Agronomy Day 2014

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The 58th annual Agronomy Day provides countless opportunities for growers, industry representatives, business owners, researchers, and the general public to discover the latest research findings from the Department of Crop Sciences. From plant breeding and pest control to biomass production and horticulture, our department is leading the way in education, research, and extension.

But don’t just take my word for it. Interact with our researchers and extension specialists and enjoy their presentations. Ask the crop sciences students on site to tell you about the various courses and opportunities they are offered. When our students graduate, they often have more than one lucrative job opportunity waiting. The demand for U of I graduates is high, and the future looks even more promising.

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Agronomy Day is a partnership among several academic units in the College of Agricultural, Consumer and Environmental Sciences (ACES). This event is our way of reporting directly to the citizens of Illinois on the scope, value, and importance of our programs.

We are delighted to have you join us today, and we hope to see you again soon!

Best Regards,

Germán A. Bollero
Head of the Department of Crop Sciences
gbollero@illinois.edu, 217-333-9480
From the university’s beginnings, agronomic research has been conducted on or near the University of Illinois. From 1876 to 1931, most field research took place on “campus proper.” This involved work on the Davenport Plots (sacrificed in 1930 to allow the expansion of Goodwin Avenue), directly east of the Morrow Plots, and, from 1920 to 1936, on the land west of the football stadium to the Illinois Central tracks.

Field operations on the present research farm began in 1903. The original Agronomy Farm consisted of the 80 acres directly south of the Seedhouse, completed in 1930. Since then the area, which became known as the South Farms, has expanded slowly but steadily to its present 1,300 acres. The Seedhouse still serves as the headquarters for farm operations.

In 1984, the farm operations of the Department of Agronomy were combined with those of the Department of Plant Pathology. In 1995, the college reorganized, merging those departments into a new unit, the Department of Crop Sciences. The research facility received a new name at the same time: the Crop Sciences Research and Education Center (CSREC).
The CSREC mission is to provide land, equipment, and facilities for plant and soil research in a field laboratory setting close to campus. We assist scientists and extension personnel by providing a central place from which to plan, coordinate, and conduct field research, and we support on-campus teaching by providing field laboratory facilities for graduate students and by educating undergraduates through work and field trip experiences.

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Sincerely,

Robert Dunker
Agronomist and Superintendent
Crop Sciences Research and Education Center
r-dunker@illinois.edu, 217-244-5444

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Resistant varieties help combat losses from soybean cyst nematodes

It is estimated that soybean cyst nematodes (SCN) cause the greatest yield loss of any soybean disease or pest in the U.S. SCN, a significant threat to Illinois soybean production, has been shown to be present in approximately 80 percent of the soybean fields in the state. Aboveground symptoms include patches of stunted and yellow plants, often most noticeable in areas of low fertility or during drought conditions. Belowground symptoms include dwarfed or stunted roots and a reduced number of nodules. The roots may also have small, lemon-shaped female nematodes, or cysts, that start as white and turn brown over time (Figure 1). In many cases, however, SCN is present in a field and causing yield reductions without showing any aboveground visible symptoms. The best way to know if a field is infested with SCN is to have soil samples analyzed by a professional diagnostic laboratory. Information on sampling methods can be found at http://ipm.illinois.edu/diseases/rpds/501.pdf.

If a field is infested with SCN, the two primary methods for controlling the pest are the planting of resistant varieties and rotation with a nonhost crop such as corn, small grain, or alfalfa. SCN populations will decline when a nonhost crop is grown, but rotations will not totally eliminate SCN from fields. Growers have many choices for SCN-resistant varieties, and breeders have been successful in breeding SCN resistance into high-yielding genetic backgrounds. Most SCN-resistant varieties in the Midwest have their resistance from PI 88788, introduced into the USA from China in 1930. The use of this resistance source can provide yield benefits in SCN-infested locations and has no negative yield drag in noninfested locations (Figure 2).

A concern, however, is that dependence on resistance from PI 88788 will result in the selection of nematode populations in fields that can overcome this resistance. We find evidence for this in the analyses of soil samples from midwestern locations where SCN-resistant experimental lines are tested. This testing is organized by the University of Illinois and funded by the United Soybean Board. In 2013, nematodes were analyzed from soil samples from 22 locations; in all but one location, the nematodes could overcome resistance from PI 88788 (defined as when the female index [FI] of the sample is equal to or greater than 10 percent on PI 88788). This FI is calculated by comparing the number of nematodes on the resistance source to a susceptible check.

Across the 21 locations where the nematodes can overcome PI 88788 resistance, the lowest FI was

Figure 1. SCN females (cysts) on soybean roots. Photo courtesy of Carolyn Fox, University of Illinois.
10, the highest was 37, and the average was 20 (Figure 3). This means that although SCN can overcome this resistance source in most soil samples, PI 88788 still provides partial resistance and can provide protection against yield losses. There are some fields, however, where PI 88788 resistance has completely broken down and no longer provides yield protection.

University of Illinois researchers have been breeding for resistance to SCN since the 1970s. Many important SCN-resistant varieties have been released from the university, and they continue to be important because they are the ancestors of resistant varieties that are now being marketed by the private and public sectors. The U of I breeding program continues to breed for SCN resistance and is using unique sources of resistance, including PI 437654 and wild soybean PI 468916. For both of these sources, the locations of the SCN resistance genes have been mapped, allowing breeders to rapidly select for these genes. It is expected that more varieties will be released with these and other unique sources of resistance, giving growers more choice of varieties that can be used to combat SCN in their fields.

Figure 2. A comparison of the yield of SCN-resistant and SCN-susceptible varieties in an infested location in Decatur, MI, and a noninfested yield location in West Lafayette, IN. The resistance levels of varieties were determined through greenhouse testing. A high female index (FI) means that the variety is susceptible; a low FI means that it is resistant.

Figure 3. The female index on PI 88788 of SCN from soil samples taken from 22 midwestern field locations.
Soybean aphid resistance genes

The soybean aphid (*Aphis glycines* Matsumura) is an exotic pest of soybean (*Glycine max* [L.] Merr.), first identified in North America in 2000. As the most damaging insect pest of soybean in the midwestern U.S., the soybean aphid feeds on the sap of soybean plants, causing puckered leaves and reducing plant vigor, growth, and pod and seed numbers, all of which can contribute to yield loss. In severe infestations, yield losses can exceed 50 percent and could lead to plant death. Even infestations at low numbers (20 aphids per plant) can reduce photosynthesis, ultimately reducing plant health and yield.

The primary control of soybean aphids is through insecticide application. Systemic seed treatment insecticides can protect young seedlings, but the protection does not persist into reproductive stages. Foliar-applied insecticides can effectively control soybean aphids, but the timing and frequency of application are critical to avoid unnecessary costs to the producer, unintended environmental harm, and insecticide-resistant aphids. The most economical and environmentally safe way to protect soybean from the soybean aphid is through genetic resistance.

There are currently four known biotypes of soybean aphid and several genes that confer resistance to the pest. Two such genes are *Rag1*, which was derived from the southern U.S. cultivar Dowling, and *Rag2*, which was derived from PI 200538, an exotic Japanese line. Both genes have been introgressed into midwestern-adapted soybean lines; in tests, the effect of both genes on yield and other agronomic traits were evaluated in aphid-free environments. These tests showed that *Rag1* was not associated with a yield drag, but *Rag2* was associated in one of two backgrounds where it was tested. In our current study, we compared the effect of both *Rag1* and *Rag2* on yield and other agronomic traits in a population that comprises lines with *Rag1*, *Rag2*, *Rag1&2*, and no resistance genes. The populations were tested in three Illinois environments in 2013 with no aphid infestation. Results from the 2013 tests showed that while *Rag1* was not associated with yield, *Rag2* was associated with reduced yield. Lines with *Rag2* alone yielded approximately 3 bushels per acre less than lines with *Rag1* or neither resistance gene. The reduced yield is likely the result of genes linked to *Rag2* instead of the *Rag2* gene itself, and experiments are being conducted to determine whether the association between *Rag2* and reduced yield can be broken. In addition to our work with *Rag1* and *Rag2*, we are working on combining the resistance gene *Rag3* to lines with *Rag1&2* to provide durable protection against the soybean aphid.

Figure 4. Aphids per plant in a 2013 Iowa State University experiment. (Data courtesy of Michael McCarville, Matt O’Neal, and Ken Pecinovsky, Department of Entomology, Iowa State University.)

Figure 5. Yield of lines containing Rag1, Rag2, Rag1&2, and no resistance genes.

Figure 6. Aphids.
Breeding for resistance to sudden death syndrome of soybean

Sudden death syndrome (SDS) is an economically important disease of soybean (*Glycine max* [L.] Merrill) in Illinois caused by the soilborne fungus *Fusarium virguliforme*. SDS was first observed in Arkansas in 1972 and has since spread north to almost all soybean-growing regions in the U.S. and into Canada. *F. virguliforme* overwinters in soil and plant residue and infects soybean early in the growing season when conditions are cool and wet. It then produces a toxin that moves into leaves, resulting in foliar symptoms that commonly develop after flowering and before pod fill. Early symptoms tend to appear on the uppermost leaves as small, scattered, interveinal light green or chlorotic spots, giving a mottled appearance (Figure 7). The spots then enlarge and can become necrotic. In severe cases, defoliation occurs, with petioles remaining attached to the stem. Premature death may also occur. SDS is a particularly troubling disease because it tends to be associated with fields that have good fertility and a high yield potential.

Between 2006 and 2010, estimated yield losses due to SDS averaged 34 million bushels per year.

The most effective way for growers to manage SDS is through genetic resistance. Fungicides and cultural methods, such as crop rotation and tillage, have had limited success in decreasing disease symptoms. While several commercial SDS-resistant varieties are available, none have complete resistance—even the most resistant variety will display some SDS symptoms if conditions are favorable. However, losses can be reduced by planting resistant varieties. Seed dealers should have information on the relative SDS resistance of their varieties.

Resistance to SDS is controlled by many genes, each having a small effect on the disease. Several of these genes, known as quantitative trait loci, that confer resistance to SDS have been identified by the soybean community. Follow-up studies on these genes, including incorporating them into high-yielding breeding material, have been limited. In order for a gene to be useful to a breeder in creating new resistant varieties, it must be effective across multiple backgrounds. Researchers at the University of Illinois have been actively evaluating resistance genes found in old varieties and exotic soybean by breeding the genes into several Midwest-adapted lines that are high yielding.

In conjunction with other universities, soybean lines with the resistance genes are planted each year at locations in Illinois and Michigan. The lines are inoculated with *F. virguliforme* at planting and irrigated during the reproductive growth stages to help enhance disease symptoms. Later in the growing season, foliar symptoms are recorded and the data analyzed.

In the past two years, two genes have been found to significantly decrease foliar symptoms across different soybean backgrounds and environments, suggesting they could be actively used in a breeding program to help control SDS. While SDS remains a problem for many soybean producers, it is our hope that by identifying genes that can be widely used, breeders will become more efficient at protecting yields from this disease by releasing more resistant varieties.

Acknowledgments

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Lillian Brzostowski
Department of Crop Sciences,
PhD research assistant,
brzosto2@illinois.edu, 217-333-5521

Brian Diers
Department of Crop Sciences, professor of plant breeding and genetics, bdiers@illinois.edu, 217-265-4062

Figure 7. Classic foliar symptoms of SDS: interveinal chlorosis and necrosis.

Figure 8. Resistance is the best option available to control SDS.

Figure 9. Rating SDS symptoms in Urbana, Illinois.
Do soybeans need nitrogen fertilizer?

There has been much recent interest in the idea of using nitrogen fertilizer during the growing season to increase soybean yields. This is somewhat surprising, given that there is so little evidence, published or unpublished, that the practice increases yields, let alone provides a return on the cost of doing it.

Soybean plants in virtually every Illinois field produce nodules when roots are infected by Bradyrhizobium bacteria, and bacteria growing inside these nodules are fed by sugars coming from the plant. In one of nature’s more amazing feats, these bacteria are able to break the very strong chemical bond between N atoms in atmospheric N2. (N2 makes up some 78 percent of the air, but it is inert in that form.) This “fixed” N is available to the plant to support growth.

The soybean crop has a high requirement for N; it takes up nearly 5 lb of N per bushel, and about 75 percent of that is removed in the harvested crop. It is generally estimated that, in soils such as those in Illinois, N fixation provides 50 to 60 percent of the N needed by soybeans. A small amount comes from atmospheric deposition, including some fixed by lightning. The rest comes from the soil, either from that left over from fertilizing the previous corn crop or from the mineralization of soil organic matter carried out by soil microbes.

Nitrogen fixation takes a considerable amount of energy in the form of sugars produced by photosynthesis in the crop. Estimates of just how much energy range widely, but it could be in the vicinity of 10 percent of the energy captured in photosynthesis, at least during part of the season. Because photosynthesis also powers growth and yield, it seems logical that, especially at high yield levels, the crop might not be able to produce enough sugars to go around and that either yields will suffer or N fixation will be reduced. Might adding fertilizer N fix this problem, resulting in higher yields?

We’ve added fertilizer N in a series of trials over the past several years, with some of the research funded by the Illinois Soybean Association. These studies involve applying some form of urea in midseason, usually July. Figure 10 shows the result of 22 such comparisons from 2010 to 2013.

Yields ranged widely among these studies, but in only one case did adding N fertilizer significantly increase yield (by 6 bushels per acre), and there was no relationship between yield level and response to fertilizer N. With yields as high as 80 bushels per acre, these results provide no support for the idea that the higher the yield, the more response to fertilizer N. In fact, yields above 70 seemed more likely to show decreases from adding N, though these differences were small and not statistically significant.

While these results don’t prove that adding N fertilizer doesn’t increase soybean yields, it clearly shows that we can’t count on such an increase, and it certainly calls into question the wisdom of making such applications, at least with our current understanding. It is possible that soils often contain more N than we realize, especially under good mineralization conditions, which are also good growing conditions. It is also possible that we don’t really understand the photosynthetic capacity of soybeans under field conditions, and that our guess that yield is limited by photosynthetic rates when the plant is also fixing its own N is just incorrect.

The usual signal of N deficiency in crops—light-green leaves—is rarely seen in soybean plants during the period of pod setting and seed filling unless the crop is under prolonged drought stress. Late in seed filling, leaves start to mobilize their N as chlorophyll and photosynthetic proteins break down, and much of this N moves to pods and into seeds as photosynthesis winds down. If there were a way to get more N into the leaves early in this process, it might be possible to maintain photosynthesis a bit longer and move more material into seeds. It is clear that getting this to happen consistently will be difficult, especially under an unpredictable water supply.

Until and unless we find a way to learn to make N application to soybeans work consistently, or in most cases to work at all, this practice increases both economic and environmental risks. Under dry late-season conditions such as we experienced in 2013, much of the N we apply will stay in the soil and become part of the mobile pool of soil N going into the fall.

Figure 10. Response of soybean to N fertilizer in 22 Illinois trials, 2010–2013.
Evaluating options for managing western corn rootworm larvae in Illinois

Costs associated with yield loss and management of the western corn rootworm are estimated to exceed $1 billion annually in the United States. Tinsley et al. (2013) determined that for every node of roots consumed by corn rootworm larvae, a 15 percent reduction in yield can be expected. In Illinois, this pest represents the primary insect threat to corn production, and it is particularly challenging to manage. Many options exist that aim to reduce damage associated with larval feeding; however, integrating these tactics into an overall management program may be difficult depending on a farmer’s geographical location or individual production needs. Annual crop rotation with a nonhost crop (e.g., soybean) was widely successful until the mid-1990s, when severe injury to first-year cornfields was reported on many Illinois corn acres.

Today, this rotation-resistant variant renders annual crop rotation insufficient to prevent economic damage across the northern two-thirds of Illinois. Bt hybrids targeting the western corn rootworm have been commercially available since 2003 and have been widely adopted. The first generation of Bt hybrids targeting this pest all expressed a single Bt toxin; however, many recently commercialized Bt hybrids for western corn rootworm control are pyramided (i.e., express more than one Bt toxin for this pest). However, resistance to one of these toxins, Cry3Bb1, has already been confirmed in a number of Illinois counties. In addition, researchers at Iowa State University have determined that in these Cry3Bb1-resistant populations, cross-resistance to mCry3a also exists (Gassmann et al., 2014). The overwhelming majority of Bt resistance reports for the western corn rootworm have been associated with continuous corn production where the same trait has been used repeatedly over a number of years. Matters have been complicated further by reports of suspected Bt resistance in first-year corn in a number of east-central Illinois counties.

The situation surrounding how to manage this important pest is perhaps most complex in Illinois due to the presence of western corn rootworm populations with demonstrated rotation resistance, confirmed Bt resistance, and potential rotation and Bt resistance. Each year our research team evaluates root protection products (soil-applied insecticides, Bt hybrids, and combinations of the two) aimed at preventing corn rootworm larval injury and associated yield loss. We establish our experiments in fields that were devoted to trap crops (late-planted corn, interplanted with pumpkins) the previous season to increase the likelihood of sufficient pressure in our control plots. Our studies are conducted at the University of Illinois Research and Education Centers near DeKalb, Monmouth, Perry, and Urbana. Results from our trials at these sites will provide critical information for guiding management decisions for 2015.

References

Ronald E. Estes
Department of Crop Sciences, principal research specialist, restes@illinois.edu, 217-244-1961
Nicholas A. Tinsley
Department of Crop Sciences, postdoctoral research associate, tinsley@illinois.edu, 217-265-4113

Figure 11. Western corn rootworm beetle. Courtesy of Mike Gray.
Western corn rootworm resistance in Illinois

Discovery of field-evolved western corn rootworm (WCR) resistance to corn rootworm (CRW)-Bt corn hybrids in Iowa (Gassmann et al., 2011) revealed a troubling threat to the primary tool used to protect U.S. corn from WCR damage. This report also documented Bt resistance in WCR as a phenomenon associated with the year-after-year cultivation of CRW-Bt corn hybrids (continuous corn) expressing the same Cry toxin, in this case Cry3Bb1.

Subsequent to Gassmann et al. (2011), unexpected rootworm injury was reported in continuous cornfields from several Illinois counties (Gray, 2012). Suspected Bt-resistant WCR adults were collected from a number of fields that experienced unexpected damage and were maintained in a laboratory to collect eggs to supply larvae for single plant Bt-resistance bioassays using the methods of Gassmann et al. (2011). The larval offspring of the suspected Bt-resistant populations were bioassayed to evaluate larval survival on Bt and non-Bt near-isoline corn hybrids. Survival of suspected Bt-resistant populations was compared to survival of control Bt-susceptible laboratory populations. Bioassays have so far identified six Illinois counties with WCR populations with field-evolved resistance to Bt hybrids expressing the Cry3Bb1 toxin.

Land-grant university and USDA entomologists have offered specific IPM recommendations to growers that will help delay the further evolution and spread of Bt resistance (reviewed in Cullen et al., 2013). Among the key recommendations was rotation to a nonhost crop (e.g., soybean) to break the continuous corn cycle and act as a possible “reset button” for cornfields harboring suspected Bt-resistant WCR populations. Switching to a hybrid expressing multiple rootworm resistance traits (i.e., pyramided hybrid), switching to a different Bt trait, and

Figure 12. Bt hybrid injury.
using non-Bt corn with a planting-time soil insecticide are also excellent options. Use of a soil insecticide on a pyramided hybrid is not recommended. Soil insecticide does not significantly improve root protection or increase yield. In addition, delayed adult emergence from soil insecticide–treated Bt-hybrid plants may diminish the efficacy of the non-Bt refuge.

Reports of greater-than-expected injury in 2013 to first-year, rotated corn across northeastern and east-central Illinois added new urgency to grower concern regarding CRW resistance to Bt corn hybrids. Given that Illinois was the epicenter of WCR resistance to crop rotation, the report (Gray, 2013) exposed a threat to that gold standard of management practices in an area where CRW-Bt corn hybrids are routinely planted in rotated cornfields to counter the persistent threat of WCR rotation-resistance. Bt-resistance bioassays are underway using larvae obtained from some of the 2013 problem fields. The presence of suspected Bt resistance among rotation-resistant WCR populations links two very significant pest management challenges.

During 2014, we will work on-farm with Livingston and Kankakee County producers to evaluate several management approaches, including early vs. late broadcast applications of insecticides to soybean fields in combination with soil insecticides and Bt rootworm hybrids in rotated corn. WCR adults will be collected from rotated corn and adjacent soybean fields and Bt-resistance bioassays performed on the offspring to document possible variations in resistance among early- and late-emerging WCR adults. This research will answer fundamental questions about resistance and evaluate practical management options of interest to corn growers. Testing management approaches and measuring resistance will improve our understanding of CRW management tactics and support the development and deployment of more effectively targeted management strategies.

Acknowledgments

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References


New genes for increasing soybean yield from what?

You may have never heard of *Glycine tomentella*, but this Australian native could help increase soybean yield in Illinois. For more than 30 years, we have been working to increase the rate of yield improvement for Illinois soybean varieties by utilizing new genetic diversity. We have made enormous progress in using exotic germplasm, and our high-yielding experimental lines are being used as parents in both public- and private-sector variety development. Research with the closest relative of soybean, the wild soybean, to improve yield has been underway for a much shorter period, but we have already obtained some promising results. However, the increases that we have achieved by breeding with *G. tomentella* exceed all of our previous results.

*Glycine tomentella* is one of 26 perennial *Glycine* species that are very distant relatives of soybean. The wild soybean is native to far eastern Asia, but the perennial species are indigenous to Australia. The annual and perennial *Glycine* species have been isolated from each other for millions of years and have diverged so extensively that direct fertile hybrids between them are not possible. The perennial *Glycine* species have seeds that are approximately 1/20th the size of commercial soybean varieties and are produced on very slender vines. They are very unlikely candidates for increasing soybean yield.

After testing the suitability of several soybean varieties, we selected Dwight, released by the University of Illinois in 1997, to cross with PI 441001, the *G. tomentella* line with...
resistance to several soybean diseases and pests. Through a patented process, we developed fertile progeny from this cross. We extract immature 3-week-old seeds that are the result of cross-pollination and then culture them in the laboratory to produce hybrid plants. These plants have only one copy of each of the 20 pairs of chromosomes from Dwight and one copy of each of the 39 pairs of chromosomes from PI 441001 and are totally sterile.

By treating these plants with the chemical colchicine we can double the number of chromosomes to 118. This plant produces some seeds but is different from both parents. We crossed this plant back to Dwight and repeated the process of rescuing and culturing the immature seeds. These progeny now have two copies of every soybean chromosome, but every time we cross back to the soybean parent we randomly lose about half of the G. tomentella chromosomes because they have no pairing partner. After several backcrosses, we obtain fully fertile plants with only the 20 pairs of soybean chromosomes, but with genes that have been transferred from the G. tomentella parent. Because of the number of backcrosses to soybean, we would expect that our derived lines would have fewer than 5 percent of the genes from G. tomentella. We have confirmed the transfer of resistance to soybean rust and Phytophthora rot and have tentatively demonstrated the transfer of SCN resistance from G. tomentella to experimental soybean lines, but using this process to improve yield seemed very unlikely.

In 2013, with support from the United Soybean Board, we were able to evaluate lines at 6 to 8 locations in Illinois, Missouri, Nebraska, and Ohio. In these tests, we identified one line that was the same maturity as Dwight, the soybean parent, and yielded 3.3 bu/A more (Figure 16). The best G. tomentella–derived line matured 5 days later than Dwight but yielded 7.6 bu/A more (Figure 16). The best G. tomentella–derived line matured 5 days later than Dwight but yielded 7.6 bu/A more (Figure 16). It was essentially identical in maturity and yield to the best check variety in the test. Because of the large genetic differences between soybean and G. tomentella, it is likely that these increases are the result of genes not in the soybean species (G. max). Research is ongoing to identify the chromosomal regions transferred from PI 441001 to Dwight and to determine which ones are responsible for the yield increase. If these large increases can be maintained with more extensive testing and in additional crosses, G. tomentella has the potential to significantly improve the yield of Illinois soybean varieties.

<table>
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<th>Relative maturity (days)</th>
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<tr>
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<td>5</td>
<td>34</td>
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<tr>
<td>LG09-12059</td>
<td>Dwight (5) x PI 441001</td>
<td>52.5</td>
<td>0</td>
<td>31</td>
<td>1.8</td>
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<td>1.1</td>
<td>3.7</td>
<td>0.3</td>
<td></td>
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Figure 16. Agronomic data for G. tomentella—derived experimental lines collected at 7 locations in Illinois, Missouri, Nebraska, and Ohio.
Uncovering maize genetic response to applied nitrogen

Nitrogen utilization—efficient maize will play a key role in sustainable intensification to provide the necessary 70 to 100 percent increase in food production required over the next 40 years. The physical maize response to N is clear—the plants are greener and bigger, and they produce higher yields. However, relatively little is known about the gene regulatory systems that modulate N response. Recent advancements in technology have allowed us to peer into the maize genome and how it functions. The cost of high-throughput sequencing has plummeted over the last five years, making sequencing a viable method for surveying gene expression.

To understand maize genetic response to N, the Moose lab grew maize plants in an N-response field site with either no applied N or 225 kg/ha N (Figure 19). Samples were taken over a developmental series from ear and leaf tissue to capture the N response at key growth stages (Figure 20). High-throughput sequencing was performed on these samples to quantify gene expression.

N response varied tremendously between tissues and was rarely consistent across developmental time, indicating that N response is a dynamic process. At any growth stage, between 4 and 13 percent of genes were considered N-responsive. In total, 43 percent of all genes expressed in this experiment responded to N in at least one sample, indicating that different N genes are active at each growth stage and plant tissue. Other groups have surveyed genetic response to N but looked at the genetic response of seedlings. Not surprisingly, our data indicates that seedling responses are unlikely to predict genetic changes in growth stages such as flowering and grain fill, which are critical for improving yield.

The N assimilation and utilization pathways have been characterized extensively in the laboratory model.

Jennifer Arp
Department of Crop Sciences, PhD research assistant, jarp2@illinois.edu, 217-244-6308

Stephen P. Moose
Department of Crop Sciences, professor of maize functional genomics, smoose@illinois.edu, 217-244-6308

Figure 19. Maize physiological response to applied nitrogen. Photo courtesy Jay Boddu.

Figure 20. Maize development from seedling to mature plant. Gene expression was measured at seven developmental time points as indicated by arrows (dap refers to days after planing).
Rediscovering our tallgrass prairies: Fuel, forage, and conservation

Farming is an integral part of American history, culture, and economy that spans generations and sustains the world with food, fiber, and fuel. Changes in agriculture advance with changing consumer demands, advances in technology, agency emphases, and government programs. Health-conscious consumers are seeking out local producers to supply them with fresher foods. Industry is tapping into agricultural production for fuel and fiber sources. Government is looking to landowners to improve air and water quality and conservation practices.

The Prairie State is rediscovering the potential locked in the native tallgrass prairies that once dominated the landscape. Yield potential, best management practices, and end uses are being investigated in order to sustain our adapting farm systems.

(Continued)

Fundamentally, changing N response pathways is a big challenge. Existing maize genes are the product of millions of years of evolution for plant survival. Under limiting N, plants are biologically wired to conserve resources and allocate them to a few good seeds to ensure survival. Maize as a crop must use those genes for an entirely different purpose—to produce high yields. Moreover, the N response genes may interact with each other and form tradeoffs, where perhaps increased expression of a gene in kernels would increase yield, but the same gene would decrease yield when similarly expressed in the leaf.

A biotechnology approach may be most appropriate to overcome this challenge. By understanding the genes involved and the inherent tissue-specific tradeoffs inherent to maize development, we can develop maize plants with high yields and high nitrogen-utilization efficiency.

The main message is that maize N responses are very different at the key growth stages, and we need to consider the complex tradeoffs in both management decisions and during genetic improvement.

Acknowledgments

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Fuel

Biomass production for renewable energy sources is coming from the Renewable Fuel Standards initiative, which seeks to promote energy independence through the use of renewable fuels. Biomass production is possible from many different sources, such as municipal wastes, crop grain residues, and dedicated energy crops like switchgrass, Miscanthus x giganteus, and short-rotation woody crops. Proponents in the food versus fuel debate will find common ground as farmers are able to maximize their land usage through tailored cropping systems and improved yields.

Forage

A growing trend among consumers is to purchase beef and other livestock that have been raised on grass-fed diets. Hay and pasture are dominated by European grass species and alfalfa, yet herds of wildlife were sustained for millennia on the North American prairies. As grass-fed farm systems try to meet the demand, increasing the rate of gain will be important. Warm-season grasses, such as big bluestem, switchgrass, and Indiangrass, were all primary components of the tallgrass prairie and could become useful in providing the nutritional needs for forage systems during summer months.

Conservation

Illinois was a part of the tallgrass prairie region prior to the Westward Expansion and cultivation. Crop rotation as a means of replenishing and resting farmland has become less common as more acres are planted in corn and soybean rotations, and with the change has come increased erosion. Implementing conservation tillage practices helps reduce the rate of soil erosion but is no substitute for perennial ground cover. Conservation research using native prairie species integrated into as little as 10 percent of an area can reduce soil runoff by 95 percent with no negative impact to the surrounding cropland (STRIPs Project at Neal Smith National Wildlife Refuge). Prairie cordgrass is one plant species that provides great erosion control but has additional uses on mesic and saline-affected soils.

Over a century ago A.S. Draper, then the president of the University of Illinois, said, “The wealth of Illinois is in her soil, and her strength lies in its intelligent development.” Agriculture has changed and will continue to face the challenges needed to sustain the world, yet the principle voiced by President Draper will continue to point future farmers in the direction they need to be going.

Cover crops for Illinois:
What we hear and what we know

Despite a great deal of research reported on cover crops, most of which has shown positive effects, adoption rates remain low in the corn–soybean rotation in the Corn Belt, at least as measured by observation of fields after harvest. In recent years, interest in cover crops has exploded, as gauged by articles, NRCS promotional efforts, and sales promotions from those who sell seed and services (such as aerial seeding). Still, it has to be acknowledged that cover crops have not been shown definitively to provide a positive return on investment, at least in farming systems most commonly used in the region. Furthermore, some of the negatives associated with cover crops, such as difficulties in establishing the cash crop that follows, have hardly been mentioned in the recent flurry of publicity.

The need for neutral information on cover crops is huge, and to address this deficiency, we initiated research both on producer fields and at U of I research centers, supported by the Illinois Nutrient Research and Education Center. Our objective is to develop the knowledge and skills needed to effectively use cover crops in Illinois, or at least to decide whether and how they should be used. We think that a combination of on-farm, participatory research along with on-station trials that allow for evaluation of different species and how they affect soil nutrient values and crop yields will provide the knowledge we need to make good decisions about cover crops.
Trials were established in fall 2012 at research centers in Urbana, DeKalb, Monmouth, and Brownstown; two more locations in southern Illinois and 10 research sites in farm fields were added in fall 2013. We evaluated several cover crop species planted before corn and soybean for their effects on soil nitrates up to 3 feet of depth and on cash crop yields. Preliminary results from the first four sites after the first year of the experiment showed that, as expected, the nitrate level in the soils present before the cover-crop growing season was related to the 2012 crop, with more nitrates after corn (Figure 24). In spring, the soil nitrate levels were similar, yet there was a significant reduction with the use of rye after corn (Figure 25); no other cover crop had a different effect from the controls with no covers. Soybean yield was not affected by the cover crops in 2013, yet corn yield was lowered when we used either ryegrass or red clover (Figure 26). These are, of course, preliminary results that have included two challenging growing seasons, and we need more years of data to successfully evaluate this practice under several environmental conditions and locations.

Figure 23. Test plots at Brownstown Experiment Station where ongoing research is conducted on a variety of cover crops.

Figure 24. Fall 2012 soil nitrate-N.

Figure 25. Spring 2014 soil nitrate-N.

Figure 26. Crop yields, 2013.
Where is the price of cropland headed?

Cropland values throughout much of the United States have increased dramatically in recent years. The average value of an acre of Illinois cropland increased from $3,250 in 2005 to $7,900 in 2013. This represents an average annual increase of 13.2 percent in nominal terms and 9.8 percent when controlling for inflation. Illinois values grew faster than in the nation as a whole. Between 2005 and 2013, U.S. average values increased at an annual average rate of 10.5 percent nominally and 7.2 percent in real terms. In 2013, the average value for an acre of cropland was $4,000.

The rapid growth in cropland values has been supported by record-high farm incomes and unprecedented low interest rates. As farm incomes and commodity prices have moderated sharply and uncertainty surrounds future Fed policy, there is some indication that cropland markets are beginning to soften. Recent surveys from the Federal Reserve provide mixed indications on the likely future of farmland prices. The Chicago Fed suggests that first-quarter farmland prices on a whole were 1 percent higher than the previous year, but the price of "good" quality land had fallen by 1 percent. Similarly, the Kansas City Fed suggests that the value of nonirrigated cropland fell by 1.4 percent between the fourth quarter of 2013 and the first quarter of 2014, while the value of irrigated cropland increased by just 0.5 percent over the same period.

What would a decline in cropland values suggest for the farm sector?

Farmland values are often cited as a barometer of the financial health of the agricultural sector, as farm real estate accounts for more than 80 percent of the total value of U.S. agricultural assets. Many throughout the agricultural sector who weathered the farm financial crisis of the 1980s are concerned about the potential decline in farm real estate values. However, there are many important differences between today’s farm financial conditions and those of the early 1980s. While farm incomes are forecast to decline, the expected income is still above the long-term average. The financial industry supporting agricultural production has undergone substantial changes following the farm crisis, and current farm operators possess a sophisticated suite of risk management practices and policies. As a result, it is believed that the farm sector is well positioned if land markets continue to soften.
Farm programs in the new Farm Bill

The Agricultural Act of 2014 (the 2014 Farm Bill) has revised the farm safety net, requiring farmers and landowners to sort through a series of decisions to determine how the safety net will operate on their farms beginning with the 2014 crop year.

Title I of the 2014 Farm Bill includes a price-based assistance program called Price Loss Coverage (PLC) and two versions of revenue-based assistance called Agriculture Risk Coverage (ARC). All programs make payments based on the difference between the national price received by farmers and the reference price. Individual ARC provides assistance with price declines but PLC does not. If marketing year average prices collapse, PLC would all be ineligible for PLC and SC. However, PLC provides more assistance than ARC, especially in years 4 and 5 of a price collapse.

Initial conclusions

Some initial conclusions are possible from comparing ARC and PLC (including updated yields and SCO); keys for decision-making include individual farm finances, break-even price levels, production costs, market expectations, and crop insurance. For example, a break-even price for corn at $4.30 per bushel means the $3.70 per bushel PLC corn reference price will be effective. The same is true for soybeans, where a break-even price of $10.70 per bushel is well below the PLC soybean reference price of $8.40 per bushel. In general, price expectations are the biggest component of the decision: for PLC to be effective for midwestern corn and soybeans, prices will have to collapse, but County ARC guarantee will decline if prices decline. It is important to keep in mind that if the marketing year average prices stay above the reference price ($3.70 for corn; $8.40 for soybeans), County ARC provides assistance with price declines but PLC does not. If marketing year average prices collapse and remain extremely low ($3.00 or less), PLC might provide more assistance than County ARC, especially in years 4 and 5 of a price collapse.

Jonathan Coppess
Department of Agricultural and Consumer Economics, clinical assistant professor of law & policy, jwcoppes@illinois.edu

and individual farm-level revenue (Individual ARC) programs. The PLC versus County ARC election can be made covered commodity by covered commodity, but Individual ARC applies to all covered commodities on the farm, and a farm cannot elect PLC for some commodities and Individual ARC for others. If County ARC is elected for a covered commodity, the commodity is ineligible to receive PLC payments; it is also ineligible for the Supplement Coverage Option (SCO) created in the crop insurance title of the bill. If Individual ARC is selected, it applies to all covered commodities, and they would all be ineligible for PLC and SCO. All of the producers on a farm must agree on this program decision for the 2014 crop year. If they fail to make a unanimous election, they will not receive any payments for that crop year from the programs. Additionally, the farm will automatically be deemed to have elected PLC for all covered commodities beginning with the 2015 crop year.

County ARC makes revenue-based payments on 85 percent of the covered commodity’s base acres when actual county revenue is between 86 percent and 76 percent of the benchmark county revenue. The benchmark county revenue is calculated using the 5-year Olympic rolling average (drop the highest and lowest crop years) of county yields for the commodity and the 5-year Olympic rolling average of its national prices. Individual ARC calculations include all covered commodities planted on the farm, with revenue-based payments made on 65 percent of the farm’s total base acres. The calculations for Individual ARC must also take into consideration the individual producer’s share of all farms in the same state in which the producer has an interest and for which Individual ARC has been selected. Individual ARC makes payments whenever the actual revenue for all covered commodities on the farm is between 86 percent and 76 percent of the benchmark revenue, which is calculated using a 5-year Olympic average of the sum of the revenues (prices multiplied by yields for each commodity) for all covered commodities.
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How shalt thou rotate?

The first lecture of the typical “Weed Control 101” course usually identifies why controlling weeds is so important to crop production—so more of the finite resources needed for plant growth and development are available to the crop instead of being used by the weeds. Subsequent lectures provide examples of how to achieve that goal. Numerous weed control tools and methods are available to farmers, including chemical, mechanical, and cultural methods. Herbicides are perhaps the most integral part of weed management programs in midwestern agronomic crops, but intense reliance on herbicides for weed control can result in the evolution of additional challenges. Of particular concern in recent years has been the continual selection of various weed biotypes no longer controlled by previously effective herbicides. In other words, repeated use of herbicides that act in a similar manner in the target weed has resulted in the selection of weed biotypes resistant to these herbicides.

The development of herbicide resistance in weed populations can result in significant economic losses for farmers. Many, however, continue to use a successful herbicide program until it no longer provides acceptable weed control instead of proactively implementing herbicide-resistance management strategies. Some have suggested that the greatest economic losses farmers encounter due to evolution of herbicide-resistant biotypes occur not in the years following the identification of the herbicide-resistant population, but during the initial year(s) of poor weed control.

Extension specialists and those from private industry have proposed numerous management strategies to retard the selection for herbicide-resistant weed biotypes, including non-chemical weed management (such as mechanical cultivation), crop scouting and rotation, herbicide tank-mixtures, and rotation of herbicides that control weeds differently. If weed control practitioners elect to implement herbicide rotation or tank-mixtures as a resistance management strategy, information is needed to identify which herbicides act in a similar or dissimilar manner.

But, by which system should herbicide rotation be implemented? Should one rotate based on herbicide mode of action or herbicide site of action?

Herbicide mode of action describes the metabolic or physiological plant process impaired or inhibited by the herbicide. Essentially, mode of action refers to how the herbicide acts to inhibit plant growth. Herbicide site of action describes the specific location(s) in the plant where the herbicide binds. Site of action thus identifies the herbicide target site in the plant. Historically, most herbicide classification schemes utilize mode of action, but with much ambiguity.

Understanding herbicide mode of action is beneficial, but classifying herbicides by site of action may be more useful from a resistance-management standpoint. The ambiguity of classification based on mode of action includes the fact that classification systems vary, with anywhere from 7 to 13 categories, such as “cell membrane disruptors,” “seedling growth inhibitors,” and “amino acid synthesis inhibitors.” Rotating herbicides based on these categories could cause confusion; for example, the category “amino acid synthesis inhibitors” places Pursuit (imazethapyr) and Roundup (glyphosate) in the same family, whereas classification by site of action would place the herbicides into two distinctly different families, allowing growers to more accurately rotate herbicides for resistance management.

Take Action Against Herbicide-Resistant Weeds (http://takeactiononweeds.com), a recent initiative among extension weed scientists, industry collaborators, and the United Soybean Board, was forged to address the challenges of herbicide-resistant weeds. The initiative has released a new resource (Figure 28) that helps practitioners rapidly and easily identify the site of action, mode of action, and site of action group number for many herbicides and herbicide premixes used to control weeds in corn, soybean, wheat, and other crops. More discussion and a complimentary copy of this publication will be provided at this tour stop.

Figure 28. Take Action Against Herbicide-Resistant Weeds classification chart.
The quest for high corn and soybean yields

Feeding a growing world population will require producing 300-bushel corn and 85-bushel soybean, which will require closing the gap between potential and realized crop yields. Data collected over many years by the Crop Physiology Laboratory led to our identifying and ranking categorical management factors that affect yield, seven for corn (the “Seven Wonders of the Corn Yield World,” Figure 29) and six for soybean (the “Six Secrets of Soybean Success,” Figure 30). These concepts provide a framework for understanding the value of different management factors and inputs on corn and soybean yields and allowed us to develop high-technology packages of optimized practices for each crop that we compared to a typical grower’s standard management using an “omission/addition plot” design where each factor is either added one at a time to the standard-technology system or removed one at a time from the high-technology system.

High-technology management using the Seven Wonders of Corn Yield

Although the specifics we evaluated have changed slightly over the five years of our corn studies, the research has generally involved five factors:

- Improved plant nutrition from a) use of fertilizer sources that provide more than one key nutrient or that have chemistries associated with them to enhance nutrient availability or to prevent loss; b) improved placement (e.g., banding directly under the crop row) to enhance the likelihood of uptake by plant roots; or c) sidedress applications that coincide with the period of rapid uptake or that extend availability later into the season
- Selecting hybrids that possess biotech insect protection and/or “racehorse” types that exhibit greater response to enhanced levels of crop management
- Higher plant populations to increase light interception along with narrower rows to optimize plant spacing
- A strobilurin-containing foliar fungicide application at the VT/R1 growth stage to control leaf diseases and for its growth regulator effect on leaf health or leaf performance
- More recently, fertigation to provide both water and mineral nutrients

In all years of the study, the high-technology management package has outyielded the grower’s standard package by a range of 26 to 75 bushels, but the management factor exhibiting the greatest impact varied among years and locations and appeared to depend on weather. The most important factor by year was biotech rootworm

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</table>

Figure 29. The seven categorical management factors, in rank order, with the biggest impacts on corn yield.
protection in 2009; fungicide application in 2010; banded N, P, S, and Zn fertility in 2011; irrigation in 2012; and higher plant population with 20-inch row spacing in 2013. In all cases, the yield contribution of an individual management factor was greater when it was applied as part of the full complement with the other factors in the high-technology system than when it was added individually to the standard production system.

High-technology management using the Six Secrets of Soybean Success

A similar approach was used for soybean, where the high-technology package included five factors:
- Banded fertility at planting of a multinutrient fertilizer source (containing N, P, S, and Zn)
- A complete seed treatment containing a fungicide, insecticide, and nematicide

We compared the high-technology package to a grower's standard practice consisting of fertility applied the year before to corn or reliance on adequate soil test values; no seed treatment or minimal (fungicide only) treatment; a normal maturity group variety for the region; no foliar protection; and 30-inch row spacing. Averaged over locations, the high-technology package increased yield an average of 9.9 bushels per acre in 2012 and 5.0 bushels in 2013. Although nearly all management factors increased yield in both years, the most important practices were the banded fertility, fullest maturity variety, and foliar insecticide in 2012 and banded fertility, foliar fungicide, and narrow row spacing in 2013. Unlike corn, where the combination of management factors acted synergistically, the value of an individual factor to soybean was not enhanced when combined with the other factors in the high-technology system, although the use of multiple enhanced practices was at least partially additive.

Summary

Understanding which factors have the biggest impact on corn and soybean yields each year gives farmers the opportunity to increase yields with better crop management. But which factor or factors have the biggest impact depend highly on the season's weather. For corn, the positive interaction among multiple management factors gives farmers the greatest opportunity to produce high yields, while for soybean a number of single management practices can be used to increase yield.
Improving corn yield potential with banded phosphorus fertilizer

Between 2005 and 2010, Illinois median test levels of soil phosphorus (P) have dropped by 10 ppm, suggesting that the measured decline in soil P is a cumulative effect of crop removal exceeding fertilizer applications. High fertilizer costs and concerns about water quality have caused many corn producers to take a greater interest in improving the efficiency of P fertilizer applications for raising corn. An effective way of improving nutrient uptake efficiency (how well a plant responds to a nutrient application in terms of yield) results from positioning fertilizer nearer to crop roots; this is especially important for P due to its immobility in soil. The specific concern is that P binds tightly to soil particles and can be lost from agricultural fields through soil erosion, ultimately leading to eutrophication of nearby water bodies. Traditionally, most P fertilizer applications are broadcast across the entire soil surface, which makes the fertilizer more vulnerable to loss to the environment and inaccessible to the plants. A more proactive approach to managing P fertilizer efficiency is banding the fertilizer beneath the soil surface.

Why banded P fertilizer?

As a result of recent advancements in fertilizer-banding capabilities and GPS technology, fertilizer can be placed at a specific depth with minimum disruption to soil structure in all tillage systems, including conservation systems using strip-tillage. Applying P fertilizer in a band below the plant alleviates the challenges associated with higher levels of P in the upper soil profile that are more susceptible to runoff and erosion, and it places the fertilizer in closer proximity to plant roots. Banding P fertilizers is generally more advantageous where soil test levels are low, when soils are cool or wet, where root growth is limited, or for soils that have a high tendency to fix P into unavailable forms. In cool geographies, a band or row application of fertilizer at planting provides a readily available supply of nutrients to corn seedlings early in the season, when root growth and nutrient release from the organic matter are slow. A major advantage of banding fertilizer P is to initiate better early-season plant growth, setting the potential for higher yields.

Improving corn yield potential with banded P

Our research the last two years has looked at different rates of P application (0, 50, 100, and 150 lb P2O5/acre) and two methods (broadcast vs. banded), with the goal of improving P use efficiency in high-yield corn production systems. Though the research was conducted on soils testing high in P (approximately 45 ppm), we have consistently observed a substantial increase in early vegetative growth from increasing the rate of P application, and especially from banding the P fertilizer 4 to 6 inches deep directly beneath the crop row (Figures 31 and 32). Associated with this enhanced growth is greater accumulation of a number of macro- and micronutrient elements. Since kernel ovule potential is being determined during vegetative growth,
management practices like adequate P fertility that lead to robust early growth and enhanced nutrient accumulation should help to optimize yield potential and set the stage for high yields. However, while early growth and nutrient enhancement are certainly a step in the right direction, they do not guarantee higher yields, as subsequent biotic or environmental stresses could prevent realization of the higher yield potential; this is what we observed in 2013. Although plants receiving banded P fertility in 2013 produced substantially more kernels, dry conditions during August and September led to smaller individual kernel weights, which offset the advantage from having more kernels.

**Summary**

Banded P fertilizer has several advantages over broadcast applications, enabling corn plants to respond to fertilizer in a timely fashion under nonideal growing conditions that typically hinder early plant growth. Rapid early plant growth sets the foundation for high yields by optimizing yield potential. The results of this research indicate that proper P fertilizer management can set the potential for higher corn yields, even though they are not always realized.

Figure 32. Early-season biomass yield comparing banded and broadcast fertilizers over multiple phosphorus fertilizer rates.
Fertigation: A new solution for high corn and soybean yields

While irrigated crop acreage in Illinois is limited in scope (435,000 acres, or approximately 2 percent of Illinois crop acres), it has experienced a near 50-fold increase compared to the first estimate in 1950, and it is anticipated to expand by an additional 40 percent by 2025. Irrigation is often a necessity in areas with sandy soil textures, and it may become attractive to crop producers as a strategy to reduce yield variability associated with insufficient precipitation or for high-value crops such as corn and soybean. It is likely, however, that other factors may accelerate the prevalence of irrigation in Illinois and other traditionally non-irrigated parts of the Corn Belt, including high commodity and input prices and catastrophic weather events, such as the 2012 drought. Use of irrigation cannot be approached without considering regional impacts on water resources; current technologies such as center-pivot irrigation could be replaced in favor of more efficient innovations, such as subsurface drip irrigation.

Subsurface drip irrigation: among the most efficient systems available

With support from Netafim USA, a 10-acre subsurface drip irrigation system was installed in 2013–2014 by the U of I Crop Physiology Laboratory (Figure 33). Subsurface drip irrigation is defined as a low-pressure, low-volume, and highly efficient belowground irrigation system that can deliver water, nutrients, and pesticides directly into the actively growing root zone. After filtration, water is...
distributed to each treatment zone for a highly controlled research environment (Figure 33). The benefits of a subsurface drip irrigation system relative to more traditional irrigation forms include reduced water use through less evaporation loss and the ability to adapt to any field size, geometry, or topography. Subsurface drip irrigation also allows for efficient nutrient application through fertigation (i.e., liquid fertilizer sources supplied with irrigation water). Fertigation of nutrients directly into the root microenvironment, particularly during periods of rapid uptake, can minimize nutrient losses associated with immobilization, volatilization, surface runoff, and leaching. The ability to precisely apply plant nutrients at the right place, in the right amount, and at the right time, however, requires understanding the seasonal nutrient accumulation patterns in corn and soybean production systems, as recently discovered by our lab.

Optimizing water and nutrient management with subsurface drip irrigation

Total nutrient requirements for soybean are similar to those for corn, despite the misconception among farmers that nutrient management in soybean is less critical because of N fixation as well as the notion that fertilizer supplied to a corn crop will also meet subsequent soybean fertility requirements. Nutrient harvest index values—the portion of total nutrient uptake represented in grain tissues—of N, P, S, and Zn in both corn and soybean are generally between 60 and 80 percent, which suggests that soil test levels may quickly decline if adequate crop nutrition is not provided (Figure 34). Achieving maximum yields while also sustaining the productivity of Illinois soils will require a comprehensive season-long fertility plan designed to meet the uptake needs of well-managed corn and soybean crops. In corn, for example, the majority of N and K accumulation occurs before pollination, compared with uptake of P, S, and Zn, which occurs primarily during grain filling. A similar challenge exists in soybean production, where limitations in nutrient availability during pod set and seed filling may be reducing final yield.

Summary

Our research suggests that irrigation may become a component of the future agricultural landscape in Illinois, but also, and perhaps more importantly, that improved water and nutrient use efficiency might be achieved with subsurface drip irrigation. The importance of supplying nutrients at key growth stages may be more crucial for intensively managed corn and soybean production systems where other factors such as germplasm, pest control, plant density, and row spacing have been optimized. Preliminary aboveground drip irrigation results in 2012 and 2013 showed significant yield improvements with supplemental fertility applications delivered in-season with drip irrigation. We believe that the full utility of a subsurface drip irrigation system may not only provide water during periods of limited rainfall but also maximize grain yield with highly efficient, season-long nutrient availability.
After Agronomy Day, keep up to date on the latest research and news from U of I agricultural researchers and specialists at the click of a button. Visit these web resources for valuable information:

**ACES News**

news.aces.illinois.edu

Up-to-date information on the latest projects, research, and findings among all the departments within the College of ACES.

**Illinois Extension News**

web.extension.illinois.edu/state/news.cfm

U of I Extension is the flagship outreach effort of the university, offering educational programs to residents of all of Illinois’ 102 counties – and far beyond.

**WILLAg**

will.illinois.edu/agriculture

Regional, national, and international information and analysis of commodity markets and agricultural weather.

**farmdocdaily**

farmdocdaily.illinois.edu

Round-the-clock access to integrated information and expertise for producers to better manage their farm businesses.

**Policy Matters**

policymatters.illinois.edu

U of I economists share research-based analyses on timely policy issues in blog style. Subscribe to receive postings via an RSS feed or email.

**The Bulletin**

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Pest management and crop development information for Illinois.
AgrAbility Unlimited (AU)

Helping individuals stay on the farm after a disability

Chip Petrea, Department of Agricultural Engineering; principal research specialist, ag safety and health; repetrea@illinois.edu, 217-333-5035

Illinois was one of the first states to benefit from the USDA initiative for a state-level program to provide information on accommodating disability in agriculture. Building on the strength of nationwide resources and a statewide network of agricultural, rural health, safety, and social agencies, AgrAbility Unlimited offers education and assistance in identifying ways to accommodate disabilities, eliminate barriers, and create a favorable climate among rural service providers for people with disabilities. AgrAbility strives to help agricultural people maintain their livelihoods by keeping them "on the farm," providing information on safe and affordable modifications and solutions, regardless of disability, whether the farming operation is large or small.

AU is a partnership among University of Illinois Extension, the U of I Department of Agricultural and Biological Engineering, and Central Illinois Easter Seals. Using funds granted from public and private organizations and individuals to establish the program, AU offers comprehensive assistance to individuals, their families, and employees engaged in farming or a farm-related activity who have been affected by a disability.

Center for Advanced BioEnergy Research (CABER)

One-stop shop for Illinois bioenergy information

Hans Blaschek, director
Vijay Singh, associate director for engineering
Natalie Bosecker, coordinator for communications and external relations, bioenergy@illinois.edu, 217-244-9270, bioenergy.illinois.edu

The Center for Advanced BioEnergy Research (CABER) helps facilitate cross-disciplinary research, education, and outreach programs that promote the use of biorenewable resources. At the CABER Bioprocessing Laboratory, researchers and commercial partners can test scale-up and commercialization steps for new feedstocks, biofuels production, and biochemical production. Progress in this lab will create opportunities and new crops for farmers and help produce sustainable renewable energy sources.

For a daily review of bioenergy news and research throughout the world, visit the CABER bioenergy research blog: bioenergyuiuc.blogspot.com.

EDUCATION

CABER coordinates the professional science master’s degree in bioenergy, a 16-month program that integrates science and business classes and an internship. The Advanced Bioenergy Topics seminar series, held in the spring semester, is open to the public. An online class in bioenergy is also offered in the spring semester.

The Illinois Biomass Working Group discusses opportunities for farmers, industry, academia, and the financial industry to work together on biomass issues, including logistics, market creation, research, and small-to large-scale heat and electricity projects. Visit www.illinois biomass.org.
Field and Furrow Club
An agricultural club for students

Wendy White, club advisor, wgwhite@illinois.edu, 217-244-0484

The Field and Furrow Club informs and exposes members to every aspect of agriculture and supplies them the leadership skills needed for success. We strive to incorporate students of a range of majors to become a well-rounded and diversified agricultural club. Since celebrating our 75th anniversary in 2010, Field and Furrow Club has become more involved and active than ever before. In 2010 and 2012 we were named the outstanding club in the College of ACES. In addition to serving breakfast at Agronomy Day for more than 30 years, we hold fundraising events and participate in social and philanthropic activities throughout the year. Our money is used for our monthly meetings and to attend regional and national conferences in conjunction with the American Society of Agronomy.

Illinois Farm Business Farm Management (FBFM) Association
Helping farmers manage successful businesses

Dwight D. Raab, FBFM program coordinator, dwight.raab@fbfm.org, 217-333-5511, www.fbfm.org

Illinois Farm Business Farm Management is a cooperative-educational service, record keeping, and business analysis program for operating farmers. There are nine local associations in the state and just under 5,800 members. The Pioneer FBFM Association, in existence since 1924, is the oldest, and the Shawnee FBFM Association the youngest, having started in the early 1960s.

The participating farmer-members elect representatives to serve on a board of directors that provides for the services offered and establishes policy. The board employs field staff to deliver services, each working with about 100 members. Our 60 professional staff, all with at least a bachelor’s degree in agricultural economics or a closely related field, deliver current expertise in financial management, accounting, and tax planning/preparation to commercial farmers. They meet with clients three or four times annually to discuss the farm’s business analysis, income tax planning, agronomic analysis, estate planning, and other topics related to operating and managing the farm business.
The Illinois Soybean Association (ISA) invests checkoff dollars in programs that help soybean farmers increase yield potential as well as activities that help increase demand for Illinois soybeans at home and abroad. ISA’s mission is to ensure Illinois soy is the highest quality and the most dependable, sustainable, and competitive in the global marketplace. ISA’s priority target areas for investment are animal agriculture, transportation, soybean yield and composition, and freedom to operate. ISA also funds programs tied to organizational excellence and leadership development. ISA partners with livestock and poultry producers to increase soybean use in feed rations, seeks solutions to the transportation challenges that threaten Illinois competitiveness, works to enhance yields and soybean quality to meet all buyer needs, and coordinates with industry stakeholders to keep market pathways open for the future.

SARE, the Illinois Sustainable Agriculture Research and Education program, advances profitable and environmentally sound farming systems that are good for communities through a nationwide program of research and education grants. Illinois offers competitive grants in five areas:

1. Farmer Rancher—For farmers and ranchers who want to explore sustainable solutions to problems through on-farm research, demonstration, and education projects.
2. Research and Education—With a strong outreach component and significant farmer/rancher or other end user involvement from inception of the idea through implementation of the project.
3. Professional Development Program—Supports state professional development programs and competitive grants for training agricultural educators in extension, the Natural Resources Conservation Service, and private and not-for-profit sectors, using farmers as educators and addressing emerging issues in the farm community.
4. Graduate Student—Funds graduate student projects that address issues of sustainable agriculture.
5. Youth Educator—Supports educators in providing programming on sustainable agriculture for youth.

This project is supported by the Beginning Farmer and Rancher Development Program of the National Institute of Food and Agriculture, USDA, Grant # 2012-49400-19565. The project has these goals:

1. Increase the number of new farmers producing fruits and vegetables throughout Illinois and enhance the viability, profitability, and sustainability of new and beginning enterprises to meet increasing demand for local produce and contribute to local economies.
2. Assist a specific target audience—seasonal Hispanic farm workers—in beginning viable, profitable, and sustainable small produce farms.
3. Increase the expertise of university extension educators, high school and community college teachers, and educators in community organizations so they can better aid new farmers.

In year two of a three-year grant, over 100 students are enrolled at three locations: St. Charles Horticulture Research Center (northern Illinois); Urbana Research and Education Center (central Illinois); and Dixon Springs Agricultural Center (southern Illinois).
Turner Hall Transformations

Marise Robbins-Forbes,
College of ACES director of development for Crop Sciences and NRES, mrforbes@illinois.edu, 217-244-2082

The sights and sounds of construction are coming to Turner Hall (home to the Department of Crop Sciences)! It has been over 50 years since the building was constructed in 1963, and renovations are needed throughout. As a top priority for both the campus and the College of ACES, a $10-million initiative to renovate Turner Hall classrooms and teaching laboratories received $5 million in campus funding. A volunteer committee co-chaired by alums Bill Kirk and Jerry Brookhart seeks to raise an additional $5 million to complete the project and provide light, bright, modern learning spaces in key areas of the building. Thanks to lead gifts from individuals and corporations the project is just past the halfway point, with $2.7 million raised so far. Stop by the booth to learn more about the planned improvements to Turner Hall, and visit the website to make a gift: advancement.aces.illinois.edu/turner.

University of Illinois Plant Clinic

What’s wrong with my corn (or soybeans, or favorite tomato plant)?

Suzanne Bissonnette, Plant Clinic and extension IPM coordinator, sbissonn@illinois.edu, 217-333-0519

Bring a troubled-plant sample to the U of I Plant Clinic display and we will diagnose it as you wait (one per person, please). The clinic is the Illinois representative in the North Central region of the National Plant Diagnostic Network (NPDN). The network’s goal is to provide rapid, accurate diagnoses of exotic pests, select agents, and other introduced insects, pathogens, and weed threats, and it provides funding to improve the capability of member clinics. The U of I Plant Clinic offers the public unbiased diagnoses of plant problems and access to opinions of specialists in multiple disciplines. A support fee is charged for all plant and soil samples. Find details on sample selection as well as submission forms at web.extension.illinois.edu/plantclinic. You can also follow us on Facebook (https://www.facebook.com/UofiPlantClinic) to keep up with current pest issues and what’s happening at the clinic.

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Rick Atterberry, ACES Information Technology and Communication Services, ratterbe@illinois.edu, 217-244-2828
www.pubsplus.illinois.edu.

Be sure to visit the PubsPlus sales table in the main tent. Among the titles featured this year are the new Growing Under High Tunnels in Illinois, the Midwest Cover Crops Field Guide, and the Forage Field Guide. Other publications on hand for immediate purchase include Identifying Weeds in Midwestern Turf and Landscapes, Field Crop Scouting Manual, Growth Stages of Agronomic Crops, Field Guide to Corn Diseases, and Pest Management in the Home Landscape. We’d also like to hear what future publications or mobile apps would be helpful to you, so be sure to stop by for a chat. And, once Agronomy Day is over, you can visit us online at any time. PubsPlus is your source for books, CDs, and other educational materials prepared by experts at the University of Illinois and elsewhere. Home gardening, commercial agriculture, educational kits for K-12 — whatever interests you, you’ll find information you need at attractive prices.
Faqiang Wu, Department of Crop Sciences, postdoctoral research associate, faqwu@illinois.edu, 347-604-5283

Yoshie Hanzawa, Department of Crop Sciences, assistant professor of plant biology, yhanzawa@illinois.edu

Steve Long, Department of Crop Sciences, professor of plant biology, slong@illinois.edu, 217-244-0881

CONSTANS (CO) plays a central role in photoperiodic flowering control of plants. However, much remains unknown about the function of the CO gene family in the short-day flowering soybean. We identified 26 CO homologs (GmCOLs) in the soybean genome. Phylogenetic analysis classified these GmCOLs into three clades conserved among flowering plants. Two homeologous pairs in Clade I, GmCOL1a/GmCOL1b and GmCOL2a/GmCOL2b, showed the highest sequence similarity to Arabidopsis CO. The mRNA abundance of GmCOL1a and GmCOL1b exhibited a strong diurnal rhythm under flowering-inductive short days and peaked at dawn, which coincided with the rise of GmFT5a expression. In contrast, the mRNA abundance of GmCOL2a and GmCOL2b was extremely low. Our transgenic study demonstrated that GmCOL1a, GmCOL1b, GmCOL2a, and GmCOL2b fully complemented the late-flowering effect of the co-1 mutant in Arabidopsis. Together, these results indicate that GmCOL1a and GmCOL1b are potential inducers of flowering in soybean. Our data also indicate rapid regulatory divergence between GmCOL1a/GmCOL1b and GmCOL2a/GmCOL2b but conservation of their protein function.

Eric Sedivy, Department of Crop Sciences, graduate student, esedivy2@illinois.edu, 773-344-4712

Yoshie Hanzawa, Department of Crop Sciences, assistant professor of plant biology, yhanzawa@illinois.edu

Steve Long, Department of Crop Sciences, professor of plant biology, slong@illinois.edu, 217-244-0881

Glycine soja (G. soja), the wild ancestor of cultivated soybean, contains a wide range of unexplored genetic diversity and thus presents itself as a potent source of desirable traits. Our aim is to identify genetic loci underlying the diversity of temperature response on agronomically important traits in G. soja. We have selected 96 G. soja accessions spanning 13 maturity groups from across east Asia and southeastern Russia. The 96 lines are being grown under two different temperature conditions (25 °C and 32 °C) at a 14-hr light/10-hr dark photoperiod to measure flowering (R1), beginning seed filling (R5), beginning maturity (R7), bud number, pod number, internode length, height, branching, lodging, and vining. We observed that all traits except bud number, inter-node length, and lodging were positively correlated with the maturity groups at 25 °C. Association mapping will be conducted using the obtained phenotype data. Identified loci will be used to elucidate genetic diversity in a wider range of soybean varieties and provide important genetic resources for breeding superior germplasm that are adaptive to fluctuating agricultural environments.
Innovative approaches to increasing crop yield

Steve Long, Department of Crop Sciences, professor of plant biology, slong@illinois.edu, 217-244-0881

Lisa Emerson, grant program manager, lemerson@illinois.edu, 217-333-9107

Yield potential increases of key C3 crops such as rice, wheat, and legumes have stagnated over the past decade. This comes at a time when FAO estimates that 70 percent more production will be needed by 2050. The RIPE project—Realizing Increased Photosynthetic Efficiency for sustainable increases in crop yield—is exploring new routes to achieve the needed jump in productivity.

RIPE seeks to realize increased and sustainable rice, grain legumes, and cassava crop yields to engineer improved photosynthesis. Coupled leaf- and canopy-level models are used to identify innovative approaches at the molecular level to yield in field environments. These approaches include the following:

- Importing algal carbon-concentrating mechanisms (CCMs) that concentrate carbon dioxide at the site of Rubisco
- Improving the photorespiratory bypass to reduce loss of fixed carbon, which consumes energy that would otherwise be used in photosynthesis
- Replacing Rubisco in C3 crop plants with foreign versions that are more efficient
- Improving leaf photosynthetic carbon metabolism by regulating the expression of specific proteins

Common background field experiments are being performed at the University of Illinois South Farms.

Turning sugarcane and sorghum into oil-producing crops

Steve Long, Department of Crop Sciences, professor of plant biology, slong@illinois.edu, 217-244-0881

Ank Michielsen, grant program manager, michiels@illinois.edu, 217-244-7473

Demand for biofuels is rapidly increasing. Biofuels are reducing the dependence on foreign oil, improving trade deficits in the energy market, and reducing air pollution and greenhouse gas emissions while creating economic development opportunities. Future growth of biofuels needs to come from domestically produced feedstock other than corn and soybeans. Our PETROSS crops—Plants Engineered to Replace Oil with Sugarcane and Sweet Sorghum—can help fuel our nation’s needs.

This project aims to convert sugarcane and sweet sorghum, already two of the world’s most productive crops, into biodiesel crops. Three components are engineered to produce PETROSS crops with yields and profit margins significantly higher than any existing biofuel crop: producing and storing oil in the stem in place of sugar by altering gene regulation, increasing leaf and crop photosynthesis, and increasing cold tolerance.

So far in sugarcane we have achieved an oil content of 2 percent, we have increased the efficiency of the conversion of sunlight by 30 percent, and we now have a sugarcane hybrid derived from a cross with Miscanthus.
Enhance your credentials and advance your career with ACES online courses and programs. Through the Center for Innovation in Teaching and Learning (CITL), the Department of Crop Sciences offers an online master's degree program, two professional development certificates, and a variety of courses. The online courses are equivalent to their face-to-face campus counterparts in terms of academic rigor and quality, and most courses are taught by the same faculty. The primary difference is that the online programs are designed for professionals who want to complete a master’s degree or certificate on a part-time basis and/or to improve or update their present competencies. Courses meet in “virtual classrooms” during evening hours to give students flexibility.

Noncredit courses for professional development are also available, enabling interested parties to sign up for courses purely for professional enrichment or to network with colleagues in their professions.

Other ACES departments offering online programs and courses through CITL include Natural Resources and Environmental Sciences, Food Science and Human Nutrition, Agricultural Education, and Animal Sciences.

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Continuing Education from the Department of Crop Sciences

**Online programs and courses for professionals in agriculture**

Anna Mehl, program coordinator, annamehl@illinois.edu, 217-244-7023, www.cropsci.illinois.edu/ocgs

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Thank You

for attending the 2014 University of Illinois Agronomy Day.

Your support of our programs is greatly appreciated.

We encourage you to stop by any time to view ongoing research projects.

And please plan to join us again next year on August 13, 2015!

Department of Crop Sciences
AW-101 Turner Hall
1102 South Goodwin Avenue
Urbana, IL 61801
Phone: 217-333-3420; fax: 217-333-9817;
e-mail: cropsci@illinois.edu

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Continuing Education from the Department of Crop Sciences

**2014 AGMasters Conference and 2015 Corn & Soybean Classics**

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