Influence of Planting Date on the Seasonal Abundance of Tobacco Budworms (Lepidoptera: Noctuidae) and Tobacco Aphids (Homoptera: Aphididae) on Georgia Flue-Cured Tobacco[1]

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ABSTRACT The influence of planting date of flue-cured tobacco, *Nicotiana tabacum* L., on the seasonal abundance of tobacco budworms, *Heliothis virescens* (F.), and tobacco aphids, *Myzus nicotianae* Blackman, was examined in field plots in Georgia during 1987-89. Tobacco aphid population densities (aphids per plant) were influenced by yearly effects; however, tobacco budworm populations (budworms per 10 plants) were similar among the three years. A planting date (PD) effect (late March, mid-April, late April) was observed for tobacco aphids only in 1989, when higher population densities occurred in the late-planted tobacco. Planting date influenced tobacco budworm population densities in two of the three years. Significant differences in tobacco aphid populations were detected between PD's in all three years for the weekly samples in June and July, the period when seasonal aphid densities were the highest. Population peaks were higher in the mid-and late planting dates, except in 1987 when high aphid densities (3000 per plant) occurred only during the early planting date. Weekly differences in tobacco budworm populations also were detected among planting dates on many sampling dates throughout the season in all three years. Tobacco budworms occurred earliest in the early-planted tobacco, but peak densities were highest in the late-planted tobacco. Both tobacco budworm and tobacco aphid populations declined after the plants were topped (terminal floral branch removed) and a fatty alcohol sucker control was applied.

KEY WORDS *Heliothis virescens, Myzus nicotianae,* cultural control, planting date, seasonal abundance, tobacco aphid, tobacco budworm, tobacco.

The tobacco budworm, *Heliothis virescens* (F.), and the tobacco aphid, *Myzus nicotianae* Blackman, are annual economic threats to flue-cured tobacco (*Nicotiana tabacum* L.) production in the United States. These pests may cost Georgia tobacco producers in excess of $9.5 million annually due to insecticide costs and crop damage (Douce and McPherson 1988). Tobacco budworm larvae

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feed on tobacco foliage near the terminal bud (Mistric and Pittard 1973), while all stages of aphids colonize and feed on the tobacco leaves on the upper portion of the plant (Lampert 1989).

Tobacco budworm larvae often escape direct exposure to conventional insecticide applications due to feeding in the terminal bud (Lampert and Southern 1987). Tobacco aphids are more readily exposed to conventional insecticide sprays; however, many of these materials no longer provide acceptable control (Koziol and Semtner 1984), especially against the red color form of this pest (Harlow and Lampert 1990, McPherson and Bass 1990). Certain cultural practices (e.g., early topping, sucker control, and fertility level) have been reported to alter tobacco budworm population densities (Rabb et al. 1964, Girardeau 1969, Reagan et al. 1974), and thus potentially reduce the need for some insecticides. Planting date is another cultural practice that has been reported to affect green color forms of tobacco aphids (Semtner 1984a) and flea beetles (Semtner 1984b).

Data on the impact of planting date on seasonal tobacco budworm population densities are lacking. Also, information on the effects of this cultural practice on the red color morph of tobacco aphid, the predominate form now observed on tobacco in the southeastern states (Lampert 1989, McPherson 1989), is limited. Therefore, this field research project was conducted during 1987-1989 to determine whether planting date (late March, mid-April, and late April) affects the seasonal abundance of tobacco budworms or red morphs of tobacco aphids in Georgia flue-cured tobacco.

Materials and Methods

Field experiments were conducted at the University of Georgia Coastal Plain Experiment Station in Tifton, GA in 1987, 1988, and 1989. Flue-cured tobacco, cultivar NC 2326, was planted on three dates in field plots measuring 7 m wide × 38 m long arranged in a repeated-measures split-plot design with four replications. Planting date was the main analytical plot and consisted of an early date (2 April 1987, 28 March 1988, and 29 March 1989), a middle date (17 April 1987, 13 April 1988, and 12 April 1989), and a late date (1 May 1987, 27 April 1988, and 26 April 1989). Sampling date (12 weeks) was the split-plot. Each main plot within each replicate measured 7 m × 12.7 m (6 rows wide and 25 plants per row.)

All plots were maintained by applying recommended Georgia Cooperative Extension Service production practices (Ga. Coop. Ext. Serv. 1992), including a pre-plant incorporated tank mix of pebulate (Tillam®) and napropamide (Devrinol®) for weed control, metalaxyl (Ridomil®) for blue mold control, fenamiphos (Nemacur®) for nematode suppression, and chlorpyrifos (Lorsban®) for mole cricket, wireworms and grub control. Fertilizer (6-6-18, N-P-K) was applied at a rate of 1122 kg per ha, in a split application. No foliar insecticides were applied in the test plots in any of the three years.

Each plot was sampled weekly, beginning in early May after all plots were planted and continuing until late July when the final tobacco leaves were harvested. Our preliminary sampling in the early planted tobacco prior to early May revealed very low tobacco aphid population densities. The foliage and terminal buds from 10 plants in each plot (plants 2-11 on row two of each six-row plot) were visually examined. The number of live tobacco budworm larvae and tobacco aphids (all stages) was recorded per plant. In 1989, tobacco aphid population estimates were obtained every other week (referred to as biweekly) while tobacco budworms were counted weekly. Since over 95% of all tobacco aphids observed were the red color form during this period (McPherson 1989), the discussions that follow will concern the red morph.

Insect count data were transformed to the square root of N + 1 and analyzed by the GLM procedure of SAS (SAS Institute 1989). Data from each species were analyzed separately for each week within each year, to determine whether there were differences between planting dates and when these differences occurred each year. The model contained effects due to replicate (REP) and planting date (PD). To determine the year effect on insect population densities, data from all three years were combined and analyzed using a model that included effects due to YEAR, REP, YEAR × REP, PD, and YEAR × PD. YEAR × REP was used as the error term for the test of YEAR effect (Error-a). In addition, data from all weeks sampled were analyzed each year. The model for yearly analysis included REP, PD, REP × PD, WEEK, and PD × WEEK effects. REP × PD was used as the error term to test the significance of PD effect. The overall analysis included data from all weeks and all years and employed a model including effects due to YEAR, REP, YEAR × REP, PD, YEAR × PD, REP × PD (YEAR), WEEK, YEAR × WEEK, PD × WEEK, and YEAR × PD × WEEK. YEAR × REP was used as an error term for YEAR effect and REP × PD (YEAR) as an error term for PD and YEAR × PD effects. Pairwise mean comparisons, using PDIFF option of the GLM procedure, were made if YEAR or PD effect was detected significant at $P = 0.05$ (SAS Institute 1989). Standard error of the mean (SEM) was computed by the STDERR option of PROC GLM (SAS Institute 1989) as the square root of the error mean square divided by the number of observations in each mean group. Because of the balanced experiment with no missing data, the SEM for all means in each class were equal.

Results and Discussion

The overall analyses of variance of tobacco aphid and tobacco budworm population densities (e.g., the number of tobacco aphids per plant and number of tobacco budworms per 10 plants) are summarized in Table 1. The environmental differences among experimental years (YEAR effect) significantly influenced population densities of red tobacco aphids. However, effects of PD, YEAR × PD, and PD × WEEK on aphid abundance were not significant. Repeated measures of biweekly sampling WEEK, YEAR × WEEK, and YEAR × PD × WEEK interaction effects significantly influenced tobacco aphid population densities. Effect of year on tobacco budworm populations was not significant; however, effects of PD, WEEK, and all interactions involving PD and WEEK were significant for tobacco budworm populations (Table 1). These interactions indicate that changes in weekly abundance of tobacco aphid and tobacco budworm populations vary from one year to another and across different planting dates. The three yearly analyses showed similar trends in the

Table 1. Overall (3 year) analysis of variance, including degrees of freedom (df), mean squares (MS) and F values, for aphid and tobacco budworm population densities in flue-cured tobacco planted on three dates (PD) in Georgia during 1987-89.

	Aphid populations			Budworm populations		
Source	df	MS	F	df	MS	F
YEAR	2	4418031	5.18*	2	2.18	1.09
REP	3	1338247	1.57	3	0.79	0.40
Error-a	6	853463	–	6	2.00	–
PD	2	113989	0.09	2	4.42	8.90**
YEAR × PD	4	2542625	1.96	4	2.18	4.40**
Error-b	18	1298997	–	18	0.74	–
WEEK (Wk)	5	5805024	13.48**	11	8.34	16.81**
YEAR × Wk	10	3475078	8.07**	22	3.04	6.13**
PD × Wk	10	218339	0.51	22	3.91	7.89**
YEAR × PD × Wk	20	1516627	3.52**	44	1.12	2.45**
Residual	135	430593	–	297	0.50	–

*, ** F value computed from Type III SS significant at the 0.05 (*) or 0.01 (**) probability level.

effects of PD, WEEK, and PD × WEEK on tobacco aphid and tobacco budworm populations. A significant PD effect was noted for aphids only in 1989, a year with relatively few aphids until late in the season when aphid population increases were observed only in the late planted tobacco. The early and middle planting date tobacco had already been topped (removal of the terminal floral branch) by this time and only the late planting date tobacco remained attractive to colonizing adults. The planting date effect was significant for tobacco budworms in 1987 and 1988. No significant planting date effects were noted in 1989, when overall populations were relatively low, never exceeding two tobacco budworms per 10 plants.

The means of tobacco aphid population densities for main effects of PD and YEAR are presented in Table 2. Aphid densities were highest in the early transplanted tobacco on weeks 1 and 3 as compared to middle or late planting dates. However, peak populations were attained on sampling week 7 for all three planting dates, and although statistically not significant, these peak densities were observed to be higher in the middle and late planting dates. Aphid densities varied greatly between years and peaked at over 2,100 per plant on week 7 in 1987 and nearly 1,400 per plant on week 11 in 1988. Aphid populations were relatively low in 1989 and peaked at 320 per plant on week 9. These results indicate that tobacco aphid population density is influenced by transplanting date during the first two months after transplanting begins, but the change in yearly environmental conditions strongly affects aphid population peaks and when they occur in the season (Table 2).

Effects of PD and YEAR on weekly mean tobacco budworm population densities are presented in Table 3. The average numbers of tobacco budworms

Table 2. Planting date (PD) and year effects on the seasonal abundance of aphids on flue-cured tobacco in Georgia, 1987-1989 (SEM indicates standard error of the mean).

Sampling	Mean number of aphids per plant per week							
	PD Effect				YEAR Effect			
Week	Early	Mid	Late	SEM	1987	1988	1989	SEM
1	0.3^{a}	0.1^{b}	0.0^{b}	0.03	0.3^{x}	0.0^{y}	0.1^{xy}	0.04
3	18.7^{a}	4.5^{b}	0.1^{b}	3.4	6.2	4.3	12.7	6.2
5	154.3	90.7	18.1	39.0	128.6	81.7	52.8	72.8
7	846.4	1047.6	1051.3	391.5	2114.9^{x}	815.4^{y}	14.9^{y}	416.5
9	342.8	597.8	898.7	178.4	519.9^{y}	999.3^{x}	320.0^{y}	237.4
11	597.7	526.3	462.3	135.9	63.0^{y}	1399.4^{x}	123.8^{y}	335.9

a,b,x,y PD means or year means within a row (sampling week) followed by different superscripts are significantly different ($P < 0.05$), Pairwise mean comparisons, GLM (SAS Institute 1989). The absence of superscripts indicates no difference among PD or YEAR for that sampling week.

Table 3. Planting date (PD) and year effects on the seasonal abundance of tobacco budworms on flue-cured tobacco in Georgia, 1987-1989 (SEM indicates standard error of the mean).

Sampling Week	Mean number of budworms per 10 plants per week							
	PD Effect				YEAR Effect			
	Early	Mid	Late	SEM	1987	1988	1989	SEM
1	0.0	0.1	0.0	0.05	0.1	0.0	0.0	0.08
2	0.5[a]	0.1[b]	0.0[b]	0.08	0.0[y]	0.0[y]	0.6[x]	0.14
3	1.3[a]	0.4[b]	0.0[b]	0.17	0.3[y]	0.4[y]	1.0[x]	0.29
4	1.0[a]	0.4[b]	0.0[b]	0.18	0.4	0.3	0.6	0.31
5	0.7[a]	0.3[ab]	0.0[b]	0.20	0.3	0.1	0.6	0.36
6	0.4	0.6	0.5	0.22	0.6	0.6	0.4	0.39
7	1.1	1.3	1.5	0.35	2.3[x]	1.0[y]	0.6[y]	0.61
8	1.5	1.1	2.1	0.28	1.3[y]	2.7[x]	0.7[y]	0.49
9	0.1[b]	0.3[b]	2.9[a]	0.24	0.8[y]	1.9[x]	0.6[y]	0.43
10	0.2[b]	0.2[b]	0.9[a]	0.22	1.0[x]	0.3[y]	0.0[y]	0.38
11	0.0[b]	0.0[b]	0.6[a]	0.13	0.5[x]	0.1[y]	0.0[y]	0.23
12	0.1	0.1	0.3	0.11	0.3	0.1	0.1	0.19

a,b,x,y PD means or year means within a row (sampling week) followed by different superscripts are significantly different ($P < 0.05$), Pairwise mean comparisons, GLM (SAS Institute 1989). The absence of superscripts indicates no difference among PD or YEAR for that sampling week.

per 10 plants were higher in the early planted tobacco during weeks 2-5. On weeks 6, 7, and 8, populations were similar on all three planting dates. On weeks 9, 10, and 11 tobacco budworm densities were highest in the late planted tobacco, but no planting date effect existed beyond week 11. Tobacco budworm populations were similar in 1987 and 1988 for the first 6 weeks of sampling, but significant differences between the two years appeared from week 7 to week 11. Peak densities of 2.3 larvae per 10 plants were attained on week 7 in 1987, and 2.7 larvae per 10 plants on week 8 in 1988. Tobacco budworm populations were lower in 1989 and peaked at 1 per 10 plants on week 3, then remained relatively low for the remainder of the season. As was the case with planting date, environmental differences among years did not significantly influence tobacco budworm population density beyond week 11 (Table 3).

The seasonal distribution of tobacco aphids in flue-cured tobacco planted on three dates in 1987-1989 are presented in Fig. 1-3. Overall seasonal population densities were higher in 1987 and 1988 than in 1989. Populations were significantly higher in the mid- and late-planted tobacco in June to early July in 1987, while large populations never developed in the early-planted tobacco (Fig. 1). Aphid population densities increased rapidly during a short period of time from early June to 22 June for both middle- and late-planted tobacco. The early planting date tobacco was topped on 8 June and was no longer attractive to colonizing aphids. Temperature was an important factor in limiting the tobacco aphid population buildup in early planted tobacco in 1987. On 1 April, the day before transplanting, the low temperature was 32°F (0°C) and a light frost occurred on the plants being removed from the plant bed. On four of the next six days after transplanting, daily lows were in the 30's°F (0-4°C) and high temperatures ranged from 51° to 67°F (8-16°C). Thus, the early planted tobacco was establishing in the field at an abnormally slow rate and colonizing aphid populations remained very low.

In 1988, tobacco aphid populations began a rapid increase in the early planted tobacco in mid-June, then declined in early July, while populations in the mid and late planted tobacco peaked in mid-July at densities much lower than those in the early-planted tobacco (Fig. 2). Tobacco aphids began colonizing the early planted tobacco in early June, prior to topping (13 June), and peaked at nearly 3,000 aphids per plant on 28 June. Significant differences in tobacco aphid populations were detected among PD's on eight consecutive dates from early June to late July in 1988. Aphid populations were very low in the early and mid-planted tobacco in 1989. The overall tobacco crop was slower to develop this season due to cool spring weather. A rapid aphid population buildup did occur in the late planted tobacco in early July in 1989, reaching a peak of around 900 aphids per plant in mid-July, but then it quickly declined (Fig. 3). Weekly differences in aphid populations were detected among planting dates on only three sampling dates in 1989.

In all plantings each year, the red tobacco aphid populations declined after the plants were topped and a fatty alcohol sucker control was applied. This was also reported for the green color form (Lampert 1989, Semtner 1984a). If subsequent populations developed after topping, they occurred on newly developed suckers, which has little effect on yield or quality. Planting date did influence the seasonal abundance and time of population increase of tobacco

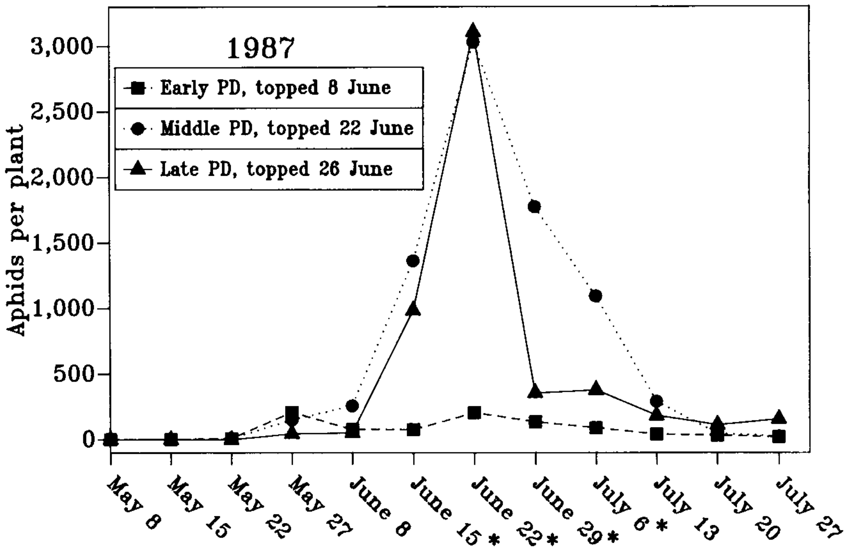

Fig. 1. Seasonal abundance of tobacco aphids in Georgia flue-cured tobacco planted on three dates (PD), 1987. Sampling dates with * indicates significant difference among planting dates.

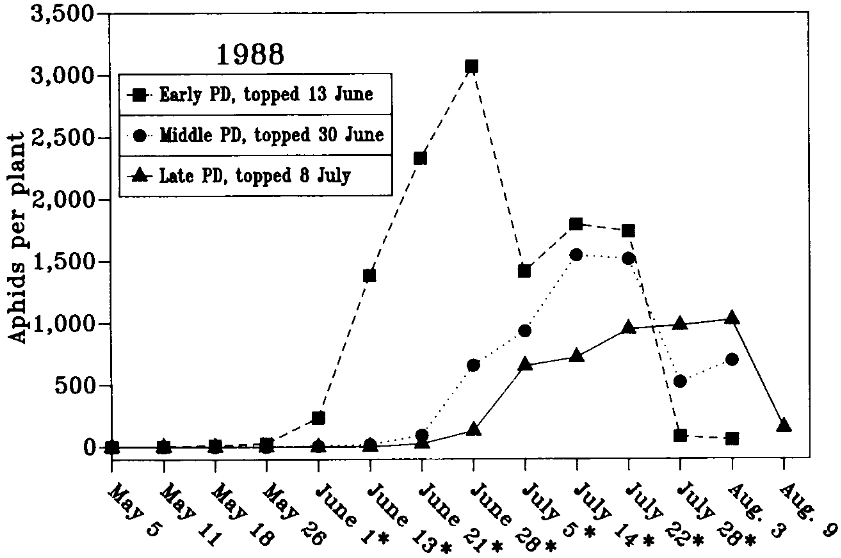

Fig. 2. Seasonal abundance of tobacco aphids in Georgia flue-cured tobacco planted on three dates (PD), 1988. Sampling dates with * indicates significant difference among planting dates.

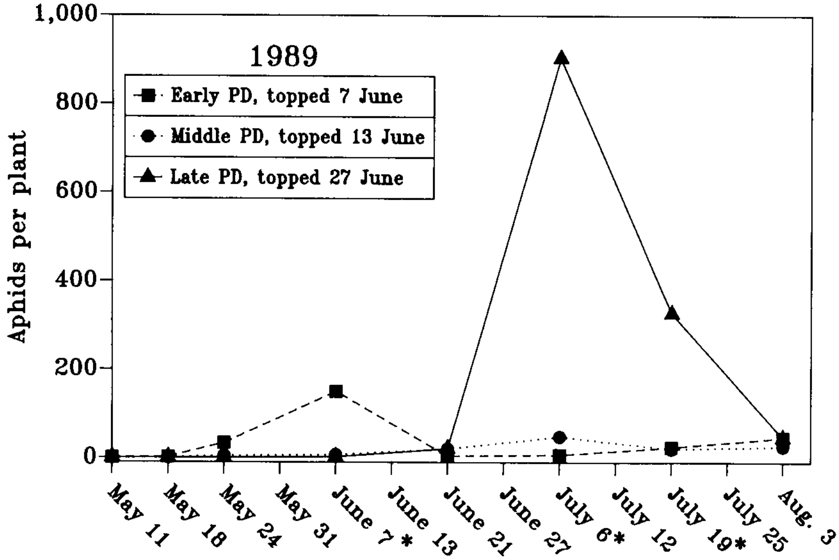

Fig. 3. Seasonal abundance of tobacco aphids in Georgia flue-cured tobacco planted on three dates (PD), 1989. Sampling dates with * indicates significant difference among planting dates.

aphids during this study. The abnormally cool weather in the early growing season in 1987 and during most of the spring of 1989 was the main cause for yearly variation in tobacco aphid populations.

The seasonal distribution of tobacco budworms on flue-cured tobacco planted on three dates during 1987-1989 are presented in Figs. 4-6. Significant differences in tobacco budworm populations were detected between planting dates on many of the sampling dates throughout the season in all three years. Peak tobacco budworm populations occurred earliest in the early planted tobacco, but peak densities were highest later in the season in the late planted tobacco. Populations in the mid-planting date tobacco usually had the lowest peak populations of the three planting dates except in 1987, when it was between the early and late planting dates. The seasonal trend for tobacco budworms in the early planting date tobacco was bimodal in 1987 and the population density never exceeded 1.5 budworms for 10 plants (Fig. 4). The peak period was rather brief for the mid-and late planting date tobacco, but the peak densities were higher and a much lower rate of decrease was observed in the late planting date tobacco (Fig. 4). Significant planting date effect was observed for 8 sampling dates in 1987. The peak tobacco budworm densities were much higher in 1988 (Fig. 5), but these peak densities lasted for a brief period. Significant planting date effect was observed for three sampling dates. Early-season tobacco budworm populations were high in the early- and mid-planting date tobacco in 1989 (Fig. 6), but subsequent population densities were low except in the late-planted tobacco where tobacco budworms exceeded 2 per

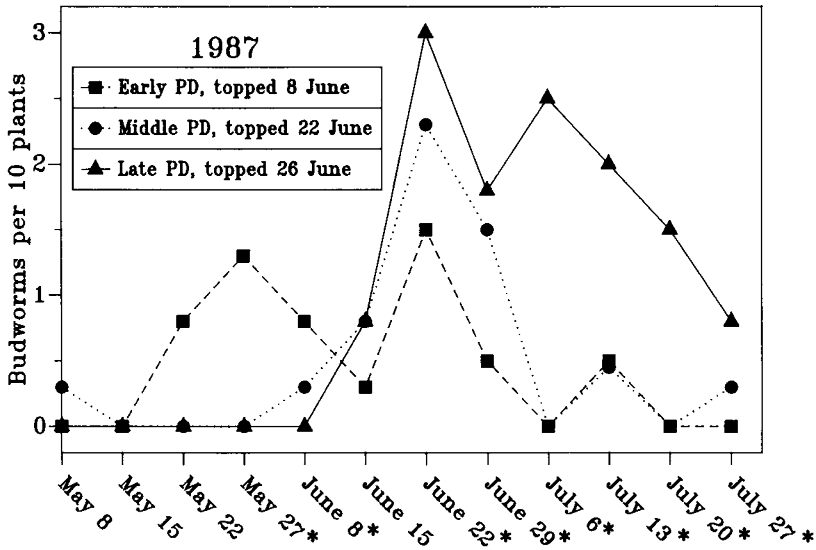

Fig. 4. Seasonal abundance of tobacco budworms in Georgia flue-cured tobacco planted on three dates (PD), 1987. Sampling dates with * indicates significant difference among planting dates.

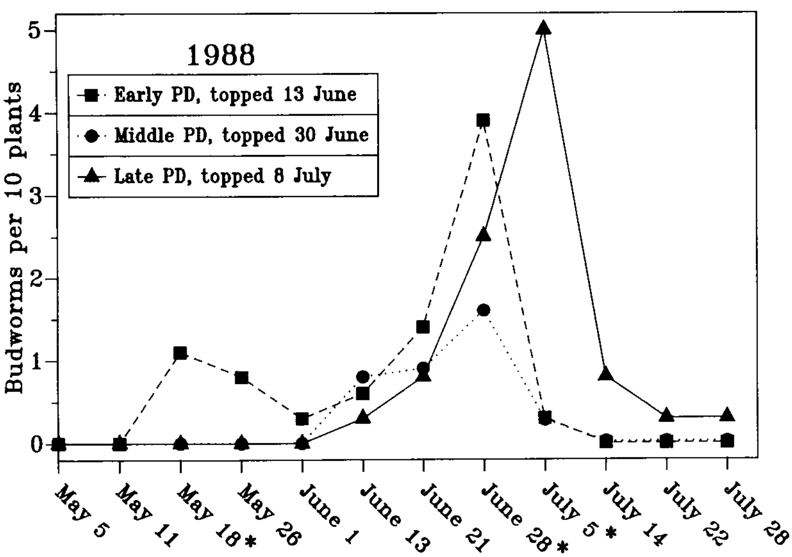

Fig. 5. Seasonal abundance of tobacco budworms in Georgia flue-cured tobacco planted on three dates (PD), 1988. Sampling dates with * indicates significant difference among planting dates.

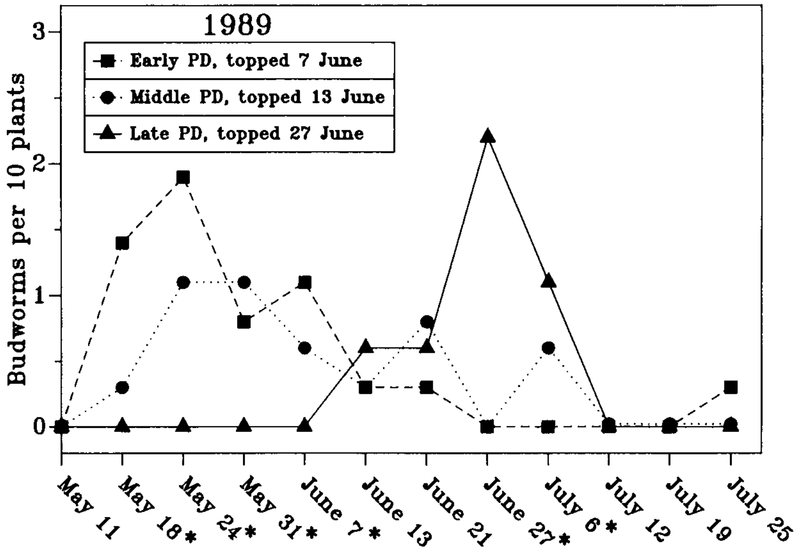

Fig. 6. Seasonal abundance of tobacco budworms in Georgia flue-cured tobacco planted on three dates (PD), 1989. Sampling dates with * indicates significant difference among planting dates.

10 plants in late June. Significant planting date effect was observed for 6 sampling dates in 1989.

In conclusion, this field study documents the impact of planting date on the seasonal abundance of tobacco aphids and tobacco budworms. Red tobacco aphid population densities also were greatly influenced by the change in environmental conditions (YEAR effect). The overall planting date effect within each year was significant only in 1989, a year with relatively low aphid populations until early July when only the late-planted tobacco remained attractive. In 1987 and 1988, when aphid populations were much higher, the overall planting date effects were minimal; however, the week of peak densities was different between planting dates. Significant differences in tobacco aphid populations were detected among planting dates on specific sampling dates in all three years. Tobacco budworm populations initially develop on the early planting date tobacco; however, the highest peak populations occurred 3-4 weeks later in the late planted tobacco. The early-planted tobacco would require earlier applications of insecticides to control the economic threshold of one tobacco budworm per 10 plants (Ga. Coop. Ext. Serv. 1992), but potentially more tobacco budworm damage would occur in the late-planted tobacco due to higher population densities. Tobacco growers should be able to use planting date and environmental conditions, along with weekly field scouting, to manage tobacco budworms and tobacco aphids more economically.

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