



PEST MANAGEMENT & CROP DEVELOPMENT

BULLETIN

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UNIVERSITY OF ILLINOIS
EXTENSION

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INSECTS

Bt Soybeans: University of Georgia Results Examined

Since 1996 we have witnessed a steady increase, particularly in the United States, in the use of transgenic Bt crops for insect control. Because of the escalation of Bt corn hybrids and Bt cotton varieties that express Cry proteins, conventional insecticide applications have been reduced considerably for several key insect pests. Recently released estimates by the USDA Economic Research Service reveal that 59% of all corn planted in Illinois during 2009 was a “stacked” hybrid. In 2009, stacked cotton varieties were planted on 48% of the cotton acres in the United States. For a complete report, please go to www.ers.usda.gov/Data/BiotechCrops.

To date, Bt soybean varieties have not been commercialized; however, some transgenic Bt lines of soybean have been examined for their effectiveness against lepidopteran insect pests. In this month’s issue of the *Journal of Economic Entomology* (Vol. 102, No. 4, pp. 1640–1648), entomologists Robert M. McPherson and Ted C. MacRae, Department of Entomology, University of Georgia, Tifton, reported on the effectiveness of Bt soybean lines against several species of defoliators. Their work was conducted in replicated field experiments over several growing seasons, 2003 to 2007. The Bt lines they examined were developed with *Agrobacterium*-mediated DNA techniques. All of the Bt soybean lines evaluated contained a copy of the Bt gene *tic107* that resulted in the expression of a synthetic *cryIA* construct described as similar to Cry1Ac.

Bt soybean lines and their controls were examined for insect defoliation caused by velvetbean caterpillars, soybean loopers, and green cloverworms. The entomologists reported that densities of these defoliators were negligible in the Bt soybean lines each year of the study. However, in the controls, which consisted of isogenic segregants and parental lines, insect densities ranged from 5 to 10 larvae to 20 to 30 larvae per meter row. Defoliation levels in the control treatments (non-Bt lines) ranged from 53% (2003) to 17.5% (2007). The level of defoliation in the Bt soybean plots was near 0% (less than 1.5%). Yield comparisons between Bt and non-Bt treatments were similar throughout this multiyear investigation.

Will the future landscape of Illinois include stacked (herbicide-tolerant and Bt) soybean varieties? I suspect that this might be the case. The most immediate economic benefit regarding the commercialization of Bt soybean varieties will come to producers in the southeastern U.S., where lepidopteran pests reach economic thresholds more frequently. In the north-central U.S., the most common insect threats to soybean production are soybean aphids and Japanese beetles. These insects will not be affected by Bt soybean varieties that have been developed to provide control of lepidopterans. However, recall that the first commercial Bt corn hybrids also targeted lepidopterans, essentially the European corn borer. In 2003, Bt corn hybrids were commercialized for corn rootworms, a coleopteran species. So, in time, will we see Bt soybean varieties sold that express Cry proteins to control Japanese beetle populations? Perhaps.

As I have stated many times in *the Bulletin* and during some of my extension presentations, we are in the midst of an agricultural revolution dominated by exciting scientific discoveries and the commercialization of new transgenic products that have fundamentally altered the manner in which we manage pests in commercial agriculture.—*Mike Gray*

Soybean Aphid Densities Remain Well Below Economic Threshold

The good news continues regarding the very low densities of soybean aphids throughout Illinois this season. A review of the sentinel plot data through early August reveals no aphids in many of the plots and very low numbers in several. On August 10, Jim Morrison, crop systems extension educator, Rockford Extension Center, reported that a late-planted soybean field (V8 stage) in Boone County had an average density of 30 aphids per plant. He also observed an average of 20 aphids per plant in a soybean field (R4 stage) in Jo Daviess County. As we move beyond the R5 (beginning seed) stage of development in some areas of the state, many soybean fields will become less susceptible to this insect pest. I urge growers not to treat soybean fields that are below the economic threshold (250 aphids per plant, 80% of plants infested) because of the questionable yield benefit and the certain negative effects an insecticide application will have on natural enemies. If fields in your area of the state begin to exceed the economic threshold, please share these observations with me and I will inform readers.—*Mike Gray*

Volunteer Bt and Herbicide-Tolerant Corn Plants: Ratchet Up Potential for Corn Rootworm Resistance

In a recent journal article (*Agronomy Journal*, Vol. 101, No. 3, pp. 797–799), some Purdue University scien-

tists, led by Christian Krupke, reported the results of an interesting survey in June 2007 of eight soybean fields located in northern Indiana. Between 81 and 141 volunteer corn plants, with an average height of roughly 14 inches, were collected per field. The researchers determined that 87% of the volunteer corn plants were glyphosate-resistant, 65% expressed the corn rootworm Cry3Bb1 protein, and 60% tested positive for both transgenic traits.

The authors accurately characterized these results as an example of “unforeseen consequences” of the use of multiple traits (stacking) within single plants. One of these unforeseen consequences is the potential for escalating the evolution of resistance to the Cry3Bb1 protein by corn rootworms. The researchers suggest that when western corn rootworm larvae feed on the roots of volunteer corn plants expressing the Cry3Bb1 protein (at reduced levels), this may result in increased survival of heterozygous individuals (those carrying both resistant and susceptible alleles), thus increasing the frequency of the resistant gene in the overall population more quickly.

As I drove across several midwestern states this year, I observed many soybean fields with significant densities of volunteer corn. To date, we have been fortunate that no one has reported the field development of resistance to Bt hybrids by corn rootworms. However, this paper should serve as a warning call about the importance of controlling volunteer corn expressing Cry proteins for resistance-management purposes alone.—*Mike Gray*

WEEDS

Volunteer Corn Can Be More Than an Eyesore

A person has not needed to drive very far around the Midwest in recent weeks to realize that unsightly volunteer corn plants are one of the most prevalent weeds in soybean fields. Dr. Aaron Hager provided helpful advice for

controlling volunteer corn back in Issue 3 of *the Bulletin* (April 10), which was certainly an appropriate time to offer recommendations for the current season. However, because this weed becomes so obvious this time of year, it is on the minds of many farmers.

Volunteer corn is certainly not a new weed in soybean, given that corn and soybean have long been annually rotated in Illinois and the greater Midwest. But there are some new and rather interesting nuances about the nature of its weediness. I thought it would be a good time to review some causes, impacts, and interesting differences about this “new” weed challenge. While it might be too late for most farmers to do much about volunteer corn this season, this article may provide some perspective and thoughts to ponder while planning to avoid the problem next year.

The complete collection of corn during fall harvest—100% harvest efficiency—is never achieved. Some corn is always left in the field due to deteriorating cornstalk qualities beyond physiological maturity, which allow for dropped ears and/or lodged and broken stalks prior to harvest. Also, some corn is always left due to the harvest operation itself. Whole corn ears can escape the combine header, or corn kernels can manage to travel all the way through the combine but exit the back of it rather than catch the right elevator to the grain tank. The amount of corn left behind can certainly be lessened or exacerbated by factors including hybrid selection, late-season disease pressure, harvest timing in relation to corn maturity, windy fall weather conditions, and combine settings. Nonetheless, a portion of the corn seeds left behind will survive winter and establish themselves the next spring as weeds in a succeeding soybean crop.

So what’s so “new”? Glyphosate is an effective, broad-spectrum herbicide with excellent activity on grass, including volunteer corn, providing the corn does not also have the genetic

trait that confers resistance to glyphosate. So controlling volunteer corn was easy for many years due to the widespread adoption of glyphosate-resistant soybean fields that were primarily rotated with corn hybrids susceptible to glyphosate (lacking the glyphosate-resistant gene).

As the adoption of glyphosate-resistant corn hybrids has gained popularity more recently, so has the prevalence of volunteer corn in soybean increased. A field survey conducted in northern Indiana showed a high correlation between the presence of volunteer corn and the adoption of glyphosate-resistant corn, from 3% of soybean fields sampled in 2003 to 12% sampled in 2005 (Davis et al. 2008). Volunteer corn was found in both tilled and no-till fields, but it was found in tilled fields twice as often. Although I am sure these results still reflect current observations, much more than 12% of our current soybean acres (in Illinois at least) is infested with volunteer corn. This points up nuance number one: if you have to use additional herbicides to control volunteer (weedy) herbicide-tolerant crop plants, in a crop grown with the same herbicide resistance, the increased cost is a direct result of using the first herbicide-tolerant crop. In contrast, the evolution of herbicide-resistant weeds is more of an indirect result.

What is the impact? Volunteer corn can reduce soybean yield through competition and crop quality due to contamination of corn kernels in soybeans at harvest. Yield reduction from volunteer corn can be difficult to estimate because it depends not only on plant density but on “clump” density. If the plants originate from a dropped ear, there tend to be many plants growing in a clump. Furthermore, volunteer corn loses plant vigor and competitiveness because it is two generations from the cross that produced the hybrid you purchased, and its competitiveness also depends on residual nitrogen levels of the soil. Work done here in Champaign by Beckett and Stoller (1988) found that

soybean yield decreased 7%, 19%, 27%, 31%, and 32% for clumps that had 1, 4, 7, 10, and 13 plants, respectively, at a constant clump density of 1 per 20 square feet. They also found that soybean yield decreased in a linear trend up to 51% at a clump density of 2 per 20 square feet at a constant clump size of 10 plants. Recent research in Lafayette, Indiana, found that significant soybean yield reductions started at about 12 plants per 20 square feet (Marquardt et al. 2008), and in Brookings, South Dakota, Alms et al. (2008) found that soybean yields were reduced between 50% and 60% for approximately 26 plants per 20 square feet.

However, in addition to yield impact, it is the genetically modified insect resistance (Bt) traits that give volunteer corn its second interesting nuance. Research published in the most recent *Agronomy Journal* raises the question of the potential impact volunteer corn plants may play in the resistance management for western corn rootworm (Krupke et al. 2009). Their work showed that many volunteer corn plants in Indiana fields not only contained genes to make them resistant to glyphosate, but they also contained the genetically modified genes to make them express Bt toxin at reduced levels. They express lower Bt levels for the same reasons: they are not as large, or as competitive, as the corn planted in your designated corn fields. The authors suggested this consequence may facilitate more rapid evolution of Bt resistance in corn rootworm populations. While an arguable notion, it is certainly plausible and warrants careful thought. After all, the attention given to governing the appropriate levels of refuge requirements for the sustainable use of Bt corn products reflects the importance of this issue.

How might I avoid this next year?

With increasing genetic technologies in your farming toolbox, planning your crop rotations will require more thought to help avoid this weed problem. This fall it might be very helpful to do the following:

1. Make note of the pressure of volunteer corn in your soybean fields and determine how dire changes in your harvest practices need to be this fall in regard to timing and combine settings.

2. Make note of corn fields that you may expect will have more volunteer corn pressure next year because of increased amounts of “downed” corn or dropped ears, then adjust your crop and/or herbicide plans as necessary to possibly avoid an additional herbicide in your postemergence program for those fields.

3. Carefully assess the density of volunteer corn early in the growing season next year. Volunteer corn doesn’t look as “thick” early in the growing season before it starts to tower over the soybean canopy. That is the stage when the eyesore begins to prompt the question we’re asking now: What is the impact of this weed problem?

I hope I have provided some angles of thought regarding this “new” problem weed in soybean and the greater implications of what you’re currently observing in many soybean fields, as well as ways you might plan to ameliorate this for the future. — Vince M. Davis

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PLANT DISEASES

Soybean Disease Update

Soybean rust in Arkansas and Mississippi. Soybean rust has been confirmed in Holmes County, Mississippi (August 6) and in Chicot County, Arkansas (August 10). These were the first soybean rust observations for these states in 2009. Given that the Mississippi River Valley seems to be the pathway that soybean rust has taken to reach Illinois the past three years, it is important that we watch this disease’s northward progression in the next few weeks (soybean rust observation maps are available at www.sbrusa.net). Most research has shown that soybean rust infections that take place when plants are past the R5 growth stage (beginning seed stage) do not cause economic yield losses.

White mold. White mold (aka *Sclerotinia stem rot*) is being observed in several fields in central and northern Illinois. In issue 18 of *the Bulletin* (July 24, 2009), I described this disease and the available management practices. Once white mold symptoms are observed on plants, there are *no* in-season management practices available. Most research has shown that foliar fungicides must be applied between the R1 and R2 growth stages to achieve the best protection against white mold (see the article in issue 18). The warmer weather that has moved into the state will slow down or stop white mold progression within infected plants. When temperatures move into the upper 80s and 90s, the white mold fungus shuts down.

Sudden death syndrome. Symptoms of sudden death syndrome (SDS) are being observed in different areas in the state. SDS is caused by the fungus *Fusarium virguliforme*. Initial symptoms appear as light-yellow flecking on the leaves. The yellow areas enlarge to cause interveinal chlorosis (yellow leaves with the veins remaining green) and eventually interveinal necrosis (dead leaves with the veins remaining green). The foliar symptoms generally do not appear until soybean plants are into the reproductive growth stages. Foliar symptoms of SDS are identical to those caused by brown stem rot, another soybean disease. To properly diagnose SDS, split the stem with a knife and look for internal discoloration in the pith. If the pith is discolored, then it is likely that brown stem rot is the causal disease; if the pith is not discolored, SDS is the likely cause.

Although SDS symptoms appear on plant foliage, the *Fusarium* fungus that causes SDS actually infects the soybean roots early in the growing season. The foliar symptoms of SDS are caused by a toxin that the fungus produces, which then moves upward in the vascular system of the plant.

Unfortunately, there are no silver bullets available to control SDS completely, so using multiple management practices is encouraged to help limit its damage:

- **Variety choice:** One of the most important SDS management decisions can be made before the growing season begins. Although no soybean varieties with complete resistance to SDS exist, there are differences in susceptibility. Many seed companies provide SDS-resistance ratings for their soybean varieties. Additionally, many varieties are rated for SDS by University of Illinois, Southern Illinois University, and USDA-ARS personnel in field and greenhouse trials as part of the Illinois VIPS (Varietal Information Program for Soybeans) program. The results of these trials are available on the VIPS website (www.vipssoybeans.org).

- **Planting date:** Early planting may predispose soybean plants to infection by the SDS fungus. Plant fields with no history of SDS first and those with a history of SDS last.

- **Soil compaction and drainage:** Soils with compaction and/or drainage problems may lead to bigger problems with SDS. Using management practices that alleviate soil compaction and drainage problems in a field may also help limit losses from SDS.

- **Interaction with soybean cyst nematode:** Although it is not always been easy to prove in research trials, there appears to be an interaction between SDS and the soybean cyst nematode. If both are present in a field, then yield losses may be more dramatic than if either one were present alone in a field. Using good management practices for SCN will certainly reduce losses due to SCN and may also provide some benefits with SDS management.

—Carl A. Bradley

Bin-Run Wheat Seed from Fields Affected by Fusarium Head Blight (Scab)

This season *Fusarium* head blight (aka scab, caused by *Fusarium graminearum*) was very severe in southern Illinois wheat fields. This resulted in reduced test weights and high levels of the mycotoxin deoxynivalenol (DON, or vomitoxin), which led to big discounts and in some cases rejections of wheat at the elevator.

As tempting as it might be, it is *not* a good idea to use seed from these *Fusarium* head blight-affected fields for planting this fall. Seeds affected by *Fusarium graminearum* may be shrunken and discolored (white/chalky or pink). The germination rate in seed lots infected with *Fusarium graminearum* will be greatly reduced compared to disease-free seed lots. In addition to having *Fusarium* head blight, many fields also were affected by glume blotch (caused by the fungus *Stagonospora nodorum*) this past

season, which can also reduce seed quality.

If you decide to go ahead and use bin-run seed, it is extremely important that the seed be professionally cleaned and that a fungicide seed treatment be applied. In a University of Illinois wheat fungicide seed treatment field study conducted this past season with *Fusarium graminearum*-infected seeds, plant emergence was increased by an average of 35% and yields were increased by 11% when seeds were treated with a fungicide.—*Carl A. Bradley*

CROP DEVELOPMENT

Corn Crop Canopy 2009

It takes about 60 days from the end of pollination to physiological maturity (black layer) in most corn hybrids grown in Illinois. By the middle of August the Illinois corn crop is normally about halfway through the grain-filling period, or mostly in the dough stage, with some early-pollinated fields in or approaching early dent. By that time, it's generally possible to assess how well the canopy has held up, how well the grain has filled so far, and the prospects of how well the second half of grain-filling will go.

Things won't be quite as clear this year, given the late start for the crop and an unusually slow rate of growing degree-day (GDD) accumulation due to cool temperatures in July. The warm temperatures of the past week have helped bring the crop around some in terms of development. This is a mixed blessing. Average high temperatures during August are in the mid-80s, not too far below the cutoff temperature of 86 degrees, above which we say that GDDs do not continue to increase. That means that the only way to have above-normal GDD accumulation during August is for night temperatures to be above normal. The crop is never very well served by night temperatures above normal during August, so it's not clear whether catching up through increased GDD accumulations will

be a net positive. The crop in parts of Illinois where planting was very late may end up needing the extra GDD to reach maturity before frost, but overall the crop will likely be harmed more than helped by warmer-than-normal August weather.

We think that pollination was successful in most fields and that the water supply was adequate to keep to a minimum the abortion of kernels that were successfully fertilized. In a few fields I have seen a few late-emerging silks like we have observed in previous years. These have stayed fresh after the rest of the silks turn brown, and the lack of pollen means that they won't be fertilized. But their number is relatively low—only 15 to 30 or so silks remain attached at the tip when the husks are removed—and the number of developing kernels is high enough in most cases that a few tip kernels won't be missed.

Our biggest concern now is the current state of the canopy and whether it will stay in shape to fully fill the grain that has formed. Kernels that have reached the milk stage are entering the period of linear, rapid dry weight accumulation, and the only possible way for them to reach their full potential will be with "care and feeding" by a canopy that can photosynthesize at the maximum rates allowed by the sunlight and temperature.

Water supply is a critical part of this. The stomata—tiny openings that allow water vapor out as CO₂ enters the leaf—need to remain wide open during the day, and they can do this only when there is enough water available to the roots. Water use rate, which is closely tied to the health and activity of the crop canopy, should be as high as 0.2 to 0.25 inches per day now, with higher rates soon after pollination and with high temperatures, windy conditions, and maximum sunlight. Plants can generally hydrate at night even if soils are getting dry, but as water uptake begins after the stomata open, deficits develop when the demand for water exceeds to ability of the crop

roots to take up water. Well before you see leaves starting to wilt or to take on the silver-gray appearance indicating that they're starting to dry out, the stomata start to close. When soils get very dry, stomata may open in the morning but close again before noon. In such cases most of the sunlight that falls that day will do the crop no good.

We have started to get some reports of upper leaves starting to lose their color (and to see them—overpasses are a good vantage point for this). This may be due to loss of N and to availability of water in the soil; water uptake moves N to and into the roots, and lack of water almost always means some lack of N. In some cases lower leaves are showing some firing as well. Loss of color from upper leaves is more problematic, since upper leaves are in a position to receive maximum sunlight. Upper leaves are the farthest from the water in the soil, and under hot, dry conditions they may simply not get enough water even if there is water in the soil. In such cases rainfall may help restore color (and photosynthetic capacity) in these leaves. The lowermost leaves are typically shaded, so their firing may not mean as much direct loss. If the leaves in the vicinity of the ear remain healthy and active, the plant can still take up much of the sunlight, and yields can be good. But it's still best if all leaves on the plant, other than perhaps those that are completely shaded, retain their green color to near the end of grain-filling.

As I've said many times before, the real health of the corn crop canopy can best be seen by noting how well the canopy intercepts sunlight during midday. Any sunlight that hits the ground is lost forever to the crop—the grain will continue to develop almost regardless of how much dry weight is deposited in kernels on a given day. So the fewer patches of sunlight that hit the ground the better. The amount of light getting through the canopy is never zero, but it can be less than 2% to 3%, and for best yields it needs to be this low.

We normally point to the pollination period as the most critical stage for the corn crop; yields are certainly limited without adequate kernel. But it's the grain-filling stage that usually makes the difference between good, very good, and outstanding yields. Normally, the linear phase of kernel weight accumulation starts about 15 days after pollination (this might have been closer to 20 days this year with the cool temperatures) and lasts about 40 days, slowing as the crop approaches black layer. We have measured yield accumulation rates as high as 11 bushels per acre per day during the middle part of the grain-filling period.

To put this in perspective, note that a 200-bushel crop averages only about 5 bushels per day for 40 days, and if we can move that to 7 or 8 bushels per day we can approach 300-bushel yields. Why does this happen so rarely? To a large extent it is because of events we can't control. Filling rates can be decreased by hail damage to leaves, for example, and a windstorm can lodge plants and decrease light interception. But the larger causes are loss of sunlight, lack of adequate water, and temperatures that are too low during the day or too high at night. High night temperatures do not directly affect daytime photosynthetic rates, but they do mean higher-than-normal rates of respiration at night, which uses up some of the sugars produced during the day, so they have the same effect as reducing photosynthesis.

Unless we can turn a switch to put water on a field when it's dry, there is not a great deal that can be done at this point to assure maximum rates of photosynthesis and grain-filling over the next month. It is very useful to look at canopy completeness and health, and in a few cases (mostly in late-developing crops) it might pay to apply fungicide if diseases are starting to affect leaf health, or even insecticide in that rare case when insects might be eating a lot of leaf area. You will also be able to see where stands are too thin for maximum sunlight interception

and where row spacing might be too wide for the hybrids used. "Managing for canopy" means using such observations to fix management-related problems, and it is a sound approach, even if it's after the fact. —*Emerson Nafziger*

REGIONAL REPORTS

Extension center educators, unit educators, and unit assistants in northern, west-central, east-central, and southern Illinois prepare regional reports to provide more localized insight into pest situations and crop conditions in Illinois. The reports will keep you up to date on situations in field and forage crops as they develop throughout the season. The regions have been defined broadly to include the agricultural statistics districts as designated by the Illinois Agricultural Statistics Service, with slight modifications:

- North (Northwest and Northeast districts, plus Stark and Marshall counties)
- West-central (West and West Southwest districts, and Peoria, Woodford, Tazewell, Mason, Menard, and Logan counties from the Central district)
- East-central (East and East Southeast districts [except Marion, Clay, Richland, and Lawrence counties], McLean, DeWitt, and Macon counties from the Central district)
- South (Southwest and Southeast districts, and Marion, Clay, Richland, and Lawrence counties from the East Southeast district)

We hope these reports will provide additional benefits for staying current as the season progresses.

Northern Illinois

A large portion of the region received 1 to 2 inches of precipitation last week. Western bean cutworm moth trap catches have declined this week compared to the previous two. There has been some fungicide application

on corn the last several weeks, but it appears that fewer acres are being treated than last year. According to the Illinois State Water Survey WARM database, at Freeport and DeKalb from May 10 to August 11 accumulated corn growing degree-days are more than 200 below the 11-year average.

Jim Morrison, crop systems extension educator, reported that a soybean field at R4 (full pod) in Jo Daviess County averaged 20 soybean aphids per plant and a Boone County soybean field at V8 averaged 30 aphids per plant. However, no winged aphids were observed.

West-Central Illinois

Corn pollination is all but over, with the exception of a field or two of late planted/replanted corn. The most mature corn is dent stage. There are very few concerns with pollination, with the exception of wet areas of fields where maturity has been delayed. Those who have taken advantage of air flights to review corn stands report erratic growth and development, which one would expect considering the wet season.

Soybeans range in maturity from late vegetative to R5, depending on plant date. Some symptoms of SDS can be seen on a few fields of early-planted soybean. Some low-level soybean aphid populations exist as well. Loretta Ortiz Ribbing found some white mold at the WIU research center this week.

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