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Feature

Controlling food mycotoxins.

Regional News

Empty pesticide container collection (Canada East), recent tomato fruit disorders in the mid-Atlantic region (Northeast), and sod demands decrease as water needs increase (Southern).

Continuing Education


Regulatory News

Farm bill update. Plus, the EPA announces CAFO rule changes.

New Products

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Company Strategies

EQIP incentive payments attract farmers to higher-intensity nutrient management. Plus, tips for storing this year’s harvest.

Technology

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Unavoidable, natural contaminants in foods may have either chemical or biological origin. Mycotoxins—toxic secondary metabolites of fungi—are biological in origin. Despite efforts to control fungal contamination, toxigenic fungi are ubiquitous in nature and occur regularly in worldwide food supplies due to mold infestation of susceptible agricultural products, such as cereal grains, nuts, and fruits. Thousands of mycotoxins exist, but only a few present significant food safety challenges. The natural fungal flora associated with foods is dominated by three genera—Aspergillus, Fusarium, and Penicillium, which except for the Fusarium plant pathogens, may include commensals as well as pathogens. The chemical structures of mycotoxins produced by these fungi are very diverse, as are the characteristics of the mycotoxicoses they can cause (ICMSF, 1996).

Ergotism is the oldest identified mycotoxicosis in humans. This mycotoxin represents a group of alkaloids that grow on the heads of grasses, such as wheat and rye. Ergot was responsible for a disease of the Middle Ages known as “St. Anthony’s Fire,” so named for the burning sensation caused in victims’ limbs. The Spartans apparently suffered an ergot epidemic in 430 B.C., and European epidemics date back as far as 857 A.D. (Bove, 1970). Ergotism has also been associated with the Salem witch trials in the 1600s in Massachusetts (Caporael, 1976). More recent outbreaks, associated with economic upheaval and war, have occurred in Russia (1924 and 1944), Ireland (1929), France (1953), and Ethiopia (1978). Although ergot poisoning continues to pose a challenge for the livestock industry, the toxin is less of a challenge for the food industry because current food quality control procedures screen out ergot-infected grains.

Of the thousands of existing mycotoxins, a few hundred are associated with food, and only a handful present food safety challenges to the farm-to-fork food continuum. At the farm level, mold growth can result in reduced crop yields and livestock productivity stemming from illness or death due to consumption of contaminated feed. In food manufacturing, destruction of mycotoxins by conventional food processing is difficult because they are typically highly resistant and detection is complicated due to limitations in analytical methodology. In the marketplace, mycotoxins can be a hurdle to international trade, leading to increased regulation of foods and feeds that may contain them and removal from the market of commodities not meeting regulatory limits.

When present in foods in sufficiently high levels, these fungal metabolites can have toxic effects that range from acute (e.g., liver or kidney deterioration) to chronic (e.g., liver cancer), mutagenic, and teratogenic; and resulting symptoms range from skin irritation to immunosuppression, birth defects, neurotoxicity, and death (ICMSF, 1996).
1996). Aflatoxin B$_1$ (AFB$_1$), fumonisins, and patulin are suspected human carcinogens. Deoxynivalenol (DON) and other trichothecenes as well as AFB$_1$ are likely to exert immunosuppressive effects, and fumonisin B$_1$ (FB$_1$) may contribute to neural tube defects.

Renal dysfunction due to ochratoxin A exposure (suspected in Balkan endemic nephropathy) is also a potentially significant problem, especially as this could exacerbate impaired renal function in individuals with diabetes, a burgeoning worldwide epidemic that is highly likely to grow. There is also uncertainty related to the effects of chronic, low-level, long-term exposure to single and/or multiple mycotoxins, which may be the case even for those individuals consuming a diverse diet (Lopez-Garcia et al., 1999).

Environmental factors affect mycotoxin presence in raw and stored commodities. Data on optimal temperature and water activity for toxin production by *Aspergillus*, *Penicillium*, and *Fusarium* spp. in culture are provided in Table 1 (above). Traditionally, control of mycotoxin contamination of foods has been attempted through control of water activity, pH, and quality control of incoming ingredients. Novel control avenues are emerging, including availability of genetically modified grains with increased insect resistance and, thus, lowered rates of fungal infection; improved management of grain ingredients; and inclusion of controls for mycotoxins in food manufacturing Hazard Analysis and Critical Control Point (HACCP) plans.

Genotyping techniques have shed new light on mycotoxin-producing fungi and provided the foundation for advances in detection methodology. Historically, fungi have been identified on the basis of traditional taxonomic characteristics (e.g., morphological features); more recently, the tools of molecular biology have enabled genetic analysis and classification on the basis of nucleic acid sequence. Since analytical methods for detecting mycotoxins have become more prevalent, sensitive, and specific, surveillance of foods for mycotoxin contamination has become more common.

### Mycotoxin control strategies

**Good agricultural practices.** The first line of defense against the introduction of mycotoxins is at the farm level and starts with implementation of good agricultural practices to prevent infection. Preventive strategies should be implemented from pre- through post-harvest. Preharvest strategies include maintenance of proper planting/growing conditions (e.g., soil testing, field conditioning, crop rotation, and irrigation), antifungal chemical treatments (e.g., propionic and acetic acids), and adequate insect and weed prevention. Harvesting strategies include use of functional harvesting equipment, clean and dry collection/transportation equipment, and appropriate harvesting conditions (low moisture and full maturity). Postharvest measures include use of drying as dictated by

<table>
<thead>
<tr>
<th>Microorganism (mycotoxin)</th>
<th>Temperature °F</th>
<th>Water activity</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aspergillus flavus, A. parasiticus</em> (aflatoxin)</td>
<td>91.4</td>
<td>0.99</td>
<td>Hill et al., 1985</td>
</tr>
<tr>
<td><em>Aspergillus ochraceus</em> (ochratoxin)</td>
<td>86</td>
<td>0.98</td>
<td>Ramos et al., 1998</td>
</tr>
<tr>
<td><em>Penicillium verrucosum</em> (ochratoxin)</td>
<td>77</td>
<td>0.90 to 0.98</td>
<td>Cairns et al., 2003</td>
</tr>
<tr>
<td><em>Aspergillus carbonarius</em> (ochratoxin)</td>
<td>59 to 68</td>
<td>0.85 to 0.90</td>
<td>Mitchell et al., 2003</td>
</tr>
<tr>
<td><em>Fusarium verticillioides, F. proliferatum</em> (fumonisin)</td>
<td>50 to 86</td>
<td>0.93</td>
<td>Marin et al., 1999</td>
</tr>
<tr>
<td><em>Fusarium verticillioides, F. proliferatum</em> (DON)</td>
<td>51.8</td>
<td>0.90</td>
<td>Hope and Magan, 2003</td>
</tr>
<tr>
<td><em>Fusarium graminearum</em> (zearalenone)</td>
<td>77 to 86</td>
<td>0.98</td>
<td>Sanchis, 2004</td>
</tr>
<tr>
<td><em>Penicillium expansum</em> (patulin)</td>
<td>32 to 77</td>
<td>0.95 to 0.99</td>
<td>Sanchis, 2004</td>
</tr>
</tbody>
</table>

† Most data generated on environmental optima for mycotoxin production were obtained from cultures rather than actual field or storage environments.
moisture content of the harvested grain, appropriate storage conditions, and use of transport vehicles that are dry and free of visible fungal growth (CAC, 2003; Quillien, 2002). While implementation of these precautions goes a long way toward reducing mycotoxin contamination of foods, it alone does not solve the problem and should be an integral part of an integrated HACCP-based management system (Lopez-Garcia et al., 1999).

HACCP. Inclusion of mycotoxin control in HACCP plans, an important aspect of an overall management approach, should include strategies for prevention, control, and quality from the farm to the fork. In the food industry, postharvest control of mycotoxins has been addressed via HACCP plans, which include use of approved supplier schemes. Implementation at preharvest stages of the food system needs more attention. Such action provides a critical front-line defense to prevent introduction of contaminants into the food and feed supplies. Preharvest HACCP programs have been documented for controlling aflatoxin in corn and coconuts in Southeast Asia, peanuts and peanut products in Africa, nuts in West Africa, and patulin in apple juice and pistachio nuts in South America (FAO/IAEA, 2001). Aldred and Magan (2004) outlined a number of HACCP schemes for wheat-based commodities, and Lopez-Garcia et al. (1999) provided guidance for development of an integrated mycotoxin management program. Table 2 (above) displays the effective use of an HACCP-based postharvest hurdle approach to nearly eliminate aflatoxins from peanuts.

Biological control measures. DON levels have been shown to be reduced in the field and in storage without intervention, as discussed by Karlovsky (1999). Such findings include:

- degradation mechanisms resulting in reduced mycotoxin levels in the field. Limited research on DON has suggested the possibility that the mycotoxin may be metabolized by corn enzymes; and
- decline in DON levels in grains stored at −18°C to 4°C and trichothecenes at temperatures greater than 0°C.

Karlovsky explained that such reductions in mycotoxin levels have proven to be inconsistent and decreased levels of mycotoxins in the field do not substantiate the occurrence of biological degradation.

The potential for using microorganisms to detoxify mycotoxins has shown promise. Exposure of DON to microbes contained in the contents of the large intestines of chickens completely transformed it in vitro to de-epoxy-DON (He et al., 1992), which is 24 times less toxic than DON itself (Eriksen, 2003). Similar findings were demonstrated with the microflora of cow intestines (Binder et al., 1998).

Transgenic approaches. Current research efforts are focusing on methods to prevent infection at the preharvest stage.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Aflatoxin level</th>
<th>Percentage reduction</th>
<th>Percentage cumulative reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmer’s stock</td>
<td>217</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Belt separator</td>
<td>140</td>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>Shelling plant§</td>
<td>100</td>
<td>29</td>
<td>54</td>
</tr>
<tr>
<td>Color sorting§</td>
<td>30</td>
<td>70</td>
<td>86</td>
</tr>
<tr>
<td>Gravity table§</td>
<td>25</td>
<td>16</td>
<td>88</td>
</tr>
<tr>
<td>Blanching/color sorting</td>
<td>2.2</td>
<td>91</td>
<td>99.0</td>
</tr>
<tr>
<td>Re-color sortings§</td>
<td>1.6</td>
<td>27</td>
<td>99.3</td>
</tr>
</tbody>
</table>

† Results were obtained from processing of a 44-ton lot of contaminated peanuts.
‡ From Park and Liang, 1993.
§ Data based on medium-category peanuts only.
stage with emphasis on mechanisms by which the affected plants may inhibit growth of molds or destroy mycotoxins that they produce. Traditional grain-breeding strategies to select for preferred genetic traits have been conducted for many years. There has been limited success with this approach to *Fusarium graminearum* and *Aspergillus flavus*. There are hybrids currently in use that limit mycotoxin production; however, the potential to reach unacceptable levels remains. Fumonisin production has received less attention from researchers; however, quantitative trait loci (QTL) have been mapped. Unfortunately, QTL accounted for less than half the variance in *Fusarium* phenotype, and despite improved resistance, unacceptable levels are still possible (Munkvold, 2003). Traditional methods are plagued by many hurdles, however, including inconsistent, labor-intensive inoculation techniques, lack of single genes and resistant control genotypes, and the financial implications of evaluating results (Munkvold, 2003). Duvick (2001) pointed out that visible symptoms of plant mold can be selected for using traditional breeding techniques, but many of the mycotoxin-producing fungi surface with no visible signs.

Genetic modification of mold-susceptible plants holds great promise for controlling this food safety issue. Articles by Karlovsky (1999), Duvick (2001), and Munkvold (2003) review a variety of approaches that are being or have been pursued. One such approach involves increasing production of compounds (e.g., antifungal proteins or secondary metabolites, such as hydroxamic acids, phenolics, and stilbenes) that reduce infection by the microorganism. This may be accomplished by introducing a novel gene to express the target compound. Another option is to enhance expression of such a compound by the existing gene, thereby capitalizing on the plant’s own defense mechanisms. For example, enzymes that catalyze production of antifungals could be targeted for expression. Alternatively, genetic engineering methods to increase production of enzymes that degrade mycotoxins are also being pursued (Duvick, 2001; Munkvold, 2003). Transgenic maize has been patented for fumonisin-degrading corn for swine consumption (Duvick and Rood, 1998). Efforts are also under way to engineer plants to produce compounds that disrupt mycotoxin synthesis. For example, enhanced expression of an α-amylase inhibitor in *Aspergillus* spp. could result in significantly reduced aflatoxin levels (Duvick, 2001; Munkvold, 2003).

Another avenue for reducing mycotoxin levels would be to reduce insect injury to plant kernels. Insects play an important role in the proliferation of mold growth in the field and in storage. Resistance developed through the use of several Bt (*Bacillus* thermophilus) genes in corn, wheat, and other cereal grains to minimize insect damage has led to effective reduction in *Fusarium* ear rot (*F. verticillioides* and *F. proliferatum*) mycotoxin levels in grain. Munkvold (2003) cited 19 reports on Bt hybrids, with 12 of these demonstrating reduced mycotoxin production compared with the parent corn. It is important to note, however, that this approach is not a long-term solution for fumonisin production because *Fusarium* spp. can enter the kernels regardless of insect injury. Additionally, reductions of aflatoxin production in the Bt hybrids were not observed.

**Bioterrorism**

Because a number of mycotoxins, which may be lethal in relatively low doses, may be cultured and grown on a wide variety of grains, the possibility of deliberate mycotoxin contamination of commodities and/or foods should be recognized by the food industry when developing defense plans. The impact of an intentional act of mycotoxin contamination could be severe, with potential public health outcomes involving high mortality and devastating economic consequences stemming from the corresponding impact on the healthcare system, public fear, and avoidance of affected products. Prior to September 11, 2001, there was little concern pertaining to defense against intentional contamination. Because of this, grain storage and delivery systems, as well as food manufacturing plant security systems, deserve attention, and crisis plans should be in place to deal with possible biological and chemical terrorism incidents. Where appropriate, these efforts should include mycotoxins.

**Risk assessment**

Risk assessment of human health hazards associated with mycotoxins must rely on extrapolation from toxicity data obtained in animal models and human exposure assessments. Exposure assessments are quite sketchy at best, given that there is no publicly accessible ongoing systematic surveillance for human mycotoxin exposures. There are some interesting recent examples of attempts to perform such extrapolations and comparisons. Advances in the statistical estimation of uncertainty make extrapolations...
has been replaced by the term reference dose (RfD). Kodell and Gaylor (1999) have provided evidence-based extrapolation factors, combining data across hundreds of studies of toxic effects of nongenotoxic agents and deriving best estimates of major sources of variability in experiments (including interspecies, interindividual, and duration of toxic exposure). In the example of zearalenone, based on the NOEL in pigs and a combined factor of 46 for interindividual and interspecies variability (95% confidence estimate), a revised estimate of human RfD would be 0.87 ppb/day.

Kuiper-Goodman et al. (1996) performed a risk assessment for fumonisins based on human exposure data from Canada and the extant toxicity literature on these mycotoxins. Because fumonisins are almost exclusively found in corn, this is a somewhat simpler case than for most other mycotoxins. Based on 361 corn food samples analyzed over four years, human fumonisin intake was estimated to be <0.089 ppb/day. This dose was 1,700-fold less than the lowest NOEL obtained from animal studies (a 4.4-year study of nine vervet monkeys showing a NOEL of 0.15 ppm/day). The authors concluded that human fumonisin intakes in Canada were very unlikely to pose health risks. A more recent two-year rodent carcinogenicity study (NTP, 2001) confirms this finding, with a NOEL of >0.2 ppm/day with altered sphingosine/spinganine ratios as a toxic endpoint. The NOEL in this study for cancer (renal carcinogenesis in male rats only) was 0.6 ppm/day. Kuiper-Goodman (2004) recently reviewed mycotoxin risk assessment and risk management and the efforts of countries to harmonize regulations.

Due to the variation in mycotoxin content of human foods across world regions and seasons, and the continually improving toxicological data sets for mycotoxins, increasingly sophisticated models will be developed to assess human health risk from these foodborne toxins. Progress in the science of risk assessment is allowing a greater level of certainty regarding risk, but toxin interactions and emerging human epidemics of various chronic and infectious diseases will continue to pose major challenges in this field.

**Food safety implications**

Public awareness of issues surrounding mycotoxins is increasing. Karlovsky (1999) provides three explanations for this phenomenon. First, analytical chemistry is increasingly able to quantify the presence of toxins in a growing number of food commodities. Second, new and improved bioassays for toxicological studies on specific targets have surpassed the abilities of less sophisticated methods and allowed identification of negative health effects where previously none had been found. Third, the availability of routine testing methods that are both efficient and affordable has allowed for in-house monitoring, resulting in greater numbers of identified contaminations.

The variability in mycotoxin contamination and the potential for novel mycotoxicoses to emerge make the prospects for ongoing significant human mycotoxicoses likely, especially in low-income countries in which surveillance is less available because of economical and technological constraints. The human health consequences of acute aflatoxicosis alone range from
mycotoxin contamination of human foods could have a significant effect on public health in low-income countries and deserves significant attention. The food industry should take the lead in these efforts because it will lead to improved economic sustainability of the industry, enhanced food safety efforts, enhanced international trade efforts, and improved public health.

References
Canada East
Empty pesticide container collection

By Russel Hurst, CCA, Manager of Stewardship Development, CropLife Canada, Etobicoke, ON, Canada.

The environment is a hot issue, not only for Canadians, but everyone around the world. Environmental regulations, policy, and resource protection topics have become significantly more prevalent. Issues such as global warming and greenhouse gas emissions have been hotly debated on a daily basis. We are increasingly concerned about sustainability and are constantly examining ways we can help protect our planet. Across all industry sectors, consumers are demanding the highest standards in food production and environmental stewardship. Together with farmers, the Canadian agriculture industry continues to build on its commitment to environmental protection and sustainability, which have been key components of business for years.

Truth be told, the agriculture industry has been at the forefront of initiating and undertaking sustainable business practices and exhibiting a heightened level of awareness of potential production risks for quite some time, not to say that more cannot be done. Through industry leadership including that of many certified crop advisers (CCAs), several programs are helping to make a difference, such as the empty pesticide collection program showcasing the industry’s commitment to both human health and environmental safety.

Over the years, the empty pesticide container collection program has been a stewardship initiative undertaken on behalf of the industry that many producers and industry professionals have participated in, but many don’t fully understand the significance and importance of the program.

Since the program’s inception in 1989, more than 70 million empty plastic pesticide containers have been safely collected and recycled. Approximately six million empty containers are collected at over 1,100 designated collection sites throughout rural Canada each year. In Ontario alone, there are over 250 sites, based at participating ag retail facilities, collecting over 600,000 containers in 2006.

A key component involving the human health, environmental safety, and responsible use of crop protection products is that all containers must be triple-rinsed before being returned to collection sites, thus ensuring the safety of everybody involved. To date, rinse rates of empty pesticide container collected at ag retail sites across the country have been impeccable, showing the agriculture industry’s overall commitment to product stewardship.

The empty containers upon being collected are consolidated, shredded, processed, refined, and transported to various recyclers across the country where the granulated plastic is used for several low-impact end uses including field drainage tile, guard rail spacers, energy, and farm fence posts.

Industry partnership toward a common goal. A key factor in the widespread success of the empty container collection program and associated return rates has been the participation of various industry stakeholders. The ag retail industry has played a vital role in the development and implementation of the program. Through leadership, advocacy, education, and by
Northeast

Recent tomato fruit disorders in the mid-Atlantic region

By Gerald Brust, IPM Vegetable Specialist, Maryland Cooperative Extension, Salisbury, MD

I have seen tomato fruit and have received many inquiries about ripe tomatoes that seem to be “sprinkled with gold dust” in the last few weeks. This disorder is called gold fleck, or just fleck, and it develops as small irregular green spots found randomly on the surface of green fruit that become yellow (gold) as the fruit ripens. Spots can vary from few to many. There is evidence from North Carolina that insecticide use may reduce flecking; however, other work has shown fleck appearing when no thrips or sucking insects are present. Certain varieties show a predisposition to develop fleck, whatever its cause.

In Florida, fleck is not associated with thrips feeding even though they have thrips present in the field eight or nine months of the year. Our flecking problem started about one to two weeks after we started having very high temperatures and has appeared all over the mid-Atlantic region. I have been monitoring thrips populations over the season, and overall their populations have not increased over this same time period in tomato fields, which would indicate that fleck is a physiological disorder and not caused by thrips or other sucking insects. We see this disorder every year just around the end of July or the beginning of August when tomato plants have large fruit loads on them and are stressed from environmental factors.

I have also seen a great deal of blossom-end rot in tomatoes over the last two weeks. Blossom-end rot begins with tan, water-soaked areas at or near the blossom end of fruit, which usually enlarge and turn black and leathery. This area is then prone to invasion from fungi such as Alternaria. This malady is caused by a localized shortage of available calcium as the fruit develops. While the problem usually occurs externally at the blossom end of the fruit, it may also occur internally with no visible symptoms on the outside of the fruit.

There are several conditions that may increase the likely hood of blossom end rot. These include: (1) widely fluctuating soil moisture, which can temporarily reduce calcium concentrations in expanding fruit (because calcium is carried through the plant in the water flow, those plant parts that are rapidly transpiring will have more than adequate levels of calcium, while fruit often receives just adequate levels of calcium). Any moisture stress will reduce calcium uptake and therefore concentration in the plant. (2) Nitrogen in the form of ammonium can cause a reduction in calcium absorption and concentration in the tomato plant. (3) Damage to the root system can reduce uptake of calcium from the soil. Foliar applications of calcium seldom reduce blossom end rot because the calcium taken up by the leaves is inadequately translocated to the fruit. This fruit problem can be most easily prevented with good water management and proper fertilization. Most fields with the problem this year had inadequate irrigation when the plants had large fruit loads and needed the water (and calcium).

—Source: Pest Net Report, published by the University of Maryland’s College of Agriculture and Natural Resources. See http://extension.umd.edu/agriculture/IPM/mdIPM/network/pestNet/reports/index.cfm

Blossom-end rot on tomato fruit. Photo courtesy of Louisiana State University AgCenter’s Department of Crop Pathology and Physiology.
Southern

Sod demands decrease as water needs increase

Sod producers could not grow grass fast enough last spring to keep up with demand, but late-summer sales have plummeted because of enormous water demands during the hot, dry conditions.

Wayne Wells, turf specialist with the Mississippi State University Extension Service, says 2007 has been a good year for growing sod across the state, and sales were strong during the first months of the year. At the same time, water demands and energy costs have added to the cost of production.

“The hot, dry weather is not encouraging sod installation,” Wells says. “Someone has to be attending to the water needs of newly installed sod constantly in these conditions. It looks like new construction is slowing down, especially in north Mississippi, and that will decrease the demand for sod, too.”

The turf specialist said the state has about 5,000 acres in sod production. Prices went up about 10% to 15% in 2006 and have stayed there.

“Environmental conditions and input costs in 2007 have been very similar to 2006,” Wells says. “Growers have seen minimal insect and disease pressure this year, except in July when ample rains triggered an increase in disease development.”

Chris Hussey, owner of Hussey Sod Farm near Tupelo, MS, says it was another dry year, but not as bad as last year when there was no break in the drought. Ninety percent of his farm is irrigated.

“We can water about two-thirds of the farm every two weeks,” Hussey says. “Center pivots water about 120 acres of the 450-acre farm, and traveling (water) guns cover the rest of the irrigated acres. The guns are labor-intensive to move, so some grass just has to wait in line for the water. The good rains in July provided a break in irrigation needs and helped grow some grass.”

Hussey says his farm sells sod year-round, closing only the week after Christmas.

“Just about every farm in north Mississippi ran out of Bermuda grass this spring. Sales only started slowing down in August,” he says.

John Cobb, owner of the Mississippi Grass Nursery in Hattiesburg, says the July rains were a welcome relief.

“We didn’t have to turn on irrigation the whole month of July,” he says. “I don’t think that’s ever happened before. But it’s a different story now, and irrigation needs have resumed.”

Cobb lost all his farm buildings when Hurricane Katrina hit two years ago. The first months after the storm, he did not sell any grass.

“But business bounced back and hasn’t slowed down,” Cobb says.


Steve Hughes lays down new sod near one of Mississippi State University’s new residence halls. Photo by Linda Breazeale (Mississippi State University Agricultural Communications).
Improving fall nitrogen use efficiency in North America

By Cliff Snyder, Nitrogen Program Director, International Plant Nutrition Institute, Norcross, GA

Farmers face increased challenges to capture good crop market conditions by producing high yields. Increased fertilizer N costs in recent years have added to the challenges of making wise economic decisions. The use of anhydrous ammonia as a fertilizer N source has been decreasing in some states, and since about 1990, use has declined across six leading corn states: Illinois, Indiana, Iowa, Minnesota, Nebraska, and Ohio. In recent years, the combined urea N and urea-ammonium nitrate solution N consumption has increased compared with anhydrous ammonia.

In 2005, the Upper Mississippi River Sub-basin hypoxia nutrient committee (UMRSHNC) estimated that 25% (12.9 million acres) of the 50.6 million acres of corn in an eight-state area (IA, IL, IN, MI, MO, MN, OH, and WI) received N in the fall. A relatively recent survey (von Holle, unpublished M.S. thesis, 2005) in tile-drained watersheds in east-central Illinois indicated that fall anhydrous N sales have increased since the 1980s. Survey data collected by the USDA-ERS from 1996 to 2005 (data not collected from 2002–2004) showed that 25 to 45% of all corn acres received fall N applications, and the rate ranged from 72 to 94 lb of N/acre.

Fertilizer dealers and crop advisers are in a key position to assist farmers in making sound logistical fall N management decisions to improve N use efficiency and effectiveness, to improve farm profitability, and to protect water and air resources. A recent paper by Snyder and Bruulsema (2007) offered guidance in understanding and estimating nutrient use efficiency.

Fall application timing

In regions of North America where anhydrous ammonia is fall-applied for spring crops like corn, it is critically important to delay fall applications until the average daily soil temperatures at 4 to 6 inches deep (measured mid-morning) reach 50°F and are sustained at or below this for the winter (Snyder et al., 2001). Fall application of anhydrous ammonia (or other sources) for spring-planted crops is generally discouraged where these low soil temperatures do not persist on soils that have a high potential for winter and spring leaching and/or drainage loss of NO₃-N. These soils include: coarse-textured, excessively well-drained soils or medium-textured, well-drained soils in humid regions (especially where the annual rainfall exceeds 28 inches) and where tile drains may be present.

Research in the northern Great Plains (western Canada) has shown that proper fall timing of banded urea (with or without nitrification inhibitors) is more critical in poorly drained areas of fields to obtain optimum agronomic benefits (Tiessen et al., 2006). Delaying application of fall-band ed urea fertilizer into the late fall (October 15 in southern Manitoba, with air temperature approximately 40°F), and the use of the urease inhibitor NBPT [n-(n-butyl) thiophosphoric triamide] and the nitrification inhibitor DCD (dicyandiamide), slowed nitrification and increased the recovery of fertilizer N as NH₄⁺ in the soil before it froze. This study demonstrated the importance of minimizing the length of time that fall-applied N fertilizer is exposed to the soil before the soil freezes, even after the soil temperature has reached a prescribed level to limit nitrification.

Nitrification

Warm temperatures and moist soil conditions increase the rate at which NH₄⁺-N converts to NO₃-⁻N, termed nitrification. With soil temperatures above 50 to 60°F, much of the NH₄⁺-N applied in fertilizer, and that resident in the soil including NH₄⁺ released from soil organic matter, manure applications, and urea or NH₄⁺-containing N fertilizers, may be converted to NO₃-⁻N in the matter of a few weeks. By early spring, warm temperatures can cause nitrification to proceed rapidly. If the crop does not have a well-established root system, NO₃-⁻N uptake may not proceed at a rate sufficient to capture and use available soil NO₃-N to prevent its leaching and loss to drainage waters, especially when heavy spring rains occur.

Nitrification inhibitors

Crop responses to fertilizer N applied with a nitrification inhibitor have varied across regions. Benefits of nitrification inhibitors with fall N application are greatest in warm, wet years because of their ability to slow nitrification, which may lead to reductions in NO₃-⁻N leaching. Work in Illinois has shown that half of fall-applied anhydrous ammonia can be kept in the NH₄⁺ form for up to five months when soil temperatures were below 55°F at the time of fall application (see Snyder et al., 2001).

Urea and urease inhibitors

Urea is an acceptable source for fall applications in most climates if it is incorporated soon after application on soils with relatively low leaching and denitrification loss potentials. Once incorporated (by tillage or rainfall), in the pres-
ence of adequate moisture, urea readily converts to NH$_4^+$ because of the action of the urease enzyme, which is present in virtually all soils. Movement of urea N in soils is somewhat comparable to NO$_3^-$N movement. So, fall applications of urea in sandy soils with a high leaching potential are generally not recommended (Murrell and Snyder, 2006).

Application of urea treated with NBPT (urease inhibitor) on spring-planted crops in many parts of the U.S. has helped slow urea hydrolysis, reduce NH$_3$ volatilization losses, enhance crop N uptake, and increase crop yields. The inhibition of urea hydrolysis may last from 10 to 14 days, depending on the environmental conditions. Inclusion of a urease inhibitor with fall-applied urea-containing N sources may improve crop N recovery and enhance N use efficiency, based on wheat nutrition research in Canada (Tiessen et al., 2006). If N rates are not properly adjusted to account for such improved recovery efficiency, there is some potential for elevated soil NO$_3^-$N levels.

In some states, the only fertilizer N source recommended for fall application for corn is anhydrous ammonia. The fall use of sources like UAN (28 to 32% urea ammonium nitrate solution), ammonium sulfate, urea, and ammonium nitrate for spring-planted crops (e.g., corn) are discouraged in Iowa, for example (Sawyer, 2006).

**Controlled-release N**

Polymer-coated or slow-release fertilizer N sources may limit or control conversion of the source to NH$_4^-$N, and thereby reduce the potential conversion to NO$_3^-$N. However, research results with these controlled-release sources are still considered somewhat preliminary at this time. They are typically not recommended for fall application for spring-planted crops.

In Iowa (Sawyer, 2006), preliminary fall application research with newer controlled-release urea products has indicated that polymer-coated urea (PCU) provided an average 4 bu/acre corn yield increase compared with fall-applied urea. However, the fall-applied PCU had a 4 bu/acre lower yield compared with spring-applied urea: an 8 bu/acre yield advantage for spring urea application vs. fall-applied urea. Other research is continuing to evaluate controlled-release N sources to determine their economic use and potential environmental benefits.

**Drainage losses of fall-applied N**

The effects of fall N application vs. spring N application on NO$_3^-$N transport in tile drainage depend on many factors, including soil temperatures, soil texture, precipitation amount and intensity, soil organic matter levels, and drainage intensity. Drainage losses of NO$_3^-$N, dominated by spring flow from fields, are often on the order of 20 to 30 lb of N/acre/year. Some reports have documented losses above 40 lb of N/acre/year. This environmental loss of N presents both local and downstream water quality concerns.

The National Research Council (2000) estimated the average annual load of N in streams and rivers of the...
Mississippi River Basin at about 1 lb of N/acre/year, prior to human disturbance. The U.S. Geological Survey estimated the annual total N discharged by streams and rivers in different watersheds in the Mississippi River Basin for 1980 to 1996, and in some watersheds, the annual N load or discharge considerably exceeded the estimates of background natural conditions.

Scientists in Minnesota have shown that fall N application can result in 15% more N loss in tile drainage than with spring-applied N. This represents a direct economic loss to the farmer ranging from $8 to $16/acre/year, if one assumes a N price of $0.40/lb of N and the range of NO$_3$–N drainage loss from 20 to 40 lb of N/acre/year. Changing from fall to spring sidedressed N application for corn and altering the N rate to account for more efficient use of spring-applied N resulted in at least 30% lower NO$_3$–N concentrations in tile drain water in Iowa studies (Jaynes et al., 2004). The majority of the published agronomic N research has shown that spring-applied N for spring-planted crops (e.g., corn) is used more efficiently than fall-applied N.

With an increasing trend for corn–corn rotations associated with expansion of ethanol markets, fertilizer N use is expected to increase (Fixen, 2007). Some fear that good corn prices will result in greater fall N application for corn and a greater risk of NO$_3$–N loss in field drainage to streams and rivers. Indeed, federal and state water quality agencies have become more concerned, are more watchful of agricultural nutrient management practices, and are closely monitoring water quality in intensive agricultural areas. So, everything that can be done to manage fall N for maximum spring recovery in the soil and targeted crop will raise the potential for crop recovery and profitable response and also help lower the risk of environmental loss.

Summary and suggestions

- Fall N applications can be used to provide economic crop production, provided that good management practices are followed.
- Fall N applications for spring-planted crops should be confined to soils that are well drained, but not excessively drained (silt loams to clay loams), where risk of NO$_3$–N drainage losses are minimal.
- Sources containing NO$_3$–N should not be used in fall applications for spring-planted crops.
- Fall application of urea-containing N sources (even with broadcast incorporation or band injection) for spring-planted crops is generally discouraged because of the risks of NO$_3$–N losses before the crop has a well-established, extensive root system capable of rapid nutrient uptake.
- Ammonia losses (volatilization) of fall-applied urea-containing N sources and surface runoff losses of N can be reduced or avoided by placing the fertilizer into the soil, beneath surface residues.
- When applying fall N for cool-season forage grasses, winter cereals, and other winter crops, the N rate should be closely managed to be sure that no more N is provided than can be effectively utilized by the crops from fall through winter, before rapid spring growth begins. This helps minimize the potential for buildup of soil NO$_3$–N levels.
- Account for residual soil N supplies from previous fertilizer applications, manure applications, legumes or N-fixing crops (e.g., alfalfa), and N release from soil organic matter mineralization in determining appropriate fall N application rates. Use of nitrification inhibitors with fall N applications can be successful in keeping N in the NH$_4^+$ form for a time, in some growing regions.
- By spring, the nitrification potential may be high enough to overwhelm the effects of nitrification inhibitors that were included in fall N applications. As a consequence, NO$_3$–N losses in drainage may still be unacceptable in some watersheds.
- Correct or eliminate other nutrient limitations. For example, properly maintain soil pH and apply recommended rates of P, K, and other essential nutrients.
- For corn following corn: although laborious and requiring calibrated sampling expertise, basal corn stalk samples collected at black-layer for NO$_3$–N analyses can be helpful in determining if excessive available N may be present at the end of the corn growing season (Balkcom, 2003; Brouder et al., 2000). Soil profile (at least 2 to 3 ft deep) NO$_3$–N sampling may also be a helpful diagnostic tool, where properly calibrated...principally, in lower-rainfall, less humid production regions.
- Consider all N loss pathways (ammonia volatilization, leaching, runoff, immobilization, and denitrification) and adjust fertilizer N management to provide optimum N use efficiency and prevent or minimize costly and environmentally concerning N losses.


References


Fall 2007 Self-Study Exam

Improving fall nitrogen use efficiency in North America (no. SS 03755)

1. Since about 1990, the use of ammonia as a nitrogen source has declined across leading corn states, including
   a. Illinois, Indiana, Iowa, Minnesota, Nebraska, and Ohio.
   b. Illinois, Indiana, Iowa, Nebraska, and Wisconsin.
   c. Illinois, Iowa, Florida, Minnesota, Ohio, and Texas.
   d. Illinois, Iowa, Texas, Florida, and Nebraska.

2. Survey data collected by the USDA-ERS from 1996 to 2005 (data not collected from 2002–2004) showed that 25 to 45% of all corn acres received fall N applications, and the rate ranged from
   a. 45 to 100 lb of N/acre.
   b. 72 to 94 lb of N/acre.
   c. up to 55 lb N/acre.
   d. 12 to 45 lb N/acre.

3. In regions of North America where anhydrous ammonia is applied in autumn for spring crops like corn, applications should be delayed until the average daily soil temperatures (at 4- to 6-inch depth) in midmorning are at least
   a. 35°F.
   b. 50°F.
   c. 65°F.
   d. 72°F.

4. Warm temperatures and moist soil conditions increase the rate at which NH₄ – N converts to NO₃ – N, a process termed
   a. nitrification.
   b. nitrogen fixation.
   c. nitrogen conversion.
   d. nitrogen loss.

5. When soil temperatures are above 50 to 60°F, the NH₄ – N applied in fertilizer and that resident in the soil, including NH₄ + released from soil organic matter, manure applications, and urea or NH₄ + containing N fertilizers, may be converted to NO₃ – N in the matter of
   a. seven days.
   b. a few weeks.
   c. a few months.
   d. a year or so.

6. Application of urea treated with NBPT on spring-planted crops in many parts of the U.S. has helped slow urea hydrolysis, reduce NH₃ volatilization losses, enhance crop N uptake, and increase crop yields. What is NBPT and what does it do?
   a. n-(n-butyl) thiophosphoric triacid. It is a uric acid enhancer.
   b. n-(n-butyl) thiophosphoric triamide. It is a urease inhibitor.
   c. n-butyric triacid triamine. It is an alkali treatment for acid soils.
   d. n-beryl-thioacid triamine. It is a mineralization supplement.

This exam is worth 1 CEU in Nutrient Management. A score of 70% or higher will earn CEU credit. The International CCA program has approved self-study CEUs for 20 of the 40 CEUs required in the two-year cycle. An electronic version of this test is also available at www.certifiedcropadviser.org. Click on “Continuing Education” and then “Self-Study CEUs.”

Directions

1. After carefully reading the article, answer each question by clearly marking an “X” in the box next to the best answer.
2. Complete the self-study exam registration form and evaluation form on the back of this page.
3. Clip out this page, place in envelope with a $15 check made payable to the American Society of Agronomy (or provide your credit card information on the form), and mail to: ASA c/o CCA Self-Study Exam, 677 S. Segoe Road, Madison, WI 53711. You can also complete the exam and pay online at www.certifiedcropadviser.org ($12 charge).

www.agronomy.org
7. With an increasing trend for corn–corn rotations associated with expansion of ethanol markets, fertilizer N use is expected to increase. There is increasing concern that good corn prices will result in greater fall N application for corn to what result?
   - a. greater risk of NO$_3$–N loss in field drainage to streams and rivers.
   - b. greater uptake in N in corn tissues.
   - c. reduced yields in corn.
   - d. lower functionality in corn grain.

8. Fall application of urea-containing N sources (even with broadcast incorporation or band injection) for spring-planted crops is generally discouraged because of the risks of NO$_3$–N losses before the crop has
   - a. developed a well-established, extensive root system capable of rapid nutrient uptake.
   - b. developed enough leaves to continue photosynthesis.
   - c. developed strong stalks to withstand weather conditions.
   - d. become pollinated.

9. When applying fall N for cool-season forage grasses, winter cereals, and other winter crops, the N rate should be closely managed to be sure that no more N is provided than can be effectively utilized by the crops from fall through winter, before rapid spring growth begins. This helps minimize the potential for
   - a. too much foliage and weak infrastructure.
   - b. buildup of soil NO$_3$–N levels.
   - c. developing shallow root systems.
   - d. reduced soil nutrients.

10. Consider all N loss pathways (ammonia volatilization, leaching, runoff, immobilization, and denitrification) and adjust fertilizer N management to provide
    - a. best use of N in plants.
    - b. N use efficiency and prevent or minimize costly and environmentally concerning N losses.
    - c. most economical use of N fertilizer.
    - d. reductions in other mineral use.

**SELF-STUDY EXAM REGISTRATION FORM**

Name: ____________________________

Address: ____________________________

State/province: __________________ Zip: ____________

CCA certification no.: __________________

☐ $15 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 exam and recognize that an ethics violation may revoke my CCA status.

This exam issued September 2007 expires September 2010

**SELF-STUDY EXAM 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: ____________________________
ew to Certified Crop Advisers (CCA) is the CCA Toolbox, a brainstorming idea of the American Society of Agronomy and ICCA leadership to develop both electronic and hard copy “tools” that CCAs can use in their every day work. We tested some early ideas with the CCA technology team to evaluate their usefulness.

The first of these tools are the conversion charts below. They are a collection of commonly used conversion tables, formulas, and reference charts. The hard copy version here is meant for easy retrieval when in the field, but you can also access the same information plus more (e.g., a conversion calculator) on the CCA website (www.certifiedcropadviser.org). The electronic toolbox is only available to CCAs—to access it, you will need to log in with your email address and password (your certification number followed by the first initial of your first name unless you changed it).

We will be adding more tools as they are discovered and will announce their arrival in *Crops & Soils*. Please feel free to let us know if you have ideas for new tools that would be helpful to CCAs by emailing Luther Smith at lsmith@agronomy.org.

### Yield†

<table>
<thead>
<tr>
<th>Unit of measure</th>
<th>Symbol</th>
<th>kg/ha</th>
<th>t/ha</th>
<th>cwt/acre</th>
<th>bu/acre (60 lb)</th>
<th>bu/acre (56 lb)</th>
<th>bu/acre (48 lb)</th>
<th>bu/acre (32 lb)</th>
</tr>
</thead>
<tbody>
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<td>Kilogram/hectare</td>
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<td>1</td>
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<td>15.932</td>
<td>18.587</td>
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<td>Hundred weight/acre</td>
<td>cwt/acre</td>
<td>112.1</td>
<td>0.1121</td>
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<td>2.0833</td>
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<td>bu/acre</td>
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<tr>
<td>Bushel/acre, 56 lb</td>
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<td>0.56</td>
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<td></td>
<td></td>
<td></td>
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<td>Bushel/acre, 48 lb</td>
<td>bu/acre</td>
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<td>0.0538</td>
<td>0.48</td>
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<td>Bushel/acre, 32 lb</td>
<td>bu/acre</td>
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<td>0.0359</td>
<td>0.32</td>
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<td></td>
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† 1 ton/acre = 2.2418 t/ha = 2.2418 Mg/ha • 1 lb/acre = 1.1209 kg/ha.

### Volume, liquid measure†

<table>
<thead>
<tr>
<th>Unit of measure</th>
<th>Symbol</th>
<th>mL</th>
<th>L</th>
<th>hl</th>
<th>oz</th>
<th>qt</th>
<th>gal</th>
<th>ft³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milliliter</td>
<td>mL</td>
<td>1</td>
<td>0.001</td>
<td>1.0 × 10⁻³</td>
<td>0.033814</td>
<td>0.0010567</td>
<td>2.6 × 10⁻⁴</td>
<td>3.5 × 10⁻³</td>
</tr>
<tr>
<td>Liter</td>
<td>L</td>
<td>1,000</td>
<td>1</td>
<td>0.01</td>
<td>33.814</td>
<td>1.0567</td>
<td>0.26417</td>
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<tr>
<td>Hectoliter</td>
<td>hl</td>
<td>1.0 × 10²</td>
<td>100</td>
<td>1</td>
<td>3,381.4</td>
<td>105.67</td>
<td>26.417</td>
<td>3.5315</td>
</tr>
<tr>
<td>Ounce</td>
<td>oz</td>
<td>29.574</td>
<td>0.029574</td>
<td>2.9 × 10⁻⁴</td>
<td>1</td>
<td>0.03124</td>
<td>0.0078125</td>
<td>0.0010444</td>
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<tr>
<td>Quart</td>
<td>qt</td>
<td>946.35</td>
<td>0.94635</td>
<td>0.0094635</td>
<td>32</td>
<td>1</td>
<td>0.25</td>
<td>0.033420</td>
</tr>
<tr>
<td>Gallon</td>
<td>gal</td>
<td>3,785.4</td>
<td>3.7854</td>
<td>0.037854</td>
<td>128</td>
<td>4</td>
<td>1</td>
<td>0.13368</td>
</tr>
<tr>
<td>Cubic foot</td>
<td>ft³</td>
<td>28,317</td>
<td>28,317</td>
<td>0.28317</td>
<td>957.51</td>
<td>29.922</td>
<td>7.4805</td>
<td>1</td>
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</tbody>
</table>

† 3 teaspoons = 1 tablespoon = 14.787 mL • 2 tablespoons = 1 fluid oz = 29.574 mL • 1 fluid pint = 0.47317 L • 1 qt/acre = 2.3386 L/ha • 1 gal/acre = 9.3541 L/ha • 1 ft³ = 2.83 × 10⁻² m³ • 1 in³ = 1.64 × 10⁻³ m³ • 1 acre-inch = 102.8 m³.
### Volume, dry measure†

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<thead>
<tr>
<th>Unit of measure</th>
<th>Symbol</th>
<th>L</th>
<th>pt</th>
<th>qt</th>
<th>pk</th>
<th>bu</th>
<th>ft³</th>
<th>yd³</th>
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<tbody>
<tr>
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<td>L</td>
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<td>Pint</td>
<td>pt</td>
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<td>1</td>
<td>0.5</td>
<td>0.0625</td>
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<td>0.019445</td>
<td>7.2 × 10⁻⁴</td>
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<td>qt</td>
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<td>0.12499</td>
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<td>Peck</td>
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<td>15.999</td>
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<tr>
<td>Bushel</td>
<td>bu</td>
<td>35.238</td>
<td>63.989</td>
<td>31.998</td>
<td>3.9997</td>
<td>1</td>
<td>1.2444</td>
<td>0.046091</td>
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<tr>
<td>Cubic foot</td>
<td>ft³</td>
<td>764.55</td>
<td>1388.4</td>
<td>694.29</td>
<td>86.785</td>
<td>21.698</td>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>Cubic yard</td>
<td>yd³</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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</tr>
</tbody>
</table>

† 1 ft³ = 2.83 × 10⁻² m³ • 1 in³ = 1.64 × 10⁻⁵ m³ • 1 acre-inch = 102.8 m³.

### Bushel weights of various crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>Unit</th>
<th>Crop</th>
<th>Unit</th>
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</thead>
<tbody>
<tr>
<td>Grains</td>
<td>lb</td>
<td>Fruits/vegetables</td>
<td>lb</td>
</tr>
<tr>
<td>Corn (shelled)</td>
<td>56</td>
<td>apples</td>
<td>48</td>
</tr>
<tr>
<td>Corn (ear)</td>
<td>70</td>
<td>peaches</td>
<td>48</td>
</tr>
<tr>
<td>Wheat</td>
<td>60</td>
<td>beans (dried)</td>
<td>60</td>
</tr>
<tr>
<td>Soybeans</td>
<td>60</td>
<td>peas (dried)</td>
<td>60</td>
</tr>
<tr>
<td>Oats</td>
<td>32</td>
<td>potatoes</td>
<td>60</td>
</tr>
<tr>
<td>Barley</td>
<td>48</td>
<td>sweet potatoes</td>
<td>55</td>
</tr>
<tr>
<td>Rye</td>
<td>56</td>
<td>tomatoes</td>
<td>53</td>
</tr>
<tr>
<td>Sorghum</td>
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<tr>
<td>Peanuts</td>
<td>22</td>
<td>Miscellaneous</td>
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<tr>
<td>Rice</td>
<td>45</td>
<td>alfalfa</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>rape (canola)</td>
<td>50</td>
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<tr>
<td>Grasses</td>
<td></td>
<td>vetch</td>
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<tr>
<td>Bluegrass</td>
<td>14–30</td>
<td>flaxseed</td>
<td>56</td>
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<tr>
<td>Ryegrass</td>
<td>56</td>
<td>hemp</td>
<td>44</td>
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<td>Timothy</td>
<td>45</td>
<td>buckwheat</td>
<td>43–52</td>
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<tr>
<td>Meadow fescue</td>
<td>24</td>
<td>cotton</td>
<td>32</td>
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<tr>
<td>Sudangrass</td>
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</tr>
<tr>
<td>Orchardgrass</td>
<td>14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Temperature†

<table>
<thead>
<tr>
<th>°C</th>
<th>°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>212</td>
</tr>
<tr>
<td>90</td>
<td>194</td>
</tr>
<tr>
<td>80</td>
<td>176</td>
</tr>
<tr>
<td>70</td>
<td>158</td>
</tr>
<tr>
<td>60</td>
<td>140</td>
</tr>
<tr>
<td>50</td>
<td>122</td>
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<td>104</td>
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<td>30</td>
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<td>10</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>41</td>
</tr>
<tr>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>-5</td>
<td>23</td>
</tr>
<tr>
<td>-10</td>
<td>14</td>
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</tr>
<tr>
<td>-30</td>
<td>-22</td>
</tr>
<tr>
<td>-40</td>
<td>-40</td>
</tr>
</tbody>
</table>

† To convert °C to °F, use this formula: \( \frac{9}{5} \times °C + 32 \). To convert °F to °C, use this formula: \( \frac{5}{9} \times °F - 32 \).

### Plant nutrient conversion

<table>
<thead>
<tr>
<th>To convert elemental into oxide, multiply by</th>
<th>Elemental</th>
<th>Oxide</th>
<th>To convert oxide into elemental, multiply by</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.29</td>
<td>P</td>
<td>P₂O₅</td>
<td>0.437</td>
</tr>
<tr>
<td>1.20</td>
<td>K</td>
<td>K₂O</td>
<td>0.830</td>
</tr>
<tr>
<td>1.39</td>
<td>Ca</td>
<td>CaO</td>
<td>0.715</td>
</tr>
<tr>
<td>1.66</td>
<td>Mg</td>
<td>MgO</td>
<td>0.602</td>
</tr>
</tbody>
</table>

† To convert °C to °F, use this formula: \( \frac{9}{5} \times °C + 32 \). To convert °F to °C, use this formula: \( \frac{5}{9} \times °F - 32 \).
### Area

<table>
<thead>
<tr>
<th>Unit of measure</th>
<th>Symbol</th>
<th>m²</th>
<th>ha</th>
<th>km²</th>
<th>in²</th>
<th>ft²</th>
<th>yd²</th>
<th>acre</th>
<th>mi²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square meter</td>
<td>m²</td>
<td>1</td>
<td>0.0001</td>
<td>1.0 x 10⁻⁶</td>
<td>1,550.0</td>
<td>10.764</td>
<td>1.1960</td>
<td>2.4 x 10⁻⁴</td>
<td>3.9 x 10⁻⁷</td>
</tr>
<tr>
<td>Hectare</td>
<td>ha</td>
<td>10,000</td>
<td>1</td>
<td>0.01</td>
<td>1.55 x 10⁻⁶</td>
<td>1.07 x 10⁻⁵</td>
<td>11,960</td>
<td>2.4711</td>
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<tr>
<td>Square kilometer</td>
<td>km²</td>
<td>1.0 x 10⁶</td>
<td>100</td>
<td>1</td>
<td>1.55 x 10⁵</td>
<td>1.07 x 10⁴</td>
<td>1.2 x 10⁴</td>
<td>247.11</td>
<td>0.38610</td>
</tr>
<tr>
<td>Square inch</td>
<td>in²</td>
<td>6.4 x 10⁻⁴</td>
<td>6.4 x 10⁻³</td>
<td>6.4 x 10⁻¹⁰</td>
<td>1</td>
<td>0.0069444</td>
<td>7.7 x 10⁻⁴</td>
<td>1.6 x 10⁻⁸</td>
<td>2.5 x 10⁻¹⁸</td>
</tr>
<tr>
<td>Square foot</td>
<td>ft²</td>
<td>0.092903</td>
<td>9.3 x 10⁻⁵</td>
<td>9.3 x 10⁻⁸</td>
<td>144</td>
<td>1</td>
<td>0.11111</td>
<td>2.3 x 10⁻⁵</td>
<td>3.6 x 10⁻¹⁸</td>
</tr>
<tr>
<td>Square yard</td>
<td>yd²</td>
<td>0.83613</td>
<td>8.4 x 10⁻⁵</td>
<td>8.4 x 10⁻⁸</td>
<td>1,296</td>
<td>9</td>
<td>1</td>
<td>2.0 x 10⁻⁴</td>
<td>3.2 x 10⁻¹⁷</td>
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<tr>
<td>Acre</td>
<td>acre</td>
<td>4,046.9</td>
<td>0.40469</td>
<td>0.0040469</td>
<td>6.3 x 10⁵</td>
<td>43,560</td>
<td>4,840.1</td>
<td>1</td>
<td>0.0015625</td>
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<tr>
<td>Square mile</td>
<td>mi²</td>
<td>2.6 x 10⁶</td>
<td>259</td>
<td>2,5899</td>
<td>4.0 x 10⁶</td>
<td>2.8 x 10⁵</td>
<td>3.1 x 10⁵</td>
<td>640</td>
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### Length

<table>
<thead>
<tr>
<th>Unit of measure</th>
<th>Symbol</th>
<th>mm</th>
<th>cm</th>
<th>m</th>
<th>km</th>
<th>in</th>
<th>ft</th>
<th>yd</th>
<th>mi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millimeter</td>
<td>mm</td>
<td>1</td>
<td>0.1</td>
<td>0.001</td>
<td>1.0 x 10⁻⁶</td>
<td>0.039370</td>
<td>0.0010936</td>
<td>0.0033</td>
<td>0.0010936</td>
</tr>
<tr>
<td>Centimeter</td>
<td>cm</td>
<td>10</td>
<td>1</td>
<td>0.01</td>
<td>1.0 x 10⁻⁵</td>
<td>0.039370</td>
<td>0.0033</td>
<td>0.0010936</td>
<td>0.0010936</td>
</tr>
<tr>
<td>Meter</td>
<td>m</td>
<td>1,000</td>
<td>100</td>
<td>1</td>
<td>0.001</td>
<td>39.370</td>
<td>3.2808</td>
<td>1.0936</td>
<td>6.2 x 10⁻⁴</td>
</tr>
<tr>
<td>Kilometer</td>
<td>km</td>
<td>1.0 x 10⁶</td>
<td>1.0 x 10⁵</td>
<td>1,000</td>
<td>1</td>
<td>39.370</td>
<td>3.2808</td>
<td>1.0936</td>
<td>6.2 x 10⁻⁴</td>
</tr>
<tr>
<td>Inch</td>
<td>in</td>
<td>25.400</td>
<td>2.5400</td>
<td>0.025400</td>
<td>2.5 x 10⁻⁵</td>
<td>1</td>
<td>0.083333</td>
<td>0.027778</td>
<td>1.6 x 10⁻⁵</td>
</tr>
<tr>
<td>Foot</td>
<td>ft</td>
<td>304.80</td>
<td>30.480</td>
<td>0.30479</td>
<td>3.0 x 10⁻⁴</td>
<td>12</td>
<td>1</td>
<td>0.33333</td>
<td>1.8 x 10⁻⁴</td>
</tr>
<tr>
<td>Yard</td>
<td>yd</td>
<td>914.40</td>
<td>91.440</td>
<td>0.91439</td>
<td>9.1 x 10⁻⁴</td>
<td>36</td>
<td>3</td>
<td>1</td>
<td>5.6 x 10⁻⁴</td>
</tr>
<tr>
<td>Mile</td>
<td>mi</td>
<td>1.6 x 10⁶</td>
<td>1.6 x 10⁵</td>
<td>1,609.3</td>
<td>1.6093</td>
<td>63,360</td>
<td>5,280.0</td>
<td>1,760</td>
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</table>

### Weight

<table>
<thead>
<tr>
<th>Unit of measure</th>
<th>Symbol</th>
<th>mg</th>
<th>g</th>
<th>kg</th>
<th>t</th>
<th>lb</th>
<th>short ton</th>
<th>long ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milligram</td>
<td>mg</td>
<td>1</td>
<td>0.001</td>
<td>1.0 x 10⁻⁵</td>
<td>1.0 x 10⁻⁹</td>
<td>2.2 x 10⁻⁶</td>
<td>1.1 x 10⁻⁹</td>
<td>9.8 x 10⁻¹⁰</td>
</tr>
<tr>
<td>Gram</td>
<td>g</td>
<td>1,000</td>
<td>1</td>
<td>0.001</td>
<td>1.0 x 10⁻⁶</td>
<td>2.2 x 10⁻⁵</td>
<td>1.1 x 10⁻⁵</td>
<td>9.8 x 10⁻⁷</td>
</tr>
<tr>
<td>Kilogram</td>
<td>kg</td>
<td>1.0 x 10⁶</td>
<td>1,000</td>
<td>1</td>
<td>0.001</td>
<td>2.046</td>
<td>1.1 x 10⁻⁵</td>
<td>9.8 x 10⁻⁸</td>
</tr>
<tr>
<td>Metric ton</td>
<td>t</td>
<td>1.0 x 10⁹</td>
<td>1.0 x 10⁶</td>
<td>1,000</td>
<td>1</td>
<td>2,046.4</td>
<td>1.1023</td>
<td>0.9842</td>
</tr>
<tr>
<td>Pound</td>
<td>lb</td>
<td>4.5 x 10⁵</td>
<td>453.59</td>
<td>0.45359</td>
<td>4.5 x 10⁴</td>
<td>1</td>
<td>4.9 x 10⁻⁴</td>
<td>4.4 x 10⁻⁴</td>
</tr>
<tr>
<td>Short ton</td>
<td>short ton</td>
<td>9.1 x 10⁸</td>
<td>9.1 x 10⁵</td>
<td>907.44</td>
<td>0.90744</td>
<td>2,000.6</td>
<td>1</td>
<td>0.89310</td>
</tr>
<tr>
<td>Long ton</td>
<td>long ton</td>
<td>10.2 x 10⁹</td>
<td>10.2 x 10⁵</td>
<td>1,016.0</td>
<td>1.0160</td>
<td>2,240.0</td>
<td>1.1197</td>
<td>1</td>
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### Pressure

<table>
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<tr>
<th>Unit of measure</th>
<th>Symbol</th>
<th>g/cm²</th>
<th>kg/cm²</th>
<th>lb/in²</th>
<th>atm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram/square centimeter</td>
<td>g/cm²</td>
<td>1</td>
<td>0.001</td>
<td>0.014223</td>
<td>9.7 × 10⁻⁴</td>
</tr>
<tr>
<td>Kilogram/square centimeter</td>
<td>kg/cm²</td>
<td>1,000</td>
<td>1</td>
<td>14.223</td>
<td>0.96784</td>
</tr>
<tr>
<td>Pound/square inch</td>
<td>lb/in²</td>
<td>70.308</td>
<td>0.070307</td>
<td>1</td>
<td>0.068046</td>
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<tr>
<td>Atmosphere</td>
<td>atm</td>
<td>1,033.2</td>
<td>1.0332</td>
<td>14.696</td>
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</tbody>
</table>

### Seedbed density

#### Unit of measure (symbol)

<table>
<thead>
<tr>
<th>English</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lineal bed foot (bed ft)†</td>
<td>Lineal bed meter (bed m)†</td>
</tr>
<tr>
<td>Square foot (ft²)</td>
<td>Square meter (m²)</td>
</tr>
</tbody>
</table>

#### Conversion chart

- **42-inch usable bed space‡**
  - English to English
    - 1 bed ft = 3.5 ft²
  - English to metric
    - 1 bed ft = 0.3252 m²
  - 1 ft² = 0.09290 m²
  - 1 ft² = 0.08709 bed m

- **48-inch usable bed space‡**
  - English to English
    - 1 bed ft = 4 ft²
  - English to metric
    - 1 bed ft = 0.3716 m²
  - 1 ft² = 0.09290 m²
  - 1 ft² = 0.07620 bed m

† One lineal bed ft (or 1 lineal bed m) equals an area of seedbed 1 ft (or 1 m) long times the width of the bed.

‡ Usable bed space is the area of seedbed actually occupied by seedlings.

### Fertilizer

#### Unit of measure (symbol)

<table>
<thead>
<tr>
<th>English</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ounces per square foot (oz/ft²)</td>
<td>Grams per square meter (g/m²)</td>
</tr>
<tr>
<td>Pounds per acre (lb/acre)</td>
<td>Kilograms per hectare (kg/ha)</td>
</tr>
</tbody>
</table>

#### Phosphorus (P)

- Phosphoric acid (P₂O₅)
- Conversion chart
  - English to English
    - 1 oz/ft² = 2,722 lb/acre
  - English to metric
    - 1 lb/acre = 1.121 kg/ha
  - Metric to English
    - 1 kg/ha = 0.8921 lb/acre
  - P = P₂O₅ × 0.4364
  - P₂O₅ = P × 2.291

#### Potassium (K)

- Potash (K₂O)
- Conversion chart
  - English to English
    - 1 oz/ft² = 2,722 lb/acre
  - English to metric
    - 1 lb/acre = 1.121 kg/ha
  - Metric to English
    - 1 kg/ha = 0.8921 lb/acre
  - K = K₂O × 0.8301
  - K₂O = K × 1.205
Soil phosphorus is affected by biosolid application

Biosolids are nutrient-rich organic materials resulting from the treatment of domestic sewage. When treated and processed, the sewage sludge can be recycled and applied as fertilizer in accordance with regulatory requirements to improve and maintain productive soils and stimulate plant growth. According to current U.S. EPA regulations (40 CFR 503 regulations), biosolids must be applied at agronomic rates based on crop N requirements. Concerns about agricultural P pollution of surface water prompted the state of Maryland to require P-based agronomic rates. Because of the need to protect the Chesapeake Bay from nutrient contamination, several eastern states have developed programs for biosolid land application at predetermined rates, using subsurface injection or surface spreading, and usually followed by tilling to incorporate into the soil. Nitrogen is released slowly throughout the growing season, and therefore not released into ground or surface waters—again protecting the Chesapeake Bay watershed. There are mandatory waiting periods between biosolid applications and crop harvesting or pasturing.

The original use of N requirements is gradually changing because applying biosolids at agronomic rates based on crop N requirements leads to P accumulation in the soil; biosolid borne-P often exceeds crop removal. Many states have P-index rating systems in place, including Colorado, which has developed a P risk index for confined animal feeding operations (CAFOs) that accounts for differences in soil permeability, slope, soil-test P concentrations, P application rates, P application method, and best management practices (e.g., credits for reducing potential off-site P movement).

A recent article in the May–June 2007 issue of the Journal of Environmental Quality (“Biosolids Impact Soil Phosphorus Accountability, Fractionation, and Potential Environmental Risk”) reported on specific portions of a larger experiment described by researchers from Colorado State University, aimed at determining P bioavailability in biosolid-affected soils. The field study began in the summer of 1982 on plots approximately 18.6 miles east of Brighton, CO. The plots were planted with a dryland wheat (Triticum aestivum L.) summer fallow, conventional tillage rotation system in which one crop was produced every other year.
The soil was a Platner loam (fine, smectitic, mesic Aridic Paleustoll). Littleton/Englewood, CO wastewater treatment facility (L/E) biosolids were generated by anaerobic digestion followed by approximately two months of sand-bed drying. Biosolid samples were collected just before application and kept refrigerated at approximately 3°C until chemical analyses. After digestion with HClO₄–HNO₃–HF–HCl, elemental composition of biosolid samples was determined using inductively coupled plasma–atomic emission spectroscopy (ICP–AES). Every second year between 1982 and 2002, except in 1998, biosolids were applied at varying rates (0, 3, 6, 12, and 18 dry tons/acre). Biosolids were not applied in 1998 because the land was intended to be sold to developers in that year. Beginning in 1992, the highest application rate was discontinued with the overall goal of determining how much time was needed for agronomic parameters in these high-application plots to return to the control levels (e.g., received no biosolids or fertilizer application during the rest of the study). Biosolids were weighed and corrected for moisture content, evenly spread over the plots using a front-end loader, hand-raked to improve the uniformity of distribution, and incorporated to a shallow depth with a rototiller. The objectives were to assess the 20-year impact of repeated, increasing biosolid applications on (i) the total recovery of P applied in biosolids, (ii) the dominant inorganic and relatively labile organic soil P phases, (iii) the degree of phosphorus saturation of surface soils, and (iv) the evaluation of the P index and risk assessment using the Colorado Phosphorus Risk Index.

Yearly and cumulative amounts of P added with each application rate were calculated based on biosolid P content and load. Grain samples were taken each year, digested with concentrated HNO₃, and analyzed for P. Yearly and cumulative mass of grain P removed were determined based on P content and grain yield. Phosphorus contained within wheat straw was assumed to be returned to the soil during conventional tillage practices. The potential soil P accumulation was estimated as the difference between the amount of biosolid P added and the amount of P removed in grain. The actual increase in soil P (at shallow and moderate depth) was calculated from the difference between the background (i.e., 1982) and 2003 soil P concentrations.

In tests of soil to about 8 inches deep, it was found that Ca-P phases were most often found in this system. Research determined the additional amount of P that could be sorbed by the soil at that depth using the difference in the initial and final-solution P concentrations. Using the predictive tools formulated by the experiment, the amount of P was predicted at various depths of soil, but actual and predicted increases for each treatment compared poorly. However, increasing the soil P-sorbing capacity by adding P-sorbing materials can be considered for fixing excess soil P, preventing off-site movement and subsequent waterway eutrophication. One such method increased amounts of Al-based water treatment residuals (WTR) to the treated soil described in this paper and showed that, at a ratio of 4:10 WTR/soil or greater, water-extractable P significantly decreased to near detection limits. A number of studies suggested promoting WTR use as a best management practice to reduce P loss from agricultural land, so that addition of P-sorbing materials to systems similar to that discussed in this research can prolong their life expectancy regarding long-term biosolid application and P loading.

The agronomic rate of biosolids presented in this study resulted in a risk index of 11, which is in the medium category for potential risk for off-site P movement. Biosolids application could continue to be based on the crop N needs, and P accumulation should not be a problem. A doubling of the dryland wheat agronomic rate increased the AB-DTPA soil test P concentration to a level considered “very high” based on the Colorado P Index. This resulted in a risk index of 12 and placed this application rate in the “high” category for potential off-site P movement. Biosolid application would have to be based on crop P requirements, not N. This would limit the amount of biosolids that could be land-applied, and a supplemental N source would have to be applied to supply crop N requirements. Based on previous research, biosolid land application would need to cease for about six years to allow a reduction in soil test P levels comparable to agronomic rates, thus reducing the overall risk of off-site P movement. These results emphasize the need to strictly follow sound environmental practices when applying biosolids.

If biosolids are to be included in future risk indices, a complete biosolids analysis should be considered, especially regarding Fe and Al content. The current Pennsylvania P index groups biosolids and manures into a single category, yet research shows that most biosolids studied had runoff P losses less than dairy manure. In the case of Philadelphia, PA biosolids, Fe content was exceptionally high due to disposal of Fe-based WTR into the sanitary sewer system.

Forty-seven states have adopted a P index approach, yet only nine use estimates or weighting factors for determination of organic-P-applied availability. In terms of best management practices, using P source coefficients for individual biosolids has been suggested because the susceptibility of P to leaching and runoff is variable, and without source coefficients, site vulnerability risk could be compromised. Biosolid source coefficients would reflect the portion of total applied P susceptible for off-site transport. Other best management practices could include the addition of P-sorbing materials (e.g., WTR) at time of application.

Conclusions

- After 20 years of repeated biosolid land application at various rates to dryland winter wheat, between 93 and 128% of the added P can be accounted for via soil displacement from conventional tillage practices, grain removal, and soil adsorption.
- Increasing biosolid application increased the Al-P, Fe-P, and occluded-P fractions and the occluded-P fraction in the 0- to 8-inch to 8- to 24-inch depths, respectively.
Fall 2007 Self-Study Exam

Soil phosphorus is affected by biosolid application (no. SS 03756)

1. What are biosolids?
   - b. Decaying plant materials.
   - c. Residue from cotton and paper mills.
   - d. Untreated sewage products.

2. How many states use a P index approach, and how many use a determinant for organic-P-applied availability?
   - a. 52 and 3.
   - b. 47 and 9.
   - c. 26 and 8.
   - d. 52 and 4.

3. Of the two organic fractions studied, labile organic P dominated the soil surface, while biomass organic P dominated the subsurface. Biomass P decreased and increased with increasing biosolid application in the 0- to 8-inch and 8- to 24-inch depths, respectively. This suggests that
   - a. the formation of other soil P phases would be expected.
   - b. the formation of other soil P phases would be unlikely.
   - c. P reduction would be caused by excessive rain.
   - d. P was decreased because of increased dissolved oxygen.

4. The average biosolids P/Fe molar ratio indicated that biosolids did not contain enough Fe to bind P completely, and
   - a. the formation of other soil P phases would be expected.
   - b. the formation of other soil P phases would be unlikely.
   - c. the P concentration would increase.
   - d. N would be affected.

5. Of the two organic fractions studied, labile organic P dominated the soil surface, while biomass organic P dominated the subsurface. Biomass P decreased and increased with increasing biosolid application in the 0- to 8-inch and 8- to 24-inch depths, respectively. This suggests that
   - a. the formation of other soil P phases would be expected.
   - b. the formation of other soil P phases would be unlikely.
   - c. P reduction was caused by excessive rain.
   - d. P was decreased because of increased dissolved oxygen.

This exam is worth 1 CEU in Soil & Water Management. A score of 70% or higher will earn CEU credit. The International CCA program has approved self-study CEUs for 20 of the 40 CEUs required in the two-year cycle. An electronic version of this test is also available at www.certifiedcropadvisor.org. Click on “Continuing Education” and then “Self-Study CEUs.”

Directions

1. After carefully reading the article, answer each question by clearly marking an “X” in the box next to the best answer.
2. Complete the self-study exam registration form and evaluation form on the back of this page.
3. Clip out this page, place in envelope with a $15 check made payable to the American Society of Agronomy (or provide your credit card information on the form), and mail to: ASA c/o CCA Self-Study Exam, 677 S. Segoe Road, Madison, WI 53711. You can also complete the exam and pay online at www.certifiedcropadvisor.org ($12 charge).
5. Increasing biosolid application increased the
   a. calcium component at greater depths.
   b. Al-P, Fe-P, and occluded-P fractions and the occluded-P fraction in the 0- to 8-inch to the 8- to 24-inch depths, respectively.
   c. soil particulate size.
   d. formation of P-silicone aggregates.

6. After 20 years of repeated biosolid land application at various rates to dryland winter wheat,
   a. the wheat no longer absorbed P into the grain or straw.
   b. all of the added P was reclaimed from the grain and straw.
   c. between 93 and 128% of the added P can be accounted for via soil displacement from conventional tillage practices, grain removal, and soil adsorption.
   d. most of the P was leached into the water supply and lost into surface waters.

7. The current Pennsylvania P index groups biosolids and manures into a single category, yet research shows that most biosolids studied had runoff P losses
   a. less than dairy manure.
   b. more than chemical fertilizers.
   c. equal to pig herd manure.
   d. less than poultry litter.

8. Littleton/Englewood, CO wastewater solids were generated
   a. by aerobic digestion and spray drying.
   b. by anaerobic digestion followed by approximately two months of sand-bed drying.
   c. by anaerobic digestion and applied as liquid.
   d. by anaerobic digestion and drying by settling only.

9. The specific objective was to assess the 20-year impact of repeated, increasing biosolid applications on
   a. the total recovery of P applied in biosolids.
   b. how the biosolids affected N recovery.
   c. how P reacted with other minerals.
   d. whether P and N were recovered at all.

10. What controls the amount of biosolids that can be applied to a field?
    a. 40 CFR 503 regulations from the U.S. EPA.
    b. USDA regulations.
    c. Discretion of the local administrator.
    d. The physical ability to incorporate the material into soil.
Reconsidering integrated crop–livestock systems in North America

Humans developed agricultural systems that combined crop production with animal husbandry 8,000 to 10,000 years ago. These integrated systems provided a greater variety of products to a farm family than did either enterprise alone and offered a means of utilizing crop residues or noncultivated land to produce meat, milk, and associated products, while generating manure to improve the fertility and quality of cultivated soil. In the past 60 years, however, agriculture in many industrialized countries has become increasingly specialized, resulting in a separation of crop and livestock enterprises.

Although direct consumption of crops provides more protein and energy to humans than when crops are processed by livestock, and although some livestock production systems have contributed to environmental degradation, livestock can utilize crops and residues not suitable as food and fiber for humans. In addition, crop–livestock systems that are appropriately integrated and intensified for the location can provide multiple benefits.

Some believe that cheap resources lead to specialization, whereas restricted use of resources leads to mixing of crop and livestock enterprises. In an analysis of agricultural systems around the Great Lakes, it was concluded that cheap fossil fuel energy was responsible for de-emphasizing pasture in beef and dairy production, abandoning the one real advantage that ruminants have over other animal classes, namely their ability to convert cheap, environmentally benign, scale-neutral feedstuffs into human-usable products. With decreasing economic margins, higher energy and fertilizer N costs, declining soil organic matter levels, increasing concerns over the long-term sustainability of many contemporary agricultural systems, and greater regulation of agricultural practices, it is time to reconsider the potential benefits of integrating livestock and crop production. Current interest in this topic is evidenced by a number of research trials and programs that examine various facets of integrated systems, a small selection of which are listed in Table 1. Such studies can be used to develop improved farming systems that integrate crop productivity, manure use, animal health, soil and water quality, and economic returns. The objective here is to provide a general review of some of the benefits and challenges associated with these integrated systems.

### Improved cropping systems

Integration of livestock and crop enterprises generally entails changes in crop rotations. About 80% of the Corn Belt...
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The region of the USA is in a simple two-species, corn–soybean rotation. In the northern Great Plains of North America, typical farms produce either winter wheat in rotation with fallow or a limited number of other grain crops. Multiple agronomic and environmental benefits can be realized when land is converted from annual cropping to rotations that include perennial forages. Introduction of perennial crops into previous annual crop systems has reduced the risk of environmental damage during the perennial cropping phase by decreasing nitrate leaching and nearly eliminating soil erosion by water and wind. Perennial cropping can also increase soil organic matter levels. Improvements in soil organic matter content are correlated with improved soil tilth, water-holding capacity, nutrient supply, and higher grain yield potential. Simply changing crop rotations, however, does not necessarily alter soil organic matter levels.

One of the keys to environmental protection with perennials is reduction of N losses. Alfalfa in crop rotations, for example, can utilize excess soil N and reduce nitrate leaching compared with annual crops. In one study at a fertilizer spill site, alfalfa removed 870 lb/acre over three years, more than threefold that of annual grain crops. Perennial legumes, like alfalfa, also add large amounts of available N to the farm in feed and soil organic matter. Estimates of fixed N in harvested alfalfa range from 40 to 400 lb/acre in the Mississippi River Basin, depending on yield and soil N availability, and estimates of net soil N addition range from 90 to 135 lb/acre from a three-year alfalfa hay crop. For this reason, legumes like alfalfa have reduced fertilizer N requirements for succeeding nonlegume crops by up to 100%, thereby reducing input costs, energy demands, and environmental impacts of farming.

Another improvement from diversifying cropping systems is that they reduce yield losses from insects, weeds, and diseases. These multiple mechanisms have contributed to improved resilience of cropping systems with forage legumes. However, such systems are not obtained without risk. Reduction of soil erosion during perennial establishment on sloping land requires companion cropping and/or conservation tillage. Similarly, to minimize runoff of dissolved P, farmers need to limit P accumulation in perennial vegetation and soils and reduce or avoid application of P fertilizer and manure near surface water. Because soil nitrate concentrations can increase when growing alfalfa, rapid establishment of a nonlegume to reduce the risk of nitrate leaching after alfalfa is required.

Integrating livestock into cropping systems is perhaps most critical in organic crop production. Long-term organically managed commercial farm fields are showing signs of P deficiencies, and hence nutrient recycling via ruminants may be critical to long-term sustainability of these soils. While nutrient recycling and also weed control benefits of forage crops are well known to organic farmers, a high proportion of northern Great Plains organic farms do not include forage crops in their rotations.

Just as crop selection is dictated by climate, factors such as slope, past erosion, soil depth, soil texture, and drainage status, etc. should be considered in the selection, sequence, and placement of crops. Alfalfa provides significant protection for water quality and enhances subsequent crop yields in humid environments but can reduce subsequent crop yields because of excessive subsoil moisture depletion in semiarid environments. For this reason, annual legumes may be superior to perennial legumes in drier regions. Maximum environmental and economic benefits from diverse cropping systems may accrue when a well-adapted forage crop is placed strategically in the landscape. A study in western Iowa evaluated the likely environmental impacts if land use were converted from primarily corn–soybean cropping (70% of the current land area) to integrated crop–livestock farming. The alternative land use scenario involved a two-year corn–soybean rotation limited to slopes <5%, a six-year corn–soybean–corn–oat /forage–forage–forage rotation on 5 to 14% slopes, and permanent pasture on steeper land. The researchers estimated that annual soil erosion loss would decrease to <3 tons/acre from the current 10 tons/acre. Median annual N load in streams also would decrease by 28%.

Integrating livestock

Economic and environmental benefits are enhanced when crop rotations with forages include livestock enterprises. Of primary importance is economic return. Farmers already have integrated beef cattle production onto cropland in the Great Plains to improve profitability. In North Dakota, for example, a study showed net worth was nearly $9,000 greater for farms with crops and beef cows compared with crops only. Crop residues represent a large source of biomass for ruminant feed in areas where utilization would not increase the risk of environmental degradation. Beef cows can utilize both forage and crop residues, whereas calves can be fed grain during preconditioning and finishing.

Recycling of crop C through manure and decomposing residues improves soil C sequestration. Grazing effects on soil C storage may vary with grazing intensity, grassland type, or precipitation gradient. The net effect on global warming due to greenhouse gas emission is largely unknown because increased nitrous oxide emission from grazed or manured land and increased methane emission from ruminant livestock offset lower net carbon dioxide emission from grassland. More research is needed to quantify the net balance under different environments.

Improved manure use

The importance of manure as a source of recycled nutrients has been recognized for millennia. The economic value of manure, though significant, has not overcome the convenience and relatively low cost of inorganic fertilizers, and the lower confidence farmers have in nutrient supply from manure. Larger, more specialized livestock operations that import nutrients from distant sources have resulted in high
nutrient concentration in localized areas. These factors can contribute to excessive manure (or total nutrient) application and subsequent degradation of water resources, which in turn can lead to regulations.

Laws that regulate manure application rates and methods have changed the siting and expansion of concentrated animal feeding operations (CAFOs). Manure transport from CAFOs has become more expensive because of increased attention on achieving appropriate nutrient application rates. Both N and P are causes for environmental concern when applied excessively. There have been several technological solutions developed for manure-generated problems, including use of phytase in nonruminant diets to increase P use efficiency and lowering the P levels in ruminant diets to reduce P excretion. These solutions reduce manure P concentration and therefore allow greater manure application rates. Other approaches, such as altering dietary N, composting, secondary treatment, and methane generation are also possible.

Manure contains partially digested and transformed plant-derived N and C, which contribute to soil organic matter maintenance and accumulation. In addition, bedding included in solid manure or litter increases the C application rate. The value of manure for C sequestration, however, may have declined with a reduction in organic bedding used in barns and contained in manure slurries. Manure slurries are easier to move and apply but may contribute less to soil organic matter levels than solid manures (mixed with bedding) when compared on the basis of equal C loading. However, there is a lack of quantitative information about the stability of manure C, which limits our ability to predict soil C response.

The main limitation to manure distribution from concentrated livestock facilities may be unwillingness of other farmers to accept the manure; the second most important limitation is the energy requirement, and therefore the economic cost. With higher fossil fuel prices, the cost of transport increases, but other farmers are more likely to accept manure as a means of reducing their payments for commercial fertilizer. Under an N-based application standard in the Chesapeake Bay watershed, average hauling distance for manure-producing farms was estimated at 23 miles when 100% of farms without livestock were willing to accept manure, but 75 miles if only 20% of such farms were willing to accept manure. Given 100% willingness to accept manure, but changing from a N-based to a P-based standard, average hauling distance increased from 23 to 40 miles. In a Manitoba study using N-based manure application rates, the fossil fuel energy costs associated with application of pig slurry (agitation, pumping, and field injection) 1 mile from the barn required 60% as much energy as using inorganic N fertilizer. The energy cost of applying this manure increases further if: (i) the distance from the barn increases and (ii) as the basis for manure application changes from N to P. Thus, substantial energy savings can be realized by reducing the distance that feed and manure are transported, and this can be achieved by integrating crops with livestock on individual farms or by integrating operations among local farms.

Nature and scale of integration

During the past several decades, most literature on crop–livestock integration has come from developing countries where integration is linked to improved soil fertility, and hence crop yield, and animal power. While the principles of integration, especially nutrient cycling, are similar among countries, the nature of crop–livestock integration in industrialized countries is different mainly because the drivers for change are different. Two main drivers for integration in North America are environmental problems associated with excess nutrients from intensive livestock operations and the high cost of energy needed to sustain monoculture grain production systems.

There are two practical scales of integration of crop and livestock farming enterprises: (i) within-farm integration and (ii) among-farm integration. Some have argued that with time and sophistication of agricultural systems, crop–livestock integration would move from a local (within-farm) to a regional (among-farm) scale. The notion that all integration eventually ends up at the regional level is attractive to large-scale agribusiness and national policymakers who often prefer large, industrial-scale systems with fewer stakeholders. However, other examples show crop–livestock integration is dynamic and that both within-farm and among-farm integration are practiced and worthy of scientific exploration. Individual farmers differ in knowledge and management skills, so integrated systems need to be appropriately designed and adapted.

Within-farm integration

Because of complementary interactions such as nutrient “sharing” and biological pest control, integrated systems can exhibit better physical and financial stability than specialized enterprises. Market signals require rapid response
from specialized producers, whereas managers of integrated systems can take more time to determine whether economic trends are persistent, and if so, alter the mix of enterprises.

In areas previously dominated by perennially based crop–livestock systems, optimum cropping strategies may involve more annual cropping. This is best exemplified in other countries, where perennial pastures have played a larger role in modern livestock production. In response to market signals, the past decade has seen a shift toward less perennial pasture and a greater proportion of annually cropped land on mixed crop–livestock farms in much of southern and eastern Australia. Integrated systems have included leys, where pastures are regenerated after each cropping cycle. In the case where crop residues were grazed, however, no sown pasture component was necessarily present. On highly permeable soils near Hamburg, Germany, it has been reported that conversion of some grass silage and grazed land to corn silage would reduce N loss by 17% while improving net economic return to management by 11%. Increased economic return largely was due to improved milk production from adding corn silage to the ration, while reduced N losses occurred because a better balance between degradable protein and energy in the ration reduced N excretion. A mix of short-term pastures and annual silage crops also has been increasingly adopted for ruminant finishing and dairying operations in New Zealand.

Within-farm integration with ruminants often includes grazing for part of the year. Examples of such systems are grazing winter wheat in early spring in the southern Great Plains, and extended grazing with late-season grain crops (e.g., swath grazing) in the northern Great Plains. Grazed dairy systems appear to have similar profitability as confined systems, suggesting that farm management skills play a major role in both systems. Although grazed dairy cattle may have lower somatic cell count in milk and relatively high reproductive success than cattle in confinement systems, breed differences will affect system performance. Better performance of Jerseys than Holsteins with regard to conception success may make Jerseys the better choice for seasonal calving operations. Milk and meat produced on pasture may be suitable for market niches (such as “free range” labeling) that can improve product value because of perceived or actual improvements in animal welfare. Human health benefits from ruminant animal products in forage-fed systems, especially pastures, are related to higher levels of omega-3 fatty acids and conjugated linoleic acids.

Integration of livestock on crop farms would likely increase the complexity and rapidity of N cycling. Just as in fertilized crops, N losses increase rapidly when inputs exceed the level required for maximum production. This means that farmers on integrated crop–livestock farms need to be more cognizant of nutrient flows on the farm and, in particular, need to recognize and appropriately credit nutrient availability from manure. Additionally, the unevenness of nutrient distribution in pastures due to animal behavior may require management approaches that encourage more random distribution of excrement to prevent adverse environmental outcomes.

The idea of integrating crop and livestock production—of adopting more complex crop rotations; a wider array of equipment; more restricted crop protection chemical programs; greater workload through the year; increased skills in crop, soil, and animal management; and detailed knowledge of marketing a broader range of products—may not be palatable for everyone. Nor does it need to be. Another means of achieving some of the synergies provided by integrated crop–livestock systems is by integrating across farms.

Regional (among-farm) integration

Where government regulations for nutrient management exist, growth in CAFOs has required partial integration among farms to distribute the manure on cropland or pasture. These arrangements have been and largely remain unidirectional—manure moves from the feeding operation to other farms, but nutrients do not necessarily return directly as feed. Furthermore, farmers who receive the manure often do not adequately account for its nutrient supply.

On dairy farms in Wisconsin, the average area of land available for manure spreading was 2.5 acres per animal unit for farms with <50 cows, but only 1.5 acres for farms with >200 cows. The area available has dropped by 27% between 1997 and 2002 for the larger farms. Furthermore, a majority of Wisconsin dairy farmers spread all manure on fields within a 5-minute driving distance from the barn. The median proportion of land that received manure ranged from 23 to 44% of total available cropland. Less land receives manure as the relative amount of rented land increases, presumably because farmers do not want to invest this resource on land they might not be allowed to utilize in the future.

A variety of planning approaches for integrating manure management among farms is being pursued. Expanding the idea of using a geographic information system (GIS) approach to manure allocation within a farm (e.g., the Missouri Spatial Nutrient Management Planner www.cares.missouri.
researchers had used data from several sources to classify land that is suitable for manure application (based on slope, land cover, soil characteristics, and distance from surface water) and categorize the parcels into priority acres (little or no restrictions except soil nutrient levels), cautionary acres (runoff or leaching concerns), and acres that are unsuitable for manure application. Such map products can be used to help farmers or agricultural consultants locate manure producers or potential acceptors.

There are, however, examples of more fully integrated neighborhoods of farms, two of which are described here. Hytek Ltd. is a company formed by specialized farmers in Manitoba that integrates beef cattle, swine, pastures, and grain crop operations among farms. Manure is used to fertilize annual grain crops and pasture, grains are processed and utilized by livestock, and cow–calf pairs with replacement heifers are supported on pastures. In 2005, the company consisted of 40,000 sows; 100,000 finishing and young, segregated piglet sites; 600 cow–calf pairs; and 300 yearling heifers, supported by 500 acres of cropland, 2,000 acres of hay, and 10,000 acres of pasture. In this situation, the majority of grain (about 70%) was imported because most of the land in the immediate area is of low quality for grain cropping and traditionally is used as pasture.

In Maine, a number of regionally integrated potato–dairy farm operations have developed, in which land and other resources are shared and manure is applied to land that has not received it earlier. There were three common outcomes noted by the farmers: (i) increased soil quality (i.e., improved friability and water-holding capacity), (ii) increased proportion of marketable potatoes, and (iii) improved crop yield. Farmers emphasized the need for trust between partners that was based on a handshake rather than formal contracts. They also showed little interest in assigning an explicit economic value to exchanged goods and services. Key issues limiting broader development of these relationships were distance between farms (ideally <15 miles), basic trust between individuals (which required lengthy relationships or references from other farmers), and a willingness to begin slowly with modest exchanges. An advantage in these among-farm collaborations is that more people have a stake in assuring successful and mutually acceptable outcomes. Questions remain as to whether these collaborations might achieve the same range of synergies as within-farm integration.

At either scale of integration, farmers’ goals must be met at least as well as they would be in other systems. These goals will vary according to cultural background, but a recent list from Australia reveals deep interest in achieving environmental goals, a clear need to improve and stabilize profitability, and a desire to have weekends off and annual vacations (Table 2). There is growing realization that agriculture can contribute not only to food and fiber production for society, but also to environmental services, such as water quality protection, wildlife habitat, landscape scenery, flood control, nutrient cycling, and C sequestration, as well as to the quality of life on farms.

Large-scale research initiative needed

Despite numerous challenges for integrating crop and livestock production, synergies in these systems provide significant benefits in profitability and environmental sustainability and do not necessarily involve trade-offs between profitability and improved environmental outcomes. For example, greater profits may accompany declines in soil erosion and improvements in soil organic matter, as shown in a number of long-term integrated crop–pasture and crop–livestock experiments.

There is a need for more advanced research on crop–livestock systems within the climatic and soil conditions and policy environments in which they will be employed. A challenge will be to integrate crop and animal researchers, most of whom now work separately and have different experimental requirements. Because animal scientists

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<th>Table 2. Major goals articulated by farmers at a workshop in New South Wales, Australia.</th>
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require many animals per treatment, the labor and land-base requirements for these integrated field experiments will be larger than what most crop scientists have used. On the other hand, adequate assessment of economic and environmental outcomes will require longer-term experiments than are typical in animal science research. We suggest that a coordinated national or international program will produce better results than regional and local efforts, even considering the high quality of those listed in Table 1. The program would require: (i) in-depth analysis to determine what combination of crops, livestock, and inputs to test; (ii) large research and extension teams to examine various aspects of system performance; (iii) patience on the part of researchers and funding entities to collect data over a sufficient time period to understand behavior with varying weather conditions; and (iv) sufficient funding to support the required staff, facilities, equipment, and analyses. Problems raised in these systems would be similar to those in the Long Term Ecological Research (LTER) studies that have been undertaken in the USA and elsewhere over the past quarter century. Much of the experience, methods, and knowledge developed in the LTER program could be used to develop a new, competitive, integrated agricultural systems grant program producing fundamental knowledge with immediate application in agriculture.

While simulation models could be an important first step in exploring climatic, soil, and management scenarios and could be useful in determining “best-bet” integrated systems, the complexities of integrated systems might limit the reliability of models. Moreover, practitioners will want to see real data. Integrated crop–livestock systems are fundamentally knowledge intensive, and experienced extension personnel likely will be more valuable than simulation models as farmers and agricultural consultants design their systems. In any case, human resources would be a critical part of the package and would complement model output.

Current research and extension are not sufficient, and changes in agricultural policy likely will be needed to help achieve the environmental benefits that integrated crop–livestock systems offer. It appears that in the United Kingdom and Western Europe, a switch from production- or area-based payments to stewardship payments has diversified agricultural practices. A similar change in farm subsidies in the U.S. from commodity support to adoption of conservation practices should lead to agricultural diversification through the Conservation Security Program. With increasing costs for inputs like diesel fuel, natural gas, and fertilizer, it can be anticipated that North American farmers also will be seeking alternative practices to help them achieve their short- and long-term goals.


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**Fall 2007 Self-Study Exam**

Reconsidering integrated crop–livestock systems in North America (no. SS 03754)

1. The primary advantage of integrated crop–livestock production systems is that
   - [ ] a. livestock can utilize food sources not suitable for humans.
   - [ ] b. they eliminate environmental problems.
   - [ ] c. livestock can provide more protein and energy for humans than direct consumption of crops alone.
   - [ ] d. they are most cost effective when energy sources are inexpensive.

2. Combining crop and livestock enterprises generally means changes in
   - [ ] a. crop rotations.
   - [ ] b. animal species used.
   - [ ] c. how soil nutrients are tested.
   - [ ] d. income expectations of farm operators.

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This exam is worth 2 CEUs in Crop Management. A score of 70% or higher will earn CEU credit. The International CCA program has approved self-study CEUs for 20 of the 40 CEUs required in the two-year cycle. An electronic version of this test is also available at www.certifiedcropadviser.org. Click on “Continuing Education” and then “Self-Study CEUs.”

**Directions**

1. After carefully reading the article, answer each question by clearly marking an “X” in the box next to the best answer.
2. Complete the self-study exam registration form and evaluation form on page 32.
3. Clip out all exam pages, place in envelope with a $15 check made payable to the American Society of Agronomy (or provide your credit card information on the form), and mail to: ASA c/o CCA Self-Study Exam, 677 S. Segoe Road, Madison, WI 53711. You can also complete the exam and pay online at www.certifiedcropadviser.org ($12 charge).

3. A general characteristic of integrated crop–livestock programs and research sites is that they are
   - [ ] a. located in states with significant livestock numbers.
   - [ ] b. concentrated in the Corn Belt.
   - [ ] c. 20 or more years old.
   - [ ] d. privately owned and financed.
4. The percentage of the U.S. Corn Belt that is in the two-species corn–soybean crop rotation is about
   - a. 40%.
   - b. 60%.
   - c. 80%.
   - d. 100%.

5. Increases in soil organic matter are associated with increases in each of the following EXCEPT
   - a. soil tilth.
   - b. soil erosion.
   - c. water-holding capacity.
   - d. grain yield potential.

6. An advantage of alfalfa in crop rotations is that it
   - a. can utilize excess soil N.
   - b. is inexpensive to establish.
   - c. has few insect and disease concerns.
   - d. needs small amounts of phosphorus and potassium.

7. A disadvantage of using alfalfa in drier climates is that it
   - a. is difficult to establish.
   - b. can increase soil salinity.
   - c. depletes soil moisture.
   - d. suffers greater winter kill.

8. A risk associated with a more diverse cropping system is
   - a. increased disease.
   - b. soil erosion that can occur during perennial crop establishment.
   - c. potassium leaching when manure is applied near surface water.
   - d. nitrate leaching under perennials.

9. A method to reduce the amount of phosphorus in manure is
   - a. using phytase in nonruminant diets.
   - b. ensiling grain.
   - c. rations low in calcium.
   - d. the use of hormones and supplements to increase production.

10. Factors that would increase the economic value of manure applied as opposed to inorganic fertilizers include
    - a. low energy prices.
    - b. low fertilizer prices.
    - c. application sites close to livestock.
    - d. soils high in organic matter.

11. A driver for more integration of crop and livestock farming operations is the
    - a. high amounts of energy needed for monoculture grain production systems.
    - b. need for specialization to achieve greatest efficiency.
    - c. presence of traditional farm commodity support programs.
    - d. environmental advantage of nutrient dispersal associated with intensive livestock operations.

12. Examples of within-farm changes that can occur when integrating crops and livestock include all of the following EXCEPT
    - a. more annual crops in areas previously dominated by perennial forages.
    - b. grazing certain crops for part of the year.
    - c. changing animal breeds.
    - d. eliminating managed grazing.

13. In Maine, the advantages of integrating dairy with potato production included
    - a. increased soil friability.
    - b. higher prices received for potatoes marketed.
    - c. elimination of disease concerns.
    - d. developing contracts that better defined relationships.

14. A geographic information system (GIS) approach to integrating manure management among farms might include
    - a. identifying land suitable for applications.
    - b. using remote sensing to detect soil nutrient status.
    - c. using autoguidance to precisely apply nutrients.
    - d. tracking the intake and excrement of nutrients in an animal confinement operation.

15. A policy change that could aid diversification is a switch to more
    - a. stewardship incentives.
    - b. production-based payments.
    - c. relaxed regulations on CAFOs.
    - d. on-the-go soil nutrient sensors.

16. One of the overall goals listed by Australian farmers included
    - a. guaranteed income payments.
    - b. relaxed environmental emphasis.
    - c. matching land use with capability.
    - d. avoiding vertical integration and its associated loss of independence.
17. A characteristic of existing among-farm integration of crops and livestock includes

- a. an even two-way flow of nutrients between grain farms and livestock operations.
- b. a greater tendency to apply manure on rented ground.
- c. decreasing amounts of land on which to spread manure.
- d. lowering of environmental standards to expedite cooperation between crop and livestock systems.

18. A characteristic of larger, more specialized livestock operations is that they

- a. can concentrate nutrients in local areas.
- b. are less efficient than smaller operations.
- c. contribute more to global warming.
- d. have been shown to decrease the quality of life in rural areas.

19. Challenges associated with research in integrating crop and livestock production include

- a. a lack of technical skills to be able to develop simulation models.
- b. government restrictions related to animal welfare.
- c. the importance of limiting research trials to just one year.
- d. building relationships among crop and animal scientists.

20. In addition to research and extension, advancing integrated crop–livestock systems requires

- a. changes in agricultural policy.
- b. increases in commodity payments.
- c. plant breeding programs to develop varieties that respond better to manure.
- d. support from animal health and crop protection companies.

**SELF-STUDY EXAM REGISTRATION FORM**

Name: ________________________________

Address: ________________________________ City: ________________________________

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- $15 check payable to the American Society of Agronomy enclosed. CCA certification no.: __________________

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Signature as it appears on the Code of Ethics: __________________

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

*This exam issued September 2007 expires September 2010*

**SELF-STUDY EXAM 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: ____________________________________________________________
Farm bill update  
By Luther Smith, Director of Certification Programs

In the summer issue of Crops & Soils, we thought we might have a new farm bill ready to go before Congress. At this writing, we have the House-passed version and the Senate draft with hopes of a compromised version in September. There is still a chance that the current farm bill will be extended for another year or two. Some groups support the extension since they don’t like what might get passed while the Senate agriculture committee promises to have a new farm bill by the end of September.

ASA and SSSA, along with its certification programs, do not focus on all issues that are covered by the farm bill. The certification programs have focused on the delivery of technical assistance (TA) through the technical services provider (TSP) program. This was new in the 2002 farm bill, and we have suggested some adjustments to it in hopes of improving the process.

The following five points were suggested to House and Senate agriculture committee staff—here is where each point currently stands in the House and Senate versions of the bill:

A. Farmers should be allowed to make the decision on which TSP they use for technical assistance whether government or nongovernment qualified individuals.

Update: The House and Senate versions contain this language.

B. The current pilot test project that USDA-NRCS is working on with ASA and SSSA through their certification programs (i.e., CCA, CPAg, and CPSS) should continue with the results implemented. This process will streamline the certification and renewal of TSPs in nutrient, pest, and irrigation management while incorporating the new performance criteria developed by USDA. These certification programs are recognized through memoranda of understanding (MOUs) with USDA and set the standard of their respective professions of agronomy and soil science.

Update: The farm bill versions empower the Secretary of Agriculture to establish a certification process for TSPs, effectively allowing the potential for Point B to be implemented in the rules process. This point is really at the agency level and working with USDA to implement an acceptable standard. We are currently doing that and will continue to do so. The pilot tests were recently evaluated, and the eight states that are participating agreed to continue the process through the end of the year.

C. USDA should eliminate the not-to-exceed (NTE) rates and should utilize the farmers’ current service providers, where appropriate, to save resources by engaging the farm’s current agronomist or soil scientist who already understands the resource conditions of the farm.

Update: The NTE rates are being changed. This is mentioned in the House version to move towards a market-based approach. The agency is already considering going to a “reimbursement” approach, but it will still need to compare to what it would cost NRCS to provide the service.

D. USDA should eliminate the self-certifying option to avoid the potential of certifying unqualified individuals and eliminate a double standard where professionally certified individuals like CCAs, CPAg’s, and CPSS’s are certified at a higher standard.

E. USDA should only utilize established certification and licensing programs to avoid unnecessary redundancy.

Update: The last two items (D and E) could be included in the rules process. The agency will determine how best to implement the new standards where we will encourage these two points to be included.

The commodity section of the farm bill, for the most part, looks pretty much like the 2002 version. There were no major changes though many conservation-minded groups tried in the House version and now will focus on the Senate version. Conservation programs are pretty much intact with increased funding for EQIP. Available funding is the primary issue for all programs. The Senate version merges several conservation programs into the comprehensive stewardship incentives program. The Senate will debate its version and then conference with the House to have a final draft by October 1, when the current farm bill expires. Nothing is final at this point. Stay tuned...

EPA announces CAFO rule changes

The EPA is extending the dates for newly defined concentrated animal feeding operations (CAFOs) to seek National Pollutant Discharge Elimination System (NPDES) permit coverage and for all permitted CAFOs to develop and implement nutrient management plans (NMPs) as required by EPA’s 2003 CAFO Rule. The extensions are necessary to allow the agency time to finalize a rule in response to the decision issued by the Second Circuit Court of Appeals in Waterkeeper Alliance et al. v. EPA. The EPA is setting February 27, 2009 as the new date for newly defined CAFOs to seek water permit coverage and for permitted CAFOs to develop and implement their NMPs. For further information, visit www.epa.gov/npdes/caforulechanges. Photo courtesy of New Mexico State University’s News Center.
Cotton picker

John Deere recently introduced its 7760 Self-Propelled Cotton Picker, which the company says has an industry-exclusive on-board round module builder.

“This is a big step forward in new technology to bring even more productivity to our customers in their cotton-harvesting operation,” explains Jamie Flood, product marketing manager, John Deere Des Moines Works. “The 7760 Picker will build a round module on the machine while harvesting cotton. Then it will wrap the cotton module in a protective film to preserve fiber and seed quality and minimize any crop loss during handling and transport.

“Without ever stopping the machine during picking, the operator can then carry the module to the end of the field to be transported later to the gin. This efficient, nonstop harvesting system eliminates unloading into a boll buggy and processing in a module builder. Ultimately, the producer saves time, fuel, and manpower when harvesting and processing the cotton.”

The module builder receives the cotton from the accumulator. Together, a rockshaft and 11 heavy-duty rubber belts inside the module builder gently shape the round module into a size from 36 to 90 inches in diameter. The completed round package, wrapped by the special protective film, is then ejected onto a module handler, which holds the package until the operator is ready to drop the module. The wrapped module, unloaded at the end of the field, is protected from the weather and provides easy transportation flexibility.

For more information, contact your local John Deere dealer or visit www.JohnDeere.com/Ag.

Herbicide tolerance traits

Dow AgroSciences recently introduced its new family of herbicide tolerance traits known currently as Dow AgroSciences Herbicide Tolerance (DHT). According to Dan Kittle, vice president of research and development at the company, this technology will enhance the performance of glyphosate and glufosinate cropping systems.

“DHT traits will enable the use of additional broad-spectrum herbicides with differing modes of action in both the burndown and postemergence application timings,” Kittle says. “These technologies will provide solutions to improve the control of hard-to-kill broadleaf weeds, reduce selection pressure for glyphosate resistance, and help to sustain the use of the glyphosate tolerance cropping system in crops like corn, soybeans, and cotton.”

For more information, see www.dowagro.com/homepage/index.htm.

Soil-sampling equipment

Forestry Suppliers, Inc. says its AMS Signature Series soil-sampling equipment can save time and effort. According to the company, the Signature Series thread design allows connection and disassembly with only 1.5 turns, significantly faster than with thinner thread designs.

“Because the threads are thicker and more durable than traditional threads, they can also withstand tough use in the field,” the company notes. “The rounded bail design is easy to use, and the cylinder holds almost 10% more soil than standard AMS augers. The auger bits are designed to speed the augering process even more."

For more information, visit www.forestry-suppliers.com.

Wheel loader

Case Construction Equipment introduces its new biodiesel-compatible wheel loader. The Case 621E Wheel Loader can be used to clean out barns, haul straw, move bedding material, and perform other necessary work on the farm.

The company says it is the first manufacturer to offer heavy construction equipment approved for use with a biofuel and diesel mixture.

“This is a major step forward for our industry and for the environment,” says David Wolf, marketing manager for Case. “Including biofuel in the blend helps reduce greenhouse gas emissions and reduce our dependence on foreign oil. It also supports the American farmer who grows the crops for biofuel.”

The Case 621E Wheel Loader has an electronically controlled engine that supplies up to 168 horsepower (125 kW). Its hydraulically controlled bucket can lift up to 3 yd³ of material (3,200-lb material density). The company says air conditioning, return to dig, ride control, and adjustability make the Case 621E Wheel Loader a favorite among equipment operators. It is easy to use and maintain.

For more information, see www.casece.com.
EQIP incentive payments attract farmers to higher-intensity nutrient management

By Bill Angstadt, Executive Secretary, Delaware Maryland Agribusiness Association, Reading, PA

Farmers strive for higher profits by achieving increased yields through more effective nutrient management. In several states, farmers can also receive USDA-NRCS payments for more efficient nutrient use, which leads to improved soil and water resource conservation.

The concept of higher-intensity nutrient management at NRCS began with one of its agronomists, Charles H. Lander, who wrote the following in 2003:

“NRCS has recognized that it is both possible and desirable to design and implement nutrient management systems that exceed the minimum requirements of 590. Such systems incorporate the use of the technologies or management activities identified in the considerations section of the standard. They may also include other management activities or technologies that are not even mentioned in 590.

“NRCS is developing a process that considers what we are calling the ‘Intensity’ at which nutrient management is planned and applied…”

Virginia NRCS offered the first higher-intensity nutrient management practices under the Environmental Quality Incentives Program (EQIP). Local fertilizer retailers then worked to obtain approvals for precision agricultural practices in Delaware, Maryland, and finally Pennsylvania (other states also have additional 590 practices under EQIP, such as Missouri, Illinois, Ohio, North Carolina, and others.)

Delaware EQIP FY 2005 offered incentive payments to farmers for improvements in nitrogen timing and product selections, such as “use of urease inhibitor and split application of nitrogen, or use of slow-release, controlled-release, or stabilized nitrogen fertilizers.”

And further, precision agriculture practices such as “utilizing a GPS and yield monitor system to collect field-specific crop data and a software/record keeping system that analyzes that data. The analysis then has to be utilized to adjust within-field inputs, including variable-rate fertilizer, lime, and/or variable-rate planting.”

Delaware and Maryland also offer EQIP incentives for pest management (595 National Conservation Practice Standard).

How to initiate in your state

Each state NRCS has a state conservationist who is advised by a state technical committee. Hopefully, your state retailer association has a designated seat on the state technical committee. The state agronomist and staff will usually work in the summer to review and update EQIP practices for the new federal program year (October).

At the Delaware Maryland Agribusiness Association (DMAA), we began our work with Ginger Murphy when she was Delaware State Conservationist, and her staff, Sally Kepfer and Les Stillson; and then fortunately Ms. Murphy was appointed to Maryland, and we continued our efforts. The principles of nutrient management intensity also became the basis for nutrient management in the Conservation Security Program in the four mid-Atlantic States:

- on-site nitrogen test (PSNT, chlorophyll, etc.)
- split nitrogen applications
- GPS/record keeping/yield monitoring
- variable-rate application
- slow controlled-released formulation nitrogen fertilizer
- incorporating manure within 24 hours
- applying manure based on P crop uptake

Incentive payments vs. technical assistance

Farmers that enroll in EQIP may need technical assistance from NRCS staff, conservation district staff, or technical service providers. Since fertilizer retailers with certified crop advisers (CCAs) were best positioned to assist farmers with the EQIP precision agriculture technologies, NRCS expected CCAs to provide the technical assistance. At DMAA, we made a decision to imbed the technical assistance dollars in the EQIP payment to the farmer, rather than separate the technical assistance payments from the incentive payments. This allowed for two important farmer and individual CCA benefits:

1. the farmer and CCA could maintain their current business relationship without interference by NRCS contracting technical assistance with an outside contractor; and
2. the CCA could bundle the fee for the technical assistance with other products and/or services without dealing with the “not-to-exceed” technical service provider payment structure.

The new farm bill Programs for 2008 will probably expand the opportunities for CCAs to advance higher-intensity nutrient management technologies to farmers in their states. Now is the time to pursue these opportunities through your state conservationist.

CORRECTIONS: In the spring issue of Crops & Soils, page 42, linolenic acid was defined as “one of the amino acids naturally found in grains.” It should have read, “one of the fatty acids naturally found in grains.” In the summer issue, page 13, Dr. Cliff Snyder’s location was mistakenly identified as Conway, AK. It should be Conway, AR. We apologize for any confusion.
Tips for storing this year’s harvest

With fall harvest underway for some and around the corner for others, producers need to prepare their storage bins, according to Ken Hellevang, North Dakota State University Extension Service agricultural engineer.

“Grain quality can be maintained in storage bins if managed properly,” Hellevang says. “It is a wise investment of time to spend a few hours maintaining a bin for the $40,000 to $80,000 worth of stored grain in each bin.”

He recommends these steps for preparing a bin for storage:

- Repair any holes that may allow water to enter. Look for holes by looking for sunlight coming into the bin. However, do not seal openings intended for aeration.
- Clean the inside of the bin using brooms and/or a vacuum.
- Examine the inside of aeration ducts for debris and insects.
- Service the aeration ducts, fans, and vents to ensure proper operation.
- Clean around the outside of the bin.

Grain stores best when it is dry, clean, and cool. Weed seeds and fine foreign material, which usually are wetter than the grain, will accumulate in the center when loaded into a bin, which can cause storage problems. This material should be removed from the grain by using a grain cleaner or other methods before storage.

Maintaining the right temperature

Temperature plays an important role in grain storage. The optimum temperature for insects is between 70 and 90°F, so grain should not be stored at this temperature. Cooling below 70°F reduces insect reproduction and feeding activity. Cooling below 50°F causes the insects to become dormant.

The optimum temperature for mold growth is about 80°F. Mold growth is extremely slow below 30 to 40°F. The expected grain allowable storage time is approximately doubled for each 10°F that the grain is cooled.

Aeration should be used to cool the grain whenever outdoor temperatures are at 10 to 15°F cooler than the grain. For winter storage, it should be cooled to a temperature of about 20°F in northern states and 30 to 40°F in southern states.

“The time required to cool grain weighing 56 to 60 pounds per bushel using aeration can be estimated by dividing 15 by the airflow rate,” Hellevang says. “For example, the grain will cool in about 75 hours using an airflow rate of 0.2 cubic feet per minute per bushel. Air takes the path of least resistance, so cooling times will vary. Measure grain temperature at several locations to ensure that all the grain has been cooled.”

Stored grain must be monitored, so insect infestations or grain spoilage can be detected before serious losses occur. Check stored grain biweekly during the critical fall and spring months, when outside air temperatures change rapidly, and during the summer. After the grain has been cooled to winter storage temperature, check the grain at least monthly. Check and record the grain temperature and condition at several locations.

The temperature history can be used to detect grain warming, which may indicate storage problems. Look for indications of problems, such as condensation on the roof or crusting of the grain surface. Probe to examine grain below the surface.

“Bring a grain sample indoors if the grain temperature is below 50°F and allow it to warm to room temperature,” Hellevang says. “Place the grain on a white surface and examine for any insect activity. Fumigation is not recommended when grain is stored at temperatures below 60°F. Most storage problems can be controlled during the winter by cooling the grain.”

More information about dry grain aeration, handling, and storage is available at www.ag.ndsu.nodak.edu/abeng/postharvest.htm.

—Source: North Dakota State University Agriculture Communication. See www.ag.ndsu.edu/news.
Ozonator blasts bugs in grain bins

Ozone is electrified air, similar to the air that humans breathe, and it can be used to kill bugs and fungus and eliminate mold in grain bins, according to a Purdue University expert.

An ozonator takes oxygen from the atmosphere and adds an electric charge to make ozone, which is then pumped into a grain bin by a generator, explains Linda Mason, a Purdue extension food pest entomologist. The grain bin has a fan at the bottom that pulls the ozone through. The remaining ozone is then recycled through a tube back to the top and used again.

“Many are familiar with ozone, they just aren’t aware of it,” Mason says.

For example, the smell after a lightning storm is ozone, and the smell from a welder’s arc also is ozone. Ozonators also are placed in public restrooms to remove odors.

“The great thing about ozone is that it does not leave a pesticide residue on the product, and it doesn’t affect food quality,” Mason says.

The ozone goes in at a very high concentration, and the first time ozone is put into a bin, it attacks and breaks all the double bonds on the grain kernels and all the dust and debris in the bin, Mason says. It also will do the same to insects. Now the grain is considered to be in Phase II.

Effectively controls bugs, fungi

When ozone is put into the grain bin in Phase II, instead of having to break double bonds as it goes through, it will kill any bug that has entered the bin.

Mason and the Purdue Post-Harvest Grain Quality Program experimented with corn, popcorn, rice, malting barley, and wheat. These grains were ozonated and then processed for food. The team was concerned that the process might cause some food quality issues, such as the food losing its flavor and adhesiveness, because of the attacking of double bonds. Fortunately, the food quality is not affected by the process, Mason says.

“The other advantage is that ozone will attack fungal pathogens like Aspergillus flavus, a mold that affects corn and produces an aflatoxin within the grain bin,” Mason says. “When we treat with ozone, we reduce conidiation, or essentially eliminate mold spores from the grain and considerably reduce the aflatoxin concentrations in there, too.

“However, that doesn’t mean that if you were to re-wet the grain that you’re not going to get a mold problem. New spores are always entering the bin and ready for conditions to accelerate growth. Because there is no residual, there is always potential for reinfestation with insects and mold.”

Ozonation is only effective while it’s ozonating, Mason says. Once the bin is opened, a bug can safely enter because there is no ozone left in the bin. Mason recommends ozonating every six to eight weeks to reduce the number of insects and molds that may have gotten into the bin since the last ozonation.

Future applications

This technology is used widely in the potato industry for storing potatoes. Mason predicts the organic industry will be the next to adopt the process.

“They have no alternatives to use right now,” she says. “They are really struggling to find ways to control insects in bins, and ozone is already approved for the organic market.”

From the organic market, Mason predicts the process will then find use in the high-value grain and specialty crop industries. ■

—Source: Purdue University News Service. See http://news.uns.purdue.edu/.
Nutrient management key to clean environment

There comes a time when organizations and especially people need to take a proactive position on certain things that affect the good of all people. Clean water, air, and food are very necessary to agriculture and life, and we need to protect our natural resources. The Clean Water Act will come before Congress next year, and ASA and the ICCA program need to have a plan for what we can do to ensure that there is clean water, air, and food. Proper management of nutrients is an important part of this. If you haven’t already started developing nutrient management plans (NMPs), the time to start is now. If you already have an NMP, you should share with other CCAs the knowledge and programs you are using to help protect natural resources.

The process of acquiring a clean environment will always be ongoing, and science will need to help the practicing professionals. This does not need to be a government program, but one carried out by all of society. The part we play in providing food to the world is just as important. I was asked the other day which is the most important: food, water, or air. Realizing that this was a proverbial trick question, I gave it much thought and answered that they are all equally important. My answer proved invalid, however, when I was asked to hold my breath while the questioner went to get me some water and food.

We all know we must have food, air, and water to survive, so we must act responsibly. Developing NMPs will aid in providing abundant food supplies while keeping the water and air clean.

In order to assist CCAs, ASA needs to provide access to the different management programs that are available and make sure that the CCA Toolbox is current and accurate. Nevertheless, ASA cannot do this without the help of CCAs who are the professionals possessing the practical experience in this area. We are aware that all things that work on paper do not necessarily equate to what will work in real-life situations. ASA is willing to help, but doesn’t know what it is you need to do your job. You can help by informing Luther Smith (lsmith@agronomy.org or 608-268-4977) and members of the Toolbox Committee about any plans that you are using.

Using CEU programs to train CCAs in nutrient management

A good way to start the development of nutrient management programs is for each state or province to make a coordinated effort to use CEU programs to train CCAs in nutrient management planning. The CEU training provided in each state needs to be focused on the specific program that is chosen by that state’s NRCS state conservationist. Some of these programs have components of a Comprehensive Nutrient Management Plan (CNMP). However, there is a difference between a CNMP and an NMP. The NMP and AFOP programs have been written for NRCS, but have a workable NMP component.

Keep in mind that an NMP should be written by a CCA and is subject to approval by the official agency for a particular state. The approved plan is then given to the grower for implementation, Certified persons must provide verification of implementation, and the proof of implementation is to be sent back to the NRCS. This is a voluntary program, and some financial assistance is available for interested growers.

If NMPs are implemented, the NRCS will have sufficient data to support our efforts. Information provided by an NMP will prove that farmers are indeed making an effort to protect our environment. Many farmers like me love the land and also view the land they own as part of their 401(K). They certainly are not going to willingly do anything to depreciate this valuable asset.

Working for the greater good

Taking this proactive step and promoting the idea of having an NMP will get state agencies and industry involved with each other. I have found that sometimes you may have a simpler way to do your job, but simplifying your job will make another person’s job a lot harder. We have to be considerate of others and help them so their jobs will be a little easier. If we do, then maybe they will put in a good word for us to those who don’t understand what we are doing. I know there are a lot of ways to accomplish this goal, and I challenge you to speak up. If we keep on doing business the same way, government is going to get even more involved as they have with the medical industry. Do us all a favor by taking a voluntary proactive stance on nutrient management, and we will all stand to benefit from your actions.

I want to thank all CCAs for the opportunity to serve them as chairman, and I hope that my efforts will have benefited the program. I think the best way for us to help our environment, industry, and society is for each of us to help the ICCA program to become the best it can be starting today. There is a lot of passion in the program, which needs to be harnessed and directed. When this is done, we can move on together to build the necessary tools for clean air, water, and food.
New look for websites

The certification websites are changing and being upgraded with new features and benefits. The new format will be much more intuitive and designed around three basic premises: already certified, wanting to become certified, and looking for a certified person. Information for the general public will be on the home page. All the related content will tie back to the original criteria. The majority of people reading Crops & Soils are already certified, so content pertinent to someone certified, such as checking CEUs, the CCA Toolbox, and the certification forums, will be found under that tab.

Certification forums, or discussion groups, are a new benefit that will appear on the certification pages. We have had several requests for a mechanism that would allow CCAs, CPAg’s, and CPSS/C’s to informally discuss issues related to what they are doing in their work with others who are also certified. For example, there might be a new pest in your area, and you are trying to figure out the best pest management strategy. You could raise the question in the forum and receive expert advice from other certified professionals who have had experience with the same pest. An individual will have to be certified to access the forum.

The CCA forum will be found in the CCA Toolbox. The CPAg and CPSS/ C forums will be found on the home page for each certification. These will be available in late September. The code of ethics applies to the forum discussions, so acceptable business conduct is expected.

Meet a professional: Fred Vocasek

A t times, “I feel like a stranger in a foreign land,” says Fred Vocasek (pronounced vote-sah-seck). “I’m not doing what a typical CCA might be doing. I have two sets of clients, dealers and co-ops focused on agriculture and regulatory people who often have a hazardous waste background.”

Vocasek has been with Servi-Tech Laboratories in Dodge City, KS for the last 24 years, starting as the laboratory technical services manager prior to his current position as manager of agriculture and environmental consulting. Before Servi-Tech, he worked for Antelope Co-op Association in Northeast Nebraska as a field crop consultant and technical sales representative. He has a B.S. in agronomy–crop production and communications from the University of Nebraska, where he was also president of the agronomy club. Since then, Vocasek has completed several graduate-level courses in soils, hydrology, statistics, soil microbiology, water quality, and environmental law. He’s been a CCA since 1993 and was a CPAg prior to that.

Vocasek’s primary duties at Servi-Tech are to develop sampling and nutrient management programs for industrial and agricultural waste management for land application. He conducts environmental site assessments for real estate property transactions and coordinates soil and ground water investigations.

We recently had the opportunity to talk with Vocasek about his professional choices and being a CCA.

C&S: “Why are you a CCA?”

Vocasek: “[Certification] is an illustration of professionalism. It is the right thing to do. It is not an end in itself. I make the comparison between a business card, professionally produced, and a piece of note paper with your name and phone number on it. Both contain similar information, but one sets a much more professional image.”

C&S: “Are there advantages to being certified?”

Vocasek: “I think of my car mechanic. I went to him because he came recommended by a friend as someone you can trust and he does good work at a fair price. When I went to see him, I had already decided to give him a try and then I saw the ASE (Automotive Society for Excellence) certification on his wall. That gave me an increased level of assurance that he was qualified. I think the same thing can be said of being a CCA. It’s not the only reason why you get the job, but it adds to the credibility and provides a sense of assurance to the farmer or employer that the person is qualified.”

C&S: “What do you like most about your job?”

Vocasek: “Problem solving, helping two groups (agribusiness and regulators), who may speak the same language but not understand each other, come together to a common solution.”

C&S: “What do you like the least?”

Vocasek: “Frustration of having the two sides not understand each other. Being required to do because ‘that is how they are done’ vs. ‘getting things done based on the quality of the data.’ ”

C&S: “What is the most rewarding part of your job?”

Vocasek: “Seeing the ‘light come on.’ Helping people to understand a situation better and make the right decision.”

Fred has served the CCA program on the Kansas and International Boards. He is finishing his term as past chair this fall. When asked what was the most rewarding aspect of his service on the board, he replied “I can’t take the credit for this one, but seeing Crops & Soils get started again.”

“Meet a Professional” will be a new regular feature in Crops & Soils. We’d like to showcase individuals who are doing outstanding work. Please contact Luther Smith (lsmith@agronomy.org) to nominate someone for this honor.
**Certified crop advisers play important role in virtual farm tour online**

A new project at the home of *Successful Farming* magazine on the web is giving you an opportunity to present to a whole new audience some of your top farmers and the innovations they’re putting to work in their fields this year.

The magazine’s website, Agriculture Online, has a new feature this year called Crop Tech Tour (www.agriculture.com/croptechtour2007), which is a virtual tour of farm throughout the Ethanol Belt seen from both the farmers’ eyes and those of their certified crop advisers (CCAs). With stories, video, and other interactive content, users can learn what technology the selected farmers are using this year, how it works, and what it will mean to this year’s crops.

“We’ve received input from CCAs in Iowa, Illinois, Indiana, Ohio, and Minnesota who have recommended to us their top farmers,” says Agriculture Online Editor John Walter. “We’re featuring a wide range of ideas, from soil preparation to seed treatments, in the hopes that our users can get ideas for their own farms.

“We’re taking the crop tour concept a step further, saying ‘Here’s what the crop looks like in this area, and here’s how this farmer’s crop looks because of these new tools he’s using in the field.’ ”

Each farmer featured in the Crop Tech Tour is working closely with a CCA, making the project a good way for CCAs and farmers to share how they’re putting new tools to work in their fields and the results they’ve had in doing so.

The input of CCAs is an important basis of the Crop Tech Tour, Walter says, as Agriculture Online editors are looking to CCAs for farmer ideas as well as input into the farmers’ technology and practices.

“It is a great way to showcase the positive working relationship between farmers and their CCAs,” says ASA Director of Certification Programs Luther Smith. “They can talk about each other instead of themselves, adding more credibility to the process. It’s a win-win and allows other farmers to see the positive benefits of working with a CCA.”

If you have a customer who is utilizing a new technology to produce this year’s crops and you’d like to take part in the Agriculture Online Crop Tech Tour, send your ideas and information to agonline@agriculture.com.
New certification benefit on the way

Sometime in September, you will be receiving (if you haven’t already) a new identification card for your certification. It is similar to a credit card, but sorry, you can’t buy anything with it. Your name and certification number will be displayed on the front and contained in the magnetic strip and barcode on the back.

It will act as your new identification card replacing the annual paper card you received each time you paid your renewal. You will still have to renew your certification, but you will no longer receive the paper card. The new plastic card is permanent as long as you remain certified. There will be a replacement fee of $10 if the card is lost or damaged.

The other feature is that when you attend continuing education events, you will be able to scan your card to record your attendance at the event. There will be no need to sign in if the scan equipment is being used by the meeting vendor. Not all meetings will have the equipment though. The number in attendance will determine if it is appropriate to use the equipment. In the event that scan equipment is not available, then the old system of signing the form or self-reporting the meeting still applies.

We anticipate implementing the new system during the 2007–2008 meeting season. It will take time to phase in the new process, but it will make CEU reporting more efficient and cost effective, resulting in a shorter turnaround from the time you attend the event until it appears in your records.

You will receive more than one card if you are certified in more than one program. We did not want to decide for you which card you would prefer to use. Each card contains identical information for CEU reporting purposes, so you only need to use one of the cards. Don’t throw the other card away since they can serve as a replacement card, plus they are your certification identification.

Hope you enjoy this new benefit to your certification. Please let the certification office know how you like them and how they are working for you at CEU events.
Did you know CCAs can earn and self-report up to 20 CEUs by attending sessions at the ASA-CSSA-SSSA 2007 International Annual Meetings? CPAs, CPSS, and CPSC holders may self-report up to 40 CEUs.

Nearly 3,000 poster and oral papers will be presented in sessions throughout the week, covering such topics as nutrient management, soil and water management, pest management, and crop management and professional development. Division A09: Professional Practitioners features sessions specifically targeted towards certified individuals. Check the online Annual Meetings Program for an updated list of sessions. Take advantage of this great opportunity to earn half—or all—of the CEUs required! For more information, visit www.acsmeetings.org.
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