THE 2015 UNIVERSITY OF ILLINOIS

Corn & Soybean Classic

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Corn & Soybean Classic

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UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
College of Agricultural, Consumer and Environmental Sciences
Department of Crop Sciences

Weather Conditions in 2014 and the Outlook for 2015

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The outstanding features of 2014 included the harsh winter and cold, wet spring, a relatively cool summer, and a wet fall across Illinois and much of the Corn Belt. This resulted in planting and harvesting delays but may have produced less heat stress once the crops were established.

Winter 2014

For Illinois, the period of December 2013 through February 2014 was the ninth coldest on record. As Figure 1 shows, the departures from the average temperature show that the coldest air extended right out of the Arctic regions of Canada, through Minnesota and Wisconsin, and into Illinois. Temperatures in Illinois were 6 to 12 degrees below the 1981-2010 average with the more extreme conditions in the north. The much colder than average temperatures remained through March (Figure 2).

In addition to the cold temperatures, much of the Midwest experienced above-average snowfall (Figure 3). Most of central and northern Illinois saw snowfall 20 to 40 inches above average. And with the cold temperatures, the snow stayed on the ground much longer.

Another feature of the cold winter was the substantial frost depth in the soils. While there is not a widespread network of measurements, we received many reports of frost down to 3 to 5 feet in places. In fact, this last

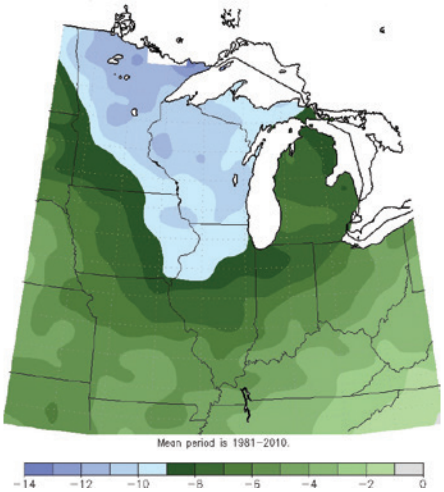
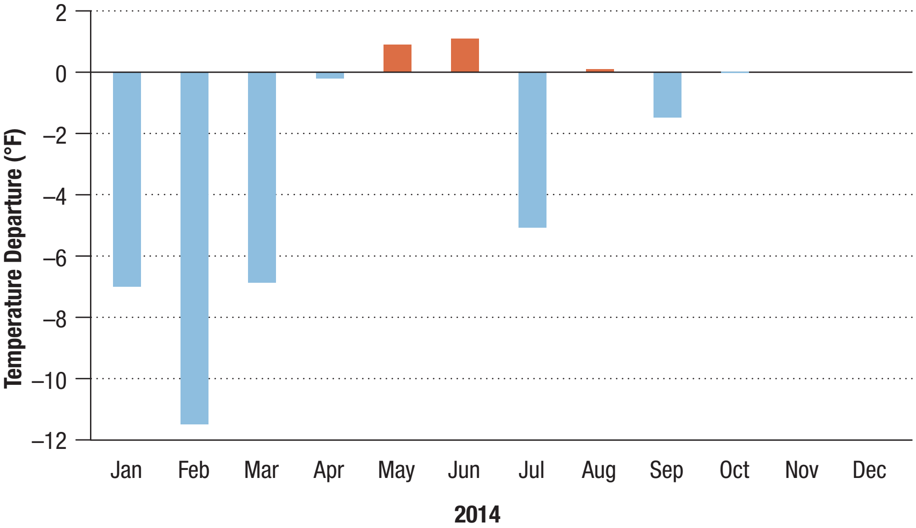


Figure 1 ■ Average temperature for the period of December 1, 2013, to February 28, 2014, as a departure from the 1981-2010 average.



(Illinois State Water Survey)

Figure 2 ■ Average monthly temperature for 2014, as departures from the 1981-2010 average.

winter was more typical of the winters in the late 1970s than what has been experienced in the last 20 years.

Spring and summer 2014

By April, temperatures had finally moderated but precipitation was above average (Figures 2 and 4). The cold, wet soils meant a slow start to the planting season. However, May was both warmer and drier than average which helped with planting and germination. Statewide, June rainfall was 2.6 inches above average which caused water problems in some fields.

One of the most interesting months during the growing season was July. The statewide average temperature was 70.3 degrees, and tied with July 2009 as the coolest July on record. Temperatures in the 90 degree range were a rare sight in July.

August, September, and October came in as close to average on temperature but above average on precipitation. The statewide average precipitation was 3.5 inches above average for those three months. That is about an extra month's worth of precipitation. Central third of Illinois

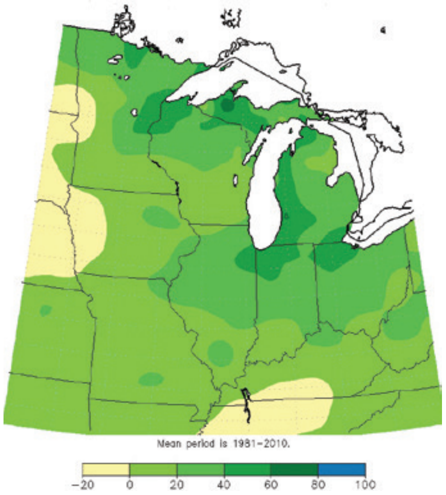
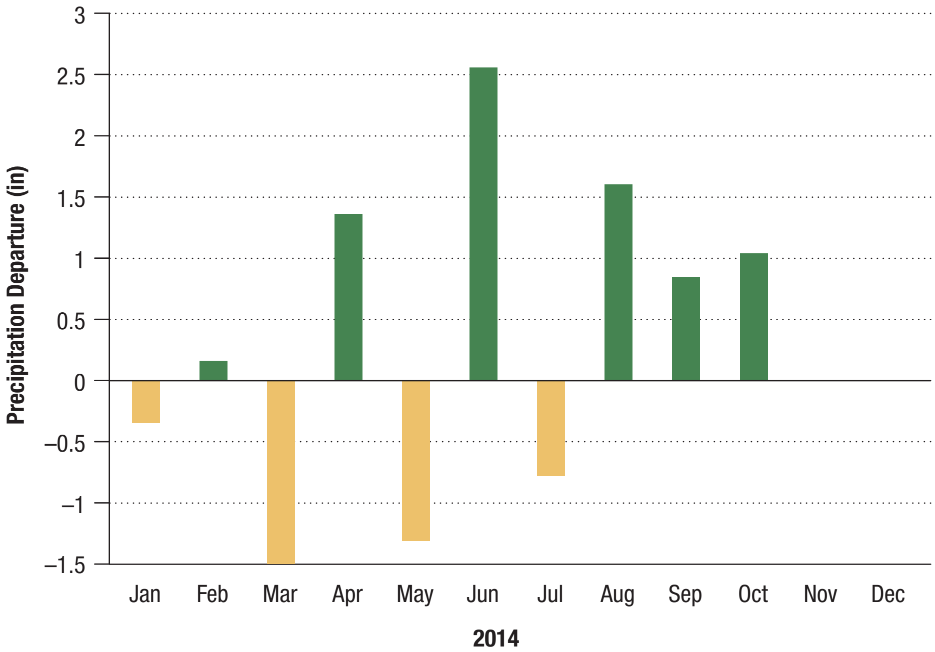


Figure 3 ■ Total snowfall for the period of October 1, 2013, to April 30, 2014, as a departure from the 1981-2010 average.



(Illinois State Water Survey)

Figure 4 ■ Average monthly precipitation for 2014, as departures from the 1981-2010 average.

was especially wet where amounts of 14 to 20 of precipitation were common. Some of the highest reported totals were at Jerseyville (Jersey County) with 24.82 inches and Hardin (Calhoun) with 23.06 inches.

Current Conditions

The presentation will provide an update on current conditions including temperature, precipitation, soil moisture, and soil temperatures.

Outlook for the 2015 Growing Season

The presentation will look at the forecasts for the 2015 growing season. Among the things to discuss are trends in growing season temperature and precipitation as well as the status of El Niño in the Pacific Ocean basin.

Helpful Websites

I have several web sites that I visit on a regular basis during the growing season. They include:

- US Drought Monitor: **droughtmonitor.unl.edu**
- National Weather Service: **www.weather.gov**
- NOAA Climate Prediction Center: **www.cpc.ncep.noaa.gov**
- USDA Crop Progress and Conditions: **www.nass.usda.gov/Statistics_by_State/Illinois/Publications/Crop_Progress_&_Condition/**
- Soil Moisture and Soil Temperatures: **www.isws.illinois.edu/warm/soil/**
- Midwestern Regional Climate Center: **mrcc.isws.illinois.edu**

Optimizing Drainage Systems to Improve Yields and Water Quality

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Conservation Drainage is the optimization of drainage systems for crop production, water quality and water harvesting benefits. In light of the importance of drainage to agriculture in the state, conservation drainage practices should reduce nutrient transport from drained land without adversely affecting drainage performance or crop production. Two of these practices, bioreactors and drainage water management, are eligible for cost-share in Illinois.

Bioreactors

A bioreactor is a buried trench with woodchips through which the tile water flows before entering a surface water body (Figure 1). Organisms from the soil colonize the woodchips. Some of them break down the woodchips into smaller organic particles. Other microorganisms "eat" the carbon produced by the woodchips, and "breathe" the nitrate from the water. Just as humans breathe in oxygen and breathe out carbon dioxide, these microorganisms breathe in nitrate and breathe out nitrogen gas, which exits the bioreactor into the atmosphere. Through this mechanism, nitrate is removed from the tile water before it can enter surface waters.

Drainage Water Management

In drainage water management, a control structure is placed at the outlet of a tile to control the outlet level of the system (Figure 2). This practice can be used to store more water in the soil profile after harvest, thereby reducing nitrate loading from tile effluent, or to retain water in the soil during the growing season. The normal mode of operation in Illinois is to set the water table control height to within 6 inches of the soil surface on November 1, and to lower the control height to the level of the tile on March 15. Thus, water is held back in the field during the fallow period. In experiments in Illinois, reductions of up to 46.6 % and 82.5 % were measured for nitrate and phosphate, respectively.

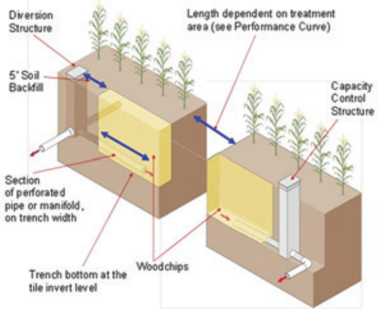

Figure 1

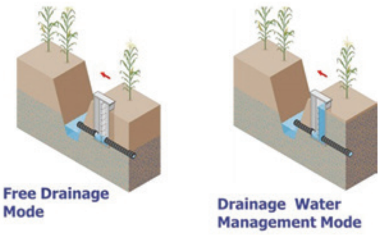

Figure 2 ■ Control structure on drain outlet facilitating Drainage Water management.

Effect of Drain Depth and Spacing on Yield

A long-term experiment was established to determine the effect of drainage depth and spacing on yield. Two drainage systems were installed in November, 2002, in a field in Livingston County. Two near-equal sections of the field were selected, and one of two drainage systems was assigned to each section. The locations and soil information for

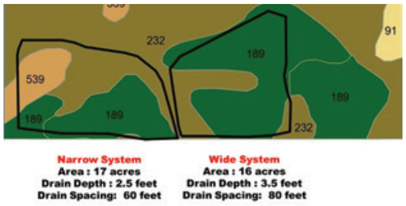

Figure 3 ■ Drainage system and soil information for the Livingston County Yield research site.

these two sections are shown in Figure 3. The dominant soils in the field are Ashkum (232) and Martinton (189). The Drainage Guide recommends that tiles be installed 3 to 3.5 feet deep, 75 to 95 feet apart; and 3 to 3.5 feet deep, 70 to 90 feet apart for these two soils, respectively. In one system the tiles were installed 3.5 feet deep, 80 feet apart, consistent with the recommendations, and the other was installed 2.5 feet deep, 60 feet apart. These systems will be referred to as the wide and narrow systems, respectively. The laterals were 4" in diameter. Both systems were designed so that the laterals would not be more that 3" above or below the 2.5' or 3.5' design depth.

The entire field was farmed as one unit without regard for the underlying drainage systems. The field was in a corn/soybean rotation for the first four years after the tiles were installed (2003-2006), and has been planted to continuous corn since 2007. Annual rainfall, taken from the Pontiac station which is within 30 miles of the site, was below average for 5 of the 11 years, above average for 5 years, and about average in 2004. Rainfall was 31% below average in the driest year, and 29% above average in the wettest.

The yield files for the entire field were converted to shapefiles, and clipped to obtain the yield within each of the sections underlain by the two drainage systems. The clipped maps were then analyzed using a yield analysis routine available on the Illinois Drainage Guide (http://www.wq.illinois.edu/dg/Equations/yields.exe).

Yield results are presented in Table 1. These results are based on trimmed yield files; the top and bottom 0.5% yield values were removed. In 2003, the first crop year after the systems were installed, the mean yield was higher, and yield was less variable for the narrow system. However these trends were reversed in all the subsequent years. For the two soybean years, the wide system yield exceeded the narrow system yield by an average of 4.5 bu/ac. With the exclusion of 2003, wide system corn yield exceed narrow system corn yield by an average of 24 bu/ac, and wide system yield variability was, on average, 23% less than narrow system yield variability. In 2012 and

Table 1 ■ Yield data for the Livingston County research site.

Year	Annual Rainfall/ Mean Annual Rainfall	Narrow System Yield (bu/ac)	Wide System Yield (bu/ac)	Standard Deviation Ratio (Narrow/ Wide)	Narrow System Moisture Content (%)	Wide System Moisture Content (%)
2003	85%	156	148	0.80	17.0	18.4
2004	98%	53	58	1.73	9.1	9.2
2005	69%	181	193	1.36	16.2	16.2
2006	109%	44	48	1.74	12.9	12.8
2007	128%	196	211	1.58	15.1	15.1
2008	118%	195	234	2.11	17.0	18.8
2009	129%	205	222	1.23	25.3	26.0
2010	88%	165	197	1.39	14.9	15.9
2011	109%	164	194	1.84	15.9	16.3
2012	74%	55	79	0.85	16.1	16.6
2013	89%	196	221	0.93	15.8	16.5

2013, however, yield was less variable over the narrow system. There was no difference in grain moisture content for the two years in which soybeans were grown. However, grain moisture content over the narrow system was, on average, 0.64% lower than over the wide system.

Narrow, shallow systems are often presented as performing better in drought years. In this particular instance, this was not consistent with the 2012 results, when yield of the wide deep system exceed yield over the narrow shallow system by 24 bu/ac.

Preliminary results from the Livingston County paired drainage system site support the use of the depth/spacing combination recommended for Ashkum and Martinton in the Illinois Drainage Guide.

Crop Economic Outlook and Responses to that Outlook

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Projected 2015 corn and soybean returns are significantly below actual returns from 2010 through 2013. Moreover, 2015 soybean returns are projected to be higher than corn returns, an unusual situation relative to recent years. Lower returns will require responses that include: 1) lowering or eliminating capital purchases, 2) lowering fertilizer and seed costs, 3) lowering cash rents, and 4) reducing other cash flows.

2015 Crop Budgets

Table 1 shows 2015 Crop Budgets for high-productivity farmland in central Illinois. Faculty in the Department of Agricultural and Consumer Economics at the University of Illinois prepare these budgets. They are available in the management section of farmdoc (www.farmdoc.illinois.edu) and are updated three or four times a year, depending on changes in prices and input costs.

Table 1 ■ 2015 Crop Budgets, Central Illinois—High Productivity Farmland

	Corn-after-Soybeans	Corn-after-Corn	Soybeans-after-Corn	Soybeans-after-Two Years-Corn	Double-Crop Wheat	Soybeans
Yield per acre	199	189	57	59	75	34
Price per bu	$3.80	$3.80	$9.75	$9.75	$5.00	$9.75
Crop revenue	$756	$718	$556	$575	$375	$332
ARC/PLC	20	20	20	20	20	20
Crop insurance proceeds	0	0	0	0	0	0
Gross revenue	**$776**	**$738**	**$576**	**$595**	**$395**	**$352**
Fertilizers	$148	$158	$49	$49	$80	$29
Pesticides	60	66	40	40	27	37
Seed	124	124	78	78	51	51
Drying	23	22	1	1	1	0
Storage	5	5	4	4	1	1
Crop insurance	27	27	18	18	9	5
Total direct costs	**$387**	**$402**	**$190**	**$190**	**$169**	**$123**
Machine hire/lease	$11	$11	$9	$9	$9	$6
Utilities	5	5	4	4	4	5
Machine repair	25	25	22	22	20	20
Fuel and oil	24	24	21	21	20	20
Light vehicle	2	2	1	1	1	1
Mach. depreciation	69	69	63	63	53	30
Total power costs	**$136**	**$136**	**$120**	**$120**	**$107**	**$82**
Hired labor	$18	$18	$16	$16	$14	$13
Building repair and rent	8	8	5	5	4	6
Building depreciation	7	7	11	11	10	5
Insurance	10	10	10	10	8	0
Misc	8	8	8	8	7	0
Interest (non-land)	11	11	10	10	12	7
Total overhead costs	**$62**	**$62**	**$60**	**$60**	**$55**	**$31**
Total non-land costs	**$585**	**$600**	**$370**	**$370**	**$331**	**$236**
Operator and land return	**$191**	**$138**	**$206**	**$225**	**$64**	**$116**

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Revised: July 2014

Four sets of budgets are prepared: 1) northern Illinois, 2) central Illinois high-productivity farmland (shown in Table 1), 3) central Illinois low-productivity farmland, and 4) southern Illinois.

Historical reports in the same format as the budgets shown in Table 1 are available in the management section of farmdoc. These historical reports give historic yields, prices, and costs for grain farms enrolled in Illinois Farm Business Farm Management (FBFM). These historic values are the basis for the projections shown in budgets. Historical costs values are adjusted up or down based on changes in input costs to arrive at cost projections.

In the budgets, gross revenue consists of crop revenue, ARC/PLC payments, and crop insurance proceeds (see Table 1). Gross revenue equals crop yield times price per bushel. Crop yield is a trend estimate of yields. A trend line is fit to previous yields and then projected into 2015. Prices are based on Chicago Mercantile Exchange futures contracts.

Costs are divided into three categories:

1. Direct costs include fertilizer, pesticides, seed, drying, storage, and crop insurance.
2. Power costs primarily relate to machinery and include machinery hire and leasing, utilities, machinery repair, fuel and oil, light vehicle, and machinery depreciation.
3. Overhead costs include hired labor, building repair and rent, building depreciation, insurance, miscellaneous, and interest costs. Interest costs are for non-land items. Interest on land purchases is not included in these budgets.

Summing up the above items gives total non-land costs. These include all financial costs except those related to controlling farmland. Subtracting non-land costs from gross revenue gives operator and land return. The operator and land return for corn-after-soybean is $191 per acre (see Table 1) and represents the amount available to split between the farmer and landowner. In a cash rent situation, the cash rent is subtracted from operator and land return to arrive at farmer return. If cash rent is $300 per acre, the farmer return for a $191 operator and land return is –$109 per acre ($191 operator and land return – $300 cash rent).

Implications from 2015 Returns

Two items are striking about 2015 returns. The first is that corn returns are projected lower than soybean returns. In central Illinois, projected returns are $191 per acre for corn-after-soybeans and $138 for corn-after-corn. Both of these corn returns are lower than soybean returns. Soybean returns are $206 per acre for soybeans-after-corn and $225 per acre for soybean-after-two-years-corn. Having soybean returns higher than corn returns is unusual. In most recent years, corn returns have been projected higher than soybean returns.

These projections may hold implications for shifts in acres in 2015. Since soybeans are projected more profitable than corn, there may be a shift of acres to soybeans. Central Illinois has a larger comparative advantage in corn production over soybean production than many other areas of the United States. Therefore, incentives to shift acres may be larger outside of central Illinois than those illustrated in budgets for central Illinois.

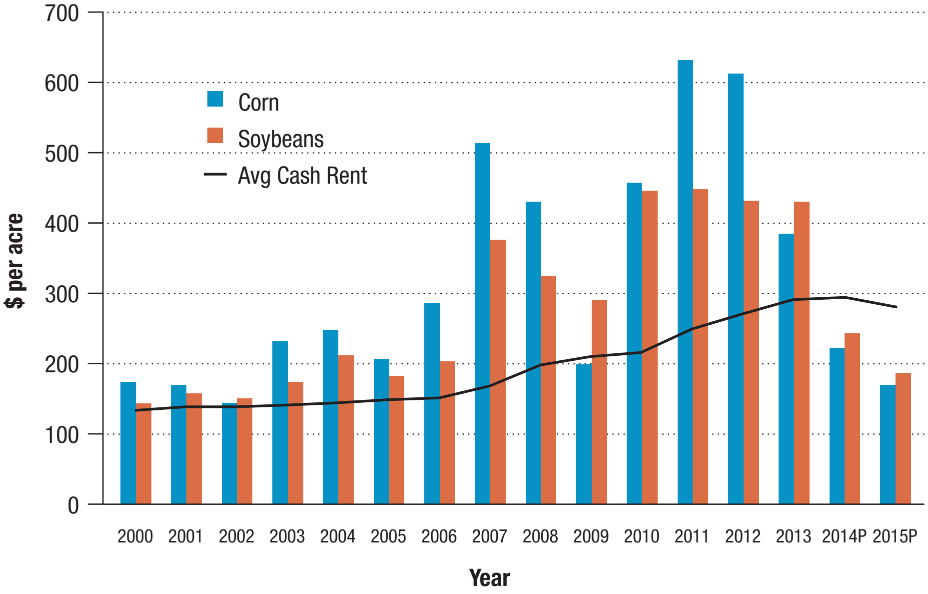

Figure 1 ■ Operator and land returns and average cash rents, central Illinois farmland with high-productivity, 2000 to 2015P. Source: Illinois Farm Business Management.

Commodity price changes between now and planting could change the incentives to switch acres. Monitoring relative corn and soybean prices will be important this year. A particularly important piece of information will be planting intentions released by the U.S. Department of Agriculture on March 31, 2015. This report will give USDA's first look at plantings for 2015. Relative prices could change depending on planting intentions published in this report.

The second striking aspect of 2015 returns is how low 2015 returns are. Operator and land returns reached high levels in 2010 through 2013 (see Figure 1), averaging $520 per acre for corn and $437 per acre for soybeans. Both of these returns are averaged over previous crops (i.e., the corn average is an average of corn-after-soybeans and corn-after-corn). In 2015, farmland returns are projected at $180 for corn and $280 for soybeans. The 2015 projected returns are over $240 per acre lower than averages from 2010 through 2013.

Responses to Lower Returns

These lower returns likely will require farmers to make the following adjustments:

Lower or eliminate capital purchases: Capital purchases were high in 2010 through 2013. During these years, capital purchases on Illinois grain farms exceeded $100 per acre. Now machinery purchases need to be reduced due to Lower cash flows.

Lower fertilizer and seed costs: Taken together, fertilizer and seed costs account for 46% of non-land costs for corn and 34% of non-land costs for soybeans. Over the last several years, these costs have risen dramatically. In central Illinois, fertilizer costs for cost rose from $82 per acre in 2006 to $193 in 2013, an increase of $111 per acre. Seed costs increased from $45 per acre in 2006 to $114 per acre in 2013, an increase of $69 per acre.

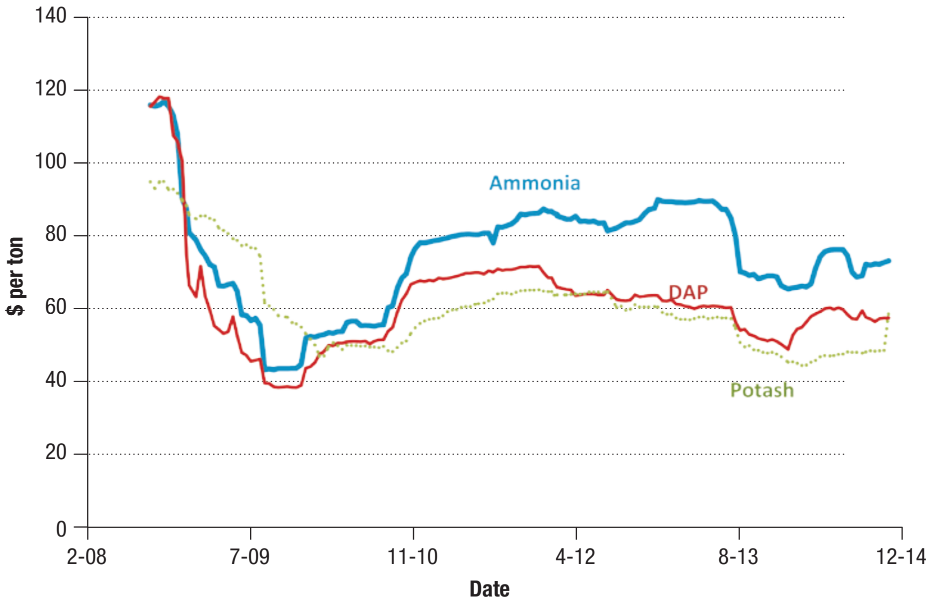

Figure 2 ■ Fertilizer prices in Illinois, bi-monthly prices. Source: Agriculture Marketing Service, USDA.

As of fall 2014, fertilizer and seed prices had not decreased from 2013 levels. On November 13th, the Agricultural Marketing Service reported the average Illinois prices for anhydrous ammonia of $725 per ton, diammonium phosphate (DAP) of $579 per ton for, and potash of $586 per ton. These prices are higher than year earlier levels (see Figure 2). Many seed companies have announced seed prices for 2015 that are relatively the same as for 2014 prices.

It seems prudent to evaluate whether fertilizer amounts can be lowered and whether lower priced hybrids and varieties should be planted.

Lower cash rents: Average cash rent levels are above those that can be supported by current projections of returns. In many cases, cash rents need to be lowered in response to the reduction in returns. If cash rents cannot be lowered, it may be prudent to no longer farm a piece of farmland. If return projections hold, significant losses in 2015 could cause the financial position of farms to deteriorate.

Reduce other cash flows: There may be a need to reduce other cash flows. In particular, an evaluation of family living expenditures may be needed as family living expenditures have increased dramatically in recent years.

Summary

Return projections are lower in 2015. In some respects, these return projections are nearer what should be expected in the future than actual returns experienced between 2010 through 2013. These lower returns bring us back to the point where all costs and cash flows need to come under scrutiny.

Inputs and Insect Management: Considerations for 2015

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Producers are faced with difficult input decisions regarding insect management considerations for 2015. Seed costs, along with other inputs, have escalated during the past decade and the selection of transgenic hybrids now forms the foundation of a corn pest management program on most large-scale commercial grain farms. Less favorable corn prices have increased the difficulty and complexity of these pest management choices. According to the USDA Economic Research Service (August 26, 2014,), seed, fertilizer, and pesticide costs were expected to rise by $2.3 billion (3.5%) this past growing season. In September, Dr. Gary Schnitkey (2014), University of Illinois, released a summary of crop budgets for 2015 across central, northern, and southern Illinois. In his calculations he used a price of $3.80 per bushel for corn and the following yield projections: central Illinois (high productivity land) corn after soybeans—199 bushels per acre, corn after corn—189 bushels per acre; central Illinois (low productivity land) corn after soybeans—184 bushels per acre, corn after corn—174 bushels per acre; northern Illinois corn after soybeans—194 bushels per acre, corn after corn 184 bushels per acre; and southern Illinois corn after soybeans—162 bushels per acre, and corn after corn—152 bushels per acre. If a cash rent of $220 per acre is assessed an operator, the following projected losses would be incurred under these assumptions: central Illinois (high productivity land)—corn after soybeans (–$29 per acre), corn after corn (–$82 per acre); central Illinois (low productivity land) corn after soybeans (–$100 per acre), corn after corn (–$154 per acre); northern Illinois corn after soybeans (–$119 per acre), corn after corn (–$176 per acre), and southern Illinois corn after soybeans (–$199 per acre), and corn after corn (–$253 per acre). This as yet unfolding scenario is sobering and will require operators to negotiate cash rents effectively and make shrewd decisions on input decisions for the 2015 growing season. As concerns intensify over western corn rootworm resistance to some Bt proteins (Cry3Bb1 and mCry3A), producers are increasingly turning to the use of planting-time soil insecticides, along with Bt hybrids, to reduce the risk of yield losses. With the anticipated profit margins likely to be much narrower than in recent seasons, the necessity of a planting-time soil insecticide, along with a Bt rootworm hybrid should be carefully considered on a field-by-field basis in 2015. This holds true for other insect management inputs as well, such as routinely applying combinations of a fungicide and a pyrethroid to both corn and soybean fields with little or no scouting prior to application. In 2014, statewide surveys were conducted of several insect pests, including the western corn rootworm. The results of these surveys revealed the areas at greatest risk to economic insect damage in 2015. The maps shown in this paper should not be considered as a substitute for scouting individual fields and making more informed pest management decisions. Even areas of the state that appear as low risk could have contained fields with high densities of a given insect pest. This information along with the latest results from our soil insecticide and Bt efficacy trials will be discussed.

Western Corn Rootworm Resistance to Bt—An Update

Gassmann et al. (2011) confirmed the evolution of field resistance to the Cry3Bb1 protein, expressed in some Bt hybrids, by western corn rootworms in some continuous cornfields in Iowa. In cooperation with Drs. Aaron Gassmann and Joe Spencer (Illinois Natural History Survey), bioassays also have confirmed western corn rootworm resistance to the Cry3Bb1 protein in the following Illinois counties: Henry, LaSalle, McDonough, Mercer, Sangamon, and Whiteside. In 2013, severe root damage was confirmed in rotated corn that was planted to Bt hybrids expressing the Cry3Bb1 protein in Kankakee and Livingston counties (**http://bulletin.ipm.illinois.edu/?p=1629**). A portion of the western corn rootworm population in these two counties is suspected of being resistant to both the Cry3Bb1 protein and crop rotation. In a recent journal article, Gassmann et al. (2014) confirmed the field evolution of western corn rootworm resistance to the mCry3A protein and its cross resistance to the Cry3Bb1 protein. So far, only four Bt corn rootworm proteins have been commercialized and they include: Cry3Bb1, Cry34/35Ab1, mCry3A, and very recently eCry3.1Ab. Frank et al. (2013) selected for western corn rootworm resistance to the eCry3.1Ab protein using a laboratory colony. These recent findings confirm the need for the implementation of sound resistance management strategies and integrated pest management to prolong the usefulness of this very limited arsenal of corn rootworm Bt proteins.

As a consequence of heightened concerns regarding western corn rootworm resistance to some Bt proteins, corn growers have begun to rely increasingly on planting-time soil insecticides along with their continued use of Bt hybrids. This dual approach is not only costly but may actually hasten the onset of resistance to Bt proteins (Petzold-Maxwell et al. 2013) according to the authors of this paper—land grant scientists at Iowa State University, University of Illinois, and University of Nebraska. The evolution of field resistance by western corn rootworms to some Bt proteins fits squarely into the definition of "practical resistance" defined by Tabashnik et al. (2014): "field-evolved resistance that reduces pesticide efficacy and has practical consequences for pest control." One of the unfortunate consequences of resistance development to the Cry3Bb1 and mCry3A proteins has been a justifiable lack of confidence in rootworm protection afforded by some Bt hybrids and an escalation in the use of planting-time soil insecticides along with Bt rootworm hybrids on some farms. Looking towards the 2015 growing season, producers need to carefully evaluate whether or not this combined approach (Bt rootworm hybrid + planting-time soil insecticide) makes sense for their operation.

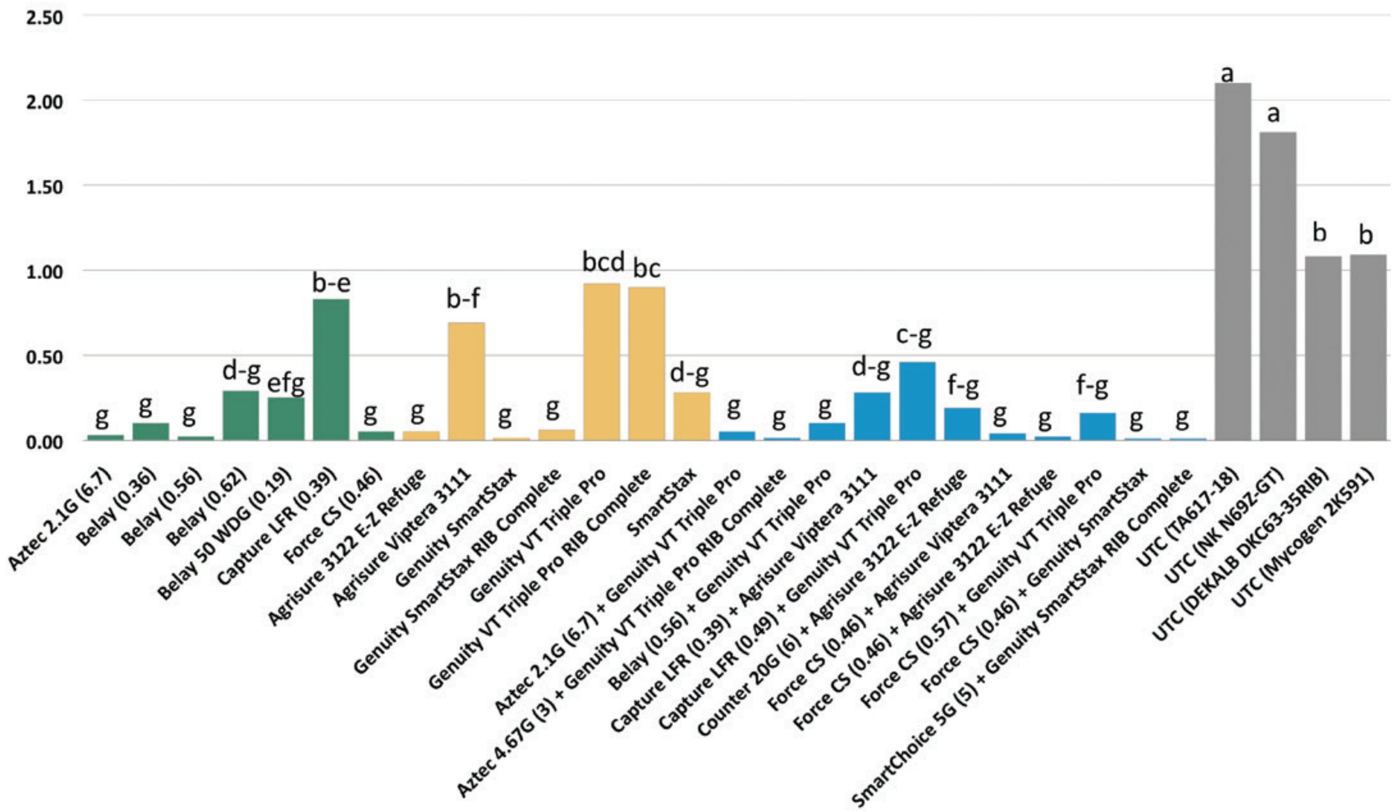
University of Illinois Corn Rootworm Trials, 2014

Significant sections of this portion of the paper were taken directly from my *Pest Management and Crop Development Bulletin* Article (**http://bulletin.ipm.illinois.edu/?p=2592**) posted on August 21, 2014.

In late July, the annual University of Illinois root "digs" and corn rootworm product evaluation trials were completed. Each experiment was established on plots that had been planted to a trap crop (late-planted corn interplanted with pumpkins) in 2013. The results for three of these studies are presented in Figures 1 to 3. The bar graphs are arranged with the soil insecticide only treatments appearing in green, Bt hybrid only products shaded in orange, Bt hybrids combined with soil insecticides represented by the darker blue color, and the untreated checks shaded in dark gray. Treatment bars that share the same letter do not differ statistically (P=0.05).

Most rootworm protection products at the Northern Illinois Agronomy Research Center (Figure 1) were able to keep root injury below 0.5 (1/2 node pruned). Products that resulted in root injury that exceeded this level included: Capture LFR (0.83), Agrisure Viptera 3111 (0.69), Genuity VT Triple Pro (0.92), and Genuity VT Triple Pro RIB Complete (0.9). These treatments were not statistically different from two of the untreated checks. The Agrisure Viptera 3111 treatment expresses the mCry3A rootworm protein along with some other proteins (Cry1Ab, Vip3A) designed to provide lepidopteran control. The Genuity VT Triple Pro and Genuity VT Triple Pro RIB Complete treatments express the Cry3Bb1 rootworm protein as well as some other Bt proteins (Cry1A.105, Cry2Ab2) for lepidopteran pests. With respect to the checks, three were treated with insecticidal seed treatments: NK N69Z-GT—Cruiser 500; DeKalb DKC63-35RIB—Poncho 500, and Mycogen 2K591—Cruiser 250. Seed for the TA617-18 check did not have any insecticidal treatment.

Overall rootworm pressure in the DeKalb trial was good with approximately two nodes of roots pruned in two of the check treatments. Under this level of injury, the root protection afforded by Bt hybrids

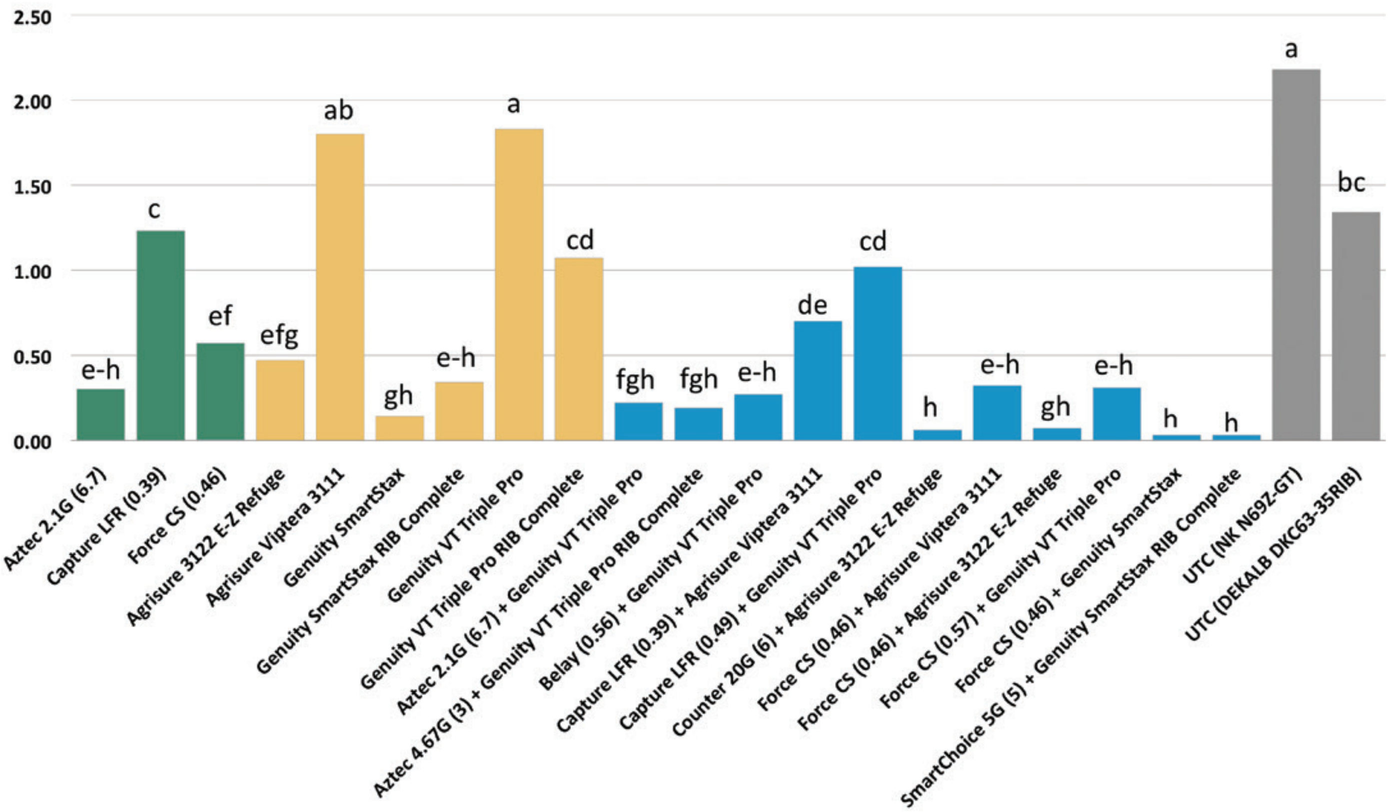


Rates for insecticides are given in ounces of product per 1,000 row-ft.; means for RIB treatments may or may not include ratings for refuge root systems.

Figure 1 ■ DeKalb Root Evaluations • Node-injury ratings for root protection products, Northern Illinois Agronomy Research Center, Shabbona, IL. Planting date May 8; Root dig date July 28. Node injury scores: 1 = one node of roots pruned to within 1.5 inches of the stalk (or soil line if roots originate from above ground nodes); 2 = two complete nodes pruned; and 3 = three or more complete nodes pruned. Means for RIB treatments may or may not include ratings for refuge root systems.

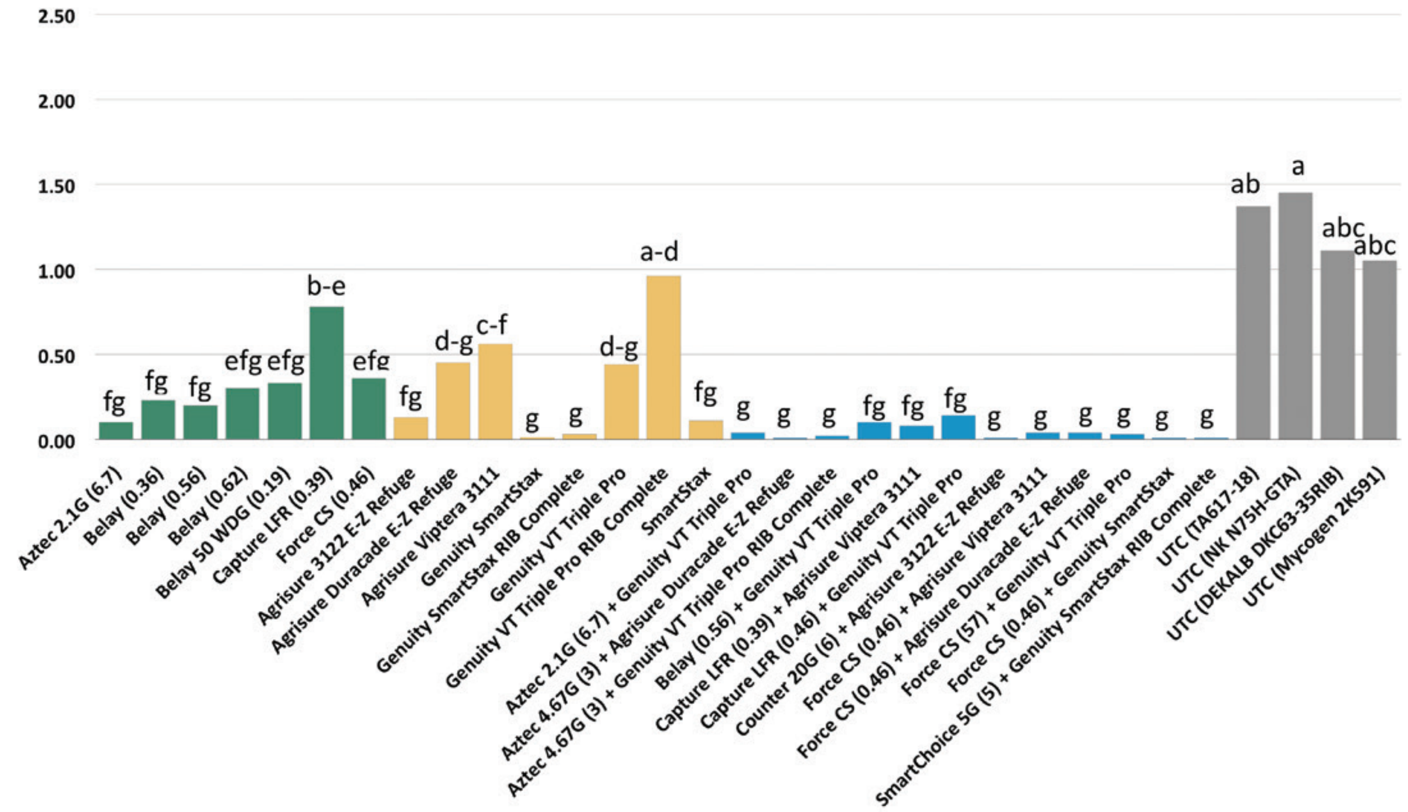
expressing only the Cry3Bb1 protein was not stellar. With the exception of Capture LFR, the soil insecticide (only) treatments offered very good levels of root protection. Overall, the combined use of a planting-time soil insecticide and a Bt hybrid did not statistically improve root protection over that of a soil insecticide used alone.

The past few seasons, corn rootworm injury at the Monmouth location has been low and difficult for us to effectively evaluate product performance. In 2014, root injury in one of our checks (NK N69Z-GT, treated with Cruiser 500) exceeded two nodes (2.18) of roots destroyed (Figure 2). The other check (DeKalb DKC63-35RIB, treated with Poncho 500) had less root injury (1.34). Most of the root protection treatments in Monmouth keep root injury below 0.5 (1/2 node pruned). However, root pruning in several treatments exceeded 1.0 (one node pruned) and included: Capture LFR (1.23), Agrisure Viptera 3111 (1.8), Genuity VT Triple Pro (1.83), Genuity VT Triple Pro RIB Complete (1.07), and Capture LFR + Genuity VT Triple Pro (1.02). Root protection afforded by Agrisure Viptera 3111 and Genuity VT Triple Pro was not statistically different from the untreated check (NK N69Z-GT) and use of both treatments resulted in nearly 2 nodes of roots destroyed. Resistance to the Cry3Bb1 protein has been confirmed in several northwestern Illinois counties and cross resistance with this protein to the mCry3A protein has been confirmed in Iowa. Although not confirmed, it seems possible that the



Rates for insecticides are given in ounces of product per 1,000 row-ft.; means for RIB treatments may or may not include ratings for refuge root systems.

Figure 2 ■ Monmouth Root Evaluations • Node-injury ratings for root protection products, Northwestern Illinois Agricultural Research and Demonstration Center, Monmouth, IL. Planting date May 7; Root dig date July 14. Node injury scores: 1 = one node of roots pruned to within 1.5 inches of the stalk (or soil line if roots originate from above ground nodes); 2 = two complete nodes pruned; and 3 = three or more complete nodes pruned. Means for RIB treatments may or may not include ratings for refuge root systems.



Rates for insecticides are given in ounces of product per 1,000 row-ft.; means for RIB treatments may or may not include ratings for refuge root systems.

Figure 3 ■ **Urbana Root Evaluations** • Node-injury ratings for root protection products, Agricultural and Biological Engineering Farm, Urbana, IL. Planting date May 12; Root dig date July 23. Node injury scores: 1 = one node of roots pruned to within 1.5 inches of the stalk (or soil line if roots originate from above ground nodes); 2 = two complete nodes pruned; and 3 = three or more complete nodes pruned. Means for RIB treatments may or may not include ratings for refuge root systems.

resistant western corn rootworm strain may have affected the performance of these treatments within this trial.

As compared with the DeKalb and Monmouth experiments, the overall root injury in the Urbana study (Figure 3) was lower with the four checks ranging from approximately 1 to nearly 1.5 nodes of roots pruned. Even with this moderate pressure, root injury in the Capture LFR (0.78) and Genuity VT Triple PRO RIB Complete (0.96) treatments approached one node of roots pruned and were statistically similar to several of the untreated checks. Root injury in the other treatments was generally below 0.5 (1/2 node pruned).

Statewide Insect Surveys in Corn and Soybean Fields

Surveys of corn and soybean fields were conducted during two sampling periods during the summer of 2014. Western corn rootworm adults were sampled in cornfields by counting the number of adults on 20 consecutive plants beyond end row areas of a given field. A beetle per plant average was calculated for each field. Within an adjacent soybean field, 100 sweeps were taken beyond the field edge (at least 12 rows). Five corn and soybean fields were sampled per county. Figures 4 through 8 depict the results of sampling key insect pests in corn and soybean fields for 2011 (last week of July, first 2 weeks of August), 2013 (period I—August 1 to 6, period II—August 14 to

August 16), and 2014 (period I—July 31 to August 5, period II—August 18 to September 8).

Bean leaf beetle. Bean leaf beetles are an occasional threat to profitable soybean production. In 2011, densities were greatest in east central Illinois (Figure 4). In 2013, the statewide population of bean leaf beetles was very low. During the most recent growing season, densities of this insect pest were greatest along the western edge of the state exceeding 20 beetles per 100 sweeps in some areas. Producers are encouraged to pay close attention to bean leaf beetles throughout the 2015 growing season in these portions of Illinois, especially if the winter of 2014–15 is mild. Seedling soybeans rarely warrant a rescue treatment from bean leaf beetle injury requiring densities of 16 beetles per foot of row (early seedling stage) or 39 per foot of row at the V2 (two sets of unfolded trifoliate leaves) stage of development. As the season progresses rescue treatments are dependent upon levels of leaf feeding and should be considered when defoliation reaches 30% before bloom and 20% between bloom and pod fill. During the seed maturation phase, rescue treatments may be justified when 5% to 10% of the pods have been fed upon, the leaves remain green, and at least 10 beetles per foot of row are present. As input decisions are made in 2015, producers should carefully assess the potential value of an insecticide application if these bean leaf beetle threshold levels have not been reached.

Japanese beetle. Since 2011, densities of Japanese beetles have been most significant in northwestern and north central counties of Illinois (Figure 5) exceeding 40 beetles per 100 sweeps in some soybean fields. A mild winter (2014–15) will favor survival of the grub and producers should be alert for damaging levels of the insect, especially in these areas of the state. Economic thresholds for Japanese beetles in soybean are the same defoliation thresholds used for bean leaf beetles: 30% before bloom and 20% between bloom and pod fill. The greatest densities of Japanese beetles are often along field margins and producers should scout field interiors before making any final treatment decisions. Japanese beetles are mobile and frequently travel between corn and soybean fields. They represent the greatest threat to corn production during the reproductive phase of development and rescue treatments should be considered if silk feeding is occurring and three or more beetles per ear are present and pollination is on-going. Similar to soybean fields, Japanese beetles often reach greater numbers along the margins of corn fields. Take the time to scout field interiors to accurately determine the overall level of silk clipping prior to any management decision. Early-planted (e.g., first week of April) corn fields are at greater risk to root injury by annual white grubs such as Japanese beetles; however, this injury is not widespread in any given spring. Planting-time soil insecticides applied in-furrow can control this type of injury. Rescue treatments are not an option in infested fields.

Northern corn rootworm. Northern corn rootworms are frequently overlooked as an insect threat due to the dominance of the western corn rootworm. Surveys of soybean fields since 2011 (Figure 6), reveal a surge of northern corn rootworm adults in northern Illinois during the later sampling periods of 2013 and 2014. Corn is the preferred oviposition site (Boetel et al. 1992) for northern corn rootworms. Rotated corn is still susceptible to northern

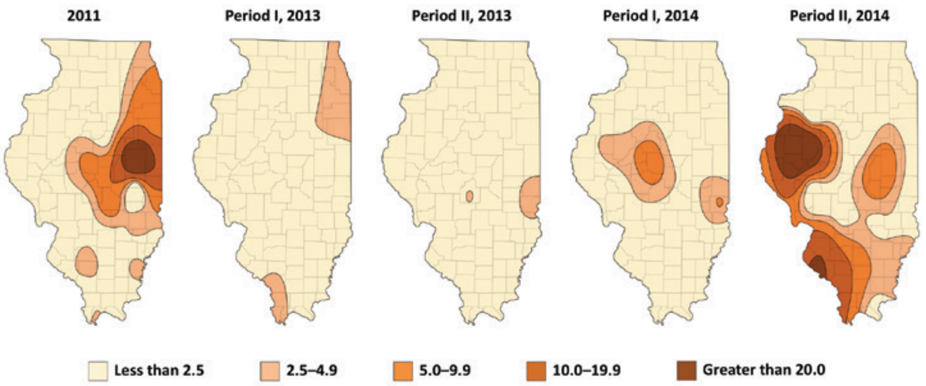


Figure 4 ■ Mean number of bean leaf beetles per 100 sweeps in soybean.

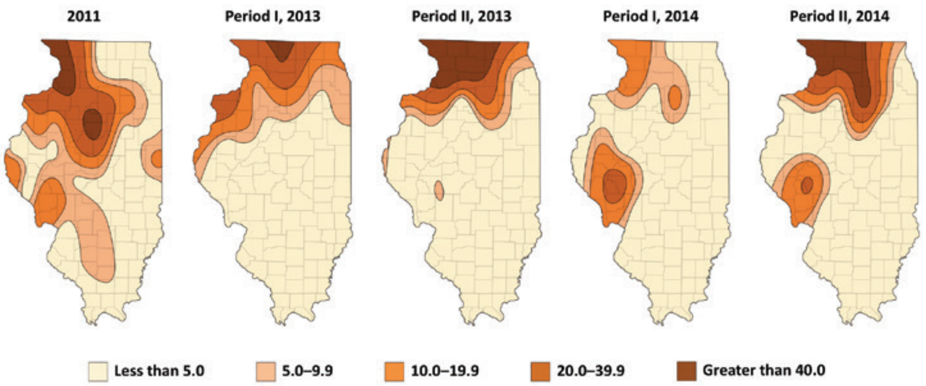


Figure 5 ■ Mean number of Japanese beetles per 100 sweeps in soybean.

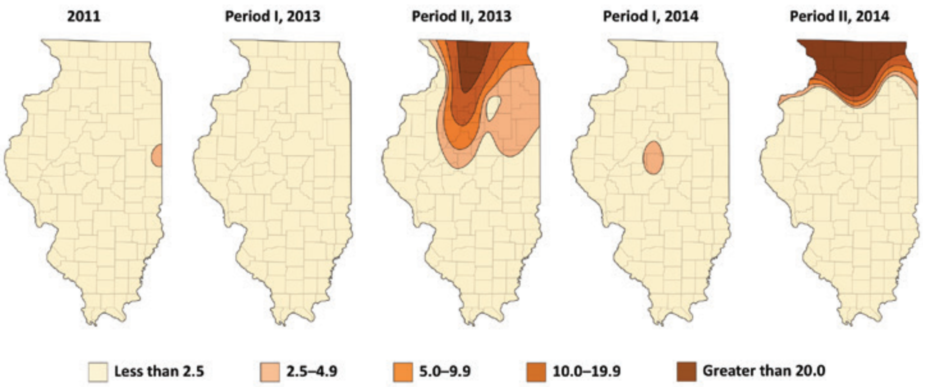


Figure 6 ■ Mean number of northern corn rootworm beetles per 100 sweeps in soybean.

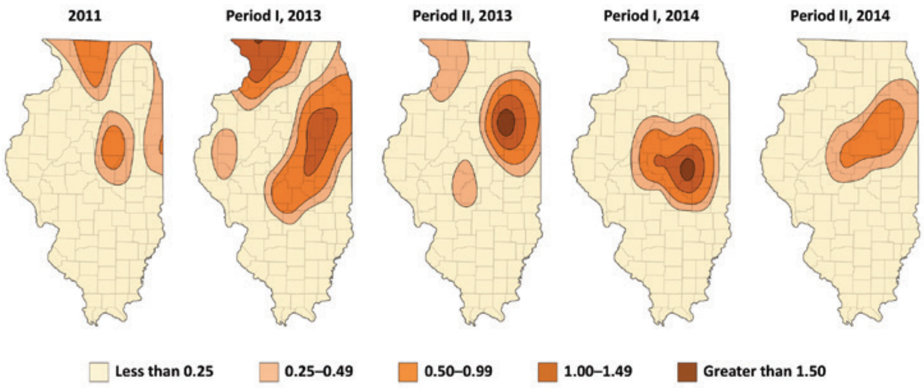


Figure 7 ■ Mean number of western corn rootworm beetles per plant in corn.

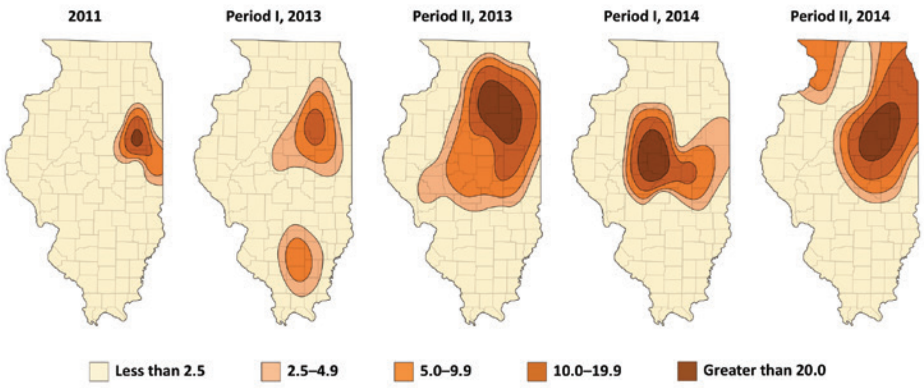


Figure 8 ■ Mean number of western corn rootworm beetles per 100 sweeps in soybean.

corn rootworm larval injury, not because of egg laying in soybean fields, but due to a segment of the population that prolongs diapause during the egg stage and overwinters for more than a single winter. The winter of 2013–2014 was harsh with temperatures far below normal in many areas of the Midwest, including Illinois. These survey data suggest that northern corn rootworms may have fared well during that winter accounting for an apparent upswing in their numbers during the summer of 2014. Northern corn rootworm adults are mobile and many of the beetles found in soybean fields likely returned to corn to lay eggs, setting the stage for potential root injury in continuous corn production fields in 2015.

Western corn rootworms in corn. Densities of western corn rootworm adults in corn have been greatest in east central Illinois during 2013 and 2014 as compared with other areas of the state (Figure 7). When beetle numbers reach or exceed 0.5 per plant (first-year corn) or 0.75 per plant in continuous corn, larval injury the following season may lead to economic losses unless management inputs (Bt rootworm hybrids, planting-time soil insecticide) or crop rotation are utilized. These threshold levels have been commonly reached in many east central Illinois counties the past two growing seasons. Western corn rootworm adults can also feed on silks and interfere with the pollination process. A rescue treatment should be considered when five or more beetles per plant are found, silks have been clipped to ½ inch of ear tips, and pollination is on-going. Western corn rootworm densities in cornfields were very low in many other areas of the state during the summer of 2014. Historically, western corn rootworm numbers have been very low across much of southern Illinois. Producers are encouraged to carefully scout fields for western corn rootworms each summer and critically evaluate the potential return on investment regarding the use of a Bt rootworm hybrid the following season. This is especially relevant for southern Illinois, an area not prone to perennial rootworm damage.

Western corn rootworms in soybean. In 2013 and 2014, densities of western corn rootworm adults in soybean fields were greatest in central, east central, and northeastern Illinois counties (Figure 8). Numbers of western corn rootworm adults exceeded 20 beetles per 100 sweeps in many fields. These data suggest that first-year corn fields within these areas are susceptible to potential economic losses due to western corn rootworm larval injury in 2015 unless management inputs are utilized. For nearly two decades, first-year corn in east central, central, and northeastern Illinois has been susceptible to injury caused by the rotation-resistant western corn rootworm. Other pockets of the state are also susceptible to first-year corn injury caused by the so-called "variant" however, it has been less frequently reported in recent years in those locations. Sampling procedures and economic thresholds have been developed that rely upon the use of Pherocon AM traps within soybean fields. If western corn rootworm adults average 5 beetles per trap per day during a 4-week monitoring period, producers are encouraged to utilize a Bt rootworm hybrid or planting-time soil insecticide the following season. Unfortunately, this sampling protocol is not commonly used.

Concluding Remarks

The upcoming growing season will require producers to carefully evaluate all input decisions with as much data, insights, and forethought as possible. Profit margins are likely to be narrow due to rising input costs, the record 2014 harvest, and the subsequent weak outlook for corn prices. By making more informed choices about insect management, some producers will be able to maintain a competitive advantage. Utilizing inputs that are not needed will cut into profits and may hasten resistance development of some key insect pests such as the western corn rootworm. Scouting fields, becoming familiar with economic thresholds, integrating management tactics, and thinking beyond a single growing season regarding pests will become increasingly important in the current economic climate.

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Getting to Know the Foliar Diseases of Corn

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Pathogens of corn are always present in Illinois, and can cause economic yield losses in susceptible hybrids when weather conditions are favorable for infection and disease development. High levels of foliar disease severity can lead to reduced yields, stalk rot, and lodging. Since photosynthesis rates are reduced in leaves blighted with disease, the plant may not be able to keep up with the carbohydrate demands of the ear. This can lead to "self-cannibalization" of the corn plant, where carbohydrates stored within the root and stalk systems are reallocated to the ear. This reallocation can weaken stalks, making them more susceptible to stalk-rotting fungi.

Although most of the major foliar diseases of corn in Illinois are caused by fungal pathogens, Goss's wilt, caused by a bacterial pathogen, has been on the increase in Illinois since the late 2000s. Being able to identify these different diseases will help when considering management options. Depending on the disease, resistant hybrids, crop rotation, and foliar fungicides may be available options to consider for disease management.

Goss's bacterial wilt. Goss's wilt, caused by the bacterium *Clavibacter michiganensis* subsp. *nebraskensis*, was first observed in Illinois in 1980. For approximately 30 years, Goss's wilt observations in Illinois had been sporadic. Since 2009, Goss's wilt observations have been on the increase in Illinois.

Leaf symptoms of Goss's wilt appear as large tan to gray lesions with dark spots, often referred to as "freckles", within the lesions. Edges of lesions may appear "water-soaked", and bacterial exudates may be visible on the surface of affected leaf areas, giving the lesions a shiny appearance (Fig. 1). In severe cases, bacteria may become systemic, enter the xylem, and cause wilting. Because wounds on the plant tissue must be present for the Goss's wilt bacterium to cause infection, fields that have been subjected to hail, high winds, and heavy rainfall are more likely to be affected.

No in-season control options are available to protect against Goss's wilt or to reduce the spread of disease within a field. A copper hydroxide product (Kocide 3000; DuPont) and a citric acid product (Procidic; Greenspire

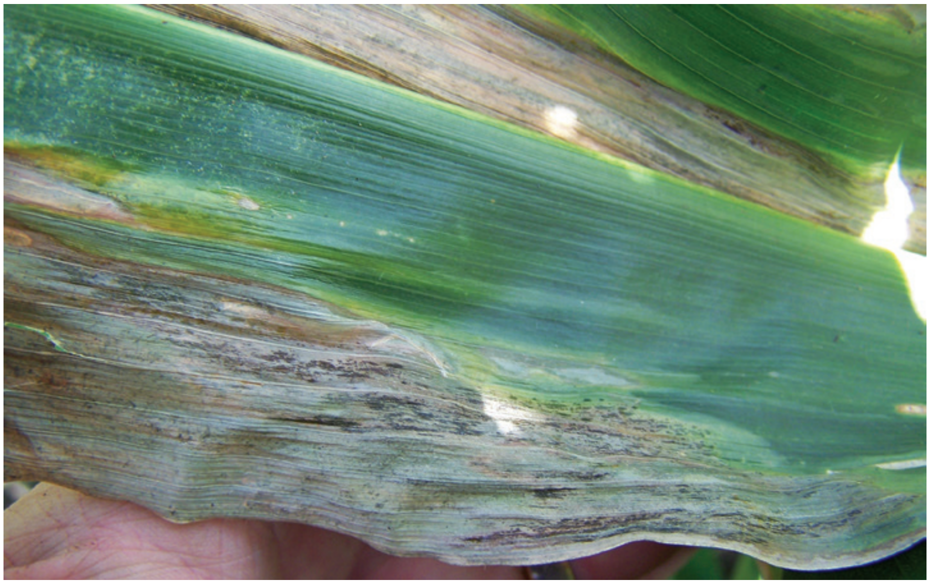

Figure 1 ■ Symptoms of Goss's wilt on a corn leaf.

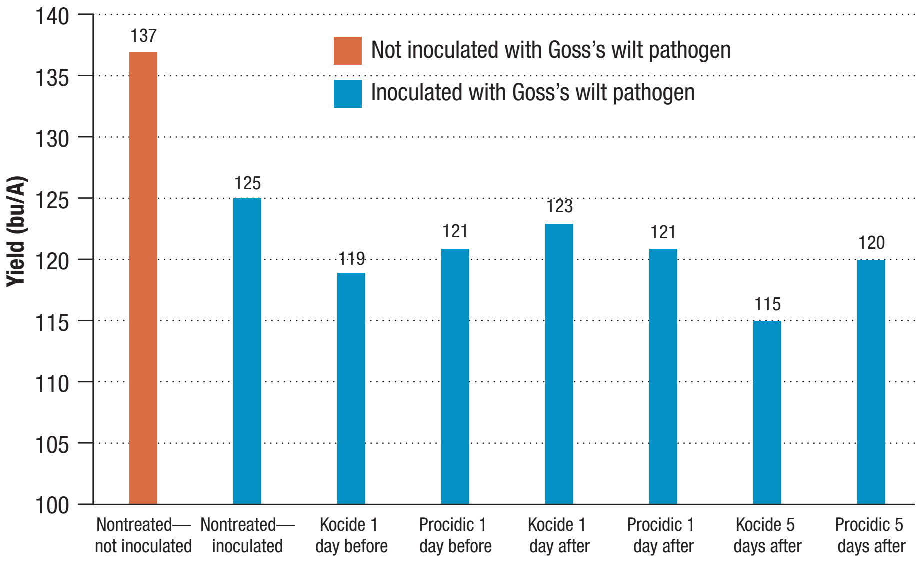

Figure 2 ■ Effect of chemical products on Goss's wilt-affected corn in a trial conducted over 3 environments in Urbana and Champaign, IL.

Global) were evaluated for their control of Goss's wilt in field trials located in Champaign and Urbana, IL in 2011 and 2012. The results from this trial indicated that these products did not reduce Goss's wilt severity, nor did they protect against yield losses caused by Goss's wilt (Fig. 2). The primary Goss's wilt management methods are planting corn hybrids with higher levels of resistance to Goss's wilt, rotating to non-host crops, and tilling to bury and speed up the decomposition of affected residue.

Northern leaf blight. Northern leaf blight, caused by the fungus *Exserohilum turcicum*, is a common disease under moderate temperatures and frequent rainfalls. Symptoms of northern leaf blight appear as tan-colored "cigar-shaped" lesions that are long with tapered ends.

Management practices used to limit losses caused by northern leaf blight include planting resistant hybrids, applying foliar fungicides, rotating to non-host crops, and tilling to speed up decomposition of affected residue. Many hybrids utilize the *Ht1* gene for resistance to northern leaf blight, but some races of the fungus have developed that are virulent (causes disease) against the *Ht1* gene. When race 0 affects hybrids with the *Ht1* gene, a "chlorotic" lesion may form, which is a resistant reaction by the plant. However, when race 1 affects hybrids with the *Ht1* gene, a susceptible "necrotic" lesion may form (Fig. 3). Recent research in the Bradley laboratory at the University of Illinois has revealed that many of the current *E. turcicum* isolates found in Illinois are virulent against the *Ht1* gene (race 1). Foliar fungicides can help protect hybrids from infections by the northern leaf blight fungus. Foliar fungicides that contain an active ingredient from the triazole class of fungicides may provide better protection against the northern leaf blight fungus.

Gray leaf spot. Gray leaf spot, caused by the fungus *Cercospora zeae-maydis*, was observed and reported for the first time ever in Alexander County, Illinois in 1924. Appearances of this disease have increased as conservation tillage

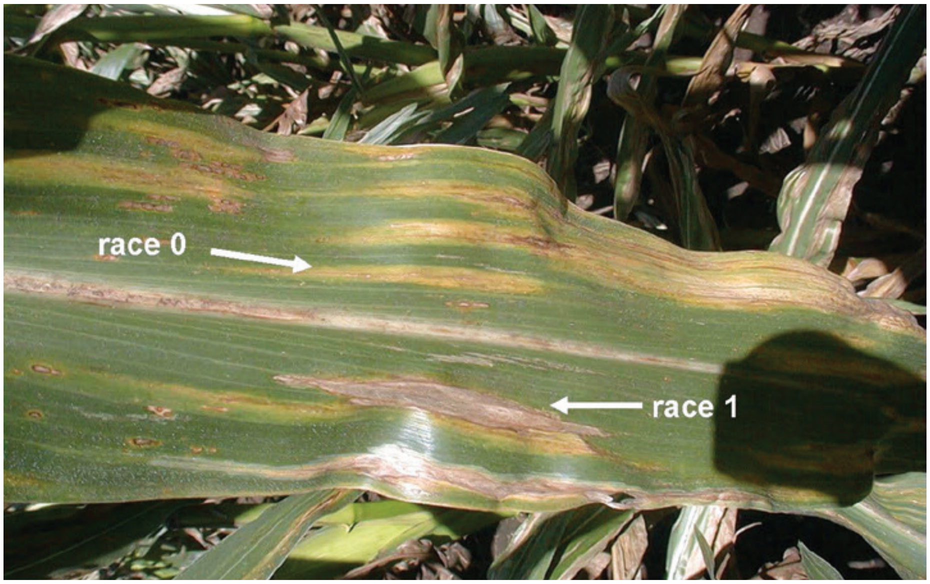

Figure 3 ■ Chlorotic (race 0) and necrotic (race 1) type lesions caused by the northern leaf blight fungus on a corn hybrid utilizing the *Ht1* resistance gene (picture courtesy J. Pataky).

practices have increased. Symptoms of this disease appear as rectangular lesions on the leaves. Eventually, lesions can coalesce, causing large blighted areas on leaves (Fig. 4).

Management practices used to limit losses caused by gray leaf spot include planting resistant hybrids, applying foliar fungicides, rotating to non-host crops, and tilling to speed up decomposition of affected residue. No hybrids are available that have complete resistance to gray leaf spot, but hybrids differ in susceptibility. Less susceptible hybrids will have smaller and fewer lesions compared to more susceptible hybrids. Fungicides are effective in protecting against gray leaf spot. Under situations with high risk of gray leaf spot (corn-

Figure 4 ■ Symptoms of gray leaf spot.

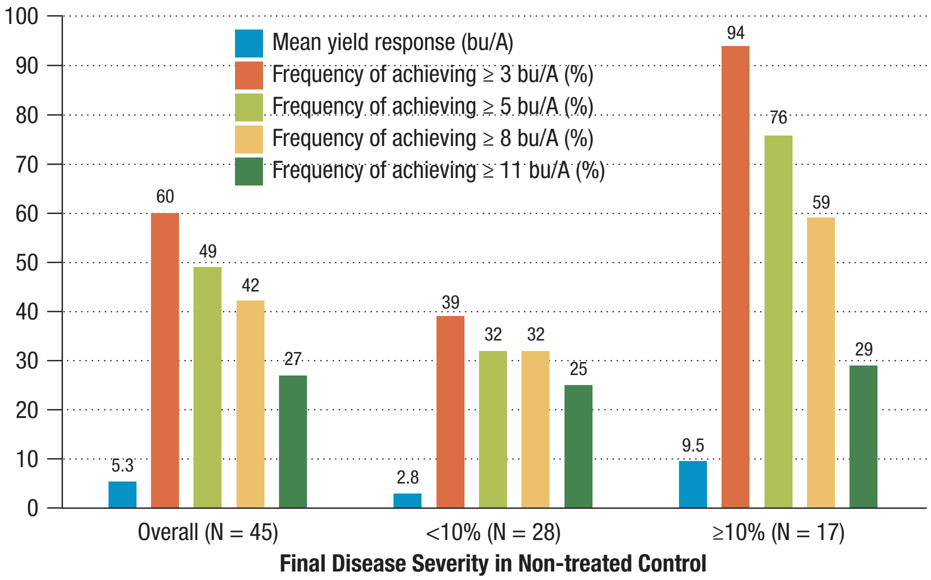

Figure 5 ■ Corn yield responses due to foliar fungicides across two different levels of disease pressure (based on University of Illinois trials conducted 2008 to 2014).

on-corn, susceptible hybrid, high relative humidity and temperature), keeping disease severity under 10% of the leaf area affected with foliar fungicides may be the most profitable (Fig. 5).

Foliar fungicide application timing. Foliar fungicides were evaluated in research trials conducted at 5 locations in Illinois in 2014 (DeKalb, Monmouth, Urbana, Auburn, and Dixon Springs). These trials evaluated several products applied at the V5 growth stage, at the R1 growth stage, and applied at both the V5 and R1 growth stages compared to non-treated controls. Disease levels and yield responses varied by location and product, but overall, the greatest yield response was observed when products were applied at the R1 growth stage (Fig. 6). In general, the greatest yield responses occur when disease pressure is more severe (Fig. 5).

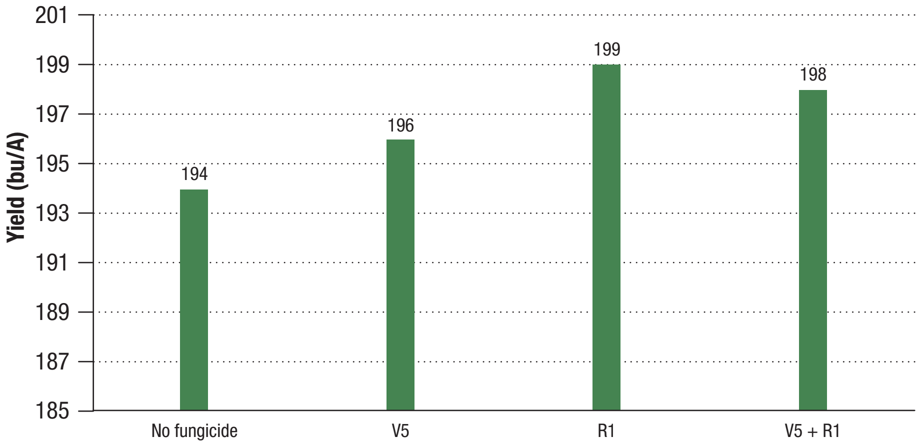

Figure 6 ■ Effect of different fungicide application timings on corn yield (based on University of Illinois trials conducted across 5 different locations in 2014).

Nitrogen on Corn: Are We Making Progress?

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High corn yields in 2014, low corn prices relative to nitrogen fertilizer prices, and ongoing pressures to decrease the amount of N released to the environment have combined to make managing N fertilizer more challenging than ever. At the same time, a widening array of services to sell site-specific N rate maps or other advice "products," along with claims of improved N use efficiency from new N products or practices has greatly widened choices—and created confusion—about the "right" way to manage N. How do we cut through some of the confusion and return some calm and rationality to how we approach N management?

Nitrogen on corn: What do we know and what do we control?

The nitrogen cycle—where N comes from, where it goes, and how and why it moves—involves the interactions of soils, weather, plants, and microbes; as a result it is very complex. It helps when thinking about supplying N fertilizer to list what we know (with reasonable certainty) or can predict about this cycle for a particular field, and what is unknowable or unpredictable.

We tend to know what rate, form, and timing of N we plan to apply, with good certainty concerning rate and form but less certainty about actual timing. This should include knowing what additives such as nitrapyrin and urease inhibitors are used for and when we should use them. We also know soil texture, topography, and drainage class, in general at least. And we usually have a good idea of yield potential based on actual yields, along with some idea of year-to-year variability in yield.

Things that we don't know prior to the growing season are mostly related to what the weather will be that year. The major uncertainty for most fields is what the actual yield will be, and because actual yield is closely tied to total N uptake, this means we don't know actual N requirement. There is also uncertainty about how timely we will be with field operations. How much N will be freed up through the process of mineralization of soil organic matter, and how much N loss there will be due to leaching or denitrification (loss of N from saturated soils) are not predictable for most fields. We can add to this uncertainty about how the crop will grow, and whether (and when) it might be damaged by insects or diseases.

The list of what we don't know and can't really predict is longer than the list of things we do know, and the consequences of things happening that were not predictable is generally greater than those based on changes we can make in things such as N rate. So the decision on what N rate to use can be almost meaningless if it doesn't rain in July or if excess water damages the root system in June. This is a difficult conundrum; the things we can control and that we spend most of our time and effort making decisions on often end up making little difference in yield or in the efficiency with which N is used. The same applies to environmental effects from using N fertilizer.

Despite the difficulty in having things turn out as planned in producing and fertilizing corn with nitrogen, we can use current research results to try to hone in on those practices that maximize return to N fertilizer while minimizing loss of N to the environment. We will present examples of these, keeping in mind that consistency of such results among sites is not great. Rate

Although we know that "best" rate can be different for different forms and timing of N application, it is critical that we identify a base N rate that can

Table 1 ■ Guideline N rates for corn following soybean in central Illinois under different corn and fertilizer N prices. Numbers are from the N rate calculator at http://extension.agron.iastate.edu/soilfertility/nrate.aspx

Corn Price	**N cost, $/lb actual N**			
$/bushel	**$0.30**	**$0.40**	**$0.50**	**$0.60**
		lb N/acre		
$3.00	167	154	143	133
$3.50	173	161	151	142
$4.00	178	167	157	149
$4.50	183	172	162	154

be reasonably expected to maximize return to N without too much deficiency or excess N. We have done this in Illinois by helping to develop and to keep updating the extensive database (we have more than 600 response trials from Illinois alone) in the N rate calculator that is now used in seven Corn Belt states. This calculator uses all of the response data available for corn following soybean and for corn following corn in each region of Illinois to calculate a best rate using what we called the Maximum Return to Nitrogen (MRTN) approach that includes adjustments of rates depending on prices of corn and N. Table 1 shows provides an illustration of how guidelines N rates based on Illinois data change with prices.

While the N rate guidelines from the calculator are the best estimates we can get from current research, we know from experience that actual N rates needed to optimize yield in different trials are almost never exactly what the calculator indicates we should use. Actual rates needed may be higher or

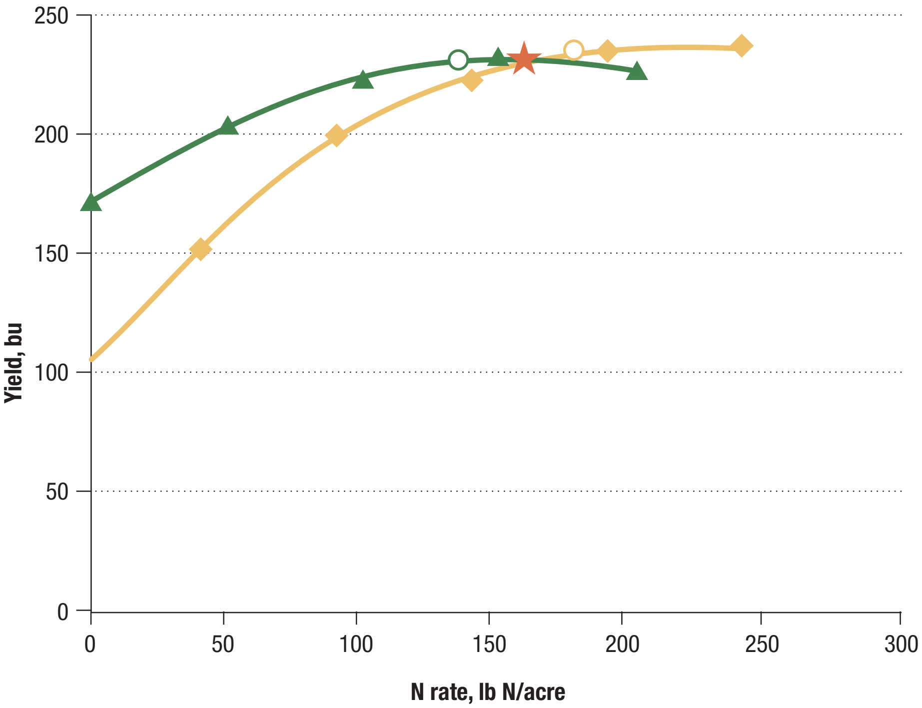


Figure 1 ■ Responses of corn following soybean to N rate in two on-farm trials in Illinois in 2014. Taking corn at $3.75/bu and N at $0.45/lb, the optimum N rates are shown as circles. The MRTN (calculator) rate for corn following soybean in central Illinois is 159 lb N/acre, marked by a star.

lower than the calculator rate (there are about equal numbers of each), but the problem is that *we do not have any way to know before the season starts, or even after the crop is growing, what actual N rate will be needed for that field.*

As an example, two on-farm trials in central Illinois in 2014 showed different requirements for N even though yield levels at higher N rates were very similar; the optimum N rate at one site was only 135 lb N/acre with yield at 230 bu/acre, while at the other site the optimum rate was 178 lb N/acre with a yield of 234 bu/acre (Figure 1). Dollar loss from using the MRTN rate of 159 lb N/acre at both sites instead of the calculated optimum N rates would have been about $4.50 per acre at the site where the MRTN rate was higher than the actual optimum, and about $5.10 per acre at the iste where the MRTN rate was lower than the optimum. Other trials showed different responses, with optimum N rates showing a considerable range across sites.

Timing and form

In a small-plot study conducted at Urbana in 2014 with corn following soybean, the base N application was done using UAN injected between the rows right after planting. Yield with no N was 144 bu/acre, and rose in a very typical fashion as a curved line as N rate increased, reaching a maximum of 238 bu/acre at the N rate of 238 lb N/acre. The "optimum" rate—the N rate where the return to N is maximized at $3.75/bu corn and $0.45/lb N—was 193 lb N/acre (Figure 2). Applying 50 lb N at planting and the rest at sidedress time (V5) didn't increase yield compared to planting-time N at total N rates of 100, 150, or 200 lb of N (Figure 2).

In this study we also applied N at 150 lb per acre in a variety of forms and times, and saw a range of yields (Table 2). The base treatment (UAN injected at planting) yielded 223 bu/acre, and even though some treatments showed lower yields, there was enough variability that we aren't able to say

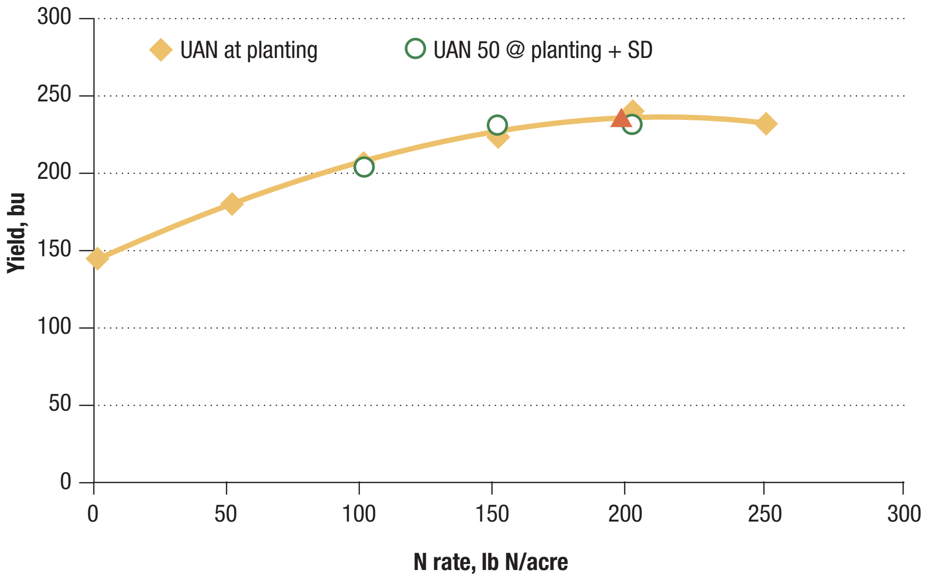


Figure 2 ■ Response of corn following soybean to N rate at Urbana in 2014. The curved line (data points are diamond shapes) shows a maximum yield of 238 bu/acre at 230 lb N. The triangle shows the optimum N rate, which was 196 lb N with a yield of 236 bu/acre. The open circles are yields from applying 50 lb N as UAN at planting followed by 50, 100, or 150 lb N at sidedress (V5).

with certainty that any of these actually yielded less than the check. Urea + Agrotain® and SuperU® are both of dry, urea-based N forms; Agrotain is a urease inhibitor and SuperU contains both a urease inhibitor and a nitrification inhibitor. Both of these treatments broadcast at planting yielded significantly more than the check (UAN at planting).

While dry urea with inhibitors did very well when applied at planting, treatments with 100 lb N as UAN at planting followed by 50 lb N as urea at normal or late sidedress time were among the lowest-yielding treatments; both yielded 11 bushels less than the treatments with 100 lb N at planting followed by 50 lb N as UAN dribbled at sidedress time (Table 2). Urea needs to convert to ammonium then to nitrate so it can move down into the soil; it's possible that this happened quickly when applied early but not as rapidly when it was applied at sidedress time. Limited movement of N to the roots several weeks after planting might also explain why there was no response to adding N-Serve to NH_3 (which would have delayed conversion to nitrate) applied at planting time.

We ran this same study at two other sites and a similar study at three sites in southern Illinois, long with a number of other on-farm N strip trials, some of which included N timing. One on- farm site comparing fall NH_3 + N-Serve with spring preplant NH_3 (without N-Serve) showed virtually no difference in yield or N response between the two timings (Figure 3). By all indications, the cold weather in the fall, winter, and early spring of 2013-14 meant very little loss of N through tile lines in 2014. Under such conditions we saw few differences due to timing of preplant N.

Table 2 ■ Yields of corn in an Urbana N trial in 2014 using different forms and timing of 150 lb N/acre. Yields are the averages over 4 reps. Due to variability among plots treated the same, we cannot be certain (at the 90% level) that yields followed by the same letter were actually different in this trial. Those in bold were not significantly different from the highest-yielding treatment, and those in italics were not significantly higher than the lowest-yielding treatment.

Nitrogen fertilizer treatment (all 150 lb N/acre)	Yield (bu/acre)	
UAN injected at planting	*223*	*cdef*
UAN dribbled in bands at planting	*220*	*ef*
Urea+Agrotain (AT) broadcast at planting	**241**	**a**
SuperU broadcast at planting	**233**	**ab**
ESN broadcast at planting	226	bcde
UAN+AT broadcast at planting	*221*	*def*
NH_3 injected at planting	**231**	**abc**
NH_3+N-Serve injected at planting	227	bcde
UAN injected at V5	*225*	*bcdef*
UAN dribbled at V9	*218*	*ef*
UAN 50 bdcst at planting + UAN 100 inj at V5	230	bcd
UAN 100 inj at planting + UAN 50 inj at V5	*218*	*ef*
UAN 100 inj at planting + urea+AT 50 bdcst at V5	*216*	*f*
UAN 100 inj at planting + UAN 50 drbl at V9	227	bcde
UAN 100 inj at planting + urea+AT 50 bdcst at V9	*216*	*f*

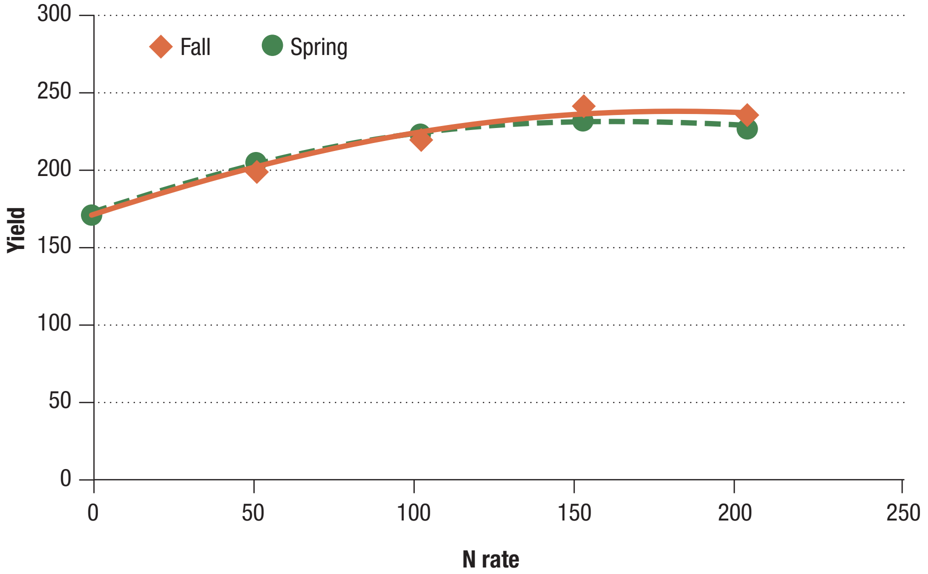


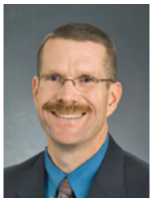
Figure 3 ■ Corn response to N rates and timing in an on-farm trial in Illinois in 2014, where corn followed soybean. Nitrogen was applied as NH_3 in the fall or early spring. With corn at $3.75/bu and N at $0.45/lb, fall application showed the largest net return to N at 158 lb of N/acre and at yielded 235 bu/acre at this rate. The optimum N rate was 135 lb and the yield at that rate was 230 bu/acre when N was applied in the spring.

Is there progress?

We continue to see, as shown in this report, that N management can and does have a considerable influence on corn yield, and on economic returns from N. But we also know that, while we can clearly see these differences in trials, we also find that such differences are not consistent over fields and years. This should not really surprise us, given the extent to which weather and soil factors affects of N transformations and movement, as well as crop growth. With funding from the fertilizer tonnage checkoff in Illinois, first through FREC and now through the Nutrient Research & Education Council (NREC) we are continuing to initiate new trials, and to run on-farm N rate trials.

We don't continue to run such trials out of habit, nor just to add more data to what we already have. Rather, it's to try to find N management systems—form, timing, and rate—that provide the most consistent response to the investment in N fertilizer and how we apply it to the corn crop. We believe that we'll eventually be able to match N management with weather in a way that can move the system to greater consistency, especially as weather forecasts improve. This will make the investment in finding the best system well worth the effort. But we can't take any shortcuts to reach this goal.

The Best Laid Plans for Weeds by Man Sometimes Go Awry



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If the title sounds a bit familiar, it was modified from the original work "To a Mouse", written by Scottish poet Robert Burns. The contemporary translation of the original phrase is often rendered, "The best-laid plans of mice and men often go awry," which can be interpreted to mean that regardless of how thoroughly plans are conceived and put into action, sometimes the actual outcome is not the desired outcome; in other words, expect the unexpected.

While not without exceptions, anecdotal observations across much of Illinois suggested the consistency of weed control in the 2014 corn and soybean crops was greater than in recent seasons. Integrated weed management programs that include the use of soil-residual herbicides in both corn and soybean were more common in 2014 than during any season in recent memory. Integrated weed management programs offer the greatest potential for long-term, sustainable solutions to weed populations demonstrating resistance to herbicides from multiple families.

Herbicide resistance in Illinois Waterhemp Populations

Waterhemp has evolved resistance to more herbicide mechanisms of action than any other Illinois weed species, including resistance to inhibitors of acetolactate synthase (ALS), photosystem II (PSII), protoporphyrinogen oxidase (PPO), enolpyruvyl shikimate-3-phosphate synthase (EPSPS) and hydroxyphenyl pyruvate dioxygenase (HPPD). Not every individual waterhemp plant is resistant to one or more herbicides, but the majority of field-level waterhemp populations contain one or more types of herbicide resistance. Perhaps even more daunting is the occurrence of multiple herbicide resistances within individual plants and/or fields. Waterhemp plants and populations demonstrating multiple herbicide resistance are becoming increasingly common and greatly reduce the number of herbicide options that remain effective for their control.

Since 2010, the Illinois Soybean Association has provided funding to screen waterhemp samples for herbicide resistance. During the first three years of screening, approximately 1000 samples were submitted; in 2013 alone over 1200 samples were submitted. These samples have allowed us to monitor the spread of herbicide resistance (and in particular glyphosate resistance) across Illinois (Figure 1). One point of particular interest during 2013 and 2014 was that the vast majority of samples were submitted from counties north of Champaign County.

The screening results also indicate another disturbing trend; an increase in the frequency of PPO resistance in waterhemp. Waterhemp samples from 295 fields were submitted for screening in 2014. Figure 2 shows that, of the 295 fields from which waterhemp samples were submitted for resistance screening in 2014, resistance to PPO-inhibiting herbicides was present in two-thirds of the fields. An increase in the frequency of PPO resistance in Illinois waterhemp populations can be explained by the increased use of soil- and foliar-applied PPO-inhibiting herbicides in corn and soybean. Some incorrectly believe this type of resistance exists only to foliar-applied PPO inhibitors. Biotypes of waterhemp resistant to PPO-inhibiting herbicides are resistant to those herbicides regardless of whether the herbicide is applied to the soil or foliage. Selection for herbicide resistance occurs each time a

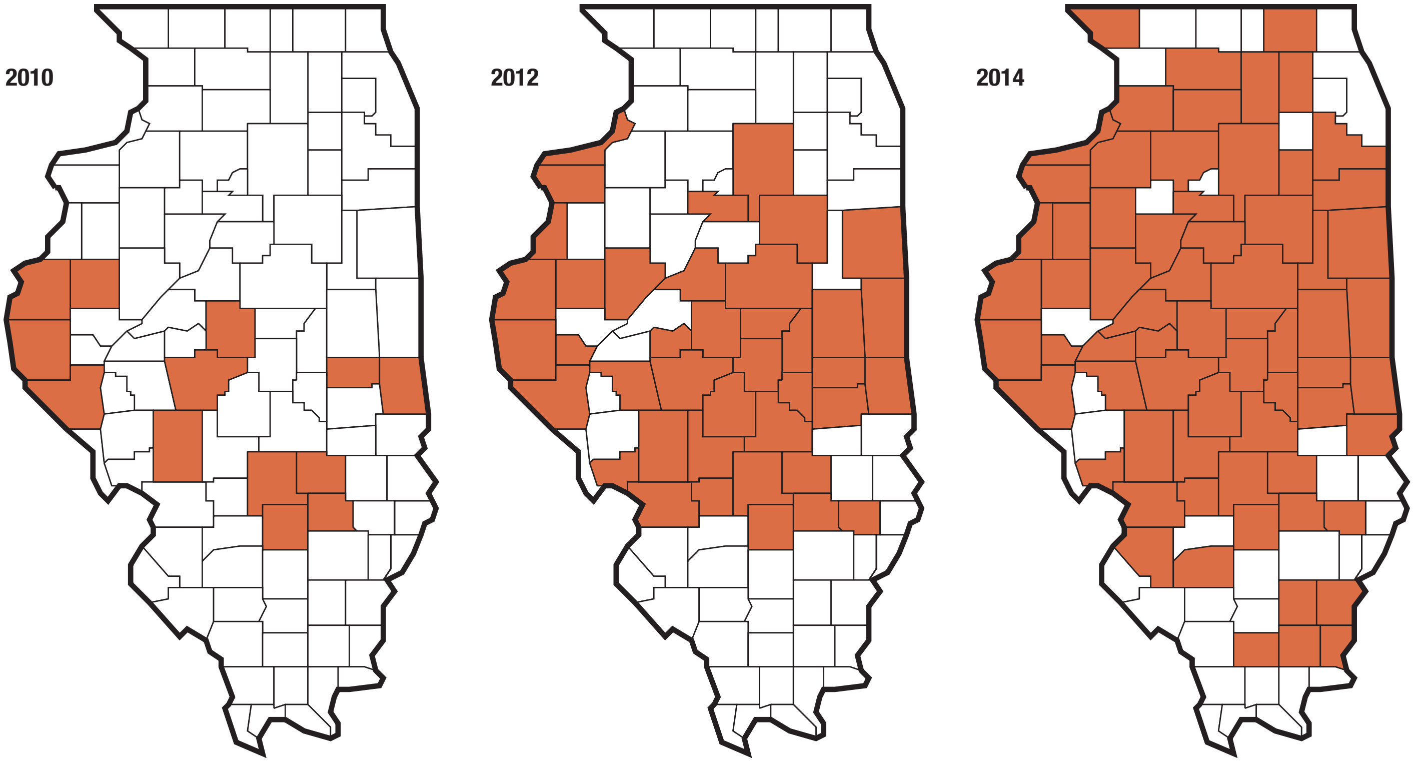


Figure 1 ■ Range expansion of glyphosate-resistant waterhemp. Shaded counties confirmed with GR waterhemp, based on grower submissions.

herbicide is applied, regardless of the herbicide or whether it is applied to the soil or plant foliage.

Palmer amaranth: where can it be found?

Palmer amaranth is a weed species that must be thoughtfully and carefully managed; simply attempting to control Palmer amaranth often leads to ineffective herbicide applications, substantial crop yield loss, and increasing weed infestations. Ignored or otherwise not effectively managed, Palmer amaranth can reduce corn and soybean yield to near zero.

In January 2014, the weed science program at the University of Illinois developed recommendations for management of Palmer amaranth in agronomic crops. These recommendations were developed in accordance with the somewhat unique growth characteristics of this weed species. The goals of the recommendations are twofold: 1) to reduce the potential for Palmer amaranth to negatively impact crop yield, and 2) to reduce Palmer amaranth seed production that ultimately augments the soil seed bank and perpetuates the species. Three general principles of Palmer amaranth management include:

- Prevention is preferable to eradication. Prevention refers to utilizing tactics that prevent weed seed introduction and weed seed production. Palmer amaranth is not native to Illinois, so any population discovered in the state originated from seed that somehow was moved into the state. The myriad of ways in which Palmer amaranth seeds can be transported, however, makes preventing seed introduction extremely challenging. Once

Palmer amaranth populations become established, utilization of any and all tactics to prevent seed production becomes of paramount importance.

- It is not uncommon for annual herbicide costs to at least double once Palmer amaranth becomes established. There are simply no soil- or foliar-applied herbicides that will provide sufficient control of Palmer amaranth throughout the entire growing season. At least three to five herbicide applications per growing season are common in areas where Palmer amaranth is well established.
- Control of Palmer amaranth should not be less than 100 percent; in other words, the threshold for this invasive and extremely competitive species is zero. Female Palmer amaranth plants produce tremendous amounts of seed and in less than five years a few surviving plants can produce enough seed to completely shift the weed spectrum in any particular field.

As anticipated, populations of Palmer amaranth were identified in more Illinois counties during 2014. The most current distribution map (Figure 3) shows that Palmer amaranth populations now have been identified in over 30 Illinois counties. Additionally, of those Palmer amaranth plants identified with the aid of molecular markers, approximately two-thirds tested positive for resistance to glyphosate.

The following management recommendations for Palmer amaranth are based on the growth characteristics of this species:

- Be certain to control all emerged Palmer amaranth plants before planting corn or soybean. Burndown herbicides or thorough tillage are effective tactics to control emerged Palmer amaranth plants before planting. Keep in mind, however, that glyphosate will not control glyphosate-resistant Palmer amaranth and growth regulator herbicides (such as 2,4-D or dicamba) are most effective on Palmer amaranth plants less than 4 inches tall. If preplant scouting (which is especially important prior to planting soybean) reveals Palmer amaranth plants taller than 4 inches, consider using tillage instead of herbicides to control the plants.
- Apply a full rate (based on label recommendations for soil texture and organic matter content) of an effective soil-residual herbicide not sooner than seven days prior to planting nor more than three days after planting. Many soil-residual herbicides that are effective for controlling waterhemp are also effective for controlling Palmer amaranth. Soil-applied herbicide families that demonstrate control or suppression of Palmer amaranth include the triazines (atrazine, simazine, metribuzin), HPPD inhibitors (isoxaflutole, mesotrione), dinitroanilines (trifluralin, pendimethalin), chloroacetamides (metolachlor, acetochlor, dimethenamid, etc.), and protox inhibitors (flumioxazin, sulfentrazone, saflufenacil). Do not apply less than the rate recommended by the product label. In soybeans, products containing sulfentrazone (Authority) or flumioxazin (Valor) have provided effective control of Palmer amaranth. Application rates of products containing these active ingredients should provide a minimum of 0.25 lb ai/acre sulfentrazone or 0.063–0.095 lb ai/acre flumioxazin.
- Begin scouting fields within 14–21 days after crop emergence. We recommend this interval even for fields previously treated with a soil-residual herbicide applied close to planting.

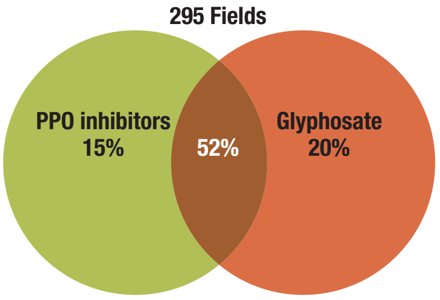
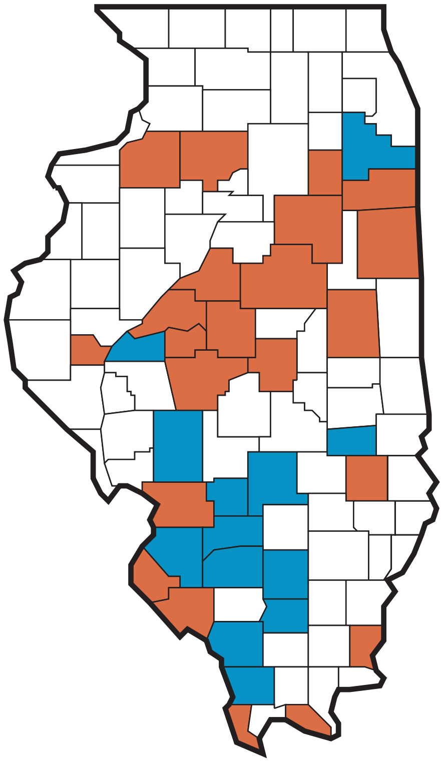


Figure 2 ■ 2014 Multiple-Resistant Waterhemp Summary



Palmer amaranth confirmed in counties colored **orange** or **blue**

Orange: counties with glyphosate-resistant Palmer amaranth

Figure 3 ■ Palmer amaranth Distribution in Illinois 2012–2014 sampling.

- Foliar-applied herbicides must be applied before Palmer amaranth plants exceed four inches in height. T*he effectiveness of most foliar-applied herbicides dramatically decreases when Palmer amaranth plants are taller than four inches*. Postemergence herbicides that demonstrate control or suppression of Palmer amaranth include synthetic auxin herbicides (dicamba, 2,4-D), diphenylethers (acifluorfen, lactofen, fomesafen), glufosinate, glyphosate, and HPPD inhibitors (mesotrione, tembotrione, topramezone). Palmer amaranth can germinate and emerge over an extended period of time, so there is often a wide range of plant sizes by the time postemergence herbicides are applied. This can present problems with spray interception by smaller plants under the protective canopy of larger plants. Adjustments in spray volume and pressure can help to overcome some of the challenges with coverage.
- Consider including a soil-residual herbicide during the application of the foliar-applied herbicide. A soil-residual herbicide applied with the foliar-applied herbicide can help control additional Palmer amaranth emergence and allow the crop to gain a competitive advantage over later-emerging weeds.
- Fields should be scouted 7–14 days after application of the foliar-applied herbicide to determine:
  - herbicide effectiveness
  - if the soil-residual herbicide included with the POST application is providing effective control
  - if additional Palmer amaranth plants have emerged.
- If scouting reveals additional Palmer amaranth plants have emerged, make a second application of a foliar-applied herbicide before Palmer amaranth plants are four inches tall.
- Physically remove any remaining Palmer amaranth plants before the plants reach the reproductive growth stage. Plants should be severed at or below the soil surface and carried out of the field. Severed plants can root at the stem if left on the soil surface, and plants can regenerate from stems severed above the soil surface.

Soybean response to soil-applied herbicides

In the vast majority of instances, soil-applied herbicides control target weed species with little to no adverse effect on the crop. However, soybean plants sometimes are injured by these herbicides. Soybean injury from soil-applied herbicides was common across a large area of Illinois in 2014, and the following text will review some of the factors that can contribute to herbicide-induced soybean injury.

Herbicides vary in their inherent potential to cause soybean injury. Many university-generated herbicide effectiveness rating tables also provide estimates of soybean injury potential. Some herbicide active ingredients, such as cloransulam and clomazone, are often rated as having very low potential to cause soybean injury, whereas other active ingredients are rated as having a greater inherent potential to cause injury. The rate at which the herbicide is applied can influence the potential for soybean injury by increasing or decreasing the amount of herbicide in a given volume of soil.

Most cultivars are not overly sensitive to any particular herbicide, but other soybean cultivars can vary in their sensitivity to certain herbicides. Data in the scientific literature and company-generated variety trials demonstrate cultivar sensitivity differences to various soil-residual herbicides. Some cultivars demonstrate sensitivity to one active ingredient, whereas other cultivars can be sensitive to more than one active ingredient.

The environment has a large influence on the severity of soybean injury caused by soil-applied herbicides. Environment-induced crop stress, often caused by cool, wet soil conditions, can enhance soybean injury from soil-applied herbicides. In most cases, herbicide selectivity arises from the soybean plant's ability to rapidly metabolize the herbicide to a nonphytotoxic form before it causes much visible injury. Soybean plants growing under favorable conditions are able to adequately metabolize the herbicide before any injury symptoms are expressed. However, when the soybean plant is under stress, its ability to metabolize the herbicide can be sufficiently reduced to the point at which injury symptoms develop.

Soil physical properties can increase or decrease the potential for soybean injury by impacting how much herbicide is available for plant uptake. Soils with higher amounts of clay and organic matter have a greater ability to adsorb more herbicide onto these soil colloids. Herbicide bound to soil colloids is not available for plant uptake. In contrast, coarse-textured soils have less adsorptive capacity so more herbicide remains available for plant uptake. Labels of soil-applied herbicides often contain precautionary language about the increased potential for soybean injury when the product is applied to sandy soils or soils low in organic matter.

The application timing of soil-residual herbicides also can impact the potential for soybean injury. Applications made immediately before or after

Figure 4 ■ Injury symptoms evident on emerging soybean plant.

Figure 5 ■ Reddish-colored hypocotyl tissue near the soil surface.

Figure 6 ■ Emerged soybean with damage to hypocotyl and cotyledons.

Figure 7 ■ Injury to cotyledons.

soybean planting result in a high concentration of herbicide near the emerging soybean plants. In contrast, a herbicide is often more widely distributed within the soil profile by the time of soybean emergence when applications are made several days or weeks prior to planting.

The soil-applied PPO-inhibiting herbicides, including saflufenacil, flumioxazin, and sulfentrazone, are very effective for control of *Amaranthus* species. These herbicides (and many others) also can cause soybean injury. Our first experience with soybean injury from soil-applied PPO inhibitors occurred in 1996 while evaluating sulfentrazone for control of herbicide-resistant waterhemp. Soybean injury symptoms caused by these soil-applied herbicides can vary depending on the soybean developmental stage when exposure occurred. The most commonly encountered injury symptoms occur on the hypocotyl and cotyledons (Figure 4), often indicating the plants were exposed to a high concentration of herbicide as they were emerging. Symptoms include necrotic lesions on the soybean hypocotyl near the soil surface and reddish-colored spots or lesions on the hypocotyl and/or cotyledons (Figures 5 and 6). Lesions on the hypocotyl may not always kill the young soybean plants, but can create an area of weakened tissue that may lead to stems breaking during rain or high wind. In severe cases, plants may actually die following emergence of the cotyledons. Plants with damage only to cotyledons usually develop normally (Figure 7). Other symptoms can occur after soybean emergence if treated soil is splashed into the soybean meristem by heavy precipitation.

There likely is no solitary reason for the recent instances of soybean injury from soil-applied PPO-inhibiting herbicides. As previously mentioned, our first experience with this type of soybean injury occurred almost 20 years ago and we have continued to observe this type of injury intermittently ever since. These herbicides have become very popular choices for the management of herbicide-resistant *Amaranthus* populations, and widespread application of these herbicides increases the probability of encountering soybean cultivars that inherently are more sensitive to one or more of these herbicides. In many instances of soybean injury, the herbicide was applied after soybean fields were planted and a precipitation event occurred within a few days of soybean emergence. Cool air and soil temperatures during the same interval can further increase injury potential by slowing the rate of herbicide metabolism. A crusted soil surface can slow soybean emergence, increasing the time the hypocotyl and cotyledons remain in the zone of high herbicide concentration. Once the herbicide is moved deeper into the soil profile, the potential to cause additional injury is greatly reduced.

Evaluating Drift Reduction Technologies for Making Applications of Dicamba and Glyphosate

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The advent of dicamba tolerant crops will lead to more frequent applications of dicamba. Associated with these applications is the risk of drift onto susceptible crops or other vegetation. Drift reduction technologies can be used to mitigate the risk of drift. When using drift reduction technologies, however, it is important to maintain efficacy while lowering the risk of drift. Every application is a balance between two objectives: making an effacious application while simultaneously mitigating the risk of drift to the greatest extent possible.

Two commonly used types of drift reduction technologies are nozzles and adjuvants. In both cases, these technologies work by increasing spray droplet size or reducing the number of the smaller, more drift-prone droplets. Larger spray droplets are heavier and thus less susceptible to being moved off-target by the wind. Larger droplets, however, reduce coverage because there are fewer of them, and they tend to not deposit and retain as well as smaller droplets on plant surfaces.

Drift reduction nozzles and adjuvants were evaluated over four years to access both weed control efficacy and potential for drift mitigation. Efficacy was evaluated through the use of plot trials while drift reduction was evaluated through the droplet size measurement. The speeds and nozzle orifice sizes used during the applications were selected to be similar to real world commercial applications.

Methods

Weed control plots were sprayed using an ATV mounted sprayer that used either CO_2 or compressed air for pressure. Nozzles were mounted 20 inches apart and the boom was set to a height 20 inches above the target. In 2010 the speed was 10 miles per hour (MPH); in all subsequent years the speed was 13 MPH. Nozzle orifice sizes and pressures were selected to provide a spray application rate of 10 gallons per acre (GPA). Plots were 20 feet wide with only the center 10 feet sprayed, leaving a 5 foot buffer on either side. The length of the plots varied over the years, but an alleyway of sufficient distance was used before the start of each plot to ensure the sprayer was up to speed when the spray was turned on. Three replications were used for each treatment. Applications were made with weeds at various heights over the four years of trials. Percent weed control was evaluated for each plot at various days after treatment (DAT), typically between 7 and 28.

All weed efficacy trials were applied to a standing crop. For all years except 2011 the crop was soybeans; in 2011 it was corn. In 2010, weed height averaged 4 inches for all trials. In 2011, two separate tests were conducted with all treatments, one with an average weed height of 6 inches and the second with an average weed height of 20 inches. In 2012 the average weed height was 6 inches; the trials conducted in 2012 also included seeding the plots with glyphosate tolerant corn and adding clethodim to the spray solution. The 2010, 2011, and 2012 trials were located on the South Farms at the University of Illinois at Urbana-Champaign campus where the dominant weed species was tall morningglory. The 2013 study was moved to a Southern Illinois University research farm where the dominant weed species was glyphosate resistant waterhemp, which averaged 6 to 8 inches in height.

Table 1 ■ Nozzle types, nomenclature, operating pressure measured in pounds per square inch (psi), and the years tested.

Nozzle type	MFR	Nomenclature	PSI	Years tested
Air Induction Extended range (AIXR)	TeeJet	AIXR11005	40	2010
Air Induction Extended range (AIXR)	TeeJet	AIXR11004	48	2011–2013
Air Induction Turbo TwinJet (AITTJ60)	TeeJet	AITTJ60-11004	48	2011, 2013
DR Series (DR)	Wilger	DR110-04	48	2012
Extended Range* (XR)	TeeJet	XR11006	44	2011
GuardianAIR Twin Spray (GAT)	Hypro	GAT110-04	48	2013
Low Volume Sprayer Turbo** (CP)	CP	CP-65T-SL	40	2010
MR Series (MR)	Wilger	MR110-04	48	2013
TurboDrop TwinFan (TDTF)	Greenleaf	TDTF11004	62	2010
TurboDrop Asymmetric DualFan (TADF)	Greenleaf	TADF04	48	2013
Turbo TeeJet (TT)	TeeJet	TT11005	40	2010
Turbo TeeJet (TT)	TeeJet	TT11004	48	2011, 2012
Turbo TeeJet Induction (TTI)	TeeJet	TTI11004	62	2010
Turbo TeeJet Induction (TTI)	TeeJet	TTI11004	48	2011–2013
Turbo TwinJet (TTJ60)	TeeJet	TTJ6011005	40	2010

* This nozzle was used with a Capstan Sharpshooter pulse width modulation system set at 70% duty cycle to achieve the flow rate required for 10 GPA.

** This nozzle was used with the #5 orifice and #6 deflector selected

To measure the droplet size for all treatments, a Sympatec Helos laser diffraction droplet sizing system was used. All measurements were conducted at either the USDA-ARS low speed wind tunnel in College Station, TX or a similar wind tunnel in North Platte, NE operated by the University of Nebraska-Lincoln. In all cases, the spray solutions used for droplet testing were identical to those used in the field portion of the trial. Tests were performed within the guidelines provided by ASTM E1260-05, Standard Test Method for Determining Liquid Drop Size Characteristics in a Spray Using Optical Nonimaging Light-Scattering Instruments.

For each treatment tested, volume median diameter (VMD) was determined. VMD is the droplet diameter (microns) where 50% of the spray volume consists of droplets of equal or lesser diameter and the other 50% of the spray volume consists of droplets of larger diameter. The percent volume less than 100 microns (%<100), which is an indicator of the "driftable" portion of a spray, was also determined. VMD was used to access potential impacts to coverage of the target and thus efficacy, and the %<100 was used to access potential drift reduction.

A variety of nozzle types and drift reduction adjuvants were tested over the course of the studies. Every nozzle type was tested with and without the use of a drift reduction adjuvant. All spray solutions contained both glyphosate

Table 2 ■ Drift reduction adjuvants, the principal components, and years evaluated.

Adjuvant name	MFR	Principal components	Years evaluated
Array (A)	Rosen's	Guar based polymer	2011
Border (B)	Preicsion Labs	Guar based polymer	2011–2013
Control (C)	Garrco	Polyinyl polymer	2010, 2011
Interlock (I)	Winfield	Modified vegetable oil	2011–2013
No Adjuvant (N)		No additional adjuvant	2010–2013

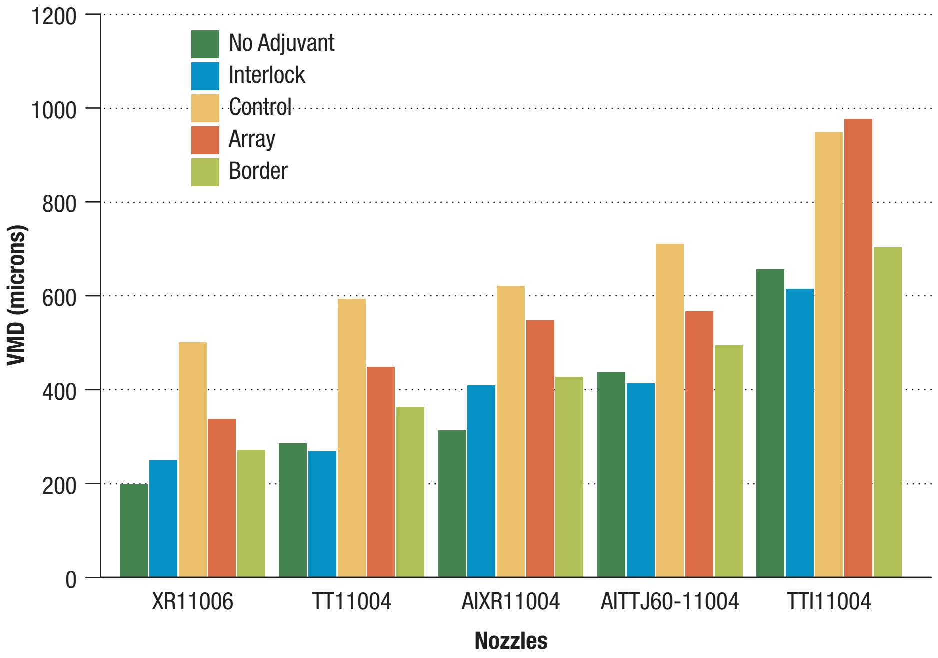

Figure 1 ■ Volume median diameter (VMD) for all nozzle and adjuvant treatments evaluated in 2011. All spray solutions included glyphosate and dicamba.

and dicamba in the tank mix. When appropriate, a water-conditioning agent was also added to the spray solution. The nozzles tested are listed in Table 1; the drift reduction adjuvants tested are given in Table 2.

Results

In 2010 all treatments were highly effective at controlling giant foxtail and common waterhemp. They showed reduced efficacy for common ragweed and tall morningglory, but there were no significant differences among any of

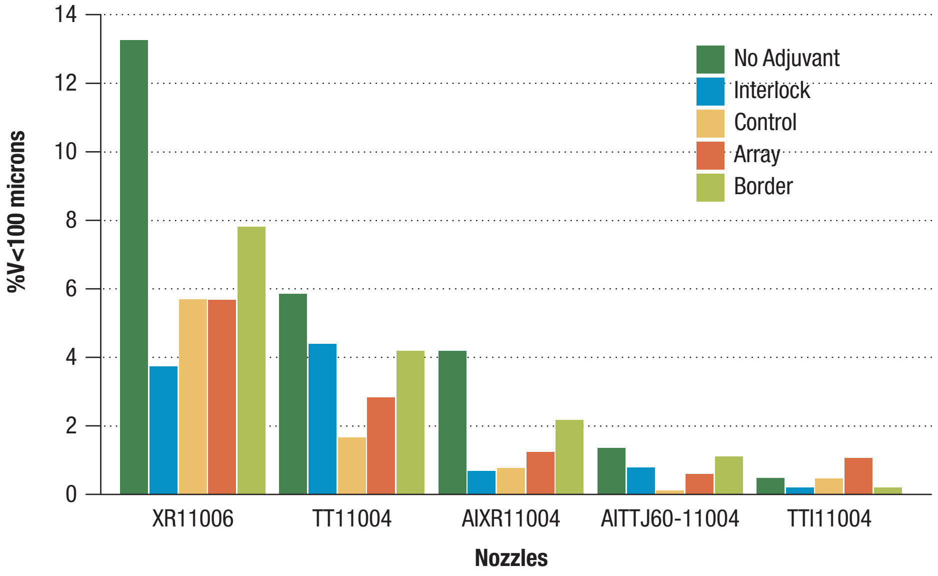

Figure 2 ■ Percentage of spray volume contained in droplets smaller than 100 microns (%V<100) for all nozzle and adjuvant treatments evaluated in 2011. All spray solutions included glyphosate and dicamba.

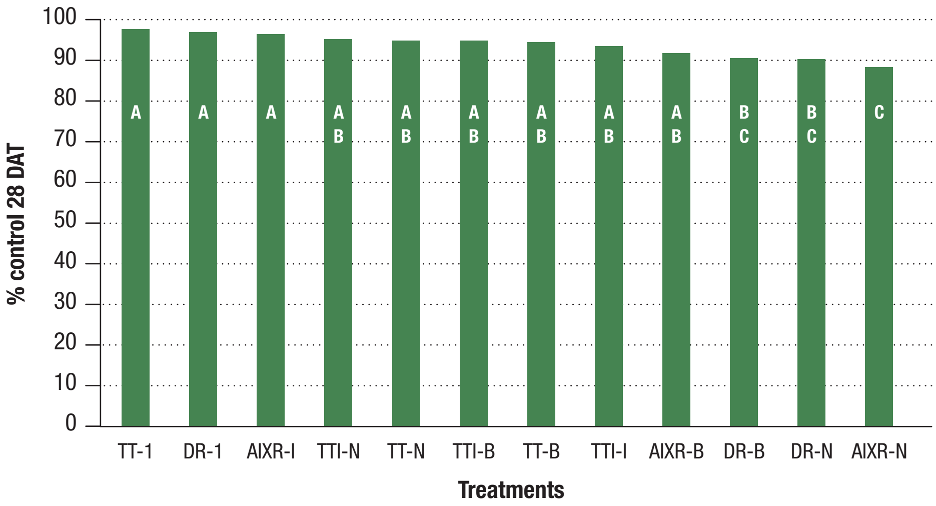

Figure 3 ■ Percent control of volunteer corn 28 days after treatment (DAT) by treatment. Different letters on bars indicate significant differences in control. The first letters of treatment name refer to nozzle type (see table 1); the last letter indicates adjuvant (see table 2).

the treatments. Droplet size measurements showed differences between the nozzles and that the use of the drift reduction adjuvant Control significantly increased overall droplet size.

All treatments were again highly effective in 2011 for both the 6 inch and 20 inch weeds. There was reduced control of tall morningglory again, but no significant differences among the treatments. The droplet size of the nozzle and adjuvant treatments varied considerably for both VMD (figure 1) and %<100 microns (figure 2). Moving from the XR to the various air induction nozzles increased the VMD and lowered the risk of drift (reduced %V<100). The use of a drift reduction adjuvant also increased the VMD and lowered the

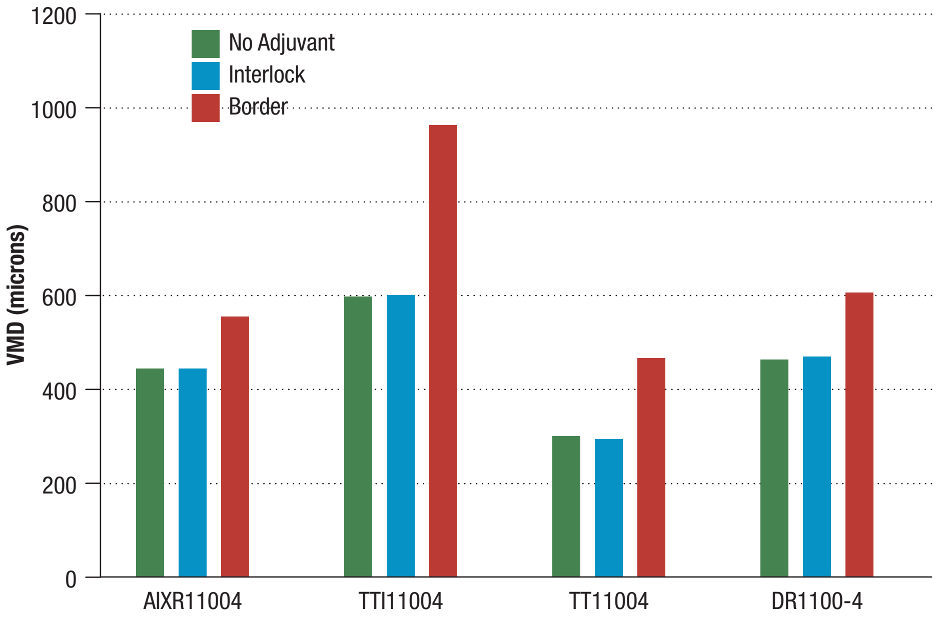

Figure 4 ■ Volume median diameter (VMD) for 2012 treatments. All spray solutions included glyphosate and dicamba.

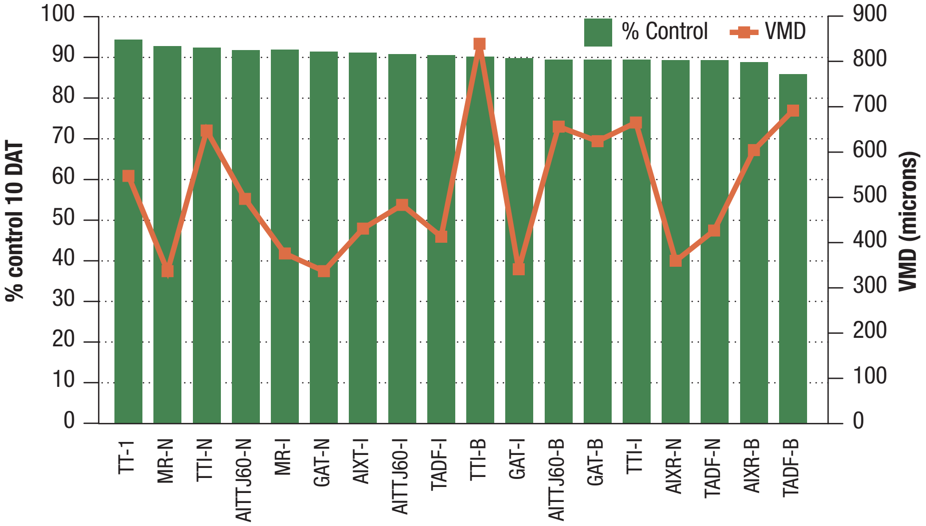

Figure 5 ■ Percent control of waterhemp 10 DAT and VMD for all treatments tested in 2013. The first letters of treatment name refer to nozzle type (see table 1); the last letter indicates adjuvant (see table 2).

risk of drift for all nozzle types. Which adjuvant reduced the fines the most varied depending on nozzle type.

In 2012, there were no significant differences in weed control among any of the treatments for morningglory, ragweed, and all grass species. There was a significant difference for control of the volunteer corn (figure 3). These differences, however, were not related to treatment VMD (figure 4) as would be the predicted reason the treatments would show variations in efficacy. For example, the AIXR11004 with no adjuvant and Interlock have almost identical VMD's yet had different levels of control for the volunteer corn.

In 2013 there were significant differences in control of glyphosate resistant waterhemp (figure 5). Once again, though, the differences in control were not related to the spray droplet size.

Conclusion

Using the drift reduction technologies tested in these studies to make applications of glyphosate and dicamba can mitigate the risk of drift without having a negative impact on efficacy. While there were some significant differences seen among the treatments for control of volunteer corn and glyphosate resistant waterhemp, these differences are not related to spray droplet size as would be expected. It is possible the differences in control are related to differences in the width of the spray pattern and overlap. While all of the nozzles tested in these studies were rated to have 110 degree fan angles at 40 psi, differences in actual fan angle were noted during the applications and while being demonstrated on a spray table. Further research will need to ne conducted to explore this possibility.

Notes

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