Soil Health: Building for the Future
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Feature

Our understanding of soil health has evolved over the years. No longer just about fertility, attributes such as organic matter, soil aggregation, tilth, porosity, and bulk density are considered key components of healthy soil. This article describes how CCAs can help their farmer clients build and maintain healthy soils.

10 Meet the Professional | Meet Allan Roman: New ICCA vice chair.

12 Regional Roundup | Canada East: Combining header modification and losses during direct harvest.
North-Central U.S.: Introducing cover crops in the rotation.
Southern U.S.: Keeping western flower thrips off peppers.
Western U.S.: Deep-band placement of fertilizer increases corn grain yield in eroded soils.

20 New Products

22 Pest Management | Airblast sprayer calibration: Opportunities to improve performance and save money.

24 Certification | What the *darn* thing does for me.

30 Career Center

32 Self-Study CEUs | Earn up to 2 CEUs with the following self-study articles: “Evaluation of Coatings to Control Ammonia Volatilization from Surface-Applied Urea” and “Fossil Fuel Use in an Integrated Cotton and Beef Production System.”

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Our understanding of soil health has evolved over the years. No longer just about fertility, attributes such as organic matter, soil aggregation, tilth, porosity, and bulk density are considered key components of healthy soil. This article describes how CCAs can help their farmer clients build and maintain healthy soils.

By Tanner Ehmke
Crops & Soils magazine contributing writer

Soil health has been receiving a lot of attention recently, particularly with USDA-NRCS’s new soil health awareness and education effort that is widely supported by numerous groups involved in agriculture, including the American Society of Agronomy (ASA), Crop Science Society of America (CSSA), and Soil Science Society of America (SSSA) (see sidebar on page 7). It is an ever-evolving concept that is no longer focused just on reducing soil compaction or increasing fertility. Soil scientists today are digging deeper and uncovering the secrets of high-performance soil. But what does soil health mean for CCAs and their farmer clients?

ASA and SSSA member Susan Andrews, the national leader for soil quality and ecosystems at the NRCS in Lincoln, NE, says soil health is simply the capacity of the soil to do what it is intended to do. In the context of crop production, she says, soil health falls into five key functions: Productivity, nutrient cycling to prevent nitrogen leaching, holding water for plant use, filtering contaminants, and withstanding erosion.

Those basic concepts, adds ASA and SSSA member Gary Steinhardt, a veteran soil agronomist at Purdue University, are an evolution from the old way of thinking in years past. “Traditionally, when we thought about soil quality, we would have thought about it in terms of fertility. That is, if we measured the chemical components of phosphorus, potassium, and pH levels,” Steinhardt says. “That’s still true to an extent. But there’s so much more involved in the soil. There’s something profoundly more important about what soil does in the environment than just a provision of nutrients.”

Central to today’s new concept of soil health, Steinhardt adds, is organic matter and the role it plays in creating better soil aggregation. Organic matter, comprised of decomposed plant and animal residue and other organic compounds synthesized by soil microbes, is the natural glue that holds soil particles together. That grouping of sand, silt, and clay particles into larger particles, Steinhardt explains, allows water and air to move through the soil pores while at the same time acting like a sponge to store plant-available water for later use.

CCA Norm Widman, the national agronomist for NRCS in Washington, DC, agrees organic matter is the primary ingredient for improving and maintaining soil functionality. According to NRCS, a 1% increase in organic matter equates to a 0.5 acre-inch increase of available soil water capacity, or 13,577 gal/ac of water. Widman, who is also an ASA and CSSA member, says that increased availability of water can make a huge difference—especially during exceptional drought years like 2012.

“Organic matter helps the soil function at its full potential, and I think this summer was a prime example with this drought that we went through,” Widman says. “Those soils that were in better shape were able to store and hold more available water for the crop.”

Well-aggregated soil with good tilth, porosity, and bulk density also...
Soil Health:
Building for the Future

allows for a more active root system that can achieve deeper penetration, adds ASA and SSSA member Mark Coyne, soil microbiologist at University of Kentucky. Plants with deeper root penetration, Coyne says, ultimately will have better access to water deeper in the soil profile and make better use of the available moisture and nutrients.

“The roots are going to grow deeper. They’re going to be more profuse, so they’ll have a better opportunity to take up those nutrients,” Coyne says. “The microbial community associated with the plant roots is also going to be able to grow better and be more extensive in terms of their distribution. Nutrients, therefore, that are added as fertilizer are going to be better used and won’t escape the rooting environment.”

As for sheer yield response? Quantifying the relationship between crop yield and organic matter has been somewhat elusive, Steinhardt says. A crop’s yield response to an increase in soil organic matter is more difficult to measure than other relationships, such as yield to fertilizer. But, Steinhardt stresses there are still clear benefits from increased organic matter with reduced erosion, greater nutrient utilization, reduced nitrogen leaching, and better water quality.

And, not every soil has the same potential as another soil, adds Widman. Getting each soil type to achieve its best potential depends on a number of environmental factors that can affect a crop’s overall performance and the economic return to the farmer.

“I don’t think we’re able to come up with that correlation yet where we can directly say that a given percentage increase in organic matter will lead to an increase of ‘x’ bushels per acre, or a reduced amount of nutrient. It’s really going to be still very climate and crop specific,” Widman says. “But, I think we will find as we start doing those things that improve organic matter and soil quality that you’re going to see better crop response with the inputs that you’re putting in there as far as nutrients.”

Testing soil health
What’s the best measure for soil health? A routine lab test for soil organic matter or carbon content is the surest way to gauge the quality of the soil, Coyne says. But scouting a farmer’s field will also reveal much to the physical senses when trying to determine a soil’s health. The most basic diagnostic is to simply poke the soil with your finger.

“If the soil is really, really hard or you’ve got a crusty soil that’s tough to put your finger in, that’s a bad sign. That means that you’ve got poor soil,” Coyne says. Soil that breaks apart easily in your fingers, though, will likely open up and have enough pore space for plant roots to grow through, he adds.

Looking at the soil’s color can also reveal its condition. Soils that are poorly drained will appear grayish or greenish instead of being more brown or black in color, Coyne says. And smell can also be a good indicator how well your soil is functioning.

“The soil should smell the classic earthy smell. You shouldn’t have all kinds of odors,” Coyne says. “You shouldn’t smell things that you would associate with decomposing material.”
Looking for signs of erosion and nutrient deficiency in plants is also an easy visual diagnostic that may indicate a soil in declining health, Andrews adds. But if you want a more comprehensive analysis of biological and physical measurements in addition to field observations or a routine soil test for carbon, she recommends working with the Kellogg Soil Survey Laboratory in Lincoln, NE and the soil test lab at Cornell University. Otherwise, Andrews says, a simple soil test for carbon is sufficient to measure the progress if you’re on a path to build soil organic matter.

Going so far as conducting a microbial analysis might be overdoing it, Coyne says. What’s most important is not the microbe population itself, he advises, but rather the ability of the microbe community to function.

“At the microbial scale, you’re talking on the order of tens of thousands or hundreds of millions per gram of soil. Your typical cultural test is giving you the diversity of these organisms, but that’s not going to tell you how well the system is functioning,” he says. “So, just trying to isolate the organisms themselves is not really going to be revealing about whether or not it’s a healthy soil.”

Building organic matter... slowly but surely

If farmers and their CCAs have in mind a plan to increase soil organic matter, don’t expect results overnight. Building organic matter is not a quick process, says ASA and SSSA member Neil Hansen, agronomist at Colorado State University. Even increasing organic matter by a fraction of a percentage point can take years—even decades—to accomplish.

“Organic matter changes slowly,” Hansen says. “If you put a ton of fresh biomass into the soil, about half of the dry matter might be carbon, and only 10% of that carbon will end up in the long-term soil carbon pool. Most of it is going to be decomposed and go off as CO₂. So, when you compare that to the amount of carbon that was already there in that 1%, you’re adding a needle to the haystack every year.”

The biggest challenge may be for those farming in a semi-arid region where a lack of precipitation makes it difficult to produce biomass that is returned to the soil and converted to organic matter. In semi-arid environments, setting a goal to double organic matter from 1 to 2% in five years would be overly ambitious, Hansen warns.

Rather, increasing organic matter from 1 to 1.2% over the course of 5 to 10 years is much more plausible for farmers in water-stressed environments. While seemingly small, Hansen says that slight improvement shouldn’t be underestimated.

“The top six inches of an acre weighs about 2 million pounds,” Hansen says. “For a semi-arid soil with 1% organic matter, that equates to 20,000 lb of organic matter in the soil. Increasing organic matter to 1.2% is an increase of 4,000 lb of organic matter in the top 6 inches. This increase of just 0.2% represents a lot of mass.”

The ability to increase organic matter is also region specific, Andrews says. Even using the exact same system will affect organic matter over different time spans based on climate, precipitation, and soil type. In southern states in the U.S. where temperatures are warmer, for example, it may take 12 to 15 years to see a measurable difference in total soil carbon. In the northern U.S.

[continued on p. 8]
Unlocking the secrets in the soil

It’s a daunting task. How do we meet the food production needs of the world’s growing population while reducing the environmental impact of production agriculture, sustaining wildlife habitat, and providing potential cost savings to producers? The key, according to the USDA-NRCS, is to improve the health of our nation’s soil.

So to help producers discover the basics and benefits of soil health—as well as ways to improve it—NRCS recently launched a soil health awareness and education effort titled “Unlock the Secrets in the Soil.” The effort is supported by fact sheets; brochures; videos; web, radio, and social media announcements; and local field days. In addition, NRCS will be making programmatic changes that will give farmers more assistance in trying the healthy soil methods on their own farms.

Soil health is achieved by disturbing the soil as little as possible, keeping it covered, growing as many different species of plants as practical, and keeping living plants in the soil as much as possible. Soil health practices, such as no-till, cover crops, buffers, etc., keep the soil in place, which improves air and water quality, reduces flooding, and enhances wildlife habitat.

“This effort will help our farmers meet current and future demands for American-grown agricultural products by encouraging good soil and natural resource practices that are beneficial to their operations,” says NRCS Chief Dave White. “We understand that soils and farms vary a great deal across the country, so our job is to provide farmers the very best information available to meet their unique needs and help their businesses thrive,” he says.

NRCS’ focus on soil health has garnered the support of farmers, businesses, and partnering agencies and organizations from communities across the country, including the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

For more information, see www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health.
Midwest, however, it may take only three years to experience the same increase due to differences in temperature and decomposition rates.

Whichever region you are in, the surest way to build and maintain organic matter involves two main steps: (1) reducing or eliminating tillage and (2) increasing residue.

Step 1: Reduce or eliminate tillage

Reducing tillage to the absolute minimum is the first key step CCAs need to remember when advising farmer clients on improving soil health. While not all tillage is bad, Widman acknowledges, reducing as many tillage operations as possible is always the preferred route when trying to build organic matter.

"Tillage introduces air immediately into the soil and the whole area that you tilled. That air oxidizes the carbon to CO₂, and that goes up into the atmosphere. That is carbon leaving your soil," Widman says. “That’s not to say that you can’t do tillage. But the less tillage you do, the faster you can build organic matter.”

Coyne agrees that while some tillage may be necessary, the best way to preserve the soil’s porosity and the microbial populations needed for building organic matter is to reduce the amount of tillage. Minimizing or eliminating mechanical impact on the soil also reduces soil compaction, Coyne notes. More compaction means small pores, and smaller pores mean a greater possibility for flooding, crusting, and more difficulty in root penetration.

But tillage cannot always be completely eliminated, Hansen points out. In drier regions, some farmers have been successful with no-till while others have adopted conservation tillage that typically involves controlling weeds with chemicals during the fallow periods and doing some tillage ahead of planting to break up hardpan soils. Completely eliminating tillage when precipitation is in short supply, he warns, may increase wind erosion. When drought results in insufficient plant growth needed to anchor soil in place, high winds can remove less-dense soil constituents like organic matter, silt, and clay.

“When we get into a drought year, some of the no-till soils are a little more prone to blowing because when you have a drought failure and your residue is low, now you’ve got a flat surface and no residue. They blow a little bit,” Hansen explains, “so some farmers are managing wind erosion with some infrequent shallow tillage. To me, you’ve got to do what you can to protect against soil erosion.”

Weed resistance to herbicides can also be a barrier to adopting programs that reduce or eliminate tillage, Widman adds. Depending on the crops being grown, CCAs and their farmer clients may have a limited list of pesticides to select from to address resistant-weed issues.

“Our biggest concern is that people will turn to using excessive tillage to control the weeds,” Widman says. “And that’s going to take us down the wrong road. It may help out temporarily, but we really need to find ways to rotate crops as well as rotate modes of action of pesticides so we don’t consistently use the same mode of action and develop that resistance.”

Step 2: Increase residue

In tandem with reducing or eliminating tillage, leaving ample residue
to protect the soil from the elements is also necessary for building and maintaining soil health. A protective layer of residue on the soil surface, Coyne says, prevents puddling during high-intensity rainfall events and shields the soil from the impact of rain drops. And, he adds, the residue will eventually be incorporated back into the soil and contribute to the building of organic matter.

“Good soil is also always going to have some sort of plant growing on top of it, whether it’s a crop or some sort of intermediate cover crop that maybe you plow in later or maybe you kill with herbicide if you’re doing no till,” Coyne says. “But the idea is that those crops are soaking up nutrients that would otherwise be lost. The residue that you would get from that cover crop is also going to eventually be turned back into organic matter, so you’re basically harvesting carbon from the atmosphere during a period when you’re not harvesting crops.”

Widman adds that incorporating high-residue crops such as corn, wheat, and rice can help increase the amount of biomass that is returned to the soil. Perennial crops such as grass and alfalfa are especially helpful in increasing residue and building organic matter, he says.

The fastest way to accelerate the rate and the amount of carbon, Andrews advises, is to rotate high-residue crops in a no-till system—and to use cover crops to keep a live root in the soil year-round to feed the soil’s food web. Recent research at the USDA-ARS National Soil Tilth Laboratory also indicates that cover crops could be used on 70 to 80% of the U.S. corn and soybean acreage to help reduce soil nitrate-N losses.

However, researchers note, cover crops have their limits. The benefits of cover crops are diminished in northern regions because of cold temperatures and frozen soils and also in drier regions west of the Mississippi River because of water limitations. Research at Kansas State University’s Southwest Research Extension Center also raises the issue of negative profitability with cover crops due to cost and reduced moisture availability for the following cash crop.

In fragile ecosystems of the semi-arid western U.S. states where farmers fallow to accumulate moisture, Hansen adds that it’s a balancing act to build organic matter with cover crops and more diverse crop rotations without increasing short-term economic risk to the producer. Still, he believes cover crops have the potential to protect the soil surface, recycle nutrients, and reduce the time required to improve soil health. Finding a profitable way to incorporate them without substantially raising economic risk, he says, may require more research on termination dates and selection of species.

No matter the region, improved soil health will benefit not just the farmer, but also the long-term sustainability of the environment, according to Widman.

“In our lifetime, we only get a chance to really manage that soil and keep it healthy one time,” he says. “If we ever allow excessive erosion or compaction, we’re going to be hurt for years. So the more proactive we can be to improve and protect our soil, the more we’re going to protect the production potential of our soils. Like anything, you can screw it up really fast, but it takes a long time to fix it.”

In 1994, Allan Romander became one of the first CCAs in California, and he has diligently maintained his certification ever since. But for many years, he admits, that’s about as far as things went.

“I never really promoted the program. I did not tell all my growers I was a certified crop adviser or what a certified crop adviser meant to them,” Romander says. “That was my own fault,” he adds with a laugh.

It’s an ironic confession considering what Romander has been up to lately. After joining the California CCA Board in 2004, Romander developed a marketing program that nearly doubled the state’s number of CCAs in just five or six years. The accomplishment led to an invitation to chair the International CCA (ICCA) Board’s Promotions and Communications Committee, which Romander accepted in 2009. And now as vice chair of the ICCA Board, he is again making marketing a priority in the form of a new “ambassador” initiative (see sidebar opposite page). Set to launch sometime this year, the program aims to help local CCA boards improve their own promotional efforts.

In short, Romander has become something of a marketing guru, although he thinks the formula for success is pretty simple: Find a way to connect with the right people and then do what he didn’t do in the past—speak up.

“One of the best things I did [in California] was to retain a marketing consultant because with this consultant’s help we started to go around and talk about the CCA program and make people aware of its existence and the value of it,” Romander relates. “And the rest, as they say, is history.”

Learning from the ground up

Romander began his career with a bachelor’s degree in animal sciences from California State Polytechnic University in 1968, after which he landed a job as a field buyer for H.J. Heinz Co. in Stockton, CA. But in those days, he says, “a field buyer was as much a field agronomist as he was a guy who signed a contract,” which meant Romander was soon on a steep learning curve. One of his first assignments was to develop an agronomy program for growing new cucumber varieties that could survive mechanized harvesting—a new process at the time.

“For a kid who had no formal training in agronomy, I had to learn from the ground up,” he recalls. “And I learned a lot—from talking to colleagues, talking to growers, talking to anybody who would listen.”

Later, Romander became a district manager for Heinz in Michigan, but by 1979 he was back in California. After stints at an agrichemical retailer and a consulting business that he helped launch, Romander worked for Western Farm Services (now Crop Production Services) until he retired in 2007. Along the way, he handled an amazing assortment of crops, including canning tomatoes, apricots, almonds, walnuts, dry and freezer lima beans, cherries, apples, and even a little corn. “[Diversity is] the hallmark of California agriculture,” he says. “It’s an interesting region.”

California is interesting for another reason, he adds: It’s one of just a few states that require people
who advise farmers on pest management to be licensed as Pest Control Advisers (PCAs). Launched in 1973 in response to public concerns about heavy pesticide use on California farms, the PCA program ensures that agronomists who make pesticide recommendations are qualified and knowledgeable. But over time, growers also came to view PCAs as their go-to advisers on fertilizers, irrigation, and many other issues, says Romander, who became a PCA himself in 1979. It’s one important reason why he often neglected to tell people about his status as a CCA.

“There wasn’t a lot of need to do so,” he says.

Regulations lead to growth in California

That began to change in 2004. With retirement looming, Romander was looking for something to do next, and so he accepted an offer to join the California CCA Board and chair its marketing committee. The number of California CCAs was at an all-time low—just under 400—and the board hoped Romander could help turn things around. Soon afterward, he hired Steve Beckley, an experienced and well-connected marketing consultant, who began arranging for Romander to speak with various groups and agencies about the CCA program.

One of those agencies happened to be the California Water Quality Control Board, which Romander and Beckley knew was looking at nitrates in groundwater at the time. The meeting with the board turned out to be astonishingly productive. When it issued regulations in 2007 mandating that California dairies develop nutrient management plans for manure, the board also stipulated that either an engineer or CCA had to write the plan.

“That was the first time CCAs were ever spelled out in regulations in California,” Romander says, “and from that point on, our numbers really started to grow.” California now has roughly 650 CCAs, and Romander predicts the ranks will soon reach 700; meanwhile, totals in other states have mostly been flat or declining. “We also had an unprecedented number—150 people—sign up to take the August 2012 exam,” he adds. “We were absolutely flabbergasted.”

Romander suspects additional water quality regulations that mandate involvement by CCAs are responsible for the bump, especially a new set of regulations pending in California’s Central Coast region. And for this reason, he now counsels local CCA boards to talk with their state and provincial regulatory agencies about the CCA program and what CCAs can do.

At the same time, he knows some of his colleagues disagree with this approach, arguing it could imply that CCAs are joined at the hip with regulators. “But I think if we promote the program from the standpoint that we’re here to help, we’re not here to regulate,” the chances of this are minimal, he says. “And, of course, I have a better feel for this because of the way the PCA license program in California is administered.”

ICCA Ambassador Program

This year, the ICCA Board will launch a new promotions and communications initiative that’s designed to help local boards throughout North America improve their marketing efforts and grow their numbers. Called the Ambassador Program, the initiative will make three experienced ICCA leaders—a.k.a., the ambassadors—available to work with local boards to evaluate their past and current promotional activities, develop long-term plans for improving those efforts, and make the most of marketing funds.

Joining ICCA Board Vice Chair Allan Romander as the first ambassadors are Kim Polizotto of Indiana and Tom Kemp of South Carolina—both of whom are past chairs of the ICCA Board. The trio will divide the 37 local CCA boards in North America into three regions and then assist the boards within these regions at the boards’ request. To learn more about the initiative, contact Luther Smith, Director of Certification Programs, at lsmith@sciencesocieties.org or 608-268-4977.

An ambassador for the program

Romander now wants to put the marketing expertise he gained in California to work as an ICCA Board ambassador. As he moves forward with his ideas, however, he’s also acutely aware of how unusual his experiences in California have been—leading to what he calls his “western prejudice.” The farm bill, for example, means very little to most California growers, while to Midwest corn and soybean growers, it’s huge, of course. Similarly, California crops are “minor to the rest of the world,” Romander says. “But to the growers who are growing them here, they’re pretty major.”

It all has him feeling pretty humble as he steps into his new role as ICCA Board vice chair. “I think the first year is going to be a real learning curve because I’ve got to pick up on all the aspects of what the majority of CCAs in North America face,” he says.

“I hope what I can bring to the program will be worthy,” he adds. “It’s certainly a big responsibility, and I recognize that.”

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March 2013 | Crops & Soils magazine

agronomy.org/certifications | soils.org/certifications
Combine header modification and losses during direct harvest

By Brian Hall, Edible Bean and Canola Specialist, Ontario Ministry of Agriculture, Food, and Rural Affairs; brian.hall@ontario.ca

Straight combining canola can save a lot of time during harvest, reduce green seed, and increase seed oil content but can also expose canola to increased pre-harvest and harvest shatter losses. In Ontario, several farmers have experimented with modifying a traditional grain head to reduce header losses when straight combining canola. To evaluate the benefit of a head modified for canola, a field trial was carried out in 2012 to evaluate header losses from several headers at a grower’s field. The initial results from the field trial look encouraging.

Combine header losses were measured from three different types of headers: New Holland 9060 combine with a 40 CF 35 ft flex header, Case IH 8120 combine with a 40 ft draper head, and John Deere 9550 combine with a custom built header. The modified head was a JD 930 flex that had the flex pan removed in place of a solid pan with an 18-inch extension and vertical side-cutter knife. Header losses were measured by placing eight ice cream pails (5.75 inch diameter) across the width of the header into the standing canola. In addition, four pans measuring a total area of 0.64 ft² were placed on the divider side of the header to measure crop divider losses. Containers were placed where combines exited.

Custom header with 18-inch extended pan and vertical knife at the divider.
the canola plot to ensure the headers were operated to receive normal capacity of plant material. There were three replications for each combine.

**Results**

The average yield of the field was 2,250 lb/ac. Table 1 is a summary of losses measured for each combine. The different widths for each combine will significantly affect the overall field loss. A wider header will require fewer passes to harvest a field, reducing the overall field loss experience at the divider. By way of example, a 100-ac field measuring 3,300 ft long by 1,320 ft wide is used to calculate loss and compare headers. Divider loss is calculated as the loss per 1 ft² under the divider (pans) multiplied by the number of combine passes multiplied by the length of the field (3,300 ft). This ignores headlands and therefore tends to slightly underestimate total loss, especially for smaller headers. Because the pans used for collecting divider loss would also collect some seed from the edge of the header, it would slightly overestimate divider loss. To adjust for this, header width was reduced by 1 ft (i.e., a 30 ft header loss is calculated as 29 ft wide).

Losses for the custom modified header were 0.9% compared with 2.2% for the draper and 10% for the flex header. The divider knife on the custom header had the lowest loss, which was one-half to two-thirds less than the other two combine heads. The divider loss was less than 10% of the total loss for both the draper and custom header. It could not be determined why the total loss for the flex head was quite high, indicating the need to do further testing.

**Summary**

Both the draper header and modified custom header reduced losses over the flex header in this trial. The loss measured from each header type varied quite a bit between each replication, so absolute values of the losses should be interpreted with caution. However, the results clearly indicate that the custom header had significantly lower loss than either of the other two combine head types. The initial results of this trial indicate the need to further evaluate headers modified for direct harvest of canola and compare this with other header types and under different conditions. Numerous factors including crop density, header adjustments, and knife sharpness can significantly affect losses and need to be considered in comparing headers. A next step would also be to include a comparison with a European style header designed for canola and small grains next year.

**Table 1. Summary of losses measured for each combine.**

<table>
<thead>
<tr>
<th>Combine header loss on 100 ac</th>
<th>Divider loss</th>
<th>Header loss</th>
<th>Total loss</th>
<th>% Loss on 2,000 lb/ac average yield</th>
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<tbody>
<tr>
<td>Flex header</td>
<td>246</td>
<td>19,696</td>
<td>19,942</td>
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<tr>
<td>Draper head</td>
<td>331</td>
<td>3,997</td>
<td>4,328</td>
<td>2.2%</td>
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<td>Custom header</td>
<td>126</td>
<td>1,648</td>
<td>1,774</td>
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<th>Economic loss on 100 ac</th>
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<tbody>
<tr>
<td>Divider</td>
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</tr>
<tr>
<td>Flex header</td>
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<td>Draper head</td>
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<td>Custom header</td>
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Cover crops play an important role in maintaining soil health and provide sustainable alternatives in agroecosystem management. Multiple terms are used interchangeably to describe them, depending on objective(s) of planting, such as green manures (add residues), cover crops (prevent erosion), and catch crops (trap nutrients from loss). However, cover crops are planted during or after the main crop and are usually killed on the surface or incorporated into the soil before they mature. Cover crops are planted mainly to (1) suppress weed germination, (2) add biomass and nitrogen in the case of legumes, and (3) physically protect against wind and water erosion. But, they provide multiple benefits directly and indirectly that are not foreseen by farmers (see Fig. 1).

Cover crop residues alter many growth factors like light, soil temperature, and soil moisture; provide physical impedance; and release allelopathic chemicals that control weed germination and establishment. Most weed species require light to initiate the germination process, and the presence of cover crops reduces light transmittance depending on canopy structure. Cover crops that have a greater proportion of leaf area and less stems like hairy vetch or rye should be best adapted for controlling weeds. Alterations of soil moisture and temperature by a cover crop canopy can either benefit or retard weed seed germination, depending on weed species, soil characteristics, and climate. Under drought condition, the canopy provided by cover crops could enhance soil moisture retention and enhance weed emergence. Cover crop residue probably inhibits the emergence of germinated weed seeds by forming a mechanical barrier to the upward growth of the seedlings. Release of toxins from cover crops has been postulated to restrict weed seed emergence, but establishing the allelopathic relationship between cover crops and weed species is a challenge. Under a conservation tillage system, cover crops have the potential to control weeds.

Cover crops add small residual biomass to soil, but rapid decomposition of residues has the potential to increase the active organic matter pool. Cover crop mixes can be formulated to control the sequestration rate based on the carbon to nitrogen ratio of the species. A residue with low C:N ratio below 20:1 will mineralize the nutrients faster than a cover
crop mix with a high C:N ratio above 40:1. For this reason, the contribution of N from non-legume small-grain crops is generally negative. On the contrary, planting leguminous cover crops before a main crop can add nitrogen, easily reduce the fertilizer nitrogen requirement of the main crop, and pay for the cost of cover crop seed. Typical nitrogen fertilizer equivalence for legume cover crops ranges from 54 to 89 lb/ac depending on species, soil, management, and climate.

Protection from wind and water erosion is one of the main reasons for growing cover crops. Annual crops, corn, soybean and wheat cover soil for four months or less each year. Cover crops modify the erosive forces by reducing the raindrop impact, increasing soil resistance to particle detachment, and dissipating soil particulate transport mainly through root anchorage and slowing down the runoff velocity. The potential of cover crops to protect soil from erosion can be increased by adopting conservation tillage practices. Cover crops can be used to manage salts by maintaining or lowering water tables. In the eastern part of North Dakota, recurring wet cycles have raised the water table, and evaporation from bare soil will bring naturally occurring salts on the surface. Cover crops that withstand saline conditions like barley and oat will transpire water and lower water table depth.

Steps for cover crop adoption

For successful inclusion of cover crops in an existing rotation, farmers should first select a set of cover crops based on their priority of objectives. Farmers should review the cover crop benefits (covering soil, adding nitrogen, and managing weeds), and depending on their primary and secondary objectives, match them with a supply of resources like nutrients, water, and growing climate. Scientists at the North Dakota Great Plains Research Laboratory prepared a chart of cover crops based on growth characteristics (annual/biennial/perennial), water use, and canopy architecture (Fig. 2), which is available online at www.ars.usda.gov/Main/docs.htm?docid=20323). If you visit the website and click on an individual cover crop name, it will bring up the crop’s characteristics. Grasses including cereal and leguminous plants can be used as cover crop.

The second step in cover crop adoption is deciding on the cover crop management issues such as (1) establishment date, (2) seed rate, (3) need for fertilizer/amendment additions, and (4) termination timing and method. Living cover crops can be fall-seeded or spring-seeded, but winter-hardy crops like winter rye are the better choice for fall-seeded cover crops that will still be alive in the spring in eastern North Dakota and Minnesota. The seed rate of cover crops can be fall-seeded or spring-seeded, but winter-hardy crops like winter rye are the better choice for fall-seeded cover crops that will still be alive in the spring in eastern North Dakota and Minnesota. The seed rate of cover crops influences weed suppression, and thick, dense cover crop stands can help reduce the establishment of weeds. But increasing the seed rate may require additional nitrogen, particularly for small grains like cereal rye. Lime application may be needed to maintain or raise the soil pH for legumes like hairy vetch and red clover. Termination of cover crops is equally important as its planting time because a delay in termination will compete with the main crop for resources. Herbicides can be efficient in controlling cover crops, but product selection and application timing are important.

In addition to considering all of these management options, availability and costs of cover crop seed mixes are important issues in adoption. During the initial cover crop establishment, indirect costs involve foregone income due to cash crop yield losses incurred from delayed planting, competition, or substitution by cover crops. Moreover, the benefits and downsides of cover crops are not always found in short-term or factorial experiments as interactions between cover crops and main crops involve long-term and cascading effects. For different agroecological regions, future research should focus on environmental services provided by cover crops and their compatibility with current cropping systems.

Fig. 2. Cover crop chart prepared by the North Dakota Great Plains Research Laboratory, USDA-ARS, Mandan, ND.
Repelling western flower thrips from Florida’s bell peppers could be as simple as giving the insects a push and a pull, say researchers with the University of Florida’s Institute of Food and Agricultural Sciences (UF/IFAS).

A team at UF’s North Florida Research and Education Center in Quincy is evaluating an eco-friendly approach called “push-pull.” It’s meant to push thrips away from the target crop with unpleasant stimuli and pull the insect to another type of plant grown as a lure.

Initial findings from a two-year study at a South Florida farm suggest that push-pull could help the state’s outdoor pepper growers reduce the thrips threat, says entomologist Joe Funderburk, a UF/IFAS professor who led the study.

Western flower thrips are native to the southwestern United States but spread to the country’s eastern half in the 1980s. The insect feeds on plant juices and preys on more than 500 species, including many vegetables, fruits, and ornamentals. It also transmits the notorious tomato spotted wilt virus.

“Western flower thrips is a pretty big problem, and one that’s easily mismanaged,” Funderburk says. “Many growers try to address it with broad-spectrum insecticides, and that’s like putting the western flower thrips on steroids.”

Funderburk says broad-spectrum insecticides kill not only western flower thrips but also natural enemies and harmless native organisms that compete with the pest for resources. The result: After a brief decline in western flower thrips populations, the pest comes back in force and may develop insecticide resistance.

The UF/IFAS push-pull strategy takes a completely different tack:

The “push” involves covering raised planting beds with plastic mulch that reflects ultraviolet light from the sun to repel the insects. Researchers also coated pepper plants with a light dusting of kaolin clay, making it tough for thrips to feed and breed on pepper leaf tissue.

The “pull” was accomplished by raising rows of sunflowers near the peppers, keeping the rows free of UV-reflecting mulch and kaolin to offer the thrips an appealing alternative meal.

But those sunflowers didn’t provide safe harbor. They teemed with a well-known predator, the minute pirate bug. And they hosted two native thrips species that are more efficient at feeding and reproducing than western flower thrips, making it harder for the pest to survive.

“These are all natural populations,” Funderburk says. “We are not buying natural enemies and releasing them.”

—Source: Institute of Food and Agricultural Sciences and University of Florida

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Western U.S.

Deep-band placement of fertilizer increases corn grain yield in eroded soils

By D.D. Tarkalson and D.D. Bjorneberg, USDA-ARS, Northwest Irrigation and Soils Research Lab, Kimberly, ID

Nitrogen and P fertilizer placement options have the potential to affect corn yield. Tillage practices often are associated with common fertilizer placement options. Strip tillage (ST) is one tillage practice being investigated in the Pacific Northwest to conserve soil and soil water through residue management and reduce tillage costs in many areas of the Corn Belt. While ST and other conservation tillage practices are less common in this region overall, ST is becoming more common in the sugar beet industry in southern Idaho, and due to the high dairy cow populations, corn production is increasing. The dual use of ST for sugar beet and corn production will likely continue to develop, increasing the need for ST best management practices in this region.

In 2007 and 2009, fertilizer placement options under ST were compared with commonly used fertilizer placement options under conventional tillage (CT) in southern Idaho.

Methods

The field study was conducted at four locations during 2007 and 2009 at the USDA-ARS Northwest Irrigation and Soils Research Lab in Kimberly, ID on a Portneuf silt loam soil.

The fields have been furrow-irrigated for 80 to 100 years and have a 1 to 2% slope. As a result, most topsoil has eroded from the top areas of the fields and some has been deposited on the bottom areas of the fields. This erosion process has decreased yields on at least 800,000 ha in the Pacific Northwest (Carter et al., 1985). During each year of the study, two locations were utilized, one at the top of a field (eroded) and one at the bottom of a field (not eroded). Prior to field operations, soil samples were collected and analyzed for organic matter (OM), free lime, bicarbonate extractable P and K, and NO₃⁻N and NH₄⁺-N. Results are listed in Table 1.

All treatments were replicated four times.

Conventional tillage treatments consisted of chisel plow, tandem disk, fertilizer application (on broadcast treatments), and roller harrow in the spring. Strip tillage was conducted using a Strip Cat implement developed by Twin Diamond Industries, LLC in Minden, NE. The study locations were irrigated with furrow irrigation in 2007 and sprinkler irrigation in 2009.

Results

Soil analysis

In both years, soil at the top of each field had free lime two times greater and OM that was approximately 20% less than the bottom. These differences resulted from the erosion of topsoil on the top end, exposing the calcareous subsoils associated with many soils in this region. The soil test P concentrations at three of the sites (2007 top, 2009 top, and 2009 bottom) were considered low to marginal according to the University of Idaho fertilizer recommendations for field corn. The recommendations suggested application of 40 to 140 lb P₂O₅/ac depending on the soil lime content. The soil test K at all sites was considered sufficient.
Grain yield

At the top location in 2007, treatment 3 (ST-band P-band N) was 12.5% (11 bu/ac) greater than the average of the CT treatments (4 and 5). At the top location in 2009, treatments 3 (ST-band P-band N) and 1 (ST-band P-broadcast N) were on average 25.9% (26 bu/ac) greater than the average of the CT treatments. A direct comparison of tillage effects on grain yield could be made between treatments 2 (ST-5×5 N-broadcast P) and 4 (CT-5×5 N-broadcast P) due to the treatments having the same fertilizer placements. Similar grain yields for the two treatments during both years of the study indicate that there was no effect of tillage on grain yield. Any differences in this study were likely due to band placement of fertilizers with ST. In 2007 and 2009, the placement of N in the CT treatments did not affect grain yield under CT at the top location.

At the bottom locations in 2007 and 2009, there were no grain yield differences among treatments. Although not statistically compared, the trend for greater grain yields at the bottom locations compared with the top locations was likely due to differing soil properties resulting from irrigation-induced erosion at the top locations (Table 1). Previous research on these types of soils in this region has shown yield reductions on the eroded areas of furrow-irrigated fields (Carter et al., 1985). Research has shown a greater immobilization of applied P in these soils due to greater free lime (Robbins et al., 1999). In this study, greater free lime at the top locations likely resulted in the advantage of applying P in a concentrated band under ST.

For more information, please contact David Tarkalson at david.tarkalson@ars.usda.gov. The full research paper can be found at: www.plantmanagementnetwork.org/pub/cm/research/2010/placement.

Table 1. Selected soil chemical properties in the surface 24 inches from top and bottom sites in 2007 and 2009.

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Top</td>
<td>Bottom</td>
</tr>
<tr>
<td>Organic matter (%)</td>
<td>1.4</td>
<td>1.6</td>
</tr>
<tr>
<td>Free lime (CaCO₃) (%)</td>
<td>20.2</td>
<td>9.6</td>
</tr>
<tr>
<td>Bicarbonate P (ppm)</td>
<td>7.3</td>
<td>17.9</td>
</tr>
<tr>
<td>Exchangeable K (ppm)</td>
<td>134.0</td>
<td>241.5</td>
</tr>
<tr>
<td>NO₃–N (ppm)</td>
<td>8.2</td>
<td>14.0</td>
</tr>
<tr>
<td>NH₄–N (ppm)</td>
<td>5.8</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Table 2. Corn grain yield and analysis of variance in 2007 and 2009 for the top and bottom sites.

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2009</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Top</td>
<td>Bottom</td>
</tr>
<tr>
<td>1-ST-band P-broadcast N</td>
<td>93 ab†</td>
<td>99</td>
</tr>
<tr>
<td>2-ST-broadcast P-5×5 N</td>
<td>94 ab</td>
<td>101</td>
</tr>
<tr>
<td>3-ST-band P-band N</td>
<td>99 a</td>
<td>100</td>
</tr>
<tr>
<td>4-CT-broadcast P-5×5 N</td>
<td>86 b</td>
<td>100</td>
</tr>
<tr>
<td>5-CT-broadcast P-broadcast N</td>
<td>90 b</td>
<td>100</td>
</tr>
<tr>
<td>Mean</td>
<td>92</td>
<td>100</td>
</tr>
</tbody>
</table>

ANOVA ‡

† For each year and location, rows with the same letter are not significantly different.
‡ Analysis of variance; * = significant difference between treatments; NS = no significant difference between treatments.

References


This article was prepared by members of the Western Extension and Research Activities (WERA 103) Committee on Nutrient Management and Water Quality. For more information about WERA 103, see: https://community.ipni.net/site/wera.nsf/home.xsp.
Brillion folding grass seeder

Landoll Corporation recently introduced the new Brillion Farm Equipment Model 4630-36 Folding Grass Seeder. The 4630-36 features three independent 12-ft seeders mounted to a Landoll folding toolbar. The seeder folds to under 14 ft wide for safe transporting from shop to field. Designed for the large grower, the unit is capable of planting 25-ac/hour at a recommended speed of 6 mph.

Each seeder is mounted on an independent three-point hitch linkage to the toolbar. “Everyone who has operated the new seeder this past spring was impressed with the way the seeders were able to follow the contours of the ground,” reports Gary Wallander, Brillion’s Product Support Manager.

An electric clutch with a cab-mounted console allows on/off control for each individual unit, and a heavy-duty coil tine harrow removes tire tracks on the wing sections.

The 4630-36 comes standard with three 12-ft three-point hitch seeders; three seeder options are available depending on the crop to be seeded. The SSBP-36 features two seed hoppers, a front hopper for alfalfa and smaller seeds and a rear hopper for brome and other grasses. The mid-sized SSP-136 features a larger hopper for the operator who wants to seed only alfalfa and small seeds. The high-capacity SSP-2361 features an extra-large hopper for alfalfa and small seeds. Optional equipment includes folding row markers, an electronic acre meter kit, and a spike or coil tine drag for the center seeder section to remove tractor and toolbar tire tracks.

For more information on the 4630-36 Folding Seeder or other Brillion Farm Equipment products, call 855-320-0373 or visit www.brillionfarmeq.com.

COBALT Advanced insecticide

Dow AgroSciences has developed a new insecticide, COBALT Advanced, which it describes as a “more powerful, low-odor tool that offers fast knockdown and residual control of a broader spectrum of insects.” The company says it controls aphids, beetles, and spider mites in soybeans; corn rootworm beetles, cutworms, and aphids in corn; aphids, beetles, and grasshoppers in wheat; and weevils, aphids, and leafhoppers in alfalfa.

“If you’re spraying at the appropriate application rate, you can expect COBALT Advanced to provide quick knockdown of all of the primary pests in these crops,” says Dr. Erin Hodgson, Extension entomologist at Iowa State University.

Dow AgroSciences claims that the product’s new low-odor formulation benefits applicators working near urban centers. And the improved formulation offers greater tank-mix compatibility with nutrients, adjuvants, and other pesticides, including fungicides. A planned approach of mixing COBALT Advanced with an effective fungicide can

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help control both insects and diseases with a single application, according to the company.

For more information, visit www.CobaltAdvanced.com.

Massey Ferguson small-frame tractors

Massey Ferguson, a global brand of AGCO, is adding four new small-frame tractors to the 7600 series of row crop tractors for North American producers. The new tractors, with 110 to 130 PTO horsepower, boast a 6 to 8% fuel-efficiency improvement over previous series. They join four other models in the 7600 Series ranging from 140 to 180 PTO horsepower, introduced in 2011.

“These tractors are a great choice for dairy and other livestock producers who want a versatile tractor that’s ideal for loader work or powering a feed mixer, but equally capable for fieldwork, such as pulling a disc mower or silage or hay wagon,” says Conor Bergin, product marketing specialist for high-horsepower tractors.

The new tractors feature a redesigned, more ergonomic cab with OptiRide cab suspension, which the company says improves comfort and ease of operation. Combined with a quieter engine, the cab reportedly helps reduce operator fatigue from long days in the field.

For more information, see your Massey Ferguson dealer or visit www.masseyferguson.us/products/tractors.
Is sprayer calibration on the top of the “to do list” for your clients next spring? Proper calibration verifies that materials are applied at the intended rate. Too little could result in a crop failure, and too much could exceed legal rates and waste valuable dollars.

Dr. Andrew Landers, a world leader in pesticide application technology, has demonstrated that 10–15% of spray material is routinely lost to drift and 40–60% to the ground during early-season applications (Hutton-Squire, 2010). These inefficiencies cost growers thousands of dollars each year and increase risks to human and environmental health.

For example, based on current prices for a commonly used fungicide tank mix, a grower can expect to spend $45/ac at recommended label rates. Sprays where an insecticide, fungicide, and foliar nutrients are included could cost upwards of $100/ac. Using an average $70/ac cost, a 10% improvement in sprayer performance on a 20-ac orchard would generate $140 in savings per spray. A 30% improvement would potentially save $420 per application in the same 20-ac orchard.

During visits with apple producers in Minnesota and Wisconsin this year, we emphasized that Extension and manufacturer-recommended calibration procedures are essential to the success of integrated pest management (IPM) programs. Grower reactions were varied. Most were skeptical. One grower suggested that if we know exact measurements of the orchard and the volume of water in the tank, it should be more than adequate to calibrate by observing how many acres it takes to empty the tank. Another indicated the sprayer was brand new and delivered ready to go, even though the dealer never inquired about the orchard’s row spacing or tractor forward speed—essential for calibrating an airblast sprayer (Hamilton, 2012).

When we calibrate, the goal is to optimize performance and prevent equipment failure. Are nozzles worn, increasing orifice size and application rate? Are other mechanical problems present? This season, we calibrated air-blast sprayers for 11 tree fruit producers in Minnesota and Wisconsin with funding from the USEPA Strategic Agricultural Initiative. Results suggest that growers generally do not know proper calibration methods and do not routinely evaluate sprayer performance. The USDA-NRCS recommends that application rates should be within 5% accuracy (USDA-NRCS, 2006). Ninety-six percent of the application scenarios we calibrated were outside of this range.

Airblast sprayers are the industry standard for applying crop protection materials in citrus groves, orchards, tree nuts, and vineyards. These axial-fan-driven sprayers deliver materials to the target by displacing air and creating turbulence in the canopy. This design has changed little since it was patented by George Daugherty in 1949 (Fox et al., 2008). Sixty-three years later, 95% of the industry is still using Daugherty’s basic airblast sprayer design (USDA, 2010).

Effective Vineyard Spraying: A Practical Guide for Growers (Landers, 2010) provides an excellent step-by-step approach to calibrating airblast and boom sprayers and outlines strategies to minimize drift and improve pesticide deposition. Here we summarize key information consultants can share with clients.

First, determine the make and model of all of the pesticide application equipment that will be used, and collect the manufacturer recommendations for maintenance and calibration. Review the instructions, and ensure they are
followed, including recommended intervals for inspection, maintenance, and replacement of key parts.

Second, address three key questions:

1. **What’s your speed?** Tractor forward speed impacts the application rate and the volume applied per acre and should be calibrated prior to first use each season. We found actual travel speeds were off by two- to three-tenths of a mile per hour, resulting in sprayer output differences of about 5%, risking exceeding USDA-NRCS standards for accuracy.

   Applicators relying on charts that estimate travel speed based on gear setting and tachometer reading need to make ground speed calibration a top priority. Tractors equipped with speedometers also need calibration. When calibrating speed, it is important to accurately measure the distance and not to rely on pacing. A tape measure or a measuring wheel is the right tool for this job (Landers, 2010).

2. **What’s your nozzle size?** Nozzles determine the droplet size and spray pattern. Droplets that are too large will not stick to the foliage; droplets that are too small are prone to drift. The ideal droplet size depends on the target. Airblast sprayers applying materials for insects and diseases on foliage should use fine (183–280 µ) or medium (281–429 µ) textured sprays (Landers, 2010).

   Applicators can influence how much spray is directed to different parts of the canopy by adjusting nozzle orientation and varying the gallon-per-minute (GPM) nozzle flow rate. For example, nozzles on the bottom and very top of the boom can be set for lower GPM than nozzles in the middle of the array.

   Spray material and tank sediments can accelerate nozzle wear and even plug nozzles. All nozzles—ceramic, brass, aluminum, stainless steel, and plastic—will wear over time, thereby changing the application rate. GPM for each sprayer nozzle should be measured at least once per season, including new nozzles. Any that deviate 10% or more from manufacturer specifications should be replaced and recalibrated immediately (Landers, 2010).

3. **What’s your pressure?** We frequently encountered broken or missing pressure gauges. These are prone to corrosion from exposure to agrichemicals and damage from improper storage. Maintaining the right pressure influences droplet size. Higher pressure creates a finer droplet; as pressure decreases, droplet size increases. Pressure also impacts the rate of nozzle wear; set pressure within the recommended range for the nozzle. Pressure can also influence GPM; a fourfold increase in pressure doubles nozzle output (Landers, 2010).

**Row spacing**

   The area covered with a sprayer is measured in linear acres traveled, not the square acres of the planting. To accurately determine area covered, tree-row spacing must be considered. Many orchards and vineyards have transitioned to high-density plantings, and many have a variety of row widths on the farm. Applicators need to be aware that as they travel between plantings, application rate changes as row spacing changes unless they adjust travel speed and/or GPM.

**Minimizing drift and improving spray deposition**

   Crop protection materials are applied to prevent crop loss from pests. If materials do not reach their target, what purpose has the application served? Assessing the quality of coverage with water or oil-sensitive cards, ultraviolet dyes, or kaolin clay allows an applicator to determine if the material is reaching the target and if the droplet size is adequate. Droplet sizing charts and instructions are included with water-sensitive paper designed for spray coverage assessments. Digital imaging software is also available for more precise measurement.

**Taking the technology to the next level**

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I laughed out loud when Fred Vocasek, past chair of the ICCA Board, shared with me a verse out of an old salesman’s poem. “So tell me quick and tell me true or else mister, the *heck*with you. Less how your product came to be and more what the *darn* thing does for me.” What does certification do for you? I love Paul Tracy’s (past chair of the CCA–North American Board) response to that question. “What is in it for you is what you make it. As an organization, CCA provides the tools, credibility, and support to its members, but they need to follow through with effort.”

When I decided to write a column for Crops & Soils magazine as the chair of the CCA–National Board, I never dreamt it would be easy … but I never thought it would be so hard either. Maybe it’s because I have chosen to share with all of you some important areas that the CCA–National Board works with that I feel are harder to defend to the CCA in the field.

In this issue, I would like to share with you a discussion of the role of our public policy work. The information, ideas, and opinions that follow are a compilation of discussions that took place among Paul Tracy (regional agronomist at Winfield Solutions, LLC), Fred Vocasek (chair of the ASA’s¹ Science Policy Committee and senior lab agronomist for Servi-Tech Laboratories), Luther Smith (director of certification programs for ASA, CSSA,² and SSSA³), Karl Anderson (director of government relations for ASA, CSSA and SSSA), and me.

### Background information

ASA is the primary political entity when it comes to public policy work. CCA is the certification program of ASA and does not get as deeply involved unless issues are specifically connected to CCA/CPAg. Why? Certification needs to be viewed as being unbiased since it potentially impacts people’s employment. Certification works from standards, set by the profession, and it is important that it is not influenced by any one person, group, or segment.

If the political issue is very specific to what CCAs do or what CCAs represent, then the communication would include both ASA and CCA. We are stronger when presented as ASA and CCA—the agronomy profession. Public policy work is “big picture” work, and each of us needs to understand that it may not benefit all CCAs all the time. But, we are very much working together for the betterment of everyone involved.

### Our role in public policy

One thing that I am certain of is in the political arena as it stands today, we will have new or revised policies and regulations around agriculture. What this group needs to concentrate on is making sure CCA is represented in policy issues for being the well-known and, more importantly, influential group that we are. There are direct and indirect benefits of being at the table. Long-term awareness of the CCA program among the policy makers and their advisers, along with the hard work of local CCA programs, has provided opportunities for us to be involved.

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¹ASA, American Society of Agronomy.
²CSSA, Crop Science Society of America.
³SSSA, Soil Science Society of America.
⁴TSP, technical service provider.
⁵DRT, drift reduction technologies.
in California nitrate management issues and the Ohio watershed issues along with the recognition of TSP4 program services.

Once we are represented in the discussions of relevant issues, our other responsibility is to predict and measure the impacts of policies so that our members and their clients are not negatively affected by the actions taken by government agencies. CCAs benefit from a strong ag economy and a regulatory structure that allows farmers the freedom to operate.

**Current issues needing CCA involvement**

The CCA program, along with ASA, collectively can provide insight, education, and guidance to several areas while raising the profile of the CCA. I feel we also bring the important aspect of being a large part of the delivery system. Although, as an organization, we need to pick and choose our public policy issues carefully so that we aren’t wasting time and resources.

The CCA board and its support team have worked to identify several key issues. These include: water quality, conservation policy, pesticide resistance, DRT5 application policy, and soil health (drought resistance/tolerance and sustainable production). Our next step is to work with the policy team to get something done.

**CCA feedback and participation**

As a board, we have always struggled with public policy issues and how to get CCAs to participate and care about them. Here is your chance to let us know what you think. Are these issues important to you? What do you expect from the board and Karl, your representative and sentinel in DC? We look forward to hearing from you. Please contact Luther Smith (lsmith@sciencesocieties.org) or me (amy@afschem.com) with your comments and questions.

---

**Newly certified**

The following list includes newly certified individuals and those who have added additional certifications since the last issue of *Crops & Soils* magazine.

**Canada**

**Alberta**

Bly, Cindy Jean, Lethbridge, AB, CCA-PP
Cowan, Steven J., New Norway, AB, CCA-PP
Heaney, Daniel John, Edmonton, AB, CCA-PP
Heather, Amy M., Coaldale, AB, CCA-PP
Klassen, Colin M., Vegreville, AB, CCA-PP
Meyer, Tracy, Leduc County, AB, CCA-PP
Myers, Trista Lee, Camrose, AB, CCA-PP
Newton, Page, Patricia, AB, CCA-PP

Palichuk, Jane Lee, Two Hills, AB, CCA-PP
Quinton, Justin J., Lethbridge, AB, CCA-PP
Redden, Mark Leslie, LloyDMINster, AB, CCA-PP
Trowbridge, Jason K., Fort MacLeod, AB, CCA-PP
Williams, Jenna D.E., Vermilion, AB, CCA-PP

**Manitoba**

Bergen, Jeremy A., Plum Coulee, MB, CCA-PP
Blyth, Mitchell Leslie, MacGregor, MB, CCA-PP
Common, Sean E.L., Rivers, MB, CCA-PP
Dyck, Greg F., Austin, MB, CCA-PP
Genik, Keith Gregory, Gilbert Plains, MB, CCA-PP
Hockin, Ian S., Neepawa, MB, CCA-PP
Jones, Ian R., Warren, MB, CCA-PP
Kieper, Thomas Charles, Russell, MB, CCA-PP
Rempel, Kevin Andrew, Rosenort, MB, CCA-PP

**Rezansoff, Mitchell Todd, Winnipeg, MB, CCA-PP**
**Smith, Gill L., Minnedosa, MB, CCA-PP**
**Theroux, Eric D.R., Notre-Dame-de-Lourdes, MB, CCA-PP**
**White, Darren J., St. Claude, MB, CCA-PP**
**Wilson, Carla D., McAuley, MB, CCA-PP**

**Ontario**

Vander Glas, Harold George, Clinton, ON, CCA-ON

**Prince Edward**

Dillman, Joshua K., Charlottetown, PE, CCA-AP
MacDonald, Erica C., Charlottetown, PE, CCA-AP

**Saskatchewan**

Alberts, Lindsay John, Yorkton, SK, CCA-PP
Finlay, Joel Frederick, Swift Current, SK, CCA-PP
Rao, Kota Annaji, AP, CCA-INDIA
Rao, Menda Govinda, Polaki Mandal, AP, CCA-INDIA
Rao, V. Venkateswar Rao, Nellore, AP, CCA-INDIA
Rao, Vadday Sathyanarayan, Visakhapatnam, AP, CCA-INDIA
Reddy Siddu, Ramamurthy, Kadapa Dist., AP, CCA-INDIA
Reddy, Alla Bharat, Guntur, AP, CCA-INDIA
Reddy, Baiireedy Singa, Khammam, AP, CCA-INDIA
Reddy, Kandula Thimma, CCA-INDIA
Reddy, Kondakindi Bhaskar, Hyderabad, AP, CCA-INDIA
Reddy, Spinivasa Sanikommu, Secunderabad, AP, CCA-INDIA
Reddyannem, Ravichandra, Nandyal, AP, CCA-INDIA
Saikia, Phanindra, CCA-INDIA
Selvam, P. Tamil, Tirupur Dist., TN, CCA-INDIA
Sengar, Narendra Singh, Gwalior, MP, CCA-INDIA
Setty, Krishna Murthy Sanny, Kurnool, AP, CCA-INDIA
Shah, Mr. Dinesh Kumar, Ahmedabad, GJ, CCA-INDIA
Shah, Vishal, Nagpur, MH, CCA-INDIA
Shaikh, Amjad, Ujjhani, UP, CCA-INDIA
Sharma, Ashok Kumar, Lucknow, UP, CCA-INDIA
Sharma, Debasis Sarmah, CCA-INDIA
Sharma, Harish Kumar, Hyderabad, AP, CCA-INDIA
Sharma, Rajesh, CCA-INDIA
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United States

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Colorado
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Claunch, Tess M. C., Monte Vista, CO, CCA-CO
Fink, Paul, Greenwood Village, CO, CCA-NW
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terrain, or boom sections in operation are available to retrofit existing equipment for as little as $1,650. Tower booms and airflow regulators are also available with new equipment and as retrofits. Michigan State University researchers report tower sprayers have lower operating costs over conventional airblast sprayers (Swinton et al., 1997). Cornell University research indicates airflow modifications can improve pesticide deposition by 30% (Landers, 2012). Finally, Smart Spray technology relies on ultrasonic sensors to regulate pesticide delivery based on tree size and canopy shape and can turn off nozzles where gaps in tree rows are present.

Training

Are you confident in your abilities to help your clients ensure accurate application rates with all of their equipment? If not, seek professional training. In our case, Peter Werts was trained by Landers in a small-group workshop, organized and hosted by Regina Hirsch of the Center for Integrated Agricultural Systems at the University of Wisconsin. This training was critical to open our eyes to the opportunities for improving and developing the skills necessary to effectively deliver this service to our clients. On average, our 11 sprayers were overapplying water and pesticide by 52%. Correcting these errors was a remarkable return on our investment in training and time on this project and a great service to our clients. We plan to expand the project this coming year.

References


Calibration resources

Calibration worksheet: http://extension.psu.edu/fruit-production/files/air-blast-sprayer-worksheet/view

Pre-calibration instructions: http://extension.psu.edu/fruit-production/files/sprayer-calibration-instructions/view


Left: Water and oil-sensitive paper was hung in this high-density planting by dividing the canopy into nine zones and using furring strips to locate the paper in through the canopy. Right: Overspray is observed where watersensitive paper turned completely blue and can result in pesticide sheeting off the leaf surface. Peter Werts/IPM Institute of North America, Inc.
Bachelors/Equivalent Required

North Carolina—Research Specialist. The Department of Crop Science small grains program supports North Carolina growers, the agricultural industry, and the public at large in maintaining robust small grain production within our state. This is done by having research in place on research stations and farms throughout the state, and through educational programs for growers and industry representatives. The Research Specialist will lead in designing and managing research plots across North Carolina. Position will operate and maintain all equipment (tractors, trucks, planters, sprayers, combines, etc.) used. S/he will manage the NC Wheat Yield Contest and assist with educational programs directed by the Small Grains Specialist. A Bachelor’s degree in a discipline related to crop science; or an equivalent combination of training and experience is required. To apply, or for more information about the position go to https://jobs.ncsu.edu/postings/15498 or contact Dr. Randy Weisz, Small Grains Specialist, Dept. of Crop Science, NC State University, Raleigh, NC. E-Mail: Randy_Weisz@ncsu.edu.

Doctorate/Equivalent Required

Texas—Associated Professor/Professor of Pedology & B.L. Allen Distinguished Chair. The Department of Plant and Soil Science at Texas Tech University seeks candidates for an Associate Professor/Professor and B. L. Allen Endowed Chair in Pedology. This is a 9-month, tenure-track position with teaching and research responsibilities and service expectations. It is anticipated that the 3-month summer salary will come from teaching duties or research grants. Endowment funds will be available for use at the discretion of the incumbent. Candidates must have an earned Ph.D. in pedology or closely related soil science or geoscience discipline. Please note that all application materials must be submitted on-line through the Texas Tech University application site at http://jobs.texastech.edu/ and search for Requisition Number 87199.

Virginia—Assistant Professor/Extension Weed Specialist: Agronomic Crops. The Department of Plant Pathology, Physiology and Weed Science at Virginia Tech is offering a tenure-track position with 70% Extension & 30% Research responsibility. The successful candidate will work at Virginia Tech’s main campus in Blacksburg, VA and will provide state-wide leadership in the development of weed control programs for agronomic crops, disseminate research results to Virginia stakeholders, train graduate students, and assist in weed diagnostic clinic and various teaching activities. Emphasis is placed on development of recommendations and other weed control information pertinent to current problems of Virginia farmers in soybean, corn, small grains, forages, and other crops. The incumbent will be expected to conduct an innovative and nationally recognized research and Extension program that addresses development of cost-effective, environmentally sustainable strategies to prevent, manage and control weeds in these economically important crops. The scientist will be expected to secure extramural funding, and will recruit, support, and advise graduate students. Scholarship will be demonstrated through publication of peer-reviewed journal articles, Extension articles, websites, and other appropriate media. The incumbent will develop and deliver educational programs to producers, Extension Agents, farm consultants, agribusiness personnel, and government agencies, and will work cooperatively with other specialists, Extension Agents, and industry groups. Opportunities for collaborative, multi-disciplinary work with campus and AREC based faculty are significant and encouraged. Required Qualifications: An earned Ph.D. in Weed Science or closely related field with major emphasis on...
weed management in row crops and/or small grains. Evidence of ability to communicate orally and in writing. Ability to work effectively in a team environment with Extension and agribusiness personnel. Ability to develop proposals to seek outside funding for program support. Ability to effectively instruct undergraduate and graduate students. Effective use of electronic media in education and communication of technical information. Preferred qualifications: Previous experience in Extension and/or outreach activities. Prior instructional experience. Evidence of the ability to publish and secure extramural funding. Application Process: Apply at http://listings.jobs.vt.edu:80/postings/26509, Posting #0122469. Provide cover letter, resume, official transcripts, statement of professional interests, and three letters of recommendation. In addition, send a list of contact information for three references for whom you have requested letters of recommendation to Dr. Shawn Askew, Associate Professor & Extension Program Leader for PPWS, Virginia Tech Glade Road Facility, 435 Old Glade Road, Blacksburg, VA 24061 (saskew@vt.edu).

**Internship/Assistantship**

**North Carolina—Graduate Research Assistantship.** A Graduate Research Assistantship is available to support a PhD student in the Department of Crop Science at NC State University. The student will work on sorghum/wheat rotations, potential allelopathic interactions, and agronomic factors to optimize yield. The student will be involved in field, greenhouse, and laboratory research. Areas of research include but are not limited to detection and quantification of sorghum allelochemicals, sorghum residue management, wheat nutrient management when wheat follows sorghum, and optimizing sorghum-wheat rotations to increase grain production. Students in the program are expected to interact and work with other graduate students and personnel to assist with other research being conducted, to publish research in refereed journals, and to translate research findings into extension publications and/or presentations. To apply submit a cover letter, resume, three references, transcript(s) (TOEFL scores for international applicants), and GRE scores to Wesley Everman (wesley-everman@ncsu.edu, 919-515-0488), NC State University, Box 7620, 100 Derieux St., Raleigh NC 27695.
Earn 1 CEU in Nutrient Management by reading this article and completing the quiz at the end. Fill out the attached questionnaire and mail it with a $20 check (or provide credit card information) to the American Society of Agronomy. Or, you can save $5 by completing the quiz online at www.certifiedcropadviser.org/certifications/self-study/452.

Urea nitrogen (N) fertilizers supply N to a majority of agricultural systems worldwide. With an increasing need to manage nutrients more efficiently, extensive research has been conducted to reduce the inefficiencies associated with fertilizers including urea. One significant inefficiency associated with nitrogen fertilizers is the loss of nitrogen in the form of ammonia that is known as volatilization. Ammonia volatilization losses from N fertilizers contribute to a relatively low nitrogen use efficiency in agronomic systems, which has been estimated to be about 33% worldwide. Nitrogen losses from urea through volatilization can be as great as 70% of the applied fertilizer N, with losses of 35 to 50% of applied fertilizer N in laboratory and field studies commonly reported under favorable environmental conditions. The major inefficiency of surface-applied urea arises from volatilization of NH$_3$ due to the hydrolysis of urea by urease.

Urea is an enzyme found ubiquitously throughout agricultural systems. The enzyme catalyzes the hydrolysis of urea to form to carbamate and ammonium. The carbamate molecule decomposes into bicarbonate and ammonium. The bicarbonate ion increases the soil pH converting ammonium to NH$_3$. Urea hydrolysis raises soil pH adjacent to urea granules, inhibiting nitrification, resulting in excess NH$_3$ and conditions favoring NH$_3$ volatilization. Surface application of urea without reducing or delaying urea hydrolysis reaction will result in a high pH zone from NH$_3$ on the soil surface.

Urease activity varies with soil characteristics such as soil texture, moisture, temperature, crop residue, and organic carbon. Soil urease is unique compared with ureases found in living organisms in that it is more stable and persistent in the soil environment. The enzyme urease accumulates in soil systems and can be adsorbed to soil mineral particles as well as soil organic matter. This adsorption to soil minerals reduces the ability of microorganisms to metabolize urease, allowing excess amounts to build within the soil and resulting in more than enough urease to rapidly hydrolyze fertilizer urea. Effective measures to control volatile nitrogen losses from urea should consider the presence of the urease enzyme in the soil.

Multiple control measures can be implemented to prevent N loss as NH$_3$ volatilization from agricultural systems. Growers typically try to apply urea-based N fertilizers before a rainfall event to ensure movement of urea into the soil profile, or they incorporate urea into the soil. Both management strategies are extremely effective in preventing NH$_3$ volatilization from urea. However, many times growers cannot wait for rain or irrigation to apply nutrients because they must ensure that nutrients are applied so that plant growth is not limited by N. Farmers may apply urea when rain is not in the immediate future, which can potentially lead to volatilization losses of N. An alternative approach uses urease inhibitors to reduce and delay urea hydrolysis. This creates a window of time after urea application in which volatilization losses are low with the anticipation that timely rainfall will move the urea into the soil.
The urease inhibitor NBPT (N-[n-butyl] thiophosphoric triamide) has been found to be the most effective in controlling NH₃ volatilization. The NBPT is converted in soil to NBPTO (N-[n-butyl] phosphoric triamide), which is a competitive inhibitor of urease. Competitive inhibitors bind directly to the active site of the enzyme, thus competing with the substrate (urea in the case of urease) at the enzyme’s active site.

The magnitude of reduction in NH₃ volatilization varies from soil to soil, and different rates of NBPT may be needed for different soil types. This supports the evidence of changing urease activity with changing soil characteristics. Until recently, Agrotain (Koch Agronomic Services) was the only commercially available source of NBPT being widely marketed. Weyerhaeuser Co. and Brooks Whitehurst Associates Inc. have developed a different solvent system (Arborite Ag) to adhere NBPT to the surface of urea granules. The NBPT solvent system developed by Weyerhaeuser Co. and Brooks Whitehurst Associates Inc. can also be used as a binder to attach physical coatings (i.e., calcium sulfate and potassium sulfate) to the surface of urea granules alone or in combination with NBPT.

In the September–October 2012 issue of Agronomy Journal, researchers set out to: (i) quantify NH₃ volatilization losses from surface-applied urea under controlled laboratory conditions favoring volatilization; (ii) measure the rate and total N volatilization loss from uncoated urea and urea coated with calcium sulfate, potassium sulfate, and with or without NBPT incorporated into the sulfur coatings; and (iii) measure the effect of NBPT application rate on NH₃ volatilization losses from granular urea.

**Trial description**

Trials I and II consisted of four different coating treatments on granular urea, urea, and a “check” Wheeling silt loam to which no N was applied, totaling six treatments. The urea treatment in Trials I and II served as the N fertilization control treatment. The urease inhibitor NBPT was applied to the granular urea using two different solvent systems to bind the molecules of NBPT to the granule.

Trials III and IV differentiate the impact of the physical coatings from the urease inhibitor NBPT. Treatments in Trial III were non-coated urea, Agrotain-coated urea, Arborite Ag urea, and the check. The last two treatments in Trial III are the CaSO₄-coated urea, with and without the NBPT supplied from Arborite Ag. In Trial IV, the first four treatments remain the same as in Trial III; however the last...
two treatments were K₂SO₄-coated urea, with and without NBPT.

Trial V and VI assessed the application rate of NBPT applied to the urea granule. Six rates of NBPT, on a percent by weight basis, were used during this trial being 0.00, 0.02, 0.04, 0.06, 0.08, and 0.1%. The Arborite Ag binder was used as the carrier to coat the urea granules with the different concentrations of NBPT during this trial.

Results and discussion

Trials I and II

Trials I and II were conducted to compare urea to coated urea containing NBPT from Agrotain and Arborite Ag as well as physically coated urea with Arborite Ag. Ammonia losses were negligible from N treatments for one to six hours after N application. At nine hours after fertilizer application, NH₃ volatilization from urea was greater than the coated treatments in Trials I (0.7% of applied N) and II (0.6% of applied N). The greatest loss of N from urea came between 12 and 24 hours after application with losses of 17.2% (1.4% of applied N/hour) and 17.6% (1.5% of applied N/hour) of applied N for Trials I and II, respectively.

Cumulative N loss for non-coated urea was significantly higher than all NBPT-coated materials for Trials I and II, but none of the coating treatments differed in cumulative N loss (Fig. 1). For the inhibitor-only coatings, Agrotain and Arborite Ag, cumulative NH₃ loss as well as ammonia loss at each sampling interval did not differ for Trial I (Fig. 1). Ammonia losses from Agrotain and Arborite Ag were greatest from 96 to 120 hours with a maximum NH₃ loss rate of 0.20 and 0.19% of the applied N/hour during Trial I. Losses during Trial II for Arborite Ag were greatest from 120 to 144 hours (0.16% of applied N/hour) whereas Agrotain did not reach a maximum NH₃ loss rate until 168 hours (0.15% of applied N/hour). Agrotain had significantly lower NH₃ loss at the 120 hour (2.7% of applied N) and 144 hour (3.3% of applied N) sampling intervals than Arborite Ag (3.5% of applied N at 120 hours and 3.9% of applied N at 144 hours) during Trial II.

During Trial II, the CaSO₄-coated+NBPT treatment reached a maximum NH₃ loss rate from 120 to 144 hours with an NH₃ loss rate of 0.15% of the applied N/ hour, while the K₂SO₄-coated+NBPT treatment reached a maximum NH₃ loss rate of 0.16% of the applied N/hour from 144 to 168 hours. Cumulative N loss did not differ between CaSO₄-coated+NBPT, K₂SO₄-coated+NBPT, Agrotain, and Arborite Ag (Fig. 1 and 2). Cumulative N loss for CaSO₄-coated+NBPT, K₂SO₄-coated+NBPT, Agrotain, and Arborite Ag ranged from 22.1 to 24.8% and 17.9 to 20.8% for Trials I and II, respectively. Physically coating the urea granule did not significantly decrease the amount of ammonia loss beyond that of the inhibitor NBPT alone over the two-week trial period.

Trials III and IV

Trial III was designed to determine the effect on NH₃ volatilization when urea was coated with CaSO₄ alone compared with products using the inhibitor NBPT alone...
or in combination with the CaSO₄ coating. Ammonia volatilization from non-coated urea was similar to Trials I and II with the peak NH₃ loss, 17.8% of applied N, occurring at the 24-hour sampling interval. When CaSO₄ alone was applied to urea granules, NH₃ volatilization was delayed 24 hours, and the maximum NH₃ loss rate was 0.74% of applied N/hour with a total of 8.9% of the applied N being lost by the 24-hour sampling interval. Ammonia losses for CaSO₄-coated urea were significantly higher than for urea over the same sampling intervals. Ammonia losses were the same for CaSO₄-coated urea and urea alone beyond 96 hours after N application. The higher losses of N from CaSO₄-coated urea resulted in cumulative losses that were the same as urea at the conclusion of Trial IV (Fig. 3).

Trial IV was identical in treatment design as Trial III with K₂SO₄ replacing CaSO₄ as the physical coating. Non-coated urea released NH₃ within nine hours after N application and reached a maximum rate of NH₃ volatilization 24 hours after application with 17.8% (1.5% of the applied N/hour) of the N being lost from 12 to 24 hours (Fig. 4). When urea was coated with K₂SO₄, NH₃ volatilization was delayed until 24 hours with 0.7% of the applied N lost. Ammonia loss from the K₂SO₄-coated urea was 3.3% of the applied N at 48 hours and was significantly lower than 8.0% loss from urea. Ammonia loss from K₂SO₄-coated urea was significantly higher than from urea at 72 to 216 hours.

Cumulative NH₃ volatilization by 120 hours was under 5% of the applied N when NBPT was applied, and no differences among treatments receiving NBPT were seen until 168 hours after N application when Agrotain differed from K₂SO₄-coated+NBPT (Fig. 4). Nitrogen loss was lower with the K₂SO₄ coating than urea alone; however, NBPT further decreased NH₃ volatilization compared with K₂SO₄ alone (Fig. 4).

The delay in NH₃ volatilization during the K₂SO₄ and CaSO₄ trials is most likely due to the reduced pH in the urea-concentrated zone after dissolution. The greater effect observed for potassium sulfate is believed attributable to its greater solubility in water vs. the solubility of calcium sulfate.

Trials V and VI

Trials V and VI were conducted to determine the effect of the rate of NBPT treatment upon the volatilization losses using the new binding technology of Arborite Ag. When no inhibitor was applied to the urea granules, the NH₃ volatilization rate again peaked at 24 hours with an NH₃ loss rate that was 1.4 and 1.2% of the applied N/hour in Trials V and VI, respectively. Ammonia volatilization did not differ as NBPT rate increased from 0.02 to 0.1% for the first 48 hours in Trial V and the first 24 hours in Trial VI. The addition of NBPT to the urea granule delayed the maximum NH₃ loss rate with each addition of NBPT up to 0.06%. As the rate of NBPT increased, NH₃ volatilization decreased in both Trials V and VI. At NBPT rates of 0.02% w/w, cumulative NH₃ volatilization decreased from 35.6 and 35.1% to 25.4 and 24.1% for Trials V and VI, respectively. However, for NBPT rates ranging from 0.04 to 0.1%, cumulative NH₃ volatilization losses ranged from 23.6 to 19.4% with no differences in either Trials V or VI.
When NBPT was applied at rates equal to or above 0.06%, NH₃ volatilization remained below 5% of applied N until 120 hours after N application (Fig. 5 and 6).

By applying more NBPT, NH₃ volatilization was delayed an extra 48 hours over the 0.02% NBPT rate; however, cumulative volatilization did not differ between the 0.04 and 0.1% NBPT rates. This delay in N loss could allow for a more flexible time frame for N application compared with trying to match rainfall events and N application to a smaller time window.

**Summary and conclusion**

Ammonia volatilization (32–35% total N loss) from urea during the six trials was similar in total N loss in other laboratory trials. Urea reached a maximum volatilization rate from 12 to 24 hours after N application when conditions were favorable for volatilization. Urease inhibitors do not stop urea hydrolysis, but their use allows for the urea in the soil solution to diffuse into a greater volume of soil, minimizing the pH increase and the resulting NH₃ volatilization.

The physical coatings did not have an additive effect in controlling NH₃ volatilization when applied with NBPT, though when applied alone, the physical coatings did delay ammonia volatilization for 24 hours. This supports other research, which reported that alkali and alkaline earth metals may reduce NH₃ volatilization. The physical coatings tested in this trial allow for S, in the form of CaSO₄ or K₂SO₄, to be applied with N, which may be useful in many regions. However, the low solubility of CaSO₄ may limit its effectiveness for NH₃ volatilization control. By coating the urea with the aforementioned physical coatings, the need for a plant-available N and S fertilizer could be met. However, applying a coating to urea adds additional cost as well as lowers the N content of urea. The additional cost associated with CaSO₄- and K₂SO₄-coated urea may be offset by the value of S and K in the coating.

Increasing NBPT rates decreased NH₃ volatilization in the initial hours after application, but cumulative N loss from the 0.04 to 0.1% rates did not differ significantly. The inhibitor NBPT is a very efficient urease inhibitor, and rates as low as 0.02% w/w NBPT can decrease NH₃ volatilization. At NBPT rates of 0.04 to 0.1% w/w, NH₃ volatilization was delayed an extra 48 hours, which could be beneficial. The data in this study indicate that 0.04 to 0.06% NBPT produce the same total NH₃ volatilization control under laboratory conditions, as the North American industry standard rate of 0.08% NBPT. Further research is needed to confirm these findings and determine optimum NBPT rates for field conditions; and to determine how NBPT in combination with various physical coatings can be most effectively used to increase N use efficiency of urea fertilizers in agronomic crop production.

Earn a CEU by taking the quiz online at www.certifiedcropadviser.org/certifications/self-study/452. This article was adapted from the Agronomy Journal article, “In Vitro Evaluation of Coatings to Control Ammonia Volatilization from Surface-Applied Urea,” by W. Hunter Frame, M. M Alley, G. B. Whitehurst, B. M. Whitehurst, and R. Campbell (104:1201–1207).
January–February 2013
self-study quiz

Evaluation of coatings to control ammonia volatilization from surface-applied urea (no. SS 04843)

1. According to the article, the major inefficiency of surface-applied urea arises from
   - a. the initial conversion to ammonium and carbamate by urease.
   - b. volatilization of NH$_3$ during the hydrolysis of urea by urease.
   - c. the reliance on soil moisture to convert NH$_4$ to NH$_3$.
   - d. neutralization of the toxic zone around where urea was applied.

2. Urea is converted to carbamate and ammonium. The carbamate molecule decomposes into bicarbonate and ammonium, and the bicarbonate ion
   - a. increases the soil pH, converting ammonium to NH$_3$.
   - b. reduces soil pH, resulting in volatilization of NH$_3$.
   - c. reacts with Ca and Mg in the soil to form lime, resulting in increased plant availability of P and Fe.
   - d. reacts with Ca and Mg in the soil to form lime, resulting in decreased plant availability of Zn and B.

3. Ammonia volatilization loss of N contributes to a relatively low nitrogen use efficiency of agronomic systems, which have been estimated to be
   - a. 35 to 50% worldwide.
   - b. as great as 70% worldwide.
   - c. as low as 18% worldwide.
   - d. about 33% worldwide.

4. Why is it believed that K$_2$SO$_4$ coating had a greater effect on N loss than CaSO$_4$ coating?
   - a. It is less mobile than CaSO$_4$.
   - b. It is a better binding agent than CaSO$_4$.
   - c. It is more soluble than CaSO$_4$.
   - d. It reduces soil pH more than CaSO$_4$.

5. Soil urease is unique compared with ureases derived from living organisms in that it
   - a. adsorbs to mineral particles, increasing microorganism metabolism.
   - b. is less stable and decreases microorganism metabolism.
   - c. is relatively rare in nature.
   - d. is more stable and persistent in the soil environment.

6. Growers typically try to apply urea-based N fertilizers
   - a. by broadcasting or double-banding.
   - b. right after a rainfall event to ensure maintenance of N within the root zone.
   - c. before a rainfall event to ensure movement of urea into the soil profile.
   - d. in the middle of the day when the soil surface is warmest.

7. Urease inhibitors do not stop urea hydrolysis, but their use
   - a. inhibits the biological oxidation of ammoniacal nitrogen to nitrate nitrogen.
   - b. allows for the urea in the soil solution to diffuse into a greater volume of soil.
   - c. extends the time urea remains intact in the soil before hydrolysis starts.
   - d. increases pH while minimizing NH$_3$ volatilization.

This quiz is worth 1 CEU in Nutrient Management. A score of 70% or higher will earn CEU credit.

**Directions**

After carefully reading the article, answer each question by clearly marking an “X” in the box next to the best answer. Complete the self-study quiz registration form and evaluation form on the back of this page. Clip out this page, place in an envelope with a $20 check made out to the American Society of Agronomy (or provide your credit card information on the form), and mail to: ASA c/o CCA Self-Study Quiz, 5585 Guilford Road, Madison, WI 53711. Or you can save $5 by completing the quiz online at www.certifiedcropadviser.org/certifications/self-study/452.

Quiz continues next page
8. Weyerhaeuser Co. and Brooks Whitehurst Associates Inc. have developed an NBPT solvent system that can be used

☐ a. as a binder to attach physical coatings to the surface of urea granules.
☐ b. as a hydrolysis catalyst that speeds up conversion of NH₃ to NH₄.
☐ c. as a hydrolysis inhibitor that reduces N movement through the root zone.
☐ d. as a trigger that releases NBPT when incorporated after urea is broadcast.

9. Increasing NBPT rates decreased NH₃ volatilization in the initial hours after application, and cumulative N loss from the 0.04 to 0.1% rates

☐ a. did not differ significantly.
☐ b. differed significantly.
☐ c. was delayed an extra 24 hours.
☐ d. differed by a factor of 3.

10. The physical coatings did not have an additive effect in controlling NH₃ volatilization when applied with NBPT, though when applied alone

☐ a. the physical coatings reduced ammonia volatilization permanently.
☐ b. the physical coatings did delay ammonia volatilization for 24 hours.
☐ c. the physical coatings did not delay ammonia volatilization.
☐ d. the physical coatings did delay ammonia volatilization for 48 to 52 hours.

Self-Study Quiz Registration Form

Name: ___________________________ City: ___________________________
Address: ___________________________ Zip: ___________________________
State/province: ___________________________ CCA certification no.: __________
☐ $20 check payable to the American Society of Agronomy enclosed.
☐ Please charge my credit card (see below)
Credit card no.: ___________________________ Name on card: ___________________________
Type of card: ☐ Mastercard ☐ Visa ☐ Discover ☐ Am. Express
Expiration date: ___________________________
Signature as it appears on the Code of Ethics: ___________________________

I certify that I alone completed this CEU quiz and recognize that an ethics violation may revoke my CCA status.

This quiz issued January 2013 expires January 2016

Self-Study Quiz Evaluation Form

Rating Scale: 1 = Poor  5 = Excellent

Information presented will be useful in my daily crop-advising activities: 1 2 3 4 5
Information was organized and logical: 1 2 3 4 5
Graphics/tables (if applicable) were appropriate and enhanced my learning: 1 2 3 4 5
I was stimulated to think how to use and apply the information presented: 1 2 3 4 5
This article addressed the stated competency area and performance objective(s): 1 2 3 4 5

Briefly explain any “1” ratings: ____________________________________________________________

Topics you would like to see addressed in future self-study materials: ____________________________________________________________
Recent instability in fertilizer prices, the limited nature of fossil fuels, and concerns over greenhouse gas emissions have highlighted the need to better understand fossil fuel energy use in agricultural systems. Agriculture in the United States typically relies heavily on fossil fuel as a direct and indirect input in the production process, but energy consumption and C emissions vary with crop and management. Energy use in agricultural systems can be evaluated by assigning fossil fuel-derived inputs an energy value and an associated C cost. Using this approach, researchers recently analyzed corn, soybean, and wheat production under different tillage practices as well as irrigated corn and cattle production. Some of these studies calculated only “direct” energy embodied in or required to produce inputs consumed on site. Direct energy accounts for most energy use and includes such inputs as fertilizer, pesticides, diesel fuel, and seeds. More comprehensive studies have also included “indirect” energy used to produce equipment that is not consumed, such as machinery, fences, and irrigation infrastructure. The sum of direct and indirect energy is total energy, sometimes referred to as “cultural” energy.

The Texas High Plains is a region characterized by intensive agricultural production made possible by availability of irrigation water from the Ogallala aquifer. The aquifer’s decline raises concerns regarding sustainability of current production practices and has prompted the search for alternative techniques and agricultural systems to maintain regional agricultural production. In 1997, a long-term experiment was established in the Texas High Plains to compare productivity, profitability, and environmental impacts of two agricultural systems: a cotton monoculture system typical of the region and an integrated cotton–livestock system designed to reduce withdrawals of water from the Ogallala aquifer. In the November–December 2012 issue of Agronomy Journal, researchers compared these two systems’ total use of energy, associated C emissions, and partitioning of energy use within each system.

Materials and methods

Research location and agricultural systems management

Two irrigated agricultural systems were established in 1997 and maintained for 10 production years (1998–2008) in northeast Lubbock County, TX. These systems were a cotton monoculture and an integrated cotton–forage–beef stocker cattle system in a complete randomized block design. Both systems were drip irrigated, and annual rainfall was noted. The cotton monoculture system was planted to a wheat cover crop in cotton furrow bottoms each autumn or winter. No cover crop was used after 2003 to the end of the
project in 2008. In all years, cotton was planted in May and typically harvested by field equipment in November. If a cover crop was present, it was terminated before planting cotton. Livestock were not part of this system.

The integrated system was comprised of three paddocks, one of which was planted to the perennial warm-season grass ‘WW-B. Dahl’ old world bluestem. The other two paddocks were in a rye–cotton–wheat–fallow rotation, such that each summer, one paddock had cotton while the other was fallow, and each autumn through spring, one paddock had rye while the other had wheat. Each September, rye was planted in one field providing grazing for stocker steers during winter and early spring, followed by cotton no-till planted into grazed-out rye in May. Wheat was no-till planted into cotton residue following cotton harvest, which usually occurred in November. Wheat was grazed out by early summer, at which time it remained fallow until rye was planted in early September. By 2006, wheat had failed to provide a viable crop and was discontinued from the rotation in 2007. Cotton was harvested each autumn.

Angus and angus × hereford steers sequence-grazed winter dormant bluestem, rye, wheat, and spring/summer growth of bluestem from January to July. In 2005 and 2006, stocking rate was increased in mid-summer due to more than usual forage growth. Cattle were supplied with a crude protein supplement when forage protein was deficient. Salt and minerals were provided ad libitum. Animals were handled under an approved animal care and use protocol. Bluestem was managed to produce a seed harvest in October. In one year only, hay was harvested from bluestem in addition to grazing, and a small amount of hay was fed to steers the following year. Triticale was used in Year 1 instead of wheat with forage not needed for grazing cut for hay. No wheat or rye grain was harvested. All crops were fertilized according to soil test recommendations. Nitrogen was applied through the drip irrigation system. Pesticides and plant growth regulators were applied based on recommendations of crop specialists.

Energy analysis

All fossil fuel energy used was included in one of six categories: irrigation, fertilizer, mechanical, pesticides, stocker steers, or “other.” The stocker steer category included off-site energy required to produce stocker steers. Energy use associated with stockers after their arrival was allocated to one of the other five categories. The “other” category included seed energy and livestock-specific costs such as veterinary service, crude protein supplementation, and salt and mineral supplementation.

Total system energy use was the weighted average (based on land area) of all components of a system. Thus, individual energy budgets were prepared for all system components (i.e., cotton, wheat, rye, bluestem, and livestock) and were weighted according to their proportional part of the system. This also allowed each component to be independently analyzed within its system context.

The energy cost of grazing was calculated two ways: per animal grazing day and per unit live weight gain. Livestock weight gain occurred on multiple fields because stockers grazed the entire integrated system area at some point during each year. Carbon released as a result of input use was calculated based on quantity of energy used and energy source. Carbon release as a result of biological and physical processes was not calculated.

Systems comparison

In 9 of 10 years, the cotton monoculture system used more energy than the integrated system, and averaged across all 10 years, the cotton monoculture system used 8% more energy than the integrated system (Fig. 1). All energy categories were greater for the cotton monoculture system than the integrated system except for stocker cattle energy and “other” energy, which were greater for the integrated system due to livestock energy expenses. Primary other expenses were mineral and protein supplements and veterinary supplies. Energy embodied in stocker calves, which was energy required to produce stocker calves
offsite before they entered the system, was also unique to the integrated system.

Most energy in the cotton monoculture system was used for production of cotton; relatively little was needed to produce the wheat cover crop in the first five years (Table 1). Cotton was also the most energy-intensive crop in the integrated system, followed by bluestem and then small grains (Table 1). Total energy use per acre was almost identical for cotton in the two systems, although there were small differences in sources of energy (Fig. 2). Wheat and rye used more energy in the integrated system than wheat in the cotton monoculture system because in the integrated system, wheat and rye received higher levels of inputs to improve forage quality and production. Wheat in the monoculture system was used as a cover crop and received little irrigation water and no fertilizer after the first two years.

Energy categories

Irrigation

Irrigation infrastructure made a small annual contribution to the overall energy budget of both systems. Most (80%) of the energy attributed to the irrigation system was embodied in the drip tape, header, flush, and mainline plastics that comprised the system. The pumping unit, ditching, and other equipment contributed the balance.

In contrast to the relatively small amount of energy embedded in irrigation infrastructure, electricity required to pump irrigation water was the single largest energy expense for both systems, accounting for 52 and 43% of the total energy used by the cotton monoculture system and integrated system. In the integrated system, irrigation was a smaller portion of the total for two reasons: (i) this system used about 25% less irrigation water and (ii) a large amount of energy was embodied in stockers.

Besides being the largest energy expense on a system basis, irrigation was also the largest energy expense for all individual crops and ranged from 37% of energy for the monoculture system cover crop to 63% of energy for integrated system bluestem. Delivery of drinking water to livestock required <1% of total energy attributed to livestock.

The large quantity of energy used for irrigation led to a strong correlation between direct energy use and quantity of irrigation water applied for both systems. For cotton
A similar relationship existed between total energy and irrigation.

**Fertilizer**

Next to irrigation, fertilizer was the largest energy cost for the cotton monoculture system. Synthetic nitrogenous fertilizers, most of which rely on natural gas for their feedstock, were primarily responsible for the high energy cost. Phosphorus and K fertilizers were also used, but their energy cost was less than that of N, and they were used in limited quantities. Fertilizer accounted for 25% of cotton monoculture system energy and 18% of integrated system energy.

Fertilizer was also the second-largest energy expense for all individual crops of the integrated system, ranging from 22% on wheat to 25% on bluestem. This was a little more than one-third of the energy used for irrigation.

**Mechanical**

In-field use of diesel fuel was a relatively minor fossil fuel energy input. Fuel and machinery contributed just 11% of the total energy in the cotton monoculture system and 10% in the integrated system (Fig. 1). In-field diesel fuel accounted for about 2 to 2.5 times as much energy as that required for machinery manufacture, repair, and delivery.

**Pesticide and other energy costs**

Pesticide energy, including seed treatment, was a much larger component of the cotton monoculture system than the integrated system. This was due to the complete lack of herbicide use on bluestem and reduced use of herbicides on the integrated system’s annual crops compared with cotton monoculture.

Seed was the only remaining energy expense shared by both systems. Cotton seed cost ranged widely in both systems. For years in which they were planted, mean energy for small-grain seed was higher in the integrated system than in the monoculture system due to different seeding rates.

The integrated system included several unique energy expenses associated with livestock production that did not occur in the cotton monoculture system. These included crude protein, salt and mineral supplements, veterinary supplies, fencing, and water troughs; the largest of these were veterinary supplies. Cumulatively, these expenses contributed just 5% of the integrated system’s budget.

**Stocker calves**

Stocker calves were considered to be indirect energy inputs similar to machinery because, unlike direct energy inputs, stocker calves are not consumed during production. They alone contributed an annual average of 19% of its total energy expenditure. The source of stocker calves could have a large impact on an integrated system’s energy cost because energy used in cow–calf production varies widely with environment and cultural practices.

The researchers calculated efficiency of livestock weight gain by summing all of the energy required for production of pastures (Table 2) over 10 years and dividing by the amount of stocker live weight gain over 10 years. Efficiency was similar to the least energy efficient cow–calf system reported in the literature and worse than...
a range-sorghum stocker operation in Colorado. Those systems did not use irrigation, which may explain why they were more efficient than the integrated system in the analysis described in this article.

**Direct vs. total energy**

Eliminating indirect energy inputs from the analysis, such as energy embodied in machinery and irrigation infrastructure, had little impact on overall cotton monoculture system energy use, reducing it by just 6%. Indirect energy was a greater proportion of the integrated system due to the livestock component. Indirect energy accounted for 73% of total livestock energy use and 20% of total integrated system energy use. Omission of indirect energy would have biased the comparison of energy use between the two systems. Most of the indirect energy in the integrated system was embedded in stocker calves when they arrived onsite.

**Energy efficiency**

Energy consumed per unit of cotton lint and cotton seed produced was nearly identical for the two systems. Energy efficiency of producing one animal grazing day was ordered as follows: bluestem > rye > wheat. Efficiency of wheat was greater than that of rye in the first two years, but wheat production eventually failed and was discontinued after eight years. In contrast, rye experienced a significant trend in improving efficiency over time due primarily to declining irrigation use and an increasing amount of grazing. Bluestem's superior efficiency was due to two factors. First, bluestem provided more animal grazing days than small grains. Second, although more energy was used on bluestem than rye or wheat, bluestem energy was divided among its two co-products, seed and grazing. If grazing was charged for the entire energy cost, bluestem's efficiency would have been similar to rye.

This seemed to suggest that energy efficiency could be improved by eliminating small-grain grazing. Eliminating small-grain grazing might achieve some efficiency gains, but gains would probably be less than previously cited numbers seem to indicate, due to interactions among system components. For example, steers sometimes alternated between forage types on a short-term basis. This extended the potential grazing season of all forage types. If small grains were removed from the integrated system, stocker calves would begin grazing later in the year and/or be provided with additional feed supplements because bluestem starts growth after small grains and has a lower crude protein content. Without small grains in the system, once stockers began grazing bluestem, there would be no alternative forage to move stockers to rest bluestem.

**Carbon release**

This study was consistent with other studies showing that Texas High Plains agriculture emitted more C due to energy use than the national average. Emissions were greater in this semiarid region partly because of greater irrigation use. Although this study did not analyze changes
in soil C, a previous study found that soil C increased in the integrated system relative to the cotton monoculture. Sequestering C in the soil can offset some of the C emitted due to fossil fuel use.

Conclusions

As fuel and fertilizer prices increase, atmospheric CO₂ concentration increases, and fossil fuel stocks diminish, it becomes more important to understand how energy is used in agriculture and identify potential improvements in efficiency. In the Texas High Plains, fossil fuel energy use and C emissions were greater for a monoculture cotton system than an integrated cotton–forage–livestock system. However, total energy use by the integrated system was highly sensitive to assumptions about how its stocker calves were raised and could exceed monoculture cotton energy under some circumstances. Most of the annual variation in energy use was explained by variation in rainfall because of rainfall’s influence on irrigation; as rainfall declined, irrigation increased to compensate for lack of moisture. Fertilizer was the second-largest source of energy use, primarily due to use of N. Direct energy, which included fuels burned onsite and those used to produce inputs consumed onsite, was 94% of total energy for the cotton monoculture vs. 77% for the integrated system. Within the integrated system, forage differed in energetic efficiency: old world bluestem produced more grazing days than small grains.

Improvements in water and N use efficiency by both systems would reduce energy use. Integrated system energy use could also be reduced by improving cow–calf efficiency and perhaps by relying more on perennial forage, such as old world bluestem, and less on annual forage.

Table 2. Energy efficiency (Mcal per unit of production) of agricultural products in a monoculture cotton system and an integrated cotton–forage–livestock system. Energy used on a given land area was divided among all saleable products based on their proportional monetary value.

<table>
<thead>
<tr>
<th>System and product</th>
<th>Unit</th>
<th>Mean†</th>
<th>SD</th>
<th>Mean portion of field revenue</th>
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<td><strong>Cotton monoculture system</strong></td>
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<tr>
<td>Cotton lint lb</td>
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<td>1.0</td>
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<td>Cotton seed lb</td>
<td>0.3</td>
<td>0.1</td>
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<td><strong>Integrated system</strong></td>
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<tr>
<td>Cotton lint lb</td>
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<tr>
<td>Cotton seed lb</td>
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<td>na §</td>
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<td>Stocker gain, non-forage inputs ¶</td>
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<tr>
<td>Grazing day on rye #</td>
<td>animal day</td>
<td>11.4</td>
<td>8.9</td>
<td></td>
</tr>
<tr>
<td>Grazing day, mean #</td>
<td>animal day</td>
<td>9.6</td>
<td>2.2</td>
<td></td>
</tr>
</tbody>
</table>

† Means are yield- and price-weighted averages of all years. See the methods section for details.
‡ Includes forage inputs only. For bluestem only, also includes crude protein supplementation. Assumes a constant rate of gain across forages and time.
§ Std. dev. not available because production occurred in only one year.
¶ Includes drinking water and waterer, transportation, veterinary supplies, feed supplements, and fencing.
# Includes forage inputs only, such as fertilizer, irrigation, mechanical operations, and pesticides. Crude protein supplement was not provided while animals grazed small grains.

1. In the two systems, energy use per acre was
   a. almost identical for cotton in terms of total energy used.
   b. almost identical in terms of fertilizer energy.
   c. greater in the monoculture system during the first five months of the year.
   d. greater in the integrated system during the first five months of the year.

2. According to the article, which of the following is true of wheat?
   a. It has lower crude protein than bluestem.
   b. It used more energy in the integrated system.
   c. It received more inputs in the monoculture system.
   d. It begins growing after bluestem.

3. One reason why it was thought that rye experienced a significant trend in improving efficiency over time in this study was because of
   a. decreased amount of grazing.
   b. declining irrigation use.
   c. hardiness of the varieties against overgrazing.
   d. resistance of the varieties to drought and heat.

4. If grazing was charged for the entire energy cost, bluestem’s efficiency would have been similar to
   a. rye.
   b. triticale.
   c. wheat.
   d. annual forage crops.

5. Emissions were greater in this semiarid region of Texas because of
   a. greater pesticide use associated with monoculture cotton.
   b. the greater number of animal grazing days.
   c. emissions associated with harvesting cotton.
   d. greater irrigation use.

6. What effect would removing small grains from the integrated system have on stocker calves?
   a. Stocker calves would alternate grazing between the bluestem and the secondary forage.
   b. Stocker calves would begin grazing earlier in the year and/or be provided with fewer feed supplements.
   c. Stocker calves would begin grazing later in the year and/or be provided with additional feed supplements.
   d. Stocker calf daily consumption would increase as would water intake.

7. Eliminating indirect energy inputs from the analysis, such as energy embodied in machinery and irrigation infrastructure
   a. had about the same impact on overall energy use of the cotton monoculture and integrated system.
   b. had a great impact on overall cotton monoculture system energy use.
   c. had little impact on overall cotton monoculture system energy use.
   d. would have a much lower impact on overall integrated system energy use.

Quiz continues next page
8. The most energy-intensive crop in the integrated system was
   - a. wheat followed by cotton and then bluestem.
   - b. cotton followed by bluestem and then small grains.
   - c. cotton followed by rye.
   - d. rye followed by cotton.

9. In terms of energy expense in the integrated system, fertilizer
   - a. used one-half of the energy used for irrigation.
   - b. was the third-largest energy expense for bluestem.
   - c. was the second-largest energy expense for all crops.
   - d. used about the same as energy used for irrigation.

10. All energy categories were greater for the cotton monoculture system than the integrated system except for
   - a. mechanical energy.
   - b. pesticide and mechanical energy.
   - c. stocker cattle and “other” energy.
   - d. stocker cattle energy.

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**Self-Study Quiz Registration Form**

Name: ____________________________________________  City: ________________________________
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This quiz issued January 2013 expires January 2016

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**Rating Scale: 1 = Poor  5 = Excellent**

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Information was organized and logical: 1 2 3 4 5

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This article addressed the stated competency area and performance objective(s): 1 2 3 4 5

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Topics you would like to see addressed in future self-study materials: ____________________________________________
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