EFFECTIVENESS OF INSECTICIDE OVERSPRAYS FOR CONTROL OF BOLLWORM AND STINK BUGS IN SOUTH CAROLINA

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Abstract

Bollworm and stink bugs are the most important insect pests of cotton in South Carolina and much of the Southeast. Stink bugs are the most significant group, but bollworm can escape control from Bt proteins and cause economic losses, especially in two-gene Bt cotton. It is standard practice in the region to use oversprays of insecticide on Bt cotton to control these pests that occur concurrently on the crop. Pyrethroid insecticides are preferred for control of stink bugs because of good initial and residual control, but susceptibility of bollworm to pyrethroids has declined, and use of alternative, lep-specific insecticides for control of bollworm has increased, particularly on two-gene Bt cotton. In trials evaluating oversprays of a lep-specific insecticide (diamide) and targeted control of bollworm and/or stink bugs with several modes of action (diamide, pyrethroid, and organophosphate), we found that insecticides were not needed under low pressure from these insect pests. Despite minimally and infrequently reaching treatment thresholds for bollworm and/or stink bugs, no statistical increases in yield were observed with oversprays. This indicated that treatment thresholds for bollworm (5% injury to squares or bolls) and stink bugs (dynamic boll-injury by week of bloom) might be marginally aggressive for low-pressure scenarios and result in unnecessary sprays, at least in a season with surplus rainfall and good growing conditions likely leading to yield compensation.

Introduction

The most important insect pests of cotton in South Carolina and most of the Southeast are the bollworm, *Helicoverpa zea*, and various species of stink bugs, such as the green stink bug, *Chinavia hilaris* (Say), the southern green stink bug, *Nezara viridula* (L.), and the brown stink bug, *Euschistus servus* (Say). Because these species overlap in time (after initial bloom) and space (near reproductive structures) on the crop in the region, they are managed concurrently with oversprays of insecticide to protect yield. Bollworm continues to put uniform and intense pressure on Bt cotton, and we are seeing continuing signs of resistance to Bt toxins (Reisig et al. 2018) due to selection in corn and cotton, and this has further increased our need for oversprays. The stink bug complex is the number one insect pest group of cotton in the Southeast. The dynamic boll-injury threshold is a proven method for protecting cotton from stink bugs, and the pyrethroid insecticides are the most effective chemical controls for the complex because of initial knockdown and residual effectiveness. However, the pyrethroids are becoming less efficacious on bollworm (Musser et al. 2015, Reisig et al. 2019), potentially compromising the concomitant control of both stink bugs and bollworm with the inexpensive insecticides. More information is needed on the importance of bollworm and stink bugs on two- and three-gene Bt cotton, so we conducted trials to evaluate the effectiveness of various insecticide regimes applied as oversprays on Bt cotton for the pests.

Materials and Methods

Research plots (8 rows by 40 ft) were established in a RCBD with 4 replications in Bt cotton fields near Blackville, SC during 2020. Varieties planted in two separate trials included the non-Bt variety NG4050XF and the varieties of two- or three-gene Bt cotton PHY400W3FE, ST5471GTLP, NG5711B3XF, and NG5007B2XF. In the first trial, oversprays of chlorantraniliprole (Prevathon 0.43 SC at 20 fl oz/acre) were applied to protected plots of non-Bt, Bollgard 2 (BG2), Bollgard 3 (BG3), TwinLink Plus (TLP), and WideStrike 3 (WS3) cotton during the first (24 July) and third (5August) weeks of bloom. Corresponding plots of each variety remained untreated as comparisons. Dicrotophos (Bidrin 8 EC at 8 fl oz/acre) was sprayed on the entire test area at least twice to protect the trial from stink bugs. In the second trial, plots of untreated non-Bt, BG2, and BG3 cotton were included as reference treatments for plots of BG2 and BG3 cotton sprayed selectively for bollworm, stink bugs, or both. Bidrin at 8 fl oz/acre, Prevathon 0.43 SC at 20 fl oz/acre, and/or bifenthrin (Brigade 2 EC at 6.4 fl oz/acre) were applied at the time of presumed greatest impact for each pest, simulating what a producer or consultant might do. Treatments in the second trial were:

1. Non-Bt untreated control
2. BG2 untreated control
3. BG3 untreated control
4. BG2 + Prevathon applied during 1st week of bloom (control of bollworm only)
5. BG3 + Prevathon applied during 1st week of bloom (control of bollworm only)
6. BG2 + Bidrin applied during the 3rd and 5th weeks of bloom (control of stink bugs only)
7. BG3 + Bidrin applied during the 3rd and 5th weeks of bloom (control of stink bugs only)
8. BG2 + Brigade applied during the 1st, 3rd, and 5th weeks of bloom (control of stink bugs and some bollworm)
9. BG3 + Brigade applied during the 1st, 3rd, and 5th weeks of bloom (control of stink bugs and some bollworm)
10. BG2 + Prevathon applied at 1st week of bloom and Brigade applied at 3rd and 5th weeks of bloom (control of stink bugs and bollworm)
11. BG3 + Prevathon applied at 1st week of bloom and Brigade applied at 3rd and 5th weeks of bloom (control of stink bugs and bollworm)

Plots were sampled for damage indices caused by bollworm (damage to terminals, squares, blooms, and bolls) and stink bugs (damage to bolls). Data on damage by bollworm to squares and bolls and damage by stink bugs to bolls are reported. Yield data were taken with a mechanical picker and evaluated to define the importance of each pest. The values of oversprays were determined by yield comparison with the untreated controls. Although all plots were to be protected from other insect pests before and after the windows of control defined for each of the insecticide and pest combinations above, no additional insecticides were used. Data were analyzed with a one-way ANOVA using ARM software.

Results and Discussion

Because stink bugs and bollworm are major pests of cotton in the southeastern USA that require overspray treatments with insecticide, we addressed several treatment options that growers used for these pests in Bt cotton (Bollgard 2, Bollgard 3, WideStrike 3, and TwinLink Plus) in South Carolina in 2020. Pyrethroid insecticides have been used for decades to control bollworm in cotton, but some loss in efficacy has occurred (Figure 1).

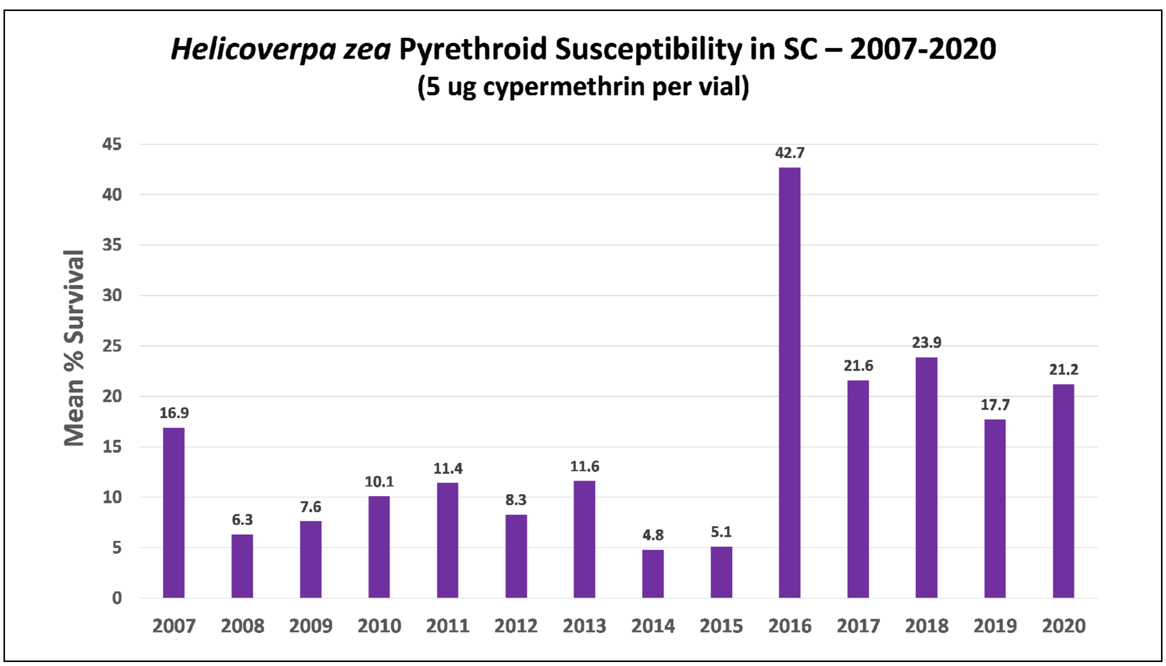


Figure 1. Mean survival of adult bollworm, *Helicoverpa zea*, in laboratory bioassay addressing contact efficacy with the pyrethroid cypermethrin in SC (2007-2020).

In laboratory bioassays in South Carolina, bollworm moths, collected from pheromone traps, began showing signs of increased survivorship in 2016, and the trend has continued through 2020. Field observations over the last decade have also indicated reduced efficacy of pyrethroids in controlling bollworm in cotton. However, because of the low cost of pyrethroid insecticides and their excellent control of stink bugs, the pyrethroid bifenthrin was used in one of our trials as an overspray option. The insecticide chlorantraniliprole was included to provide very good control of bollworm and not stink bugs, and dicrotophos was used to control stink bugs and not bollworm. In one of our trials, timings of these products used alone or in series were investigated.

Pressure from bollworm was low to moderate in South Carolina during 2020, as indicated by relatively low levels of capture in pheromone traps (green line on inset line chart), causing significant injury to non-Bt cotton but not two- and three-gene Bt cotton (Figure 2).

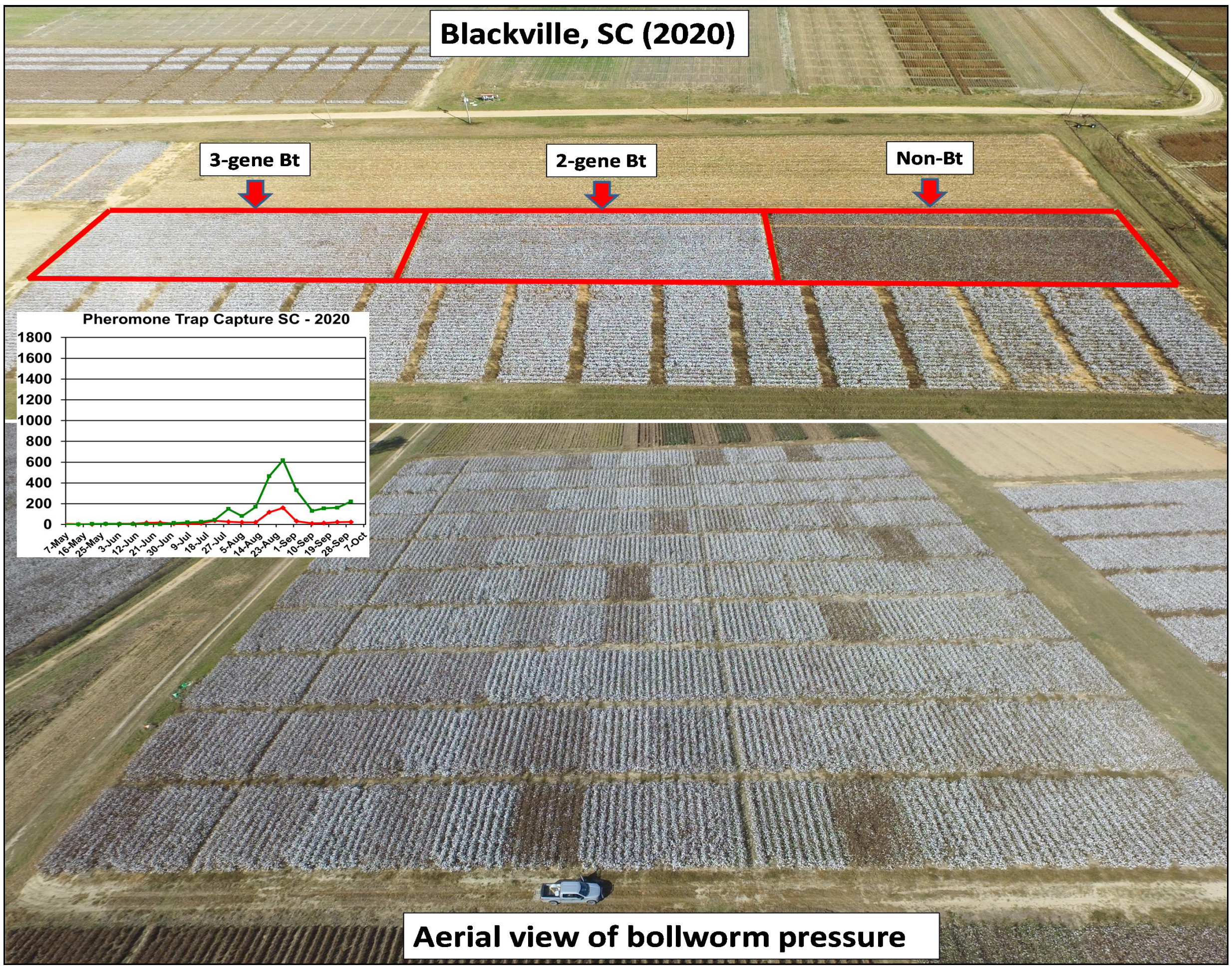
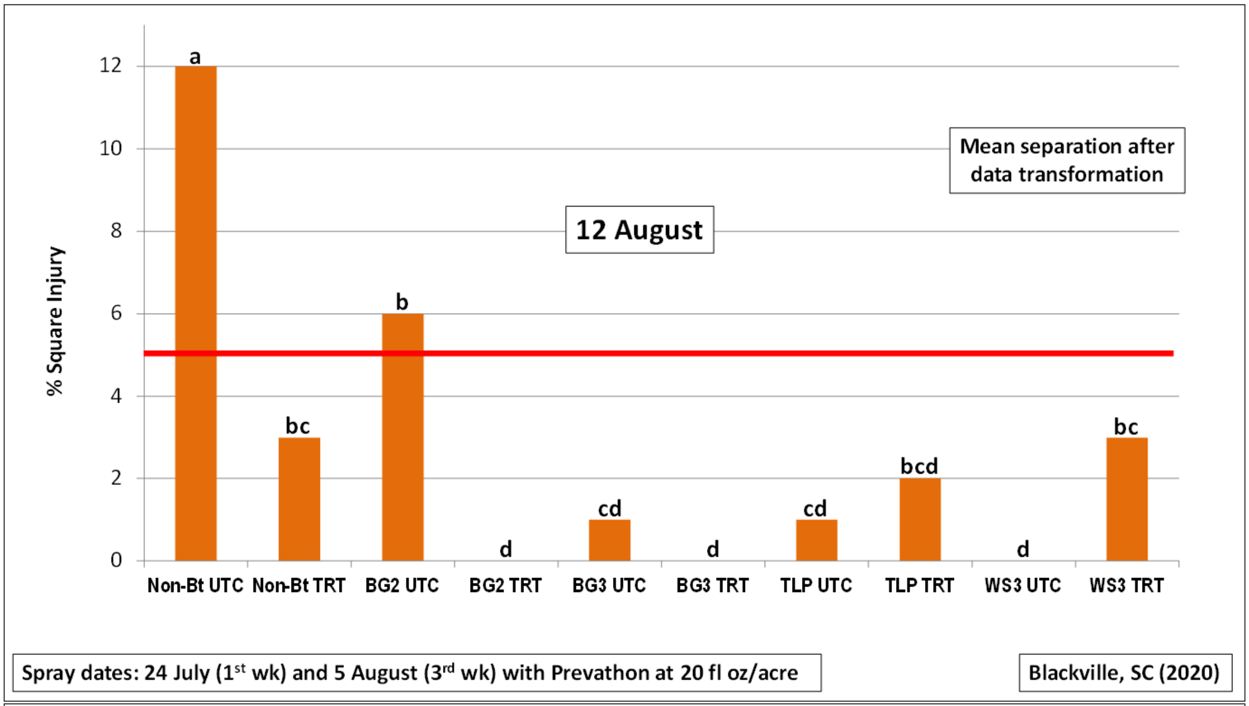


Figure 2. Aerial view of untreated demonstration plots of non-Bt, 2-gene, and 3-gene Bt cotton just prior to harvest in Blackville, SC (2020).

In our trial evaluating cotton treated (1st and 3rd week of bloom) with Prevathon (20 fl oz/acre) selectively for bollworm compared with untreated plots, injury by bollworm rarely exceeded a treatment threshold (red line) of 5% damaged squares or bolls (Figure 3).



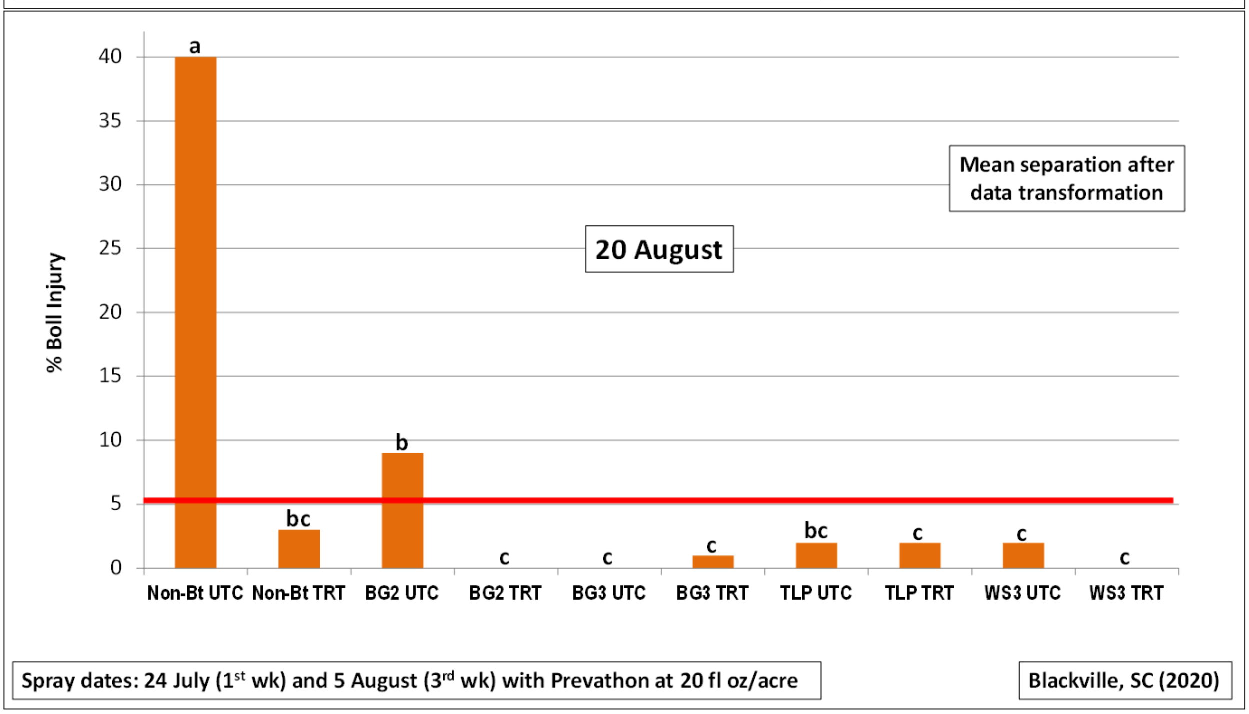


Figure 3. Mean percent squares (top) and bolls (bottom) damaged by bollworm in non-Bt and Bt cotton after oversprays with chlorantraniliprole (Prevathon) compared with untreated plots in Blackville, SC (2020).

Yield data from this trial showed that we lost significant yield from untreated and treated non-Bt cotton, but all Bt technologies had statistically similar yields, with no clear benefit to the selective oversprays for bollworm (Figure 4). Low-to-moderate pressure from bollworm did not require an overspray in three-gene technology, and the two-gene entry demonstrated how resilient cotton could be with compensation for injury caused by bollworm infrequently reaching threshold. This indicated that our treatment thresholds are appropriate when populations of bollworm were below injury thresholds (5% square or boll injury) for most of the susceptible window (late July through August) and rarely reached those thresholds under good growing conditions.

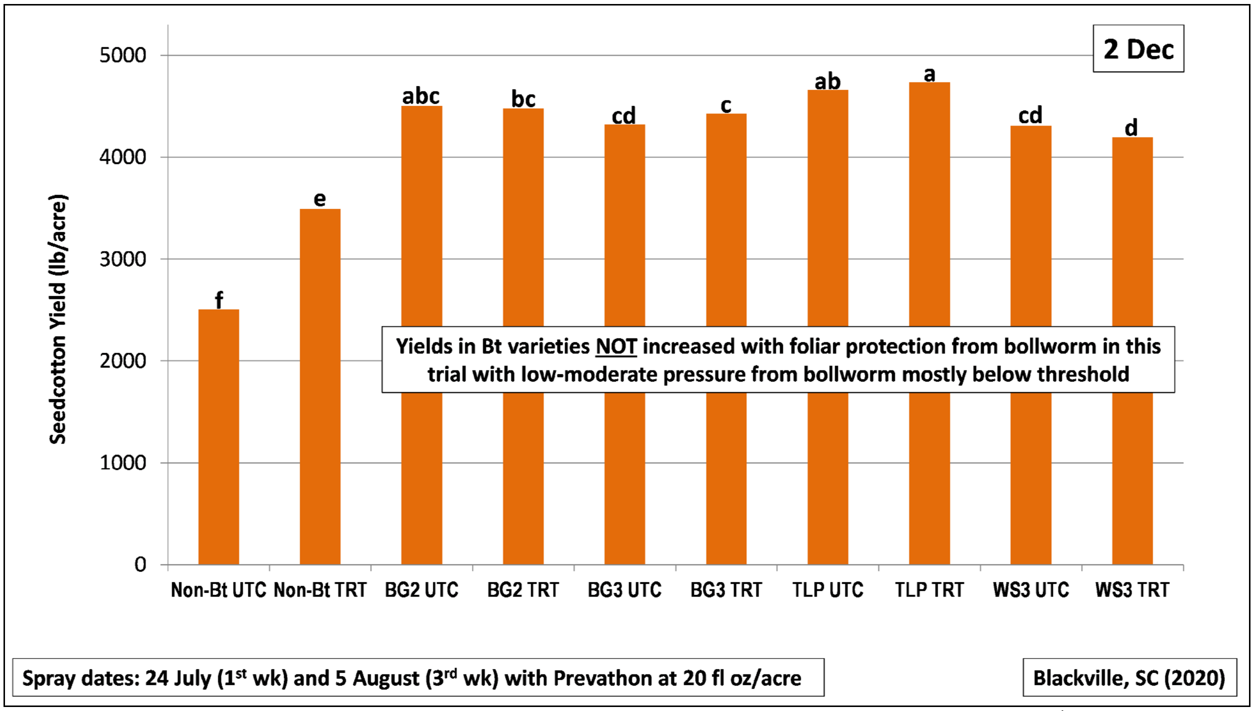


Figure 4. Seed cotton yields in non-Bt and Bt cotton technologies after two oversprays (1st and 3rd week of bloom) of chlorantraniliprole (Prevathon at 20 fl oz/acre) compared with untreated entries in Blackville, SC (2020).

In our second trial with oversprays for bollworm and stink bugs, most treatments remained below threshold for bollworm (Figure 5). Bollworm injury to squares and bolls exceeded 35 and 40% (not shown), respectively, in the untreated non-Bt plots, but injury in the untreated two-gene Bt cotton never exceeded threshold. One entry (BG3 sprayed with Prevathon) reached the bollworm square damage threshold during the third week of bloom, but this was likely a sampling anomaly. At the fourth week of bloom, only two entries reached the bollworm square damage threshold – those were BG2 with Prevathon applied at the first week of bloom and BG3 sprayed the third week of bloom with Bidrin for stink bugs. During the fifth week of bloom, only one entry exceeded the bollworm square damage threshold (BG3 with 1st wk spray of Prevathon). Bollworm boll damage during the fifth week of bloom reached threshold in two treatments (both BG2 entries not treated with Prevathon), but all other entries were below threshold for bollworm boll damage.

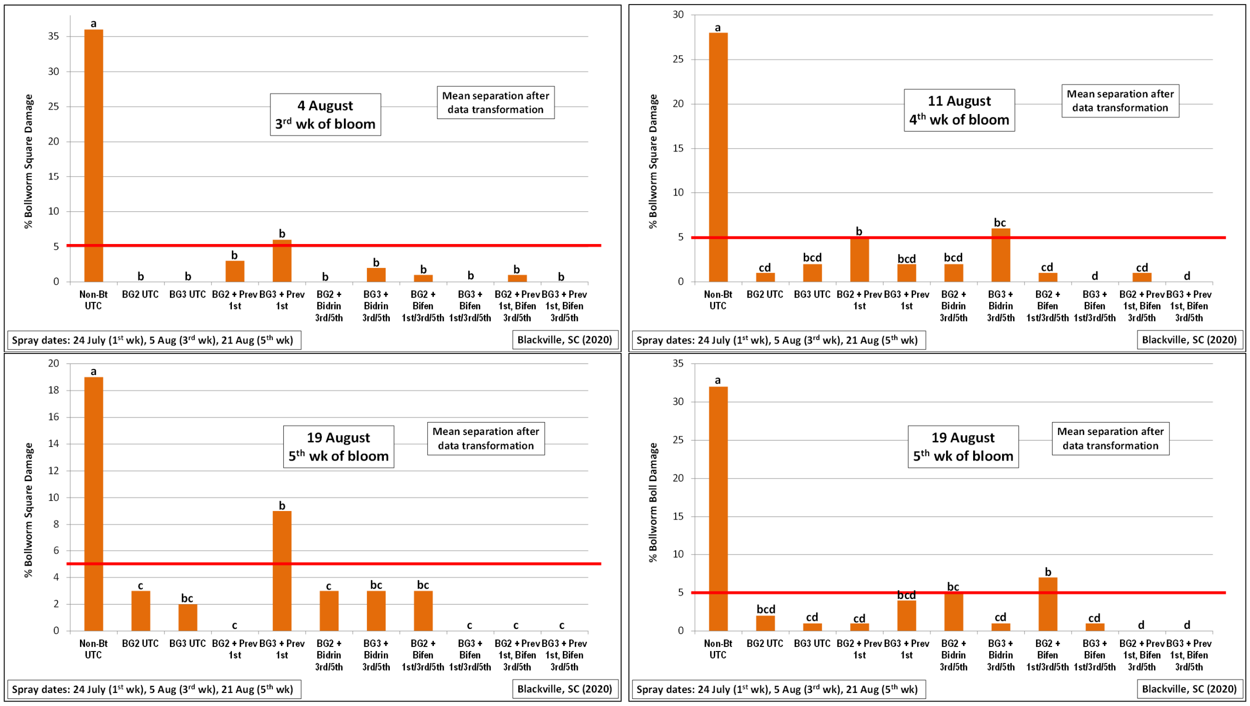


Figure 5. Mean percent squares and bolls damaged by bollworm in non-Bt and Bt cotton technologies after oversprays with chlorantraniliprole (Prevathon), dicrotophos (Bidrin), or bifenthrin (Brigade) compared with untreated plots in Blackville, SC (2020).

Boll damage caused by stink bugs was low, with most estimates of injury below the dynamic boll injury threshold by week of bloom (Figure 6). The highest level of boll injury from stink bugs (30%) was late in the season (3 September, the 7th week of bloom), but boll injury in the untreated plots never exceeded 15% during August (Figure 6). Average injury across untreated plots never exceeded the threshold, a clear sign of low pressure from stink bugs.

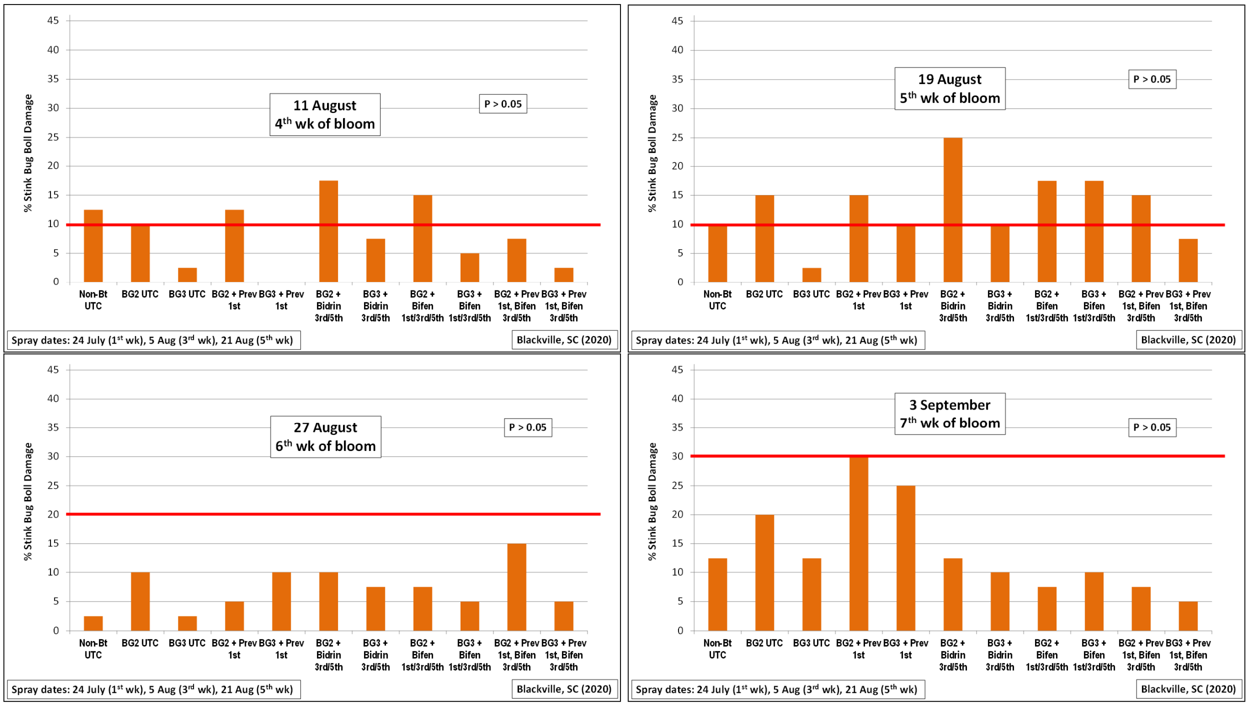


Figure 6. Mean percent boll damage by stink bugs in non-Bt and Bt cotton technologies after oversprays with chlorantraniliprole (Prevathon), dicrotophos (Bidrin), or bifenthrin (Brigade) compared with untreated plots in Blackville, SC (2020).

Yield data from this trial with selective oversprays for bollworm and/or stink bugs showed no differences when compared with the untreated Bt entries (Figure 7). Because most measurements of damage indices did not reach thresholds or did so only marginally and rarely, this indicates that our thresholds could be slightly aggressive, at least under low-to-moderate pressure from bollworm and stink bugs in a good growing season likely allowing for some yield compensation. Under higher pressure from these major insect pests, these treatment thresholds are likely adequate and appropriate.

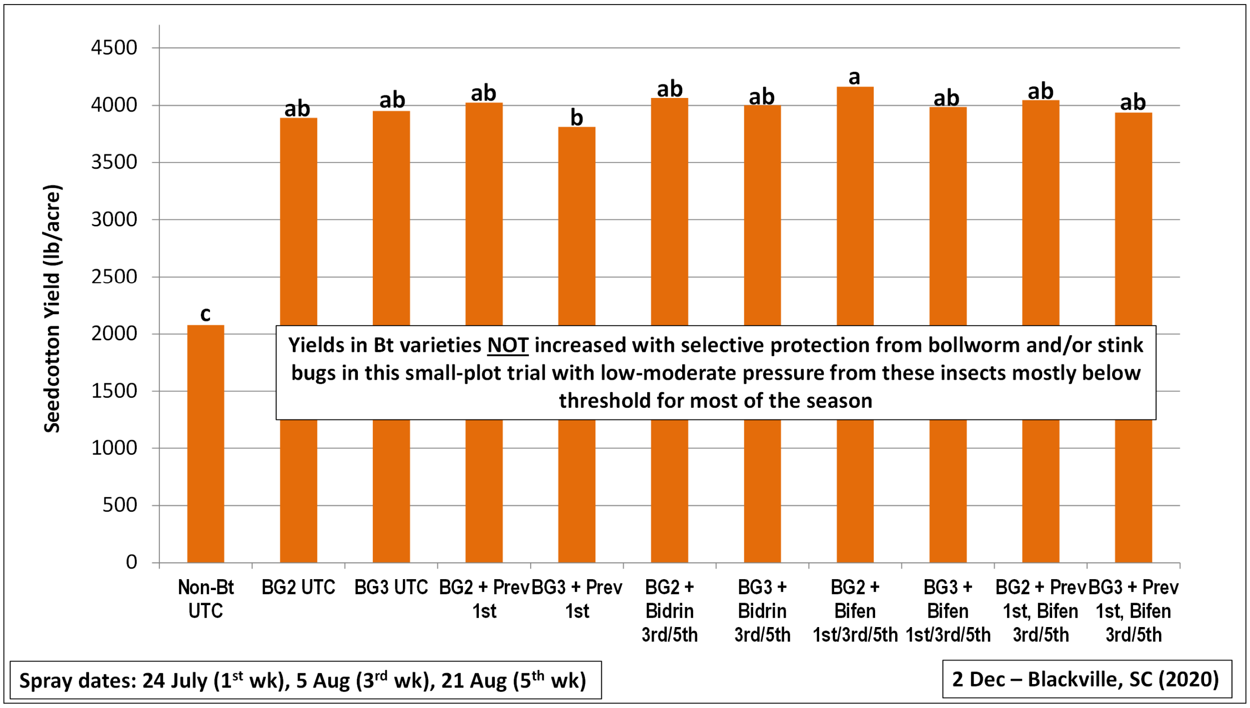


Figure 7. Seed cotton yields in untreated non-Bt, 2- , and 3-gene Bt cotton compared with Bt cotton after oversprays of chlorantraniliprole (Prevathon), dicrotophos (Bidrin), and/or bifenthrin (Brigade) at various timings by week of bloom in Blackville, SC (2020).

Summary

Overall, insecticide oversprays for bollworm and/or stink bugs were not necessary to preserve yields in our small-plot trials during 2020. Despite an increase in pressure from bollworm compared with 2019, Bt cotton did not benefit from automatic sprays of chlorantraniliprole (Prevathon) and/or bifenthrin (Brigade) when applied for bollworm at strategic timings (first week of bloom for Prevathon or first, third, and fifth week for Brigade). Treatment thresholds for bollworm injury to squares or bolls were reached (infrequently, but met), indicating that thresholds using these damage indices (5% injury) seemed slightly aggressive under a low-pressure situation. This is only one trial for one year, so limited inference should be made overall. Under higher pressure, the 5-6% fruit injury mark is likely an appropriate treatment threshold for bollworm. The 6% threshold level is currently recommended in the mid-southern states. Pressure from stink bugs was low in our trial, as was injury caused to bolls by the complex. Despite low levels of boll injury by stink bugs, thresholds were reached infrequently for individual treatments, but average injury across untreated control plots did not exceed threshold. Because the dynamic boll-injury thresholds used to manage stink bugs in cotton have proven to be effective across a wide range of pressure in the Southeast, crop managers should continue to trust and use the recommendations.

Consultants and crop managers should use all available information in determining when and if insecticides are needed to control bollworm and stink bugs in cotton. Scouting reports (moth and true bug activity, egg deposition, fruit injury, etc.), weather data, state of the crop (stressed, optimal, etc.), commodity price, etc., should all be considered when deciding to invest in treatment with insecticides. Recommendations regarding treatment thresholds are merely guidelines for managing insect pests under most circumstances, but low-pressure situations can represent a challenge. Most action thresholds are developed with substantial populations of insects, so low-to-moderate levels often need more sampling to determine the necessity of intervening with chemical control.

Bollworm continues to put uniform and significant pressure on Bt cotton technology, so meticulous care should be taken in evaluating injury and potential escapes in each field, particularly with two-gene varieties. Stink bugs also remain the most important insect pest complex of the crop in the Southeast. We know from our previous research that the first two weeks of bloom are critical for detection and control of bollworm and that weeks 3-5 of bloom remain important for controlling stink bugs. Pyrethroids continue to be a viable and economic option for control of

stink bugs and some populations of bollworm that escape control provided by Bt cotton. As the industry transitions from two- to three-gene Bt cotton, pyrethroid insecticides will likely provide the most economical control of stink bugs and any bollworms escaping Bt toxins in three-gene varieties. Use of lep-specific chemistry is warranted in two-gene Bt cotton in locations with a history of heavy pressure from bollworm or where pyrethroids have shown poor control of the species, indicating resistance.

Acknowledgements

Support of this research was provided by state Cotton Boards/Commissions and Cotton Incorporated. We thank AMVAC, BASF, Bayer, Corteva, and FMC for providing seed or insecticides for this research. We also thank other technical support staff and temporary workers for assisting with this work.

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