# PEST FLUCTUATIONS AND TRENDS IN NORTH CAROLINA COTTON

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## Abstract

To quantify year to year pest fluctuations and longer-term pest status trends of a number of North Carolina's cotton insect pests, several large scale surveys were undertaken. The surveys consisted of treatment and pest information received from licensed independent crop consultants, county agents and producers (1993 to present), and from direct damaged boll assessments (1985 to present) (Bacheler and Mott, 1995).

With this past year's finding of potential shifts in the tolerance of bollworms, *Helicoverpa zea* (Boddie), and tobacco budworms, *Heliothis virescens* (F.), to pyrethroids (J.W. Van Duyn and J.R. Bradley, Jr., pers. comm.) via adult vial testing, it is essential to have accurate baseline data on the status, damage and acreage treated for both our major and presently-minor cotton insect pests on Bollgard and conventional cotton, so the inevitable shifts in pest abundance and damage can be more quickly and reliably recognized.

Plant bugs, *Lygus lineolaris (*Palisot de Beauvois*),* appear to be increasing in general, and, for the first time in 1998 (except for previous observations of plant bugs in selected cotton fields adjacent or near Irish potato fields in several northeastern North Carolina cotton fields) as a late season post-bloom pest of Bollgard cotton. Tobacco budworm levels have fluctuated significantly, but the percent of North Carolina's acres treated for second generation budworms has averaged approximately 5% for the past 5 years, with beneficial insects, high levels of plant compensation, and few insecticide treatments resulting in very little insecticide pressure for resistance development in this generation. European corn borers, (*Ostrinia nubilalis*) (Hubner), have shown a steady decline from 6.6% damaged bolls across the state in 1985, compared with a low of 0.12% in 1998. Boll damage from bollworms, fall armyworms, (*Spodoptera frugiperda*) (J.E. Smith), and stink bugs, primarily *Acrosternum hilare* (Say) and *Euschistus servus* (Say), and overall late season boll damage has fluctuated from year to year, but no trend or change in overall or individual pest status is evident. Cotton aphids, *Aphis gossypii* Glover, show some yearly variability in acreage treated, but natural factors, primarily 2 species of mummifying wasp parasites and the fungus, *Neozygites fresenii*, routinely hold damage to very low, sub-economic levels. In 4 of the past 5 years, less than 1% of North Carolina's cotton acreage has been treated with insecticides for cotton aphids. Beet armyworms, *Spidoptera exigua (*Hubner*),* can inflict very heavy localized damage to cotton; however, these migrating pests have only been present at economic levels in 1977, 1995 and 1998 in North Carolina. Overall applications of late season insects have varied between 2.0 (1997) and 3.8 (1994) in the 1985 to 1998 time period, with no apparent trend toward a greater or lesser application frequency.

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## Introduction

The annual Cotton Insect Loss Estimates reported in the various Beltwide Cotton Conference Proceedings (Williams, 1998), provide state by state estimates of the acres infested by various cotton insect pests, acres treated for each pest, number of insecticide applications and associated costs, and yield losses for each reported insect, as determined by the respective state reporting coordinators and their contributors. Although the pest status, damage, yield losses and costs for Bollgard cotton are different in most cases from that found in conventional cotton, the Cotton Insect Loss Estimates reports do not yet differentiate between the two technologies. To develop a data base which would more accurately reflect the year to year fluctuations and potential trends or changes in the status of North Carolina cotton pests, to provide similar comparative information for Bollgard vs. conventional cotton, and to help predict the potential impact of budworm and/or bollworm resistance to pyrethroids or Bollgard cotton, the aforementioned surveys were undertaken.

## Materials and Methods

A survey of bolls damaged by late bollworms, European corn borers, fall armyworms and stink bugs, was initiated in 1985. The evaluation protocols were described in detail by Bacheler and Mott (1995). In North Carolina, most economic insect losses are inflicted by these late season cotton pests. The number of randomly-selected fields assessed for boll damage varied from 118 in 1985 to 462 in 1996, and included both Bollgard and conventional fields from 1996 through 1998. To be counted as larval-damaged, the carpal wall of the selected boll must have been penetrated, rendering one or more locks destroyed (typically, most or all of the boll is destroyed). All potential stink bug-damaged bolls were cut open with a knife. To be scored as damaged, internal damage to the boll had to be expressed either as brownish areas on the exposed locks, often adjacent to individual seeds, or rotted or hard locks with associated characteristic external and/or internal carpal wall spots or warts.

In 1993, an informal survey of licensed consultants, growers and selected agents was undertaken to gather information on the amount of acreage treated for thrips (foliar), plant bugs, cotton aphids, second generation budworms, and total insecticide applications. In 1995, the survey was more formalized, and mailed to all consultants and selected

growers and agents (to avoid redundancy in reporting, the growers and agents were selected to fill in North Carolina acreage not managed by consultants). In addition to the above mentioned information, this survey also requested information on Bollgard vs. conventional cotton, and how much Bollgard acreage was untreated, vs. treated 1, 2, or 3 times (Bacheler, et al, 1998). From 1995 through 1998, between 94 and 100% of the consultants returned completed surveys. In this time period, this group accounted for between 30 and 38% of North Carolina's total cotton acreage.

## Results

### Plant Bugs, 1994 to 1998

From a historical (prior to 1994) average of less than 1% of North Carolina's acreage being treated for plant bugs, in 1997 and in 1998, 3.2 and 6.6%, respectively, of the state's cotton acreage was treated for plant bugs, indicating a possible upward trend in the status of this pest (Figure 1). In addition to significantly more reports of plant bugs on pre-bloom cotton in 1997 and 1998, plant bugs were also reported on post-bloom Bollgard cotton this past year. In 1998, 3.2% of the Bollgard acreage was treated specifically for late season plant bugs.

### Cotton Aphids, 1993 to 1998

Although present in almost every cotton field at some level, cotton aphids are controlled almost entirely via natural factors in North Carolina, with predators typically being the primary limiting factor in pre-blooming cotton. Two mummifying aphidid wasp species often reduce aphid populations dramatically beginning in mid-July through August. Although pyrethroids can limit the impact of these parasites, in moderate to heavy aphid populations significant aphid reductions are often observed during multiple pyrethroid applications. The fungal parasite typically builds up in early to mid August, and can drastically and quickly reduce aphid populations to very low levels. North Carolina's cotton acreage treated for cotton aphids has varied between a very low 0.25 and 2.6% between 1993 and 1998 (Figure 2). An additional reason for the low acreage treated is that cotton aphid populations have become resistant to organophates and all pyrethroids with aphid activity, such as bifenthrin (Lee, 1992, J.R. Bradley, pers. comm., JSB). In opening cotton from 1990 through 1998, 0 to 3.3% (mean = 0.68%) of the surveyed fields had met the treatment threshold for cotton aphids (n = 2,246 fields surveyed).

### Tobacco Budworms, 1994 to 1998

The amount of cotton acreage treated for second generation tobacco budworms has shown a wide range in year to year variability, although the percentage of treated acreage has been low - 0.5 to 8.3% from 1994 to 1998 (Figure 3). Plant compensation for early square loss, coupled with budworm suppression from beneficial insects at this time of year, have reduced second generation budworms to minor pest status. In the event of budworm resistance to the pyrethroids, second generation budworms will likely remain a minor problem on cotton here. However, in years in which budworms constitute even a small to moderate proportion of the 3rd and 4th budworm/bollworm generations (F2 and F3), changes to more Bollgard cotton or to significantly more expensive non-pyrethroid chemistry and tank mixes can be expected.

### Bollworms, 1985 to 1998

Boll damage from bollworms has fluctuated from a high of 6.6% in 1985 to a low of 1.1% in 1987, although no damage trends are evident in the 1985 to 1998 time period (Figure 4). Since its introduction, Bollgard cotton has sustained just under 50% as much damage as conventional cotton under grower conditions from 1996 to 1998. Because this boll damage information can be examined on a regional or even county scale, and because the damage counts were taken separately for conventional and Bollgard cotton, information on the economic impact of a more significant (than the annual fluctuations) increase in localized boll damage due to increased resistance to either pyrethroids or Bollgard cotton will be available.

### European Corn Borer, 1985 to 1998

European corn borer (ECB) damage to bolls has shown a steady decline over the 1985 to 1998 assessment period, dropping from a high of 6.2% in 1985, down to less than 1% for the time period 1995 to 1998 (Figure 5). This drop can not be solely explained by the drop in corn acreage relative to cotton during this time period. Like ECB, most of the major 3rd and 4th generation adult bollworms which invade cotton are derived from field corn, and bollworm moths in light traps, bollworm-damaged bolls and insecticide applications have remained relatively steady during this time of increasing cotton acreage. During the typical early to late August time period for ECB establishment on cotton, 6 of the last 7 years have been either dry or no more than moderate in moisture, possibly accounting for some the low boll damage from ECB. Establishment of ECB on cotton, like corn, is higher under humid, wet conditions. If one eliminates the very high ECB year of 1985, the trend, though still apparent, is less dramatic. Like tobacco budworms, ECB larvae have a very difficult time becoming established on Bollgard cotton, and thus virtually no damage is anticipated on Bt cotton unless or until ECB resistance to Bt occurs.

### Fall Armyworm, 1990 to 1998

As was the case with bollworms, no statewide damage trends are apparent with fall armyworms (FAW) (Figure 6). However, in the southeast counties, FAW have influenced the chemical(s) of choice, particularly tank mix additions of low to moderate rates of thiodicarb, and to a lesser degree profenophos and chlorpyrofos, with pyrethroids. Surprisingly, FAW on Bollgard cotton has averaged just over 50% as much boll damage to Bollgard as on conventional cotton from 1996 to 1998. It would appear

that beneficial insects on Bollgard cotton are exerting greater pressure on FAW populations than the pyrethroids are protecting from FAW boll damage on conventional cotton. Across the state as a whole, FAW have averaged approximately 1% boll damage on conventional cotton during the time in which their damage has been monitored, 1990 to 1998.

**Stink Bugs, 1989 to 1998**

Stink bug damage (primarily from the green and brown stink bug) has fluctuated at low levels in conventional cotton from 1989 to 1998, varying from a low of 0.3% in 1995 to a high of 1.25 in 1989, with a mean of 0.57% (Figure 7) . Stink bugs are regarded as an almost non-existent problem on cotton which has been treated 2 or more times. With its fewer insecticide treatments, Bollgard cotton has sustained consistently higher state-wide boll damage from stink bugs than has conventional cotton. During the 1996 to 1998 time period, stink bugs averaged 2.3% boll damage on Bollgard cotton which was treated an average of 0.77 times, compared with 0.57% boll damage on conventional cotton treated an average of 2.83 times. For each of the last 3 years of the damaged boll survey, stink bug damage on Bollgard cotton was 4-fold higher than on conventional cotton. The consultants' survey revealed that 3.1% of Bollgard fields were treated specifically for stink bugs in 1998, despite the Bollgard acreage being treated an average of 1.24 times this past year, compared with approximately 0.5 times in 1996 and 1997. Very few Bollgard fields were treated specifically for stink bugs in either 1996 or 1997. Stink bugs overall, however, have remained a relatively minor pest of Bollgard cotton so far. However, scouting for stink bugs can not be overlooked in Bollgard cotton. Occasional fields have sustained damage in the 10 to 15% range.

**Overall Boll Damage, 1985 to 1998**

Overall total damage to bolls from the preceding late season insects, appears to showing a slightly downward trend over the past 14 years (Figure 8). For example, the 1st 7 years' boll damage averaged 7.74%, while the 2nd 7 years averaged 5.20% damage, or 1/3 less damage. Because a very high percentage of North Carolina's economic, yield-reducing insect damage results from late season boll damage, insect damage in general has not increased during this time and may have declined slightly. Overall boll damage in Bollgard cotton has been 80.2% of that found in conventional cotton from 1996 to 1998.

**Insecticide Applications for Late Season Insects**

From 1985 to 1998, no trends were evident in the number of insecticide applications used to control insect pests in conventional cotton in North Carolina (Figure 9). The number of treatments varied between 2.0 (1997) and 3.8 (1994), with a mean of 2.85. Bollgard acreage averaged only 28.5% as many treatments as did conventional cotton (0.76 vs. 2.65 treatments) in the 1st 3 years of its introduction.

## Discussion

Except for a possible increase in plant bug levels during the past 2 years, and a trend toward less boll damage by European corn borers, other pests of cotton in North Carolina, such as cotton aphids, tobacco budworms, bollworms, fall armyworms and stink bugs, have shown year to year fluctuations but no indications of longer term treatment increases or declines. In the initial 3 years of its introduction, Bollgard cotton has sustained approximately 50% as much boll damage by bollworms (1.99 vs. 4.2%) and fall armyworms (0.33 vs. 0.62%), 10% as much damage from European corn borers (0.022 vs. 0.2%), and 400% more damage caused by stink bugs (2.23 vs 0.56%). Bollgard cotton has been treated just under 30% as much as conventional cotton for late season insects (0.77 vs 2.67 applications).

Because stinks bugs were found at elevated levels in Bollgard cotton, and due to the apparent increase in plant bug populations in Bollgard cotton, producers and consultants will increasingly be required to evaluate the simultaneous damage of several pest species. Because of this, the use of 'multiple pest thresholds' is now recommended in North Carolina, to respond to situations in which the combined effects of sub-threshold levels of 2 or more species justifies treatment. This recommendation will also be employed in conventional cotton, particularly if resistance to the pyrethroids occurs, and more selective and less efficacious alternative are in use.

Despite the present relatively low number of insecticide applications required to control pests insects, which have not increased in severity over the past 6 to 14 years (except, perhaps, the tarnished plant bug), adult bollworm and tobacco budworm survival at the 5.0 and 10.0 microgram level of cypermethrin, could result in the beginning a shift away from pyrethroids. Initially much of this shift, if confirmed, would probably take the form of greater planting of Bollgard acreage and less use of pyrethroids for 2nd generation budworms. Both a shift to more Bollgard acreage or to alternative chemistry could significantly alter the status and relative importance of a number of the aforementioned pests. A continuation of the above surveys will provide a mechanism of assessing and quantifying the impact of these upcoming inevitable changes in pest status.

## Acknowledgment

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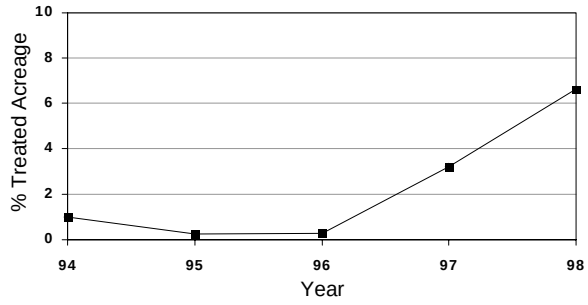


Figure 1. Proportion of North Carolina cotton acreage treated for plant bugs, *Lygus lineolaris*, 1994-1998.

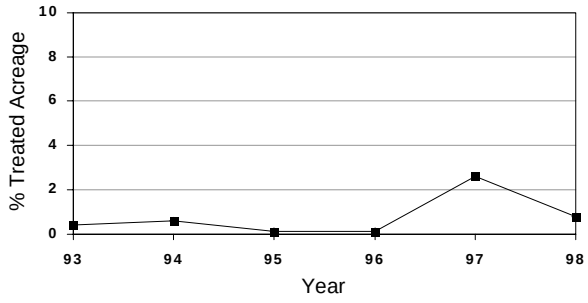


Figure 2. Proportion of North Carolina cotton acreage treated for cotton aphids, *Aphis gossypii*, 1993-1998.

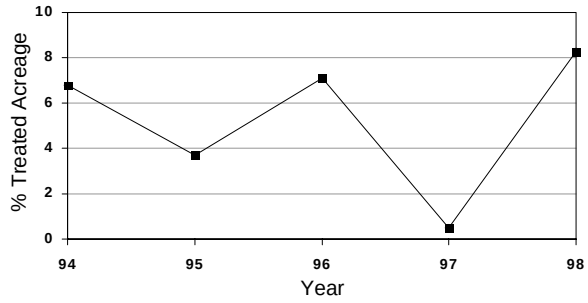


Figure 3. Proportion of North Carolina cotton acreage treated for tobacco budworms, *heliothis virescens*, 1994-1998.

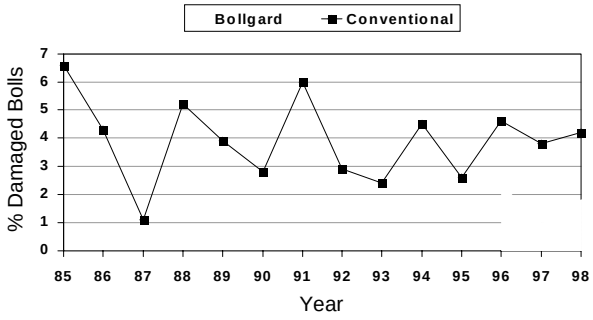


Figure 4. Boll damage caused bollworms, *Helicoverpa zea*, in coventional (1985-1998) and in Bollgard (1996-1998) cotton.

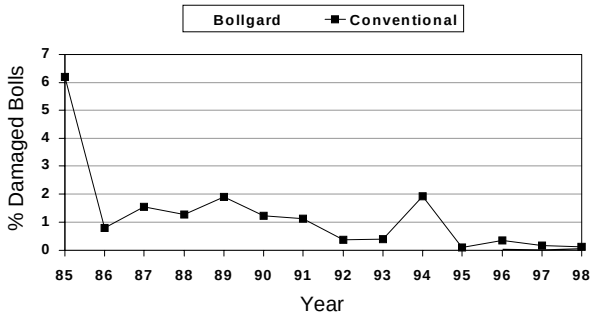


Figure 5. Boll damage caused by European corn borers, *Ostrinia nubilalis*, in conventional (1985-1998) and in Bollgard (1996-1998) cotton.

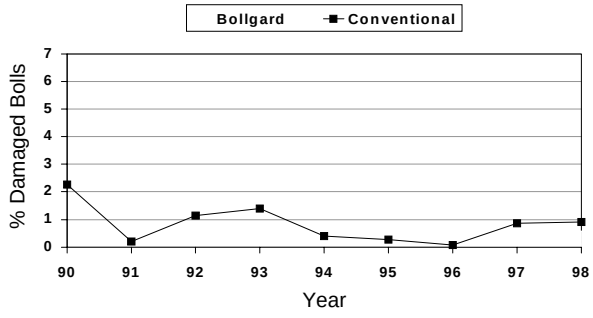


Figure 6. Boll damage caused by fall armyworms, *Spodoptera frugiperda*, in conventional (1990-1998) and in Bollgard (1996-1998) cotton.

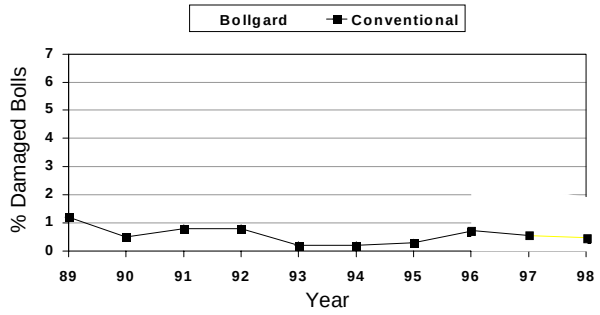


Figure 7. Boll damage caused by stink bugs, mostly A*crosternum hilare* and *Euschistus servis*, in conventional (1989-1998) and in Bollgard (1996-1998) cotton.

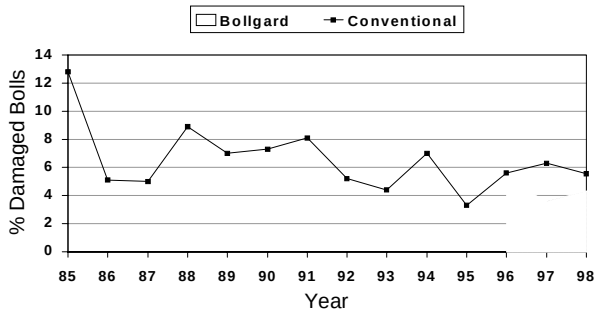


Figure 8. Overall boll damage in conventional (1985-1998) and in Bollgard (1996-1998) cotton.

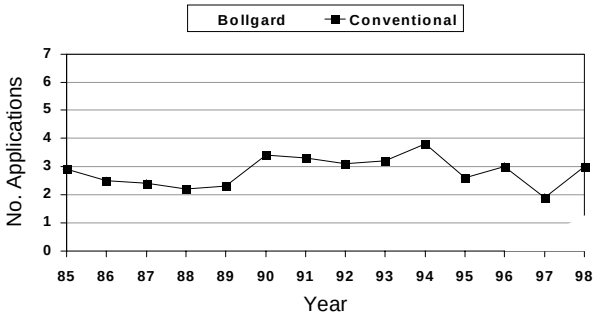


Figure 9. Number of insecticide applications for late-season insects in North Carolina, 1985-1998.