MINNESOTA

Vol. 54, No. 1, Spring 2002 **Agricultural Experiment Station** **University of Minnesota**

SCIENCE

DELICATE WORK

Growing Azaleas in Minnesota

The azalea's delicate-looking blooms appear as fragile harbingers of spring in Minnesota. But frail as they appear, the perennial azaleas developed by the U of M are obviously much tougher than their ubiquitous southern counterparts.

The release of 'Northern Lights' in 1978 was the culmination of farsighted efforts: 28 years of crosses and tests to insure hardiness started by researchers Al Johnson and Leon Snyder. Plants differ greatly in their hardiness, or ability to grow and thrive in a given climate. Generally, the more southern the seed source, the less hardy the plant will be. And azaleas were southern, until then. "It was exciting for northern gardeners, and a noteworthy achievement for the University," says Harold Pellett, who has headed the Agricultural Experiment Station funded research since 1978.

'Tri Lights' azalea—a coming attraction

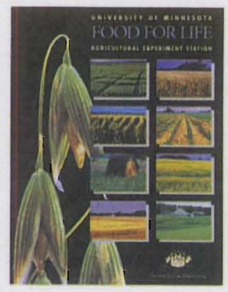
The success of 'Northern Lights' as a fully hardy azalea led to other breakthrough adaptations. In 1984, two new releases, 'Pink Lights' and 'Rosy Lights' showed success in varying color. Since then eight other azaleas have been introduced, in colors from white to salmon to yellow, and with various desirable characteristics—"compact," "extremely floriferous," or "greater mildew resistance." "The first criterion was hardiness," said Pellett. "Once that was achieved, we started looking for other genetically determined qualities such as color range, plant foliage, disease resistance, and flower quality." The newest release, set for spring of 2003, is the first azalea to incorporate three colors, appropriately named 'Tri Lights.'

"The development of new characteristics can happen faster now, because we know more about the parents," says Pellett. In the beginning there were very few people involved and there was limited knowledge about, for example, whether the plants would self-pollinate or not. Now, researchers have learned which techniques to use to make crosses, and can do more predictable manipulations.

That said, developing a new, reliable variety still takes years, because plants have to

AZALEAS *continued on back page*

INSIDE



FOOD FOR LIFE

Included in this issue is a history of agronomic crops developed by researchers of the Minnesota Agricultural Experiment Station. The information was gathered to commemorate the Sesquicentennial of the University of Minnesota, 1851–2001.

FACING A CENTURY-OLD DISEASE

Major Steps Toward Detection and Control of Johne's in Cows

Several interrelated projects by the Minnesota Johne's Working Group (a multidisciplinary group of researchers and diagnosticians at the University of Minnesota, College of Veterinary Medicine, in collaboration with the Minnesota Board of Animal Health) are addressing the challenge of control of Johne's disease, supported by the Agricultural Experiment Station, Rapid Response funding from the state legislature, and USDA funding.

Kay Faaberg leads a team in the Minnesota Veterinary Diagnostic Laboratory developing a quicker Johne's detection test.

Johne's disease (pronounced Yo-knees) has been known to afflict cattle since 1895. It disrupts nutrient absorption, leading to chronic weight loss and eventual death. There is no effective treatment for Johne's. Because current testing detects the agent only in later stages of the disease, after a cow is two to three years old—and most farmers purchase cattle to add to their herds each year—it has spread worldwide, according to veterinary epidemiologist Scott Wells.

The economic impact in Minnesota—the nation's fifth highest producing dairy state—is high, because Johne's disease reduces milk production and shortens the productive life of cattle. Minnesota's dairy industry generates over $1 billion each year in income from milk production. Beef production from dairy and beef cattle operations generates another $800 million. Annual

Faaberg, a molecular biologist, leads a team working to develop a quicker test. The group has already developed and evaluated an experimental DNA-based polymerase chain reaction (PCR) test. With additional funding, an improved DNA-based PCR test will be developed using information from the Kapur sequencing project. When perfected, a

role of wildlife (deer and rabbits) and the environment in the transmission of Johne's involves 90 dairy farms.

Two Minnesota dairy farms are being monitored to evaluate factors related to the onset of fecal shedding and clinical disease. The goals are to identify management practices that could slow the onset of clinical disease in infected herds and to estimate the cost of the disease.

RAPID RESPONSE FUND TARGETS MAJOR ISSUES

The Minnesota State Legislature provides special funding to address urgent issues challenging Minnesota. In addition to the ongoing research on Johne's disease reported on here, these University research projects received funding through the Rapid Agricultural Response Fund:

- Disease and Insect Resistant Potatoes
- Soil Pathogens in Irrigated Dry Beans
- Soybean Aphids
- Anthrax Patterns in Minnesota
- New Kentucky Bluegrass and Perennial Ryegrass
- Best Use of Drugs in Dairy Herds
- Early Warning Diagnostic System for Swine
- Alternative Swine Production Systems
- Microbial Safety of Organic Produce
- Potato Disease Prevention
- Restoring Native Legumes
- PRRS Virus in Swine
- Turkey Respiratory Disease

Details of these projects will appear in Minnesota Science, or may be checked at www.rapidresponse.umn.edu mated at over $200 per cow.

While the scientific evidence for related disease in humans is not strong, concern has arisen that *M. paratuberculosis*, the bacteria causing Johne's disease, may be a cause of Crohn's disease in humans.

Wells estimates more than half of Minnesota's dairy herds have infected cattle, many with over one-fourth of their cattle diseased. Typically, infected animals are removed from the herd as soon as signs of the disease appear, but due to ongoing expansion of dairy herds, the disease is spreading rapidly. "The bottom line is that it is a difficult disease to study," says Wells. "There is a two- to five-year incubation period from infection to disease onset."

Research Goals

Researchers are looking for earlier and faster ways to detect the disease. Genomics researcher Vivek Kapur is leading the team working to sequence the genome of *M. paratuberculosis*, key to both improved diagnostic tests and development of a vaccine. The group has already identified several unique DNA sequences that could lead to new tests.

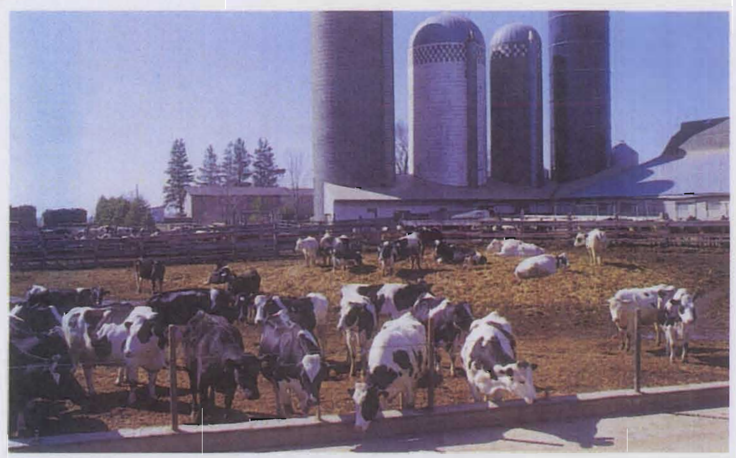
Improved diagnostic tests that rapidly detect the pathogen in individual animals and herds will support herd monitoring and control efforts. Currently, culturing results take 16 weeks. Kay

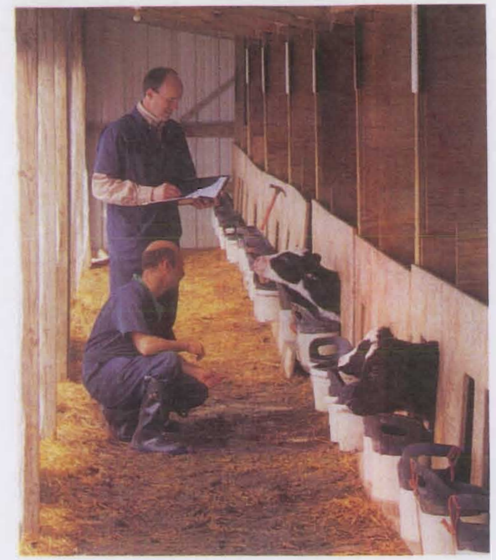
tion of Johne's within two days.

A group led by veterinary geneticist Doug Weiss has identified different immune responses to *M. paratuberculosis* compared to that for other bacteria. Once those components are known, tools can be used to identify susceptible and resistant cattle. Cows that are uninfected will become sources of disease-resistant, healthy replacement animals for other herds. "Over the next few months, we expect to determine if disease susceptibility is linked to differential gene expression. If true, we could breed this disease out of Minnesota dairy herds," says Weiss.

Several projects have been initiated to develop effective control programs through herd management. Nine Minnesota dairy herds are currently participating in a demonstration herd control project. Records of milk production, cow reproduction, and herd culling will be collected. Reductions in disease and infection are being measured after changes in management practices on the farm based on a risk assessment approach.

A study to evaluate the potential





Scott Wells and Eran Raizman collect data for a risk assessment on a dairy farm. Calves are isolated from the mature herd to reduce spread of infection.

Recommendations

"Even as we are monitoring dairy herds to determine how to best control the disease, motivated producers have to act as if every cow is infected," Wells said. "At this point our tests are not adequate, but we have identified ways to reduce the onset of Johne's disease in infected cows." The Minnesota Johne's Working Group makes the following recommendations:

- Because there is a fecal-oral connection in the spread of the disease, University veterinarians recommend that calves be born in a clean, dry area and raised away from adult cows and their manure.

- Colostrum—the first milk after calving that is essential to a calf's immune system—is commonly collected and fed to newborn calves. On some farms, that colostrum is pooled and fed to all newborns. If one of the mothers carried Johne's, all of those calves would become infected. A second recommendation is that each calf gets only its mother's colostrum.

- A third recommendation is to feed milk replacer to calves instead of unpasteurized and often unsaleable milk produced when cows are treated with antibiotics. Sandra Godden, an epidemiologist, and Joellen Feirtag, a food scientist, are experimenting with pasteurization of waste milk to inactivate pathogens that could infect calves.

Research veterinarians are now meeting across Minnesota with dairy producers and veterinarians to communicate this research and gather ideas to implement the results. ■

Arlene West

Scott Wells and Sandra Godden are in the Department of Clinical and Population Sciences. Vivek Kapur and Doug Weiss are in the Department of Veterinary Pathobiology. Kay Faaberg is in the Minnesota Veterinary Diagnostic Laboratory. All are in the College of Veterinary Medicine. Joellen Feirtag is in the Department of Food Science and Nutrition, College of Agricultural, Food and Environmental Sciences.

More information is available at www.cvm.umn.edu/dairycenter/johnes.

MANAGING MESSY NEIGHBORS

Curbing Canada Goose Populations in Urban Areas

The numerous lakes and wetlands of the Twin Cities—many bordered by parks, golf courses, and athletic fields—create an ideal habitat for Canada Geese. So ideal, that James Cooper, who has studied geese since the late '60s, calculates that the area could support 1.5 million honkers.

Currently there are fewer than 25,000 Canada Geese in the metro area. But without controls that began in the early '80s, there would be at least ten times that many according to Cooper, the country's leading expert on urban geese. A case in point is southern Ontario, which like the Twin Cities had about 500 geese in the '60s and now has more than 350,000.

Finding an appropriate balance of geese in urban areas is a problem. "If we didn't manage them, people would view them as pests," says Cooper. "I hope that by keeping goose numbers reasonably low through effective management, peo-

ous. According to Cooper, an average goose is so large it can destroy a jet engine and cause serious damage if it hits the fuselage.

Transmitters placed on geese show that they return to the same fields every fall. Since 1984, researchers have banded geese within 10 miles of the Minneapolis-St. Paul airport to identify and remove nuisance birds. Today, the likelihood of a commercial jet colliding with a goose has been reduced by 90%, and it is estimated that goose management saves more than $1 million a year in reduced aircraft repairs and down time.

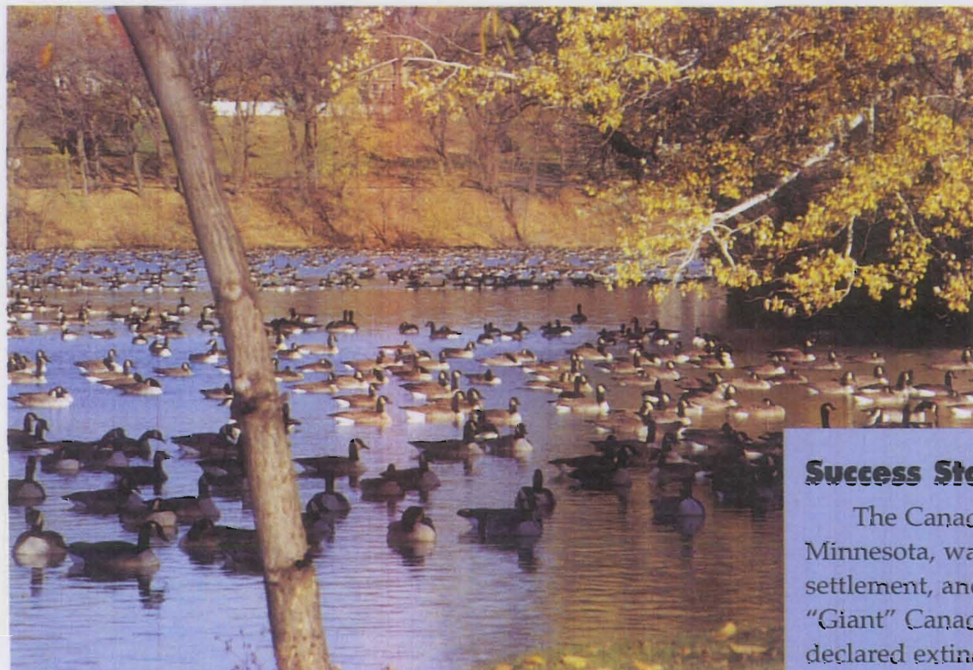


Photo by Jim Cooper

period, but can impact other shoreline animals like turtles. Herding animals, such as border collies, can keep geese away. Geese displaced by dogs or fences, however, just move to another site.

■ **Limit nests.** Kansas City and St. Louis tried a program to destroy eggs, but workers couldn't keep up. Those cities now have to remove 9,600 geese per year for the next 10 years, says Cooper. "Because population growth is exponential, the longer you fail to limit the population, the longer you will have to work to do so," says Cooper.

■ **Limit the population.** Goslings always return to the place where they learned to fly, so young goslings are sent to amenable rural locations in Minnesota and Iowa. Mature geese are processed and given to food shelves.

"Effective management uses programs that have a reasonable chance of working," says Cooper. "When they don't have respect for animals, people will use pellet guns, poison, run over them with golf carts—not the ethical treatment of wildlife we'd like to see." ■

Arlene West

James Cooper is professor emeritus in the Department of Fisheries, Wildlife, and Conservation Biology in the College of Natural Resources. His work has been a collaborative effort of the University and the Wildlife Division of the Minnesota Department of Natural Resources for more than 20 years.

Success Stories

The Canada Goose, native to Minnesota, was extirpated during settlement, and the midwestern "Giant" Canada goose race was declared extinct in the 1950s. However, the bird survived in captive hunters' live-decoy flocks. When live-decoys were outlawed in the 1930s, some flocks were maintained by farmers and others—primarily on the estates of wealthy folks—who liked geese. Offspring from these flocks were used to found additional captive flocks, which in turn were

"endangered species" program—before the term was coined—surprised everyone by being so successful that the bird is now considered by many to be a "pest," particularly in cities. For example, in the northern Mississippi flyway states of Minnesota, Wisconsin, Michigan, Iowa, Ohio, Illinois, and Missouri, giant Canada goose numbers have gone from a few thousand to more than one million in the past three decades. The Twin Cities program has removed more than 70,000 geese, rats."

During fall migration, the metro goose population almost triples. They congregate in farm fields, athletic fields, golf courses, and airports, where they are not only a messy nuisance, but danger-

manage goose populations, which are used by most cities with large numbers of the birds:

■ **Limit access.** Fences keep geese off of shorelines during the summer flightless

cies. It's a success story showing that farmers were instrumental in keeping a wildlife subspecies from extinction.

But what started out as an

success story gone bad as a result of human alterations of the environment—large, lush lawns—and it impacts millions of people nationwide. ■ *Dr. James Cooper*

FUNGI HAS ITS PLACE

Prairie Diversity Depends on Interplay of Plants and Disease

Most of us see microorganisms that cause diseases in plants in a negative light. That's understandable, because diseases are usually noticed only when they threaten food, fiber, or ornamental plants. Black stem rust, which threatened wheat crops up until the '60s, and white pine blister rust, which kills trees, are notable examples.

But in natural ecosystems, plant diseases play a role in maintaining a more stable, resilient, and diverse community. "We shouldn't let what we see in agriculture influence how we treat natural ecosystems," says plant pathologist James Groth. Flare-ups of a disease in a diverse setting are never as bad as in a monoculture system, and fungi and other plant parasites are vital to native prairie diversity by preferentially curbing dominant plants that could take over and eliminate rarer species.

Groth and graduate student Charlie Barnes are engaged in a five-year research project at the University's Cedar Creek Natural History Area, north of the Twin Cities. Funded by the Agricultural Experiment Station, with the support of the National Science Foundation Long-Term Ecological Research Project, they are working to determine how fire and other preserve management techniques affect rust fungi. Rust fungi (rust colored plant parasites) are used in these studies because they occur on both native and agricultural plants in Minnesota, and because each of the many rust species is specific to a few plants.

Plant pathologists study the effects of prairie fires on fungi, which in turn affect other prairie species such as Little Bluestem.

Barnes monitors 78 plots and records the complicated life cycle of a rust fungus that, like many, needs two hosts. It moves from small flowering Camandra plants in the spring to Big Bluestem grass in the summer and fall. Spores typically travel 20 to 30 meters, but plots isolated by managed burns have shown that they will survive up to 100 meters. Still, if large prairie remnants are burned at one time, and the nearest unburned host plants are miles away in the next remnant, survival of the fungus is threatened.

"There is no reason whatsoever to eradicate native plant diseases," Barnes says. "You may be making room for another more aggressive plant or disease. Disease is valuable to diverse ecosystems, where lots and lots of different plants share the same place." The beauty of native prairie should not be underestimated, says Groth. Natural preserves provide a scenic contrast around intensively farmed areas. "Naturally occurring disease in plants is the norm, not the exception," says Groth. "Prairie preserves should not be managed to the extent that we eliminate fungi. Some disease fungi are conspicuous and unusual, and can be just as interesting to visitors as butterflies and flowers." ■ *Arlene West*

James Groth is in the Department of Plant Pathology in the College of Agricultural, Food and Environmental Sciences.

PARENTS IN GRIEF

Living with the Loss of a Child

Of all the pains a parent can imagine, the death of a child is probably the worst. For most parents that nightmare never comes true, but for a few it comes and never goes away.

Questions of how parents grieve, and how they relate to each other during the process, is the focus of family life researcher Paul Rosenblatt's recent publication, *Help Your Marriage Survive the Death of a Child*. Meant for grieving couples to help them through the strain and stress, it is a compilation of interviews with 58 parents in 29 couples or former couples. His eighth book, it follows *Parent Grief*, a scholarly book published in 2000 for educators and therapists.

Rosenblatt's research relies on narrative interviews, lasting from one to three hours. "The people who were interviewed are experts on their own experiences, and there is enormous value in taking what they have to say seriously and understanding it in its own terms," he said.

When Rosenblatt distributed an ad through the University news service, he was surprised by hundreds of responses from people who had lost a child—some as recently as a few months to as long as 35 years before. "They come with a range of issues—some want to say they're fine, some have a religious message, or really want to talk about their families," he said. Although he would like more diversity, all 58 participants in the parent grief study are white. "We look for patterns in their narratives, for what issues come up repeatedly." Divorce is not as common as assumed—only two of the couples in the study are divorced, and both marriages were in trouble before the child's death. The tragedy brought most couples closer together.

Rosenblatt is now focusing on how African Americans may handle grief differently. "A history of having to deal with a racist world can change how you grieve," he said. "A lot of people talk about being strong, and I think it is much more the norm in that population." Family social science graduate student Beverly Wallace, a pastor and former hospital chaplain who is black, is conducting the interviews and collaborating on the writing.

Rosenblatt has studied grief and loss with support from the Agricultural Experiment Station for more than 30 years. He says in many ways he feels like a beginner every day. "I have always watched people, and have been curious and wanted to know more. I love interviewing, and I love teaching students those techniques," he said. ■ *Arlene West*

Paul Rosenblatt is in the Department of Family Social Science in the College of Human Ecology.

Fertilizing by the Numbers

When farms and fields were smaller, a farmer could remember the atypical areas of a field, and treat those areas differently. Today, computers and guidance systems, coupled with yield monitors and advances in aerial and satellite photography, have increased awareness of variability within fields.

The technology for variable rate fertilizer application has progressed in tandem with Differential Global Positioning Systems (DGPS), the two combining to provide for accurate "on-the-go" variation in fertilizer application. A new publication from the Agricultural Experiment Station, *Soil Sampling for Variable Rate Fertilizer and Lime Application*, summarizes the economics and strategies of different procedures. The 16-page booklet is available by calling 800/876-8636 or 612/624-4900. Ask for item #SB-7647-S.

WHEN COWS BITE THE DUST

Simply Composting in Sawdust

A low-cost, single stage composting process to dispose of livestock carcasses could simplify the problems farmers face when animals die. Researchers are testing the effec-

reached 140° to 150° F. before declining, with the pile going dormant over winter. A second, less pronounced heating cycle occurred in the spring and summer of 2000, but by fall, bones were still hard. The other two piles

FLAX FIGHTS CANCER

Study Confirms Cancer Prevention

The cancer fighting benefits of an ancient seed—flax—are receiving new attention thanks to a study involving 32 postmenopausal nuns from the Order of St. Benedict near St. Cloud. The women added either 5, 10, or no grams of ground flax seeds to their daily diets. Nutrition professor Joanne Slavin and graduate students analyzed urine and blood samples to measure the impact on each subject during the 21-week study supported by the National Cancer Institute and the Agricultural Experiment Station.

The results demonstrated an increase in protective estrogen levels, which may prevent some hormonally related cancers, such as cancers of the breast and uterus. Flax is rich in lignans—chemicals that act like the female hormone estrogen in the human body. The phytoestrogen—"phyto" means "plant"—helps the body fight against disease by replacing protective estrogen.

Soy has similar qualities, says Slavin, but a little flax goes a long way. In the study, five grams a day (about a tablespoon) had a good impact, with 10 grams showing only slightly better results. For comparable effects, a greater amount of foods containing soy would have to be consumed.

As a registered dietician, Slavin is committed to helping people get phytochemicals through foods. "Ground flax is fairly easy to put into foods, especially breads and cereals. In the study, seeds were ground and then stored in the freezer because the meal oxidizes fairly quickly. The women put it on cereal or stirred it into yogurt. Since then, research has shown even when ground flax is baked into bread, the lignans are still viable," she said.

Flax is sold in several forms. Flax oil—the edible version developed at the U of M—provides one of the Omega-3 acids proven to prevent cancer. The seeds themselves have laxative properties, but are not as digestible as ground seeds. Slavin cautions against a trend toward isolating the phytoestrogens—both from soy and flax—and selling it in tablet form: "As a food, flax has fiber and phytochemicals. We're not sure what compound in flax gives it the health benefits, so for now it's best to eat flax as a food rather than as isolated lignans."

Although the tiny, purplish seeds were known to the Greeks and Romans as a healthy food, in modern times flax has been relegated to animal feed status. Slavin wants to promote the benefits of flax, and welcomes recent publicity in the *Chicago Tribune* and the Twin Cities' *Star Tribune*." We can add flax to our diets so easily, and because it is a safe food that has been consumed for years and years, there doesn't seem to be a down side," she says.

The nuns in the study agree. Many of them reported that they felt better and would continue adding flax to their diets. ■ *Arlene West*

Joanne Slavin is in the Department of Food Science and Nutrition, College of Human Ecology. She worked with Amy Olson of the College of St. Benedict, and U of M graduate and undergraduate students.

until they decompose. For many farmers, disposal methods now approved are either impractical, unavailable, or deemed too costly.

Although the process is taking longer than anticipated, researchers are optimistic about the potential for the technique. After all, says James Boedicker, agricultural engineer, "What's time to a dead cow?"

At the North Central Research and Outreach Center's Beef and Forage Research Farm south of Grand Rapids, a test pile was formed in the fall of 1999 containing three 400- to 500-pound calf carcasses. Two more piles were formed in spring of 2000, each containing the carcass of a mature cow and that of one or two stillborn calves. Piles were formed by placing the carcasses on a 12- to 15-inch thick sawdust base and covering them with additional sawdust at least one foot thick.

Temperatures in the first pile

Disposing of dead livestock is a challenge in rural areas. Agricultural engineer Jim Boedicker uses a four-foot long thermometer to check the internal temperature of carcasses buried in sawdust.

By fall of 2001, hard bones could still be felt in all piles. Also, pile interiors had dried considerably. Adding water to the piles is being considered this spring to accelerate bone breakdown. When decomposition is considered complete, each pile will be sampled for pathogen analysis.

Over time, incidents of animal intrusion into the piles—probably skunks, dogs, and foxes—have increased. Although a multi-strand electric fence around the piles has been considered, it is assumed most farmers would be unwilling to make that investment.

In addition to funding from the Agricultural Experiment Station, the project was initially sponsored by the MN Department of Agriculture. ■ *Arlene West*

James Boedicker is a biosystems/agricultural engineer at the North Central Research and Outreach Center.

AZALEAS *continued from front cover*

grow to maturity before crosses are made, and there are always surprises, both in the field and in labs. "The weather conditions that cause most home gardeners to worry and rush to add cover can be just what the research staff is waiting for," says Pellett. Typically, the plants are not protected in the field, the exception being a specific parent with valued characteristics.

"You do have to throw out a lot of plant materials—not only if there is a hard freeze that shows you which plants are most hardy, but in the greenhouse. We're looking for very specific characteristics: for improvements and variations in color or in quality of the bloom, for example. Very slight differences can make a difference in what we choose to continue," he says.

Researchers work in labs equipped to freeze plant materials at levels down to –40°F. Stems and buds from various plants are monitored with a thermocouple, and then examined under microscopes to determine at what temperature damage occurs. Damage varies according to the time of year and how acclimated the plant is; plants can survive extreme cold at the peak of winter, but in late fall, a cold snap causes great damage.


'Mandarin Lights' azalea

After nearly 25 years of working with azaleas and other woody ornamentals as varied as red maples, dogwood, and viburnum, Pellett is retiring from the U of M. He will continue his work as executive director of the Landscape Plant Development Center, a national organization housed at the Minnesota Landscape Arboretum. An Iowa native, who grew up in a market gardening family and often harvested two acres of vegetables before school, Pellett says he may even find time for work on his own yard and garden. And he won't stop thinking about new types of azaleas: red azaleas…azaleas that bloom later in summer…azaleas resistant to mildew… ■ *Arlene West*

Harold Pellett is in the Department of Horticultural Science in the College of Agricultural, Food and Environmental Sciences.

RESEARCH CONNECTIONS

Research of the Minnesota Agricultural Experiment Station is conducted throughout Minnesota by investigators in five colleges of the University of Minnesota. For more information explore the following Internet sites:

- *College of Agricultural, Food and Environmental Sciences,* www.coafes.umn.edu/
- *College of Biological Sciences,* www.cbs.umn.edu/
- *College of Human Ecology,* www.che.umn.edu/
- *College of Natural Resources,* www.cnr.umn.edu/
- *College of Veterinary Medicine,* www.cvm.umn.edu/
- *Minnesota Agricultural Experiment Station,* www.maes.umn.edu
- *University of Minnesota Extension Service,* www.extension.umn.edu/
- *Minnesota Impacts!* www3.extension.umn.edu/mnimpacts

MINNESOTA SCIENCE

Volume 54, Number 1
ISSN No. 0026-5675

MANAGING EDITOR
David L. Hansen

PRODUCTION AND COPY EDITOR
Arlene West

DESIGNER
Nancy H. Teufert

PHOTOGRAPHER
David L. Hansen

Minnesota Science is produced three times a year. It is published by the Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul, Minnesota. Printed on recycled paper with minimum 10% postconsumer waste, using agribased inks. For Americans with Disabilities Act accommodations, please call (800) 876-8636. Also available online at www.maes.umn.edu

Address all correspondence and requests to the Editor, *Minnesota Science*, 405 Coffey Hall, 1420 Eckles Avenue, University of Minnesota, St. Paul, MN 55108-6068.

Minnesota Agricultural Experiment Station

UNIVERSITY OF MINNESOTA

Minnesota Agricultural Experiment Station
University of Minnesota
120 BioAgEng
1390 Eckles Avenue
St. Paul, Minnesota 55108-6005

CHANGE SERVICE REQUESTED

Non-Profit Org.
U.S.Postage
PAID
Mpls, MN
Permit No. 155

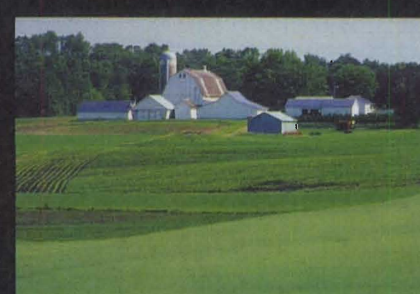
***********************AUTO**5-DIGIT 55105
S19 P5

JENNIFER OBST
1596 JEFFERSON AVE
SAINT PAUL MN 55105-2001 96

UNIVERSITY OF MINNESOTA

FOOD FOR LIFE

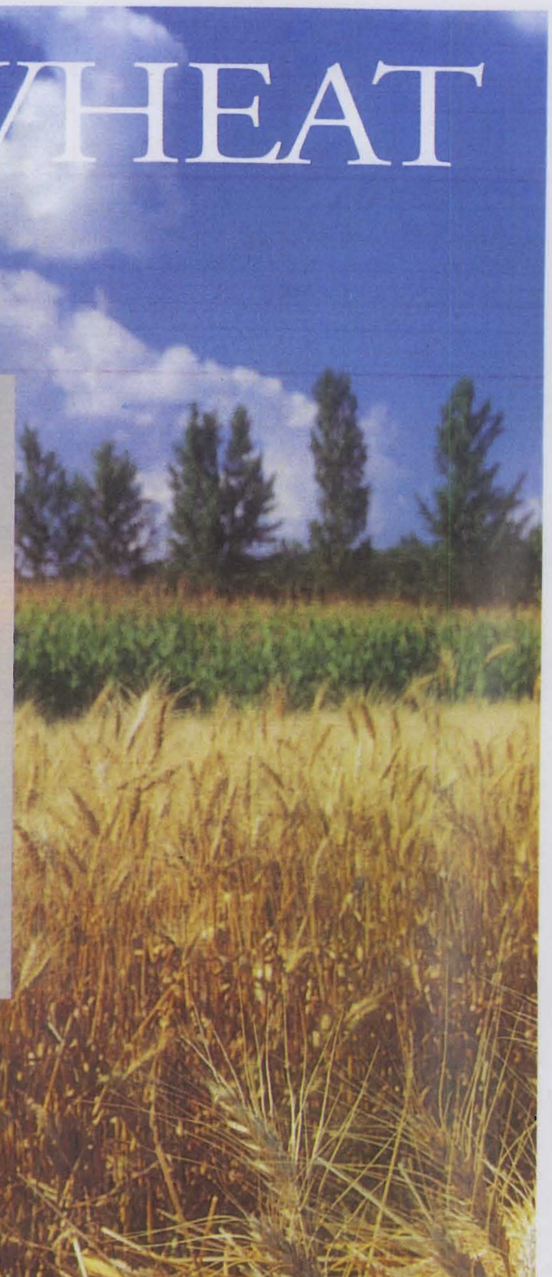
AGRICULTURAL EXPERIMENT STATION



150 YEARS
1851 2001

UNIVERSITY OF MINNESOTA

WHEAT



Minnesota farmers harvested about 10 bushels of wheat per acre in 1890. Up to that time feeding more people meant planting more land: by cultivating prairies, clearing forests, or draining wetlands. Today, yields of 60 bushels per acre are not uncommon, thanks largely to land grant university research. Society and scientists now face other land use issues: restoration to prairie or forest, conservation, recreation, or development.

Research to improve wheat started at the University of Minnesota in 1889 when plant breeders and a cereal chemist first evaluated wheat varieties from Minnesota, Hungary and other parts of Europe, Russia, and Canada. After 10 years, their report summarized work with 552 varieties planted on the St. Paul campus:

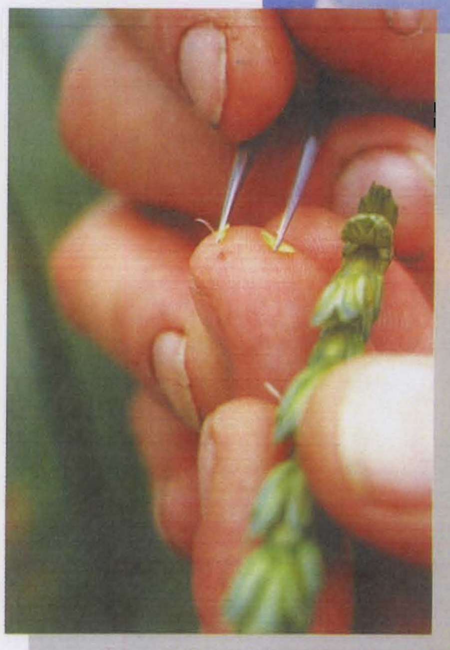
Plant breeding is in its infancy, and plans for extensive scientific breeding of this crop had to be devised rather than copied.... Not only yield but the quality of the grain and other characteristics were taken into account in selecting plants to become the mother of varieties.

The first of 35 U of M wheat varieties was released to farmers in 1895.

This era marked the practical beginning of the science of genetics and plant breeding and of worldwide improvements in yield and grain quality. While Swedish monk Gregor Mendel discovered in the 1860s how traits were inherited by plants, the information was not widely known – and certainly not applied – until the 1890s.

The next revolution in plant breeding began with the 1970s discovery of how to view and change a plant's structure at the molecular level, rather than selecting chance variants from among tens of thousands of plant crosses. Still, the goals of wheat improvement are much the same as a century ago: high yield, good baking characteristics, disease resistance, and the ability to stand up until harvested. Growers contribute to the research efforts through the Minnesota Wheat Research and Promotion Council.

The U of M wheat breeding program has been a cooperative project with USDA-ARS since 1907. These plots are at Morris, next to both U of M and USDA research facilities.



In greenhouse laboratories, plant breeders use 100-year-old techniques to painstakingly fertilize a head of wheat to cross it with a plant possessing other desirable traits.

In 1881 the Minneapolis Grain Exchange – originally called the Minneapolis Chamber of Commerce – was organized to promote fair trade of wheat, corn and oats between growers and millers. Today, options on 20 million bushels a day are handled, making it the largest cash exchange market in the world. Crops grown from the upper Midwest to the Pacific – wheat, barley, oats, durum, rye, sunflower seeds, flax, corn, soybeans, millet, and milo – are traded.

One plot at a time, small combines harvest, weigh, and determine seed moisture content of potential new wheat varieties at the Northwest Research and Outreach Center, Crookston. Research began here after James J. Hill donated the land to the University in 1895, to encourage development of agriculture on the Great Plains.

The Soo Line railroad, planned and paid for by grain millers, shipped flour to export markets via Sault Ste. Marie beginning in 1887. Competing lines serving Chicago and Milwaukee tried to divert milling business from Minneapolis – the "Mill City" – by offering cheaper rates. Today, Minnesota is the undisputed center of food and agriculture industries, with over $200 billion of business annually.

■ **GLYNDON,** 1915, was the result of a cooperative UM-USDA breeding effort that began in 1907 and continues today.

■ **MARQUILLO,** 1928, was the first stem rust resistant variety from the U of M, but its flour was dark and was not accepted by the milling industry.

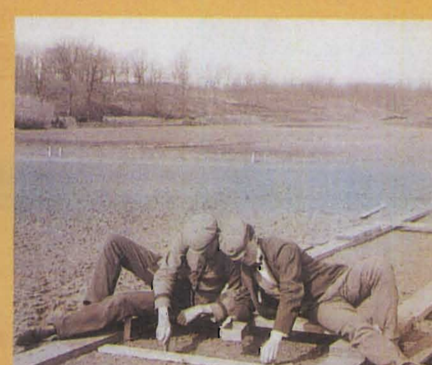
■ **THATCHER,** 1934, became one of the most popular wheat varieties ever grown in the U.S. By 1941 it occupied 17 million acres here and in Canada. Good yielding and resistant to stem rust, it was the result of plant pathologists working closely with plant breeders. In 1951 'Thatcher' was still the principle wheat in North America.

■ **ERA,** 1970, was the first semidwarf spring wheat released by a public institution. Semidwarfs are short and less likely to fall over before harvest, and growing energy is directed to the grain rather than leaves and stem. 'Era' was the dominant variety in Minnesota until 1983.

■ **MARSHALL,** 1982, quickly became a leading variety and was planted on 70 percent of the state's wheat acres and over 5 million acres in the U.S. until 1990.

U of M Wheat Varieties

Hard Red Spring Wheat	
Preston	1895
#163	1899
#169	1902
#188	1905
Glyndon	1915
Reliance	1926
Marquillo	1928
Thatcher	1934
Newthatch	1944
Lee	1951
Willet	1954
Crim	1963
Chris	1965
Polk	1968
Era	1970
Fletcher	1970
Kitt	1975
Angus	1978
Centurk	1981
Marshall	1982
Wheaton	1983
Vance	1989
Minnpro	1989
Norm	1992
Verde	1995
BacUp	1996
HJ98	1998
McVey	1999
Hard Red Winter Wheat	
Minard	1915
Minturki	1919
Marim	1940
Minter	1948
Durum Wheat (for pasta)	
Mindum	1917
Spelmar	1917
Soft Red Winter Wheat	
Minhardi	1920



Beginning in 1889, wheat breeders planted hundreds of varieties in small plots on the University's St. Paul campus.

FORAGE LEGUMES

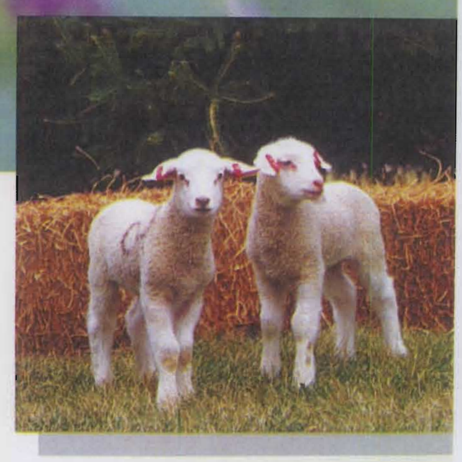
U of M breeding of red and white clovers and bromegrass began in 1946. The goal is to improve winter hardiness and disease resistance. 'Minn A' white clover germplasm was released to industry breeders in 1974 and is found in many commercial varieties.

Forages are a main source of livestock food, and unlike most other crops they have no direct human use. Alfalfa, clover, vetch – all legumes – and grass make up 70 percent of the diet of beef cattle and 90 percent of sheep intake. Perennial forages protect against erosion because the soil is not tilled each year.

In the 1880s alfalfa was an experimental crop that wouldn't survive Minnesota winters, though it was the forage of choice for European dairy herds. In 1895 the U's Agricultural Experiment Station released its first three plant varieties: an oat, a wheat, and "Grimm" alfalfa. The name honors the Carver County farmer who brought 20 pounds of alfalfa seed from Germany in 1857. By collecting seed from surviving plants, he developed a winter-hardy alfalfa that researchers used for extensive management studies and breeding.

Alfalfa is now the mainstay of our dairy industry, which ranks fifth in the country and brings in $1.5 billion to farmers, and adds over $6 billion to processors of milk, cheese, butter, and ice cream. Almost 150 years ago Minnesota dairying led to the establishment of the first farm cooperatives in the country. Now, we are home to two of the world's largest.

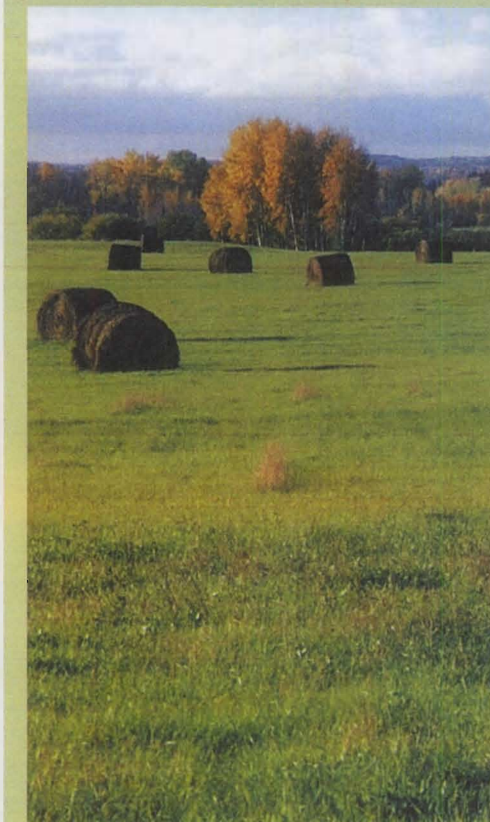
Deep rooting varieties of alfalfa were developed by UM-USDA scientists to extract nitrogen from the soil. The legume's roots reach below the root systems of cereal crops to keep nitrogen from entering groundwater or tile lines. In the last decade, alternative legumes such as kura clover and native species such as cicer milkvetch have been introduced by the University as options to help diversify Minnesota agriculture.



Livestock, like children, won't eat something they don't like. University and USDA research led to release of 'HiPal' – short for high palatability – cicer milkvetch, and a low alkaloid reed canarygrass, a native grass that cattle previously would not eat. U of M researchers were the first to prove that palatability differences are more important than crop yield, or quantity of nutrients, in grazing animal performance.

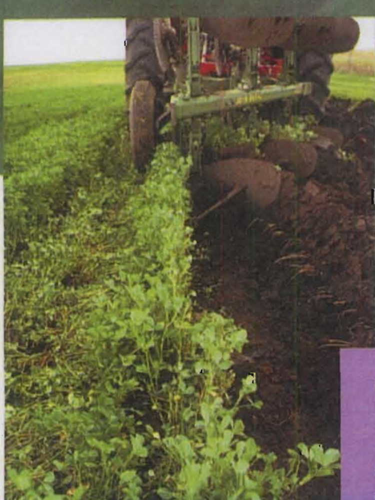
An indirect benefit of crop production is the 12 million pounds of honey produced here each year. U of M entomologists have developed "hygienic" honeybees that are helping colonies nationwide eliminate parasitic mites.

University animal scientists and agronomists determined that alfalfa should be cut in the "early flowering stage" to obtain maximum digestibility and highest nutrient concentration. Minnesota farmers typically cut alfalfa three times a year and with good management get five years of production before reseeding is necessary.



Applied research helps farmers manage forages to produce the best crop for dairy, beef, and sheep herds. In 1937 the University published the first comprehensive management guide for alfalfa, earlier considered an "exotic" crop. Today, scientists evaluate forages in many ways:

- Species selection
- Planting date
- Planting rate
- How often to harvest
- Grazing or mechanical harvest
- Forage quality and yield



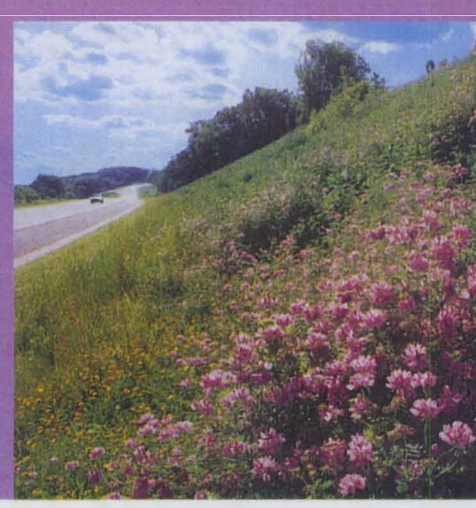
Legumes – plants with pods above ground and nodules on their roots – have the unique ability to take nitrogen from the air and convert it into soil nitrogen that can be used by later crops as fertilizer.

While alfalfa is traditionally grown as a perennial, U of M and USDA breeders released 'Nitro' in 1986 as an alternative annual crop in rotation with corn and soybeans. 'Nitro' was developed as a one-year, high-nitrogen fixing legume that does not overwinter.

U of M Forage Legumes Varieties

Plant breeders strive to develop forage crops to meet the quality and palatability or taste requirements of livestock, and practical needs of farmers including high yield, disease resistance, and winter hardiness. Forages are also valued for erosion control, both on crop land and along highways. U of M forage varieties include:

Alfalfa	Grimm Ramsey Agate ARC Nitro Wrangler
Cicer Milkvetch	HiPal
Birdsfoot Trefoil	Norcen Nueltin Roseau
Red Clover	Wegener



GRASSES

Rotational grazing allows cows access to pasture at its peak nutritional level. Agricultural Experiment Station research at Morris and Grand Rapids documented that this system of frequently moving cows to different pastures provides a more nutritious diet. In addition, it is lower in cost and protects soil and water resources.

Grasses are a nutritious forage for dairy cows, beef cattle, sheep, and bison. And, they provide a ground cover to protect roadsides, populate prairies, and beautify home lawns, golf courses, and athletic fields. Grasses are an ideal perennial crop, pleasing to look at, high in protein and fiber, and nature's best soil stabilizer.

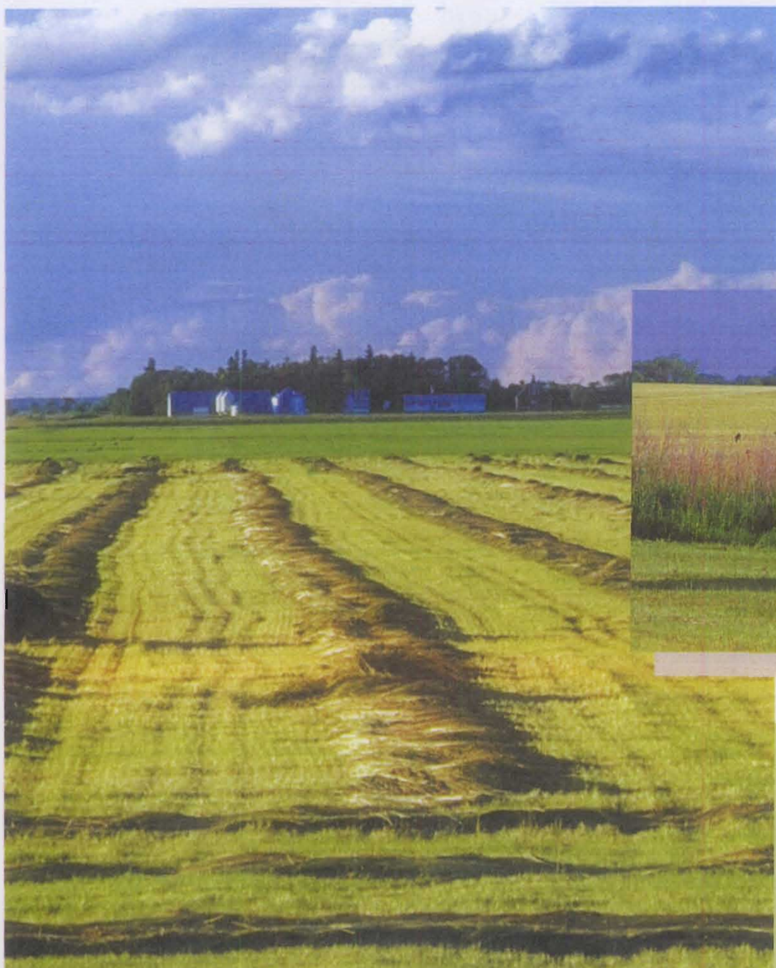
In the early 1880s, U of M agronomists showed farmers that timothy was the best pasture grass for southern Minnesota. An extensive study of sustainable crop rotations between 1900 and 1910 documented that alternating small grains, timothy, red clover, and corn was more profitable than continuous cropping of either corn or a grain. Researchers analyze cropping practices for long-term benefits: to the economy, the environment, and animal health and nutrition. In the 1950s-60s scientists continued to refine pasture management and introduced new crops to the mix, including bromegrass, birdsfoot trefoil, and Kentucky bluegrass. Now, molecular genetics research helps identify specific traits to incorporate into new cultivars.

Agricultural Experiment Station researchers have also developed tools that help producers after the harvest is in, such as an efficient technique for evaluating the chemical composition and digestibility of forages. Near infrared reflectance spectroscopy – NIRS – is now used worldwide to measure grass and legume quality after it is in storage.

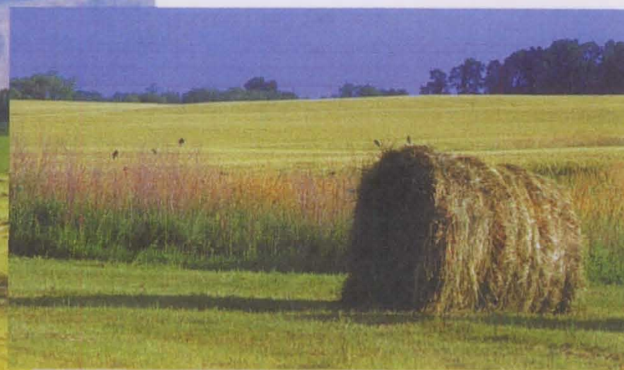
Proso millet

If a grass or legume is grown for seed rather than for animal feed or ground cover, it is managed differently. U of M research in the 1940s led to development of a major U.S. grass seed industry in our cool climate near the Canadian border. Here, almost $1.5 million of seed is harvested each year for bird feed, home lawn, golf course, and athletic field use as well as plantings for forage crops. Minnesota ranks fourth nationally in production of grass seed, and U of M plant breeders are introducing new varieties of perennial ryegrass and quackgrass to complement bluegrass used in landscaping.

Scientists work on many projects related to grasses, including inventorying remnants of native prairie. This patch, a Nature Conservancy reserve on dry soils of the beac ridge of glacial Lake Agassiz in northwestern Minnesota, provides ideal greater prairie chicken habitat. The University and USDA-AI released improved varieties of Big Bluestem, Switchgrass, and Indiangrass that can be use as warm season forages.



Extreme northern Minnesota, near Lake of the Woods, provides the cool growing conditions ideal for grass seed production. Grass, heavy with seed, is cut in July, dried, threshed, conditioned, packaged and distributed nationwide. It is planted as a home lawn, roadside, prairie, golf course, or athletic field, becoming a permanent part of another landscape.



Forages not consumed fresh are harvested and stored for off-season use by livestock. Minnesota's long winter means more grass is stored as bales, or chopped as silage, than is grazed.

Research to protect conservation set-aside acres is shared with farmers and other consumers through an efficient outreach system, the University of Minnesota Extension Service.

U of M Grass Varieties

Annual Canarygrass	Alden	1973	bird feed
	Keet	1979	
	Elias	1983	
Big Bluestem	Bonilla*	1987	prairie restoration
	Bison*	1989	
Bluegrass	Park	1957	lawns
	MinnFine	1993	
Bromegrass	Martin	1951	forage
	Fox	1968	
Creeping Bluegrass	MN 42, 117, 184, 208, 234	1994	golf course greens
Indiangrass	Tomahawk*	1988	prairie restoration
Perennial Ryegrass	P101	2001	
Proso Millet	Snobird	1973	bird feed
	Minco	1976	
	Minsum	1980	
Quackgrass	Everett	2001	
Reed Canarygrass	MN-76	1976	forage
Sorghum, Grain	Minnesota 1	1963	forage
	RS 455	1976	
	MA-4 A&B	1976	
Switchgrass	Dacotah*	1989	prairie restoration
	Forestburg*	1987	
Timothy	Itasca	1951	forage

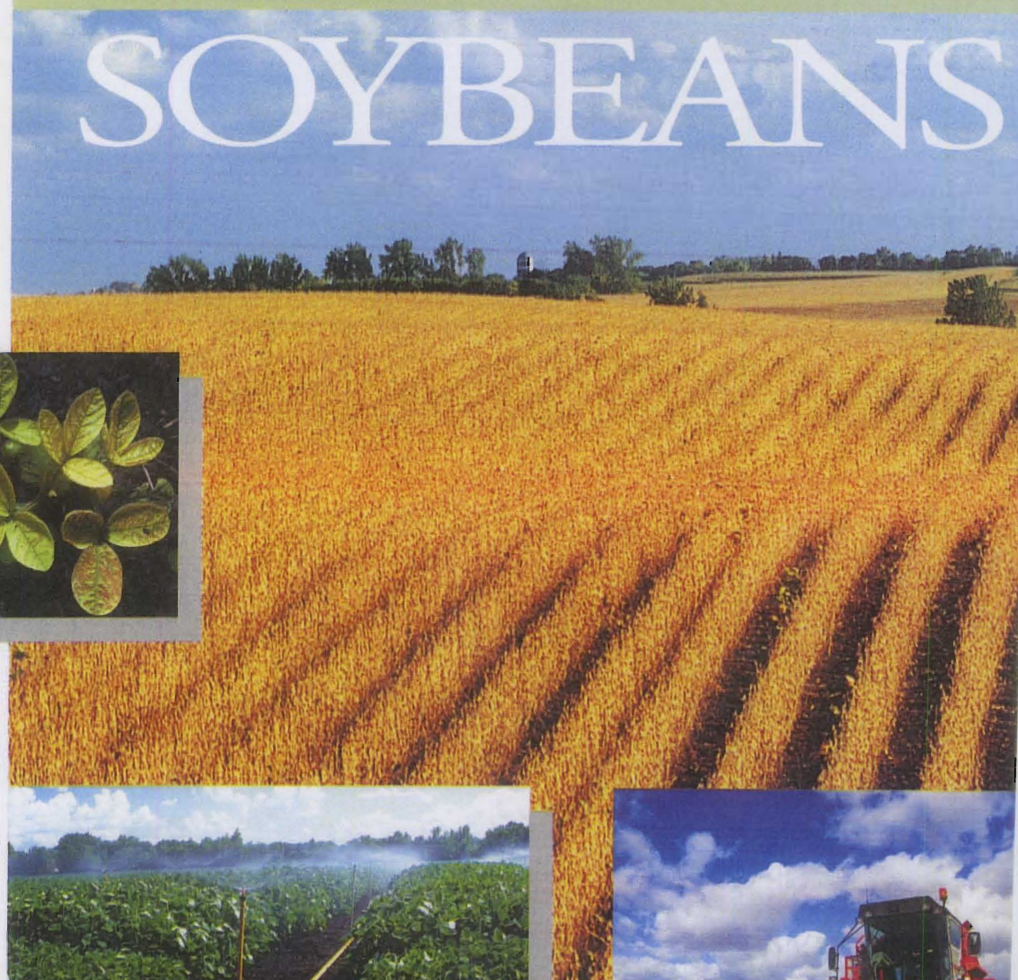
*joint release with USDA-ARS

Turf Grass

Horticultural scientists study specific traits of grasses destined for turf use on golf courses, athletic fields, and home lawns. *University breeders recently released MN 184, a creeping bluegrass* for golf course greens, tees, and fairways. Compared with bentgrass it has a higher plant population which results in a more upright leaf position that is better for putting. It is ideally suited for northern and coastal climates, and is better adapted to shady conditions. In just a few years MN 184 seed has found its way from coast to coast, including Pebble Beach (above), and courses in Europe. An improved variety, MN 234, will be even more popular, as it does not flower at heights maintained on courses.

The U of M also carries out National Turfgrass Evaluation Trials, helping select the best performing and disease resistant grasses from around the world. Through genetic analysis of biotypes of turf grasses, breeders hope to develop new varieties that will perform optimally in specific growing conditions.

SOYBEANS



Soybeans and corn are the dominant crops in Minnesota, with almost equal amounts grown – over 7 million acres each – and harvest values of between one and two billion dollars each. Soybeans were grown in China for more than 5,000 years, as corn was cultivated by Native Americans. U.S. farmers grew soybeans in the late 1800s for cattle forage, and in the 1920s began harvesting them for seeds.

University varieties released in the 1920s and 30s were selected from similar latitudes in China and Korea, and tested at U of M Agricultural Experiment Stations in Waseca and Morris. However, their 1932 annual report saw limited potential: *"The soybean crop has an important function in Southern Minnesota agriculture as an annual or emergency hay crop in case of clover hay failure."*

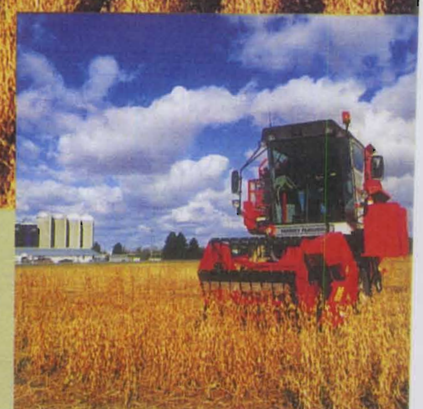
Yellow leaves are an indication of iron chlorosis. U of M breeders and soil scientists developed varieties that are tolerant of the higher pH soils where this is a problem.

By 1940, southern Minnesota farmers planted 251,000 acres of beans that yielded 15 bushels per acre. Now, yields average 41 bushels an acre thanks to breeders, plant disease experts, and soil scientists that adapted the crop to Minnesota.

In 1946 a U of M plant breeder was hired to develop varieties tailored to Minnesota, the most northerly state in the Corn Belt. By the 1970s 20 varieties were released and plant pathologists and breeders began developing plants resistant to the soybean cyst nematode (SCN), a major pest that invaded southern counties. Another measure of breeders' success in bringing the soybean north is that 16% of the Minnesota crop is now exported through Duluth; none went through that northern port 15 years ago.

Soybeans were recognized by the legislature in 1960 with funding to expand genetics and physiology work. In 1965 farmers began supporting research via the Minnesota Soybean Research and Promotion Council. The three-way partnership has made Minnesota research, varieties and products worldwide commodities.

Soybeans are evaluated under a misting system at the West Central Research and Outreach Center, Morris, to assess their susceptibility to fungal and bacterial diseases.



Soybean research plots at the Southern Research and Outreach Center, Wasec are harvested by combines that keep s from each of 5,000 potential varieties arate.

U of M Soybean Varieties

Habaro	1922	Wilkin	1972	Kato	1989	Toyopro	199
Chestnut	1922	Evans	1974	Sturdy	1989	Black Kato	199
Minsoy	1922	Hodgson	1974	Minnatto	1989	Glacier	199
Soysota	1922	Grande	1976	Proto	1989	Granite	199
Elton	1922	Hodgson 78	1978	Kasota	1990	Freeborn	199
MN Manchu	1922	McCall	1978	Bert	1991	MN 0301	199
Renville	1953	Simpson	1982	Leslie	1991	MN 1301	19
Traverse	1965	M70-187	1982	Agassiz	1992	UM3	19
Clay	1968	Ozzie	1983	Lambert	1992	Surge	19
Norman	1969	Dawson	1983	Parker	1992	Stride	19
Anoka	1970	Chico	1983	Alpha	1992	MN 1401	19
Ada	1972	Sibley	1986	Hendricks	1994	MN 0901	19
Steele	1972	Dassel	1986	Faribault	1994	MN 1801	19
Swift	1972	Glenwood	1987	M87-1567	1994	MN 0902 CN	20

Initial crosses for new soybean varieties are made at the University of Minnesota St. Paul campus.

Soybean cyst nematode samples are collected from roots by gently washing away soil and debris. Close-up view shows this pest attached to root fibers.

Soybeans are daylength sensitive – flowering and therefore seed production is triggered by hours of sun – so varieties are bred for three distinct Minnesota zones. Shorter season varieties also provide options for delayed planting in the event of late or wet springs.

The University develops soybeans that compete in world markets. 'Chico' and 'Grande' represent two extremes in size, but represent Minnesota's almost one billion dollars of beans exported annually.

- **RENVILLE,** 1953, first release adapted from a U of Illinois population, adapted to central and south-central Minnesota.
- **EVANS,** 1974, popular variety for decades, still grown in U.S. and Europe. In mid 90s occupied 57% of bean acres in north and west-central Minnesota.
- **McCALL,** 1978, earliest maturity of any UM release, still popular.
- **GRANDE,** 1976, largest seeded release, 22 grams/100 seeds vs 16 for regular beans. Developed specifically for soy flake breakfast food.
- **CHICO,** 1983, first of the small seeded types, 50% smaller than average, bred for specialty products – sprouts and miso. Followed by 'Minnatto' and 'UM-3'.
- **STURDY,** 1989, latest maturing bean from U of M program for most southern Minnesota.
- **PROTO,** 1989, first high protein variety for special uses such as tofu.
- **TOYOPRO,** 1995, higher protein, export market for tofu and soymilk.

Soybean Uses

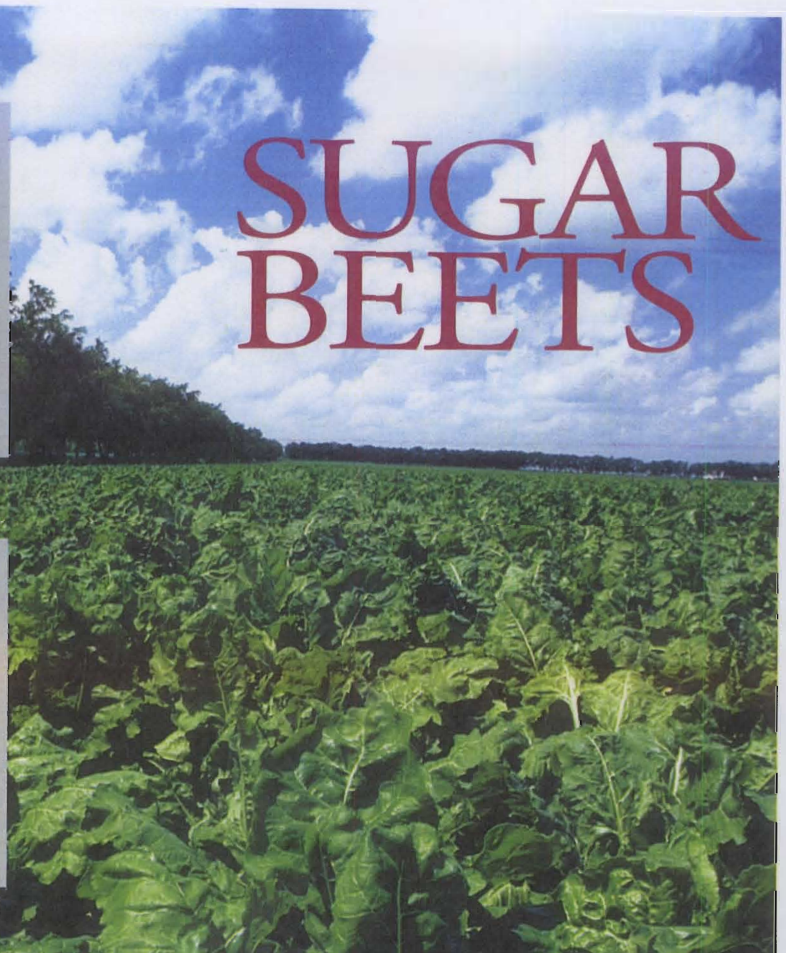
Soybeans are processed into two major components, protein and oil, and a third minor category of whole soybean products. More than 50% of the world's protein comes from this crop. Soybeans are an excellent protein source since each seed contains 40% protein, compared with other legumes – 25% – and cereal grains with about 12% protein. Most soy products are consumed by livestock.

Soybean Protein and Meal Products
Poultry, swine, beef, dairy, and pet food. Flour, meat substitute, soymilk, baby formula, pharmaceuticals, adhesives.

Soybean Oil Products
Cooking oil, margarine, salad dressing, biodiesel, dust control, printing ink, glycerol, fatty acids, sterols, lecithin.

Whole Soybean Products (less than 1%): Sprouts, roasted soy nuts, tofu, soy sauce.

SUGAR BEETS



Minnesota produces more sugar beets than any other state in the country, and North Dakota ranks second. Rich soils of the Red River Valley are the base for this crop's $2.3 billion economic impact on the region. Seven farmer-owned processing plants in the two states turn beets into refined white and brown sugars. The harvest begins in early September and the first loads go directly to processing. An inventory of raw material builds – mountains of beets – and is processed during the winter. When spring temperatures arrive the facilities shut down, as it is impractical to keep any remaining beets cool. The grower cooperatives attempt to match nationwide demand with processing capacity.

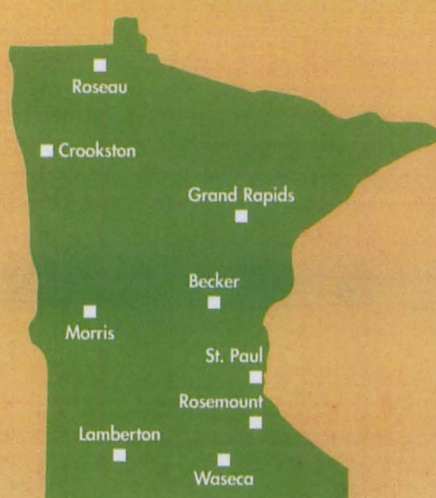
Beets originally contained about two percent sugar, but sugar beet varieties were bred to maximize their sweetness. Minnesota beets now average 17-18 percent sugar. The process for extracting sugar was developed in Germany in 1747, and a research effort to increase sugar content was underwritten by Napoleon I in the early 1800s. He feared that France's sugar supply from Caribbean cane fields would be blockaded by the British, in their continued dispute with the new America and the impending War of 1812. By the 1890s the use of beets for sugar spread across Europe and reached this country.

A 34-year joint research effort of the University of Minnesota and North Dakota State University, whose scientists work closely with the Sugarbeet Research and Education Board of Minnesota and North Dakota, has helped improve performance through:

- Weed control and management
- Understanding and controlling pathogens
- Variety performance
- Stand populations
- Planting dates
- Soils
- Insect control

Weather exclosures enable investigators to study the effects of moisture, temperature and wind on weed control.

U OF M AGRICULTURAL RESEARCH SITES



For well over a century the University of Minnesota Agricultural Experiment Station has developed plants that provide food for life. Minnesota crops feed livestock and the citizens of Minnesota, the United States, and literally the world. Potential new crops, and improved varieties and germplasm of those already established, begin their testing on the St. Paul Campus. Potential releases are tested at Research and Outreach Centers and other research facilities, which represent the wide range of moisture, soil, and temperature conditions found in Minnesota. If a variety is chosen for release it is usually marketed through the Minnesota Crop Improvement Association, or germplasm is provided to commercial seed companies that use it to adapt their varieties to Minnesota conditions.

POTATOES

U of M potato breeders evaluate:

- Yield
- Processing quality
- Baked flavor
- Disease resistance
- Shape
- Size
- Maturity date
- Skin color
- Eyes, skin texture

Researchers have aphid traps on the borders of potato fields throughout Minnesota. If and when counts reach the threshold of causing economic damage, producers are alerted and take control measures. Upper left, reseachers harvest field plots at Morris.

Potatoes are the world's most popular vegetable, produce the most food per acre, and have the best balance – of any plant – of the eight amino acids needed by humans. The U of M breeding program uses wild sources from the Andes of Peru and Chile to improve disease resistance, and tolerance to cold, heat, and drought.

Minnesota is at the center of U.S. potato production. The industry has three main segments: fresh market, seed, and processing for chips, fries, and dehydrated foods. Minnesota, North Dakota, Michigan, and Wisconsin are big in all three. The region produces almost a third of all potatoes grown in the country, supports a huge processing industry that adds about $500 million a year to Minnesota's economy, and grows almost half of the seed potatoes used in the U.S. The country's largest potato farming operation is in Minnesota.

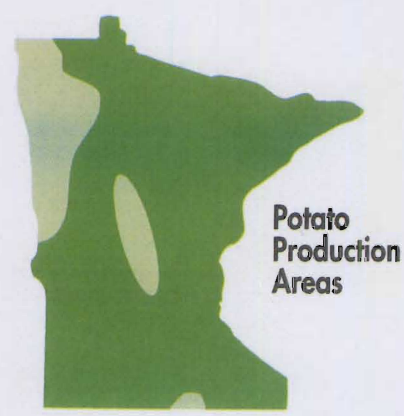
U of M plant scientists have been improving potatoes since 1919. Today, researchers from horticulture, entomology, plant pathology, and soil science team up to improve yield, pest resistance, and quality. Culinary, storability, and nutritional traits are also emphasized, such as flavinoids that reduce risk of prostate cancer and optic impairments. Graduate students learn by working on these interdisciplinary projects, and help solve multiple problems simultaneously.

While an ideal food, the potato plant is susceptible to more than its share of diseases – blight, viruses, wilt, scab – and the foliage is a delicacy for insects. For example, besides causing direct damage, aphids quickly spread plant diseases from field to field. A high intensity research effort is now under way to control late blight and two viruses that have reached epidemic proportions, reducing Minnesota's seed potato business by 40 percent in the last five years. The problem is complex, and investigators seek answers that will reduce the need for chemical inputs.

U of M Potato Varieties

Warba	1933	Agassiz	1983
Mesaba	1938	Erik	1983
Red Warba	1939	Tolass	1984
Kasota	1948	Krantz	1985
Chisago	1949	Reddale	1985
Satapa	1949	Eide Russset	1991
Waseca	1949	Itaska	1994
Osseo	1954	Red Ruby	1994
Anoka	1965		

Potatoes are grown in three areas of Minnesota: under irrigation on the sandy soils from Elk River to Park Rapids, on the rich soils of the Red River Valley from Fergus Falls north to Canada, and on peat soils near Albert Lea.



UNCOMMON

Uncommon crops diversify Minnesota's economy and landscape. When U of M researchers introduced "new" crops such as alfalfa and soybeans they had specific objectives of breeding for winter hardiness or earlier maturity. They were motivated, knowing that markets for the crops existed. In 1948 an adventurous research effort was initiated to evaluate all crops with potential for agricultural production. Some of the possible uses were in crop rotations, as exotic foods or beverages, for medicinal applications, for industrial products, for pulp and paper, or to benefit the environment.

Over the last half-century 225 species from 26 plant families were evaluated at U of M research stations throughout the state. Agronomists studied management and breeding of promising crops while food scientists and agricultural economists explored utilization and markets. The results are an encyclopedia of alternative crops that are used to diversify crop production in Minnesota and throughout the plains states.

Plants have many uses besides direct consumption by humans or livestock. In1954 U of M trials documented that rye acts as a bio-control of weeds in row crops such as soybeans, naturally suppressing weed growth. Rye straw is used for livestock bedding and the grain as feed, Christmas tree growers plant rye between rotations as a natural weed control, and there is a small market for human use in breads and rolls.

U OF M RYE VARIETIES

Caribou	1954
Elk	1959
Emerald	n/a
Pearl	1964
Swedish Minn. #2	n/a
Von Lochow	1964
Rymin	1973

Colorful amaranth is a healthy grain used in pastas and crackers. The first University studies of yield, varieties, and production practices were planted in 1966. Originally from South America, amaranth was considered one of 3 crops of the Aztec gods. Use of the leaves for livestock feed was also researched by U of M and USDA scientists.

Minnesota is a major producer of birdfeed. Many of the companies that mix and package the products are located in the northwestern part of the state. In addition to the varieties listed below, U of M research has helped develop other crops that are for the birds, including sunflowers, millet, and annual canarygrass.

U OF M VARIETIES USED AS BIRDFEED

Alden canarygrass	1973	Snobird millet	1973
Keet canarygrass	1979	Minco millet	1976
Elias canarygrass	1983	Minsum millet	1980
		Petite tickbean	1975

CROPS

Echinacea, or coneflower, is reportedly the top-selling herbal and natural cold and flu product in the U.S. It was used by American Indians for medicinal purposes more than any other plant. Echinacea plants originally grew on the dry beach ridges of glacial Lake Agassiz in northwestern Minnesota. University biologists are studying how it may be cultivated, in order to supplement farm income and save wild populations from plant poachers.

Fababean is the common name U of M scientists originated in 1968 as the now internationally accepted designation for all *Vicia faba* subspecies.

Many uncommon crops, including chickpea (garbanzo beans) are used extensively by the growing number of vegetarian consumers and organic farmers.

UNCOMMON CROPS EVALUATED BY U of M

CROP	USES
amaranth	grain for flour, cereal
annual canarygrass	birdfeed, potential food
buckwheat	pancake flour, (Japanese) noodles
camelina	vegetable oil
canola	major edible oil
chickpea	salads, soups
comfrey	tea
coneflower	herb, natural medicine
crambe	industrial oil
crownvetch	roadside reclamation
fababean	Middle Eastern food, livestock feed
fieldbean	navy, pinto, kidney, great northern
fieldpea	animal feed, human
flax	linseed oil, edible oil, linen, paper
grain sorghum	livestock feed, African staple
hemp	fiber for rope, paper, medicinal
kenaf	fiber for cardboard, cheap paper
lentil	soups, sprouts
millet	African grain, flour, birdfeed
mustard	spice
pumpkin	snack, roasted & fried
niger	birdfeed, cooking oil
oilseed radish	industrial oil
peanut	oil, food
quinoa	grain, flour, cereal
ragi	bread, puddings, liquor
rape	industrial oil, ancestor of canola
rye	flour, livestock feed, whisky
safflower	cooking oil, bird feed
sesame	garnish on baked goods, cooking oil
sunflower	cooking oil, snacks, bird feed
tef	African grain, flour
vetch	forage, roadside restoration

University crop scientists have evaluated hundreds of lesser known and grown field crops. The information is passed on to farmers in many ways, including publications, web sites, and personal presentations by research and extension faculty such as this 1978 field tour of U of M research plots at the Sand Plains Research Farm, Becker.

U of M Varieties of Uncommon Crops (not pictured)

Adzuki	Minoka	1980	Oriental soups, sweet cakes
Field Pea	Procon	1986	livestock feed
Horsebean	Minnesota Horsebean	1968	livestock feed
Sorghum, Grain	Minnesota 1	1963	flour, livestock feed
	RS 455	1976	
	MA-4 A & B	1976	

OIL CROPS

A rolling landscape of yellow-flowered canola, a bright field of sunflowers, soybeans drying in the September sun, and waving stalks of corn all indicate the vast quantity of vegetable oil consumed in this country.

Oils are used for frying and baking, and in products from salad dressing to margarine. Still, they have an even longer list of industrial uses, from the ink on this publication to road deicers and bio-diesel fuel. From a dietary perspective, the last 50 years have seen a complete turnover in the source of oils. In 1950 U.S. consumption of vegetable oils was 15.5 pounds per person, in 2000 it was 60.7 pounds. All crops combined, Minnesota produces over one billion pounds of vegetable oil, making it one of the top producers in the U.S.

Food scientists at the University of Minnesota analyze fatty acids of specific crop varieties, to determine – for example -- which future soybean variety produces the healthiest cooking oil. Because of America's great dependence on fried foods, the most desirable oils remain stable longer, even while subjected to high heat.

A fundamental change occurred in agricultural commodities utilization over the last 50 to 75 years. Crops once used directly as feed, such as corn for pigs, are now broken down into primary components – oil, fiber, and protein – with many markets for each.

The U of M's long-term investigation of new crops, and new uses for the more common, enables Minnesota farmers and industries to compete nationally and globally. Fifty years ago soybeans and sunflowers were not grown here, but U of M research made it possible. And today, farmers and health-conscious consumers benefit from efforts to improve and expand production of canola.


Safflower


Canola


Sunflowers

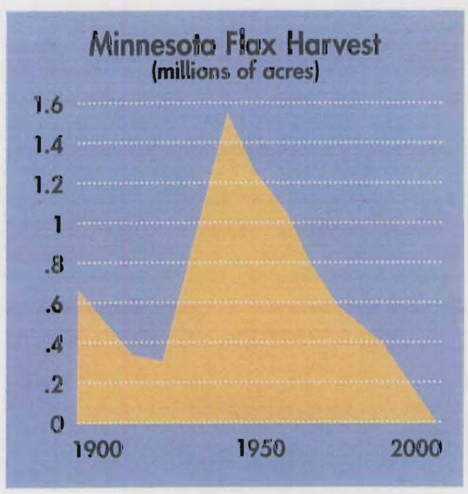
Sunflowers were not a U.S. farm commodity until U of M agronomists began work with Russian varieties in 1948. In 1967 the first sunflower oil extraction plant in the country was built in Gonvik. Minnesota is now fifth in sunflower production, with specific types for oil production, human, or bird use.


Soybeans

Vacationers crossing northwestern Minnesota likely are unaware that Minnesota is the country's second largest producer of canola. Low in saturated fat and high in Omega-3 fatty acid, canola oil is growing in popularity. Minnesota acreage has increased from 8,000 acres to over 250,000 acres in the last decade, providing an alternative crop in an area devastated by diseases in wheat and potatoes. University researchers evaluate canola varieties, nutrient needs, pest control, and rotation with small grains.

Flax

Flax is a history lesson in itself. It was brought by colonists and planted for fiber to weave into heavy linen clothing. Linseed oil was extracted from the seed and used as a preservative and paint. As America moved west and urbanized, demand for paint jumped and flax production soared. A huge linseed oil and paint industry developed alongside the country's major flax growing areas of Minnesota and the Dakotas. The first manufacturer of prepared paints in the U.S. was in the Twin Cities, and over half of the major paint companies operated here. By the 1940s Minnesota produced half of the country's flax.

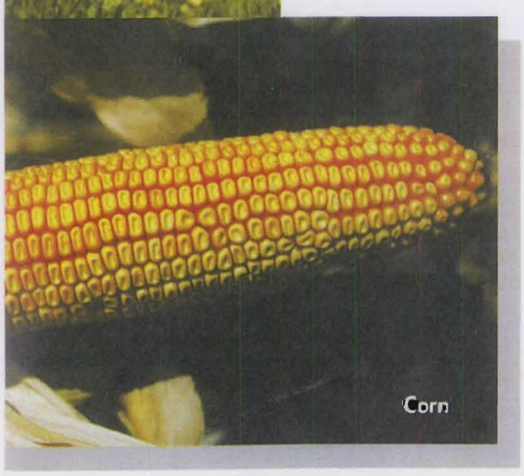


Flax production was critical during both World Wars to make paint for military equipment, and as feed – flax cakes – for livestock overseas in WWI. Flax acreage dropped sharply after WWII and again as synthetic fibers were developed, and almost disappeared by 1980 as latex paint displaced oil-based products. Today, flax is grown on limited acreage, but there is a renewed interest in the fiber for paper making and as a healthy, edible oil, thanks to plant breeders.

University of Minnesota flax research efforts over the past 110 years reflect society's needs. In 1890, after flax wilt hit the crop several times, the governor appointed the University's botanist and entomologist to, "make all necessary experiments and to find a remedy against this disease." By 1894 one plant that demonstrated resistance was selected, out of thousands evaluated. The progeny was named 'Primost' and released in 1900, the first pure-line flax variety in the U.S. The U of M Agricultural Experiment Station established the world center for flax testing and, until 1972, maintained the thousands of accessions in the world germplasm collection.

U of M Flax Varieties

Primost	1900
Redwing	1916
Winona	1922
Chippewa	1923
Redson	1943
Biwing	1943
Crystal	1944
Minerva	1949
Dakota	1949
Redwood	1952
Arny	1961
Marine 62	1962
Windom	1962
Nored	1968
Norstar	1969
Culbert	1975
Verne	1987



Corn oil is obtained from seed by squeezing it out, through rollers or hydraulic presses.

Development, Certification, and Marketing of U of M Varieties

While the University of Minnesota's Agricultural Experiment Station has responsibility for developing new agronomic – and horticultural – crops, the Minnesota Crop Improvement Association (MCIA) makes the new agronomic varieties available to farmers. MCIA's ties with the University date to 1903, when U of M plant breeders interested in the "systematic encouragement of the use of pedigreed seeds" founded the organization.

Today, the independent non-profit association is Minnesota's official seed certifying agency, providing Identity Preserved and Quality Assurance seed that is high quality and weed free, having been tested in purity and germination laboratories. MCIA also provides pre-certification of forest crops, and native plants – grasses and forbs – services.

BARLEY

Two basic types of barley – feed and malting – are grown in Minnesota. The U of M breeding program focused on malting varieties for the last half century. Earlier, high protein feed varieties for livestock were developed. As rail and truck distribution improved, breweries in St. Louis, Milwaukee, St. Paul, and other Midwest centers dominated the U.S. market. Quality barley was made possible by the climate and soils of western Minnesota and the Dakotas, matched with highly desirable seed developed by U of M researchers. A 1992 economic study documented that about two-thirds of all beer produced in the U.S. contained barley developed by U of M Agricultural Experiment Station scientists.

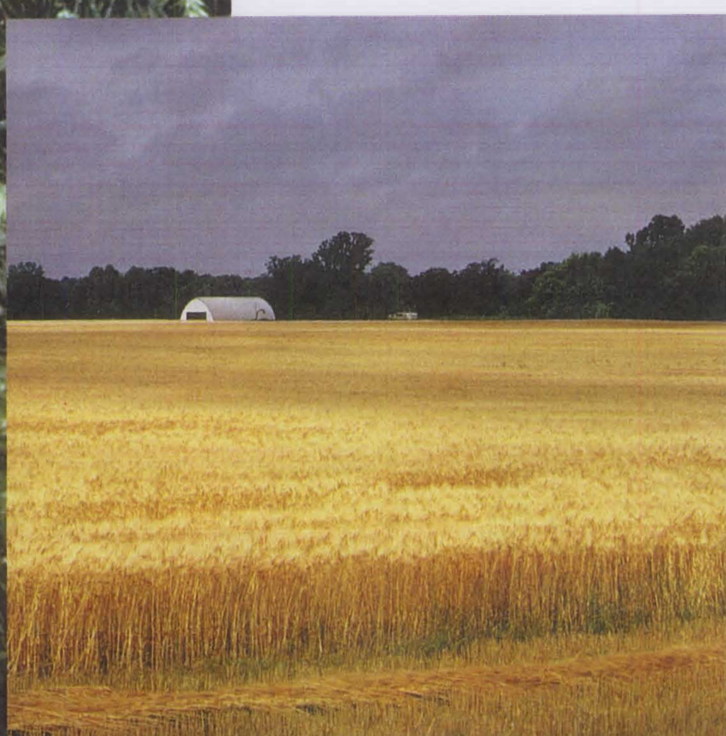
Barley production in Minnesota is now at its lowest point since the 1880s, due to the 1990s emergence of fusarium headblight, or scab. Scientists are making progress over the disease.

The primary goals of the barley breeding program are to develop high yielding varieties that are disease resistant, and that demonstrate exceptionally high malting and brewing qualities. The American Malting Barley Association supports U of M research, and tests rail-car quantities of any upcoming release to ensure it will offer brewers an improved product. For example, the varieties 'Morex' and 'Robust' provided malt houses with a higher percent of malt extract per bushel, as well as reduced malting time. Over a ten-year period this amounted to $297 million more for farmers and the brewing industry, from a $9 million investment in research and extension work. Growers support those efforts through the Minnesota Barley Research and Promotion Council.

Agronomists, plant pathologists, and molecular geneticists are now breeding barley – and wheat – for resistance to fusarium head blight, or scab. Through the 1990s this fungal disease resulted in over 1 billion dollars of losses. In 1998 the University released 'MnBrite' – a variety with some resistance – and in 2000, 'Lacey' -- a moderately resistant variety. Fully resistant varieties are the goal of a focused research effort enabled by special legislative funding.

Technology plays an increased role in the development of new crops, including barley. Genetic engineering allows scientists to more precisely improve plant characteristics.

U of M researchers harvest barley test plots in late July at the Northwest Research and Outreach Center, Crookston.



The flat and fertile Red River Valley of northwest Minnesota and eastern North Dakota is a major U.S. barley production area.

University of Minnesota malting barleys are "6-row" types, which yield the most grain per acre. Only one U of M variety, 'Svansota,' was a 2-row type like those grown in the drier, western production areas of Montana and Idaho.

■ **MANCHURIA**, was named and released in 1918 but was first selected in 1901 as Minn 184. The first nine U of M Agricultural Experiment Station barley varieties – through WWII – were feed types.

■ **VELVET**, 1926, was developed to eliminate the sharp hairs – awns – that prick farmers' skin and cause sores in animals' mouths. All but two barley varieties released since then have smooth awns.

■ **MOREX**, is named for "more extract" that it provides brewers. From 1980-84 it was grown on twice as many U.S. acres as any other barley.

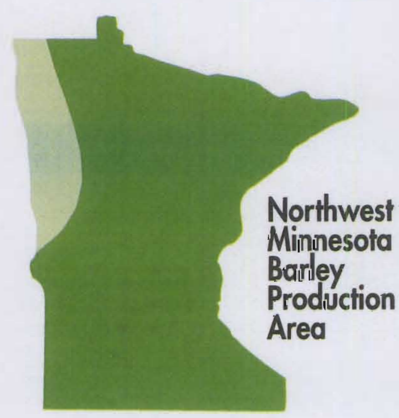
■ **ROBUST**, yields the plump, robust kernels favored by the malting industry. A 1983 release, it has a higher grain yield than 'Morex' and was grown on half the acreage in the tri-state area (ND, SD, MN) from 1985-99.

■ **EXCEL**, is a 1990 U of M release that combined the high grain yield of 'Robust' and high malt extract of 'Morex'.

U of M Barley Varieties

Manchuria	1918	Cree	1957
Minsturdi	1922	Manker	1974
Svansota	1926	Morex	1978
Velvet	1926	Robust	1983
Peatland	1926	Excel	1990
Glabron	1929	Stander	1993
Regal	1931	Royal	1994
Mars	1945	MNBrite	1998
Forrest	1957	Lacey	2000

Much of the beer produced in major U.S. breweries is made from Minnesota barley varieties.



SWEET CORN & GREEN PEAS

Sweet corn makes many people smile. Minnesota grown corn-on-the-cob is a culinary sign of midsummer, awaited by gourmets of every age. However, consumption of fresh produce is dwarfed by quantities commercially processed and sold frozen or canned. The Midwest region of Minnesota, Wisconsin, and Illinois produces more than 45 percent of the U.S. supply of processed vegetables, with a wholesale value close to two billion dollars. Much is sold directly to the food service industry: restaurants, schools, and hospitals.

Minnesota's canning industry began in the 1920s, and expanded because the cool and somewhat dry climate in Minnesota reduces insect and disease problems. Even so, up to 10 percent of the pea crop is lost to root rot. U of M horticultural research focuses on root rot in peas, and control of European corn borer and ear worm damage in sweet corn.

Breeders developed and released to seed companies germplasm with improved resistance to these pests, and scientists are improving crop management systems for sustainable production. Also, food scientists have increased the nutrient levels of processed foods, through improved storage and processing technology.

Commercial and experimental peas are examined for signs of root rot, obvious in some varieties that are already wilting and turning brown. In the first plot, MN 314 exhibits the most resistance and is used by commercial seed companies to improve their lines.

Minnesota ranks first in green peas production.

U of M Green Pea Varieties

MN 108	1976
MN 494 A11	1980
MN 144	1994
MN 313	1994

U of M Sweet Corn Varieties

Minhybrid 201, 202, 203	1936
Minhybrid 204, 205	1937
AS 9	1980
AS 11, AS 12	1986
AE-HY-13A, AE-HY-13B	1987
A 684su, A 685su, A 686su	1992

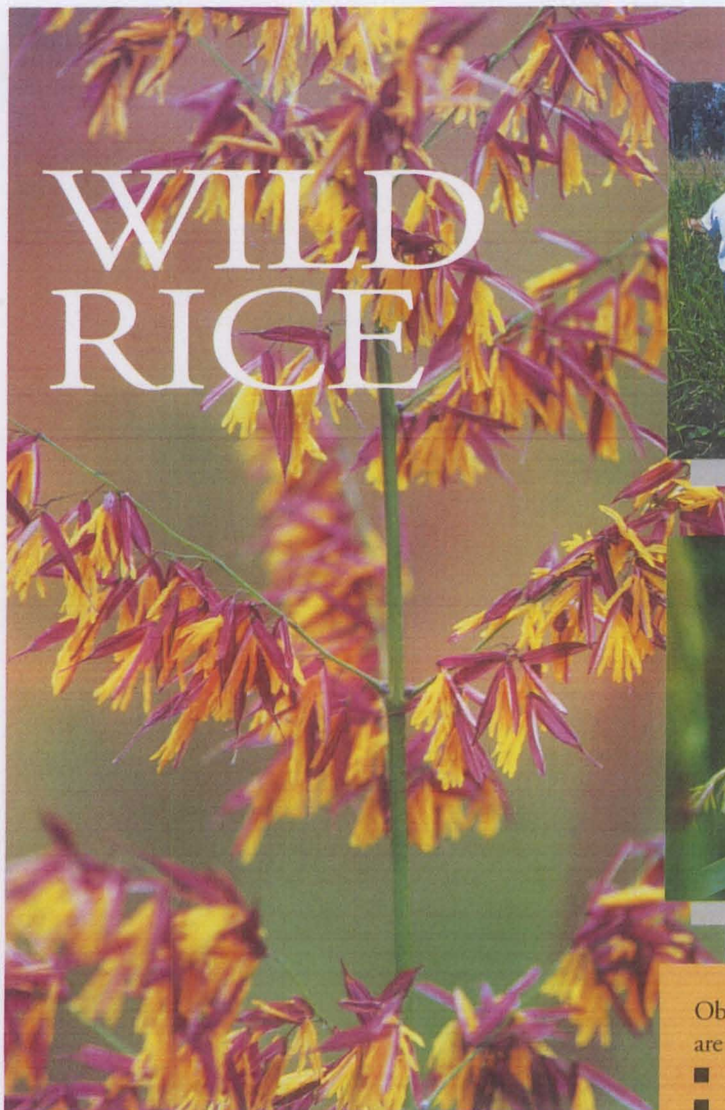
Minnesota ranks second in sweet corn production, with one and a half billion pounds grown annually. Most is canned or frozen.

Vegetables as Medicine

Cabbage grown at the Southern Research and Outreach Center, Waseca, is part of a U of M medical and nutrition study. Plant scientists are developing methods to enhance the plant's production of nutriceuticals, chemicals such as glucosinolates that reduce one's risk of cancer.

The relationship of plants and human health is the focus of additional studies by food and biomedical scientists and horticulturalists. Other crops being evaluated for cancer chemopreventive agents include watercress, Chinese cabbage, carrots, turnips, and tomatoes.

WILD RICE



'Purple Petrowski' is the newest wildrice variety from the U of M Agricultural Experiment Station, with a natural maroon and gold color scheme. It has high resistance to shattering and lodging, produces high yields and is moderately resistant to a major fungal disease.

Much of the U.S. wildrice research takes place at the University's North Central Research and Outreach Center, Grand Rapids, where results are shared with growers and others interested in this unique crop. Nets cover the paddies to protect the research from birds.

Wildrice beds, lake or paddy, are home to a wide variety of insect, aquatic, waterfowl, and amphibious species, such as this frog.

Objectives of the wildrice breeding program are to develop:

- More lodging resistance
- Earlier maturity
- Resistance to leaf diseases
- Increased shattering resistance
- Multiple stems that mature together
- Seed that can be stored dry

Wildrice is an aquatic grass revered by Native Americans in the Lake States, New England, and Canada. The only cereal grain native to the United States, this delicacy is Minnesota's State Grain. In the 1950s University plant scientists began studying hundreds of alternative crops, including wildrice. At the same time, interested farmers in northern Minnesota began to form a cultivated wildrice industry to meet increased demand.

Researchers were challenged in taming the wildrice plant to make it suitable for paddy production. There were limitations of planting, caring for, and harvesting an aquatic species. The seed head "shatters" when ripe, sending the precious crop into the water. Plants in natural stands mature at widely different times so several harvests must be made. And, the seed is not viable unless it is stored in conditions similar to a lake bottom.

Nevertheless, by 1964 selections were successfully grown in U of M paddies in St. Paul. Since then, nine varieties of paddy wildrice have been developed, each with improved production or disease-resistance characteristics.

Today there are two wildrice communities. Native Americans hand-harvest wildrice by traditional methods, from canoes and using flails to dislodge the grain, which is labeled "lake grown." U of M varieties are grown by commercial producers in paddies where mechanical harvesting is done by specialized combines. Minnesota produces over 6 million pounds of "paddy grown" wildrice, and much of it goes to food processors that market it in blends with white rice.

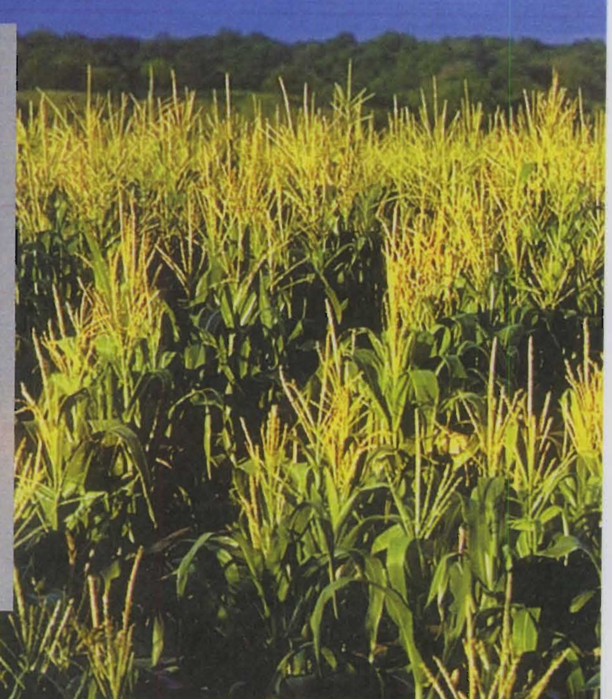
Interestingly, recent DNA analysis shows that white rice and wildrice have some common ancestry, contrary to earlier thinking that these species evolved separately in Asia and North America.

U of M Wildrice Varieties

Johnson*	1968
M1*	1970
K2*	1972
M3*	1974
Netum	1978
Voyager	1983
Meter	1985
Franklin	1992
Purple Petrowski	2000

* released by commercial growers, research conducted in cooperation with U of M

CORN



Of all major food crops in Minnesota, corn – or maize – is the only native of the Americas. Maize was domesticated about 5,000 years ago in tropical Mexico, and cultivation spread among Native American tribes. Unlike other grasses it produces separate male (tassels) and female flowers (silks) and can adapt quickly to different environments.

In 1970, molecular biologists discovered where on the chromosome the genes responsible for protein synthesis are located. In 1975 U of M geneticists were also first to regenerate corn from tissue culture.

Until about 1915, farmers collected seed for the next crop from their best plants. They graded the cobs following University guidelines that even included plans for the wood rack used to sort the cobs. While this open pollinated seed was somewhat customized to local conditions, the plants matured unevenly and the stalks often broke and fell over. U of M agronomists released exceptional open pollinated varieties in the early 1900s as they developed the science of controlled pollination – leading to hybrids – along with breeders at other land grant universities in Illinois, Iowa, Missouri, and Nebraska.

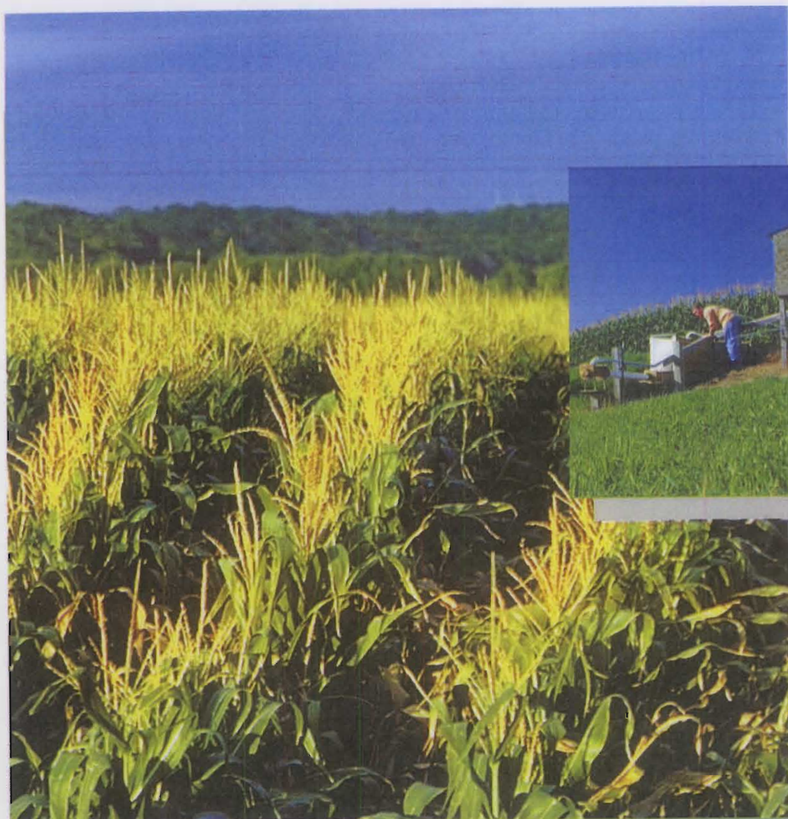
Efforts from 1915-20 identified "inbred" lines possessing specific, desirable traits that could be combined to create hybrids for particular regions and uses. In 1920 U of M corn breeding efforts expanded by adding staff at a branch of the University's Agricultural Experiment Station inWaseca. Earlier maturing hybrids – for northern regions – were tested on the St. Paul campus, while researchers at Waseca developed higher yielding, full season hybrids.

Experimental hybrid corn varieties were released by the U of M in the late 1920s, as researchers conducted two landmark studies defining the trait of genetic "combining ability" and how important it was to hybrid success. The best in the reservoir of superior inbreds were used over the next 50 years to create almost 100 "Minhybrids" adapted to Minnesota's extreme conditions. U of M researchers have long worked for farmers through the Minnesota Corn Research and Promotion Council.

From dry sandy areas up north to moist organic soils and a longer growing season in the south, the University varieties set performance standards for a rapidly developing private seed corn industry.

The United States provides about 80 percent of the world's corn. Minnesota, on the northern fringe of the Corn Belt, ranks fourth in the U.S. Corn has over 3,500 uses, falling into several broad categories:

- **50 % Animal feed – cattle, hogs, poultry**
- **23 % Exports – almost all for livestock feed**
- **10 % Reserves – provides a supply in bad crop years**
- **8 % Sweetener – candy, and over half of all non-diet soda**
- **5 % Ethanol fuel – reduces pollution**
- **4% Direct human consumption – thickener in processed foods**



University soil scientists analyze runoff from row crops to determine what tillage systems best protect the soil. The results influence how farmers plant, till, and harvest crops; lead to improved water quality; and impact marine life in the Gulf of Mexico.

U of M Corn Releases

99 Hybrids	1920s - 1970s
98 Inbred Lines	1920s - 2000
3 Popcorn Hybrids	1930s
12 Open Pollinated	1893 - 1920s
■ Minn. 13	■ Pearl Flint
■ Rustler	■ Dakota Whit
■ NW Dent	■ Golden King
■ Longfellow	■ Golden Jewel
■ Silver King	■ Murdock
■ Gehu	■ Minn. 23

Researchers evaluate plants for:

- Early season vigor
- Resistance to stem & leaf diseases
- Insect resistance
- Plant height
- Number of ears per plant
- Ear length
- Number of rows of kernels
- Root systems & standability
- Date of maturity
- Yield performance

Field workers take a break from a 1930s harvest at Waseca, center of much of the University's corn research In 1939 the state legislature approvec maturity testing of all seed corn sold, an early consumer protection act for farmers. Five zones were established from north to south, with the U of M Agricultural Experiment Station designated as official testing agency. Researchers plant and test hybrids in each zone and compare days to matu rity (30 percent ear moisture) to a reference hybrid. Seed compaies provid this rating on each bag of seed sold.

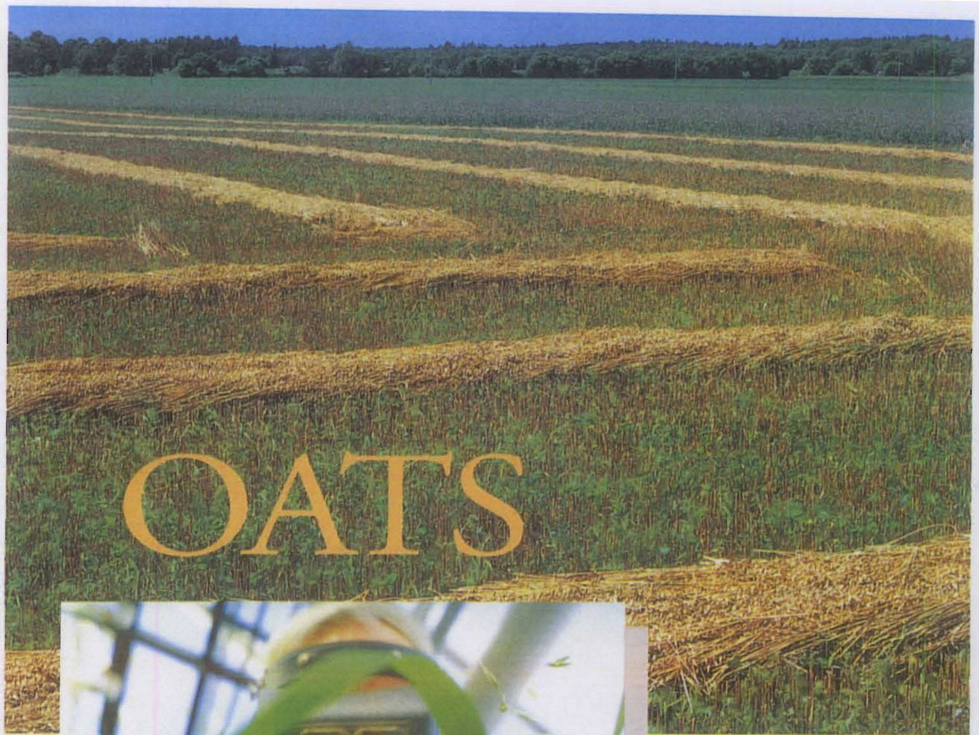
50 Years of U of M Research Shared Globally

From 1950 to 2000 the U of M released to commercial seed companies more than 100 inbred lines and germplasm – the specific, unique characteristics of a plant. Traits captured in germplasm solve specific challenges: disease resistance, natural protection from insects, drought tolerance, or efficient use of nitrogen. The genetic information is developed by traditional and modern breeding techniques, including molecular genetics. Hybrid seed contains germplasm from many sources, built upon decades of public and private research.

A major analysis of corn grown two decades ago showed that U of M germplasm was used in hybrids growing on 21 percent of U.S. corn acres. Two of the inbred lines ranked first and fourth of all corn parents in the country.

A U of M genetic engineering effort created high lysine, an essential amino acid, germplasm. The goal is to improve human and animal nutrition in parts of the world where maize is a major component of the diet.

University accomplishments in corn breeding are recognized globally. In the 1950s and 60s Minnesota breeders worked with the United Nations Food and Agriculture Organization and shared Minnesota corn germplasm worldwide. These efforts have attracted many international students. After working on genetics, disease, insect, or soils research, they have gone on to establish or strengthen research programs worldwide.



OATS

Oats were originally one of the most widely grown farm crops in the Midwest. The grain was used for protein and fiber in animal diets and the straw as bedding. Oats fit well into the labor and livestock intense system of 1900.

As America developed so did its manufacturing, transportation, and agricultural systems. Farms became specialized and mechanized, with fewer and fewer draft animals needed to work on farms, or in cities, mines, or forests. In Minnesota, oat production was on 2,500,000 acres in 1900, peaked in 1945 at 5,392,000, and is 300,000 acres today. The average farm is now 356 acres and specializes: in corn-soybeans, small grains, or forage crops, and/or a single livestock species.

Oats is often used as a "companion crop" to establish alfalfa. The oat plants emerge and grow quickly, protecting the tiny alfalfa seedlings from erosion and the drying sun until they can survive on their own. The oats may then be cut, chopped, and used as silage to feed livestock. Or, the oat crop may be grown to maturity and harvested, the grain used as livestock feed and the straw for bedding. 'Preston,' 'Starter,' and 'Pal,' were developed to serve as companion crops.

Oats are still a multiple-use crop. In addition to animal feed and bedding, they are found in a wide variety of breads, cereals of all types, granola bars and as a thickener in infant foods. University of Minnesota cereal and nutrition scientists documented how beta-glucan, found in abundance in oat and barley fiber, lowers the risk factors for heart disease. Oats are now widely promoted as the "most healthy" grain.

Early U of M research led to higher yielding varieties resistant to fungal diseases that can spread extremely fast and destroy the crop. In 1966 oat scientists began a cooperative research effort with Mexican breeders after stem rust decimated that country's oat fields. After improving Mexican varieties to incorporate rust resistance, Experiment Station researchers began work with scientists in Argentina, Brazil, Chile, and Uruguay where crown rust is still a severe problem.

Plant breeders use winter nurseries to speed variety development. The U of M oat program has off-season plots in New Zealand, in a site with soils and growing conditions similar to Minnesota. For more than 50 years, the Quaker Oats company has supported U of M international and domestic research as well as many graduate students.

Plant breeders working with oats, wheat, and barley learn to work carefully with the small flowers when they cross pollinate two parents.

150 YEARS 1851 2001

'Sesqui' is the most recent oat variety and commemorates the University of Minnesota Sesquicentennial. Oat breeding was one of the first applied research projects at the University, and in 1895 an improved oat variety was released by the Minnesota Agricultural Experiment Station.

U of M Oat Varieties

Improved Ligoua	1895
Swedish Select	1908
MN #281	1910
MN #289	1910
Minota	1910
Silvermine	1914
Gopher	1923
Anthony	1929
Minrus	1931
Mindo	1946
Bonda	1946
Zephyr	1949
Andrew	1949
Minland	1955
Minhafer	1957
Minton	1959
Otter	1970
Lyon	1977
Moore	1978
Benson	1979
Preston	1982
Proat	1983
Starter	1986
Premier	1990
Milton	1994
Pal	1994
Jim	1995
Richard	2000
Wabasha	2001
Sesqui	2001

HOW RESEARCH WORKS

A Case Study: Disease Resistance in Small Grains

Agricultural research, be it current or historic, molecular or applied, meets pressing needs of Minnesotans. While many successes are documented here, a look at an ongoing project illustrates the complexity of agriculture and research.

Fusarium headblight, commonly known as "scab", is a disease affecting wheat and barley that emerged in 1993. By 1995 the outbreak became an epidemic and by 2000 had caused $1 billion of crop losses in Minnesota and the Dakotas. The Minnesota Legislature responded by funding a research effort of over a million dollars a year. In the last century, no plant disease in this region has caused so much damage, though rust outbreaks from 1900-30s came close.

Researchers found that the scab devastation was caused by a convergence of a number of factors.

- Wheat and barley varieties used did not have resistance to scab.
- Increased popularity of reduced tillage, leaving more surface residue which reduces erosion, but also harbors the pathogen.
- New crops – some host fusarium – were grown in the small grain areas as farmers diversified.
- Rotten weather, specifically, more than usual warm-moist conditions during grain heading that provided ideal conditions for fungal growth.

U of M and USDA geneticists had previously identified some resistance in Chinese varieties. However, as the timeline below shows, it takes almost a decade to release a new variety. Gene splicing allows more precise control over the results, but a genetic source of resistance must first be identified.

Besides breeding efforts, fusarium headblight is being fought on other fronts. Plant pathologists developed techniques to more rapidly test for the disease. Agricultural engineers invented processes to separate infected kernels from clean ones, providing hope that producers would still be able to market their crop. Food scientists and livestock researchers test consumer acceptance of food, feed, and beverages that contain residual levels of scab.

While the fight to control fusarium headblight is not over, new varieties represent incremental improvements. Other spin offs from this effort will help when future challenges arise: techniques to measure traces of disease, and new nurseries, irrigation systems, and greenhouses that will be used far into the future.

Progress Against Scab

- **BacUp,** wheat, 1996, reasonable yield and kernel quality even in scab conditions, introduced as a "bridge" to farmers in areas with severe scab conditions until more resistant varieties are developed.
- **HJ98,** wheat, 1998, high yield wheat, medium protein, medium-high scab resistance.
- **McVEY,** wheat, 1999, first wheat variety with very high yield under either scab or no-scab conditions.
- **MnBRITE,** barley, 1998, malting variety with some resistance to fusarium headblight.
- **LACEY,** barley, 2000, moderately scab-resistant malting barley.

Development of a new variety of a crop – barley in the example below – begins with the selection of parents with desirable traits. Breeders may be searching for resistance to a specific disease – such as scab – or higher yield, improved milling and baking quality, protein content, or malting quality. This example tracks one pair of parents from cross-pollination to eventual distribution to producers. Each breeding program will have many (10-100) different crosses in progress, using parents with diverse genetics to meet different requirements. The likelihood of any one cross surviving these rigorous years of testing is slight, and those few that do are listed in this publication.

Plant Breeding Timeline: A Decade of Commitment

YEAR 0 – Initial cross-pollination of parents, one may include a gene spliced from another source. Many crosses (up to 200) of these parents are made to ensure an adequate seed supply for future tests.

YEAR 1 – Three consecutive generations of self-pollinated plants are grown, to ensure uniform genetic backgrounds.
- greenhouse (1 seed per pot, about 1,000 pots)
- field (800 plants per cross)
- greenhouse (random selection from 200 field plants, 1 seed taken from each)

YEAR 2 – Seed (4th generation) is increased in winter nursery (Arizona) from 200 plants. Spring planting (5th generation) in 6 foot rows at St. Paul and Crookston, 20 best performing lines are identified. Initial, small scale malting test is conducted.

YEAR 3 – Seeds from 20 best are grown in Arizona to obtain 2 pounds of seed (6th generation) from each. Preliminary yield tests (7th generation) are grown in St. Paul and Crookston: 2 rows, each 10 feet long, replicated 3 times. Highest yielding lines move on.

YEAR 4 – Advanced yield trials in 5 Minnesota locations. Plots are 10 rows, each 10 feet long, with 3 replications.

YEAR 5 – 1st year of regional tests, 8-10 locations in Manitoba, North Dakota, and Wisonsin. Very competitive. 1st year of pilot plant malting tests, using a few pounds of seed.

YEAR 6 – 2nd year of regional performance tests and pilot plant malting. Variety release process begins with a seed increase program designed to supply expected grower demand.

YEAR 7 – Seed increase continues. Large scale malting and brewing evaluations by American Malting Barley Association, using minimum of 2,500 bushels.

YEAR 8 – New variety officially named and released by U of M Agricultural Experiment Station. Year of release is listed in this publication

YEAR 9 – Seed widely available to growers through seed companies

University research on diseases and weed control is shared with growers during tours of fieldbean plots. Current research by plant pathologists seeks to control white mold, which causes significant losses each year in commercial plantings.

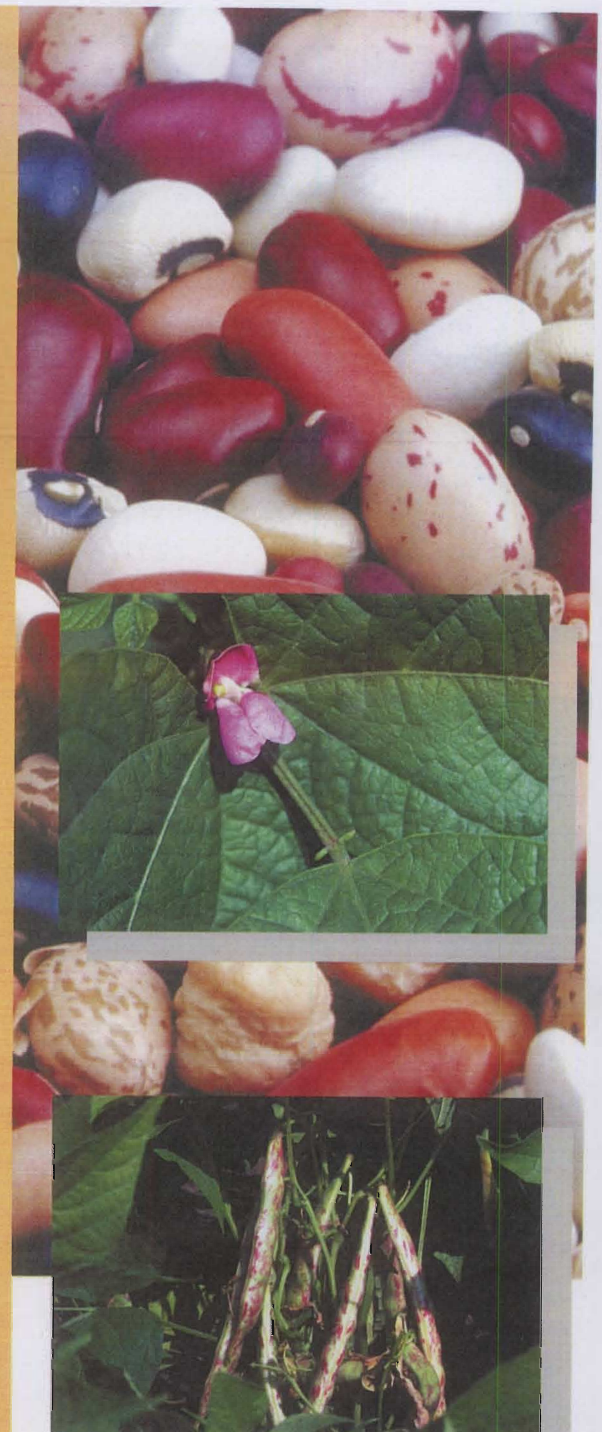
FIELDBEANS

Minnesota supports a healthy industry that grows and packages beans used for soups, chilis, tacos, and burritos. Farmers harvest about 250 million pounds of beans each year and most of it is exported. Plant scientists with the University of Minnesota Agricultural Experiment Station have studied this specialty crop since the 1950s. Researchers tested hundreds of varieties, identified the best performers, worked on field practices, improved processing, and helped create products and a new industry in the 1970s.

Some of the market classes of beans grown here – and their main uses - include:

- Adzuki – salads, soups, vegetable burgers, confectionary uses in Japan
- Pinto – chili, bean dip, refried beans, burritos, export markets
- Navy – soups, baked beans, export to England
- Kidney – chili, salads, baked dishes
- Great northern – soups, stews, cassoulet, export to England
- Black turtle – Cajun dishes, soups, beans and rice, export to Central and South America
- Cranberry – specialty bean dishes, soups, spreads

Minnesota now leads the nation in production of dark red kidney beans, with four times the harvest of the next competitor, Michigan. About 165,000 acres of fieldbeans are grown, in the Red River Valley and on irrigated sandy soil between Elk River, Park Rapids, and Wadena. The crop adds diversity to consumers' diets, to farm income, and to Minnesota agriculture.



Red-banded cranberry beans, like other fieldbeans, are harvested in September by combines that separate beans from pods. The black turtle bean's blossom is tiny, but Minnesota beans show up big in markets from the Far East to Great Britain.

FOR COPIES OF THIS AND OTHER PUBLICATIONS, 1-800-876-8636

Published by: University of Minnesota ■ Minnesota Agricultural Experiment Station www.maes.umn.edu ■ College of Agricultural, Food, and Environmental Sciences www.coafes.umn.edu

Content coordinator: Leland L. Hardman ■ Writer, editor, photographer: David L. Hansen ■ Copy editor: Arlene West ■ Designer: Nancy H. Teufert, River West Design ■ Printed by University of Minnesota Printing Services using soy-based inks.

For additional information: "Agronomy and Plant Genetics at the U of M, 1888-2000," MAES, MN Report 247-2000 ■ MAES bulletins and annual reports, 1893-2001 ■ "Minnesota Agricultural Statistics," USDA & MN Dept. of Agriculture