SCOUTING *B.t.* COTTON FOR LEPIDOPTEROUS PESTS

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Abstract

Scouting intensity and focus in transgenic B.t. (Bollgard™) cotton for lepidopterous larvae will vary greatly from area to area across the cotton belt. In a state by state survey of anticipated scouting emphasis and procedures for caterpillar pests in transgenic Bollgard cotton, the primary extension entomologists from each of the cotton-producing states (with the exception of Maryland and Kansas) were contacted. California and New Mexico entomologists anticipated very little Bollgard cotton would be planted in their respective states, with the major Bollgard-susceptible caterpillar pests of little economic importance. Arizona producers can anticipate their pink bollworm emphasis to focus upon the manual opening of bolls to confirm the establishment of larger instars to gauge the effectiveness of Bollgard cotton lines, while scouts elsewhere in the cotton belt will focus on the budworm/bollworm complex. Generally, the entomologists surveyed felt that tobacco budworm scouting would become easier or remain about the same and bollworm scouting to remain about the same or become more difficult. In most of the southeastern and mid-south states, a scouting shift from egg and 1st instar monitoring to 2nd and larger stage larvae was expected, with the recognition of stage of early instar larvae and species recognition (bollworm vs. budworm in either the egg or neonate larval stage) important. Fall and beet armyworm scouting was expected to remain approx. the same by most entomologists, while the status and scouting for European corn borers (primarily a southeastern cotton belt problem) was regarded as minimal. Most of the entomologists surveyed felt that the need for independent crop consultants would increase to accommodate the greater complexity of monitoring pests and beneficials in this new technology, in part due to an anticipated increase in secondary pests and the need for dual (or "platoon") scouting to accommodate producers with both Bollgard and traditional cotton. Several responders offered that the demand for marginal consultants who have traditionally taken an overprotective approach to managing untransformed cotton, will drop sharply as producers try to maximize returns on their Bollgard license investment via more limited larvicide use. Considerably greater entomological expertise will be required to manage lepidopterous pests along with the expected shifts in the status of a broad spectrum of cotton pest and beneficial arthropods.

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Methods and Materials

A survey was mailed out to all extension entomology specialists with the primary cotton recommendation responsibility in their respective states, as well as the research entomologists from South Carolina and Georgia. Due the great biological diversity of its various cotton production areas, 4 entomologists from TX were contacted. The responders and their respective states are listed below:

CA: Peter Goodell
AZ: Peter Ellsworth
NM: Charles Ward
OK: Miles Karner
TX: James Leser, Thomas Fuchs
Charles Allen, Roy Parker

AZ: Donald Johnson
MO: Clyde Sorenson
LA: Ralph Bagwell
MS: Blake Layton

TN: Phillip Roberts
AL: Barry Freeman
Ronald Smith
FL: Richard Sprinkel
GA: Gary Harzog
(Research)
William Lambert III
SC: John DuRant
(Research)
Mitchell Roof
NC: Jack Bacheler
VA: Ames Herbert

Questions included the following: 1) Will the taking of new data be required for lep larvae in your area? If so, what?, 2) Will the scouting of transgenic cotton for lep larvae in general be easier or more difficult?, 3) Will the status of the following lep pests likely be greater, less or approx. the same?: bollworm, budworm, pink bollworm, Europ. corn borer, fall and beet armyworm, soybean looper, and others., 4) Will the correct identification of larvae be important, if so which ones?, 5) Will the scouting of secondary pests change as a result of the deployment of this technology? If so, how?, 6) In your estimation, will the need for independent crop consultants increase or decrease in B.t. cotton?, 7) Other comments.

It should be noted that a number of the entomologists contacted regard their responses to the questions posed as very preliminary. Additionally, the symbols in the graphs only provide a generalized guide to the direction in which scouting for these different larvae may be headed. Finally, the low resolution (a one-symbol response per state, in many cases) in these figures does not reflect the sometimes considerable differences in pest pressure and allied scouting emphasis throughout most of our states.

Results

Larval Pest Status on Bollgard Cotton and Observations

Bollworm/Budworm:
The bollworm/budworm complex is clearly the primary target of B.t. (Bollgard) cotton in most of the cotton belt. As can be seen in Figure 1, a wide variation in the anticipated scouting requirements was expressed across the cotton belt. The separate symbols shown for TX are the result of responses from each of their surveyed entomologists. The large symbol in the High Plains area is from Dr. Jim Leser, who is responsible for this area and had provided generalized responses for the state as a whole.

Most entomologists commented that much more emphasis would be placed upon finding early (usually newly-molted 2nd instar larvae or caterpillar of a given size) larvae, and training individuals not allow the presence of eggs and neonates (1st instars) trigger treatments, but only to gauge the frequency of scouting trips. Scouts additionally will need to be able to recognize the difference between superficial and economic square damage in those situations where damaged fruit will be the threshold trigger for an insecticide response in Bollgard cotton. A number of entomologists expressed the opinion that Bollgard cotton will require a closer scouting interval, particularly in areas where bollworms predominate, such as in the southeastern cotton growing states.

Pink Bollworm:
The pink bollworm (PBW) presents a unique scouting dilemma. Because 1st instar PBW enter both non-Bollgard and Bollgard bolls directly, leaving evidence only of exterior feeding- "warts and mines on the carpal wall and insect frass", scouts must open bolls to determine the extent of larval survival to a later stage. Therefore, less emphasis will be placed on finding small larvae which may not have consumed enough B.t. protein to have died. Because research conducted in Arizona has demonstrated that Bollgard cotton is highly resistant to pink bollworms, in the initial years of sampling bolls (prior to possible resistance development to Bollgard cotton lines), this boll opening by scouts will likely be a confirmation of the extremely low survival of 3rd and later stage PBW larvae. Less emphasis will be placed upon adult monitoring, and most of the adult pheromone trapping will be used to help determine the intensity of in-field checking for PBW larvae. Bollgard cotton represents the first true larvicide for PBW.

European Corn Borer:
European corn borer (ECB) has shown essentially no survival in Bollgard cotton in 4 yr of evaluations in North Carolina (see elsewhere in this volume 'Efficacy of B.t. cotton against bollworms, European corn borers and stink bugs in North Carolina', Bacheler and Mott). Therefore, initially little or no emphasis will be placed upon scouting Bollgard cotton for ECB larvae in the southeastern states (plus occasionally MS and MO) where this caterpillar is sometimes a boll-damaging pest (Fig. 2) (see comments in Discussion section on B.t. corn).

Beet Armyworm:
Most entomologists expect scouting efforts and procedures for beet armyworms (BAW) to remain about the same (Fig.3), at least partially because the Bollgard cotton lines evaluated to date have shown little resistance to BAW. Several of the entomologists who offered that beets would be somewhat easier to deal with and monitor, expressed the opinion that removing most of the chemical protection needed for budworm/bollworm in Bollgard cotton would remove at least one cause of disruption in some situations. Under these circumstances, beneficial insects such as Cotesia, could help keep BAW populations from being released.

Fall Armyworm:
As was the case with the beet armyworm, most entomologists felt that fall armyworm (FAW) also would retain approx. the same pest status (Fig. 4), and be scouted in the same way as with non-transformed cotton. In several of the southeast states, a slight trend toward anticipating greater emphasis on FAW scouting in Bollgard cotton was noted, partly due to the fact that FAW have been reported to have difficulty becoming established following applications of pyrethroids for budworms and bollworms.

Soybean and Cabbage Looper:
Cabbage and soybean looper scouting was expected to remain the same procedurally, but decrease in emphasis (Fig. 4).

Other Lepidopterous Larvae:
Several individuals reported that they had observed high mortality of salt marsh caterpillars and cotton leafperforators in Bollgard cotton, thus these occasional pests can probably be kissed off, at least for the foreseeable future.

Impact of Scouting B.t. Cotton on the Demand for Consultants
Almost all of the entomologists surveyed indicated that the need for independent crop consultants would stay the same or increase in Bollgard cotton (Fig. 5), although 4 individuals offered that the demand for the better, more technically-oriented consultants would rise and the need for the more marginal consultants would fall. Because virtually all cotton producers using Bollgard cotton lines will have either non-transgenic cotton as a major part of their varietal strategy or as part of the 25% refugia (few so far have indicated much of an interest in the 4% non-treated refugia option), consultants will likely offer 2 different scouting approaches, one for standard and another for Bollgard varieties. In many areas these 2 approaches to scouting may be quite different. In the Southeast, for example, a consultant may deploy one set of scouts to specialize in Bollgard cotton, emphasizing a close scouting frequency and the finding of second instar bollworms and stink bugs, while another set of scouts would monitor standard varieties emphasizing 2nd generation budworms, using an egg and/or 1st instar larval threshold for bollworms, and being more acutely aware of the reentry intervals behind the anticipated insecticide applications. More entomological expertise will be needed to develop efficient systems to provide producers a maximum return on their license fee. Although not addressed here, the status of a number of secondary pests are expected to change, several of which will likely increase following the removal of a significant number of broad spectrum larvicide applications. Consultants who have been able to

hide behind a protective blanket of insecticide treatments with a "complete plant protection" philosophy will become a significantly rarer breed with the advent of Bollgard cotton.

Conclusions

The above survey responses and observations represent only initial impressions of what we may encounter as we begin to scout this new genetically modified B.t. cotton for larval pests. Bollworms, budworms, European corn borers, pink bollworms beet and fall armyworms and cabbage loopers have each have their own "personality" in traditionally-protected cotton, and such will be the case in transformed varieties, although probable shifts in the importance of various lepidopterous pests and in scouting emphasis can already be forecast.

Tentative treatment thresholds for bollworms and budworms, presently being researched and formulated, will utilize square damage (MO, TN), early surviving instars (GA, FL, LA, MS, SC and TX), or a combination of both (NC, AL) as the treatment trigger, thus shifting scouting emphasis in many cases away from eggs and 1st instars and toward an indication of whether or not small caterpillars are surviving in high enough numbers to cause economic damage.

In areas of anticipated reductions in larval insecticide, the emergence of secondary pests such as stink bugs, will underscore the importance of careful scouting for these "new" pests (see next paper 'Managing non-lepidopterous pests' by Dr. Blake Layton. Conversely, a lowering of the larvicide load will likely also increase levels of beneficial arthropods, resulting in an increased scouting emphasis on quantifying the abundance and diversity of this arthropod complex.

With the confirmation of budworm resistance to all effective labeled classes of insecticides, scouts may also take on the added important responsibility of resistance monitoring in transformed cotton. Finally, although both bollworms and European corn borers have thus far defied resistance development to insecticides, the introduction of transgenic B.t. corn into areas of cotton production could significantly alter the selection pressure placed on both species which presently undergo 2 generations on non-transformed, untreated field corn.

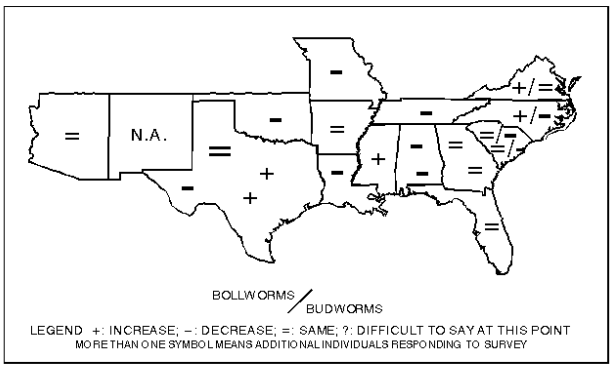

Figure 1: Will scouting requirements for bollworms / budworms increase or decrease in *B.t.* cotton?

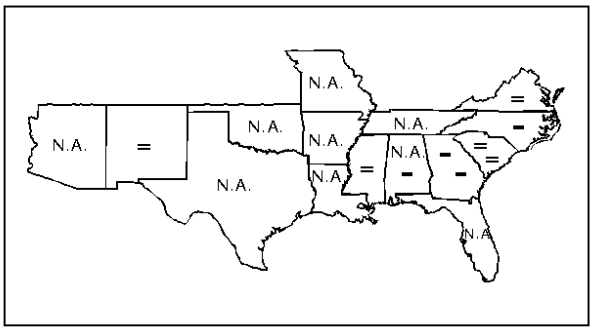

Figure 2: Will scouting requirements for European corn borers increase or decrease in *B.t.* cotton

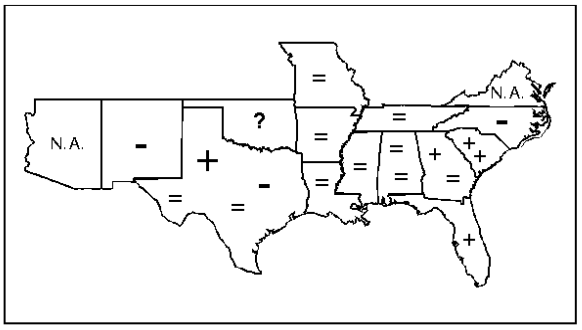

Figure 3: Will scouting requirements for beet armyworms beet armyworms increase or decrease in *B.t.* cotton?

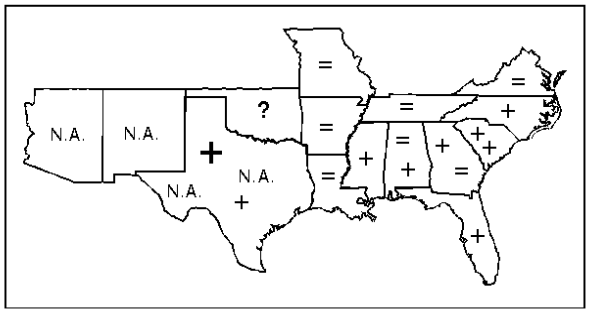

Figure 4: Will scouting requirements for fall armyworms increase or decrease in *B.t.* cotton?

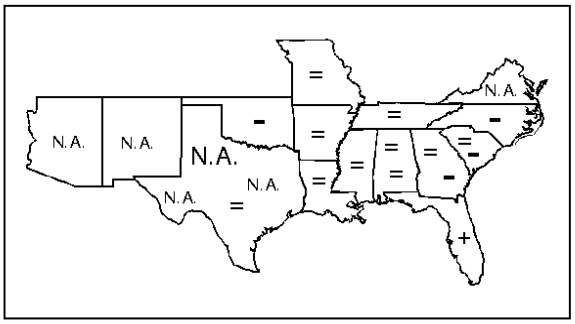

Figure 5: Will scouting requirements for soybean / cabbage loopers increase or decrease in *B.t.* cotton?

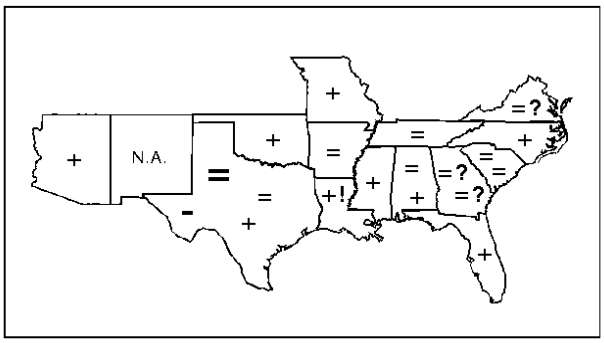

Figure 6: Will the need for independent crop consultants increase or decrease in *B.t.* cotton?

Legend: + = anticipated increase; - = decrease; = = approx. the same; **NA** = not applicable to this area; +/= = upper figure refers to the bollworm, the lower figure refers to budworms; **?** = estimate uncertain at this time; **Large symbol** in TX refers to an overall state estimate.