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UTILIZING END OF THE SEASON BOX MAPPING TO ASSESS WITHIN THE SEASON INSECT PROBLEMS

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Abstract

Four existing data sets were used to study relationships of the tobacco budworm *Heliothis virescens* F. and cotton bollworm, *Helicoverpa zea* (Boddie) with end of the season plant damage. End of the season yield or 'box mapping', within season plant mapping, and within season insect samples were used in the analysis. The specific fruiting branch/position combination of the surviving fruit was grouped into comparable same age-class cohorts. The estimated date of initiation of these cohorts was used to compare end of the season box mapping results with within the season information. Correlation analysis was used to examine the results of individual data sets and combined information across the four data sets. When all fields were combined, the number of budworms and bollworms present on an insect sampling date was negatively correlated with the number of harvested bolls that were produced from the previous sampling date based on end of the season yield mapping results.

Introduction

Plant responses to insect feeding are fundamental to developing economic injury levels, which are a major component of integrated pest management (Pedigo 1989). Stern et al. (1959) described the objective of integrated pest management as treating pest populations when densities reach a level that would result in economic losses if not treated. Plant compensation complicates matters by allowing some damage to occur to immature fruit without reducing the final yield. The plants ability to compensate may be influenced by the time of the growing season and other environmental conditions in addition to insect feeding. For this reason, Mi et al. (1998) have proposed the use of the COTMAN computer program that uses a plant-based economic injury level for control decisions in early-season cotton production.

Research has shown that each square on the cotton plant does not contribute equally to yield (Jenkins and McCarty 1995). Estimates of damage caused to a cotton plant by a single insect provide information about insect densities that may warrant control, but these estimates do not consider the value of the fruit available for insect feeding or the probability of which fruit may be destroyed. Cotton plants with adequate fruit retention during the early part of the season may produce late season fruit that is of less value to total yield. These plants should possess a higher economic injury level if insects prefer to feed on the younger, less valuable fruit. Subsequently, plants with early season fruit loss may produce late season fruit that contribute to a large percentage of the total yield, which would cause the economic injury level to decrease. This complicates our ability to understand the impact of insect damage at any given time in the season.

Jenkins and McCarty (1995) described a method to measure the contribution of each fruiting site of the cotton plant using "end of the season plant maps". This is in essence a picture of a plant taken at the end of the season that reveals the location of surviving fruit and the contribution of these fruiting locations to the final yield. Same age class fruit may be grouped together to estimate the survival and contributions of these fruit cohorts. End of the season mapping provides information about fruit survival, but provides no evidence of the causes of fruit loss. Parker et al. (1999) used end of the season mapping to analyze cotton plants that were artificially infested with tobacco budworm, *Heliothis virescens* F., larvae, but low survival limited the interpretation of the data. If studies of end of the season mapping along with within season insect scouting information revealed an association of insect densities with loss of fruit within particular age cohorts, an examination of the plant's response to these insect induced losses may be estimated. Also, the probability of insect damage to the different age classes of fruit may be evaluated for infestations present on a particular day. One of the obstacles of using the end of the season mapping technique to analyze insect damage is to properly match the insect information with the time of fruit development. This paper explores four existing data sets that contain insect scouting information, within season plant monitoring information and end of the season mapping and attempts to associate differences in end-of-season fruit loads with within season densities of the tobacco budworm, *H. virescens* and cotton bollworm *Helicoverpa zea* (Boddie) (collectively referred to as heliothines in this paper).

Materials and Methods

Four existing data sets were obtained and organized to analyze differences in end of the season yield mapping, within season plant mapping, and insect scouting information. Two data sets were from field studies conducted in Leflore County, MS during 1996 and 1997. During 1996, four replicates of each treatment were available, while in 1997 only one replicate was available for Leflore County. During both years of the Leflore Co., MS study, field plots were approximately 5 acres in size. The treatments for Leflore Co., were: 1) Bt cotton managed for insects as described in the Mississippi Insect Control Guide (Layton 1996 & 1997) (BTC), 2) Bt cotton treated with early-season applications of Orthene (BTO), and 3) a commercial non-Bt variety chosen by the participating grower and managed as described in the Mississippi Cotton Insect Control Guide (GV or S424). Yield mapping data from a study conducted at the Mississippi State University Research Farm in Starkville, MS during 1996 was also analyzed. The experimental design for this study was a randomized complete block with four replicates and insect data were obtained from the M.S. thesis of Shane Hand (1997). The treatments analyzed in this study were; 1) cotton managed for insects as described in the Mississippi Cotton Insect Control Guide (Layton 1996) for the entire season (CIC-CIC), 2) cotton untreated pre-bloom and then treated for insects as described in the Mississippi Cotton Insect Control Guide post-bloom (Unt-CIC), and 3) Bt cotton. The most recent study was conducted in Tillar, AR during the 2002 season. The Tillar location consisted of ¼ acre plots with four replicates for each treatment. The treatments at Tillar were: 1) conventional cotton (CONV), 2) cotton expressing an experimental insecticidal gene (GMO), and 3) the conventional parent line of the experimental cotton (NONGMO). For all plots, the total number of heliothine larvae present on an insect scouting date was recorded. Weekly within season plant mapping provided information, which included the total nodes for each treatment, total number of bolls, and estimates of first position fruit retention.

When all bolls had opened, four 10-foot sections of row was removed from each plot at the Leflore County MS location, one 10-foot section from plots at the Mississippi State location, and two 6-foot sections were removed from plots at the Tillar, AR location. All samples were loosely tied and transported to facilities where end of the season yield mapping was conducted. Procedures for yield mapping followed those of Parker et al. (1999). Non-typical plants were grouped separately from the typical plants, and also vegetative branches were removed from the typical plants. The weight of atypical and vegetative bolls were weighed and recorded separately. The remaining seed cotton was separated and based on the main stem node and vertical position of the fruit as described by Jenkins and McCarty (1995). For the MS locations, a wooden box with 4-rows representing 4-horizontal positions on a reproductive branch and enough columns for the number of main stem nodes was used for end of the season "box mapping" of the samples. The cotyledonary node was assigned a value of node zero and the subsequent fruit from fruiting branches were placed in their proper cell of the box. For each boll placed in a cell, a pinto bean was also placed in a small cup in the cell to maintain a count of the number of bolls present in each cell. After a sample was processed, the number of bolls was recorded for each cell by counting the number of beans present. The seed cotton was then removed and the weight recorded for each node-position fruiting site. Weight data were converted to a per plant average to equalize the number of plants mapped. For the Tillar, AR location, this procedure was slightly modified. While all other procedures were held constant, plastic flowerpots replaced the wooden box. The pots were arranged in the same manner as the box with each pot representing one cell. These pots may be stacked and transported easier than the large wooden box.

Cohorts of same age class fruit were grouped based on a 2.0 fruiting ratio of vertical to horizontal fruit, which is a typical fruiting sequence found in MS (3 days between vertical fruit and 6 days between horizontal fruit [Jenkins and McCarty 1995]). For example, main stem node 4 horizontal position 2 fruit was grouped in the same cohort as main stem node 6 horizontal position one fruit. These cohorts may be analyzed individually or accumulated to examine the yield response of plants over time. Figures 1-4 present the cumulative yield for the different treatments in all four studies.

Within season plant mapping was used to estimate the date of initiation of the different cohorts of fruit. Insect scouting information, within season plant mapping, and estimated date of cohort initiation were assigned a common Julian date for each week. The variables matched to the common Julian date were then analyzed using correlation. The variables used for correlation analysis were: 1) the accumulated weight of bolls harvested from end of the season yield mapping that were estimated to be present on the common Julian dates, 2) the total number of bolls present on each date from within season plant mapping, 3) the number of surviving bolls estimated from end of the season yield mapping that were initiated from the previous sampling date, 4) the total number of heliothine larvae present on a within season sampling date, 5) the number of first position fruit present on a within season sampling date, 6) the percent retention of first position fruit calculated from a within season sampling date.

Results and Discussion

Correlation results from the Mississippi State field study produced highly significant correlations for the density of heliothine larvae and first position fruit (negative) calculated from within season plant mapping, and the density of heliothine larvae and first position fruit retention (negative) (Table 1) calculated from within season plant mapping.

The 1996 Leflore County, MS location produced a significant negative correlation between the density of heliothine larvae and percent retention of first position fruit estimated from within season mapping, but a positive correlation between the number of heliothine larvae and total number first position fruit estimated from within season mapping (Table 2). The number of total bolls obtained from within season plant mapping was positively correlated with the density of heliothine larvae, while the number of bolls obtained from end of the season box mapping was negatively correlated with the density of heliothine larvae present for a particular sampling date (Table 2).

A significant positive correlation was detected in the 1997 Leflore Co. data between the density of heliothine larvae and number of first position fruit estimated from within season plant mapping, but a highly significant negative correlation resulted when the density of heliothine larvae was compared to percentage of first position fruit retention estimated from within season sampling (Table 3). The density of heliothine larvae also had a highly significant positive correlation with the number bolls obtained from within season mapping (Table 3).

The density of heliothine larvae and the percent retention of first position fruit (within season mapping) produced a highly significant negative correlation for the 2002 Tillar, AR study (Table 4). The number of bolls from within season plant mapping had a highly significant positive correlation with the density of heliothine larvae, while the number of bolls from end of the season box mapping produced a highly significant negative correlation with the density of heliothine larvae present (Table 4).

When the four data sets were pooled, a highly significant negative correlation was detected between the density of heliothine larvae and the number of bolls obtained from end of the season box mapping (Table 5). This shows that the density of heliothine larvae present on a particular sampling date may be a good indicator as to the ultimate survival of fruit that is initiated on approximately the same week.

End of the season box mapping is a useful tool to measure the survival and contribution of specific node/position fruiting locations of a cotton plant to the final yield. But box mapping does not reveal the time and cause of fruit injury. Within season plant mapping provides a way to estimate the time of fruit loss and within season insect sampling provides information of the possible cause of the fruit loss. Pooling these three types of information together may provide a way to measure a cotton plant's end of the year response to varying amounts of insect damage at different times of the year.

References

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Table 1. Correlation results from 1996 Mississippi State Universtiy study.

	acc. wt.	pmap boll	bmap boll	heliothines	FPF	% ret.FPF
acc. wt.	1					
pmap boll	0.9063**	1				
bmap boll	-0.1363	-0.3032	1			
heliothines	-0.2778	-0.0982	-0.243	1		
FPF	0.7273**	0.811**	-0.1849	-0.2505	1	
% ret.FPF	0.5375**	0.4631*	0.0836	-0.7867**	0.7633**	1

acc. wt. = accumulated weight to date; pmap boll= bolls from within season mapping
bmap boll= bolls from end of season box mapping;
heliothines = number of bollworms and budworms from within season sampling.
FPF = first position fruit estimated from within season sampling;
% ret. FPF = retention of FPF estimated from within season sampling.
(P ≤0.05 = .439; P ≤ 0.01= .530

Table 2. Correlation results from 1996 Leflore Co., MS study.

	acc. wt.	pmap boll	bmap boll	heliothines	FPF	% ret.FPF
acc. wt.	1					
pmap boll	0.7744**	1				
bmap boll	-0.812**	-0.7863**	1			
heliothines	0.4508	0.7845**	-0.5898**	1		
FPF	0.9216**	0.8077**	-0.8183**	0.5749**	1	
% ret.FPF	-0.2923	-0.5512*	0.4777	-0.467	-0.1509	1

acc. wt. = accumulated weight to date; pmap boll= bolls from within season mapping
bmap boll= bolls from end of season box mapping;
heliothines = number of bollworms and budworms from within season sampling.
FPF = first position fruit estimated from within season sampling;
% ret. FPF = retention of FPF estimated from within season sampling.
(P ≤0.05 = .462; P ≤ 0.01= .555

Table 3. Correlation results from 1997 Leflore Co., MS study.

	acc. wt.	pmap boll	bmap boll	heliothines	FPF	% ret.FPF
acc. wt.	1					
pmap boll	0.6601**	1				
bmap boll	-0.0482	-0.5527*	1			
heliothines	0.4237	0.7654**	-0.4509	1		
FPF	0.9745**	0.6876**	-0.1385	0.5046*	1	
% ret.FPF	-0.6547**	-0.8985**	0.5338*	-0.6034**	-0.6688**	1

acc. wt. = accumulated weight to date; pmap boll= bolls from within season mapping
bmap boll= bolls from end of season box mapping;
heliothines = number of bollworms and budworms from within season sampling.
FPF = first position fruit estimated from within season sampling;
% ret. FPF = retention of FPF estimated from within season sampling.
(P ≤0.05 = .488; P ≤ 0.01= .585

Table 4. Correlation results from 2002 Tillar, AR study.

	acc. wt.	pmap boll	bmap boll	heliothines	FPF	% ret.FPF
acc. wt.	1					
pmap boll	0.6874**	1				
bmap boll	-0.5769*	-0.7582**	1			
heliothines	0.3656	0.6462**	-0.7057**	1		
FPF	0.8420**	0.4277	-0.434	0.0384	1	
% ret.FPF	-0.1954	-0.5695*	0.6159**	-0.8709**	0.2368	1

acc. wt. = accumulated weight to date; pmap boll= bolls from within season mapping
bmap boll= bolls from end of season box mapping;
heliothines = number of bollworms and budworms from within season sampling.
FPF = first position fruit estimated from within season sampling;
% ret. FPF = retention of FPF estimated from within season sampling.
(P ≤0.05 = .488; P ≤ 0.01= .585

Table 5. Correlation results from all combined studies.

	acc. wt.	pmap boll	bmap boll	heliothines	FPF	% ret.FPF
acc. wt.	1					
pmap boll	0.5958**	1				
bmap boll	-0.3059**	-0.5119**	1			
heliothines	-0.0145	0.1562	-0.4796**	1		
FPF	0.6028**	0.6335**	-0.2341	-0.1808	1	
% ret.FPF	-0.0862	-0.0422	0.057	-0.1812	0.4721**	1

acc. wt. = accumulated weight to date; pmap boll= bolls from within season mapping
bmap boll= bolls from end of season box mapping;
heliothines = number of bollworms and budworms from within season sampling.
FPF = first position fruit estimated from within season sampling;
% ret. FPF = retention of FPF estimated from within season sampling.
($P \leq 0.05$ = .241; $P \leq 0.01$= .297

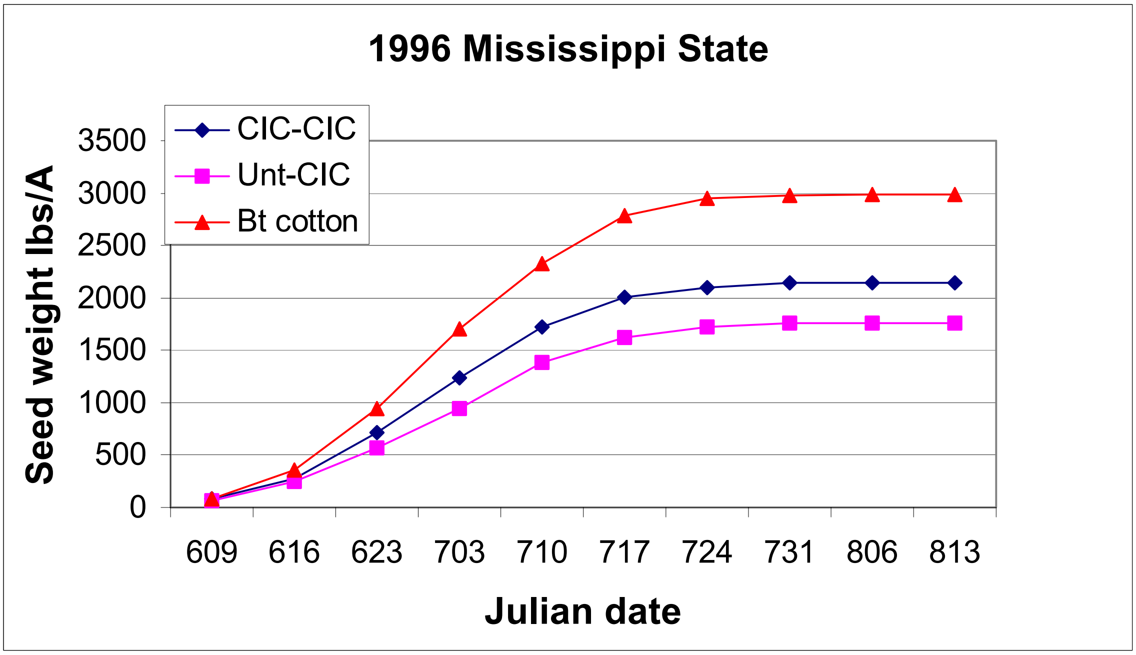

Figure 1. Accumulated yield (lbs seed cotton per acre) based on estimated date of fruit initiation.

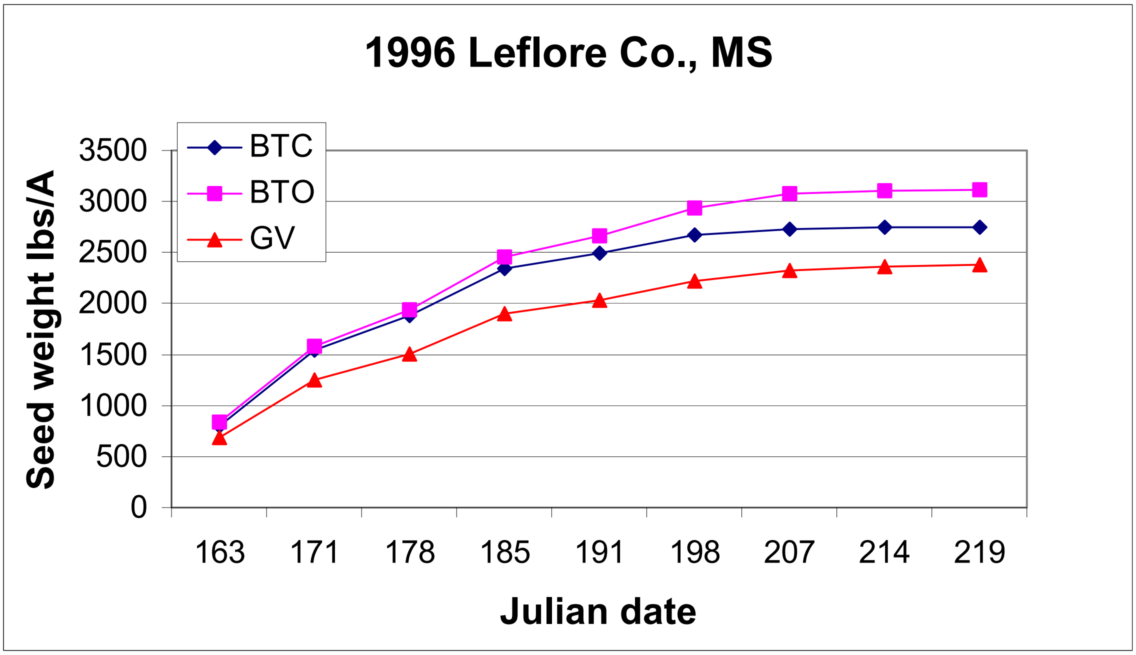

Figure 2. Accumulated yield (lbs seed cotton per acre) based on estimated date of fruit initiation.

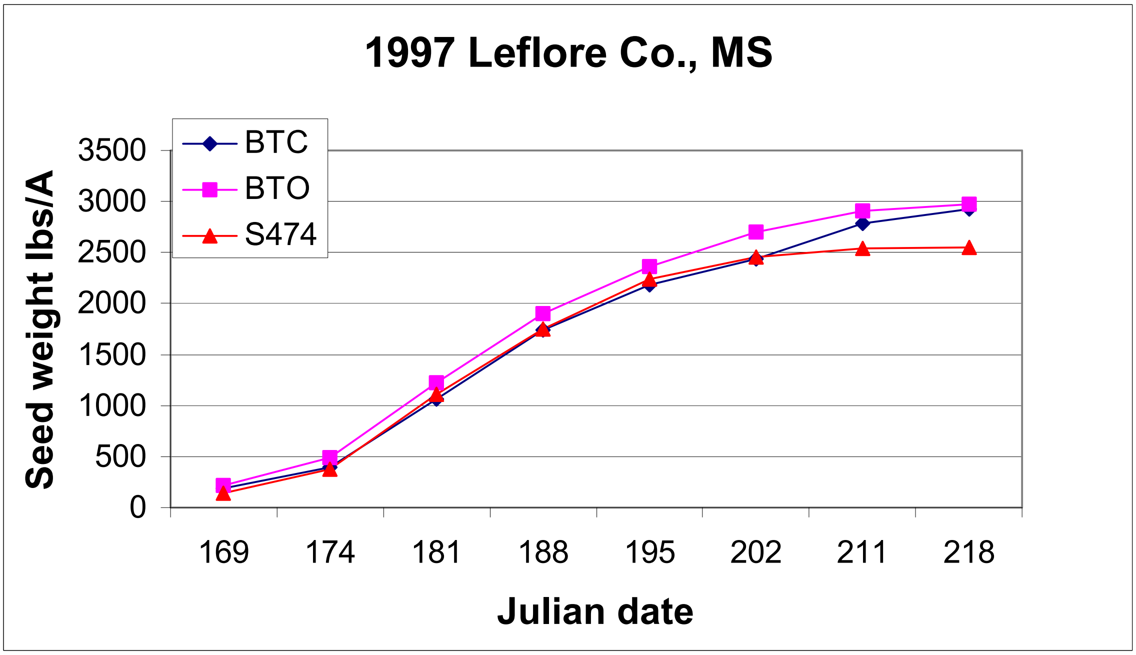

Figure 3. Accumulated yield (lbs seed cotton per acre) based on estimated date of fruit initiation.

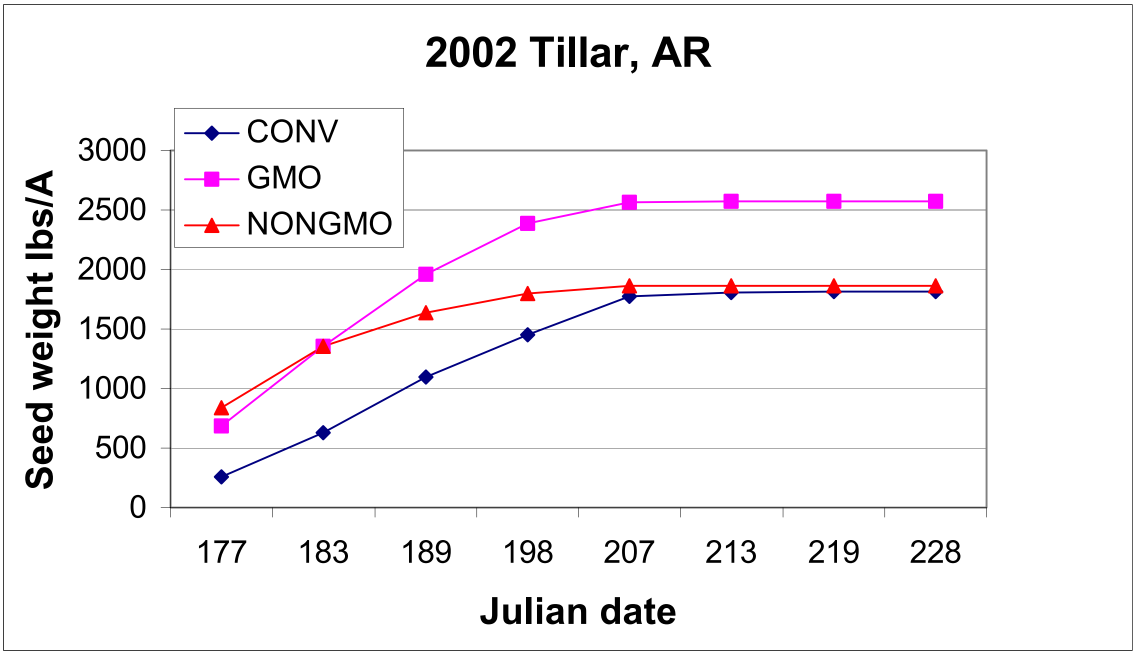

Figure 4. Accumulated yield (lbs seed cotton per acre) based on estimated date of fruit initiation.

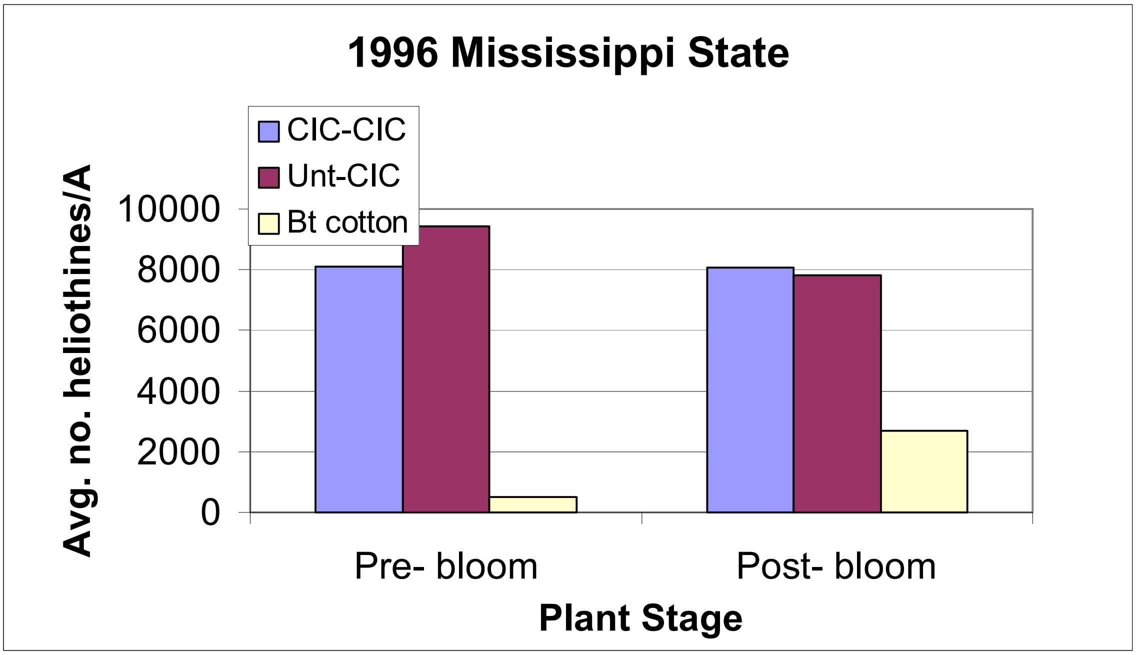

Figure 5. Average number of heliothines per acre on pre and post bloom sampling dates.

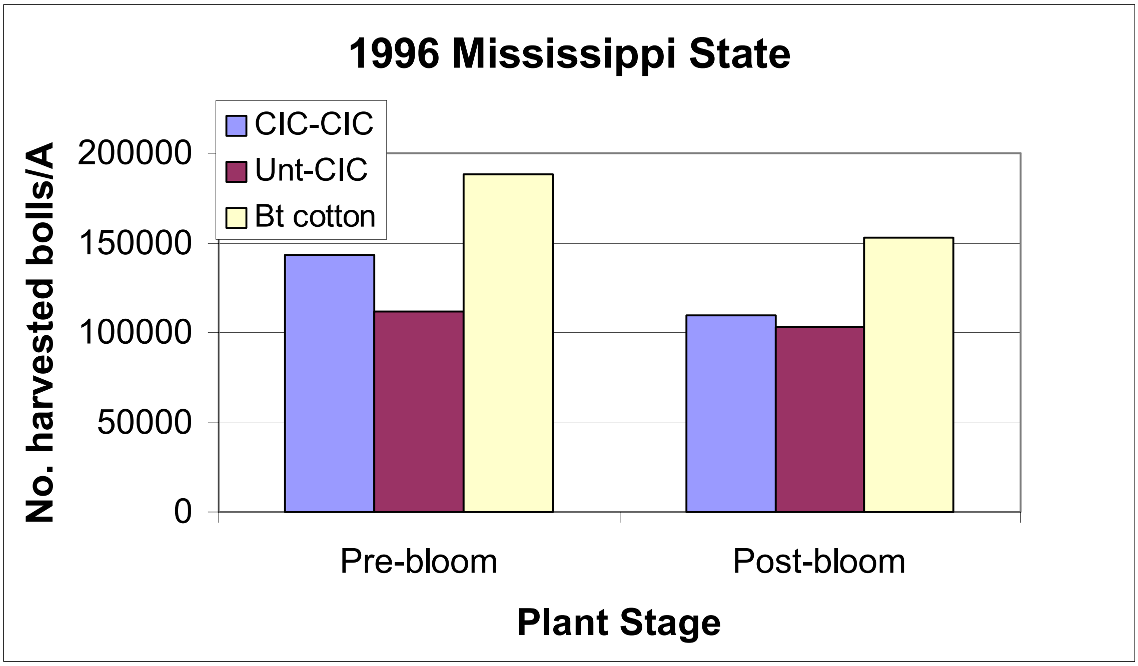

Figure 6. Number of harvested bolls obtained from end of the season yield mapping and their estimated date of fruit initiation.

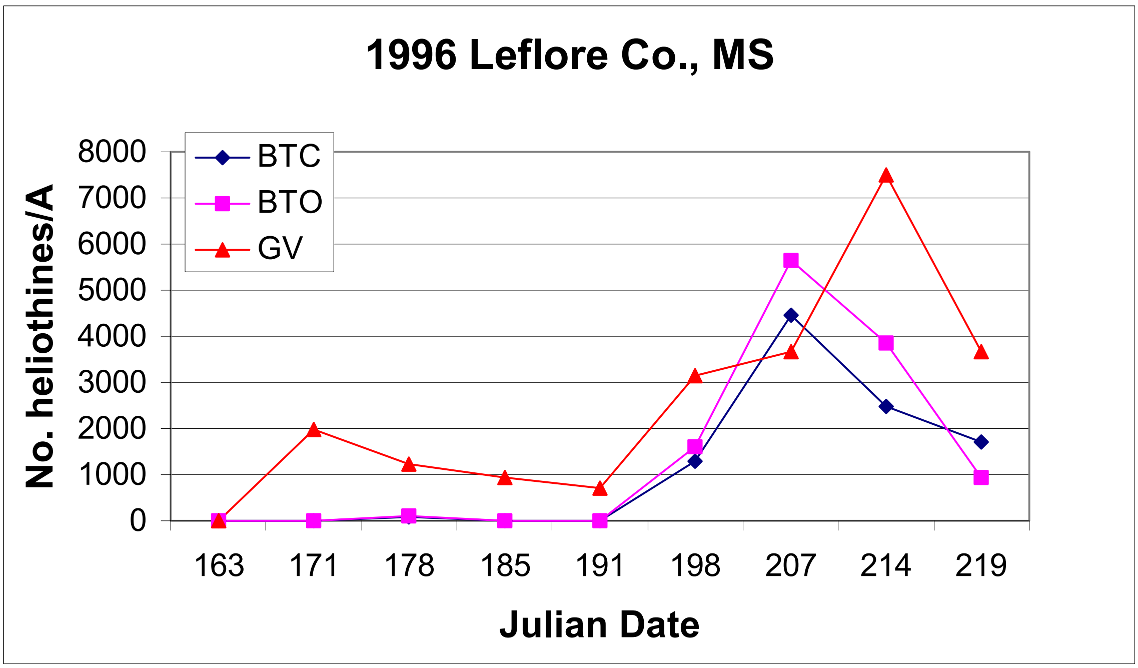

Figure 7. Number of heliothines per acre on each sample date.

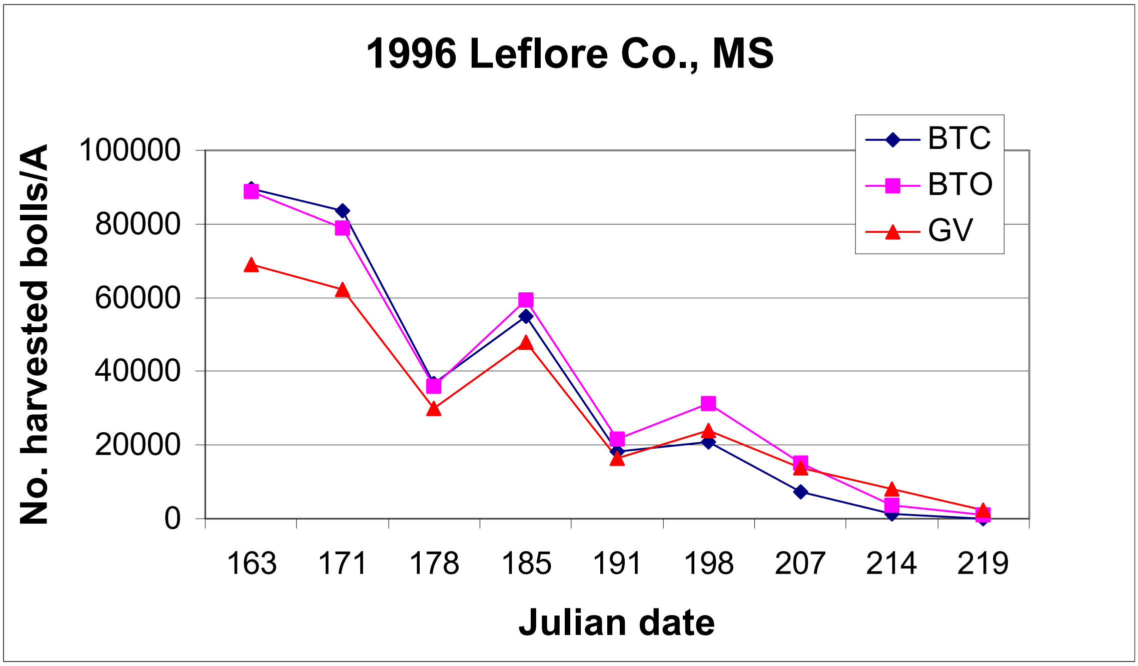

Figure 8. Number of harvested bolls obtained from end of the season yield mapping and their estimated date of fruit initiation.

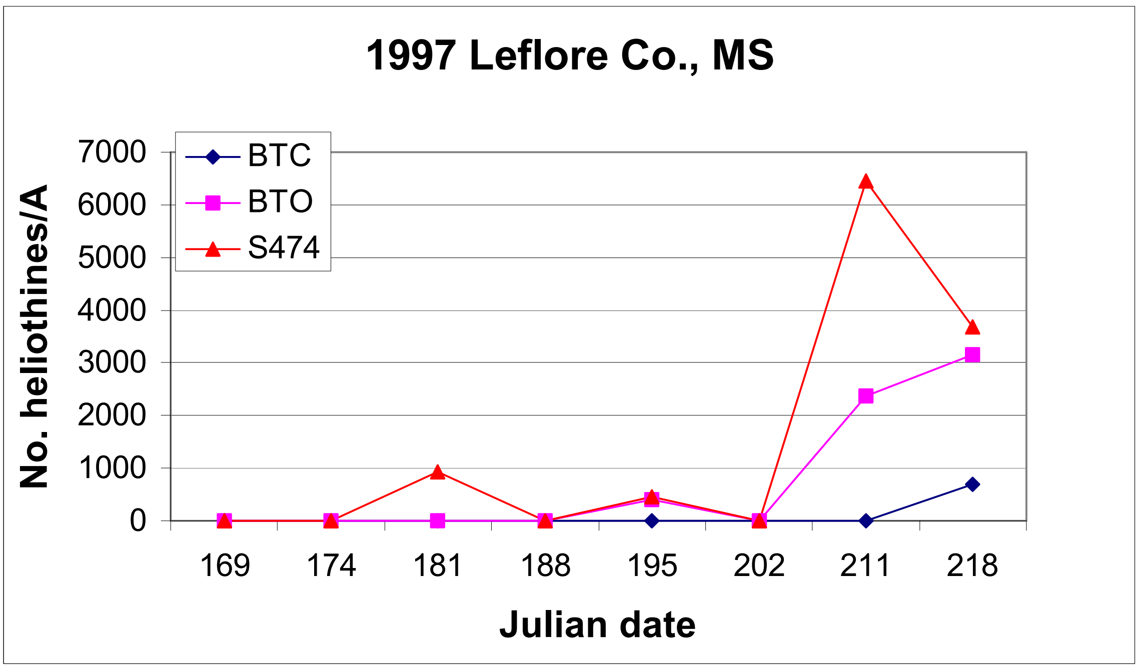

Figure 9. Number of heliothines per acre on each sample date.

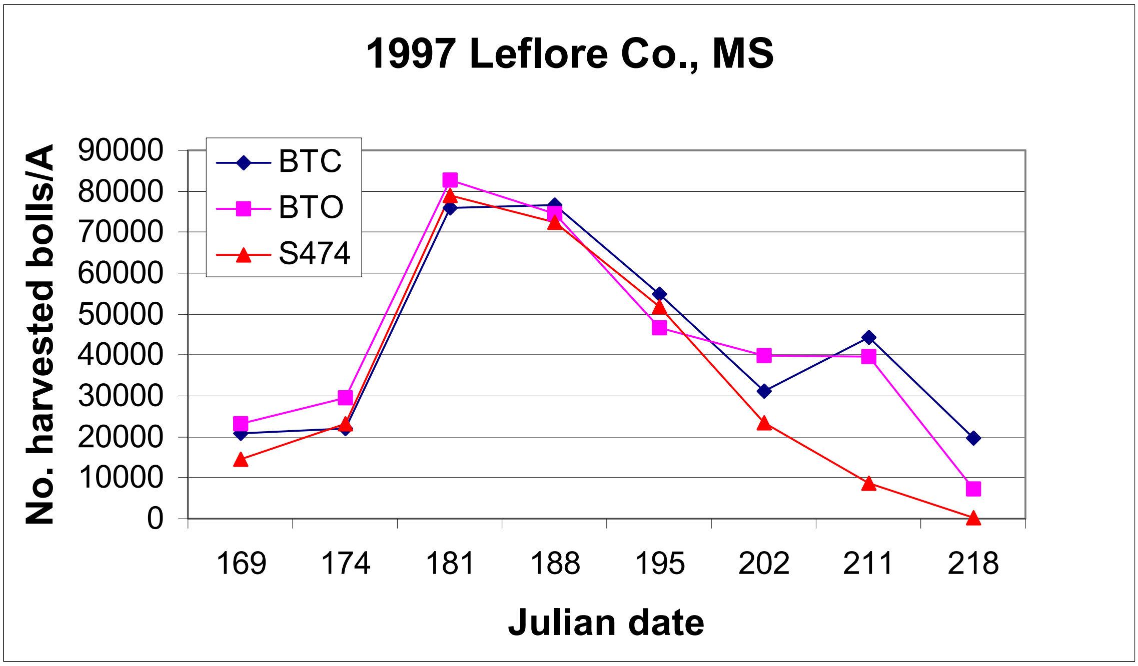

Figure 10. Number of harvested bolls obtained from end of the season yield mapping and their estimated date of fruit initiation.

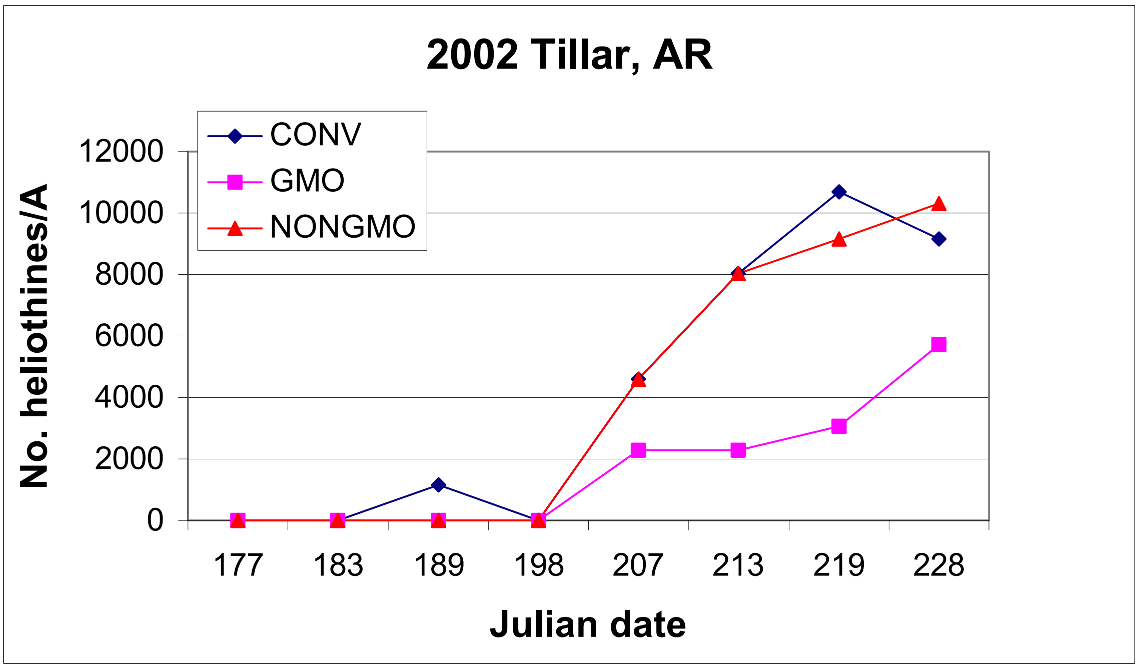

Figure 11. Number of heliothines per acre on each sample date.

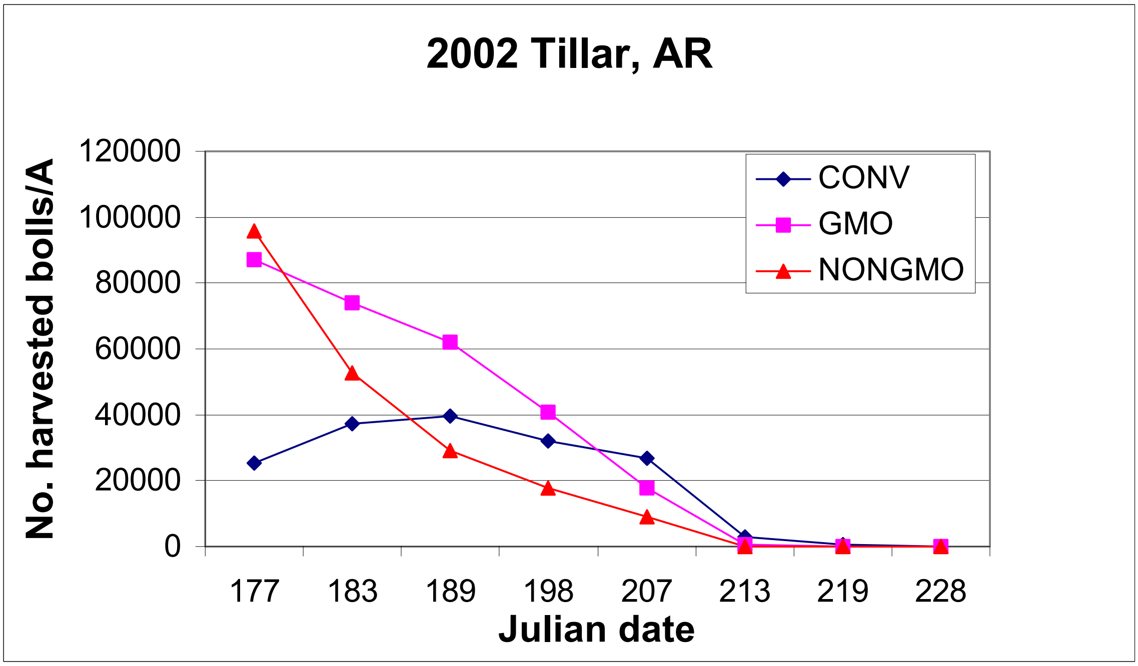

Figure 12. Number of harvested bolls obtained from end of the season yield mapping and their estimated date of fruit initiation.