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Farm and Home Research: 54-1

Mary Brashier

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Utilizing and developing our resources to enhance quality of life

Farm & Home RESEARCH

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South Dakota State University · College of Agriculture & Biological Sciences · Agricultural Experiment Station

PRECISION FARMING:
'more likely to make money'

ONE SIZE DOES NOT FIT ALL
Transgenic spring wheat could add flexibility to production systems

HOW MANY FOXTAILS
can you or your corn tolerate?

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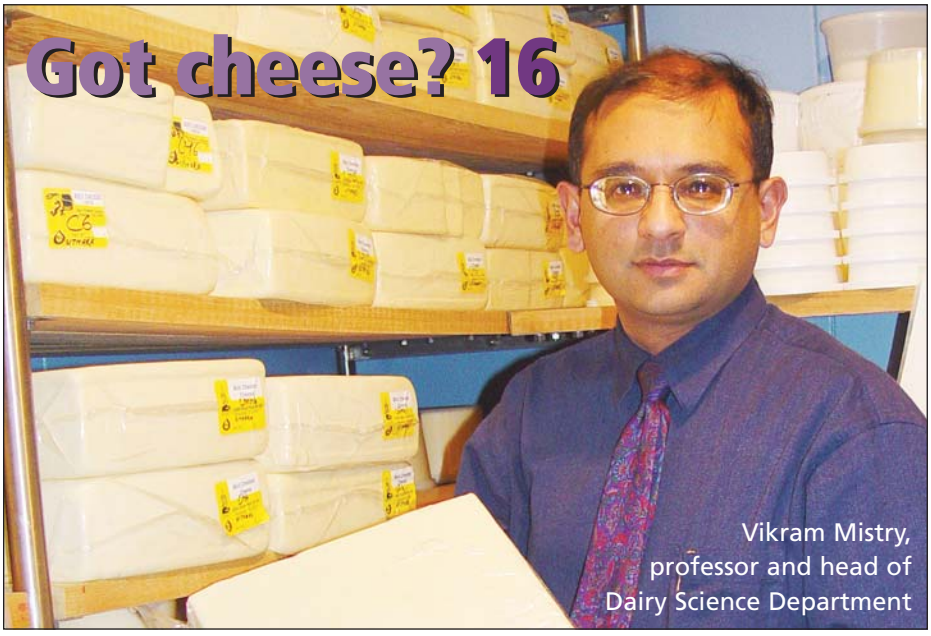

On the cover:
A computer generated map of a 160-acre field in eastern South Dakota illustrates different concentrations of phosphorus in the field.

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Director's comments

BY KEVIN KEPHART
Director, South Dakota Agricultural Experiment Station

'Knowledge is power'

Kevin Kephart

Several research topics discussed in this issue of *Farm & Home Research* are somewhat futuristic. Our scientists are looking at precision farming, they're developing a transgenic spring wheat that could be approved for farmers someday, they're fine-tuning the science needed to manage irrigation systems that aren't even in use right now in South Dakota.

In a manner of speaking, everything we do as scientists of the South Dakota Agricultural Experiment Station is futuristic. True, there are current issues and problems, and people look to the Experiment Station for solving those problems in the here and now. But the majority of our work is aimed at the future.

For example, unless South Dakota State University does the research now on how to keep buried irrigation lines clean, we might be playing catch-up when our livestock producers begin looking at the technology as a means of applying wastewater to cropland.

It's very important that we work with precision farming technology for the same reason. I don't know how it's going to improve your bottom line, but I think that will reveal itself in time. One thing that precision farming does right now is give you a more precise understanding of your land and your resources. Whether that helps your bottom line or not, that is good knowledge to have. Knowledge is power.

That's what is also driving our research concerning chronic wasting disease in deer and elk. We simply don't have enough knowledge about this disease. What we have, instead, is a frightened populace.

We have people worried about contracting chronic wasting disease from potentially infected deer. We have a similar fear with scrapie, a disease in sheep. But yet we don't have any documented cases where people have come down with the transmissible spongiform encephalopathy, or TSE, from consuming sheep products. Nor do we have any documented evidence that people have been negatively affected by consuming deer infected by chronic wasting disease.

The fear, of course, comes from mad cow disease, where there are documented cases of humans coming down with a fatal, brain-wasting disease from consuming infected animals. Mad cow disease is similar to but still different from chronic wasting disease or scrapie. All three are TSE diseases that leave the brain riddled with holes. That creates a sponge-like texture, which is why the word "spongiform" is used to described them.

Going back to that statement that knowledge is power, we need to come to an understanding, and quickly, of TSE diseases and how they might impact humans. But there's more to it than that: Yes, people enjoy consuming deer, but they also like to have healthy wildlife populations. That's also part of what's driving our research.

Of course much of what our scientists do is firmly rooted in the here and now—our dairy science research, for example. We envision dairy playing a much more important role in decades to come in South Dakota. Fred Cholick, dean of our College of Agriculture and Biological Sciences, sometimes uses the term "economic engines" in this context. We're interested in dairy as a long-term, long-haul "engine" for economic development in South Dakota. The challenge is to do it right, in a way that's environmentally friendly, to create the types of communities and jobs that we want to create.

A transgenic spring wheat—breeding Monsanto's patented glyphosate-tolerant gene into a spring wheat developed for South Dakota's growing conditions—would have seemed futuristic 10 years ago. But now, with herbicide-tolerant soybeans and corn already in widespread use, it's simply another potential tool that would provide a new weed-control option if it's ever made available commercially.

In this issue, too, we discuss the federal plant variety protection process. For any soybean variety, any spring wheat variety, or any winter wheat variety we're releasing from our South Dakota State University breeding programs, our policy is to protect them because of their importance to South Dakota agriculture.

Chances are plant variety protection will become even more important in the future, here at South Dakota State University and elsewhere, as biotechnology and other advanced tools make plant breeding ever more precise. That's the future of agriculture—but it's also becoming the here and now at places like South Dakota State University.◆

Karl Glover, SDSU spring wheat breeder

One size does not fit all

Transgenic spring wheat could add flexibility to production systems

by Lance Nixon

There's nothing remarkable about the appearance of the wheat kernels Karl Glover pours into his open palm. They have the same shape and copper color as any of South Dakota's hard red spring wheats.

But biotechnology has given those spring wheats an advantage: a patented gene from the Monsanto Company that enables them to stand up to glyphosate herbicides. These seeds could be the forerunners of spring wheats that control their own weed infestations, but for now, the technology is still in development and not approved for commercial use.

That explains the way Glover repackages the wheat: in a sealed packet, placed inside another packet, placed within a third packet.

It's one of the protocols that Glover, a spring wheat breeder at South Dakota State University, must observe in handling transgenic wheat. It must be "triple containerized" to reduce the chances that any of the wheat will be lost or co-mingled with other wheat.

SOUTH DAKOTA STATE UNIVERSITY breeders began working with Monsanto breeders in 1999 to place the glyphosate-tolerant trait into some of South Dakota State University's advanced spring wheat germplasm.

"It adds flexibility. It's a trait worthy of incorporating into the production system for those producers who want to use it. ... There have to be some controls ... so that conventional, transgenic, and organic spring wheats can safely co-exist. This will provide producer, consumer, and marketplace flexibility."

—Fred Cholick
Dean, ABS College

A variety primarily composed of South Dakota State University germplasm makes perfect sense from the standpoint of serving South Dakota producers, says Bob Hall, Extension crops specialist. "You want to put that technology into germplasm that you know is adapted to the area and performs well and is going to be around for a while. We've got a lot of data on the varieties. We know they perform well."

In 1999, Monsanto breeders made the initial cross between their Roundup Ready® wheat germplasm and the South Dakota State University germplasm. The progeny was repeatedly crossed back to the SDSU parent. This "backcrossing" with the SDSU parent occurred five times, resulting in what is called Backcross 5 (BC5) seed.

"In the end, the resulting genetic makeup of the seed was 98.4375% South Dakota State University germplasm origin and 1.5625% glyphosate-tolerant-source background," Glover says. And, he already has a pretty good idea of how a glyphosate-tolerant spring wheat will perform. Performance tests began in the field with the 2000 growing season.

If and when this new biotech wheat variety reaches the market, it will bear a completely different name from its SDSU parent so there is no confusion between conventional varieties and biotech wheat.

Glover makes no guesses about when a transgenic wheat would be released for planting. There are milestones to be passed, he says, for example, demonstration of the food, feed, and environmental safety of the wheat so it can receive regulatory approvals in the United States, Canada, Japan, and several other countries; standardized grain handling and sampling protocols; development of best management practices for growers; and some assurance of buyer, processor, and consumer acceptance. "All that assumes no unforeseen agronomic problems arise with the germplasm we are currently developing."

Glover points out that delays in commercialization create challenges in variety development. "It takes several backcrosses and thus a few years to get a new gene into an adapted variety. During this time, better conventional varieties come along. Our newly released spring wheat 'Briggs' is an example."

Having this technology in the newest varieties is critical to producers, says Bob Pollmann, executive director of the South Dakota Seed Certification Service at South Dakota State University. "Since we are still several years from commercialization, we need to have a robust breeding program that keeps the glyphosate-tolerant trait in varieties that provide top performance for producers," he says.

MEANWHILE, THE WHEAT INDUSTRY is weighing both the agronomic advantages and possible market drawbacks of a transgenic spring wheat. Ongoing public discussions suggest not all consumers will want to buy it, and not all producers will want to grow it.

"It adds flexibility. It's a trait worthy of incorporating into the production system for those producers who want to use it," says Fred Cholick, dean of the South Dakota State University College of Agriculture and Biological Sciences and a plant breeder by training.

Cholick adds that the wheat industry must be careful to protect both the marketplace and those producers who don't want to use transgenic crops. "There have to be some controls in the system so that conventional, transgenic, and organic spring wheats can safely co-exist. This will provide producer, consumer, and marketplace flexibility.

"Varieties that give producers choices are a critical component of all production systems. The development and application of molecular biology, specifically transgenics, hopefully will assist our spring wheat producers to remain competitive in the market.◆

Plant Variety Protection

Certified seed assures growers of genetically pure, high-quality seed

by **Lance Nixon**

Bob Pollmann, manager of the Seed Certification Service, with first-ever PVP granted to SDSU

In 1978, the South Dakota State University

Agricultural Experiment Station applied for what is called "plant variety protection" from the federal government on a new variety of spring wheat named 'Eureka.'

The official certificate from an office of the USDA that arrived in early 1979 marked the first time that South Dakota State University had obtained plant variety protection (PVP) for one of its new releases. Since then, seeking plant variety protection has become a regular practice.

"We apply for plant variety protection because it gives the Agricultural Experiment Station protection from someone taking our variety, making some very minor variations, and then marketing it under another name," says Jack Ingemansen, manager of Foundation Seed Stocks at South Dakota State University.

"One of the reasons plant variety protection was passed into law was so that developers of new varieties could get a return on their investment," Ingemansen says, adding that it typically takes a plant breeder about 10 years or so to develop and release a new variety.

The Plant Variety Protection Act was approved by Congress in 1970 and amended several times, most recently in 1994. The act provides intellectual property rights to developers of new varieties of plants that reproduce by seed or tubers. The law does not cover bacteria and fungi.

The USDA Plant Variety Protection Office grants a "Certificate of Protection" that gives the successful applicant exclusive rights to multiply and market that variety of seed for 20 years for most crops or 25 years for trees, shrubs, and vines.

As part of the application process, the applicant has to prove that the variety is distinct, uniform, and stable; disclose the pedigree, breeding methods, and selection criteria used in creating the new variety; and put down $3,025.

The applicant may request that the new variety be entered under Title V of the plant variety protection code. That stipulates that the new variety be sold only as a class of certified seed. Farmers must purchase certified seed to obtain the new variety, says Ingemansen.

A general exemption to PVP guidelines allows public plant breeders to use the variety to develop other new varieties without violating PVP guidelines.

Another general exemption allows a producer who has purchased certified seed to save seed and replant the variety on his own holdings. A court ruling has added the interpretation that a producer can save and replant only the same amount of seed as was originally purchased. The law doesn't allow the producer to save and sell non-certified seed from his production to others for seed.

PRODUCERS REAP BENEFITS in the long run because of these restrictions, says Ingemansen.

The South Dakota State University Foundation Seed Stocks Division and the South Dakota Crop Improvement Association are nonprofit public corporations that, along with commodity check-off groups, provide significant financial support to South Dakota State University plant breeders to develop new varieties.

In addition, Ingemansen says, studies have shown that buying certified seed gives producers genetically pure, high quality seed, with enough of a yield differential to pay for the additional cost.

"There are a number of studies done over the years that show certified seed has a yield advantage of 3 to 5 bushels over seed that hasn't been professionally grown and conditioned," adds Bob Pollmann, manager of the Seed Certification Service at South Dakota State University.

Pollmann and Ingemansen say the advent of biotechnology adds new complexity to issues of plant variety protection, especially in cases where a company holds a patent on some particular trait. The glyphosate-tolerant gene from Monsanto, which South Dakota State University already is using in soybeans under an agreement with the company, is a good example.

Monsanto owns the patent on the gene, and patent law forbids growers and others from saving seed and replanting it. But South Dakota State University also routinely seeks plant variety protection on those Roundup Ready® soybean varieties released from South Dakota State University, because the variety in which the trait is packaged for South Dakota producers is South Dakota State University's intellectual property.

"It's a partnership," Pollmann explains. "Monsanto owns the patent on the gene and the South Dakota Agricultural Experiment Station owns the germplasm or variety the trait was inserted into. They can't release our varieties without our permission any more than we can release a variety with their patented trait without their approval."

Land-grant universities and private companies will likely pursue similar working relationships by which both sides benefit as biotech traits are readied for the marketplace, Pollmann says.

Both Ingemansen and Pollmann say it's entirely possible that South Dakota State University in the future could seek patents. Utility patents are most commonly sought for plant traits and require the applicant to reveal in great detail exactly how a plant or plant trait was derived, including the exact genome a trait is found on.

But applying for plant variety protection, not patents, will probably continue to be the standard way South Dakota State University protects intellectual property and helps pay for its ongoing plant breeding work in varietal development, Pollmann says.◆

PVP timeline: plants and intellectual property rights

1793: Thomas Jefferson pens U.S. patent law. It allows patents on "any new and useful art, machine, manufacture, or composition of matter, or any new or useful improvement thereof." Plants are not mentioned, and there is no inkling, for well over a century to come, that plants could be intellectual property.

1924: A handful of American farmers begin paying $1 a pound for a "hybrid" seed corn called Copper Cross. Though there is no law forbidding them to save and plant their seed, the nature of hybrids makes it unprofitable to do so. Implicit is the recognition that the company developing the particular hybrid has created something new and different that farmers will pay a premium to obtain—a first step toward recognizing plant genetics as intellectual property.

1930: The Plant Patent Act of 1930 protects "distinct" and "new" asexually reproduced varieties, or those reproduced by cutting, layering, budding, or grafting. The U.S. Patent and Trademark Office has oversight.

1970: The Plant Variety Protection Act protects varieties that are sexually reproduced by seed or are tuber-propagated. A special office of USDA oversees the law.

1980: A U.S. Supreme Court ruling in Diamond v. Charkrabarty finds that "anything under the sun that is made by man" is patentable, including a bacterium produced by science that has "markedly different characteristics from any found in nature and one having the potential for significant utility. His discovery is not nature's handiwork, but his own; accordingly it is patentable …" The ruling broadens patent law to include living organisms.

1994: The Plant Variety Protection Act is amended to stipulate that farmers cannot sell seed they have saved from a PVP variety to others for reproductive purposes. The law allows a farmer to replant a quantity of seed that is equal to the initial purchase quantity of the protected variety.

1995: A court case, Asgrow Seed Company v. Winterboer, finds it a violation of the PVP Act to sell saved seed for reproductive purposes.

1996: Monsanto Company's patented Roundup Ready® technology is made commercially available in soybeans. The soybeans carry a gene that enables them to withstand the herbicide Roundup.® Growers who buy the seed violate U.S. patent laws if they save and grow subsequent generations of the seed. Instead they must buy new seed from licensed dealers.

2000: A first-of-its-kind agreement between South Dakota State University and biotech company Monsanto highlights the increasing complexity of protecting intellectual property in plants. The agreement allows South Dakota State University to use Monsanto's Roundup Ready® gene in soybeans developed specifically for South Dakota. Monsanto owns the patent on the gene. But SDSU also seeks plant variety protection to protect its intellectual property—the variety into which the gene is inserted. Continuing work on transgenic spring wheat at South Dakota State University and other land-grant universities suggests there will be other such working agreements in the future.

How many foxtails
can you or your corn tolerate?

by Marianne Stein

Foxtails are the most common annual weeds in South Dakota, affecting nearly 100% of all crop fields. "We have other weeds that are more difficult to control, but foxtails are so widespread that they rank number one in terms of crop reduction," says Leon Wrage, Extension weeds specialist at South Dakota State University.

Many different treatment options exist, but none is 100% effective or economical to use. "You have to factor in the cost of herbicide and the work involved in applying it, as well as potential yield loss and your price per bushel. You may find out that you don't need to treat everything," adds Sharon Clay, professor of plant science.

Clay and her colleagues evaluated how different densities of foxtail affect yield loss in cornfields and developed charts to help producers determine economic thresholds for herbicide treatment (see sidebar).

At Brookings and at Morris, Minn., the scientists planted corn and four densities of yellow foxtail along with a weed-free control. Two different nitrogen levels were also used at Morris.

It was no surprise that increasing densities of yellow foxtail reduced yields.

THE WORST-CASE SCENARIO was Morris in 1996, where foxtail caused up to 65% yield loss. But the same year in Brookings was very different: At the highest foxtail density, yield loss was only 20%.

The difference stems from the difficulty of controlling foxtail growth, even under experimental conditions. "Foxtail is a grass, so it tillers, and you can't predict how many tillers you are going to get," Clay says. In the high-density foxtail plots at Morris, the scientists counted an average 141 tillers per square foot, at Brookings 88 tillers.

Corn growth and yield also were highly influenced by the weather—primarily temperature and amount of water—and level of nitrogen in the soil.

How much will weeds cost you?

Assume you have a choice of three different treatments at a cost per application of $17, $34, or $48 per acre. Assume corn prices will be $1.65, $2.50, or $3.00 per bushel.

Number of bushels per acre lost

	Percent yield loss			
Expected yield, bu/A	**5%**	**10%**	**20%**	**30%**
100	5	10	20	30
125	6.25	12.5	25	36.5
150	7.50	15	30	45
175	8.25	17.50	35	52.2

Cost of yield loss based on 125 bu/A

	Percent yield loss			
Corn price	**5%**	**10%**	**20%**	**30%**
1.65	10.31	20.62	41.25	60.23
2.50	15.62	31.25	62.50	91.25
3.00	18.75	37.50	75	108.50

How to calculate this: Assume your expected yield is 125 bu/A. If you incur a 5% yield loss due to weeds, you will lose 6.25 bu/A (top part of table). If your corn price is $1.65 per bushel, weeds will cost you 6.25 x $1.65 = $10.31 per acre.

The economics of the $48 herbicide application means that you need to be expecting about 125 bu/A, a 15-20% yield loss, and a corn price to be at or better than $2.50/bushel to break even on the application.

Leon Wrage, Extension weeds specialist

"Most people want to have a clean, weed-free field. But I suggest that they at least think about different options. Applying less herbicide may be economically sound, and ... better for the environment."

—Sharon Clay,
SDSU plant science professor

The researchers found a significant relationship between Growing Degree Days and yield loss. Growing Degree Days (GDD) is an index used to indicate conditions conducive to plant growth: the day's high temperature plus low temperature, divided by 2, minus 50 (determined as the baseline temperature for corn). For instance, if the day's high is 60F and low is 50F, the calculation would be 60+50/2 -50 = 5 GDD.

Foxtail is a general term for a whole group of plants in the genus *Setaria*. The most common types in South Dakota are yellow foxtail and green foxtail. Yellow foxtail (left) has several willowy, weak hairs on the base of the leaf, visible even in small seedlings. Green foxtail (middle) does not have hairs on the base of the leaf. Robust foxtail (right) is an emerging concern in South Dakota. Taxonomically, it is similar to green foxtail but is much larger and produces ten times as many seeds as the green foxtail. Each variety of foxtail requires a different set of management and control practices, so it is important to distinguish between them.

"For the total season, more GDD equaled less yield loss. If temperatures are warmer, the corn is growing better and the yield loss will be smaller," Clay explains. But in drought, even a small number of weeds may affect crop yield, because the crop and the weeds are competing for nutrients and water.

Nitrogen also had an effect on yield loss in the study. "Nitrogen application in the weed infested plots resulted in greater corn growth and less yield loss than when N was not applied," Clay adds.

A GROWER MAY BE ABLE to tolerate some weeds, Clay says.

"Most people want to have a clean, weed-free field. But I suggest that they at least think about different options. Applying less herbicide may be economically sound, and it may be better for the environment, by reducing groundwater contamination.

"If 20% of growers put out 20% less herbicide, we could save one million pounds of chemicals per year in South Dakota," Clay says.

It is also wise to factor in the history of the fields, says Wrage. "Weeds that were present this year are good indicators of what might be there next year."

Wrage explains that no-till practices also affect foxtail presence. "No-till leaves the seed on top of the soil, where it is more likely to be destroyed by weather or eaten by seed predators, so there will be a reduction in the seed bank."

Clay recommends post-emergence herbicide treatment.

"Then you can see where you should be treating the field. You are also using an herbicide that may not end up in the groundwater, because it is applied to the foliage rather than to the soil," she says.

But there's a narrow window when post-emergence herbicides can be applied. "If you treat more than 2 or 3 weeks after planting, you may not be able to compensate for yield loss, because yield potential is formed early in the season," Clay says.

Pre-emergence herbicides don't always work either.

"Conditions should be warm and wet for pre-treatment herbicides to be effective, because the weed plants need to be actively growing and germinating. If the herbicide has

Sharon Clay, professor of plant science at SDSU

been sitting in the soil for a long time when the plant starts growing, it will be degraded and ineffective."

Wrage suggests that a practical solution would be a combination of pre- and post-emergence treatments.

For example, growers could use a reduced rate of pre-chemicals and then wait and see whether they need to follow up with a post-treatment. "If they have maybe 75% control, they can much better fit weather variables into the post-emergence treatment."

Participants in the research project were Sharon Clay; David Clay, professor of plant science; Kevin Banken, former graduate research assistant in plant science; Frank Forcella and Alan Olness, USDA Ag Research Service, Morris, Minn.; and Michael Ellsbury, USDA Ag Research Service, Brookings.

The project received funding from the South Dakota Agricultural Experiment Station, USDA-CSREES, and the South Dakota Corn Utilization Council. ◆

Subsurface drip lines

the pros and cons

by **Lance Nixon**

Large feedlots often have large pools of wastewater. Todd Trooien, natural resources engineer at South Dakota State University, is one of several scientists in the Great Plains working on an underground system to carry nutrient-laden water to crops.

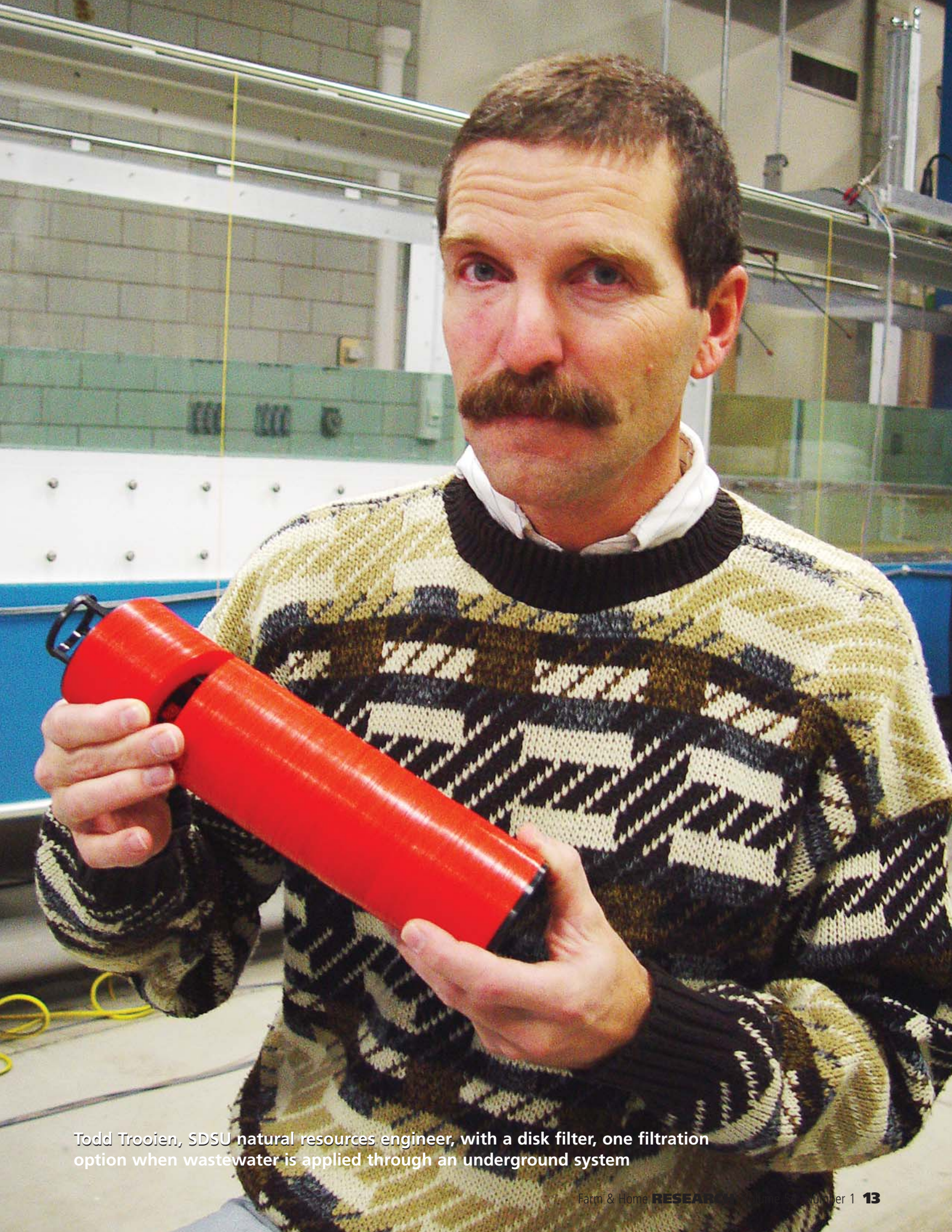
Trooien, Agricultural and Biosystems Engineering Department, is narrowing his search for the level of chlorine treatment that keeps bacteria, algae, and protozoa from growing in buried drip irrigation lines that distribute livestock wastewater to crop fields.

If left on their own, the microbes would capture and hold physical particles of silt and clay, eventually clogging up the lines and the emitters that release the water into the soil.

"Drip irrigation itself has been around for 40 years or more and is most often associated with places like Israel and California and high-value crops," Trooien says.

For vegetable fields and fruit orchards, it's not unusual for drip-irrigation lines to lie on the surface of the ground. Subsurface drip irrigation systems, an option for grain producers, use lines buried 12 to 18 inches under the fields. In a cornfield with 30-inch rows, a line might be buried under every second row, or 60 inches apart.

Those buried lines will likely last from 10 to 20 years, Trooien said, although the technology is recent enough that no one is really sure how durable such systems are. Research systems operated by Kansas State University have been in place at least 13 years and show no signs of wearing out.



Todd Trooien, SDSU natural resources engineer, with a disk filter, one filtration option when wastewater is applied through an underground system

"...how do you value not having to spray this wastewater through the air or having to haul it around in a honey wagon?"

—Todd Trooien,
SDSU natural resources engineer

Some Kansas producers are beginning to experiment with subsurface drip irrigation systems to apply wastewater from large livestock operations to fields. Jeff Sternberger, manager and part owner of Midwest Feeders, Inc of Ingalls, Kan., has had a trouble-free system in place for about 3 years. Wastewater from the feedlot lagoons is applied to a nearby cornfield.

The subsurface drip irrigation system was expensive to install, Sternberger says, but he lists two critical advantages for a feedlot: There is no odor when applying wastewater to fields, as there is when using an above-ground sprinkling system; and nutrients aren't washed away by a heavy rainfall, as sometimes happens when wastewater is applied to the surface of fields.

YES, THE SYSTEM CAN be expensive to install, agrees Trooien. "On the other hand, how do you value not having to spray this wastewater through the air or having to haul it around in a honey wagon?

"Like any other technology, it isn't appropriate everywhere, but it may be the best option in some situations. There certainly is minimized liability exposure associated with overspray and drift from conventional micronutrient sprinkler systems.

"Plus, there are reduced human contact and reduced health risks for feedlot employees because the effluent is contained in a closed system after it is pumped from the lagoon. It goes directly to the root zone—in windy weather or low temperatures. Proportionately more water and more nutrients get to the plants than with conventional above-ground chemigation systems. There's no runoff, and the soil surface stays dry, which means weeds have less chance to germinate."

Proper design and management of the system can eliminate or reduce the downsides of subsurface irrigation with feedlot wastewater, Trooien says. "Clogging of emitters by the effluent can be a major problem, but we can design and manage a system to prevent emitter clogging. We can make it work."

USING WASTEWATER FROM area livestock operations—two dairies, two swine units, and four beef feedlots—Trooien is finding the level of chlorine needed to kill bacteria that could grow and clog the emitters and lines of a subsurface system.

"Chlorine is more effective at killing microbes at a pH of 7, but many lagoons contain effluents with pH values around 8. High concentrations of ammonia in the effluents react with chlorine to form chloramines, which are up to 80 times less effective than chlorine for killing microbes," he says.

Some of the swine lagoon wastewater in the study was so rich in coliform bacteria that chlorine, even at 120 milligrams per liter, was unable to kill the bacteria. "To irrigate with these wastewaters, you'd have to dilute them with fresh water first."

Trooien found that the lower the pH level (more acidic), the more effective chlorine was in killing the bacteria. At a pH of 8 (the pH of the effluent in many lagoons) it took 30 milligrams of chlorine per liter to kill all the coliforms. At pH 7.5 all the coliforms were killed at 20 milligrams per liter. If the pH was further lowered to 7 (neutral), all coliforms were killed at only 10 milligrams of chlorine per liter. No chlorine was detected in the effluent when added at 40 milligrams per liter or more, even though all the coliforms were killed.

Chlorine treatment is one of a package of operations to keep subsurface drip irrigation lines clean when applying wastewater, Trooien says.

"It's important to choose the right hardware—emitters that are too small clog easily. It's crucial to run the wastewater through a filter such as a sand media filter to strain out suspended solids. And it's important to flush the lines at regular intervals by opening a valve at the lower end of the system.

"The other part of the package is to suppress biological growth in the effluent. Proper use of a biocide such as chlorine can help keep systems functioning. The livestock operators of tomorrow who deal with wastewater will find these systems very useful."◆

Remodeled greenhouses are big boost to plant research

by **Marianne Stein**

The College of Agriculture and Biological Sciences

has recently opened the doors of a completely refurbished greenhouse complex.

The greenhouses, dedicated February 8, 2003, are located just behind the Plant Science Building on the campus of South Dakota State University, handy to plant breeders, plant pathologists, plant physiologists, and molecular biologists.

The remodeled structure includes six greenhouses, each divided into two compartments. One greenhouse has been dedicated for teaching purposes.

The renovation was a "re-skinning" of existing greenhouses. Main steel frames and cement flooring were left intact, but glass was replaced and interiors were completely remodeled. New vents and cooling systems were added, and climate control is now computerized. Sealing prevents insects, birds, and rodents from entering.

"The remodeling provides tremendous benefits to us," says Dale Gallenberg, head of the Plant Science Department. "Better climate control allows scientists to use the greenhouses effectively all year round. This extends the number of plant generations we can grow, so we can get results sooner. We will also be able to conduct research we weren't able to do previously, such as examine new pathogens and diseases or study new conditions for crop growth."

The greenhouse renovation, which cost approximately one million dollars, was funded entirely through donations from individuals, companies, and industry groups. Key sponsors included Dakotah Banks, the South Dakota Wheat Commission, the South Dakota Soybean Research and Promotion Council, county crop improvement associations, and the seed industry in South Dakota.◆

Vikram Mistry, head of Dairy Science at SDSU, holds a base cheese from which processed Cheddar will be made.

Got cheese?

by Marianne Stein

The United States is a nation of cheese lovers.

The average American consumes almost 30 pounds of cheese per year. In 2001, 37% of U.S. milk production was used for cheese, according to the USDA.

Scientists in the South Dakota State University Dairy Science Department are developing ways to improve cheese making. Results of two such projects, both supervised by Vikram Mistry, professor and department head, were recently presented at the national meetings of the American Dairy Science Association.

One project describes what happens when concentrated milk is used to produce pasteurized processed cheese. The other deals with salt retention in Cheddar cheese production.

EIGHT OF THE 30 POUNDS OF CHEESE consumed each year are processed cheese, says Mistry.

"It is produced from a natural base cheese such as Cheddar, which is pasteurized along with salts and emulsifiers. We wanted to find out how the method of manufacturing the base cheese—specifically, if we concentrated the milk used to produce the base cheese—affects the characteristics of the processed product."

"Cheese making in itself is a concentration process, and the idea of concentrating the milk before making the cheese is not new," Mistry says. "It gives a higher yield, so cheese making efficiency is improved. But it might affect characteristics of the processed cheese. The impact of using concentrated milk has not been known."

Mistry and Mayur Acharya, Ph.D. student, manufactured base Cheddar cheese at the South Dakota State University dairy processing plant, using two techniques—vacuum condensing, which removes water from the milk, and ultrafiltration, a process that removes the water as well as some other soluble components such as salts and sugars.

Each type of concentrated milk had two different protein levels: 4.5% and 6%, respectively. A control cheese was made with milk that was not concentrated.

These base cheeses were manufactured in two batches; one batch was aged for 3 months and another for 6 months. "Processed cheese is made with a blend of young and aged base cheese," Mistry explains. "With the young cheese you get the texture, and with the aged cheese you get the flavor."

The next step was to manufacture pasteurized processed cheese from each of the five different base cheeses, repeating the procedure five times to obtain sufficient data for statistical analysis.

FOR TASTE, MOUTH FEEL, AND EYE APPEAL, a grilled cheese sandwich or a cheeseburger needs a certain kind of performance from its cheese component.

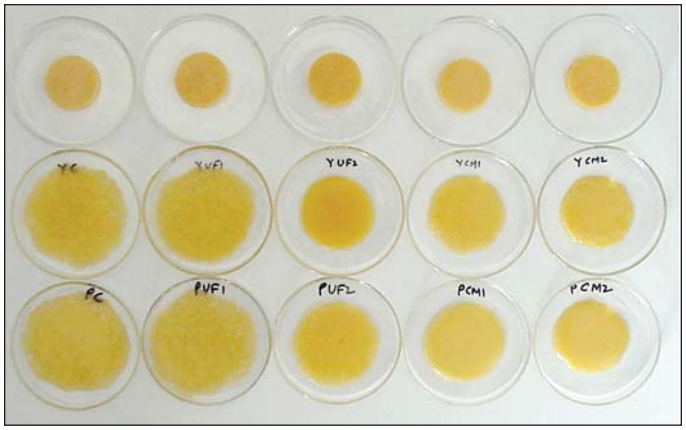
This meant studying how the cheese behaved when melting. Mistry and Acharya found that the cheese made with ultrafiltered milk containing 4.5% protein melted just like the control cheese. All other cheeses melted less.

"I'm not saying this is good or bad, but it is a characteristic of the cheese, which is important for cheese makers to know," Mistry says. "Our results show that when cheese is made from condensed milk, its melting characteristics are different. With this knowledge, cheese makers can make whatever adjustments are needed, such as adjusting emulsifying salt types and amounts."

THE FATE OF SALT in Cheddar cheese manufacture was the topic of another project, conducted by Mistry and Sithara Nair, graduate student.

Cheese makers usually add about 2.5% salt in the manufacturing process. But when the cheese reaches consumers, its salt content is usually 1.5-1.8%, Mistry explains.

Salt is cheap, so this may not seem like a problem. But what happens to the salt that is lost?



LEFT: Mayur Acharya, Ph.D. student, packages processed cheese at the SDSU dairy plant.
ABOVE: In the Schreiber melt test, the top row is the base Cheddar cheese before melting in the oven and the middle row is after melting. The bottom row is the processed cheese after melting. The cheeses in all three rows from left to right are Control, UF1, UF2, CM1, and CM2. UF is the base cheese made from ultrafiltered milk and CM the base cheese made from condensed milk; 1 stands for milk concentrated to 4.5% protein and 2 for milk concentrated to 6% protein. Note that other than the control and UF1, the processed cheeses have a lower melt, as seen by their smaller diameters.

"Part of it ends up in the whey, the watery part of milk that is left over from the manufacture of cheese. If this happens, this 'salt whey' can have a salt concentration of 6 to 7%. It is difficult to dispose of. Sewer systems don't handle it well, because the salt interferes with the ecosystem in water treatment plants."

Sometimes the salt whey is used for animal feed. Or it may be discarded onto the soil, but that's not good for the crops or environment. Sometimes manufacturers can run the whey through a process that filters out the salt and recovers the whey.

"We wanted to develop a process of making Cheddar cheese in which we could increase the retention of salt, so less would end up in the whey."

But the Cheddar would not be saltier, he adds. "Even if it's cheap, less salt would be used in the manufacture."

MISTRY SAYS he accidentally stumbled upon a solution some years ago when he and several graduate students developed a process of making Cheddar cheese using homogenized cream and noticed that the salt content had changed in the finished product.

"We decided to pursue this. We also wanted to see if concentrating the milk either through vacuum condensation or ultrafiltration would have an effect on salt retention.

"If you homogenize all the milk, it creates problems for cheese making because it influences texture. But that's not what we're doing. We are homogenizing just the cream. This is a new manufacturing process we're suggesting. The cheese maker can take the cream out of the raw milk, homogenize it, put it back in, and then make cheese."

Mistry and Nair found that salt retention in uncondensed milk and the ultrafiltered milk cheeses was significantly increased with the use of homogenized cream. Salt retention was higher in condensed milk cheeses than in those from ultrafiltered milk or control, but it was not affected by homogenization of the cream.

The researchers also found that salt recovery increased significantly with homogenized cream for control and with ultrafiltered milk, while the increase was much smaller for condensed milk cheese. "For control and ultrafiltered milk cheeses, the percentage of salt in the whey was lower with homogenization, as was the total amount of salt whey the cheese generated," Mistry says.

Mistry and Nair concluded that salt retention and recovery can be significantly increased by using a combination of homogenized cream and ultrafiltered milk. Less salt can be used in manufacture, less will be lost, and the consumer won't notice the difference. It benefits the cheese maker, who now can handle smaller volumes of corrosive waste, and consequently the environment. ◆

"We are homogenizing just the cream. This is a new manufacturing process we're suggesting."

—Vikram Mistry,
SDSU dairy science professor and department head

Participants in a precision agriculture workshop at SDSU are, l to r, Dale Tjarks, Flandreau, Rees Mielke, Conde, and Lannie Mielke, Mellette. The workshop was sponsored by NASA and USDA.

PRECISION FARMING: 'more likely to make money'

by Marianne Stein

Years ago, a farmer would peel back the husks around an ear of corn, look around the field, think a while, and come up with an estimate of bushels per acre that was pretty close.

Today, "pretty close" isn't enough. Farmers can't guess; they need information that is "on the money" from their fields.

Experts at South Dakota State University are showing them how to get and use that information.

Precision agriculture, says Gregg Carlson, professor of agronomy, may be defined as "intensive management of agronomic production to increase the productivity and profitability of farming systems."

Precision farmers are analytical, says Carlson. "They develop field profitability maps. Precision farmers monitor the field and understand exactly what factors are impacting yield."

"We want producers to look at how they can make economically based decisions," adds David Clay, professor of agronomy. "We are linking agronomy with economy and making that information available to farmers so they can make decisions that are more likely to make money for them."

IN THE PAST, GROWERS figured out an average yield for the whole field.

"Today, we have a yield monitor on the combine, and as the combine travels across the field, the yield monitor's mass flow sensor measures the amount of grain flowing through the combine while the GPS (Global Positioning

"Now I can use that information to make management decisions to improve my bottom line. "That's always the main goal."

—Dale Tjarks,
Flandreau Producer

Satellite) simultaneously determines the latitude and longitude, the machine's exact location in the field," Carlson says.

"Yield and location are recorded on a computer disk, and this information eventually results in a yield map showing site specific yield anywhere in the field."

"We can also find, down to the nearest foot, what the soil nutrient content is any place in the field," Carlson says. "We can use the estimated site specific soil nutrient content and the combine-generated yield maps to develop mathematical relationships for amendment applications. We can use a GPS-computer controlled fertilizer spreader or pesticide sprayer to vary the rate of nutrients or pesticides applied across the field."

Central to precision farming is the use of Geographic Information Systems (GIS). Precise location information is obtained through GPS technology and combined with ground-level information about soil conditions, water levels, and yield.

Precision farming also provides the tools for accurately targeted herbicide treatment, Clay adds. Remote sensing and GPS supply information that allows producers to apply chemicals only in areas where weeds are present.

Dale Tjarks, who farms 1000 acres of corn and soybean near Flandreau, uses these precision techniques to distribute fertilizer. "I soil sampled my field in 2.5 acre grids. Based on this information, we can make fertilizer recommendations for each grid.

"The goal is to apply only what the plant needs that season, so there's no waste. That's also going to help the groundwater.

"I had been collecting data from the yield monitor for several years, but I hadn't really used the data," says Tjarks. "What do you do with it besides look at pretty maps?"

Tjarks attended a precision ag workshop at South Dakota State University in January that showed him how to use computer software to integrate digitized soils information from GIS with his yield monitor data.

"Now I can use that information to make management decisions to improve my bottom line.

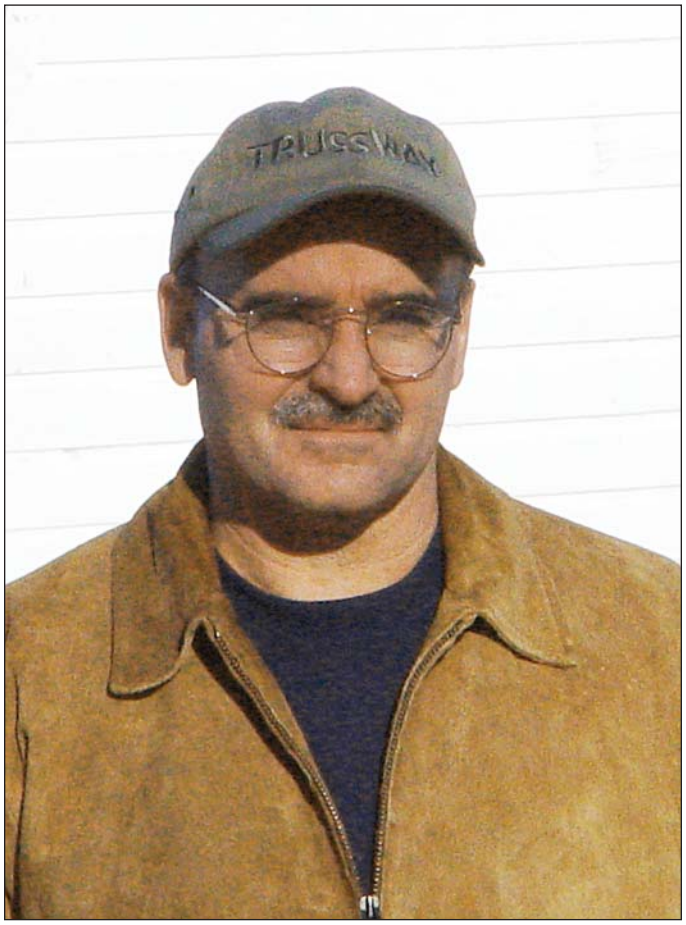
"That's always the main goal."

Tjarks has found that workshops and other information from South Dakota State University scientists help him reach that goal. "What South Dakota State University offers through the Extension Service ties everything together. The information is available to anyone who is interested, and we are taking advantage of that."

RESEARCH TOPICS ARE DRIVEN by producer needs and interests, says Clay.

"Once a year we meet with the producers and they tell us what they are interested in learning more about. So we identify experiments they can do. They conduct the actual experiments, and we help collect and analyze the data."

For example, in the wake of the 2002 drought, the producers identified water stress as one of the biggest factors limiting yield in some areas of the state, and they wanted to look at ways to increase yield in drought-



Ron Alverson, Chester area farmer and writer of the comments on the facing page, is a "believer" in precision farming, he says. He has the data to back up his commitment.

affected fields. They suggested that deep tillage could be effective.

"Deep tillage will reduce bulk density at lower soil depths, so maybe the roots can get down there," Clay explains. "Think about a potted plant: If you pack the soil really tight, the roots won't grow very well. So we think that if we can get that soil loosened up, we can get the water to infiltrate better, the roots can get down there, and they can get that water.

"We've identified a handful of farmers who will do those experiments, and we will come in and help collect calibration points and soil samples in a scientific way and we will analyze and pool the data."

Clay is a co-founder of the South Dakota State University Precision Agriculture Consortium that develops and distributes information about precision farming techniques. The consortium consists of representatives from South Dakota State University, the USDA Agricultural Research Service, the South Dakota Department of Agriculture, the South Dakota Department of Water and Natural Resources, and South Dakota producers.

The precision agriculture scientists at South Dakota State University also collaborate with colleagues across the nation, Clay says. The team works with the Upper Midwest Aerospace Consortium in Grand Forks, N.D., which coordinates activities in South Dakota, North Dakota, Montana, Wyoming, and Idaho. It participates in the Fund for Rural America project, a USDA-CSREES program in South Dakota, Montana, Minnesota, and Georgia. The team is involved in a project funded by the United Soybean Board, coordinated by the Potash and Phosphate Institute, and incorporating most of the north-central states.

"We are trying to link together and share the results from everything that's going on in this region that might be of interest to our farmers," Clay says.

The South Dakota State University Precision Agriculture Consortium will host a precision agriculture workshop for South Dakota producers in August 2003.

For more information on research, programs, and publications from South Dakota State University, or to attend the workshop, contact Cheryl Reese at 605-688-6309 (Cheryl_Reese@sdstate.edu) or Gregg Carlson at 605-688-4761 (Carlson.Gregg@ces.sdstate.edu) or look online at http://plantsci.sdstate.edu/precisionfarm/ ◆

$2 investment yields $7 to $10

by **Ron Alverson**

We use several pieces of precision farming equipment in our operation. This includes yield monitors on combines, a weigh scale-equipped grain cart, variable rate controllers on planters and fertilizer application equipment, and various pieces of software. Our total annual fixed and operating cost for this equipment is just under $2.00 per acre.

Using this equipment, we have been able to quickly and accurately conduct dozens of replicated trials annually over the past several years. In these trials we have measured the spatial yield response to various seeding rates and nitrogen application rates and found optimum rates.

Results have dictated management changes.

For example, we found that a uniform nitrogen application rate on corn that maximizes yield response across all soil types almost invariably results in over-application on much of the field. Targeting nitrogen application rates by soil characteristics has resulted in an average annual nitrogen cost savings of about $7.00 per acre.

Variable corn seeding rates have also been economically beneficial, although to a lesser degree.

We have identified sites across our fields in which corn yields rarely surpass 130 bushels per acre. Now our optimum seeding rate in these areas is no more than 25 to 26 thousand plants per acre. Areas in those same fields where yield potential has proven to be 150 to 200 bushels per acre have required 30 to 32 thousand planted seeds per acre to optimize yields.

Adjusting these seeding rates has resulted in about a $2.00 per acre savings, compared with a uniform rate meant to obtain the highest yield potential.

Variably seeding soybeans has also been profitable. Yield monitors have proven that significant yield losses can result from lodging or from diseases such as white mold attacks. The locations of these problems have turned out to be highly predictable from year to year. Reducing seeding rates in those areas has been doubly beneficial; it has increased yields and reduced seed costs.

It is essential to have replicated data to make good decisions. Our precision farming tools enable us to accurately conduct replicated yield response trials quickly and easily.

Investing $2.00 per acre annually has returned us $7.00 to $10.00. That's a great return on investment! Without a doubt, the use of these precision farming tools has been profitable and environmentally sound.

Working with the people at SDSU is very beneficial. We brainstorm about new ideas and concepts, and they provide "hands on" help with equipment and testing. We hope to work more with these fine people in the future!

Chronic wasting disease update

by Marianne Stein

By the end of summer 2003, the Animal Disease Research and Diagnostic Laboratory (ADRDL) at South Dakota State University will be equipped to test brain stem tissues for chronic wasting disease (CWD). CWD has been found in both free ranging animals and captive elk from South Dakota.

The laboratory will be one of 15 state labs nationwide approved to conduct CWD tests for the USDA, says Dave Zeman, head of the Veterinary Science Department. The USDA is funding some costs of getting the lab ready, and USDA personnel will train ADRDL staff to perform the tests. Under the agreement, the ADRDL may receive up to 10,000 test samples a year, Zeman says.

CWD belongs to a category of diseases known as transmissible spongiform encephalopathies (TSE). Other diseases of this type are scrapie in sheep and bovine spongiform encephalopathy (BSE), or mad cow disease, in cattle. In humans, there are several naturally occurring TSE diseases, including Creutzfeldt-Jacob disease (CJD).

TSEs are prion-related diseases, caused by an abnormal version of a naturally occurring protein. The abnormal prion protein accumulates and produces sponge-like holes in the brain. The sick individual gradually loses neurological control and eventually dies. A USDA-approved test for live animals exists only for sheep and is complicated to perform.

The disease can spread through ingestion of infected tissue from a sick animal. For elk and deer, there is some indication of direct transfer between animals, says Jon Jenks, professor in the Wildlife and Fisheries Sciences Department. "Once an animal becomes chronically infected with the disease, it salivates excessively. Some researchers believe that the active prion that spreads the disease is concentrated in the saliva. When animals lick each other, the disease may be transferred through the saliva."

Most types of TSE do not transfer between species. The main exception is BSE, which is believed to have caused a variant of Creutzfeldt-Jacob disease in about 125 humans,

"The [ADRDL] will be one of 15 state labs nationwide approved to conduct CWD tests for the USDA."

—Dave Zeman,
SDSU veterinary science department head

most of them in England. No cases of BSE have ever been detected in the U.S., and there are several excellent safeguards in place to prevent the disease from entering the country, says Tanya Lemire, assistant professor of veterinary science.

THERE IS NO REASON, at this point, to believe that CWD can be transmitted to humans or to cattle, says Zeman. He compares CWD to scrapie, which has existed for centuries and never posed problems for humans. Similarly, CWD has existed in Colorado and Wyoming for at least 40 years with no evidence to date of the disease being transmitted to humans.

But while the risk to humans is small, it cannot be completely ruled out. Therefore, it is wise to follow certain guidelines with wild game.

"When handling the animal, use gloves and avoid the brain, spinal cord, and lymphoid tissue," Zeman says.

"Do not consume animals that have tested positive, or that show clinical signs of the disease," says Lemire. A sick animal may be thin and lethargic, have an abnormal gait, stumble, and have difficulty walking.

There are no tests that individual hunters can use to confirm CWD. Instead, the entire head of the animal must be submitted for CWD testing, because it is very difficult to take a correct brain tissue sample, adds South Dakota State Veterinarian Sam Holland.

The South Dakota Department of Game, Fish and Parks conducts testing on hunter-harvested animals in certain parts of the state if heads are voluntarily submitted by the hunters. Testing of animals outside the defined surveillance areas are at the hunter's expense.

The South Dakota Animal Industry Board's regulations mandate testing of all elk and deer in captivity that die, no matter what the cause, Holland says.

When the SDSU lab is up and running, Holland expects all testing to be done there. "It is more convenient to send samples within the state, especially since we may sometimes send in a whole animal to be checked for other diseases in addition to CWD. We have very good lines of communication with ADRDL. It is, in fact, the official lab for the South Dakota Animal Industry Board, so it is by law required to do testing for us."

SEVERAL OTHER CWD-RELATED PROJECTS are being conducted by South Dakota State University scientists. Alan Young, assistant professor of veterinary science, conducts research that focuses on early detection of the TSEs by studying how prions enter the body and get into the nervous system.

"We are looking at cells in the immune system that are affected by prions. We are trying to determine whether these cells are critical to the development of the disease and whether they can be identified in the early stages of the infection. Immune cells circulate in the blood, so they are easier to sample than nerve cells."

Young says that one purpose of his research is to develop a test for live animals. Another purpose is to find out how the disease progresses, which potentially could lead to finding a cure. "Some neurological diseases can be treated with antibodies, so if it is possible to locate and identify the affected immune cells, it may be possible to develop an antibody that can be used for treatment," he says.

Other scientists are tracing deer movement, hoping to find out how the disease spreads. Jenks, who heads the project, says that 40 deer in Wind Cave National Park will be monitored over a 2-year period.

"We'll test 40 radio-collared deer in Wind Cave National Park for CWD by using a tonsillar biopsy," he says. This is a test that can be used on live deer, but not on elk. It is performed on a sample of tonsillar tissue, which can be extracted from a live animal.

Any animal that tests positive will be harvested and its carcass tested by the standard brain-stem tissue procedure, Jenks says. At the end of the study, the remaining Wind Cave animals will be captured again and another CWD test performed. The study may shed light on how the infection travels within South Dakota, Jenks says.

Jenks' project has received funding from the National Park Service. It is one of many projects being conducted nationwide to help understand how diseases spread in populations of wild cervids (elk and deer). Three of these projects on deer movements are also being conducted through the Wildlife and Fisheries Sciences Department and are funded by The South Dakota Department of Game, Fish and Parks and the Minnesota Department of Natural Resources. ◆

SOUTH DAKOTA STATE UNIVERSITY
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Agricultural Experiment Station
Brookings, SD 57007
Kevin Kephart, Director

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Garden Line on South Dakota Public Television

Garden Line regular panelists. Front Row: David Graper, Marty Draper (host), and Leon Wrage. Back Row: Rhoda Burrows, John Ball, and Mike Catangui.

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Garden Line is an hour-long weekly call-in program during the late spring and summer months. South Dakota State University Cooperative Extension Service specialists answer horticulture questions about lawn, garden, and house plants. Garden Line is in its 21th season during summer 2003.

Visit us on the web at http://garden_line.sdstate.edu/