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RELATING THE OCCURRENCE OF BOLLWORM, *HELICOVERPA ZEA* (BODDIE), LARVAE TO LOUISIANA CROP PHENOLOGY

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Abstract

Bollworm, *Helicoverpa zea* (Boddie), larval populations were monitored in several field crops throughout the 2002 and 2003 growing seasons (Jun to Sep) at the Macon Ridge Research Station near Winnsboro, Louisiana (Franklin parish). Larval populations were monitored weekly by counting the number of larvae in each of seven different host crops including non-Bollgard cotton, Bollgard cotton, Bollgard II cotton (2003), maturity group (MG) 4 soybean, MG 6 soybean, grain sorghum, and non-*Bacillus thuringiensis* (*Bt*) field corn. Monitoring began in early June and was terminated in early Sep. Peak densities in field corn were observed during the R2-R5 growth stages, in grain sorghum during the 4-9 growth stages, in MG 6 soybean during the R1-R6 growth stages, in non-Bollgard cotton during the 7 NAWF-1 NACB stages, and in Bollgard cotton from the 5 NAWF-10 NACB growth stages. No larvae were observed in MG 4 soybean (2002 and 2003) or in Bollgard II cotton (2003). The only alternate host crop that exhibited similar temporal synchrony with bollworm larvae in Bollgard cotton was MG 6 soybean, indicating the possibility of including it in an IRM strategy for Bollgard cotton.

Introduction

Bollworm, *Helicoverpa zea* (Boddie), and tobacco budworm, *Heliothis virescens* (F.), have been significant pests of cotton, *Gossypium hirsutum* (L.), for many years. During 2002, the bollworm/tobacco budworm complex ranked as the most costly cotton pests infesting over 10.5 million acres in the U.S. resulting in a 2.31% yield loss (Williams 2003), both increases from 2001. During 2002, the heliothine complex (comprised of ca. 82% bollworm) infested ca. 477,580 acres of cotton causing a loss of 23,370 bales, requiring ca. three insecticide applications in Louisiana (Williams 2003). Until recently, the tobacco budworm was the most important species of this complex; however, it is effectively managed by the Cry1Ac insecticidal protein in Bollgard cultivars (Perlak et al. 1990, Stewart et al. 2001). Because of bollworm's inherent tolerance to the *Bacillus thuringiensis* (*Bt*) Berliner toxin, control of large infestations is often less than satisfactory and can often require supplemental foliar insecticide applications (Luttrell et al. 1999).

Bollworm can occur on as many as 100 host plants (King and Coleman 1989), and includes many crops throughout most of the summer months in Louisiana. Larvae occur initially on wild hosts, immigrate to field corn, *Zea mays* (L.), and subsequent generations occur on less preferred hosts including cotton; grain sorghum, *Sorghum bicolor* (L.) Moench; and soybean, *Glycine max* (L.) Merrill; as field corn matures. In Louisiana, bollworm populations peak in mid-to-late summer in cotton (Lincoln et al. 1967) and develop multiple generations (four to five) in a single year (Oliver and Chapin 1981).

The use of genetically engineered cotton cultivars, including insect, disease, and herbicide resistant varieties, as a production risk management tool has been widely accepted by producers. Bollgard cotton cultivars offer producers a way to manage some key insect pests associated with producing cotton in Louisiana.

Recently, producers have become interested in reducing the non-Bollgard cotton refuge acreage required by the Environmental Protection Agency (EPA) as part of an Insect Resistance Management (IRM) strategy. Current refuge options gives producers a choice from one of three structured non-Bollgard cotton refuge options: 1) a 5% external unsprayed, 2) 5% embedded, 3) 20% external sprayed, or 4) a shared community refuge (US EPA 2001). A proposed alternative plan is to supplement or replace the non-Bollgard cotton refuge with other heliothine crop host plants. Delaying or preventing heliothine resistance to Bollgard through the use of non-cotton refuges will require more knowledge on the distribution and abundance of bollworm on alternate host crops, as well as on Bollgard and non-Bollgard cotton. Bollworm larval occurrence on cultivated field crops varies greatly based on the phenological stage of the crop: during the silking and milk stage in field corn (Steffey et al. 1994), after anthesis and during the milk stage in grain sorghum (Lopez et al. 1978), R4-R6 (when pods begin to appear) in soybean (McWilliams 1983), and up to five weeks after flower initiation in cotton (Slosser et al. 1978, Farrar and Bradley 1985). With the re-registration of the Bollgard technology occurring in the near future, researchers must address some key questions about the refuge system and the contribution of alternate hosts to bollworm production. The objective of this study was to examine the production and synchrony of bollworm larval populations in Bollgard and Bollgard II cotton with alternate crop hosts during the Louisiana cotton production season, and relate occurrence to crop phenology. This study should help to further define the temporal occurrence of bollworm larvae in various host crops in the Louisiana agricultural landscape.

Materials and Methods

Bollworm crop hosts used as treatments in these studies included non-Bollgard cotton, Bollgard cotton, grain sorghum, soybean (MG 4 and 6), and field corn (non-*Bt*). In 2003, a Bollgard II cotton variety was added to the study. In 2002, field corn was planted on 25 Mar, MG 4 soybean and grain sorghum on 24 Apr, MG 6 soybean on 28 May, and non-Bollgard and Bollgard cotton on 9 May. In 2003, field corn was planted on 10 Mar, MG 6 soybean on 29 May, MG 4 soybean and grain sorghum on 20 Apr, non-Bollgard, Bollgard, and Bollgard II cotton on 30 Apr.

Each crop was planted at the appropriate time using agronomic practices (seeding and fertilizer rates, and weed/insect management) recommended for the crop. No insecticides with activity against bollworm or tobacco budworm were applied to the plots. Plots were received supplemental irrigation as needed to maintain optimum plant growth.

Crops (treatments) were arranged in a RBD with three replicates and consisted of six plots per replicate in 2002 and seven plots per replicate in 2003. Each plot was 16 rows wide x 120 feet long (ca. 0.25 acre).

Larval surveys utilized the most appropriate sampling technique for the representative crop. Ten random samples each consisting of 10 feet of row for a total of 100 row feet were sampled in each plot. In cotton (Bollgard, and non-Bollgard), and soybean (MG 4 and MG 6) cloth shake sheets (3 feet x 5 feet) were used to make larval counts. In corn, silks on maturing ears were examined for larvae. Grain sorghum was evaluated by vigorously shaking maturing panicles into a three gallon plastic bucket and recording the number of larvae. Representative samples from each crop were collected and maintained on meridic diet to allow for species determination. Surveys were initiated during the early vegetative stage of each crop and continued until larval production ceased (two consecutive weeks of finding zero larvae) or until the host crop reached physiological maturity (7 Jun-6 Sep, 2002 and 18 Jun-5 Sep, 2003). Surveys were conducted weekly and data were expressed on a per acre basis (no. larvae/acre).

Results

During 2002, in field corn, larvae were observed during the R2-R3 growth stages (late silk, blister, and milk) and reached a peak density at R3 on 25 June (Fig. 1). On grain sorghum, bollworm larvae were present during the 4-8 (flag leaf to soft and hard dough) growth stages and peaked at 7 on 12 Jul (Fig. 1). Larval occurrence on MG 6 soybean was primarily during the R2-R6 growth stages and peaked at R3 (2 Aug). In non-Bollgard cotton, larvae were present from 7 NAWF to 1 NACB with a peak at 5-6 NAWF on 2 Aug. On Bollgard cotton, larval occurrence ranged from 5 NAWF to 6 NACB peaking at 1-2 NAWF on 16-20 Aug. No bollworm larvae were observed in MG 4 soybean for the entire year. Mean larval survival to adult emergence was 64, 71, 74, 79, and 87% on field corn, grain sorghum, MG 6 soybean, non-Bollgard cotton, and Bollgard cotton, respectively (Fig. 2).

During 2003, larvae were found on field corn during the R2-R5 (late silk, blister, milk, and dent) stages with a peak density at R2-R3 on 25 Jun. On grain sorghum, larvae occurred during the 6-9 (bloom to hard dough) growth stages reaching a peak density at stage 6 on 14 Jul. Larval occurrence in MG 6 soybean was recorded during the R1-R2 (beginning flowering to full bloom) stages attaining a peak density at the R2 stage on 4 Aug. Larvae on non-Bollgard cotton ranged from 0-2 NAWF growth stages and reached a peak density at 1-2 NAWF on 4 Aug. Larval presence on Bollgard cotton was during the 3 NAWF to 10 NACB growth stages with a peak density at 0-3 NAWF on 11 Aug. No larvae were observed in MG 4 soybean or Bollgard II cotton for the entire year. Mean larval survival to adult emergence was 66, 58, 100, 82, and 100% on field corn, grain sorghum, MG 6 soybean, non-Bollgard cotton, and Bollgard cotton, respectively (Fig. 4).

Discussion

Bollworm progression in these host crops is indicated by peak dates of densities for each treatment. Larval densities peaked in field corn on 25 Jun. Peak densities in grain sorghum occurred during 12-14 Jul for both years. Peak densities were observed in non-Bollgard cotton and MG 6 soybean, during 2-4 Aug for both years. Temporal occurrence of bollworm larvae in Bollgard and non-Bollgard cotton was similar for both years. Peak larval densities in non-Bollgard cotton were observed during the 1st week of August (2-4 Aug) at growth stages of 7 NAWF to 1 NACB, and larvae were present for a total of 24 days. Bollgard cotton supported peak densities during the 2nd to 3rd weeks of August (11-16 Aug), ranging from 5 NAWF to 6 NACB, and larvae were present for a total of 33 days. The latest generation of bollworm larvae was observed in Bollgard cotton plots, from 11-20 Aug. No bollworm larval populations were observed in any of the MG 4 soybean plots (2002 and 2003) or in the Bollgard II cotton plots (2003). The only crop that exhibited similar temporal synchrony with bollworm larvae in Bollgard cotton was MG 6 soybean. Therefore, MG 6 soybean offers some possibility of use in an IRM strategy for Bollgard cotton.

Larval survival to adult emergence was higher for all crops in 2003, with the exception of grain sorghum. All larvae collected in Bollgard cotton and MG 6 soybean in 2003 survived. The high level of survival may be explained by the fact that relatively few larvae were collected during 12 total weeks of sampling in these crops. Other crops such as grain sorghum and field corn supported relatively large densities over multiple sampling dates and allowed for a much larger sample included in the data to determine survival to adult emergence.

Future resistance management strategies may depend on bollworm production from available alternate hosts, such as corn, soybean, and grain sorghum. Knowledge about temporal occurrence of bollworm larvae in Bollgard and non-Bollgard cotton, and alternate host crops (i.e. field corn, grain sorghum, and soybean) may allow producers to use these crops as supplemental refuges for non-Bollgard cotton. These data indicate that larvae in corn and grain sorghum peak at levels earlier than in cotton and soybean. If bollworm production in these hosts can be manipulated to be temporally synchronous with adults emerging from existing non-Bollgard cotton refuges, producers may have more options from which to choose when implementing a refuge strategy. More user-friendly refuge options may help to delay or prevent the evolution of resistance to Bollgard cotton by bollworm, and indefinitely prolong the effectiveness of Bollgard cotton technology.

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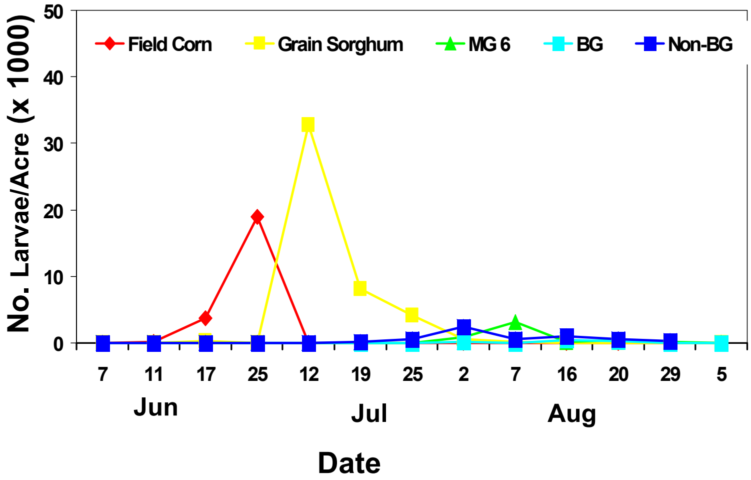

Figure 1. Bollworm peak densities at MRRS, 2002.

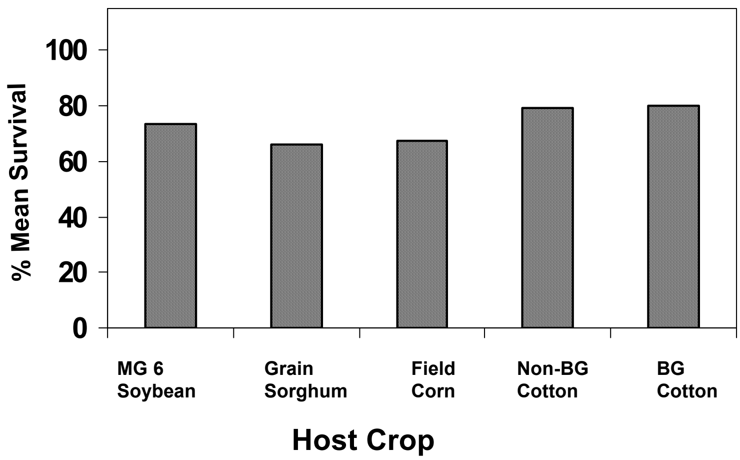

Figure 2. Bollworm survival (larval to adult) at MRRS, 2002.

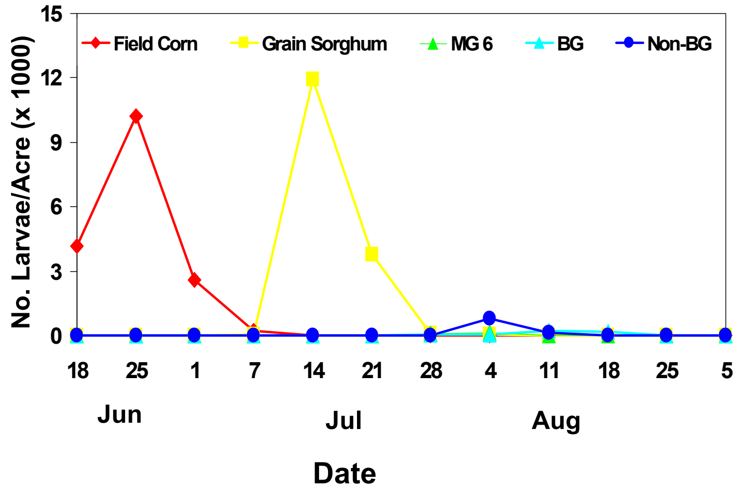

Figure 3. Bollworm peak densities at MRRS, 2003.

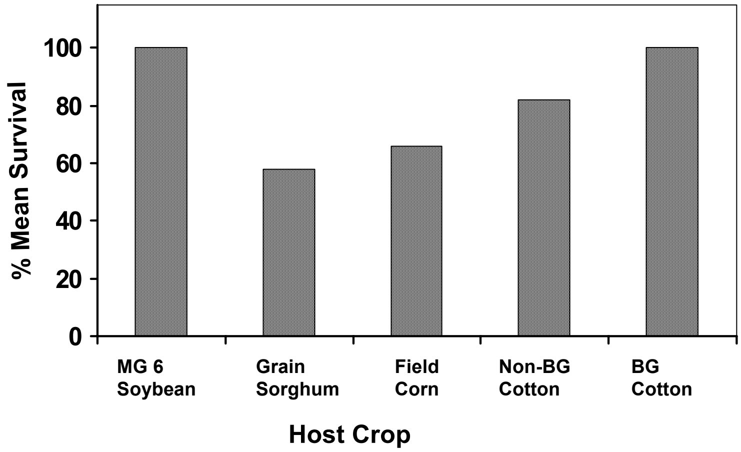

Figure 4. Bollworm survival (larval to adult) at MRRS, 2003.