INFLUENCE OF PLANTING DATE OF BOLLWORM INCIDENCE AND DAMAGE IN COTTON

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Abstract

Bollworm, *Helicoverpa zea* Boddie, is an important pest of US cotton. Bt-resistance in bollworm has spurred renewed interest in investigating various IPM principles and tactics. Several replicated small-plot trials were conducted across the southeastern US to document the effect of planting date on *H. zea* infestation and damage in cotton. In general, planting date influenced bollworm damage in the three locations where they were present. Generally, bollworm damage was higher and more persistent in later-planted cotton. This effect was more apparent in high-pressure situations (North Carolina and South Carolina) compared with the lower pressure situation (Virginia). Moreover, these differences were more apparent later in the season.

Introduction

Few studies have documented the effect of planting date on *Helicoverpa spp.* in cotton. In other crops, such as soybeans, egg deposition by and larval survival of bollworm, *Helicoverpa zea* Boddie, is almost always greater in a later-planted crop (Terry et al. 1987). However, results with cotton have proved more variable, perhaps because plant growth characteristics, such as internode length, can vary widely across planting dates (Boquet and Clawson 2009) and despite bollworm populations usually increasing as the season progresses (Parajulee et al. 1998). A study in Zimbabwe found that larvae of *Helicoverpa armigera* (Hübner) were more prevalent in later-planted cotton (Karavina et al. 2012). In contrast, a North Carolina study did not find differences in egg deposition and damage in cotton among planting dates (Agi et al. 2001). Finally, another study found that early planted cotton had more larvae and more damage than later planted cotton, although egg deposition was similar among planting dates (Lambert et al. 1996).

Bt-resistance in bollworm has spurred renewed interest in investigating various IPM principles and tactics. Growers are unlikely to shift planting dates solely because they are concerned about damage from bollworm; however, if planting date consistently influences *H. zea* infestation and damage in cotton, then scouting or controlling bollworm could be prioritized into certain management zones across a farm. Furthermore, if studies show that cotton is an important crop for Bt-resistance management, then information concerning the effect of planting date on bollworm infestation will be important.

To approach this question, experimental small-plot trials were established in various locations across the southeastern US. Our intention was to have at least one early, middle, and late planting date replicated in each location. Our hypothesis was that bollworm infestation levels would be higher in later planting dates.

Materials and Methods

Non-Bt cotton (DP1822XF; Bayer Crop Science, St. Louis, MO, or FM2322GL; BASF, Research Triangle Park, NC) was planted during 2020 in each location on at least three planting dates (early, mid-, late) that were representative of cotton grown in that region. If conditions were poor (e.g., too cold, too wet) then planting was adjusted. We used a randomized complete block design with four replications per planting date, with plots that were four or eight rows wide by forty feet long. Data were not collected from the Florida location due to unfavorable environmental conditions or from the Georgia location due to lack of pressure, and are not detailed here. In Blackville, South Carolina, plots were planted on 16 April (early), 14 May (middle), and 17 June (late). In Rocky Mount, North Carolina, plots were planted on 12 May (early), 26 May (middle), 1 June (middle-late), and 8 June (late). In Suffolk, Virginia, plots were planted on 5 May (early), 14 May (middle), and 1 June (late). Standard agronomic practices were followed, except that a disruptive spray of acephate (Orthene 97, 1.05 kg ai ha^{-1}; AMVAC Chemical Corporation, Newport Beach, CA) was applied on 21 July in North Carolina to eliminate natural enemies and to encourage bollworm establishment. Insecticide applications for bollworms were not made in any location.

Once cotton began squaring, we checked weekly for the presence of bollworm or tobacco budworm, *Chloridea virescens* F. Once a larva was detected in any plot, we scouted 50 fruiting forms (squares or flowers prior to and during first or second week of bloom, but defaulted to bolls, when present) per plot in all planting dates weekly until no more larvae were detected (generally three to six weeks, depending on the location). We recorded fruiting form as damaged if there was a hole in the sepal wall, and we also recorded the number and larval instars found on the fruiting forms. We also collected 25 larvae during one week (or as many as possible), and reared them to adulthood to identify them as bollworm or tobacco budworm.

Plant (plant mapping from late October to early December, depending on plant maturity by planting date, in South Carolina, 23 October in North Carolina, and in Virginia) and yield (box mapping performed after defoliation, but prior to harvest) variables were collected from the middle two or four rows of each plot by selecting 10 to 20 random plants. Yield was from the center two or four rows using a mechanical picker. Plant mapping variables collected included plant height, number of nodes, number of total bolls per plant, number of vegetative bolls per plant, position of the first fruiting node, and the percent retention at each position along fruiting branches at each node. Box mapping variables collected included the weight of seed cotton at each node and position on both reproductive and vegetative branches. Yield variables were not collected in North Carolina because bollworms had caused nearly 100% boll abscission across the trial.

A mixed models approach was used (PROC MIXED; (SAS Institute 2011)), and separate models were constructed for each location because planting dates varied. The independent variables included planting date, which was fixed, and replication and the interaction of replication with planting date, which were random. Dependent variables in separate analyses included averages per plot of: damaged squares or bolls (if present) at each sampling point, plant height, number of nodes, the height to node ratio (H:N), number of total bolls per plant, number of vegetative bolls per plant, position of the first fruiting node, and percent retention at each position along fruiting branches on nodes 1, 2, 3, and 4 (if present) averaged across nodes, and the weight of seed cotton at each position, averaged across nodes of both reproductive branches (positions 1, 2, and 3) and vegetative branches. Transformations were used, if needed, to satisfy model assumptions. Degrees of freedom were adjusted using Kenward-Roger's approach (Kenward and Roger 1997), and mean separations were analyzed using Tukey's honest significant differences test.

Results

In-season damaged fruiting forms. In South Carolina, there were initially (17 July) more damaged squares in the early-planted cotton (Fig. 1; $F = 5.05$, d.f. = 2, 9, $P = 0.339$), likely because it was more phenologically advanced than the other planting dates. Through the rest of July and the beginning August, infestation levels were moderate and not different across planting dates. Infestation levels increased during mid-August through September. The latest planting date had the fewest damaged bolls compared with the other two planting dates on 18 ($F = 10.36$, d.f. = 2, 9, $P = 00046$) and 25 August ($F = 7.87$, d.f. = 2, 6, $P = 0.0210$), but had the most damage bolls on the last two sampling dates (31 August ($F = 11.42$, d.f. = 1, 6, $P = 0.0149$) and 8 September ($F = 22.01$, d.f. = 1, 3, $P = 0.0183$)).

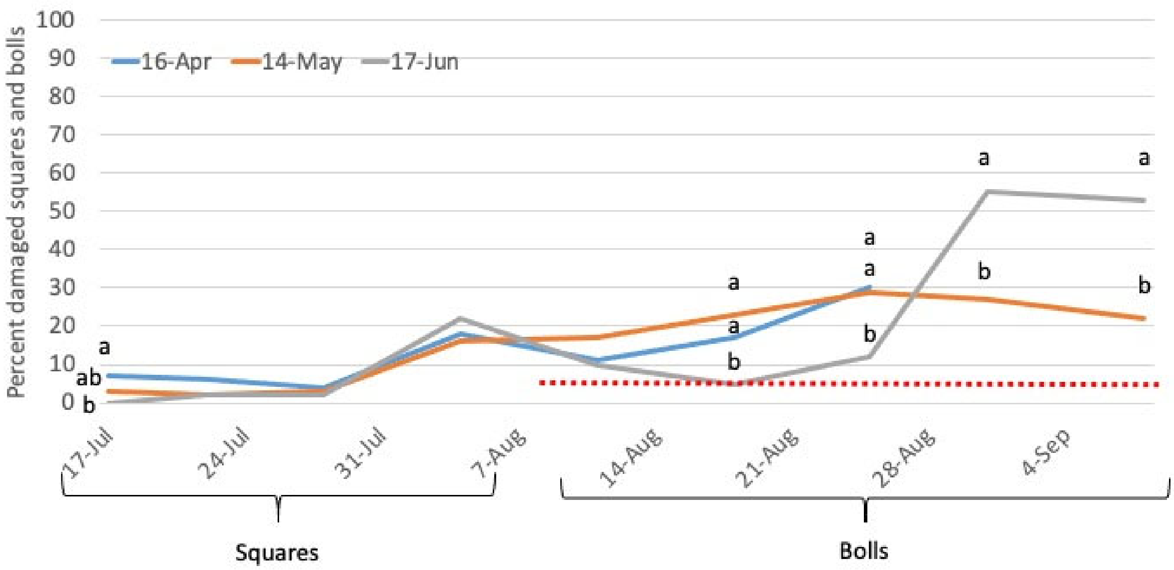

Figure 1. Percent squares and bolls damaged by bollworms across planting dates in South Carolina. 16 April = early planting date; 14 May = middle planting date; 17 June = late planting date. Dashed red line denotes a threshold of 6% damaged fruiting structures.

In North Carolina, the percent of squares or bolls (if present) damaged by bollworms could only be statistically separated among planting dates on 17 August (Fig. 2; $F = 8.99$, d.f. = 3, 8.99, $P = 0.0017$).

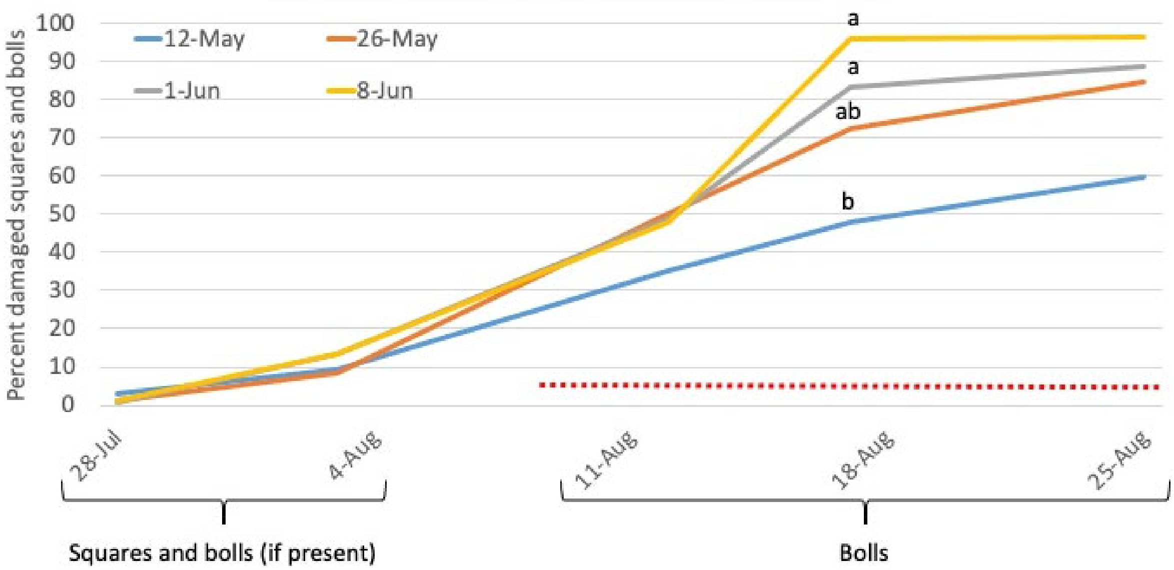

Figure 2. Percent squares and bolls damaged by bollworms across planting dates in North Carolina. 12 May = early planting date; 26 May = middle planting date; 1 June = middle-late planting date; 8 June = late planting date. Dashed red line denotes a threshold of 6% damaged fruiting structures.

In Virginia, infestation levels were moderate. Damaged bolls were significantly different on a single sampling date (13 August; Fig. 3; $F = 5.64$, d.f. = 2, 9, $P = 0.0258$), and there were fewer damaged bolls in late-planted cotton compared with cotton planted in the middle of the planting window.

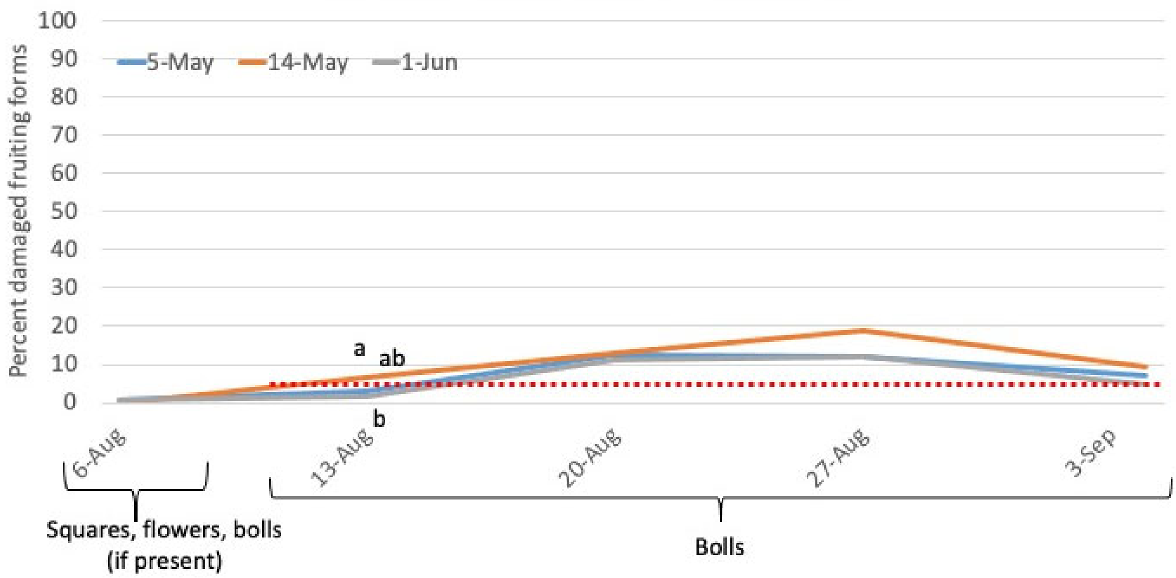

Figure 3. Percent squares and bolls damaged by bollworms across planting dates in Virginia. 5 May = early planting date; 14 May = middle planting date; 1 June = late planting date. Dashed red line denotes a threshold of 6% damaged fruiting structures.

Plant mapping. Plants were shorter on the earlier planting date (1.10 m) compared with the late planting date (1.43 m) in South Carolina ($F = 12.82$, d.f. = 2, 6, $P = 0.0068$). Plant heights were the same across planting dates in North Carolina and Virginia. Average total nodes per plant were the fewest on the latest planting date compared with all others in South Carolina (Fig. 4; $F = 8.50$, d.f. = 2, 6, $P = 0.0178$) and North Carolina (Fig. 4; $F = 14.10$, d.f. = 3, 9, $P = 0.0009$). Average total nodes per plant were the fewest in the late planting date compared with the early planting date in Virginia (Fig. 4; $F = 8.55$, d.f. = 2, 6, $P = 0.0175$). The average H:N ratio was the highest in the late planting date in South Carolina (Fig. 5; $F = 28.85$, d.f. = 2, 9, $P = 0.0001$), North Carolina (Fig. 5; $F = 16.26$, d.f. = 3, 9, $P = 0.0006$), and Virginia (Fig. 5; $F = 10.97$, d.f. = 2, 9, $P = 0.0039$), and increased with planting date across trials.

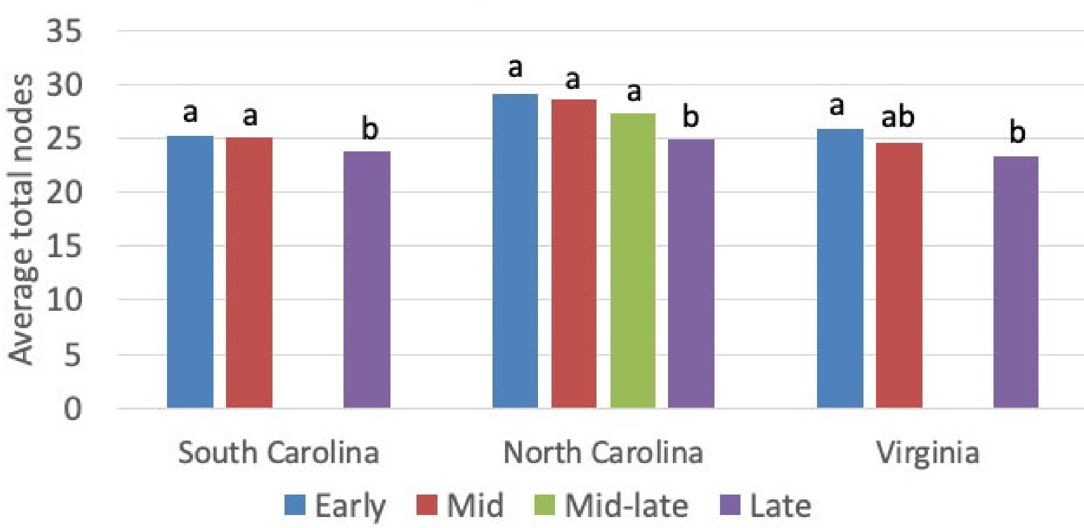

Figure 4. Average total nodes per plant. Early = early planting date; Mid = middle planting date; Mid-late = middle-late planting date; Late = late planting date.

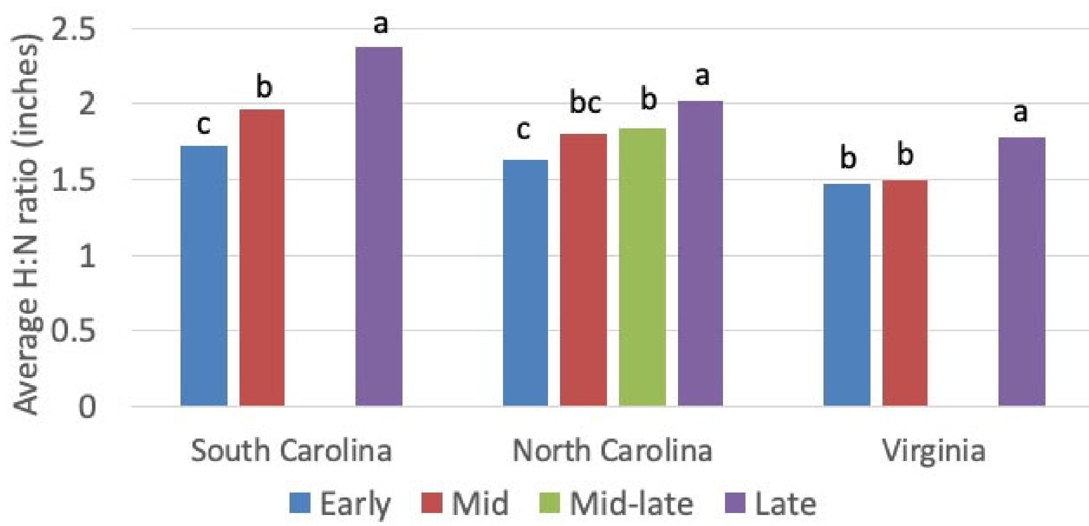

Figure 5. Average height to node ratio (H:N). Early = early planting date; Mid = middle planting date; Mid-late = middle-late planting date; Late = late planting date.

Average bolls per plant were lowest in the late planting date in South Carolina (11.31 bolls; $F = 23.79$, d.f. = 2, 6, $P = 0.0014$) compared with the middle (17.81 bolls) or early planting date (16.86 bolls). In North Carolina, average bolls per plant were lowest in the middle-late (0.98 bolls) and late (1.03 bolls) planting dates compared with the middle (3.30 bolls) and early planting date (4.63 bolls; $F = 19.10$, d.f. = 3, 9, $P = 0.0003$). Average bolls per plant were the same across planting dates in Virginia. Vegetative bolls per plant were the same across planting dates in all three locations. The first fruiting node was lower on the early (node 5.50) and late planting date (node 5.38) compared with the middle planting date (node 6.00) in South Carolina ($F = 8.18$, d.f. = 2, 6, $P = 0.0193$), the same across all planting dates in North Carolina, and lower on the late planting date (node 7.93), higher in the middle planting date (node 8.71), and highest in the early planting date in Virginia (node 9.48; $F = 17.19$, d.f. = 2, 9, $P = 0.0008$).

In South Carolina ($F = 5.53$, d.f. = 2, 9, $P = 0.0272$), North Carolina ($F = 9.82$, d.f. = 3, 9, $P = 0.0034$), and Virginia ($F = 22.61$, d.f. = 2, 5.99, $P = 0.0016$), first position boll retention was lowest in late-planted cotton, but was variable across other planting dates (Fig. 6).

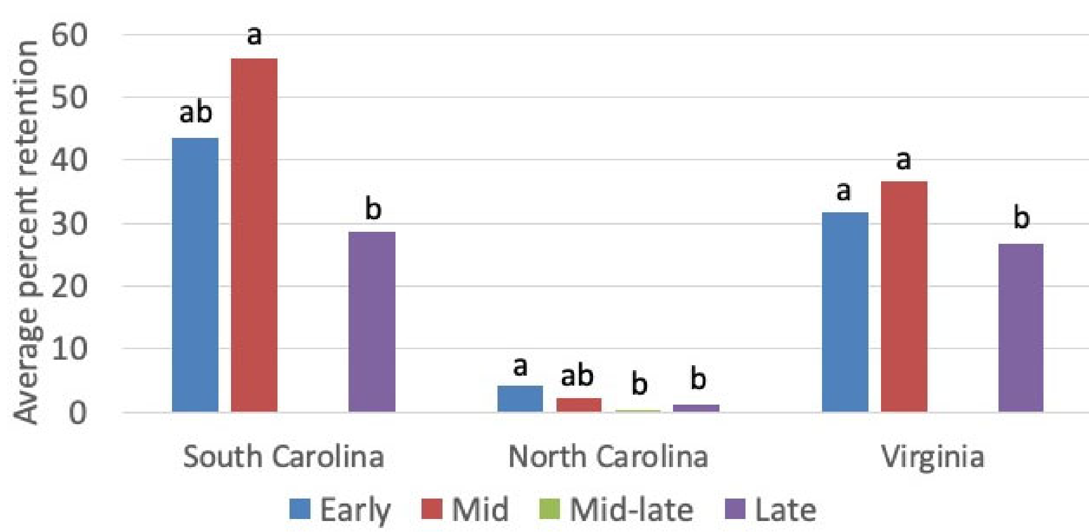

Figure 6. Average percent retention of the first position boll across all nodes.

In South Carolina, second position boll retention was lowest in the late planting date compared with the other two planting dates ($F = 10.75$, d.f. = 2, 6, $P = 0.0104$). Second position boll retention was similar across planting dates in North Carolina but was very low overall (ranging from 0.5 to 2.2%). Second position boll retention was lower in the middle planting date (18.19%) than the early planting date (35.45%) in Virginia ($F = 7.65$, d.f. = 2, 6, $P = 0.0224$).

In South Carolina, third position boll retention was lowest in the late planting date (8.41%) compared with the early (15.26%) and middle planting dates (15.19%; $F = 17.62$, d.f. = 2, 9, $P = 0.0008$). Third position boll retention was similar across planting dates in North Carolina. Third position boll retention was lower in the middle planting date (6.45%) than the late planting date in Virginia (31.58%; $F = 8.75$, d.f. = 2, 5, $P = 0.0233$). Fourth position boll retention was similar across planting dates in South Carolina and North Carolina. There were not enough fourth position bolls in Virginia for analysis.

Yield components. In South Carolina, there was less seed cotton in position one from the late planting date (29.30 g per plant) compared with the middle planting date (35.30 g per plant; $F = 12.71$, d.f. = 2, 6, $P = 0.0070$). In Virginia, seed cotton from position one was not different across planting dates.

In South Carolina, there was less seed cotton in position two in the late planting date (11.05 g per plant) compared with the early (17.47 g per plant) and middle planting dates (18.55 g per plant; $F = 9.24$, d.f. = 2, 6, $P = 0.0147$). In Virginia, there was less seed cotton in position two in the middle planting date (4.01 g per plant) compared with the early planting date (8.49 g per plant; $F = 7.54$, d.f. = 2, 6, $P = 0.0230$).

In South Carolina, seed cotton in position three was not different across planting dates. In Virginia, there was less seed cotton in position three in the middle planting date (0.72 g per plant) compared with the early (3.70 g per plant) and late planting date (3.33 g per plant; $F = 9.31$, d.f. = 2, 6, $P = 0.0145$). In both locations, seed cotton from vegetative branches was not different across planting dates.

In South Carolina, total seed cotton yield was lowest in the late planting date, higher in the early planting date, and highest in the middle planting date ($F = 238.33$, d.f. = 2, 6, $P < 0.0001$). In Virginia, seed cotton yield was lower in the late planting date compared with the early and middle planting date ($F = 10.79$, d.f. = 2, 6, $P = 0.0103$).

Summary

Planting date influenced bollworm damage in the three locations where they were present. Generally, bollworm damage was higher and more persistent in later-planted cotton. This effect was more apparent in high-pressure situations (North Carolina and South Carolina) compared with the lower pressure situation (Virginia). Moreover, these differences were more apparent later in the season.

First and second position boll retention was likely important to maintaining yield in South Carolina. In South Carolina, boll retention was lower in the late planting date, and seed cotton weight was lower in the first two positions. By contrast, in Virginia, seed cotton weight was not different across planting dates in the first position and was lower in the second position during the middle planting date than other planting dates. Despite this, total seed cotton yield from the early and middle planting dates in Virginia was higher than the late planting date. Potentially seed cotton weight was lower across all positions in the late planting data in Virginia, but not statistically significant. There was a high degree of variability in this trial, and the cotton was poor overall, with challenging conditions during May. For example, only four cotton heat units were accumulated between the early (5 May) and middle (14 May) planting date. Bollworm damage was so significant in North Carolina that yield could not be calculated.

These experiments represent a range of responses to cotton planting date by bollworm. All three experiments had population levels above recently recommended damaged-boll thresholds (Del Pozo-Valdivia et al. In press), and there was a good range of pressure. However, future experiments will be needed to fully shed light on the influence of planting date on bollworm incidence and damage in cotton.

Acknowledgements

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