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Farm and Home Research: 50-4

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Selenium:

Poison?
Miracle nutrient?

page 4

Partnerships—on and off campus—
help us in 'making a difference'

Director's comments

by Kevin Kephart

THIS ISSUE OF FARM & HOME Research concludes our year-long golden anniversary celebration of its publication by the South Dakota Agricultural Experiment Station (AES). We have marked the occasion by describing several historically significant contributions by the South Dakota Agricultural Experiment Station and its scientists. This issue completes the series by presenting a story on the many mysteries of selenium, an element that exists in relatively high abundance in many South Dakota's soils.

Early research suggested that, in much of the state, potentially hazardous levels in of selenium could accumulate in certain plants, which, when grazed, would poison livestock. Today, however, we know that much of the world is deficient in selenium and that crops

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About the cover:
Pioneering discoveries made SDSU a world leader in selenium research. Generally, the world has a deficiency of of the element; South Dakota has an excess in large parts of West River. The 1980 photo is of Ivan Palmer, left, and Oscar Olson, now deceased, two leaders in SDSU selenium research.

produced in South Dakota can be a valuable source of the element, both as a nutrient and as a protectant against several serious human diseases.

The story on selenium was planned several months ago; however, it has turned out to be very timely. One of the key scientists in our selenium research was Dr. Oscar Olson. Dr. Olson passed away in early December 1999, leaving an outstanding legacy of scientific achievement. I was fortunate to meet Dr. Olson on several occasions, and I know he was an inspiration to many AES scientists. This issue of Farm & Home Research is dedicated to him.

Since 1887 the South Dakota Agricultural Experiment Station has made important contributions to agriculture, natural resource management, and rural living. We could have written about many other historic milestones. Here are just a few the lack of space would not let us include:

- In the 1930s, AES engineers developed rammed-earth techniques for construction. Because they are economical and the raw materials are handy, rammed-earth buildings are being constructed today the world over in developing nations.
- Also in the 1930s, dairy scientists determined the role of vitamins A and D in dairy cattle.
- In the 1940s, sorghum cultivars were developed that had lower accumulations of dhurrin, the major cause of prussic acid poisoning.
- South Dakota State University entered the biotechnology era as early as the mid-1950s when tissue culture techniques were developed.

Team efforts and partnerships have been hallmarks of many of our research programs. In this issue of the magazine, there are separate articles on soybean and wheat variety development. The important take-home message of both articles is that these programs are successful because of their collaborative nature.

Programs in crop breeding, value-added agriculture, livestock feeding, dairy production and processing, and development of innovative products are all supported by check-off funds provided by soybean, corn, wheat, pork, and beef producers. Our partners in Foundation Seed Stocks and the South Dakota Crop Improvement Association help us by delivering improved crop genetics to the state's producers. Our efforts in precision agriculture, wheat scab, biomass energy, no-till, and other projects are supported by partnerships with several federal agencies. Agricultural experiment stations across the country are required by federal policy to work together, so we also have research partnerships with other universities in nearly every state.

The new motto of the SDSU College of Agriculture and Biological Sciences is "Making A Difference." The Agricultural Experiment Station is indeed making a difference in the lives of all South Dakotans through its partnerships on and off campus. ❖

South Dakota scientists pioneered selenium research.
The torch has passed but the worldwide reputation remains

Poison? Miracle nutrient?

A tendency to link symptoms to saline water sources confused settlers and scientists until the 1930s when SDSU scientists traced the disease to particular soil types. This cow was gaunt because her legs were stiff and her hoofs were sloughing off, making it too painful to move to new grazing. Many animals "walked" on their knees. Some cows had hoofs that curled upward and were 10 inches long.

SELENIUM IS AN ELEMENT THAT has been both cursed and praised.

It is implicated in the failure of cavalry horses at Fort Randall to match Indian ponies in fleetness of foot. In the second part of the nineteenth century, troopers at this frontier fort on the Missouri River habitually gave up the chase or arrived too late to engage their Indian foes.

It is responsible for dozens of letters on file at SDSU from homesteaders in the new lands of the west, settlers whose horses and oxen became so sick they either died or so lame they could not be used for farm work. Hair fell out, joints stiffened, hoofs became so malformed that animals "walked" on their knees or their hoofs sloughed off.

It is one of the most intensively studied elements in the human diet, once considered a poison and now found essential to human health. Its list of scientific publications has passed 100,000 and continues to grow. The benefits some scientists claim seem just short of miraculous–a protectant against certain cancers, AIDS, cardiovascular ailments, Alzheimer's.

It has brought SDSU chemists worldwide acclaim for their pioneering work in tracing the element to specific soils and vegetation and for their continuing expertise in its biochemistry and toxicity.

Selenium, a poison or a "miracle" health benefit depending on your point of view, was discovered and named in Sweden in 1817 from the sediments of a sulfuric acid factory. The warning flags could have gone up at that point; the story goes that chemists were called in after workers had become sick when the plant switched its source of raw materials.

It's possible that Marco Polo had contact with selenium even earlier, in the 13th century during his visits to the Far East. His guides, he wrote, would not "venture among the mountains with any beasts of burden, ... on account of a poisonous plant growing there, which, if eaten by them, has the effect of causing the hoofs of the animals to drop off."

A near-perfect description of selenium poisoning in animals, today's scientists say. With the benefit of hindsight, they think the plants were probably selenium accumulators, capable of storing toxic amounts of the element in their tissues without being adversely affected themselves.

But it fell to an Army surgeon stationed at Fort Randall in 1856 to pen the first account of the disease on record:

> A very fatal disease manifested itself among the dragoon horses. ... Four companies of the second dragoons arrived at this post about the 10th of August, 1856 ... [and] encamped on the east or lower side of the dry ravine separating the dragoon and the infantry camps. About the 20th of August the disease commenced simultaneously in all four companies and many horses

> died, not, however, until the lapse of weeks and months. ... [F]rom extreme tenderness of the feet, they were unable to move about in search of food. ... After forage was provided for the horses no new cases occurred.

Fort Randall was established in 1856 and abandoned in 1892. Located on the second terrace above the Missouri River in what is now Gregory County, the location seemed to have all the essentials for a military fort.

Except, says Ivan Palmer, retired SDSU research biochemist, there were high rates of disease, desertion, and suicide. And a poor record of engagement with "hostiles."

Cholera and suicides were frequent causes of deaths. Southerners deserted to join the Confederacy. Years later, more soldiers slipped away to join the Black Hills gold rush. Those who stayed manned extra pickets, but raiders ran off their horses and drove off their beef herds. Troops were dispatched in pursuit, but the Indians nearly always outran them.

Amateur historians to this day wonder if the outcome would have changed had the troops' horses not been "poisoned" by the forage they ate. Indian ponies could move about freely to graze, and it is now known that most animals can detect and avoid selenium-bearing plants unless drought or overgrazing leaves them no choice. Tightly pastured close to the main garrison, the fort's horses had to eat what was available.

Although Army Surgeon Madison had made the connection between forage and disease symptoms, settlers in the area blamed the water for outbreaks of "alkali disease." The water was indeed "very saline and quite capable of producing physiological disturbance," as later reported by a federal scientist. But when the "frequent loss and still more frequent illness of cattle" were investigated, "the harmlessness of the water" was established.

Soldiers at Fort Randall mined chalk rock from quarries about 2 miles south of the fort for their chapel. The 2½-foot blocks were cut by a circular saw run by an old government mule on a treadmill. The bell tower also served as a watch tower. Al Moxon from SDSU later analyzed the stones, finding they contained 20 ppm selenium.

The credit for those findings goes to South Dakota scientists reporting in an Experiment Station bulletin in 1913.

After that discovery, the alkali disease project sputtered along for a number of years without showing much additional progress. "We have found so many complicating factors entering in that ... we are not intimating or promising solution," scientists concluded. By 1922, however, the first threads of a pattern were emerging: A soil survey showed a relationship between the disease and certain soil types. Unaware of the value of this work, the scientists never published their findings.

A vigorous new Agricultural Experiment Station chemist, K.W. Franke, arrived in South Dakota in 1928 and revitalized the work. Analysis of samples sent to federal cooperators revealed, for the first time, the element selenium in plant tissues. By 1934, when Wyoming scientists connected selenium-bearing plants with acute livestock poisoning, Franke was also reporting that alkali disease in South Dakota was linked to soils derived from Pierre shale.

Now selenium research moved into the laboratory. Difficult work lay ahead; scientists had to determine toxic levels of selenium for different kinds of animals, and then they had to try to find an antidote–if possible.

Franke and his students produced scores of research reports, building up a substantial body of scientific knowledge on selenium from their laboratory work with rats, rabbits, guinea pigs, and even dogs. Their published papers on poultry work contain photos of "alkalied" chicks that are not for the faint-hearted. The eggs were fertile. However, the embryos were so malformed even the scientists called them "monsters."

Shortly thereafter, the minimum fatal dose of selenium in rats was deter-

Al Moxon filled shelves of notebooks with his data. "The volume of his contributions is truly outstanding, especdially in light of the cumbersome methods of analysis of that time," says Ivan Palmer, SDSU biochemist.

Oscar Olson continued the work, coming up with "the definitive analysis" for selenium, according to Palmer. When the South Dakota Experiment Station was virtually alone in the field of selenium research, "Oscar developed our reputation."

mined. Accepted toxicity values for sodium selenite and sodium selenate have not changed much from those early days.

Some years earlier, in 1929, a young man, newly enrolled at South Dakota State College, had announced to the Dean of Ag that he wanted to earn a degree in ag with a major in chemistry. No such option was available but the Dean remembered the brash youngster.

A year later he called the student in, told him a new department, Experiment Station Chemistry, was being formed, and the new head, Franke, would need some lab help. Would he like the job?

So Alvin Moxon, who in 1999 presided at a national seminar on selenium and vitamin E held to celebrate his contributions and his 90th birthday, began his career by measuring the breaking strength of chicken egg shells for Franke.

By 1934, Franke had discovered that a protein in grain could become toxic and be responsible for alkali disease. Franke and Moxon set out to design a rapid and accurate system to assay for the selenium-containing protein. But Franke's career was cut short; he died of undulant fever (brucellosis) in 1936.

Moxon continued the work, in 1937 writing an Experiment Station bulletin summarizing the work on alkali disease in South Dakota that is still hailed as an "historical benchmark" in the field of selenium poisoning. Its catalog of disease symptoms has never needed to be corrected: dullness and lack of vitality, emaciation and rough coat, atrophy of the heart (or dishrag heart), atrophy and cirrhosis of the liver, anemia, erosion of the long bones causing stiffness, loss of hair, and soreness and sloughing of the hoofs.

A year later Moxon made a breakthrough discovery among his rat cages. Some animals had none of the liver damage associated with selenosis. The only thing different was arsenic, added at 5 ppm in their drinking water.

"To today, nobody knows why that happens," Moxon says.

And not a lot of good it would have done, anyway.

He had used sodium arsenite, a very toxic compound which accumulated arsenic in the body tissues. Obviously, inorganic arsenic wasn't the answer to selenium poisoning.

But the discovery sent scientists off in a new and profitable direction, studying the organic arsenicals. These compounds stimulate growth of swine and poultry, and the arsenic is excreted from the body. In 1956 three SDSU scientists, Rick Wahlstrom, Les Kamstra, and Oscar Olson, reported that if farmers used the recommended rates, "protection against selenium should be obtained when feeds are toxic, whereas growth stimulation is possible when feeds are not toxic."

Now Moxon needed someone to fill the job he'd vacated to become department head of Experiment Station Chemistry after Franke's death. So he hired another promising young scientist, Oscar Olson, just finishing his Master's degree in soils. The main focus of selenium research shifted to analysis of soils and geological formations.

At some point here, Moxon married. In a piece of folklore illustrating the dedication of the man to his work, it is said that he convinced his bride that untold wonders existed in the South Dakota west. It is not known when he told her that Olson would accompany the newlyweds on their honeymoon. For Moxon, this opportunity to sample seleniferous soils could not be passed up.

He doesn't deny it, says Palmer. Elaine Olson corroborates the story.

Selenium occurs in all soils worldwide, but unevenly, depending on geology and climate. Maps show that high-selenium regions in South Dakota are roughly distributed in a band along the Missouri River and in a zone circling the southern Black Hills. Most cattle

ranchers get along fine on seleniferous soils; however, Moxon reported that "many" farmers had to give up livestock enterprises and others had trouble selling their grain, especially when discounts ran as high as 50%.

Some plants–twogrooved poisonvetch, creamy poisonvetch, and prince's plume–are "indicators" of selenium because they can grow only on selenium-rich soils. "Accumulators," which are not so restricted, store high amounts of selenium in their tissues; there are about 24 species and varieties of milkvetch, heath aster, broom snakeweed, and gumweed, among others. One milkvetch sample reported from Wyoming had 14,900 ppm dry weight, an all-time-high record.

Native grasses and forbs usually contain less than 10 ppm, western wheatgrass tends to collect more selenium than other important grasses. Common crop plants, however, take up relatively small amounts that in most cases tend to be diluted out when the elevator or processor adds grains from low-selenium areas.

People living in high-selenium areas may have higher whole-blood concentrations of selenium than the general population, but they carry this off without any poisoning symptoms, says Mike Crews of the SDSU College of Family and Consumer Sciences. "They would know," he adds. "They'd have muscle and abdominal cramps, vomiting, diarrhea, vertigo, and even garlic breath."

Reed Ranch in Lyman County was used as an AES selenium research outpost for nearly 30 years. Scientists attemped to find "practical control measures" but were largely unsuccessful. The best prevention is still a grazing intensity that maintains range in good, sustainable shape. The tree belt and one foundation remain at the end of a two-wheel track.

The Experiment Station struck a deal in 1936 with the U.S. Resettlement Administration, an agency that bought property under the "marginal land purchase program." In cooperation with various federal agencies, the Station got the use of Reed Ranch, about midway between Pierre and Presho, in Lyman County. Located in one of the most seleniferous areas of the state, the 2,160-acre ranch was devoted almost entirely to the study of selenium poisoning, for here many trials that appeared promising in the lab could be enlarged to ranch scale.

In their 1957 summary of work at the ranch, Chris Dinkel, Joe Minyard, Gene Whitehead, and Oscar Olson listed the usual frustrations of understanding selenium distribution. Selenium concentration in the plants was not strictly related to total selenium concentration in the soils on which they grew. And selenium-bearing soils could occur at distances from their parent materials, redeposited by wind and water erosion.

They dug soil samples, analyzed plants, and made detailed maps. They added soil amendments, and expanded the organic arsenicals that had worked in the lab to field scale. All benefits were so slight as to be insignificant.

They correlated gender, age, even hide color (which made a big difference in swine experiments in the lab at Brookings) to growth and reproduction on a seleniferous range. They collected hair from the ranch herd; hair accumulates selenium and is an extremely accurate measure of selenosis.

"In spite of difficulties, ... Reed Ranch is, of course, the proving ground for the ideas and methods developed in the laboratory. Without such a ranch, it would be difficult to establish practical control measures," they concluded.

But the substation was expensive to run and was closed in the 1960s.

One of the lab experiments that worked better in the lab than in the field was the addition of linseed oil meals to cattle rations. Moxon found that rats seemed to be less vulnerable to the toxic effects of selenium if they were fed high-protein diets. The cause of this protection eluded scientists at SDSU and other institutions for a long time.

"For a whole host of graduate students, linseed oil meal was the topic of their graduate papers," Palmer says. "In

1979, Dr. Olson and I found that the protective fraction was two cyanogenic glycosides, sugar-like substances with a component that could be converted to cyanide. Cyanide protects the animal from selenosis by forming a compound with the selenium that can be readily excreted in the urine.

"While that is interesting, it still didn't give us an antidote to use in the field."

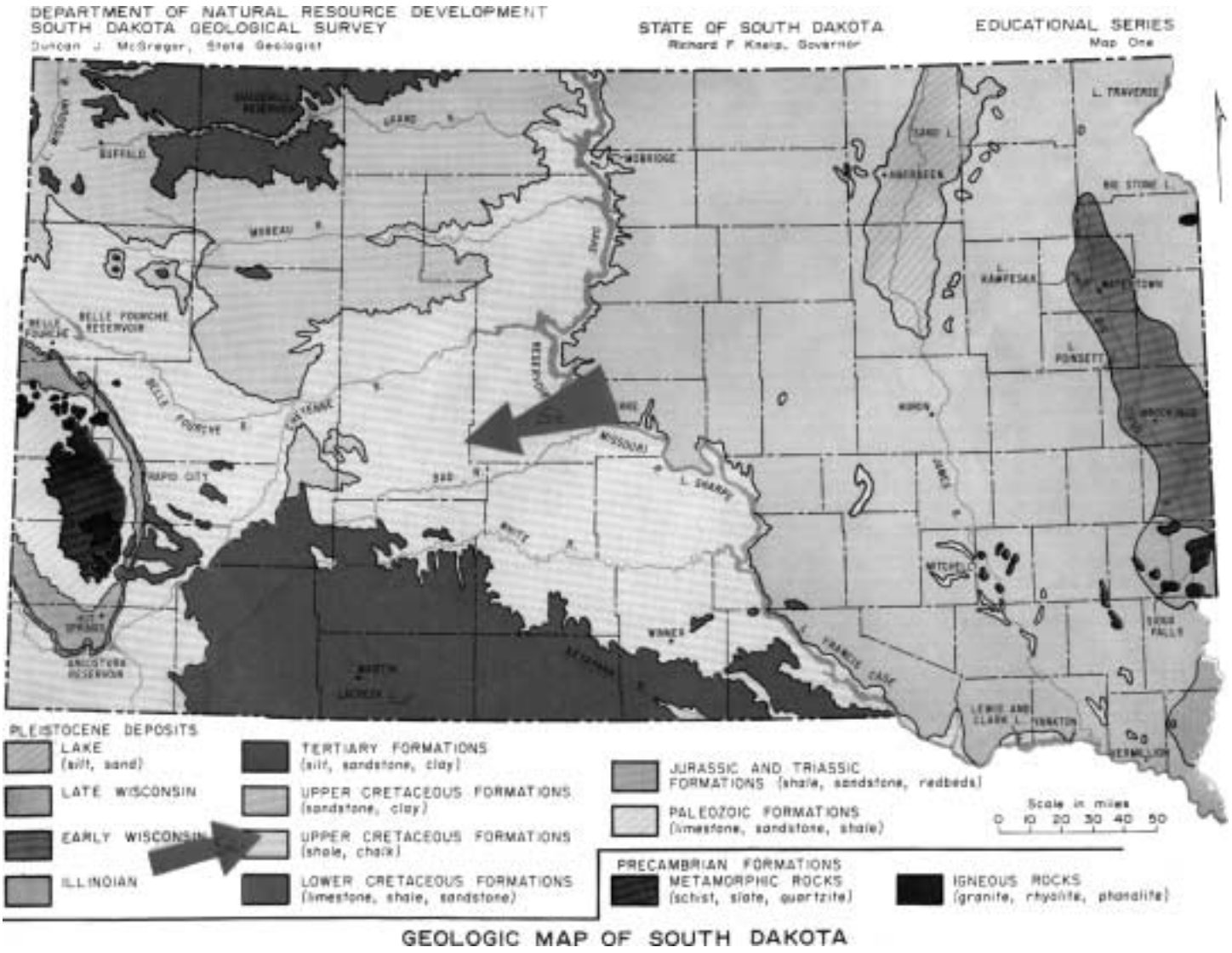
Palmer began as a hourly student laborer in Station Biochemistry, washing sample bottles. When he began helping with animal care on a project involving factors that were protective against selenium toxicity, "I was hooked."

Taking only time out to obtain his Ph.D. and to work for a "CIA-related research branch of the government," Palmer continued his selenium research until his retirement last year. "We wrote a series of scientific articles that gave the isolation, identification, and mechanism of action of the linseed oil meal factor. A nice, tight package. It was all collaborative; everybody added a piece."

Among collaborators were scientists from the departments of Animal and Range Sciences, Dairy, Plant Science and Biology/Microbiology.

And, while analyzing selenium samples for scientists from all over the world, Palmer continued to modify and improve the methods of selenium analysis, mainly using the fluorometric method developed by Olson in 1969 to measure selenium is soils, water, food products, and humans. "Then Nancy Thiex from Analytical Services and I collaborated on a method of selenium analysis for feeds and premixes. It was accepted for 'first-action status' by the Association of Official Analytical Chemists and was named their 'collaborative study of the year' in 1997."

The recognized expertise of scientists at SDSU has brought the lab a high number of contracts from other academic and research institutions, contracts that paid for analysis and also funded basic



Moxon and Olson speculated that high amounts of selenium-bearing organic matter accumulated at some locations in a shallow sea covering the Great Plains area during the Mesozoic era. Much later, glacial till covered much of South Dakota's East River, burying any geological formations that might have been high in selenium.

research projects at SDSU. The largest of these may be from the Arizona Cancer Center at the University of Arizona.

"The principal investigator there is beginning to show that selenium can lessen the impact of colon cancer. We've done the analytical work for him over the years."

The world's problem with selenium is deficiency, not excess. In New Zealand, the government recommends addition of selenium to fertilizers to ensure adequate levels in feeds and forages. In Finland, selenium is added to all NPK fertilizers, not for the plants' benefit but for human health. Keshan disease in young Chinese people and myocardial infarctions in Poland also are related to low levels of selenium in the soil, forages, and foods.

Deficiency effects are multiplied by culture.

"We supplement our foods in the U.S. for many reasons. European countries don't allow this. Officials in some countries don't even want their farmers to fertilize their fields," Palmer explains.

So it wasn't surprising that about 10 years ago, he was approached by the first of several German importers who wanted high-selenium wheat. The scientist put them in touch with South Dakota farmers in seleniferous areas.

"All we've done is the analysis. The growers do the negotiation on their own, load up the shipping containers, and send them off. The importers blend it with other wheat.

"When this started, I recommended to our farmers that they charge the market value of the wheat plus a dollar for each ppm of selenium. The very first farmer had wheat that contained 20 ppm selenium. That's high. So was the $25 per bushel he got."

The negative side, Palmer adds, is that the best areas for high-selenium wheat are also the areas that shouldn't be cultivated. They are highly erodible.

"That's why we don't promote this arrangement."

Scientists in human nutrition count 1957 as the turning point when selenium became acknowledged as an essential nutrient in animal and human diets.

"However," said a University of Georgia scientist at the selenium seminar this summer, "if we had paid more attention to a paper published by Moxon and his colleagues in 1941, we might have appreciated its importance much sooner."

That paper showed that the growth of barred Plymouth Rock chicks was significantly faster when a small amount of seleniferous grains was added to the feed. Pure selenium added to broiler feeds in this country every year is estimated to be a couple of tons.

Oscar Olson and his co-workers developed the method used worldwide to determine selenium content in foods and feeds and found the substances in linseed oil meal that protected animals from selenium toxicity. The lab where he worked is now named in his honor.

And now while the Olson Laboratories have closed down research projects on selenium, Analytical Services continues to process samples on request. Other SDSU scientists have picked up the ball.

Jim Doolittle of the Plant Science Department is working on selenium-phosphorus interactions. Biologists in the Department of Wildlife & Fisheries Sciences are tracing selenium from the bedrock formations along the tributaries of the Missouri River to spawning walleyes and endangered shorebirds.

Selenium levels in 100% of the piping plover and 97% of the least tern eggs examined exceeded expected background concentration, reaching the levels associated with embryo deformity or mortality in other bird species.

"For an abundant species, this might not make a difference," wrote Richard Ruelle. "But for an endangered or threatened species, it adds to the other environmental factors that could push it into extinction."

An early 1980s decline in Lake Oahe walleye sport fishing was pinned on poor reproduction, and contaminants were suspected. Mike Brown, knowing that concentrations of dissolved selenium in the Cheyenne River had increased considerably over the last 15 years, is collecting baseline data on selenium buildup in mature walleyes and eggs. Selenium has been implicated as a possible cause of poor reproduction in other fish populations in other places, but so far he has not found a connection in the Oahe walleye population.

Despite all the work over the years, Palmer admits selenium remains a mysterious element. There is still no antidote to selenium excess.

"The best thing is to simply manage it. Don't let your cattle graze high-selenium ranges in the spring when plants are growing fast, taking up larger quantities of selenium.

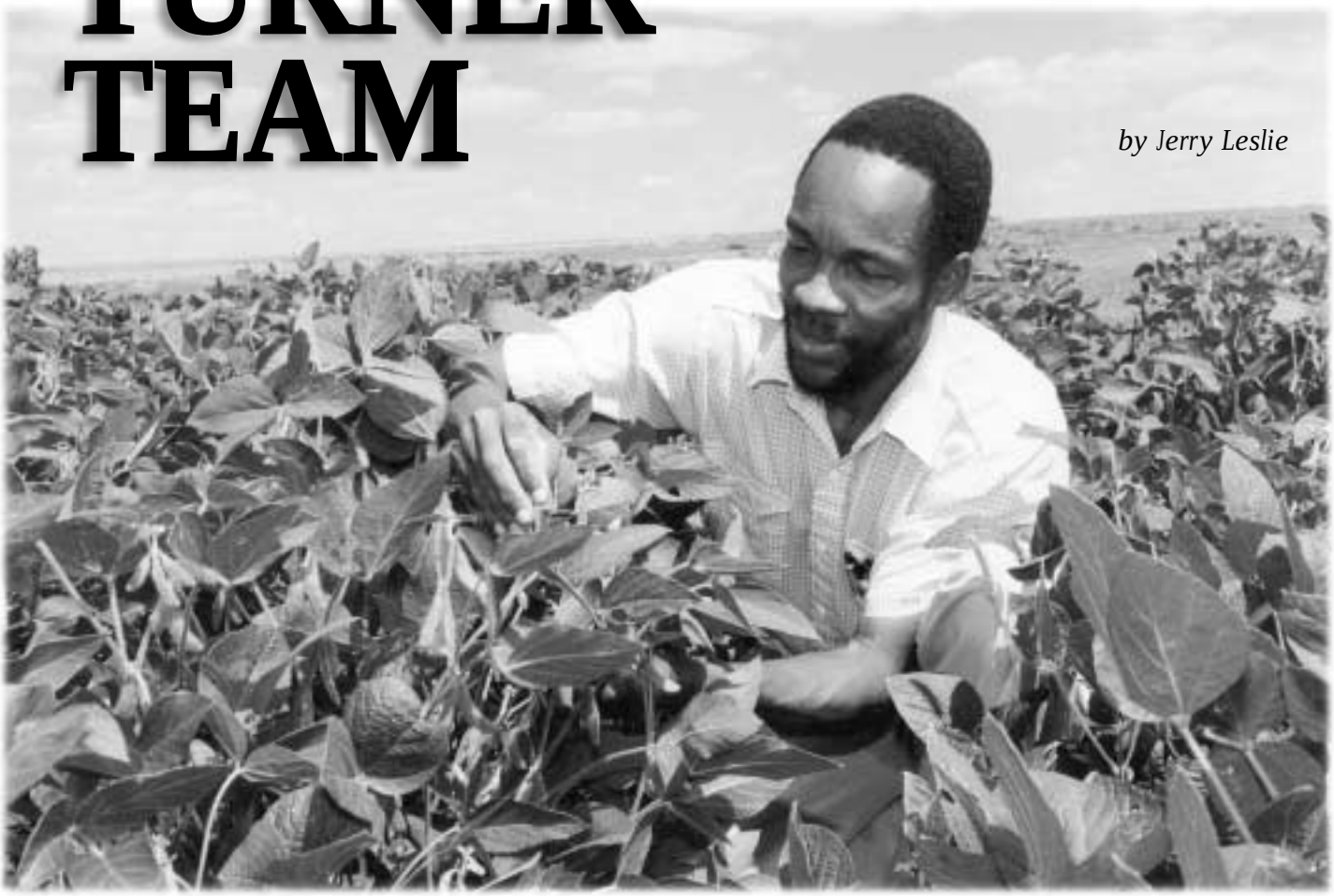
"Don't overgraze, or your animals will be forced to eat what they can get and that may be seleniferous plants. Dilute any feed that is high in selenium, including alfalfa, down to about 5 ppm."

Selenium once affected only soldiers and settlers in Dakota Territory. It is now recognized as an important component–in its absence or excess–of life itself. From early days to the present, says Palmer, SDSU scientists "have provided the baseline data that are still widely quoted today." ❖

THE TURNER TEAM

Check-off funds and cross-discipline teamwork produce nematode-resistant soybean

by Jerry Leslie



Roy Scott, Agricultural Experiment Station soybean breeder, suggests growers in and around Turner County in the southeastern part of the state consider recently released 'Turner' as their variety choice. It is resistant to race three of the soybean cyst nematode and has excellent yield in both infested and non-infested fields.

SOUTH DAKOTA GROWERS SOON WILL BE ASKING their dealers for 'Turner,' a new soybean resistant to soybean cyst nematode (SCN).

Developed by the South Dakota Agricultural Experiment Station, certified seed for Turner should be available for spring planting in 2001.

With Turner, as with most new crop varieties, progressing from greenhouse to farmer's drill box takes 8 or 10 years for breeding and testing and another 2 years for seed increase. And it takes the teamwork of scientists from multiple research specialties.

Farmers are part of the team. In round-table discussions, they tell the scientists what special characteristics they want in a new variety. When seed is available, a special group of growers plants and increases the variety so it can be sold to farmers in sufficient quantities to meet planting demands.

Development of the variety also depends heavily on the financial support of farmers through check-off dollars on each bushel sold. These funds supplement public tax support at land-grant universities for research and Extension work.

Tracking the development of Turner, one of many crop varieties released by SDSU over the years, reveals this teamwork.

Roy Scott, leader of SDSU's soybean breeding program, began working on Turner in 1991. He gives a large share of the credit for the new release to Jim Smolik, nematologist in the Plant Science Department, and Marty Draper, Extension plant pathologist.

Smolik had been surveying the state's soybean acreage for nematodes for about 10 years. In 1995, he and his graduate assistant James Jones, working with a grant from the South Dakota Soybean Research and Promotion Council, found the first SCN in South Dakota in soil samples from Union County. The next year, SCN showed up in Turner County.

With increased funding from the Soybean Council, Smolik expanded his survey work. In 1997, seven more counties were added: Clay, Lincoln, Moody, Brookings, Hamlin, Grant, and Day. In 1998, there were five more: Yankton, Minnehaha, Deuel, Roberts, and Brown. Bon Homme was added in 1999.

Even as he arrived at SDSU in 1991, Scott anticipated a nematode problem.

"I knew it was only a matter of time before we'd find it, since it was in states around us." He began making crosses among soybeans known to be resistant to nematodes.

Smolik screened these crosses in the greenhouse for resistance and also measured SCN population densities in field test plots that Scott then related to yield data. Field resistance levels helped Scott confirm the resistance levels shown by plants in the greenhouse.

Scott and Smolik appear each year before the South Dakota Soybean Research and Promotion Council with progress reports and funding requests. The Soybean Council, through producer check-off dollars, provides the main financial support for the soybean breeding project at SDSU.

Scott also collects suggestions from the farmers on future research directions.

"They are a strong voice for South Dakota soybean growers. They tell us how they would benefit from us doing research in a particular area.

"I listen to their priorities, and I set up some of my breeding objectives based on these discussions."

The Soybean Council also hires a private consultant to meet with each project leader funded by the Council to professionally evaluate the research and prevent duplication among states.

Funding of soybean research comes from farmer check-off dollars on every bushel of soybeans produced in the state, administered through the South Dakota Soybean Research and Promotion Council, and from South Dakota Agricultural Experiment Station Hatch Act dollars, the South Dakota Crop Improvement Association, South Dakota Foundation Seed Stocks, and the South Dakota Cooperative Extension Service. The United Soybean Board also contributed check-off dollars to the Extension educational effort on SCN.

Marty Draper, Extension plant pathologist, educates producers about SCN.

At producer meetings around the state, he and county Extension educators have been alerting farmers that the first SCN-resistant variety out of Scott's program was coming and that the line measured up very favorably to other SCN-resistant varieties available.

Draper tells farmers that he sees SCN as the most serious disease problem that producers face. "If you aren't dealing with it now, you will be dealing with it in coming years.

"It's a problem you've got, or a problem you're going to have, if you raise soybeans."

Jim Smolik, SDSU nematologist, has washed nematode females off plant roots. A mature female, he says, is nothing but a protective cyst for her eggs. He separates out the eggs, counts them under the microscope, and relates those numbers back to the soybean plant to determine its resistance level to SCN.

There are few management options, he says. "The list is pretty short: Recognize the problem, use resistant varieties, and rotate crops."

Draper receives funds from the South Dakota Soybean Research and Promotion Council and the North Central Soybean Research Program, a joint research funding effort supported by check-off dollars from growers in South Dakota, 13 other states, and Canada.

Smolik and Draper have published Extension Fact Sheet 902-A on managing the SCN. Research and Extension funding and a grant from the South Dakota Soybean Research and Promotion Council supported the publication. It is available from county Extension offices.

Scott acknowledges the importance of cooperative work and germplasm exchange between public soybean breeders in the region. SDSU participates in the Northern Regional Soybean Uniform Testing Program.

This is a joint project between USDA and regional ag experiment stations in which breeders from 16 states and Canada test each other's material. This testing eliminates less adapted plants before more time and dollars are spent on the unacceptable lines. Breeders also exchange germplasm.

Scott, for example, grows 10 uniform tests in South Dakota for the regional testing system. "I can cross any of those lines entered by other states into tests with my own materials without having to seek written permission," Scott said. "I give them the same courtesy. It is one of the rules in our program."

When a plant breeder has developed a line that meets standards for release as a new variety, the breeder turns over about a bushel of the pure seed to Jack Ingemansen, manager of the Foundation Seed Stocks Division. Foundation Seed Stocks is a non-profit corporation made up of growers and SDSU scientists.

Ingemansen's group will increase the seed for two cycles to get sufficient supplies of foundation seed. He may speed the process with a winter increase in South America followed by a summer increase in South Dakota, or he may use two summer increases in South Dakota.

In this time, breeder seed will go from a bushel or less to 50 or 100 bushels, and then up to a few thousand bushels the year of release.

In the third season, these several thousand bushels of registered seed are sold to growers belonging to the South Dakota Crop Improvement Association (SDCIA). The SDCIA is a statewide non-profit organization of growers who have special skills in increasing seed while maintaining its genetic purity and meeting mechanical standards, according to Bob Pollmann, their executive director.

These select growers increase the seed again to make it available in quantity to the farmer public as certified seed.

Marty Draper, Extension plant pathologist, warns a soybean grower that if he doesn't have stunting and reduced yield from soybean cyst nematode infestations now, he's bound to later. Nationally, SCN is the most damaging pest of soybeans in the U.S., causing estimated losses of $1 billion annually. Crop rotations, sanitation, and resistant varieties will help.

The Seed Certification Service sets up standards for each class of seed: foundation, registered, and certified seed.

Foundation seed has the strictest standards, followed by registered and then certified.

"The standards are stringent, even more stringent than the national certified seed standards, but within the reaches of what the growers can do, if they do everything right," Pollmann said.

"The growers used for these increases have experience in raising seed, and understand what it takes to get that job done."

Ingemansen agreed. "You want to give the seed to people who can handle it and maintain the genetic identity we've preserved."

Farmers who increase seed for the SDCIA can expect to have their fields inspected at some point in the growing season. They often choose their best fields for the increase, because they have a sizeable investment in the seed and inspection fees, Ingemansen said.

They must keep out noxious weed seeds. They need to isolate the fields to avoid crossing with pollen from similar crops. They must clean the seed in an approved certified-seed conditioning plant or sell it to a seed house that also can clean and market it.

Kevin Kephart, director of the Agricultural Experiment Station, said that for much of the last century, public institutions such as SDSU have been leaders in crop improvement.

"SDSU and its public and private cooperators have developed an effective partnership that serves our state with distinction.

"As a result, excellent modern crop cultivars have been developed by the South Dakota Agricultural Experiment Station, and high quality products are provided to all producers at a very reasonable price." ❖

Biostress challenge:
scientist/farmer team uses multiple strategies to protect crop from soybean cyst nematode

Turner, new SDSU soybean variety, is resistant to soybean cyst nematode

'Turner,' a new soybean variety resistant to soybean cyst nematode (SCN), was released by the South Dakota Agricultural Experiment Station director in the fall of 1999.

Roy Scott, soybean breeder and associate professor of plant science at SDSU, describes traits of the new variety that emerged from his breeding program.

Scott says Turner is being released mainly because of its soybean cyst nematode (SCN) resistance and also for its yield potential in non-infested fields.

Turner has 2.3 relative maturity, is resistant to race three of SCN, and has excellent yield for a SCN-resistant variety.

Scott says Turner competes very well with non-SCN varieties of similar maturity in non-infested fields. The new variety is widely adapted across the north-central United States where Group II soybeans are grown.

Turner reaches a mature plant height of about 36 inches. Seed size averages about 17 grams per 100 seeds with good seed quality and about 40% protein and 20% oil. Turner has good emergence, lodging resistance, and shattering scores.

Turner carries the Rps1-c gene for resistance to *Phytophthora* root rot, making it resistant to races 1 and 3, two of the prevalent races of root rot in South Dakota. Turner's tolerance to iron chlorosis is average.

Turner was derived from an F4 plant by crossing 'Glenwood' and 'Jack' varieties. The new variety has white flowers, gray pubescence, tan pod color, dull seed coat luster, yellow seed-coat color, buff hilum, and indeterminate growth habit.

In 2001, when Turner becomes available as certified seed to the growing public, the variety will give the state's soybean growers a new tool to help manage the problem of the yield-robbing SCN, a tiny unsegmented roundworm.

The new soybean variety is named for Turner County, a county with a potential use for the variety because of a problem with cyst nematode and where much of the testing was done.

Funding for Turner came from farmer check-off dollars on every bushel of soybeans produced in the state, administered through the South Dakota Soybean Research and Promotion Council, and from South Dakota Agricultural Experiment Station Hatch Act funds, the South Dakota Crop Improvement Association, South Dakota Foundation Seed Stocks, and the South Dakota Cooperative Extension Service. The United Soybean Board also contributed check-off dollars to the Extension educational effort on SCN.

When the water
may not be clean and safe,
citizens and scientists turn to WRI

‘A safe supply for years to come’

Kris Kappenman, SDSU biology graduate student, uses a Secchi disk to check the amount of turbidity in a WRI lake project.

by Jaimi Lammers

WATER IS NEEDED FOR survival, yet many people take clean, drinkable water for granted. When water quality becomes an issue, South Dakotans can turn to the South Dakota Water Resources Research Institute (WRI).

Scientists at the Institute are working every day to ensure a safe water supply for South Dakotans for years to come.

The Institute provides leadership in coordinating research and training in the broad area of water resources at SDSU and other state universities and agencies across the state. Research is directed toward state, regional, and national water problems. Graduate research training, technology transfer, and information transfer are also provided, said Dave German, lab supervisor.

"A big part of our research funding goes to graduate students. We give graduate students an opportunity to have a project and write a thesis on water resource problems that are relevant to South Dakota," said German.

Research projects usually are small. The funds administered through the WRI must be matched with other non-federal funds. This requirement results in more effective partnerships than if WRI funds were used alone.

WRIs at SDSU and other land-grant universities in each state are the research arm of the U.S. Geological Survey (USGS).

The Institute at SDSU has funded research projects throughout the state university system. Some include rehabilitation of petroleum-contaminated soils to prevent them from eventually polluting water supplies, conducted at Northern State University; water law issues at the University of South Dakota; and hydrology issues in the Black Hills at the South Dakota School of Mines and Technology. Many more projects deal with agriculture and have been funded and conducted at SDSU.

German is working on post-project assessment, determining if recommendations from a previous research project on non-point source pollution near Pickerel Lake are effective in improving water quality for the lake.

Farmers were encouraged to employ conservation practices during the project. German is following up on these practices and also checking if the water in the lake is maintaining its quality.

David Clay, SDSU Plant Science Department, is using Global Positioning Systems (GPS) to study precision farming issues such as how nutrient needs vary according to the lay of the land across various fields.

Diane Rickerl, SDSU Plant Science Department, and Larry Janssen, Economics, are studying wetlands in the Prairie Pothole region to determine the impact of wetland management on the viability of agronomic and wetland systems in that region.

German is midway through a project analyzing the water quality benefits of building animal waste systems at feedlots.

Before the feedlot is built, he tests the water quality above and below the feedlot. After the systems is built, another round of sampling is done. "The project has shown that animal waste management systems, if managed properly, do indeed improve water quality over feedlots where the manure is not contained," he said.

German is finishing the final report on pesticide loading in eastern South Dakota rivers. The project was a cooperative effort of the Institute, the South Dakota Department of Agriculture, the city of Sioux Falls, and the East Dakota Water Development District.

Each partner on the team had a deep interest in the study's outcomes, German said. "The Department of Agriculture is charged with managing pesticides statewide. The information from the study will give them a clearer picture of what pesticide issues are 'out there' and help them do a better job of managing any problems. The city of Sioux Falls "wants to know how many pesticides are coming their way and the effect they will have on the city's water source. And the general public has a lot of concern about pesticide use and pesticides contaminating the environment."

German's report, now in preparation "has both bad news and good news," he said.

"The bad news is that measurable amounts of pesticides were found in virtually every water sample we collected.

"The good news is that these pesticides appeared in low concentrations, rarely exceeding EPA health advisories. The water in eastern South Dakota rivers is pretty safe to drink, from the pesticide standpoint."

The most common pesticide contaminant, he said, was atrazine.

"It peaked in the samples in the spring shortly after field applications of the pesticide and gradually declined in concentration as fall approached. It's the one that bears watching in any future studies."

South Dakota has much lower pesticide concentrations in its water than do other agricultural states, German added.

The Water Quality Laboratory at the Institute serves both scientists and the general public, providing analytical services for the determination of organic and inorganic constituents in water, said German. Along with individual mineral analyses, the lab technicians conduct several package analyses.

One package, the livestock suitability analysis, is most often used by rural landowners who have their own wells. When cattle refuse to drink the water or turkeys aren't growing--situations the lab has dealt with–tests are done to determine if there's a water problem and if action needs to be taken to remedy it. Individuals receive a report showing results of the analysis. Information detailing why the high mineral content is a problem and what options for treatment could be taken is included at no additional cost.

"We don't recommend any one water conditioning service but suggest the types of treatment options they may have," he said. "If, for instance, their cows are in danger of having acute problems or dying, I'll write them a letter pointing out how severe the problem is and giving recommendations for what they should do."

Irrigation analyses utilize soil and aquifer maps from the USGS to help a farmer decide if water from a new well is suitable for irrigating specific types of soil.

"When there are excessively wet conditions and people aren't drilling a lot of irrigation wells, we don't receive a lot of these samples, but during dry times, we may analyze hundreds of them," said German.

Being located on the campus of the largest university in the state has its advantages. The Institute draws from the large population of undergraduate students on campus for research and laboratory support staff.

Students are involved in every part of the Institute's work, from information transfer services to washing lab equipment and operating computers for data management.

"We see them grow. They come here as freshman, sophomores, maybe as work-study students, and by the time they leave they really have marketable skills," German commented. "So it's an education added to what they're getting in the classroom."

Much younger students also have a place at the Water Resources Institute. The Institute has been taking part in water festivals across the state since 1993.

The water festival idea–teaching elementary students about water in a creative, hands-on manner–started in Pierre as an educational program on non-point source pollution. Local agencies, including water and conservation districts, have continued the festivals, German said.

The Brookings Water Festival annually draws 1,400 to 1,500 fourth graders from along the Interstate-29 corridor. Students come from schools as far away as Summit and Flandreau, he said.

The Institute staff also speaks in classrooms and takes school groups and organizations on "water field trips" to area lakes.

"Kids get concerned about water issues and go home and talk to their parents about it," he commented. "We try to help modify beliefs and behaviors, if that's necessary. It's easier to do it at that age."

Students and professionals, as well as the general public, have access to the Water Resources Institute library. An excellent choice of research reports, books, publications, and aquifer and geological maps is available.

"We share a network of information with the other institutes. They're all doing research out there. If that research is pertinent to something that we're doing, we'll acquire those reports," said German.

German said any 2 days at the Institute are never the same. "Water quality depends on what you're going to use it for. And we usually don't get two people with the same problem in any one day. Everybody's got their own difficulty, and we try to tailor the information to what is needed," he explained.

That is not always an easy task. Situations often call for expertise on subjects outside of water quality.

The Institute staff then turns to specialists on campus. "If, for example, a dairyman visits us with some water quality concerns, I'll call Kim Cassel (former Extension dairy specialist at SDSU) and talk to her about specific concerns with dairy animals," German noted.

"Quite often, the outside world views SDSU as a single entity, but in reality we're different colleges, different departments, different individuals with different expertise in different areas," German noted. "So, there's bound to be somebody here that can help the person with the problem." ❖

Biostress challenge:
experts will help if you suspect poor water quality

Kevin Benck, SDSU graduate student in geography and Bender's research assistant, takes samples to use in the WRI pesticide monitoring program.

SDSU scientists gaining ground on all fronts in war on scab. But ...

When can we stand down?

by Jerry Leslie

MODEST—BUT STEADY—PROGRESS IN THE WAR AGAINST WHEAT SCAB. That's the report of Agricultural Experiment Station scientists at SDSU.

Scab is the common name for Fusarium head blight, a fungal disease that devastated the 1993 spring wheat crop in South Dakota and nearby states, causing an estimated $100 million loss in South Dakota alone.

Since then, SDSU has released several new varieties with improved scab tolerance. Even more promising are other lines in the testing program.

Besides tolerant and resistant varieties, growers also have more information today on fungicides that suppress scab. And they can adapt the recommendations for crop rotations and other cultural practices that are available through their local Extension educators.

The war is by no means won, but producers and scientists are gaining ground against scab.

Producers typically first notice scab when they find white heads or white kernels called "tombstones." If grain buyers find head-blighted kernels in the grain, they will test on the spot for the mycotoxin known as vomitoxin. If it's found, they dock the price or reject the entire lot.

Perfect conditions for scab in South Dakota occurred in 1993, said Jackie Rudd, SDSU's spring wheat breeder. Wet conditions during the autumn of 1992 resulted in much corn still standing the following spring. Heavy amounts of corn residue provided good conditions to overwinter the fungus, and the wet 1993 spring and summer provided an environment conducive for fungus infection. Reduced tillage also left other debris on the soil surface, including wheat stubble, another habitat for the fungus.

The fungus does its damage during the 2- to 4-week flowering period, competing for nutrients with the developing kernels. Depending on severity of the disease, part or all of the head can become blasted.

Lowered yield is only part of the problem.

The vomitoxin produced by the fungus reduces bread-making qualities and sickens humans and livestock.

Breeding for scab resistance has been part of SDSU's spring wheat program since 1991. The scientists operate on four fronts: screening germplasm for resistance to scab and including it in the breeding program, evaluating fungicides for efficacy against the disease, identifying molecular markers for scab resistant genes to speed the germplasm screening process, and learning more about the epidemiology of the disease.

Progress is steady and measurable, according to Rudd.

After 1993, many growers stopped planting susceptible spring wheat varieties and switched to 2375, Sharp, Russ, and Oxen and others that have some tolerance for scab. As a result, they've seen less scab in the fields since then.

SDSU's last three releases of spring wheat have some scab tolerance. "They certainly were improvements over the past and are considered transitional in a step-by-step progress," said Rudd.

Forge, a 1997 release, had better tolerance than Russ or Oxen. Ingot in 1998 had better tolerance than Forge. Ember, released in 1999, has the same tolerance as Ingot but is better yielding.

Of the 30 entries in SDSU's 1999 Advanced Yield Trial, all but four had scab resistance ratings as good or better than Ingot. All yielded equal to or better than 2375.

Resistance means that plants will not become infected. Tolerance means plants may be infected but still produce grain.

From a 2-acre site in California during the winter, SD 3407 was increased to 100 acres of foundation seed planted in 1999. It will go to certified seed growers for further increase in the year 2000 if approved by the SDSU variety release committee and then released by the AES director. It comes from a Chinese line first crossed at SDSU in 1991.

Rudd outlined the difficulties of including scab-resistant lines in the regular spring wheat breeding program. "It is a complex genetic inheritance and you have to screen a lot of material for the agronomics and resistance to other diseases."

Each test cycle is about 3 years from initial cross to a true breeding line that has resistance. Good yield and grain quality do not necessarily go hand-in-hand with resistance, he warned.

"We keep getting a little better resistance and a little better growth and yield characteristics each cycle."

Yang Yen, assistant professor in Biology-Microbiology, is looking for a shortcut to identify scab resistance germplasm through molecular markers on wheat chromosomes.

Resistance may come from a cumulative effect of two or many genes at different locations on the DNA strands, said Rudd, "so maybe we can't get the whole package when we cut between two markers."

"Nevertheless, tagging for one or two of the genes would give us better odds when we do our field testing. Instead of screening 1,000 lines to find 100, we might screen 1,000 lines and find 500."

Another major contributor at SDSU is Yue Jin, small grains pathologist. Jin screens spring wheat germplasm from all over the world for scab resistance before Rudd attempts to fit them into his breeding program.

Marty Draper, Extension plant pathologist, is studying the effects of cultural practices on incidence of scab. His recommendations:

"Consider the rotation and realize if you plant wheat on corn stubble or on wheat stubble you will increase your risk of scab. Also consider the variety you plant, because some varieties out there are very susceptible to scab.

"If you are growing wheat on a site where you have had a history of scab, consider using a foliar fungicide application at flowering. It will reduce the incidence by 50%, about the best you can expect with a fungicide. The options are Benlate plus Mancozeb or a product called Folicur available on a Section 18 label for the second year.

"The advantage of Folicur is that we get a better yield response than from other chemicals. Rates and product information are available from county Extension educators."

Draper tested fungicide compounds for their effectiveness in suppressing scab at three locations last year. The sites were on a cooperating producer's farm near Groton, at the Northeast Research Farm near South Shore, and at the SDSU Agronomy Farm in Brookings.

Draper also conducted a study this year on effects of application technology, comparing aerial vs. ground spraying, different nozzles, and different dilutions.

SDSU scientists play a critical part in the nationwide effort to gain the upper hand on scab, joining with 20 other land-grant universities and private industry partners in the U.S. Wheat and Barley Scab Initiative. SDSU last year received $210,000 of the $3.5 million appropriated by Congress for the initiative.

Rudd chairs the national variety development committee, one of six program committees, and he recommends how the budget will be spent for 23 wheat and barley breeding programs funded by the initiative.

Jin is in charge of germplasm introduction and evaluation for the spring wheat breeding programs, coordinating the International Scab Nursery for worldwide collaboration. At present, eight programs participate in this evaluation, three from the U.S. (South Dakota, North Dakota, and Minnesota), two from China, and three from Japan.

Jin also is involved in projects in regional epidemiology collaboration: how the environment influences the disease, where the inoculum comes from, the proper times to spray fungicide, and the growth stage at which the wheat is most vulnerable to infection.

Groups working under the national initiative cover epidemiology/pathology, plant breeding and uniform nurseries, fungicide and crop management, food safety and toxicology, germplasm introduction, information hub and communications, and transformation through genetic engineering.

Jackie Rudd, left, spring wheat breeder, chairs a national variety development committee in the U.S. Wheat and Barley Scab Initiative. Yue Jin, small grains pathologist, coordinates the International Scab Nursery.

Eventually, scab will loosen its grip on spring wheat.

"We will achieve a very reasonable level of resistance, a level that will be acceptable in most years," Jin said. Resistance will probably balance out with the lower yield Jin expects.

Jin believes SDSU's programs "are among the best in developing scab resistance, because the breeding and pathology programs are collaborating very closely."

Winter wheat will take longer, but SDSU has started before the problem becomes worse, Rudd said. Barley will be more difficult. And in durum, no satisfactory sources of resistance have yet been identified, added Jin.

Will breeders and pathologists someday be able to declare victory and stand down?

"I don't really think we can do that, ever," said Jin. "Once you breed resistance, you need to select for it every year, even if you don't have the disease. You will lose resistance if you don't continue to select for it.

"From the producer's standpoint, yes, the battle against scab will be soon over, but the breeders will have to remain vigilant."

SDSU's scab research program has been funded by the South Dakota Wheat Commission and the South Dakota Agricultural Experiment Station. In 1995, a 3-year grant was funded jointly by the Wheat Commission, the Minnesota Wheat Council, and the Agricultural Experiment Station and renewed in 1998. The mist-irrigated field nursery used for selection was established with a grant from the South Dakota Crop Improvement Association. The USDA funds through the Scab Initiative more than double the SDSU effort. ❖

Biostress challenge:
progress is steady and measurable in SDSU program to combat scab in wheat

Three students solved a problem, built a machine, and boosted their engineering careers

'Little robot that could'

by Jerry Leslie

THIS IS A SUCCESS STORY OF three can-do ag engineering students and how they built "a little robot that could."

The three SDSU students solved an expensive and sometimes dangerous problem in large swine barns.

Their design of a boar-leading robot named "Boar Bot" earned them A's in their engineering design class, honors in a national engineering design competition, and practical experience that will boost their engineering careers. They are Joe St. Aubin, Marshall, Minn., Nick Kleinjan, Bruce, S.D., and Jonathan J. Roehrl, Redwood Falls, Minn.

Their Boar Bot (a contraction of the words Boar and Robot) enables one swine barn worker to do the work of three. One worker controlling this electric, remote-controlled vehicle can lead a 400- to 500-lb boar through the aisles of a breeding barn to help detect heat in sows intended for artificial insemination.

The little vehicle is now under commercial manufacture by Jerome Mack, a Leola pork producer, who saw a use for such a device and sought help from SDSU in the design and construction of a prototype. Mack now has formed his own manufacturing company called Swine Robotics and has hired a crew to make Boar Bots. About 40 robots had come off "the assembly line" by October. Most have been sold to other pork producers, several are out on trial.

Promotional literature says one will pay for itself in labor costs in less than 6 months on a 1,000-sow farm and in less than 2 months on a 3,000-sow farm.

The story began when Mack realized that handling the boar used for heat detection before artificial insemination was inefficient and at times unsafe.

The procedure involved leading a boar in front of caged sows to stimulate them and determine which ones were "in standing heat" or ready for artificial insemination. The job took three people, two to lead, position, and handle the 500-pound boar followed by an artificial insemination (AI) technician.

"Mack was looking for a way of turning that process into a one-man operation," said St. Aubin. "He wanted a small, remote-controlled vehicle heavy and rugged enough to handle the boar by one AI technician."

"In August of 1998 he called," said Dan Humburg, associate professor of ag engineering and class instructor. "I knew this might lend itself to a senior design project."

"Mack became their sponsor throughout the year, staying in touch every 2 weeks to see what support they needed and to make sure they were on track with a project that would meet his needs," said Humburg. "Mack, in fact, provided all the resources to build the prototype."

First came the concept and the design criteria.

Some of them: A size restricted to 18 by 20 inches, maximum height 60 inches, maximum weight 500 lb, minimum weight 300 lb. Battery operation and overnight recharging with an onboard unit. Wireless remote control.

Boar Bot leads a harnessed boar by a tether down an alley between sows at the swine operation of Jerome Mack, Leola pork farmer, who conceived the idea and sought design help from SDSU.

Ability to withstand corrosive conditions.

Excellent traction and automatic brakes. Durable and simple to maintain. Affordable. Forward and reverse, low center of gravity for stability, able to go over 2-inch steps. Variable speed range from 1 to 4 feet per second.

In sum, the unit must be able to lead an unwilling, 500-lb animal.

The students went to work. Their design class was a two-semester course, two credit hours per semester.

Sizing and identification of component parts took up the first semester, said St. Aubin. Included were motors, gearboxes, worm gears, switches, and the remote control. "We decided on the basic layout, how it would look, and how the components would set together," he said.

"We worked on it together as a team.

"The second semester we fought with the control system a lot and assembled the prototype," he said. "A lot of things we had overlooked the first semester we fixed during the second."

By the end of April 1999, they had built a working model and had demonstrated it, said Humburg.

The students took their prototype to Mack's swine facility. Mack fabricated additional machines for demonstration at the World Pork Expo at Des Moines and the Ontario Pork Congress at Stratford, Ont.

Three students with their Boar Bot in the Ag Engineering Shop at SDSU where the prototype was fabricated. From left, Joe St. Aubin of Marshall, Minn., Jonathan Roehrl of Redwood Falls, Minn., and Nick Kleinjan of Bruce, S.D.

The end product now under manufacture is a remote-controlled vehicle with four-wheel drive and skid-steering. Two 12-volt deep-cell batteries power two 24-volt high-torque DC motors. The unit guides the boar humanely by means of a tether attached to a harness that is fitted on the boar.

Promotional literature says the Boar Bot will lead or push a boar virtually anywhere in a barn. "Weighing in at over 350 pounds, ... the Boar Bot can persuade even the most obstinate animals to follow along."

The students won first place in the senior design contest at SDSU. That opened the door for them to enter and ultimately win second place in a very close finish in the national design conference of the American Society of Ag Engineers in Toronto, Ont. The win provided a $1,000 stipend to split between the three of them.

The Boar Bot was a big hit in the SDSU tent at the 1999 Dakotafest near Mitchell, especially among the younger visitors, who got the chance to operate the robot over a course against a stopwatch. The robot also roamed around outside the tent enticing visitors to come in.

The three students, along with Mack, have a patent to their credit, although the students signed away any royalty rights to their financier.

St. Aubin believes the Boar Bot gives members of the team an advantage when they begin their careers. Their resumes will describe the completed design and construction of an invention that has actually gone into commercial production even before the students graduated. The second-place finish in the national design contest is also a plus.

Kleinjan and St. Aubin graduated in December 1999; Roerhl graduated in May 1999 and is employed by Melroe Company of Fargo, N.D., at its Phoenix, Ariz., proving grounds.

Humburg, who was a graduate student during SDSU's electrical tractor design era, drew upon that experience in offering suggestions to his students. He is proud of them and their design.

But the story isn't over.

At the Pork Expo, other pork producers visualized a secondary use for the stocky little robot, said Humburg.

The Boar Bot weighs about 350 pounds with a low center of gravity. "It can pull quite a substantial load (a 200-pound tug force on a cement floor). It will pull you right off your feet," said Humburg.

Other pork producers see it used for removing dead animals from a building where narrow aisles would block heavy machinery. They also see a potential for attachments, such as a rotary broom to use in the daily sweeping of alleyways, said Humburg. The Boar Bot also has potential for pushing feed carts.

These ideas may wind up as projects for another group of students in another senior design class.

The "little robot that could" may be able to do even more. ❖

Biostress challenge:
student-designed robot saves labor, prevents injuries in the swine unit

'Agriculture' is not just for farmers and ranchers alone

IT'S OUR BUSINESS

AGRICULTURE'S IMPACT ON THE South Dakota economy declined in 1998 due to low prices for livestock and crops, but its $15 billion activity still far and away outranked all other sectors.

"Agriculture is still 'Number One' in South Dakota," said Martin K. Beutler, Rapid City, Agricultural Experiment Station scientist and Cooperative Extension Service economist. Beutler made his remarks upon completion of the annual update of this study first initiated in 1991.

"Agriculture is one of South Dakota's greatest strengths. Continued efforts to stabilize production and to seek new ways to add value to our raw agricultural products will energize the state's economy and its people as we move into the future," Beutler said. "Commodity prices have fallen, in part because we are so good at production.

"Other parts of the world have also increased production. When that is added to ours, the results have been tremendous carryover stocks, especially in grains.

"When you increase your production and can't market it, then you have oversupply. Oversupply causes prices to decline," Beutler said.

"Our producers probably have greater potential for improving their incomes by marketing better than by producing better. 'Producing better' nowdays means churning out more and more crops and livestock just to break even.

"When producers take advantage of some marketing opportunities–forward pricing, possibly the futures market, they shift some of the price risk away from themselves to other people. They are using the market to set the prices they want, not accepting the prices the market says they can have."

Total economic impact in 1998 was $15 billion for agriculture, $9.6 billion for computers, $6 billion for autos, $5 billion for service, $4.4 billion for recreation, $3.9 billion for food stores, and $3.5 billion for manufacturing, Beutler reported.

The figures he is able to work with are always available a year behind, he added.

Low prices for livestock and crops in 1998 lowered total agricultural economic activity from $17 billion in 1997 to $15 billion in 1998. Ag economic activity for 1996, at $15.3 billion, also was higher than for 1998.

Beutler explained what went into his calculations of economic impact.

Agricultural impact represents a combination of the effect of agricultural production and agricultural support.

Ag production is direct dollars generated when producers sell grain and livestock at a market. Ag support includes products manufactured to support agriculture, such as agricultural machinery and supplies, food processing, and wholesale trade.

Ag support includes the value added to raw materials when they are bought and sold for processing into consumable products either for local or out-of-state use. It includes the impacts generated as farm families spend money in town for food, clothing, and other items, Beutler continued.

"Consequently, agriculture's impacts are felt in every home and nearly every industry in South Dakota, either through direct contact or the expenditures of people employed in agriculture," Beutler said.

Of the decline in prices received by producers between 1997 and 1998, cattle dropped the least, by 4.5%. Calf prices actually gained 1.7%.
Other commodities experienced double-digit declines, however. Large percentage drops were seen in oats 39.1%, hogs 34.5%, hay 30.5%, corn 25.6%, and wheat 23.2%.

The crop declines led to the largest government payments to South Dakota producers since 1993, the flood year. The 1998 payments of $426.09 million were an increase of $158.8 million over 1997 payments.

by Jerry Leslie

Marty Beutler, SDSU economist, and director of the West River Ag Center in Rapid City, has traced agriculture's contributions to the state's economy for 9 years. Most recent figures show that the total economic impact of agriculture has declined but that "Agriculture is still 'Number One.'"

Beutler said the $3.6 billion economic impact of livestock broke down into 84% production, 5% wholesale trade, and 11% processing.

On the $6 billion crops side, production accounted for 62% of the total economic impact, wholesale trade 36%, and processing 2%.

Another $5.4 billion in economic activity was generated by businesses in support of both livestock and crops activities.

"There is great potential for economic growth in South Dakota in developing industries that produce finished goods from locally grown agricultural commodities," Beutler asserted.

"Such development would provide higher prices for ag producers for their commodities, create jobs in both agriculture and industries, and generate tax money to operate our schools and state and local governments. In addition, more money would be spent in non-ag businesses."

The benefits from encouraging the economic development of agriculturally related businesses would extend to all citizens of the state, Beutler added.

"The soybean processing plant in Volga is a good example of what South Dakota producers can do to add value to their products," Beutler said.

Ag support industries make up half of the total economic impact of agriculture and have led the way in increasing ag's impact in South Dakota, Beutler said. From 1991 to 1997, the economic impact of ag support industries has increased $3.5 billion, while ag production has increased only $110 million.

However, in 1998, ag support industries suffered the same fate as ag producers. The impact of each fell by $1 billion.

When adjusting for inflation, Beutler said, ag production actually decreased $0.9 billion from $8.5 billion in 1991 to $7.6 billion in 1998. Ag support's impact increased $2.2 billion over the same period from $5 billion to $7.2 billion, in inflation-adjusted dollars.

Producers of South Dakota's agricultural commodities "will continue to struggle with increasing production costs and declining real prices for their output," Beutler predicted.

The number of persons employed in agricultural production in South Dakota has fallen 32% since 1978, from around 63,000 to approximately 43,000 in 1998.

"Fewer persons employed in agriculture means fewer dollars are spent in local communities for groceries, cars, trucks, movie tickets, and other items.

"Fewer dollars spent lead to smaller inventories and eventually closed businesses for local merchants. The ripple effect impacts all industries and people in South Dakota.

"Agriculture is still something South Dakota does really well. It's something we will continue to do well. Agriculture is located in every county of the state, 12 months of the year, and has an impact on every individual in South Dakota.

"Every one of us has a stake in South Dakota agriculture. Whatever our role may be, we need to support it, stabilize production, and find new ways of adding value to the raw agricultural commodities we produce. We will be building a stronger South Dakota economy for all of us." ❖

Biostress challenge:
stabilized ag production and added-value products will continue to energize state's economy

SOUTH DAKOTA STATE UNIVERSITY
College of Agriculture and Biological Sciences
Agricultural Experiment Station
Brookings, SD 57007
Kevin Kephart, Director

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