



AGRONOMIC SPOTLIGHT



CORN EARWORM AND Bt SWEET CORN

- » Some Bt traits in sweet corn are less effective for controlling corn earworm than they were in the past.
- » Sweet corn growers using Bt hybrids should adopt an integrated pest management approach for managing corn earworm.
- » Scouting and moth counts can be used to determine the appropriate timing of insecticide applications.

Corn earworm (CEW), *Helicoverpa zea*, is a major threat to sweet corn production because the larval stage feeds directly on the marketed product, damaging kernels and depositing frass (Figure 1). CEW is also known as the tomato fruitworm and the cotton bollworm, and it is a pest on corn, tomato, cotton, beans, alfalfa, and tobacco.^{1,2}

Bt SWEET CORN

Bt hybrids of sweet corn contain one or more genes from the naturally occurring soil bacterium *Bacillus thuringiensis* (Bt) that result in the production of proteins that disrupt the digestive systems of certain groups of insects.³ Different strains of the bacterium produce different insecticidal proteins, and the genes that code for these proteins have been used to develop insect-resistant crops, including corn and cotton.⁴

Sweet corn hybrids with Bt traits first became commercially available in the late 1990s to help manage insect pests such as corn earworm and European corn borer. The Bt genes that have been used in commercial sweet corn hybrids to date include *Cry1Ab*, *Cry1A.105*, *Cry2Ab2*, and *Vip3A*. Some hybrids contain just the *Cry1Ab* gene. Some hybrids contain a combination of the *Cry1A.105* and *Cry2Ab2* genes, and some contain a combination of the *Cry1Ab* and *Vip3A* genes.⁴ Initially, Bt hybrids of sweet corn were very resistant to CEW damage, and the need for insecticide applications was reduced for plantings of these hybrids in many situations.⁵



Figure 1. Corn earworm larva feeding on kernels and causing ear damage.

RESISTANCE TO Bt PROTEINS

By the year 2015, 81% of the field corn and 84% of the cotton crop grown in the U. S. contained Bt traits.⁴ This widespread use of Bt crops has put a strong selection pressure on populations of CEW to become resistant to the Bt proteins, and levels of damage from CEW have increased in Bt field corn and cotton over the past few years.⁶ The effectiveness of using Bt sweet corn hybrids to manage CEW also has declined, and sweet corn growers in some areas have stopped using Bt hybrids or are increasing their use of insecticides to manage the pest.^{4,7}

A study on the effectiveness of using Bt sweet corn for managing CEW was conducted between 1996 and 2016 in Maryland.⁴ The non-Bt hybrids showed average ear damage levels of 82.4%, and that level was constant over the 20 years of the study. Many of the Bt hybrids showed increasing levels of CEW damage, even though the population levels of CEW declined over that same time period. The hybrids containing only the *Cry1Ab* gene showed the greatest level of change with 6.3% ear damage in 1996 and 85.1% ear damage in 2016. Hybrids containing both the *Cry1A.105* and *Cry2Ab2* genes were included in the study starting in 2010, and these hybrids showed 20.2% ear damage in 2010 and 59.5% damage in 2016. Hybrids that contained both the *Cry1Ab* and *Vip3A* genes did not show any damage from CEW feeding.

Other studies have shown similar results with Bt field and sweet corn.^{6,8} A study of Bt field corn in Texas found populations of CEW that showed resistance to the *Vip3A* protein, indicating that this trait may also become less effective in sweet corn in the near future.⁶

BT-resistant strains of CEW appear to be less fit than susceptible strains. In the Maryland study, Bt-resistant strains had lower hatch rates, took more time to reach adulthood, had lower pupal weights, and had a reduced rate of survival from larva to adult.⁴ This indicates that susceptible CEW strains will likely outcompete Bt-resistant strains in the absence of the selection pressure from using Bt crops.

MANAGEMENT OF BT-RESISTANT CEW

With the acreages involved, the development of Bt-resistant strains of CEW is influenced more by the use of Bt field corn

(Continued on page 2)





CORN EARWORM AND Bt SWEET CORN

(Continued from page 1)

and cotton than by the use of Bt sweet corn. Farmers growing Bt field corn and cotton are required to follow an insect resistance management plan to delay the development of resistant strains of CEW and other insect pests by planting non-Bt refuges.⁴ The use of Bt sweet corn does not require the planting of refuges, but the destruction of stalks after harvest is required.

Growers planting Bt sweet corn should use an IPM strategy for managing CEW, with the Bt trait viewed as one component of a multicomponent system. CEW has two to three generations per year in the Midwest and northern states; the first generation occurs in June followed by one in August and one in September, which causes more damage. Since eggs are small and difficult to detect¹, pheromone traps should be used to monitor CEW populations once sweet corn starts to tassel (Figure 2). Traps should be placed outside of the



Figure 2. Pheromone trap for corn earworm. Eugene E. Nelson, Bugwood.org.

planting on the upwind side of the field based on prevailing winds. One pheromone trap per farm is usually adequate. The pheromone lures should be changed every two to three weeks. Trap counts should be made at least twice a week, and the moths should be removed and destroyed after counting.^{1,2}

With most sweet corn hybrids, insecticide applications need to begin when 30% to 50% of plants are showing silks and CEW moths are present at levels above the action threshold (Table 1).^{1,9} Recommended threshold levels vary somewhat among regional production

guides^{2,9}, and thresholds should be adjusted based on temperature and the presence of silking field corn. If silking field corn is present, the action threshold can be raised to 10 moths per night. During periods of warmer temperatures, insecticides may need to be applied more frequently because the silks grow faster (up to 1 inch per day), and newly emerged silks are not protected.¹

In the past, pyrethroid insecticides provided good control of CEW, but the development of CEW with resistance to these products has made them less effective. Diamide and spinosyn insecticide products are now recommended for managing CEW on sweet corn.¹ Insecticide sprays need to be directed at the ear, usually by using drop-nozzles. A spray pressure of 30 psi or more is recommended to get adequate coverage.² Once a larva enters the ear it is protected by the husk and very difficult to kill with insecticide applications.

Table 1. Action thresholds for insecticide applications to manage corn earworm on sweet corn.^{1,9}

Average Nightly Moth Count	Frequency of Insecticide Applications
Fewer than 5 per night	Every 5 days
5 to 50 per night	Every 4 days
50 to 100 per night	Every 2 or 3 days

Action thresholds specific to Bt sweet corn have not yet been developed, but growers can use the guidelines for non-Bt hybrids and adjust the thresholds for initiating insecticide applications and the frequency of application as appropriate to their circumstances, depending on the presence of Bt-resistant strains of CEW.

Bt sweet corn hybrids still appear to be more resistant to CEW damage than non-Bt hybrids in most locations, but growers should not consider the Bt hybrids as immune from CEW damage. Lower moth count action thresholds and more frequent insecticide applications may be needed to obtain acceptable levels of control on Bt hybrids than were needed in the past. These hybrids should still be effective for controlling European corn borer, and many of the Bt hybrids also have some form of herbicide tolerance, which will still be effective.

Sources

¹Foster, R. 2017. Corn earworm. Purdue University Extension Entomology, Vegetable Insects, E-31-W. ²Bessin, R. 2006. Corn earworm management in sweet corn. Entfact-318. University of Kentucky Cooperative Extension. ³Pesticide Information Profile: Bacillus thuringiensis. Extol-net. <http://pmep.cce.cornell.edu/profiles/extolnet/24d-captan/bt-ext.html>. ⁴Dively G., Venugopal P., and Finkenbinder C. 2016. Field-evolved resistance in corn earworm to Cry proteins expressed by transgenic sweet corn. PLoS ONE 11(12): e0169115. ⁵Dively, G., Venugopal, P., Bean, D., Whalen, J., Holmstrom, K., Kuhar, T., Doughty, B., Patton, T., Cissel, W., and Hutchison, W. 2018. Regional pest suppression associated with widespread Bt maize adoption benefits vegetable growers. Proceedings of the National Academy of Sciences of the United States of America 115:3320-3325. ⁶Yang, F., Gonzalez, J. C. S., Williams, J., Cook, D. C., Gilreath, R. T., and Kerns, D. L. 2019. Occurrence and ear damage of *Helicoverpa zea* on transgenic *Bacillus thuringiensis* maize in the field in Texas, US and its susceptibility to Vip3A protein. Toxins 11(2):102. ⁷Venugopal, P. and Dively, G. 2017 Climate change, transgenic corn adoption and field-evolved resistance in corn earworm. R. Soc. open sci. 4: 170210. ⁸Kaur, G., Guo, J. G., Brown, S., Head, G. P., Price, P. A., Paula-Moraes, S., Ni, X. Z., Dimase, M., and Huang, F. 2019. Field-evolved resistance of *Helicoverpa zea* (Boddie) to transgenic maize expressing pyramided Cry1A.105/Cry2Ab2 proteins in northeast Louisiana, the United States. Journal of Invertebrate Pathology 163:11-20. ⁹Egel, D., Foster, R., Maynard, E., Weller, S., Babadoost, M., Nair, A., Rivard, C., Kennelly, M., Hausbeck, M., Szendza, Z., Hutchinson, B., Eaton, T., Welty, C., and Miller, S. 2019. Midwest vegetable production guide for commercial growers 2019. Websites verified 10-1-2019

For additional agronomic information, please contact your local seed representative.

ALWAYS READ AND FOLLOW IRM, WHERE APPLICABLE, GRAIN MARKETING AND ALL OTHER STEWARDSHIP PRACTICES AND PESTICIDE LABEL DIRECTIONS.

Performance may vary from location to location and from year to year, as local growing, soil and weather conditions may vary. Growers should evaluate data from multiple locations and years whenever possible and should consider the impacts of these conditions on the grower's fields. The recommendations in this article are based upon information obtained from the cited sources and should be used as a quick reference for information about sweet corn pests. The content of this article should not be substituted for the professional opinion of a producer, grower, agronomist, pathologist and similar professional dealing with this specific crop. BAYER GROUP DOES NOT WARRANT THE ACCURACY OF ANY INFORMATION OR TECHNICAL ADVICE PROVIDED HEREIN AND DISCLAIMS ALL LIABILITY FOR ANY CLAIM INVOLVING SUCH INFORMATION OR ADVICE.

9067_S1 Published 10-13-2019

