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Francis Reay-Jones
freayjo@clemson.edu

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Francis P. F. Reay-Jones, PhD – Clemson Extension, Agronomic Crops Program Team

Introduction

The fall armyworm (*Spodoptera frugiperda*, FAW) is native to the Americas where it is known to be a pest of numerous crops. The insect overwinters in North America in south Florida, Texas, Mexico, and the Caribbean. Seasonal dispersal from these sites occurs every year, with movement throughout most of the United States from April to August, depending on latitude.[1] Arrival in South Carolina varies from year to year, but occurs generally from late May to June. The insect recently expanded its range and has now become a major pest in many parts of Africa[2] and Asia.[3,4]

The highly mobile moth (figure 1) lays eggs in masses of 10 to 600 eggs, though 100 to 200 is more common (figure 2). The insect typically has six larval stages or instars, with pupation occurring in the soil. Late instars (figure 3) can be distinguished from the corn earworm in particular by a light-colored inverted Y-shape on the head (figure 4). The larva can feed on numerous host plants, including crops such as corn, sorghum, cotton, soybean, and many vegetables and grass hosts. Two host strains of the insect exist, which are known as the 'rice' and 'corn' strains.[5] Each strain is characterized by genetic differences, in addition to the corn strain showing preference for larger grasses such as corn and sorghum and the rice strain found mainly on pasture and turfgrasses as well as rice.

Figure 1. Fall armyworm moth. Photo credit: Lyle Buss, University of Florida, Bugwood.org.

Figure 2. Fall armyworm neonate larvae dispersing from an egg mass on a leaf of a corn plant. Photo credit: Francis P. F. Reay-Jones, PhD, Clemson Cooperative Extension.

Figure 3. Fall armyworm larva on a corn ear. Photo credit: University of Georgia, Bugwood.org.

Figure 4. Fall armyworm larva showing the characteristic 'inverted Y' on head. Photo credit: Steve L. Brown, University of Georgia, Bugwood.org.

Injury to Corn

The FAW can cause leaf, stalk, and ear damage to corn plants. However, the insect prefers to lay eggs and feed on vegetative stage corn (figure 5).[6] Larvae feed on leaves, in particular in young whorl leaves, leaving characteristic rows of holes. Corn is generally tolerant of significant leaf feeding by FAW, as plants can compensate for some degree of whorl damage. However, feeding on the apical meristem (i.e., the main growing point of the plant) can lead to stunted plants and plant death.[7] Feeding on corn ears can also occur, though injury to ears is less common than whorl feeding.[8] This type of ear feeding is similar to corn earworm feeding, but the FAW can often feed through the husk to feed on kernels with less silk feeding than the corn earworm.[9] Whorl feeding can impact yield, especially when feeding occurs at earlier vegetative stages.

Figure 5. Fall armyworm whorl damage on a corn plant. Photo credit: Francis P. F. Reay-Jones, PhD, Clemson Cooperative Extension.

Management

Insecticides

Several insecticides are labeled for control of FAW in corn. A recommended threshold for whorl infestation is 25% plants infested with live larvae.[10] Because larvae become relatively protected within the whorl as they develop, ground applications directed into the whorl will increase efficacy of insecticides.

Planting Date

Because FAW moths migrate to South Carolina from southern regions, when and where infestations occur in the state can vary substantially. In general, planting corn within the recommended window in South Carolina (mid-March to mid-April) will help to avoid heavy FAW pressure in most years. Planting corn later than in this window increases the risk of heavier pressure.[11] Planting early can often be an effective cultural control practice for this insect.

Transgenic Corn Hybrids

A number of transgenic corn products expressing insecticidal toxins from the bacterium *Bacillus thuringiensis* (Bt) can control FAW (table 1). Levels of control are generally greater with the use of Bt corn than with the use of foliar applications of insecticides alone.[11] Bt corn products were originally commercialized for control of the European corn borer, *Ostrinia nubilalis*, and Bt corn products initially produced a single toxin (Cry1Ab). Over time, the range of Bt toxins has increased, and the majority of available Bt corn products available now express more than one Bt toxin (known as 'pyramids'). These pyramids generally provide more effective control than Bt hybrids expressing single toxins.[8, 12] Research trials in South Carolina have shown that all Bt products can reduce whorl injury from FAW, though Bt products expressing Cry1F alone are not as effective under heavy insect pressure.[8, 11] Resistance to Cry1F has been reported in populations of FAW in Puerto Rico,[13] Brazil,[14] and the southeastern United States,[15] so more variable levels of control are expected with this Bt product.

Summary

FAW can cause major damage to corn in the United States, generally by causing whorl-stage damage. The degree of damage is highly variable and is often more severe in late-planted corn. Insecticidal control of FAW in corn is challenging because larvae move into the whorl where they are relatively protected from contact with insecticides. Transgenic Bt corn hybrids provide good to excellent levels of control, though resistance to Cry1F underlines the threat of resistance for durability of Bt products.

Table 1. Relative efficacy of Bt corn products for fall armyworm control.

Product Trade Name	Bt Protein(s)	Control of FAW[a]	Refuge requirements in the South[b]	Event(s)
Agrisure Artesian 3010A	Cry1Ab	F-G	50%	Bt11, GA21
Agrisure GT/CB/LL	Cry1Ab	F-G	50%	Bt11, GA21
Agrisure 3000GT, Agrsiure Artesian 3011A	Cry1Ab, mCry3A[c]	F-G	50%	Bt11, MIR604, GA21
Agrisure Viptera 3110	Vip3Aa20, Cry1Ab	E	20%	MIR162, Bt11, GA21
Agrisure Viptera 3111	Vip3Aa20, Cry1Ab, mCry3A[c]	E	20%	MIR162, Bt11, MIR604, GA21
Agrisure Viptera 3220	Vip3Aa20, Cry1Ab, Cry1F	E	20%	MIR162, Bt11, TC1507, GA21
Herculex I (HX1) or (HR)	Cry1F	G-VG[d]	50%	TC1507
Optimum Intrasect (YHR)	Cry1F, Cry1Ab	VG	20%	TC1507, MON810
Optimum Intrasect XTRA (YXR)	Cry1F, Cry1Ab, Cry34Ab1/Cry35Ab1[c]	VG	20%	TC1507, MON810, DAS-59122-7
Optimum Leptra (VYHR)	Cry1F, Cry1Ab, Vip3Aa20	E	20%	TC1507, MON810, MIR162
YieldGard VT Triple (VT3)	Cry1Ab, Cry3Bb1[c]	F-G	50%	MON810, MON88017
Genuity VT Double PRO (GENVT2P), Genuity Drought Gard VT Double PRO (GENDGVT2P)	Cry1A.105, Cry2Ab2	E	20%	MON89034, NK603
Genuity VT Triple PRO (GENVT3P)	Cry1A.105, Cry2Ab2, Cry3Bb1[c]	E	20%	MON89034, MON88017
PowerCore (Dow)	Cry1A.105, Cry2Ab2, Cry1F	E	20%	MON89034, TC1507, NK603
SmartStax (SSX, Dow) or Genuity SmartStax (GENSS, Monsanto)	Cry1A.105, Cry2Ab2, Cry1F, Cry3Bb1[c], Cry34Ab1/Cry35Ab1[c]	E	20%	MON89034, TC1507, MON88017, DAS-59122-7
Trecepta	Cry1A.105, Cry2Ab2, Vip3A20	E	20%	MON89034, MIR162

[a]E = excellent, VG = very good, G = good, F = fair, P = poor. Excellent usually means better than 95 percent control. Poor means less than about 30% control.

[b]See Insect Resistance Management (IRM) documentation from the seed companies for additional details.

[c]Indicates a toxin for rootworm control.

[d]Resistance to Cry1F has been reported in the southeastern U.S.

Adapted from D. Buntin and K. Flanders, 2014, Bt Corn Products for the Southeastern United States. Based on input from entomologists attending the annual Southern Field Crops Management Seminar.

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