data on these trials indicate a fuel savings of 1 to 1.5 gallons per hour of dryer operation when the solar collector was used along with the propane burner. Day temperatures, conditions of cloud cover and night temperatures determine the temperature rise within the collector. Temperature and relative humidity determine how much fuel saving will be realized.

A solar collector is being installed at the Fargo Agricultural Experiment Station to measure amounts of heat collected under various weather conditions.

Instant Pure Line Development by Doubled Barley Haploids

Plant breeding is a very time consuming, lengthy process with up to 10-12 years from the time of a cross to the final stages of variety release. For example, the original cross for Beacon was made in 1963, and it was released by the North Dakota Agricultural Experiment Station in 1973.

Since barley is a highly self-pollinated crop, crosses are made between desired varieties or lines, and segregating progeny are observed and selected

Barley breeder Melvern Anderson tests a method to shorten the lengthy time span of developing a barley variety in which initial crosses are treated with gas under pressure (tank, lower center) immediately after pollination for rapid pure line development.

over many years. When these selected lines reach a relatively pure form, they are entered in preliminary yield trials and tested throughout North Dakota. This testing process usually requires a minimum of five years.

NDSU researchers are using a new method in their breeding program that may greatly reduce the time for pure line development. When cultivated barley *(Hordeum vulgare)* is crossed with the related wild species *(Hordeum bulbosum)*, the resulting embryonic seed initially is composed of chromosomes from both the tame and wild barley. This zygote (seed) is treated with nitrous oxide gas under pressure for 20 hours, which doubles the chromosome number. The chromosomes from the wild species gradually are lost, leaving only cultivated barley chromosomes in the mature embryo. Since the chromosome number was doubled, the pairs of barley chromosomes are identical. Essentially, a pure line is produced as soon as the seed is formed.

At the present time, NDSU researchers are implementing this technique in their breeding program. Since they are just beginning to use this new technique, the number of lines produced is very small. For example, 68 pure lines are being increased now in Mexico and in the greenhouse, and they will be entered in preliminary yield trials next year. Original crosses were made in 1975, and this material will be evaluated as pure lines in yield trials in 1976. If this method proves to be successful, most new barley breeding lines will be developed by this method. The time saved in variety development procedures could be very beneficial to the barley producers of North Dakota and the Upper Midwest.

Weed control researcher John Nalewaja studies the effectiveness of various additives to herbicides under different environments.

Weed Control Research

The wild oat control program (supported in part by USDA funds) is very extensive involving field research on the Agricultural Experiment Station, in the greenhouse, in the laboratory and in controlled environmental chambers, and a field-scale "pilot" program on farmers' fields in North Dakota. This research includes experiments on wild oat biology in relation to herbicide response, growth habit and seed survival, development of crop rotations to minimize the wild oat problem, and herbicide evaluation and technique of use improvement for wild oat control.

Several new herbicides have been evaluated extensively for wild oat control in wheat and barley. Barley tolerance has been good to excellent with difenzoquat (Avenge); however, wheat tolerance has been marginal with some wheat varieties injured more than others. Wild oat control with difenzoquat generally has been good at the 4- to 5-leaf stage. Further, herbicides to control broadleaf weeds have been tank mixed with difenzoquat without reducing wild oat control.

Wheat tolerance has been good with HOE-23408 compound; however, some barley injury has been observed. Wild oat control with HOE-23408 was good to excellent at all stages of application in 1975; however, in 1974 applications at the 2-leaf stage were more effective than at the 4- to 5-leaf stage. Wild oat control with HOE-23408 generally has been reduced when applied with broadleaf herbicides.

MSMA, another compound for wild oat control, caused little injury to barley or wheat in our tests in 1975, but wheat was injured in 1974. Control of wild oats with MSMA has been somewhat erratic, but it generally has been more effective when applied at the 4- to 5-leaf stage. MSMA also controls certain broadleaf weeds.

Greenhouse research is an important phase of the year-around wild oat program conducted at North Dakota State University and aids in the evaluation, prediction and interpretation of field results. Through greenhouse work, it has been determined that cold temperatures following barban application increased the possibility of crop injury.

The Wild Oat Pilot Project is a four-year project being funded by the Agricultural Research Service (USDA) applying a combination of cultural, mechanical and chemical wild oat control techniques on large fields at four locations across North Dakota. Each location has seven four-year rotations compatible with the farming practices of that region. Each experimental area is heavily infested with wild oats, allowing close monitoring of the degree of control achieved.

The primary objective of this project is to determine if certain four-year rotations for each region of the state may be effective in reducing heavy wild oat infestations to low levels which may not reduce crop yields. This level would be approximately 0 to 10 wild oat plants per square meter in the growing crop. Emphasis is being placed on proper herbicide use, election of crop rotations and modification of tillage practices.

Researcher Steve Miller looks over study designed to treat wheat seed with protectant to prevent triallate (Far-go) injury.

Research results at NDSU and other agricultural universities indicate that wild oat seeds do not survive for long periods of time in continuously cropped land. The Wild Oat Pilot Project will study how long wild oat seeds survive in the soil under actual farm conditions. The first season's results in 1974-75 indicate that one season of excellent wild oat control (where little or no seed was produced and reseeded in the land) caused a large reduction in the wild oat seed reservoir in the soil. The soil-borne reservoir of seed in infested land is usually large, hence it will require several seasons of good wild oat control to reduce an infestation to low levels.

Weed researcher Peter Fay checks results of experiment in which chemical stimulants were used to promote germination of dormant wild oats.

Weed control research is conducted on a year-around basis. In addition to extensive field weed control research in the various crops grown in North Dakota, greenhouse and laboratory research is used to supplement field results. Greenhouse research has been used to evaluate the influence of various additives to herbicides upon weed control. Emulsifiable linseed oil was found to enhance the postemergence effectiveness of cyanazine by four to eight times. A water soluble linseed oil was found effective as an additive to bentazon for wild mustard control with bentazon applied post-emergence in soybeans. The greenhouse and laboratory research make possible rapid evaluation of various approaches to weed control before field testing. The influence of simulated rainfall and climatic conditions are determined in laboratory research. This information is used to interpret and help predict field results.

The weed control in sugar beets program is conducted in the dryland sugar beet production regions of North Dakota and Minnesota. Extensive field testing of herbicides for use in sugar beets is carried out at several locations. Two new preplant incorporated herbicides, ethofumesate (Nortron) and H-22234 (Antor) have given better redroot pigweed control and do not need to be incorporated as rapidly or as deeply as EPTC (Eptam) which is presently the most used herbicide in sugar beets. Nortron and Antor have not given as good green and yellow foxtail control as Eptam or TCA so the new herbicides will be used in combination with other herbicides.

Many herbicide combinations are tested each year in an attempt to achieve total chemical weed control and eliminate the need for hand labor to remove weeds from sugar beets. Good weed control from herbicides also allows the effective substitution of electronic thinners for hand labor for thinning.

Other areas investigated in the weed control in sugar beets project include the use of growth regulators to increase sugar beet yields, comparing fall and spring applications of herbicides, the effect of 2,4-D drift on sugar beet yields, and differences among sugar beet varieties in response to herbicides.

Look for Predictive Cereal Tests

The ultimate objective of the cereal physiology program is to develop predictive tests for grain yield and grain protein that could be used by plant breeders in crop improvement. The use of predictive tests should make the breeding process less laborious, less expensive, less time consuming and more precise.

Productivity of a plant depends on its ability to convert light energy, carbon dioxide, water and

Agronomist Edward Deckard looks at assay for nitrate reduction process.

nutrients into carbohydrate, protein, lipid, etc. Once the limiting aspects in the synthesis of these products are identified, it should be possible to develop the predictive tests. With these predictive tests, it should be possible to improve the biological efficiency of the plant through a concentrated breeding effort.

Most of the research effort to date has been with nitrogen metabolism, since this process is so closely related to plant growth and protein production and the cereal crops are notoriously low in grain protein. Certain limiting aspects of the process have been identified and prediction tests have been developed. Use of these tests for predicting grain yield and grain protein is being evaluated at present. The research is being expanded to include other key processes involved in plant growth.

Dry Edible Bean Research

Dry edible bean acreage in North Dakota has increased from 30,000 acres in 1968 to over 120,000 acres in 1975, mainly in the eastern third of the state.

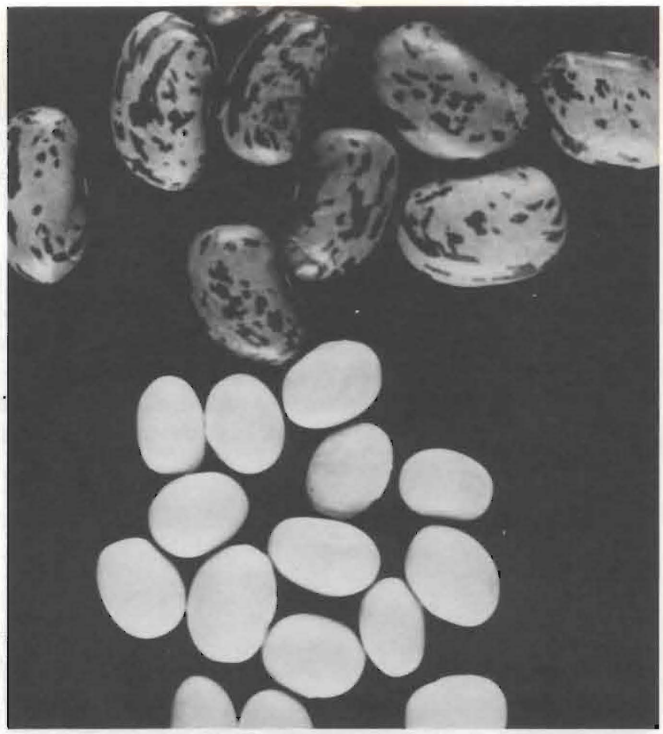
Pinto beans constitute most of North Dakota's dry edible bean acreage, with less amounts of navy and other types being grown. Pintos are grown for the open market, while most acres of the navy type are under contract. Acreages of other bean types are minimal and are generally lacking markets at the present time.

In 1975, with the cooperation of the branch stations, interested growers, seed companies and local crop improvement associations, testing of dry edible beans was significantly expanded. Several varieties of pinto, navy and red kidney types were tested at 12 locations in the state. Sites were located from Beach to Langdon and from Williston to Barney. Yields were very good with pinto beans outyielding other types.

Because of rainfall patterns, growers in the drier western area of the state normally will not be able to produce yields equal to those obtained in the eastern bean growing areas of the state. The drier climatic conditions, however, may be an advantage for the production of dry edible beans for seed purposes. Because of seed-borne diseases, only certified seed is recommended for seeding. This means that the grower should purchase new seed each year.

Certified seed produced and processed in North Dakota should be equal in freedom from disease to any that can be purchased. Historically, most of the certified seed has been shipped in from Idaho, with lesser amounts from Wyoming and Colorado.

The potential development of a dry seed production industry in western North Dakota would



Pinto (top) and navy beans make up the two major dry edible bean crops in North Dakota.

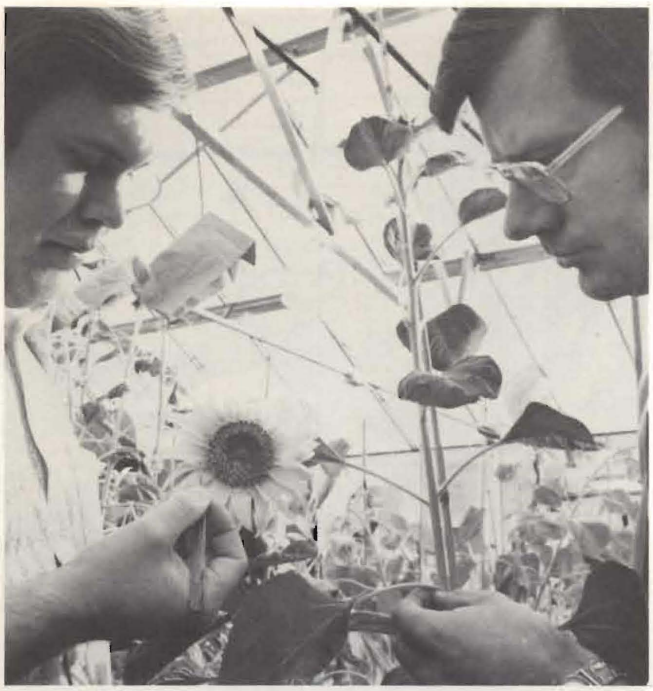
be a benefit to our state. Potential markets of seed could be not only in North Dakota but in eastern states that also use seed grown in the intermountain area. North Dakota branch stations and the Agronomy Seed Farm at Casselton have grown seed for certification in the past. The amount of certified seed produced, however, has been inadequate to meet the demands of North Dakota farmers.

Sunflower Variety and Hybrid Improvement Research

Sunflower improvement research was initiated in 1970, and is a cooperative effort of the Agricultural Research Service of the U.S. Department of Agriculture and the NDSU Agricultural Experiment Station. Research objectives include the development of disease resistant varieties or inbred lines that can be used to produce high yielding F_1 hybrids.

Sundak sunflower, released in 1973, was the first large-seeded confection variety with rust resistance available to North Dakota and Minnesota farmers. Sundak was grown on about 90 per cent of the confection acreage, about 200,000 acres, in 1974 and 1975. Estimated annual benefits to producers over alternative rust susceptible varieties were close to $4 million.

Successful research developing hybrid sunflowers has resulted in release of cytoplasmic



Research technician Dale Rehder and Gerhardt Fick, USDA-ARS sunflower breeder, work in the sunflower breeding greenhouse. Most research on the NDSU campus continues on a year-around basis.

male sterile and fertility restorer lines for use in hybrid seed production. With a few exceptions, all of the oilseed hybrids available to growers currently were produced using one or more parent lines developed by the USDA-NDSU team.

Fertility restorer lines RHA 271, RHA 273 and RHA 274, in particular, have had wide usage by industry. These lines when combined with appropriate cytoplasmic male sterile female ones can be used to produce F_1 hybrids with resistance to rust, downy mildew and verticillium wilt, thus lessening the risks associated with sunflower production. Assuming a 15 per cent yield advantage, from test results, on 500,000 acres the increased gross return to North Dakota farmers would be over $7 million.

Rust-resistant parent lines developed and released in 1974 for production of large-seeded confection hybrids also have been used extensively by industry in seed production. These hybrids are higher yielding and produce more uniform seeds of higher quality than open-pollinated varieties. Three new experimental lines for production of downy mildew and rust resistant confection hybrids appear very promising and are currently being increased in Florida on a limited basis.

Research on Corn Variety Improvement

To date, 35 inbred lines and numerous male sterile and restorer sublines have been released from the corn improvement project. Two new early maturing inbreds, ND240 and ND241, were released to commercial seedsmen in 1975. These inbreds tested in 15 different hybrid combinations in 1974 and 1975 at Larimore and Mandan outyielded adapted commercial hybrids by an average 15.22 bushels (18.3 per cent) and 11.1 bushels (27.9 per cent), respectively.

Testing of commercial hybrids has been conducted for the past 38 years to provide growers with information on the everchanging array of hybrids. The prospect of irrigation led to a site at Oakes where high potential yields have been obtained. In six years of testing, plot yields have averaged 146.7 bushels, while one hybrid has yielded an average 170 bushels per acre for this period.

Hard Red Winter Wheat

A new hard red winter wheat variety, Roughrider, was released by the North Dakota Agricultural Experiment Station in December, 1975. This is the first winter wheat variety ever released by North Dakota. Roughrider likely will replace Froid, which is grown on about half of the present winter wheat acreage. Roughrider is as winterhardy

Winter wheat breeder John Erickson examines seed of Roughrider, the first hard red winter wheat variety ever released from NDSU.

as Froid, but has outyielded Froid by about 11 per cent. In addition, Roughrider has much better test weight than Froid and is earlier maturing, shorter and more lodging resistant.

Release of improved varieties and use of recommended cultural practices should result in an increased winter wheat acreage in North Dakota. Higher yields and better labor distribution are the main advantages of growing winter wheat. If spring stands are good, better competition with weeds, particularly wild oats, is another favorable aspect of growing winter wheat. The hazard of winterkill is the major disadvantage of growing winter wheat, although good management will reduce this risk. Successful winter wheat production depends upon using proper cultural practices and varieties with adequate winterhardiness.

Durum Wheat Improvement

North Dakota released durum varieties have made up at least 95 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, Cando, in December, 1975. This release represents research 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.

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. These new varieties possess increased yielding ability over Leeds, and also have 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.

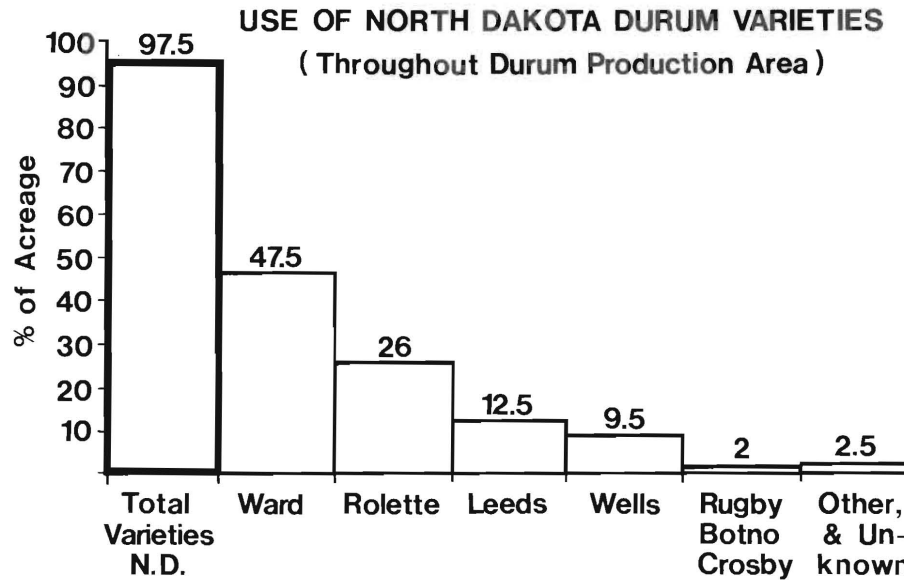
Durum breeder James Quick compares heights of new semi-dwarf Cando (right) with standard height durum.

Leeds durum, released in 1966 and possessing greatly improved grain and spaghetti quality over Wells, has been largely responsible for happy domestic durum processors and for holding the large durum export market and favorable prices enjoyed the past few years. Its acreage has been largely taken over by Rolette and Ward during the past years.

Rolette durum, released in 1971, was grown on about 38 per cent of the North Dakota acreage in 1974 and probably occupied 26 per cent in 1975. Early maturity, short stiff straw, large kernels and high yield make Rolette an attractive choice for producers.

Ward durum, released in 1972, occupied 47.5 per cent of the North Dakota acreage in 1975. Ward has about a 12 per cent yield advantage over Leeds and has stronger straw, greater resistance to leaf rust, excellent spaghetti quality and a lower incidence of leaf spotting than other varieties.

Several medium height durum selections, intermediate between Ward and semidwarf types, are undergoing final evaluation. These lines of a new height class for durums will provide shorter straw needed in most of the durum area, and allow a stem



to carry additional spike weight without lodging. A smaller effort is being applied to the improvement of semidwarf durums. Recent improvements have been made in increasing kernel size, broadening disease resistance, stiffening the straw and improving spaghetti quality in experimental lines which are used in hybridization breeding programs. Research just completed has indicated several sources of genetic resistance to leaf rust are available and easy to manipulate genetically.

Hybrid Wheat Seed Production

Experiments investigating techniques to develop hybrid wheat seed have been conducted in North Dakota for the past five years at or near Wyndmere, Langdon, Carrington, Casselton, Larimore and Minot. Cost of hybrid wheat seed will be a critical factor in determining whether hybrid wheat will be economically feasible for the North Dakota farmer to plant. Therefore, seed production research is an important factor in the overall development of hybrid wheat for a specific wheat growing region.

Agronomist Jerry Miller stands beside male-sterile line with restorer strips on both sides which are used in the production of hybrid wheat seed.

Environment has been the main factor influencing successful hybrid wheat seed production in North Dakota. Hot, drouthy conditions during pollination depress hybrid seed production by causing anthers to be "trapped" in the wheat flower or glumes and thus reducing pollen production. The region or location of production in North Dakota was of secondary importance in comparison with environmental conditions.

In favorable years when planting dates were relatively early, good hybrid wheat seed yields were obtained. If later planting conditions occurred, hot temperature periods at southern locations in North Dakota decreased yields. If the planting season is delayed, it appears the more northern locations of North Dakota will be most dependable for hybrid wheat seed production.

Yields of hybrid wheat seed were highest when the yield of nonhybrid wheat varieties at a location also was highest. All good and beneficial agronomic practices (summer fallow, timely planting, optimal weed control and fertilization, irrigation if available, etc.) that help increase normal wheat yields also will tend to maximize yields of hybrid wheat.

NDSU Seedstocks Project

During the last 15 years, 12 crops of about 100 publicly developed varieties have been increased and made available through the seedstocks project. Many of the varieties were developed at the North Dakota Agricultural Experiment Station, while others were developed in other states and Canada.

Benefits from new varieties over the next best variety have been cited in the past; for example, $6.6 million in 1961 from Larker and Trophy barley, $6.0 million in 1964 from Dickson barley and $14

million in 1971 from Waldron wheat. Because Ward durum was a prerelease increase in Arizona, North Dakota farmers gained an additional $1.3 million income in 1973, just one year after release.

First-year increases of new varieties in North Dakota by the Crop Improvement Associations, North Dakota Agricultural Association and the North Dakota Agricultural Experiment Station during the past 15 years have totaled about 300,000 acres. Conservative yield estimates of 30 bushels per acre (durum, wheat and barley) brings production to nine million bushels. At an average premium for seed of $2.00 per bushel, an additional $18 million during a 15-year period, or an average of $1.2 million per year has been earned.

The durum wheats Leeds, Rolette, Ward, Crosby, Botno and Rugby as well as the hard red spring wheats Waldron, Ellar and Olaf were all increased in Arizona prior to release. Thus, the seed available the first year was about 50 times greater than statewide increase alone would have been, resulting in about $1.4 million added income for seed increase growers based on an average seed premium of $2.00 per bushel. Seed increase growers represent a great many farmers who are interested in North Dakota and are working with the North Dakota Agricultural Experiment Station through their Crop Improvement Associations.

David Ebeltoft of the NDSU seedstocks project checks breeder seed stocks in cold storage.

North Dakota's unique seedstocks program uses southern increases in the winter, prerelease increases, County Crop Improvement Associations and their member growers and the North Dakota Agricultural Association seedsmen. These two organizations, in addition, produce the seed of the Registered class. The Branch Experiment Stations at Williston, Minot, Carrington and Langdon, along with the Agronomy Seed Farm, annually produce Foundation seed on 1,500 to 2,000 acres.

The Agronomy Seed Farm was donated by farmers and businessmen to the North Dakota Agricultural Experiment Station in 1950 for seed production. The state legislature set up a revolving fund to facilitate southern increases when deemed necessary. This has been used almost every year for the past 12 years.

All varieties released have seed deposited in cold storage, a seed source in case of emergency.

Plant Breeders Produce Major New Crop Varieties

The NDSU plant breeding team has been extremely successful and productive in creating varieties of major crops used in North Dakota, according to the 1975 crop variety survey of the Crop Reporting Service.

Durum wheat varieties produced by NDSU were grown on 95.5 per cent of the durum wheat acreage of North Dakota in 1975. NDSU barley varieties were grown on 89 per cent of the barley acres of North Dakota, 92 per cent of the barley acres in Minnesota, and 55 per cent of the barley acres in South Dakota.

In the major crop of North Dakota, hard red spring wheat, NDSU developed varieties of Waldron, Olaf, Ellar, Justin, Fortuna and Nowesta (selected from Waldron by a farmer) were grown on 75 per cent of the hard red spring wheat acres of North Dakota in 1975. Those are much better odds than available in Las Vegas! Consumer acceptance of NDSU-developed varieties of durum wheat, hard red spring wheat and barley are 96 per cent, 75 per cent and 92 per cent, respectively. This is "self-selling" of a good product without advertising.

In 1975, hard red spring wheat, durum wheat and barley provided about a $1,445,500,000 industry for North Dakota assuming average prices below:

HRS
165,500,000 bu. x $4/bu. = $662,000,000 x 75% = $496,500,000*

Durum
107,500,000 bu. x $5/bu. = $537,500,000 x 96% = $516,000,000*

Barley
82,000,000 bu. x $3/bu. = $246,000,000 x 89% = $218,940,000*

Total	$1,445,500,000	$1,231,440,000*

*crop value of NDSU-developed varieties.

Total value of these three crops in North Dakota in 1975 appears to be about $1,445,500,000, of which about $1,231,440,000 would be of NDSU developed varieties, a big return on a small research investment! But, North Dakota does not invest enough in research to improve its major agricultural products such as these three crops, hard red spring wheat, durum wheat and barley. Only about 0.3 per cent of value of agricultural products was invested in research in North Dakota, according to budget data presented to the 1975 Legislature during consideration of 1975-77 biennial budgets.

Per cent 1975 HRS Wheat Acreage

*Waldron	49.6 per cent
*Olaf	18.4 per cent
Era	8.0 per cent
Chris	2.7 per cent
Bounty 208	2.5 per cent
*Ellar	2.2 per cent
WS 1809	2.0 per cent
*Justin	1.9 per cent
Polk	1.7 per cent
*Fortuna	1.5 per cent
*Nowesta	1.4 per cent
Lark	1.2 per cent
Manitow	1.2 per cent
Profit 75	1.1 per cent
Bonanza	1.1 per cent
Others	3.5 per cent

*North Dakota-developed varieties = 75 per cent of total.

Per cent 1975 Barley Acreage

	N. Dak.		Minn.		S. Dak.[1]	
*Larker	35		73		49	55%
*Beacon	31		12	92%	6	
*Nordic	14	89%	7			
*Dickson	9					
Bonanza	7		3			
Conquest	1		1		2	
Vantage	1					
Others	2.2					

*North Dakota-developed varieties = 92 per cent of total.

[1]Others including Primus II and Prilar

Nutritional Studies of Forages

Much of the agricultural economy in North Dakota is based on forage and livestock production. Factors such as soil types, fertility, season, species of grass or legume, location and various grazing and harvesting systems all affect the feeding value of forages. A multidisciplinary project to evaluate all these variables is being conducted by the departments of Animal Science, Botany, Soils and Agronomy. The branch experiment stations, the Sheyenne Grazing Association, the U.S. Forest Service and some individual farmer and rancher cooperators also have inputs into this project.

Duane O. Erickson, animal scientist, measures forage quality as part of a multidisciplinary project to evaluate how various production variables affect the nutritional value of grasses and legumes.

The project has run for three years, but data will be collected for a longer period of time to determine the long-term effects of seasons, fertility levels and various management systems.

Research in the Sheyenne Grasslands has demonstrated that the nutritional value of all species studied decreases as the season progresses. The major lowland species fall below the level of nutrients required by beef cows from about mid-season on. Management systems such as burning, mowing and grazing rotations to improve utilization and carrying capacity and the effect of fertilization on nutrient content, digestibility and production were also studied.

Very little is known about the establishment procedures, hardiness, growth characteristics,

management and nutritional value of many native grass species. In the fall of 1974, 91 varieties representing 37 species of cool-season grasses were planted at the Main Station at Fargo. The following June, the same cool-season grasses plus 19 varieties of seven warm-season grass species were planted at Dickinson, Hettinger and Mandan. The plots will be in condition to take yield, chemical composition and digestibility data in 1976.

This trial is a cooperative effort between the North Dakota Experiment Stations and the Northern Great Plains Agricultural Research Station at Mandan.

The data from these various trials should result in improved use of North Dakota's forage resources.

Nutritive Value of Beef

Very little information is available concerning the nutritional characteristics of beef, which may be related to grades or types of cattle. The standards for grading beef carcasses have been changed four times since 1955, and during this period cattle breeding programs and other management practices have undergone extensive changes. Virtually no research has been done to determine whether or not these changes are related to nutritional qualities of beef.

There has been increasing concern among consumers about the quality of meat available to them, and the recent proposed changes have caused much controversy. Much of the concern stems from a lack of knowledge and understanding of the relationship between carcass grades and nutritional qualities of beef.

A newly initiated project in the Department of Animal Science is designed to obtain detailed information about the nutritional characteristics of beef from the various grades of cattle.

Objectives of the research are to determine the protein, amino acid, fat and mineral composition of wholesale cuts of beef; and relate the chemical composition to carcass quality and yield grades. Depending on the observations made relative to these objectives, the nutritive value of meat from beef carcasses of various grades from cattle of different breeds and from different cattle feeding regimens will be evaluated.

Selenium's Effect on Mercury

There has been much concern about the presence of mercury in the environment, particularly in foods. Generally speaking, food-producing animals can be considered potential focal points for the accumulation of mercury from certain segments of the environment. Mercury occurs widely in the environment, so exposure of food-producing animals to mercury is unavoidable. Consequently, some mercury will find its way into animal products intended for human consumption.

Scientists now recognize that dietary selenium affects the metabolism of mercury by animals. Research has only begun to yield information needed to understand the relationship between selenium and mercury. There has been considerable inconsistency in research results with respect to selenium's influence on mercury metabolism in various species of animals. Very little is known about how selenium influences the transfer of dietary mercury into animal products for human consumption.

A research product underway in the Department of Animal Science will yield information valuable for determining the significance of a selenium-mercury interrelationship which may affect mercury accumulation in meat, eggs and milk.

Sandy Matz, animal science technician, traces animal metabolic processes by means of this gamma radiation counter.

Aspen-oak woodland in the Killdeer mountains.

North Dakota's Forest Resources

Timber resources of North Dakota are utilized primarily as shelter and food for livestock and game animals, deer browse and watershed stabilization. Production of trees for lumber is virtually non-existent, but the production and ultimate usefulness of trees and shrubs for other uses far outweighs their value when compared with timber production in a virtually treeless state. When considered on a per cent of total acreage basis, the native tree species which do occur are relatively few and must be protected to perpetuate their continued existence. In terms of diversity of use and value to a broad spectrum of economic activities by the public, the shrub communities may be considered as ranking near the top in most geographical areas of the state and region.

Major tree and shrub communities are being studied mainly in western North Dakota where most rangeland is found. The occurrence, distribution, growth rates, production and phytosociological characteristics of each major woody plant species must be properly evaluated to determine its value and potential usefulness in the habitat management scheme. In areas where deer browse is of major importance, use by livestock may be in direct competition and conflicts arise. Proper management to circumvent these dual uses requires a firsthand knowledge of the individual species, as well as community responses to grazing and browsing pressures. Proper use based on this knowledge will allow continued use of existing species on a sustained yield basis.

Research has been carried out on three major species of the area to date. Rates of twig growth, relative proportion of twig length to weight growth, leaf and annual twig production, decadence, degree of hedging, methods of reproduction and propagation, and per cent utilization are parameters which have been measured. Future work will continue to stress the already mentioned investigation to include additional woody species for further studies. Coal mining and gasification development is a more recent development which will have a direct effect on woody species community management in the future. Destruction of existing communities and their reconstruction following mining will require a continuing and perhaps expanded research effort in the future. Maintenance of already limited wildland tree and shrub resources is critical for their continued use by domestic livestock, wildlife, and other uses by man.

Biological investigations look for ways to apply research findings in managing wildland resources. The intelligent and effective management and manipulation of this resource requires a firsthand knowledge of its biological capability for sustained production and integrity of use under a predictable level of utilization. The research being carried out under McIntire-Stennis projects works toward developing basic information pools and models which may then be applied as bases for management plans. The data already available from previous projects is being applied by wildlife and range managers in both state and federal agencies. Future demands for more detailed and inclusive data on various species and total communities are becoming greater as more intensive natural resource management becomes a reality.

The North Dakota State University Herbarium

Herbarium activity at North Dakota State University dates back to the very beginnings of the institution. C.B. Waldron began the collection and preservation of North Dakota plant specimens. This work was continued by H.L. Bolley, H.F. Bergman, L.R. Waldron and others. Most notably, Professor O.A. Stevens continued this initial work and has collected and exchanged plant specimens with many institutions throughout the world to build a fine university herbarium.

The North Dakota Experiment Station has provided the major support for the development of the NDSU herbarium. In recent years, active collecting has been renewed and the NDSU herbarium has grown to over 130,000 specimens. Approximately 1,200 vascular plants are known to occur in North Dakota.

The herbarium serves as a reference collection to identify and inventory North Dakota plants. In addition, the herbarium is a valuable teaching aid for the plant taxonomy, plant ecology and the range ecology and management courses taught at NDSU. Researchers involved in botanical work often rely on the herbarium to correctly identify the plants they are working with.

In addition to its local significance, the NDSU herbarium is of regional importance. Taxonomists wanting to study plants from the Northern Great Plains often borrow specimens to complete their studies. Dr. William T. Barker, who presently curates the NDSU herbarium, and his students are currently involved with the new Great Plains Flora Project. Plant distribution records from the NDSU herbarium have been combined with those from other Great Plains herbaria, and as a result an *Atlas of the Flora of the Great Plains* is scheduled to be published soon. Presently, work is underway to write a new three-volume Great Plains Flora which will serve to identify Great Plains plants.

William Barker, curator of the North Dakota State Herbarium, views two of the 145,000 specimens included in the herbarium.

The NDSU herbarium is irreplacable since it is a record of North Dakota plants dating back to the late 1880's, but its value is approximately $162,500.

Range Management Research in Sheyenne National Grasslands

Range research was started in the Sheyenne National Grasslands in 1969, through the cooperative efforts of the Department of Botany, the Sheyenne Valley Grazing Association and the U.S. Forest Service. Initially, an inventory of grassland plants was made, along with burning and mowing studies to increase livestock use of lowland areas. A fertilization study was also initiated on upland sites to improve range condition and forage production. As the work has continued, cooperative efforts between the Departments of Botany and Animal Science has allowed the study of the chemical composition and digestibility of composite forage samples and dominant native grasses. Data of this type have been collected in relation to the season and to various types of deferred rotation systems.

Burning lowland vegetation dominated by sedges and rushes in the spring increases livestock use by 62 to 87 per cent. This allows for increased carrying capacity and improved condition of a sandhills pasture. Mowing is not as effective in increasing utilization in the low prairie areas. An increase of about 1,500 pounds per acre of forage has been obtained with a May 1 application of 67 pounds of actual nitrogen per acre on upland sites in the Sheyenne National grasslands.

The chemical composition and digestibility studies are continuing and results of these studies should be available soon.

Revegetation of Mined Areas

Restoration of native grassland vegetation on strip-mined areas presents some special problems. A relatively small area of undisturbed native grassland would contain from 30 to 50 different species of grasses and forbs, and seed of most of these species is not available. Special techniques need to be developed if a truly native grassland cover is to be restored on mined land. One technique has been

Warren Whitman, head of the Department of Botany, spreads mature native grass hay to seed a leveled spoil area.

tried with some success on plots at mine sites in the Beulah, Stanton and Center areas.

A mixture of common weed seeds was sown at the sites on plots, with no topsoil, with 2 inches of topsoil, and with 12 inches of topsoil in the fall of 1973. The following summer a heavy weed cover developed on the plots. In late fall of 1974, prairie hay was cut when mature so as to have a maximum amount of seed of native grasses and forbs in it and spread in the weedy cover and punched in with a tandem disk. The development of the native vegetation on the plots was followed through the summer of 1975 by means of counts and growth measurements.

Results of this seeding method appear promising, although at this stage it cannot be said that full establishment of a native grassland cover has been achieved. The counts showed that for the most part 15 to 20 native species were found on each of the plots at the different sites. Six native grass species and 10 forbs were found to be especially abundant on the plots.

Of the grasses, prairie Junegrass *(Koeleria cristata),* western wheatgrass *(Agropyron smithii),* slender wheatgrass *(Agropyron trachycaulum),* needle-and-thread *(Stipa comata),* and green needlegrass *(Stipa viridula)* were the most abundant. Seedlings of blue grama *(Bouteloua gracilis)* were becoming frequent by the end of the season. The most abundant forbs were prairie coneflower, prairie plantain, western yarrow, rough pennyroyal, stickseed and prickly lettuce. White prairie aster, purple coneflower and prairie thistle were found on a few plots.

As would be expected, more species were found on the plots with 2 inches and 12 inches of topsoil than on the plots without soil. Plant heights were generally greatest on the 12-inch topsoil plots, slightly less on the 2-inch topsoil plots, and much reduced on the plots without topsoil.

Rangeland Improvement in Western North Dakota

A substantial portion of the western one-third land area of North Dakota is used for livestock production. Much of this acreage is still in native grassland. These grasslands are generally not suited for profitable cereal crop production due to their physiography and normally less than adequate rainfall. Heavy grazing in the past has in many instances drastically reduced the production of these grasslands to a level far below that of their potential. In addition to the reduced production, heavy grazing pressure over an extended period of time has changed the species composition of the grassland and reduced the vigor of the individual plants in the cover. Blue grama grass, a shortgrass species, increases under heavy grazing, resulting in reduced vigor and cover of western wheatgrass which generally is a highly desirable and productive species.

Natural increase of the more desirable and higher producing species might require extremely light grazing or even complete exclusion of livestock over a period of many years. In most instances, this would be impractical and probably financially impossible for the farmer or rancher using modern intensive management. Rangeland improvement must be accomplished, therefore, by other means.

Improving native range condition and production is possible by means of fertilizing and interseeding. The present experimental approach is to fertilize native grassland with relatively heavy one-time applications of 200, 300 and 400 pounds of nitrogen per acre. This treatment results in changing the plant community to a more desirable plant species combination and higher overall production. Long-lasting carryover effects are also present at the levels of fertilization indicated. Other fertilizer treatments include 67 and 100 lbs/N/acre every year and every other year, 67 N + 50 P, 67 N + 50 P + 200 K, 50 P, and 200 lbs/K/acre every year.

Other parameters measured by treatment at regular soil depths and intervals are available soil moisture and N, P and K, water use efficiency, protein content of selected native grass species at bi-weekly intervals throughout the growing season, yields and other production attributes at the end of the growing season, and species (kinds) composition changes with time due to the fertilizer treatments. Thus far, fertilization shows great promise as a useful tool in improving range condition in a considerably shorter time period than can be achieved by light or no grazing.

Rangeland interseeding is an improvement technique generally applied to native grassland which has been seriously deteriorated by overgrazing, and/or a major disturbance such as plowing. In general, the practice is to plow furrows at about 4-5 inch depths, 8-10 inches wide at 42-inch spacings with a seeding of the desired species directly into the plowed furrows.

The initial trial at the Dickinson Branch Experiment Station included 12 different varieties of grasses (both native and introduced) and legumes (alfalfa, crown vetch and Sainfoin). Three species of alfalfa have been successfully established and have more than doubled the production over check plots (no treatment). Production from the plots that were plowed but not interseeded was only slightly less than that observed from the interseeded alfalfa plots. The effects of opening the sod along with early spring and summer protection from grazing apparently elicited this response from the native range. The addition of the alfalfa to the native grassland greatly increased the quality of the forage, although grazing trials will have to be established in order to adequately test this practice as an acceptable and lasting range improvement practice.

Continued long-term studies to determine the feasibility of this type of range improvement are needed. The possible advantage in using interseeding rather than nitrogen fertilization technique to improve range condition and productivity may be that interseeding introduces desirable grass species and nitrogen-fixing species to deteriorated native stands in a single operation. Range fertilization, on the other hand, is more directly of benefit to grassland sites which still retain at least a small number of desirable species, or on better sites where productivity potential is inherently high. Fertilization may be most beneficial when employed to change the plant species composition from a less to a more desirable one and when applied on an annual basis to a selected site with high production potential. A high level and intensive management program is essential to the full positive realization from these improvement practices.

Stress Physiology

The gap between world agricultural productivity and the food and fiber requirements of the expanding world population has been dangerously diminished in the last decade. One factor in overcoming this deficiency is the efficiency of our agricultural practices, as related to the proper use of available environmental resources, and the appropriateness of existing genetic materials. Through cultural practices, limiting factors such as light, water, mineral nutrition and genetic material have been manipulated to attain optimum combinations and significantly improve yields.

However, when an environmental factor(s) becomes limiting, competition among the individuals of the population for that factor(s) becomes acute, and ultimately yield barriers or reductions occur. To overcome these limitations it becomes necessary to understand the processes by which various stresses affect the growth and development of different plants and the mechanisms of resistance and/or tolerance existing in certain species.

Utilization of available nitrogen is a major factor in the productivity of any crop or range community. The ability of a plant to sustain this function under varying degrees and periods of stress, particularly moisture deficits, is critical. As absorption and translocation are prerequisite to efficient utilization of nitrogen by plants, the objectives of the physiological studies in the Department of Botany have been directed toward understanding the process of nitrogen assimilation in various species of plants of agronomic importance to the state and the mechanisms of response to moisture stress.

Specifically, the pathway and reaction rates for the reduction and assimilation of nitrate nitrogen have been studied in soybeans, sunflowers, wheat, several rangeland grasses and selected weed species, under optimal growth conditions and when subjected to moisture stresses of varying severity and duration. The relative degree and duration these

species can withstand and the effects of such stresses on their ability to resume nitrate assimilation is being determined. The studies are providing valuable information regarding the relative tolerances of different species to limited available moisture and are providing information on the potential mechanism imparting this tolerance. They also are providing evidence suggesting that certain species are better competitors and survivors of moisture stress, and warrant further field studies as to their suitability to some of the more arid portions of the state.

Barley Quality Development

Developing superior quality North Dakota barley varieties for acceptance by the malting and brewing industries is the major emphasis of the barley section in the Department of Cereal Chemistry and Technology. The quality of approximately 2,000 samples is determined annually. The quality of comparably grown check varieties is the basis upon which the quality of each experimental selection is judged.

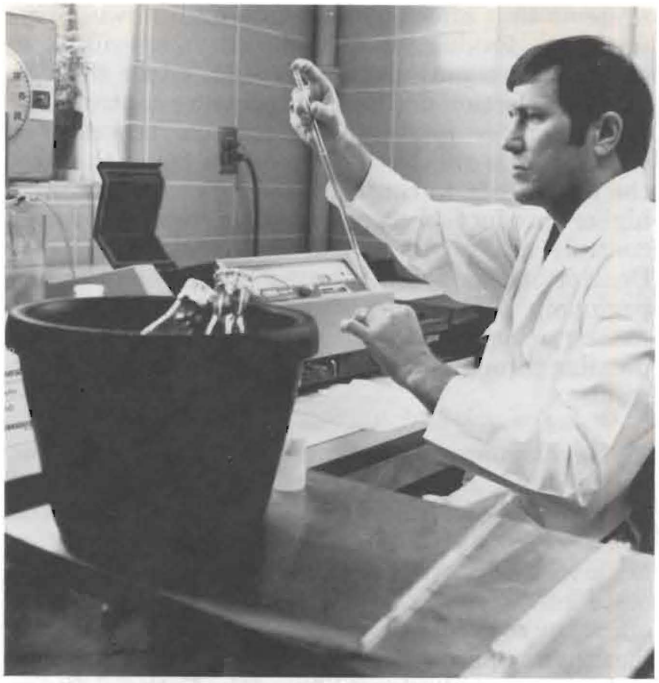
Experimental selections that are superior in quality are advanced in the program. The selections whose accumulated quality and agronomic characteristics are superior to the check variety are submitted for industrial testing. In the process, each selection has undergone 200 to 250 chemical and physical tests before submission for industrial evaluation.

Results of the two to three years of plant scale (industrial) malting and brewing tests are used in conjunction with the cumulative North Dakota State University data to determine whether or not a particular variety is acceptable. If acceptable, the variety is approved for malting. The time from initial greenhouse cross to industrial acceptance is 10 to 12 years.

In addition to variety development, current applied and basic research programs are developing methods for increasing the efficiency of quality testing, determining the effects of alternative malting procedures on malt quality and studying the influence of biochemical constituents on barley and malt quality.

An instrumental method for determining barley color has been developed. This objective method removes the bias and inconsistencies inherent in the current method of visual color inspection of malting barley. Thus, more equitable pricing of malting barley is possible.

A recently completed project shows that barley prediction tests are very sensitive guides for selecting superior quality, early generation barley



Graduate student Ed Lulai determines enzyme activity of barley extracts.

lines. This series of analyses does not have to be replaced by the costlier and more time-consuming procedures proposed to replace barley prediction testing. The quality selection of the barley varieties in the North Dakota State University program has not diminished by using the barley prediction series of testing.

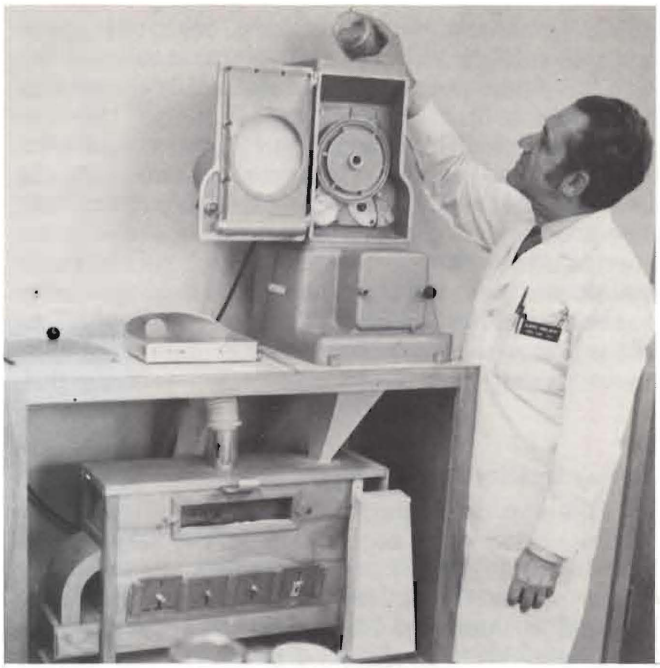
A project begun in June, 1975 is aimed at developing a rapid procedure to predict potential malting quality. This test, to be used in conjunction with the barley prediction series, would be utilized as early as the second generation of development. The relative amounts of the different size barley starch granules is the basis upon which malting potential would be predicted. This test would allow varieties showing poor malting potential to be discarded before the third or fourth generation of development. A savings in dollar and energy inputs would be realized.

Instrumental analysis of barley and malt total protein is being evaluated. This system would increase the speed and efficiency of quality analysis. Determination of wort nitrogen by automated chemical analysis is under investigation to further improve efficiency of variety development. These methodologies would allow more samples to be analyzed without increasing the present staff. Thus, initially high costs of equipment purchase would be recovered quickly because of the resultant increased capacity for quality testing.

Two on-going biochemical basic research problems are involved with studies of enzyme

systems that affect malt quality and brewing performance. Evaluation of these enzymes will allow increased economy during brewing, either through variety selection or altered processing control. One system under investigation controls the rate at which wort is able to be filtered. The faster the rate, the easier it is to control brewing and to obtain a higher production capacity. The second system controls the production of stale flavors in beer. Control of this system during malting and/or the beginning of brewing would result in a product having a longer shelf-life. Product control will be possible through practical application of these basic results.

Development of improved barley varieties for animal and human use are important research goals. High quality malting and feed barleys assure the North Dakota farmer a good economic return from his investment. Applied and basic research aids the state indirectly as the result of increased industrial efficiency of production and potential for profit. The incentive to purchase additional high quality North Dakota malting barley increases the financial return to the state.



Technician Slavko Vasiljevic demonstrates how the new durum processing unit for nursery samples works.

Spring Wheat Quality Studies

North Dakota is the major supplier of spring wheat in the United States for domestic use and export. The demand for high quality spring wheat has been shown more than ever this crop year through the payment of attractive protein premiums. The wheat quality research of the Department of Cereal Chemistry and Technology is conducted to maintain the quality edge of HRS wheat over other classes of bread wheat.

Considerable effort is put forth each year in evaluating the quality of plant breeders' samples. The department is ably assisted in this area by the USDA personnel of the regional HRS and Durum Wheat Quality Laboratory. Annually, nearly 6,000 HRS wheat samples submitted by North Dakota state plant breeders are evaluated for various quality properties associated with milling and baking. This total does not include the large number of samples evaluated by the USDA group.

In milling hard wheat to flour, there is wide variation in protein content in the various mill streams of a flour mill. The present commercial practice is to blend diverse flour streams into several grades of flour without trying to make use of the unique properties of individual streams. For these reasons, the mill streams of four HRS wheat varieties were investigated to see if the isolated protein of a stream might be especially useful in certain food products.

Gluten protein, which gives flour the ability to be baked into bread, was found to be uniformly distributed in the protein of all the mill streams except for the break streams of one poor-quality variety. Other fractions of the protein were not found to be different between streams. The amino acids composition was similar in the protein of all the streams and the nutritional value of the protein in each stream was also similar. Results of the study showed that the properties of the protein of different mill streams are similar. The main difference for food use of mill streams would be in the quantity of protein in the flour and not in its quality.

Carbohydrates present in pin-milled and air-classified fractions of different flour streams from different varieties of wheat are being examined for their effect on baking quality. Fractions of high, intermediate and low protein content are obtained by pin-milling and air-classification of flour. Very little information is available in the literature on the carbohydrates present in these flour fractions.

A baking investigation was conducted to study the physical dough properties and baking potential of various legume flours blended at different levels with a common lot of hard red spring wheat flour. The legumes used included mung bean, faba bean, navy bean, pinto bean and lentils. Bread containing up to 10 per cent of the legume flour generally had acceptable quality when sodium stearoyl-2-lactylate was incorporated into the bread formula. The legume flours did improve the crumb color of the bread when added at the 5 or 10 per cent level. The

Graduate student Sung-kon Kim determines the fatty acid composition of wheat fat on the gas chromatograph.

purpose of the legume flour bread study was conducted to determine if they can be used to supplement bread wheat flours. Future studies would be directed toward producing high protein bread from protein concentrates obtained from the legume flours.

Baking studies are being conducted to develop high protein bread products from high protein fractions obtained from oats and by using brewers spent grains.

Another area being investigated in the area of baking research is the problem of bread staling. The starch fraction of wheat flour is the prime factor responsible for bread staling. The components of starch are being examined to ascertain which component is primarily responsible. Other components including pentosans and proteins are being looked into to determine if these constituents are involved in bread staling. The possible utilization of starch derivatives in bread baking also is being examined.

In the applied area of bread baking, objective methods are being examined for bread evaluation including crumb color and crust color, as well as measurements related to the grain. A linear programming technique will be used to optimize the continuous bread baking process.

Several areas of investigation are being conducted in cereal carbohydrates. Pentosans, a carbohydrate material in wheat flour which represents 2 to 3 per cent of the flour, may have important implications in regard to rheological and baking properties. Studies in pentosans have been undertaken in the department for several years with the latest investigation being concerned with comparing the bran and endosperm pentosans.

Durum and Pasta Quality

During the past crop testing year, a total of 4,513 samples were evaluated in three major test series. There were 163 field plot samples, 650 micro-nursery samples and 3,700 prediction tests of early generation material (F_2-F_5)..

A new standard cooking test for spaghetti is being developed. Preliminary results, using statistical analysis of cooking data in conjunction with microscopic examination of thin sections of cooked spaghetti, indicate that the current time of 20 minutes is too long. It is anticipated that better quality data will be obtained with a shorter cooking time.

A micro-unit for producing durum semolina has been developed for nursery-sized samples. The unit employs a modified Brabender Quadramat Jr. mill and a small laboratory purifier. The unit is capable of producing purified semolina from durum wheat in one operation. Sample size can be varied from 50 to 500 g. A milling yield of over 50 per cent, uniform granular semolina with a low bran speck count can be obtained. The number of durum wheat samples that can be processed per man-day, as compared to the present system, has been increased 60 per cent (75 to 120 samples).

Examination of stained thin sections of durum wheat under the microscope showed that durum

Technician Linda MacArthur checks baking properties of bean flour blended with hard red spring wheat.

varieties respond differently to how protein is deposited in the kernel. Two durum varieties, Leeds and Rolette, quite similar in their external appearance and processing characteristics, were shown to have different interval structures, particularly with respect to the aleurone layer cells and protein deposition in these cells.

The project to develop a high protein, more nutritious pasta is nearing completion. Studies of individual protein combinations with durum semolina and the application of the linear programming techniques resulted in the development of 10 formulations. The protein content of each formula is at least 20 per cent, which was the minimum requirement of the project objective. The amino acid scores of the formulas indicate a good essential amino acid balance. However, protein efficiency ratios (PER) will be needed to determine the feeding value of the high protein pastas.

Consumer acceptance of several of the pasta formulas has been good. The results obtained from a test with the Fargo high school lunch program and a North Dakota homemakers group indicated a very acceptable product. Over 90 per cent of the questionnaires indicated satisfactory to excellent appearance, cooking properties, texture, taste and flavor as compared to the standard, all-wheat pasta. The consumer test indicated that nearly 60 per cent of the homemakers would pay up to six cents more per pound for the protein fortified product. This is well within the cost range of the product.

The work on developing an expanded snack food from durum wheat mill products is about completed. Wheat bran and dust (small wheat fragments) were blended with wheat starch, corn meal and isolated soy protein. The result was a high protein snack food with high fiber content. The essential amino acid content indicated a very nutritious product.

Corn meal is usually the main ingredient used to produce expanded snack foods. It was found that durum semolina could be used in place of corn to produce a product that had a more friable structure and was preferred to the corn meal product which retained the corn meal flavor.

The development of high protein pasta and fortified snack foods adds additional uses for durum wheat. These two food products should help the durum producer to maintain a high return for his production.

Shelterbelt and Shade Tree Insects

As part of the McIntyre-Stennis forestry research project, which is a state-federal matching funds program, studies are being conducted on the insect complexes associated with shelterbelts in North Dakota. Shelterbelt plantings have been praised and cursed; established and destroyed. An understanding of the complete role of shelterbelts in the agro-ecosystem and efficient means of protecting them is vital to the management of these man-made resources.

Studies are being conducted on the pest species of shelterbelt trees, beneficial species occurring in the shelterbelts and the role of shelterbelts as reservoirs for pest and beneficial insect species which are primarily active in the crops bordered by the shelterbelts. Interactions between shelterbelts and crops with regard to modification of moisture regimes, wind patterns, snow deposition and crop yields have been studied for many years. The alteration of insect complexes within the agro-ecosystem due to shelterbelt plantings has only recently been seen as a potential factor in crop production. A balance sheet of benefits and drawbacks will require the understanding of how shelterbelts contribute to the population levels of pest and beneficial insects.

Control trials on cankerworms in shelterbelts have been carried out for the past several years by members of the entomology staff. Insecticides applied aerially have been shown to reduce cankerworm numbers with subsequent easing of defoliation levels. Although cankerworms do not cause direct tree mortality, reduced vigor of defoliated trees contributes to mortality by other factors. With increased emphasis on single- or two-row belts, such tree mortality is considerably more important in reducing the effectiveness of belts for wind and snow regulation.

Dutch elm disease has been confirmed in several locations in North Dakota in recent years. During the past summer, a cooperative project between the Department of Entomology, the North Dakota Department of Agriculture and the U.S. Forest Service was initiated for detection and surveilance of the smaller European elm bark beetle. This species of beetle is an efficient vector of the disease and had not been recorded from North Dakota.

Pheromone (sex attractant) traps were placed throughout Fargo and in the Jamestown and Bismarck areas. The first record of this beetle was obtained in the Fargo trapping and the beetle seemed to be generally distributed in low numbers over the city. Subsequent records of the beetle came from the Bismarck trapping area. Although the native elm bark beetle, which is a common species, can also transmit the disease, early detection of this second species may provide some advantages in attempting to control the spread of the disease.

Livestock Insect Studies

Major livestock insect problems in the state include the horn fly, face fly, stable fly and house fly. Research is underway to evaluate current livestock insect control methods and to develop new techniques which may be more effective than currently used methods.

The face fly, *Musca autumnalis,* is a pest of cattle which is becoming more common in North Dakota. In addition to annoying the cattle and disturbing animals when feeding, it is implicated in the transmission of pinkeye in cattle and in the transmission of eyeworms. Because the females normally feed on exudates around the eyes and face of cattle, they can effectively transmit pinkeye from animal to animal.

The flies are very mobile and may disperse many miles from their emergence site. Male face flies do not usually feed on the cattle but instead are flower feeders; they can be collected easily from fence posts, logs, trees and shrubs along the edges of pastures. Ongoing field studies have shown that male flies feed on the wild sunflower, *Helianthus maximiliani;* a golden rod, *Solidago canadensis;* and leafy spurge, *Euphorbia esula.* Male face fly attraction to components from these plant species is being studied in the laboratory.

Male flies are selectively trapped in the field using screen discs coated with a sticky substance, Tanglefoot®. Trapping is being done to evaluate population fluctuations on a seasonal basis and to develop ways to study the habits of the male flies. Information gathered in this way may be used in the future for chemosterilizing male flies drawn to attractant plus chemosterilant baited traps. Sterilized male flies mating with the female flies present will produce no progeny and thus will reduce the fly population.

Estimates of facefly infestation levels secured through "Tanglefoot" traps at resting sites.

The female face fly feeds on manure fluids and on the exudates around the face of the cattle. She lays eggs on fresh manure usually less than five or six hours old. The larvae develop in the manure and reach the pupal stage in four to five days under ideal conditions. Larval physiology is being studied to determine effective ways of blocking larval development in manure. Animal feed additives which inhibit larval development derived through such studies may provide effective fly control.

Biological control of these livestock pests using insect pathogenic fungi in the genus *Entomophthora* is also under investigation. These fungi are specific to insects and many species of fungi are limited to only a few insect species which may serve as hosts. These organisms may prove to be effective and safe control agents for insects in the future, although there are many problems to overcome before they can be used effectively in the field.

House flies and stable flies are a problem around barns, premises and in feedlots. Research on these pests is designed to evaluate new pesticide treatments which may be more effective, more economical or safer than currently recommended practices.

Other livestock pests including cattle grubs and lice are also a concern, and research is aimed toward developing safe, effective, simple and economical controls for these pests.

Research on Grasshoppers

Grasshoppers have been a recurring problem on cultivated crops, pasture and rangelands throughout the history of North Dakota, but an understanding of the basic biology and ecology of these insects has been lacking.

More than 80 different species of grasshoppers live in North Dakota, each differing somewhat in distribution, habits and damage potential. By analyzing the crop (stomach) contents of grasshoppers from different habitats, the actual food plants selected by the different species was determined.

It was found that most species are very selective and eat only a few different kinds of plants out of the many available to them. Those species with a wide range of food plants, particularly when their host plant preference coincides with that of man, are the most damaging and their prosperity has been aided by the planting of large acreages of susceptible plants (corn, wheat, barley, etc.). Many species

are beneficial and feed only on undesirable plants. Grasshoppers are an important constituent of the prairie ecosystem, helping to harvest and break down plant nutrients to be returned to the soil and being part of the food chain for birds and mammals.

The behavior and physiology of host selection, how and why grasshoppers select particular plants to feed upon is important in developing management programs. The nutritional requirements of grasshoppers and how these are met by various plant species aid in understanding the relationships between grasshoppers and plants.

In addition to the direct damage caused by their feeding, great amounts of time, money and materials have been expended to control grasshopper infestations. The principal control agents used in recent years have been synthetic organic insecticides. These have been generally effective in reducing grasshopper populations and preventing the wide scale destruction that had been experienced prior to their usage. However, these compounds have some drawbacks and their continued use has been questioned. At the same time, it must be borne in mind that at present it does not appear possible to maintain the supply of high quality agricultural products without the use of some insect control agents.

The ideal of any insect control or pest management program has always been to have the maximum effect on the target insect and the minimum effect on all other organisms.

One approach to this ideal would be to develop and use extremely selective control agents that would affect only a particular species or even a particular stage of an insect. At the present time it is not really practical to anticipate the development or utilization of a traditional chemical insecticide of this type. However, there may be other possibilities for control agents. For example, work is being done on the development of Biological Control Organisms.

Another approach to the ideal would be to so selectively direct the application of the control agent that only the target organism would be affected, even employing broad-spectrum control agents.

The advantages of selective application, with baits or edible carriers are:

1. Less material (insecticide) is needed since less is lost or misdirected during application and more goes directly to the target organism.
2. Fewer non-target organisms are contacted by or affected by the control agent.
3. Selective suppression is possible. One may not desire to eradicate a population but only reduce its impact on the desired feature to be protected. Since grasshoppers are an integral part of the grasslands environment, their sudden and complete disappearance may have adverse side effects.
4. It may be possible to disperse materials as control agents, particularly biological organisms, that otherwise could not be effective.

Some of the specific problems associated with insecticide usage include the cost of materials, time and labor needed; toxicity to non-target insects; and toxicity to non-target birds and mammals.

Cost of control materials and labor for application have risen at a rate greater than that of the value of the land or commodities to be protected. Not all insects or even all grasshoppers are harmful in all habitats. Populations of pollinating and nectar gathering insects, parasites and predaceous insects, and other beneficial insects are often reduced as efforts are made to reduce the populations of target insects.

The effects of insecticides on other non-target organisms such as birds and mammals, and the accumulation of residues in food chains, including man's, have been the subject of much study and controversy. It is generally believed that decreasing the insecticidal content of the overall environment would be of benefit.

Based on a knowledge of grasshopper feeding behavior, edible carriers for grasshopper control agents and systems for distributing these are being developed. Control of grasshoppers has been achieved with 1/10 the amount of insecticide usually recommended and without affecting non-target organisms. Shredded newsprint paper with attractants and insecticides incorporated into it has been effective as an edible carrier.

Research in Horticulture and Forestry

Eighty acres of land for horticulture and forestry research was purchased on January 31, 1974. This land has a sandy loam soil and is located one and one-half miles east and one mile north of Absaraka, North Dakota.

The crop year of 1975 was primarily devoted to the cultivation of current floral and vegetable research plots, as well as planting additional permanent plantings in the tree fruits and woody ornamental blocks. These areas were the arboretum, small fruits (raspberries, strawberries, bush cherries, grapes) and tree fruits (apples, pears).

Permanent shelterbelt areas have been delineated. Ponderosa pine has been planted across the north edge of the farm, and a row of Siberian larch north and south along the east boundary. East-west windbreak divisions have been made east of the north-south plot road. This divides the east portion of the farm into six areas about three and one-half acres in size. Black walnut, bur oak, hackberry, Scotch pine and ponderosa pine are the species used in the windbreak plantings.

A plot road has been completed that is 300 feet in from the outside boundries of the land. It is situated so the greatest plot distance from the road is no more than 300 feet. There is a single entrance from the north.

This past year land was utilized for research studies by the Departments of Soils, Entomology, Plant Pathology and Agronomy and the Agronomy Seed Farm.

Hybrid Watermelons for North Dakota

Watermelons can now be produced in the northern tiers of counties of North Dakota by using techniques of transplanting, mulching, and frost protection perfected by Earl Scholz of the NDSU horticulture staff. Yields of up to 25 tons per acre have been demonstrated at the North Central Branch Experiment Station, Minot, and at the Towner SCS Nursery.

Two new early hybrid varieties, Yellow Baby and Family Fun, weighing 10 pounds and 15 pounds respectively, will mature during the first week of August — a crucial factor in commercial production since the market for watermelons extends only to the day when school opens.

Robin Olson, NDSU horticultural student, checks a "Family Fun" hybrid watermelon grown on plastic at Towner Nursery.

Horticulturist Neal Holland weighs an experimental squash.

New Vegetable Varieties

Two crops, tomatoes and squash, are major crops in the vegetable development area. These two crops are important in that they are commonly grown throughout the state. Materials that can mature under our short growing — long day season are necessary.

Tomato breeding has been in existence since 1922. Since that time, 19 cultivars have been released, the latest being Lark and Cannonball, in 1974. Selections are basically made for early maturing, high quality, non-cracking, large fruited types, borne on a determinate vine. Last year 99 segregating lines were grown. Five lines exhibiting uniformity were bulked. To compare developments and for adaptation to North Dakota conditions, observation trials from other sources are evaluated.

The squash breeding program has been in existence since the release of Buttercup in 1932. Today the program is based on the development of bush plants having fruits of about two to five pounds. This is important since less space is required in the planting area, and today people prefer the small family-sized fruits. Sixty-five segregating lines were grown in 1975, from which 17 lines were selected as exhibiting superior horticultural characteristics. New selections are tested for specific gravity, soluble solids and eating quality. Recent releases in the squash program have been Gold Nugget and Emerald.

Potato Introductions Add Income

The five potato varieties, Norland, Norgold Russet, Norchip, Viking and Bison, make up about 60 per cent of all potatoes produced in North Dakota. This is also true for the Red River Valley. With the North Dakota potato crop having an annual cash value of about $50 to $80 million, the NDSU potato introductions add about $30 to $50 million to the annual income of North Dakota.

The variety, Norchip, is now one of the leading chipping varieties in the U.S. and Canada and it is also grown in limited acreage in Europe and Mexico. Norgold Russet is one of the leading early russet varieties grown in Washington, Oregon, California and other western states. It is also grown in fairly large acreages in Wisconsin and other midwestern states. The new red-skinned variety, Bison, seems to be fairly well adapted to the Red River Valley and Wisconsin. Approximately 300 acres of certified Bison seed was produced in the Red River Valley during 1975, and by next season the variety should be found on the fresh table market.

Several new white skinned North Dakota selections are presently being increased for possible introduction. All of these new selections have good processing qualities, outstanding yielding ability and high total solids and some have outstanding disease resistance. In addition, two or three russet selections are also being increased. One of the russet selections has good chipping and french fry qualities.

Study Problems of Potato Culture

New cultural problems arise with the introduction of new potato varieties and changing technology. Also there are old problems that just persist and it is necessary to find ways to better cope with them. A wide range of problems involving irrigation, pesticide residues, fertility, hollow heart and weeds in potatoes are under study.

Irrigated potatoes account for about 1 per cent of the total acreage in North Dakota. Yields and quality of potatoes under irrigation are two factors that will figure prominently in the expansion of potato production in new irrigated areas. Work at the Oakes Irrigation Site showed marketable yields of potatoes should reach 350 hundred-weight with good cultural practices.

Cooperative work with the Department of Biochemistry has resulted in a tolerance being established for 2,4-D in potatoes. This work has permitted the continued use of 2,4-D in potatoes, and is valued at over $500,000 per acre to area growers.

Technician Bryce Farnsworth views some of the 40,000 to 50,000 seedlings grown in the greenhouse as part of the NDSU potato breeding program under the direction of Robert Johansen.

Recent work with the Department of Soils has resulted in more accurate recommendations for fertilizing potatoes. Utilization of this information can result in large scale savings on the 135,000 acres of potatoes in North Dakota.

One area that has been given added attention recently is potato weed control research. Direct and indirect costs due to weeds are probably costing potato growers over $6,000,000 in the Red River Valley. Weeds in potatoes have been mostly controlled by conventional tillage methods. It is hoped that current studies will show how these costs can be reduced.

Cultural studies in potatoes frequently involve an interdisciplinary approach. Cooperative work recently has beeen with the Departments of Biochemistry, Soils, Agricultural Engineering, Plant Pathology and the USDA.

Leaf Spots on Wheat

This study, begun in 1967, has revealed the following information and is exploring further into the nature and control of these foliar wheat diseases. Rigorous chemical control of severe fungal leaf spotting on wheat results in yield gains as high as 38.8 per cent, average 14.9 per cent. Control of severe spotting with two seasonal foliar applications of fungicide results in economic yield gains averaging 9.0 per cent. Leaf spotting is severe in growing seasons of moderate to excessive

Technician Robert MacArthur and plant pathologist Robert Hosford study leaf spot diseases of wheat.

precipitation and negligible in dry seasons. Gains from control in wet and dry seasons average 7.4 per cent, equal to 6.7 tons of wheat per 100 acres based on a 30-bushel per acre yield.

Currently, the yellow, tan to brown spots are caused principally by the fungi *Pyrenophora trichostoma* and *Leptosphaeria (Septoria) avenaria* f. sp. *triticea,* and in varying but usually minor degree by the fungi *Septoria nodorum, Helminthosporium sativum, Ascochyta tritici, Platyspora pentamera* and *Septoria tritici.* These fungi reproduce and overwinter on wheat straw and stubble and on certain other cereals and grasses. Their infective spores are carried long distances by wind.

Reduction of stubble reduces the number of spores and spotting but increases the danger of wind erosion. The reduction in foliar disease caused by reduction of stubble is often negated by windborne spores. Some crops, such as flax and oats, are immune to these fungi and are recommended where feasible for crop rotations and/or as wind barriers in strips in fallow fields. *Agropyron* grasses, used to prevent wind and water erosion, are unfortunately attacked by the *Pyrenophora.*

Many of our commercial wheats are susceptible to spotting by our principal leaf spotting fungi and even our more resistant wheats are severely spotted in prolonged wet weather. In our screening of wheats from all over the world we are finding a few wheats that are highly resistant to one or more of these fungi. These wheats are being incorporated into the breeding programs of the NDSU spring, winter and durum wheat breeders.

We are continuously screening promising wheats and NDSU breeding lines for resistance to these fungi. We are examining fungi and bacteria that are potential pathogens of wheat or that may be changing from minor to major pathogens. We have related resistance to wheat leaf spotting to the length of time the fungus is on wet leaves and are studying this phenomenon for better understanding and control of these diseases.

Slow Rusting of Spring Wheat

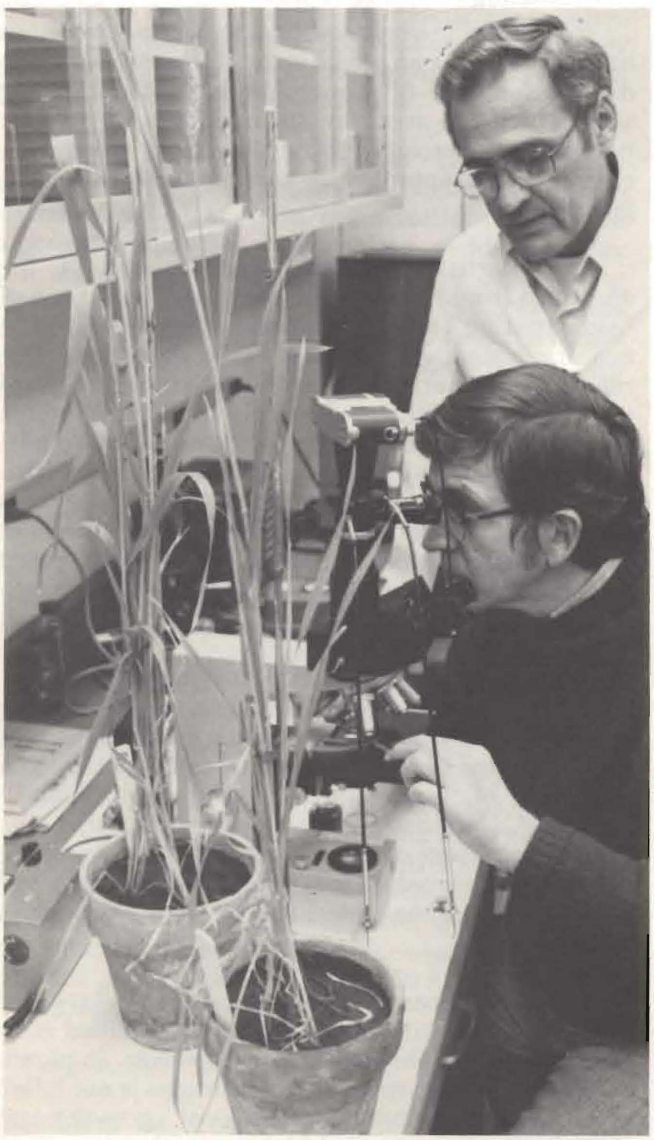
Race-specific resistance to stem rust infection has been used as an effective tool against stem rust disease for over 60 years. However, the rapidity with which the rust fungus can alter its genetic potential to overcome resistant varieties is forcing a change in our approach to control of stem rust by genetic means.

An alternative at the opposite end of the spectrum from race-specific resistance is the use of "slow rusting" wheats. In these wheats the rust is not eradicated, as in race-specific resistance, but rather it is reduced to a level that causes minimal yield loss. Our ultimate goal is to develop wheat varieties having combined specific resistance plus a background slow-rusting character. Wheat with slow rusting, non-race specific resistance plus race-specific resistance would give combined protection to the present races, protect against unexpected shifts in the rust population, and reduce the chance of a build-up of one race.

Wheats which exhibit slow rusting typically do not show a "breakdown" of resistance as do those possessing only the highly race specific resistance that is typical of most modern wheat varieties. The approach of using slow rusting more closely simulates the host-parasite relationship that has evolved in nature over millions of years as opposed to the rapid, man-directed evolution of the past half century that has resulted in numerous rust epidemics.

In plants possessing the race-specific type of resistance, the rust fungus typically is killed soon after entry into the host plant. However, in plants exhibiting slow rusting, the rust fungus is not killed upon entry; rather, its rate of growth and reproduction are retarded. Consequently, the rate at which rust develops in the field is slowed down, and the ultimate severity of infection is greatly decreased.

The nature of slow rusting is being studied in the Department of Plant Pathology, under the direction of Dr. James D. Miller, USDA, ARS and Dr. Larry Littlefield. Theirs is a combined field, greenhouse and laboratory study in which many experimental lines are being evaluated for the slow rusting characteristic. Genetic studies are underway to determine the number and nature of genes which control slow rusting. The manner in which the fungus is affected by the wheat, once inside the leaf, and the relationship between anatomy of the host tissues and the size and rate of development of rust pustules are being examined microscopically. The combination of these two individuals working on very different aspects of the same problem is an excellent example of the team approach to research used at NDSU. This is becoming increasingly necessary in our efforts to provide solutions to complex agricultural problems.



James Miller (standing) and Larry Littlefield (seated), Department of Plant Pathology, are photographing microscopic characteristics of a wheat which exhibits the slow rusting response to stem rust infection.

A Look at Soil Conditioners

Soil conditioners are not new to North Dakota, even though Dr. J.W. Bauder, soil physicist at NDSU, began field investigations with some soil conditioners and additives as recently as 1975. As part of a cooperative effort with Extension soils specialists, field plots were established at Oakes, N.D., to evaluate crop performance in the presence and absence of several so-called soil conditioners.

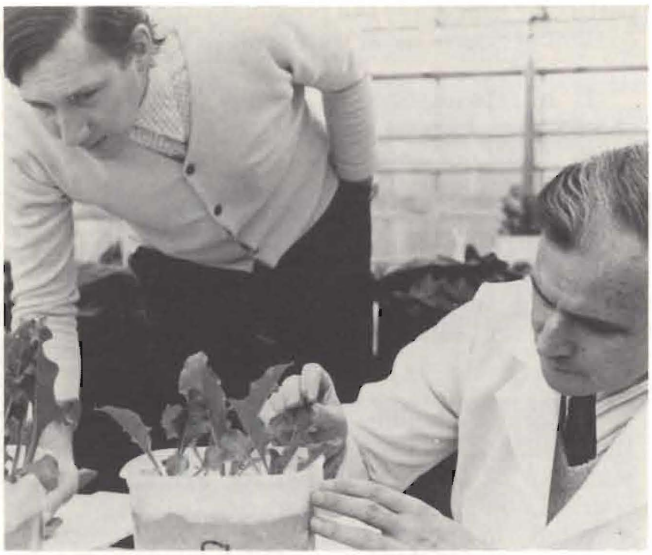
The rising cost of fuel has caused an increased concern for the efficient use of many of our resources, including fertilizer, water and machinery fuel. One means by which farm managers can offset rising fuel costs and other expenditures for inputs such as fertilizer and irrigation water is to implement management programs that contribute to maximum crop production.

Soil conditioner studies are being conducted with corn and wheat under both irrigated and dryland conditions. Field studies and greenhouse studies are being carried out to determine the possible benefits of so-called soil conditioners and to determine the efficiency of fertilizer use in association with soil conditioners. In addition to measuring crop performance, measurements are being made to determine the effect of conditioners on selected soil physical properties including soil structure (aggregate stability), soil water retention and surface water infiltration rates. All of these properties are important to a clear understanding of the possible benefits and application of soil conditioners.

Grain and silage corn grown in 1975 did not respond to nine soil conditioner treatments on either dryland or irrigated soils. The incorporation of N-P-K did not affect any response to soil conditioners, nor vice-versa. Soil water use patterns did not vary with conditioner treatments, even though irrigated plots had a higher water use efficiency than dryland plots. Greenhouse and laboratory studies are continuing during the winter months. These studies should help to provide some of the answers to questions relating to some soil conditioners and additives other than conventional fertilizer.

Research Involving Sugar Beets and Controlled Root Temperature

The growth of sugar beets early in the growing season in the Red River Valley is limited by low root temperature. Detailed studies in the greenhouse of factors influencing growth are consequently of restricted value unless soil temperature is controlled. To overcome this problem, pots containing sugar beets growing in soil are being placed in water baths regulated to temperatures from 45° to 75°F.



Graduate assistant Jorge Etchevers and soil scientist John Moraghan study phosphorus uptake by sugar beets at different root temperatures.

The reasons for slow sugar beet growth at low temperatures and the influence of root temperature on fertilizer-response patterns are under investigation. Such studies will hopefully provide information which will allow greater early season vigor in our commercially produced beets.

Fertilizer and Plant Population Investigations With Sunflowers

Field fertilizer trials are testing the effects of plant population and fertilizers applied to deficient soils upon seed yield and upon some seed quality factors of oil-type and nonoil-type sunflower cultivars.

Sunflower growers want to produce large yields of oil-type seeds with high oil concentration and large yields of nonoil-type seeds with a large percentage of large size seeds. However, average yields of both sunflower types are usually below 2,000 pounds of seed per acre. The low yields probably result from one or more of the following: incorrect plant density, inadequate soil fertility, inadequate or excess moisture, late planting, weed competition, disease, insect damage, herbicide damage. bird depredation, lodging and harvesting losses.

Data from field experiments conducted thus far indicate that both yield and some quality factors of seeds are affected by plant population and by fertilizers. Nitrogen fertilizer increased seed yield, head size, oil yield from oil-type cultivars and percentage of large-size seeds from non-oil type cultivars. However, nitrogen fertilizer reduced oil concentration of oil-type seeds. Increased seed yield to nitrogen offset the decreased oil concentration so that oil yields per acre were increased by nitrogen at all locations.

Yield responses to nitrogen were obtained at all locations tested because soil tests for nitrate-nitrogen to a two-foot depth were medium or lower. Phosphorus fertilizer failed to increase seed yields at several locations where soil tests indicated a response should be obtained. Potassium fertilizer produced no yield responses and had no effect on seed quality of both sunflower types. Soil test levels for potassium were high or very high at all locations where potash was tested.

Increasing plant population to 19,000 plants per acre for nonoil-type and to 29,000 plants per acre for oil-type cultivars increased seed yield, yield of oil from oil-type cultivars, and percentage of smaller seeds from nonoil-type cultivars. Increasing plant population reduced head size and percentage of large-sized seeds of nonoil-type cultivars. Plant population had little effect on oil percentage of oil-type seeds.

The data obtained from these experiments are useful for improving recommendations on cultural practices for producing larger yields of sunflower seeds having acceptible quality factors.

Soil and Water Management Studies at Oakes, N.D.

The Department of Soils is continuing studies on soil and water management at the Titus site (Sec. 17 T13ON-R57W), Oakes, N.D. One basic objective of this research is to measure yield potential of different crops grown under various cropping sequences and under varying water and fertilizer levels. Another is to measure plant uptake of fertilizer nutrients and movement of fertilizers and soluble salts in the soil profile as affected by fertilization, irrigation and management practices including kind of fertilizer, rate and time of application and amount of irrigation water applied. A third objective is to measure water use efficiency by crops grown under varying water and fertilizer treatments.

Nitrogen, phosphorus, potassium and in some cases zinc have been shown to limit crop yields on sandy soils such as those in the Oakes area. Yield responses by various crops to these nutrients have been reported. Because irrigation increases yield potential of crops, additional information must be developed on fertilizer practices required to optimize crop yields and minimize nutrient losses or transfers from the soil profile.

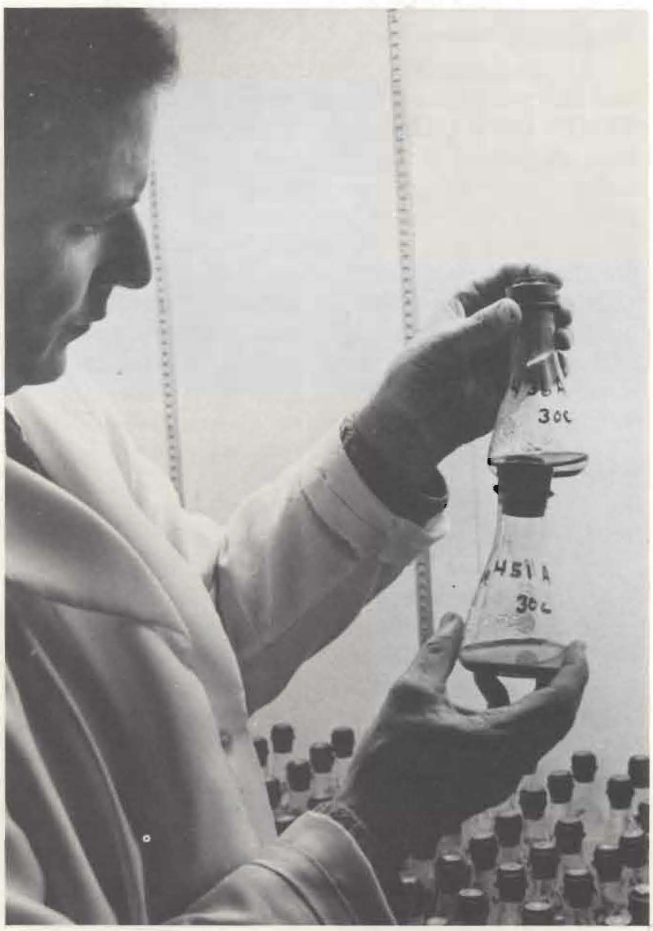
There is a definite need to evaluate methods for increasing fertilizer efficiency, for determining the fate of applied nutrients in the soil, for studying the chemistry and transport of nutrients and soluble salts, for evaluating the amount of recycling of plant nutrient elements within the soil profile by various crops, and for evaluating management

practices that increase the efficiency of water use while maintaining optimum crop yields.

Personnel of the Department of Soils who are conducting research at the Oakes site include Dr. J.C. Zubriski, professor of soils, Dr. J.W. Bauder, assistant professor of soils, Terrance Krueger, assistant in soils and L.L. Huether, technician. The kinds of projects that were conducted in 1975 are alfalfa-water level-fertility trial, corn-soil conditioner trial, corn-nitrogen source and rate trial, wheat-variety-nitrogen rate trial, and continuous corn-water level-nitrogen rate and time of application trial. Soil and plant samples have been obtained several times during the growing season from these trials. Analyses of the data obtained from these and future trials should provide answers to the objectives of this research.

Research Involving Return Flow Water and Garrison Diversion

Canadian officials have expressed apprehension that return flow waters associated with the Souris Loop section of the Garrison Diversion Unit will be contaminated with excessive levels of salts. Of particular concern is the possibility that the nitrate content of Souris River water will be increased.



Soil scientist John Moraghan is studying the stability of nitrate in return flow waters of the Middle Souris area of the Garrison Diversion Unit.

If nitrate-nitrogen, a readily leachable form, should pass beyond the rooting zone of irrigated crops it will not necessarily reach the tile-drainage system. Denitrification is a natural process which can convert nitrate to harmless gases. Whether in fact denitrification occurs in a particular environment will be dependent upon a number of factors including temperature, oxygen level and the presence of suitable organisms and an energy source.

Laboratory studies are in progress to determine the likelihood that different horizons of soils representative of those proposed for irrigation in the Souris Loop area will support denitrification. Soils collected in cooperation with the Bureau of Reclamation during the fall of 1975 are being incubated under anaerobic conditions and the fate of nitrate is being determined. The combination of such studies and of chemical analyses of the soils will aid in assessing the likelihood of nitrate pollution of return flow waters. This research is being financed by a grant from the Bureau of Reclamation.

Quality of Irrigation Return Flow Water

Irrigation agriculture is not new to North Dakota. For many years private enterprise and government agencies have been developing irrigation in the upper Great Plains. At the same time irrigation has developed in other areas of the United States.

Irrigation is somewhat unique in North Dakota because the irrigation water is a supplement to natural rainfall rather than a replacement for rainfall as it is in many arid regions. The uniqueness of irrigation results in a uniqueness of associated concerns, one of which is the quality of irrigation return flow water. Return flow water is that portion of rainfall and irrigation water which is neither stored in the soil nor used by the crop, but eventually is returned to water bodies and conveyance systems by means of deep percolation.

Existing research in irrigation return flow involves studies of many aspects of soil water movement. One of the first aspects to be considered in such studies is the efficient management of irrigation practices to attain optimum crop production. The amount and timing of irrigation events are critically important. Irrigation management programs are upgraded continuously. New studies are continuously being initiated to evaluate the physical and chemical suitability of particular soil types for irrigation.

Another phase of irrigation return flow studies is the movement of irrigation water through the soil profile, beyond the crop root zone and into the water table. The rate and quality of so-called through flow are evaluated to quantify the impact of fertilizer leaching beyond the root zone. Percolating water also leaches salts from the soil into the water table. These salts and fertilizer constituents in turn may contribute to the deterioration of ground water quality. Hence the quality of irrigation return flow is heavily dependent on efficient irrigation management.

The third, and sometimes most important phase of irrigation return flow studies, is the characterization of salts and nutrients moving beyond the root zone and into return flow streams. Studies are being conducted to quantify and qualify the salt load of deep percolation water. The amounts and types of dissolved solutes in drainage water entering ground water reservoirs need to be described.

The need for a better understanding of irrigation return flow becomes evident as increasing amounts of land are incorporated into irrigation projects and districts in North Dakota.

Soil Surveys in Organized Irrigation Districts

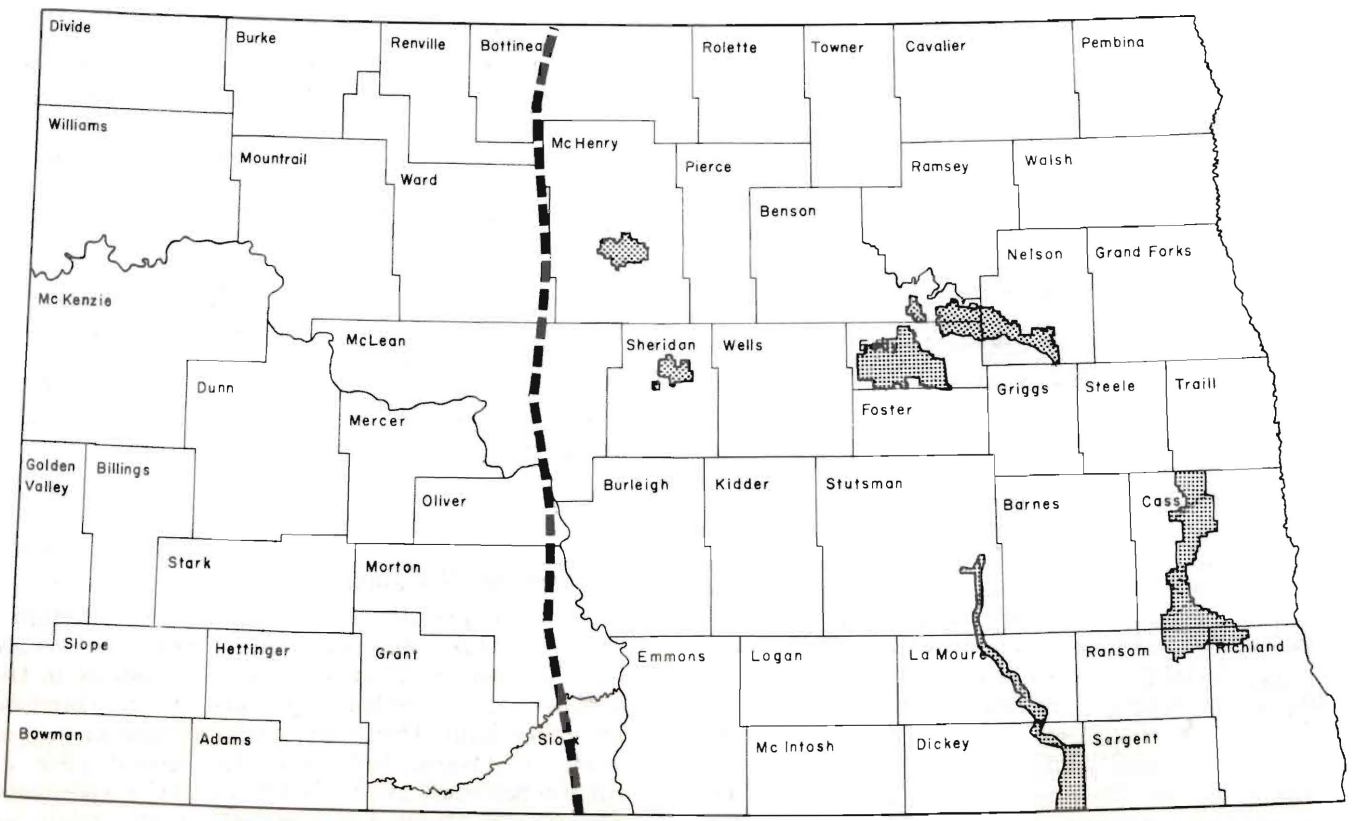
The soil survey staff of the North Dakota Agricultural Experiment Station began making detailed soil surveys of organized irrigation districts in 1956. Small areas outside the organized districts have also been mapped.

The objectives are to complete and publish detailed soil surveys of potentially irrigable lands in North Dakota, and to evaluate the soils as to their suitability for irrigation and predict soil behavior and response to irrigation management.

Standard soil survey procedures and the soil classification system of the National Cooperative Soil Survey are followed. These procedures include initial field reviews to classify the soils in the survey area, progress field reviews during the course of the survey to resolve problems and maintain quality, a final field review of the quality and adequacy of the survey and a final correlation to place the soils properly in the classification system. The surveys are made in cooperation with the Soil Conservation Service, and correlators of their soil survey staff correlate the surveys.

Field and laboratory determinations concerning soil properties necessary for soil characterization are performed by members of the Department of Soils and its laboratories.

Each survey provides a classification of the soils, their location and extent. It serves as a base



Soil surveys completed in organized irrigation districts.

for predicting the behavior of each kind of soil under defined situations.

Following is the current status of soil surveys in organized irrigation districts.

Tri-County district in Cass, Ransom and Richland counties; approximately 274,000 acres. "Soil Survey of Tri-County Area, North Dakota."

LaMoure district in LaMoure and Stutsman counties and West Oakes district in Dickey county; approximately 127,000 acres. "Soil Survey of LaMoure County and Parts of James River Valley, North Dakota."

Warwick-McVille district in Benson, Eddy and Nelson counties and New Rockford district in Eddy county; approximately 301,000 acres. "Soil Survey of Eddy County and Parts of Benson and Nelson Counties, North Dakota."

Lincoln Valley district in Sheridan county; approximately 29,000 acres. "Soil Survey of Lincoln Valley Area, North Dakota." Mimeographed report.

Karlsruhe district in McHenry county; approximately 48,000 acres. Soil survey completed and maps available at Soil Conservation Service district offices in Towner and Velva.

Middle Souris district in McHenry county. Soil survey in progress; completed maps available at Soil Conservation Service district office in Towner.

Mouse River district in McHenry country. Soil survey to begin when soil survey of Middle Souris district is completed.

The progress of the surveys depends on the size of the survey party and commitments to other projects. Necessary and essential field and laboratory studies of the soils will continue. Inquiries should be sent to M. D. Sweeney, associate professor, Department of Soils, North Dakota State University, Fargo, N.D.

Dryland and Irrigated Crop Production (Carrington)

In 1975, the early part of the growing season was cool and wet causing a three-week delay in spring planting. Small grains looked exceptionally good until it turned hot and dry in early July. Though this reduced production, yields were above average. Irrigated yields of spring wheat and durum were only 25 per cent greater than on dryland. Sunflowers, corn and pinto bean yields were about average on both dryland and irrigation. The dry, cool August limited the production of these crops, but irrigated crop yields were 50 to 100 per cent greater than on dryland.

Herbicide trials evaluating wild oat control materials in wheat and pigeon grass in flax demonstrated the potential value of several herbicides. HOE 23408 was very effective in controlling wild oats in wheat. Both Treflan and Eptam provided effective pigeon grass control in flax and increased yields by 70 to 80 per cent.

Ferma-Lizer, a product marketed as a growth stimulant, did not increase yields when applied to either the seed, the foliage, or both on durum, hard wheat and barley.

Irrigation Methods Utilizing Both Gravity and Sprinkler (Carrington)

This project studies the influence of irrigation on ground water levels and the operation and maintenance requirements of center pivot sprinkler systems. Sprinklers are used to irrigate 300 acres and gravity systems to irrigate 120 acres on the station. All irrigation water applied is measured on each field.

In 1975 the irrigation season did not begin until July because of the abundant precipitation prior to that time. This reduced irrigation water needs about 20 per cent below previous years. However, some high use crops such as alfalfa required near normal amounts of supplemental irrigation water. Crop yield response to irrigation was very evident, but to a less degree than in most previous years. Wheat was increased 8 to 10 bushels, sunflowers 600 pounds per acre and pinto beans were increased 1,000 pounds per acre. Dryland small grain yields were produced on fallow which allows only alternate year production as contrasted with continuous cropping on irrigation. This should not be overlooked when making irrigated versus dryland comparisons.

Ground water levels were unusually low at freeze-up despite the wet spring. The very limited fall precipitation undoubtedly was a factor. Ground water elevations are significant for they relate to drainage needs and deep percolation losses under irrigation.

Irrigated Crop Production Experiments (Carrington)

These experiments are conducted at off-station sites near Oakes and Karlsruhe. These locations are used to measure crop response to irrigation in the southern and northern sections of the Garrison Diversion Unit. This is the sixth consecutive year of trials at Oakes, but only the second year at Karlsruhe. Staff at the North Central Experiment Station in Minot are conducting the trials at Karlsruhe. At Oakes, such crops as corn, soybeans,

sorghum grain and forage, sugar beets and alfalfa that are responsive to warm temperatures have consistently demonstrated excellent yield potentials under irrigation. At Karlsruhe, production of all crops has been equal to or near anticipated levels.

Soils at both sites have sandy textured profiles and thus limited water-holding capacities. Careful water management requiring frequent irrigation is essential. These soils are extremely susceptible to drought periods that limit production. Irrigated crop yields are usually two to four times greater than on adjacent dryland.

Farmers in the respective areas have noted the very positive response to irrigation and have been quick to initiate private irrigation development. At Oakes, the number of center pivot irrigation systems has increased from just three to over 60 in the last three years. In the Karlsruhe vicinity at least six new systems were installed this past season. Only a very limited ground water supply is restricting irrigation development in both areas.

Irrigated Forage Crops in Beef Production (Carrington)

The station's herd of 120 cows is divided into two management groups. Thirty cows with calves are kept in drylot continuously and fed silage and hay. The remaining 90 cows graze irrigated pastures from late May to mid-September and then return to drylot. Pasture gains, reproductive efficiency, disease and management problems, feed consumption, forage utilization and production are some of the measurements made. Three years data has now been accumulated and is being summarized for publication.

The cows after weaning their calves are continued on various winter maintenance rations that compare the relative feeding values of irrigated forages and crop residues.

Calves weaned in October are grown on various high roughage rations with and without grain concentrate until March when marketed as feeders or continued on finishing rations. This is the first year steers have been in a finishing trial comparing an all-roughage (corn silage and alfalfa hay) ration with roughage plus a moderate amount of rolled barley. Feed costs, rate of gain, carcass yield and grade information and other data will be summarized upon completion of the trial.

Liquid Whey in Swine Rations (Dickinson)

The disposal of liquid whey, a by-product of cheese manufacture, has been a problem. Its resistance to decomposition in sewage systems has made it necessary to find other means of disposal. Its use as fertilizer is of limited value, but it can be used to provide protein in swine rations.

Dickinson Experiment Station researchers designed a trial to investigate the use of liquid whey as a supplement in swine finishing rations. In the experiment, whey, soybean oilmeal and lysine were compared as supplements to a basic barley and oats finishing ration.

The whey was picked up from a local cheese plant daily, stored in a fiberglass tank and was self-fed in the sour form through a gravity flow system and nipple waterers. Pigs receiving whey were not allowed water after the second week, their entire liquid intake coming from whey. Consumption of whey was roughly three gallons per pig per day.

Three years of data indicate that pigs can be raised to slaughter weights efficiently and economically when using liquid whey as a protein supplement.

Beef Production from Grass (Dickinson)

A three-pasture grazing system utilizing crested wheatgrass for spring and early summer grazing, native grass during mid and late summer, and Russian wildrye for fall grazing has been studied at the Dickinson Branch Experiment Station. With all of the pastures fertilized, beef production with yearling steers has averaged 95 pounds per acre. When only the Russian wildrye pasture was fertilized in the system, beef production averaged 65 pounds per acre. The average length of the grazing period on the pastures has been 160 days.

Best gains have been made on the crested wheatgrass and native grass pastures in the spring and summer with lower gains on the Russian wildrye in the fall. Steers on the crested wheatgrass pastures have showed an average daily gain of 1.61 pounds per head and on native grass 1.57 pounds. Over the average period of 43 days on Russian wildrye, daily gains per head have been 1.26 pounds, with gains being sharply reduced near the end of the grazing period, when cold weather and snow occurred. The average weight of the animals coming off pasture at the end of the season has been about 820 pounds per head.

Grazing capacity of the pastures has been substantially increased by the fertilization treatments which have involved 50 pounds of nitrogen each year on the crested wheatgrass and native grass pastures and the nitrogen plus phosphorus on the Russian wildrye. The season-long allowance on the fertilized pastures has been 2.3 acres per steer, while on the unfertilized pastures a total of 3.5 acres per steer has been required.

Hill versus Row Planting of Wheat (Minot)

Research at the North Central Experiment Station at Minot was conducted from 1969 through 1972, comparing wheat planted in hills to the conventional method of planting wheat in rows. Hill planting was previously evaluated in Italy (Forneris).[1] Results showed that hill planted wheat produced more than wheat planted by the conventional method. The station conducted a similiar trial.

Because there was no equipment available to plant the trial mechanically, the wheat was planted by hand. Row-planted wheat was compared to wheat planted in eight-inch spaced hills and four-inch spaced hills. The seeding rates were varied from 30 pounds per acre to 120 pounds per acre. The conventional planted wheat had rows eight inches apart and seed one inch apart in the row. This seeding rate would approximate 60 pounds per acre depending on the size of the seed. Both a normal height wheat variety (Waldron) and a semi-dwarf variety (Wisc. 271) were included in the trial.

Results are presented in Tables 1 and 2, where yield is recorded in bushels per acre.

Table 1. Hill Vs. Row Planting of Wheat, Minot (1969-72)

Seeds No.	Spacing Ins.	4 Yr. Avg. bus/A	Percent of No. 1
Normal Height			
1*	1 x 8 row	37.2	100
1	2 x 8 row	30.4	82
4	8 x8 hills	33.3	90
2	4 x 4 hills	41.2	111
4	4 x 4 hills	48.8	131
Semi-dwarf			
1*	1 x 8 row	44.7	100
1	2 x 8 row	40.9	92
4	8 x 8 hills	41.7	93
2	4 x 4 hills	47.4	106
4	4 x 4 hills	57.5	129

*conventional method of planting wheat

The yield of wheat from the plots where four seeds were planted in hills four inches apart showed a 30 percent increase in yield over the conventional method of planting wheat. Other crop measurements were also determined from each treatment. Plants in hills four inches apart were slightly shorter. Test weight and 1000 kernel weight were nearly the same for all treatments.

[1]*Forneris, Franco. 1964. Cultivation of cereals, applying the A. Forneris method with a modern precision drill. Italian National Journal of Agriculture, No. 9.*

Table 2. Hill Vs. Row Planting of Wheat, Minot (1969-72)

Seeds No.	Spacing Ins.	4 Yr. Avg. bus/A	Percent of No. 1
1*	1 x 8	41.0	100
1	2 x 8	35.7	87
4	8 x 8	37.5	92
2	4 x 4	44.3	108
4	4 x 4	53.2	130

*conventional planting method

Summary

Results indicate a 30 percent increase in yield from planting wheat in hills four inches apart with four seeds per hill. From the initial research, results would indicate the need for equipment to plant wheat in hills for further testing to substantiate these findings.

Cropping Systems and Tall Wheatgrass Barriers (Williston)

A research project has been initiated at the Williston Branch Experiment Station to determine if tall wheatgrass planted in rows spaced 50 feet apart in a field can effectively trap and hold snow which could be utilized to increase soil moisture for more intensive cropping. Results from areas in Montana where the grass barriers are being utilized indicate that the trapped snow added enough additional moisture to the soil to continuously crop the areas between the barriers and obtain yields of wheat that were better than wheat yields from fallow on a yearly basis.

Use of the barriers could increase and help stabilize production from a more intensive cropping

Tall wheatgrass barriers trap and spread out the snow cover at the Williston Branch Station.

system and to reduce the traditional summerfallow acreage. Reduced summerfallow acreage would be desirable for several reasons. The practice of fallow has been identified as the principal cause of saline seeps which are adversely affecting several thousand cropland acres in this area. Soil and water erosion have always been a serious problem in the management of summerfallow; cropping would protect more land from erosion. Higher land and production costs have prompted many farmers to more intensively crop their land for greater economic return from their cropland acreage.

Establishing tall wheatgrass is relatively easy. At the Station, two rows, 36 inches apart, with a spacing of 50 feet between each set of rows, were seeded with a disk press drill in late August on fallow land. Seeding can be done in early spring or late fall if more convenient. The spacing between the rows could also be changed somewhat to more conveniently match farm machinery size, but the maximum width should not exceed 50 feet. The barriers have protected soil from wind erosion and deposited snow up to a distance of 12 times the height of the barrier. As tall wheatgrass normally attains a height of 4 feet, the protection afforded is about 50 feet.

There are some precautions in the use of these barriers. One is the danger of water erosion from snow melt on heavier soils on sloping land. This should not be a problem on the lighter, sandier soils. Another problem with barriers: they could serve as host plants which could spread various types of plant disease to small grain crops. Further evaluation for crop performance should help to provide some answers to the effect of diseases on intensive cropping within a grass barrier system.

Safflower Improvement (Williston)

Safflower provides an alternate crop for small grains under dryland conditions in western North Dakota and eastern Montana. Cultural practices that have been or are being investigated include rate, date and depth of planting, row spacing, weed control, fertilization, disease control by fungicides and harvesting procedures. From these investigations some production guidelines have been established.

Herbicides, if properly used, control most grassy weeds in safflower. In small grains, approved herbicides control most broadleaf weed species. Thus, including safflower in crop rotations enhances yields of small grains by controlling grassy weeds and by disrupting the cycle of certain small grain diseases.

Other results indicate that ideal planting rate for safflower is 15 or 20 pounds per acre. Early May is best planting date, and because safflower has a long growing season, planting later than May 20 is hazardous. Proper fertilization is important and safflower response to nitrogen and phosphorous fertilization is similiar to that of spring grains. Safflower production is especially beneficial on dryland areas where a deep rooted, long season, annual crop is needed to extract surplus moisture from recharge areas that contribute to saline seeps.

Neil Riveland, assistant agronomist at the Williston Branch Station, inspects safflower development in the experimental plot.

Alternaria leaf spot caused by the fungus *Alternaria carthami* is the most serious disease of safflower in the western North Dakota-eastern Montana area. The disease may reduce seed yields and seed quality when extended periods of rain, dew, or fog conditions occur during flowering and ripening. Present varieties are susceptible to this disease. However, a safflower breeding program is currently underway at the Eastern Agricultural Research Center at Sidney, Montana, and cooperatively at the Williston Branch Experiment Station on a limited basis, to develop lines that have *Alternaria* leaf spot resistance plus high oil-yielding ability. Progress thus far includes the development and agronomic evaluation of safflower lines that have adequate resistance to *Alternaria* leaf spots, and excellent yield potential and acceptable oil content.

Drip Irrigation for North Dakota Gardens (Williston)

Drip or trickle irrigation is a relatively new system for applying water to orchards, vegetables

The trickle irrigation tubing at work in a row of tomatoes at the Williston Branch Station.

and fruit crops that may have potential for home gardens in North Dakota. The system is becoming widely used in California to irrigate orchards, vineyards, melons, strawberries and other vegetable and fruit crops. This system of irrigating requires much less water than the older systems and operates somewhat differently. Water is delivered to the crop through plastic tubes placed on the soil surface or, in some cases, buried at a shallow depth. The tubing has small perforations or mechanical devices called emitters located at regular intervals or selected points along the tubing which deliver small quantities of water under low pressure to the crop. The irrigations are frequent light applications of such duration to avoid excessive wetness in the soil. Only the area where the crops are grown is irrigated, the area between the rows remains dry.

A drip irrigation system was installed at the Williston Branch Experiment Station in 1974 to irrigate a garden vegetable variety trial. The system used Dow Trickle Irrigation tubing which was placed on the soil surface in the vegetable rows. Water was delivered to the system from the station's well through a storage tank, a pressure reducing valve and a screen. The system required water at about three gallons per minute and 10 pounds of pressure. The trial was irrigated during the season on a regular basis except during times when normal rainfall provided adequate moisture. Although no yield records were kept on the vegetable production in 1974 and 1975, the results were obvious and the yields were greatly increased by the irrigation system. All the vegetables responded well to the irrigation water. The tomatoes yielded exceptionally well; peas and beans produced very well over a much longer period of time than in dryland gardens. Later season vegetables such as squash, pumpkin, watermelon and cantalope yielded well and were of good size and quality.

Another advantage of this irrigation system is that less weeding is necessary in the garden. As the water is only applied in the row, the area between rows is dry and consequently has less weed growth. One of the disadvantages to the system is that the water used for irrigating must be clean and of good quality. A filtering system or series of screens must be used where the water contains sand or other impurities that would plug the perforations or emitters on the tubing.

With a modest investment in drip irrigation equipment, the production from a family garden can be greatly increased. Low water requirements make it possible for many farms with low-yield wells to irrigate a garden without overusing the farm water supply.