UK COOPERATIVE EXTENSION SERVICE
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# Bt-CORN FOR CORN BORER CONTROL

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Kentucky growers have used traditional resistant hybrids, proper planting dates, weekly scouting and use of economic thresholds to manage ECB. New European corn borer resistant corn hybrids have been genetically engineered to produce their own insecticide, the Bacillus thuringiensis (Bt) delta endotoxin. Bt corn has the potential to simplify management and effectively control corn borers throughout the season. Since their introduction in 1996, Bt-corn has been increasing rapidly as the numbers of hybrids and acres planted across the Midwest expand.

While controlling corn borers with resistant hybrids is not new, 1995 marked the beginning of the large-scale commercial use of "transgenic" plants. Growers now have transgenic corn, sweet corn, canola, papaya, cotton, potato, tomato, and soybeans available. Many other crops are being developed or are in the process of applying for EPA registration. How do these modified crops fit into our production and marketing systems? Can they be the "silver bullets" that we have been looking for?

**EUROPEAN CORN BORER AND BT CORN**

An average of one European corn borer cavity per stalk across an entire field can reduce yield by as much as 5% by the first generation and 2.5% by the second generation. How often is any particular field likely to have an average of one or more cavities per stalk at the end of the season? That is difficult to say. In general, corn borers have been under-scouted and under-treated in Kentucky. Other states report annual losses to European corn borer to be approximately 5 to 10 percent annually. Information on the average number of cavities per stalk at the end of the season is not available for Kentucky.

European corn borer levels are difficult to predict and can vary greatly from year to year. Summaries of Kentucky IPM scouting reports have indicated that corn borer populations follow cycles and that populations peak approximately every five years. However, at planting time it is not possible to predict whether or not corn borers will serious in mid summer. Keep in mind that even in low corn borer years, only a small number of corn fields will exceed the economic threshold for corn borers.

**Bt-corn Technology Available for Commercial Use**

| *Event* | *Company* | *Bt gene* | *Trade name* | *Pests controlled or suppressed* | *Refuge requirement* |
|---|---|---|---|---|---|
| Bt 11 | Syngenta Seeds Inc | CryIAb | YieldGard Agrisure | European and southwestern corn borers, fall armyworm, and corn earworm | 20% non-Bt refuge within ¼ to ½ mile of Bt fields |
| MON 810 | Monsanto | CryIAb | YieldGard | European and southwestern corn borers, fall armyworm, and corn earworm | 20% non-Bt refuge within ¼ to ½ mile of Bt fields |
| TC 1507 | DowAgrosciences, Mycogen, Pioneer Hi-Bred Intl. | CryIF | Herculex 1 | European and southwestern corn borers, black cutworm, fall armyworm, and corn earworm | 20% non-Bt refuge within ¼ to ½ mile of Bt fields |
| MON 863 | Monsanto | Cry3Bb1 | YieldGard Rootworm | Corn rootworms | 20% non-Bt RW refuge in or immediately adjacent to Bt RW field |
| MON 863 + Mon 810 | Monsanto | CryIAb + Cry3Bb1 | YieldGard Plus | European and southwestern corn borers and corn rootworms | 20% non-Bt refuge in or immediately adjacent to Bt field |
| DAS 59122-7 | Dow Agrosciences Pioneer Hi-Bred | Cry34Ab1 + Cry35Ab1 | Herculex RW | Corn rootworms | 20% non-Bt RW refuge in or |

| | | | | | |
|---|---|---|---|---|---|
| | Intl | | | | immediately adjacent to Bt RW field |
| TC 1507 + DAS 59122-7 | Dow Agrosciences Mycogen Pioneer Hi-Bred Intl | CryIF + Cry34Ab1 + Cry35Ab1 | Herculex XTRA | European and southwestern corn borers, black cutworm, fall armyworm, corn earworm, and corn rootworms | 20% non-Bt refuge in or immediately adjacent to Bt field |
| MIR 604 | Syngenta Seeds Inc | mCry3A | Agrisure RW | Corn rootworms | 20% non-Bt RW refuge immediately adjacent to Bt RW field |
| Bt 11 + MIR604 | Syngenta Seeds Inc | Cry1Ab + mCry3A | Agrisure CB/RW | European and southwestern corn borers, fall armyworm, corn earworm and corn rootworm | 20% non-Bt refuge in or immediately adjacent to Bt field |
| Mon 88017 | Monsanto | Cry3Bb1 | YieldGard VT RW | Corn rootworms | 20% non-Bt RW refuge in or immediately adjacent to Bt RW field |
| Mon 810 + Mon 88017 | Monsanto | Cry1Ab + Cry3Bb1 | YieldGard VT Triple | European and southwestern corn borers and corn rootworms | 20% non-Bt refuge in or immediately adjacent to Bt field |
| Mon 89034 + Mon 88017 | Monsanto | Cry3Bb1 + Cry1A.105 + Cry2Ab | YieldGard VT Triple Pro | European and southwestern corn borers, corn earworm, fall armyworm and corn rootworms | 20% non-Bt refuge in or immediately adjacent to Bt field |
| TC 1507 + DAS 59122-7 + Mon 89034 + Mon 88017 | Dow Chemical Co. and Monsanto | CryIF + Cry34Ab1 + Cry35Ab1 + Cry3Bb1 + Cry1A.105 + Cry2Ab | SmartStax | European and southwestern corn borers, corn earworm, fall armyworm and corn rootworms | 5% non-Bt refuge in or immediately adjacent to Bt field |
| TC 1507 + DAS 59122-7 and TC1507 | Pioneer/DuPont | 90% CryIF + Cry34Ab1 + Cry35Ab1 and 10% CryIF seed | AcreMax 1 | European and southwestern corn borers and corn rootworms | No external refuge for RW, but a 20% corn borer refuge needed within ¼ to ½ mile |
| DAS 59122-7 and non-Bt seed | Pioneer/DuPont | 90% Cry34Ab1 + Cry35Ab1 and 10% non-Bt seed | AcreMax RW | Corn rootworms | No external refuge needed |
| Mir162 and Bt11 | Syngenta Seeds Inc | VIP and CryIAb | Agrisure Viptera 3110 | Corn borers, corn earworm, fall armyworm, black cutworm | 20% non-Bt refuge needed within 1/4 to 1/2 mile |
| Mir162, MIR604 and Bt11 | Syngenta Seeds Inc | VIP, mCry3A and CryIAb | Agrisure Viptera 3111 | Corn borers, corn rootworms, corn earworm, fall armyworm, black cutworm | 20% non-Bt refuge in or immediately adjacent to Bt field |
| TC1507 and Mon810 | Pioneer/Dupont | Cry1F and CryIAb | Optimun Intrasect | European and southwestern corn borers, black cutworm, fall armyworm, corn earworm | 5% non-Bt block or strip refuge |

**NOT ALL BT-CORN HYBRIDS ARE THE SAME**

The EPA has granted registration for the Bt-corn events listed in the table above. Each of the transgenic events listed includes the insertion of a Bt gene, a promoter gene, and a marker gene (to allow corn breeders to know which plants have the new genetic material). The promoter gene allows the Bt gene to be turned on and different promoter genes may allow the Bt toxin to be expressed at different times of the year or different parts of the plant.

Differences in insertion packages and insertion events translate into real differences in corn borer control in the field. Promoters used today generally express the Bt protein throughout the plant during the entire life of the plant.

**ECONOMICS OF BT-CORN**

Bt corn is significantly more expensive, so growers need to position these hybrids such that they will have a return on this investment. Tables 2 and 3 illustrate the potential savings (or losses in some instances) of using Bt corn under various levels of damage and corn pricing.

**Table 2. Potential Savings (loss) per Acre of Bt-corn Versus No Corn Borer Control[1]**

| Average # Borers/ plant [2] | CORN PRICE per BU | | | |
|---|---|---|---|---|
| | $1.50 | $2.00 | $2.50 | $3.00 |
| 0 | ($4.55) | ($4.55) | ($4.55) | ($4.55) |
| 0.25 | ($1.99) | ($1.13) | ($0.27) | $0.58 |
| 0.5 | $0.58 | $2.29 | $4.00 | $5.71 |
| 1 | $5.71 | $9.13 | $12.55 | $15.97 |
| 1.5 | $10.84 | $15.97 | $21.10 | $26.23 |
| 2.0 | $15.97 | $22.81 | $29.65 | $36.49 |

[1]This table assumes a yield potential of 144 bu per acre; Bt corn costs $14 extra per bag (as the cost of Bt traits can vary widely, this should be adjusted as needed); a seeding rate of 26,000/acre; each borer per plant reduces yield by 5%; and Bt corn provides 95% control of corn borers.

[2]The number of corn borers that would complete development in a non-Bt hybrid.

Consider this example using Table 2. Suppose you would expect to get a potential yield of 144 bushels per acre if there were no losses to corn borer and you expect to sell the grain for $2.50 per bushel. If there is enough corn borer activity to cause an average of 1 cavity per stalk in a susceptible hybrid at the end of the season, then you would save $12.55 per acre using Bt corn versus no corn borer control at all. However, if there was only enough corn borer pressure to cause an average of one gallery in every 4 stalks in a susceptible hybrid, the Bt hybrid would lose $1.13 per acre compared to no corn borer control at all. With minimal corn borer pressure, the reduction in corn borer damage is less than the additional cost of the Bt hybrid.

Table 2 indicates that when corn borer populations are at the level that would result in an average of one cavity in every 4 plants in an untreated susceptible hybrid, the use of the hybrids would not be justified. However, when damage exceeds an average of one cavity in every 2 plants, growers would benefit economically from the use of these hybrids. As the price of corn increases, the economics of using these hybrids becomes more favorable. As the yield per acre increases, returns on these hybrids increase as well.

**Table 3. Potential Savings (loss) per Acre of Bt-corn Versus Scouting and Rescue Treatments[1]**

| Average # Borers/ plant 2 | CORN PRICE per BU | | | |
|---|---|---|---|---|
| | $1.50 | $2.00 | $2.50 | $3.00 |
| 0 | ($2.05) | ($2.05) | ($2.05) | ($2.05) |
| 0.25 | $0.52 | $1.37 | $2.23 | $3.08 |
| 0.50 | $3.08 | $4.79 | $6.50 | $8.21 |
| 1 | $9.57 | $10.11 | $10.65 | $11.19 |
| 1.5 | $10.38 | $11.19 | $12.00 | $12.81 |
| 2.0 | $11.19 | $12.27 | $13.35 | $14.43 |

[1] This table assumes a yield potential of 144 bu per acre; Bt corn costs $14 extra per bag; a seeding rate of 26,000/acre; a each borer per plant reduces yield by 5%; Bt corn provides 95% control of corn borers; scouting costs $2.50 per acre; total cost of corn borer treatment is $10 (product+application cost) and provides 80% control, treatment would occur above a one corn borer per plant threshold.

[2] The number of corn borers that would complete development in a non-Bt hybrid.

Using the previous example of a 144 bu yield

potential, $2.50 per bushel pricing, and average of 1 cavity per stalk in a susceptible hybrid at the end of the season, then the grower would save $10.65 per acre using a corn borer hybrid versus a scouting and rescue treatment (Table 3). However, if there was only enough corn borer pressure to cause an average a quarter of a gallery per stalk in a susceptible hybrid, there would be a savings of $2.23 per acre using a Bt hybrid versus a scouting and rescue treatment strategy.

**Yield Advantage with Bt Corn**

Presence of the Bt gene in a hybrid does not increase yield, it only aids in preventing yield loss due to corn borers. Yield potential is determined by the entire genetics of a hybrid. The impact of this technology on grain yield can be estimated by comparing corn isolines, hybrids that are identical except for the presence or absence of the Bt gene. Studies conducted between 1996 and 2000 in western Kentucky indicated about a 9 to 17 bushel advantage between these pairs when corn borer pressure was moderately high. Producers interested in using Bt corn should consult the Kentucky Hybrid Corn Performance Trials for more in depth and longer term yield information. Always look at the level of pest pressure when comparing Bt hybrids to their non-Bt counterparts. In the absence of insect pests, an agronomically competitive Bt-corn hybrid should yield as least much as your standard hybrids that you are currently using.

When selecting hybrids, you should select a hybrid that has the complete package of characteristics you need, including yield potential, disease resistance, relative maturity, and local adaptability for your cropping situation. Keep insect management in perspective, while it is important, it is only one aspect of corn production.

**Bt Hybrid Advantages**

***Timing:*** Timing of insecticide applications is critical for effective corn borer control. There is a relatively short time during which insecticide applications need to be made to be effective against first generation. This requires that producers monitor their corn regularly to identify fields that are above threshold and have corn borers in the proper stage for treatment. Frequently producers have realized a corn borer problem only after it is too late. Moth flight for the second generation occurs over a longer period of time. More careful scouting is needed and more than 1 application may be needed.

***Application Equipment:*** While many corn producers in Kentucky have the necessary equipment to treat for first generation corn borers in whorl stage corn, late summer infestations commonly require special application equipment (and frequently 2 or more sprays if the is an extended egg laying period). Bt corn does not require any specialized equipment so it is available to farms of all sizes.

***Applicator Safety:*** Because Bt corn would take the place of foliar insecticide applications for corn borer control, it reduces the potential insecticide exposure to applicators. The potential pesticide drift onto other crops or environmentally sensitive areas can be reduced with these genetically modified plants.

***Compatibility with Biological Control:*** Many broad-spectrum insecticides reduce the impact of biological control agents that help to control insect and mite pests. Studies to date have indicated that Bt-corn is compatible with biological control and has little effect on natural enemies of pests.

***Non-Target Effects of Pesticides Reduced:*** Because Bt corn reduces the need for foliar pesticide applications, there will be reduced impacts on non-target organisms from broad-spectrum insecticides. These non-target organisms included insect pollinators, insect parasitoids and predators that attack corn pests, and other insect species that may be in or near corn fields (such as the monarch butterfly). However, it must be pointed out that in most years few insecticide applications were used for corn borer control in Kentucky. Producers have historically under treated for this pest.

***Control of Some Other Corn Pests:*** While Bt corn was designed specifically to control European corn borer and corn rootworms, several types of Bt corn also show excellent control of corn earworm, fall armyworm, black cutworm, and southwestern corn borer.

***Reduced Pest Monitoring Needs:*** The scouting needs for first and second generation European corn borer are greatly reduced. However, producers using these transgenic hybrids still need to monitor their fields regularly for pests such as aphids, and western and northern corn rootworms which are not controlled by these new hybrids.

**Disadvantages**

***Seed Cost and Variable Pest Populations:*** Seed for Bt corn is more expensive than comparable non-Bt seed. Additionally, Bt corn is only an advantage when specific insect pests are present. There is no advantage to planting seed with the Bt gene in the absence of these pests. The added cost of the seed is not recovered. Corn borer populations can vary in size from year to year and are not predictable. At planting, there is method to predict whether or not the pest pressure will justify the use of Bt corn. But the decision to use Bt corn must be made long in advance of corn borer moth flight.

***Development of Bt Resistance by Pests:*** The potential for pest populations developing tolerance or becoming resistant to the Bt endotoxin increases as more corn acreage is planted with Bt hybrids. In such a situation, Bt-resistant pests would be able to complete development would be more likely to increase in numbers than non-resistant forms. In areas planted exclusively to Bt-hybrids, a greater proportion of borers over time may become resistant to these transgenic hybrids. Producers need to prevent the development of resistance rather than try and fight it once it becomes a problem. For information on specific approved resistance management plans that are required when producers grow Bt corn, see Entfact 140, Resistance Management and Bt Corn.

***Impact on Monarchs?*** Bt corn was once thought to be high specific insect management tool in that only the pest that feeds on the corn would be exposed to the Bt protein. We have learned that this is not entirely correct. Because there is some Bt protein produced in the pollen (different Bt events have different concentrations in the pollen), susceptible insects that feed on the Bt pollen may be harmed. This is the case with the monarch butterfly caterpillars. Lab studies have shown that they may be killed if they consume large amounts of Bt-pollen. However, fields studies have shown that the impact is likely to be minimal based on the levels of Bt-pollen which collects on the monarchs food (common, swamp, and honeyvine milkweed) under field conditions. The EPA has concluded that there is not likely to be a significant impact on monarch populations, in fact, with pesticide reductions the impact on monarch populations should be positive.

***Marketing of Bt Grain:*** With concern about Ag Biotech products in the European Union, marketing of Bt grain may be more complicated in some areas, particularly with newly approved technologies. Before deciding to plant Bt corn, producers should always check with their grain markets to determine which specific Bt corn types will be accepted. Most elevators accept Bt corn, but some may require that producers identify Bt corn so that it can be channeled for the proper use.

**POSITIONING BT CORN ON THE FARM**

When a producer has decided that Bt corn is needed, how should this it be positioned on the farm? Corn borers can attack corn planted at any time, but usually first generation damage is most severe in early planted corn and late planted corn is more severely damaged by second generation European corn borer and southwestern corn borer. Late planting are at the greatest risk to yield loss from these pests. So growers may want to select Bt corn for late plantings if they have had problems with corn borers in the past. Later plantings are also more likely to have tip damage from corn earworm and economic infestations of fall armyworm. With late plantings, growers may want to select hybrids that also control secondary pests problematic in the southern corn belt.

**SUMMARY**

Transgenic Bt-corn hybrids have reduced losses to corn pests in Kentucky since their introduction in the late 1990s. Economically, the benefits of using Bt corn is be greatest in years when insect pressure is high or with later planting dates..



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