Pink Bollworm Management in Pima and Upland Cottons: Planting Date and Termination Date Effects

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Abstract

Different planting and termination dates of Pima S-6 and Upland (Deltapine 90) cotton (Gossypium barbadense L. and hirsutum L. respectively) were tested for their effects on pink bollworm (Pectinophora gossypiella) infestations. Tests were conducted during 1989 and 1990 cotton seasons at the University of Arizona Yuma Valley Agricultural Experiment Station. Planting dates indicated little effect on early season infestations of pink bollworm for either cotton. However, irrigation termination had the greatest effect on late season infestations. In 1989, heat unit (degree day 12.8/30º C, lower and upper thresholds) accumulations were several days earlier than 1990, due to a very warm year. Pheromone trap counts indicated higher populations in 1989 than 1990; however, infestations in the field were similar between the years. Infestations dramatically increased during July through September, indicating that a longer cotton season with actively growing fruit, results in a continued population increase. The termination dates affected the amount of fruiting structures left in the field and thereby affected infestations of overwintering larvae in the field. Termination date had a dramatic effect on the % bolls infested with overwintering larvae and the density of overwintering larvae/m.

Introduction

Pink bollworm (*Pectinophora gossypiella* Saunders) is a key pest of cotton (*Gossypium* spp.) in Arizona that has a host range restricted to cotton and okra (Werner et al. 1979). This insect infests squares, flowers or bolls and completes its larva stage inside a single boll. Larvae feed on seeds and cut the lint as they move about in the bolls. A secondary infection of boll rot may also occur in damaged bolls. Henneberry et al. (1978) reported that high a level of infestation may reduce yields 50 to 80% compared to plots treated with insecticides.

Agronomic studies have indicated that Upland cottons (*G. hirsutum* L.) can be grown in a short season to help minimize in-season infestations of pink bollworm without reducing yield. This may be accomplished in one of two ways: by either delaying planting date or by early termination (irrigation termination). Delayed planting reduces infestations by promoting 'suicidal emergence' in the spring (i.e., pink bollworms emerge before host food is mature enough to sustain growth of larvae). If presquaring cotton is present (as a result of delayed plantings) as the overwintering generation emerges in the spring, female adults oviposit on cotton plants that will not support larvae (at least 10 day old squares must be present for larva survival) (Graham 1980, Werner et al. 1979). Watson (1985) and Watson et al. (1978) found that by terminating, harvesting, and destroying crop residue early (to remove host food/habitat prior to larvae entering diapause in the fall), the overwintering population is reduced to a minimum level. Overall, subsequent in-season populations should be reduced as a result, if done on a community-wide basis.

Deltapine (DPL) 90 (*G. hirsutum* L.) and Pima S-6 (*G. barbadense* L.) are commonly grown cottons in Arizona. Both of these cottons are considered full season and have a higher production potential, in either a single or double fruit set system, as compared to less indeterminate varieties. In addition, bolls of Pima cottons stay susceptible to pink bollworms longer than do those of Upland species and thereby sustain a higher density of larvae (Fry et al. 1978; George and Wilson 1983). The management of pink bollworm may be more critical with these cultivars to limit their population dynamics in the region. The purpose of this research was to test the effects of planting dates and irrigation termination dates on early and late season pink bollworm population development in Pima S-6 and DPL 90 cottons.

Materials and Methods

Tests were conducted at the University of Arizona Yuma Valley Agricultural Experiment Station in Yuma, Arizona during the cotton growing seasons of 1989 and 1990. Both DPL 90 and Pima S-6 were planted early (23 and 27 February in 1989 and 1990) and late (14 and 21 March, in 1989 and 1990, respectively) (Table 1). Plots were set up in a randomized complete block design which at terminations became a split-plot. Cotton was planted on 1.01 m rows and was irrigated by furrow irrigation on a one week to 10 day schedule, as needed. Termination was accomplished by stopping irrigation, followed by chemical defoliation within two to four weeks of irrigation termination. Termination dates were 8 and 23 August during 1989 with defoliation on 7 September and harvest 3 October (Table 1). An early termination was not used in 1989 due to a 5 cm rain during early August. During 1989 cotton was harvested only once, when plants from the final termination were ready for harvest on 3 October. During 1990, plants from each termination were harvested separately, as soon as plants were ready. In 1990, there were 3 terminations: 18 July, 7 August and 6 September, with harvests on 28 August, 12 September and 5 October. Plant data collected included the number of fruiting structures per m just prior to harvest. Heat unit data (degree days, 12.8/30° C lower/upper thresholds) were accumulated from 1 January both years at Arizona Meteorlogical Network (AZMET) station located in Yuma valley.

Adult male pink bollworms were collected in pheromone traps with oil cups attached (Cotton 1984). These traps were checked 3 times per week during May through September. Pheromone lures were attached to the lids of the cup. Lures were changed at least once during the season and any time traps or lures were damaged. Counts of adult males per trap per night were used to compare year to year differences and to compare with heat unit predictions of time of each generation peak.

Pink bollworm larvae were sampled by removing susceptible squares during early season and sampling susceptible bolls during mid and late season. Infested flowers (rosetted blooms) were counted in the field when open blossoms first appeared. Ten fruiting structures were randomly selected and removed from each plot. Samples were taken to the laboratory and then dissected to determine whether they were infested with larvae. Percent structures infested and number of larvae per infested fruit were calculated and then planting date/ termination date effects on infestation were tested with analysis of variance models (ANOVA, SAS Institute (1985)). Just prior to harvest, samples of squares and bolls remaining on the plant were removed. One hundred green bolls were removed per plot. At the laboratory, bolls were separated into those with and without emergence holes. Twenty bolls without holes were examined for infestations. The remainder of bolls without holes were used to determine the proportion overwintering. The overwintering population was determined by counting the number of larvae still in the bolls after bolls were maintained in a screenhouse in Tucson at ambient temperatures for eight to ten weeks. Pyrethroid insecticides were sprayed on all plots approximately at five to seven day intervals from mid-July to mid-September.

Results and Discussion

Heat unit accumulations were about five to seven days early for the beginning, peak and end of spring emergence for pink bollworm in 1989 versus that in 1990 due to much warmer than normal temperatures during 1989 (Table 2). However, by the predicted F_3 generation peak, 1989 was only about 3 days ahead of 1990. During 1989, adult trap counts averaged 10 to 50 per trap per night through July. During late season, counts frequently exceeded 100 per trap per night (Fig. 1). During 1990, however, trap counts were below 10 per trap per night until July. During July and August, trap counts ranged from 10 to 58 per trap per night, significantly lower than in 1989. During 1990 traps in the Pima cotton fields were separated from Upland cotton. When counts were combined across all dates, no significant differences in trap counts were calculated between Pima and Upland ($t=0.87$, $P>0.39$). However, during July and early August, traps in the DPL 90 plots had more adults than those in the Pima plots ($t= 3.45$, $P<0.006$).

In 1989, infested fruit (squares and bolls) in Pima cotton remained less than 10% until early July. Infested bolls rapidly increased during August to over 50% in all plots (Fig. 2). At the final sample date prior to harvest, proportion of bolls infested was high in all plots, regardless of planting or termination date (Table 3). Slight differences were detected among treatments. The estimated number of overwintering larvae per m (based on infestation rates and number of structures per m) was lower in the early planted, early terminated plots (Table 3) and higher in the late terminated plots. There were no consistent significant differences bewteen Pima and DPL 90 plots, except percent squares infested was higher in DPL 90 plots (Table 3).

In 1990, infestations remained less than 10% in both Pima and DPL 90 fields until late July when infestations in all plots increased (Fig. 3). In September, infestations increased to above 50% in fruiting structures still in the field. Infestations during 1990 were similar to those in 1989 despite higher adult pheromone trap counts in 1989. No significant differences among planting dates were observed for either Pima or DPL 90 cotton during the early season. During the late season no termination date effects were indicated. However, significant differences among irrigation termination dates were observed at harvest (Table 4) in both Pima and DPL 90. Infestations in the late termination were >85%. Late season infestations of squares followed a similar pattern. The final terminations in both cottons had much greater infestation than early or mid-terminations (Table 4).

In 1990, there were significant differences in the number of remaining fruiting structures at harvest among the treatments (Table 4). The early planted plots generally had more green bolls than late planted plots, especially in the early terminated plots. The late-planted, late-terminated Pima cotton had more squares but had the least number of green bolls. If this information is coupled with the infestation at harvest, then the potential number of overwintering larvae per m can be estimated (Table 4). The late-planted, late-harvested plots of both cottons had higher densities of larvae, while early-planted, early-harvested had the lowest densities. This represents a substantial difference between 1989 and 1990 termination date effects. During 1989 plants of all termination treatments were left in the field until October. When the percent total infested bolls (diapausing plus non-diapausing larvae) and percent bolls with diapausing larvae only are examined, a dramatic difference is observed among termination dates (Fig. 4). Also, the most significant change between the total infestation (diapause plus non-diapause) and the diapause only group occurs during the early and mid-termination, regardless of the planting or cotton cultivar. This matches the relationships of the predictions of density of larvae per meter (Fig. 4 and Table 4).

Summary

No planting date effects were observed on infestations of fruit in the early season. Both planting dates were early enough that both had susceptible squares during the spring emergence. A later planting date than those used in these tests may have had more effect on early season infestations. Infestations dramatically increased in all plots that had developing fruit in the field during July and August. Infestations were as high as 90% during September and October. Irrigation termination can have a dramatic effect on late season infestations, but only if plants are harvested and plowed-down immediately. If defoliations, harvest and plow-downs are delayed, then pink bollworms will continue to infest these early terminated plots. If this information is coupled with the increased costs of insect control late season (as well as potential costs the following season) and yield information, then economically based decisions for management of cotton can be made.

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Table 1. Planting, termination and harvest dates for 1989 and 1990 Yuma Valley tests, both Pima S-6 and DPL 90 cotton, and associated heat unit (H.U.) accumulations[a].

Treatment[b]	Year			
	1989	H.U.	1990	H.U.
Planting date, early	23 Feb	136	27 Feb	157
Planting date, late[c]	14 Mar	275	21 Mar	285
Last irrigation, early T, early PL	---	---	18 Jul	1519
Last irrigation, mid T, early PL	8 Aug	1960	7 Aug	1842
Last irrigation, mid T, late PL	8 Aug	1821	7 Aug	1714
Last irrigation, late T, late PL	23 Aug	2055	6 Sep	2145
Defoliation, early T, early PL	---	---	16 Aug	1985
Defoliation, mid T, early PL	7 Sep	2424	29 Aug	2174
Defoliation, mid T, late PL	7 Sep	2285	29 Aug	2046
Defoliation, late T, late PL	7 Sep	2285	11 Sep	2254
Harvest, early T, early PL	---	---	28 Aug	2158
Harvest, mid T, early PL	2 Oct	2756	12 Sep	2399
Harvest, mid T, late PL	2 Oct	2617	12 Sep	2271
Harvest, late T, late PL	2 Oct	2617	5 Oct	2590

[a] Heat unit based on 12.8°/30°C lower/upper threshold temperature degree day base; for planting date, accumulations from 1 January, and all others are accumulated from the planting date.
[b]Treatment code; Early T = Early irrigation termination; Early PL = Early planting; Mid T = Mid irrigation termination; Mid PL = Mid planting; Late T = Late irrigation termination; Late PL = Late planting.
[c] Late planting in this test, but is during the normal planting period for Yuma.

Table 2. Predicted dates for pink bollworm spring emergence and subsequent generations based on accumulated heat units[a], Yuma Valley cotton tests.

Generation	Heat Units	Date	
		1989	1990
Begin spring emergence	275	14 Mar	20 Mar
1st square (1st planting)	525	11 Apr	21 Apr
Peak emergence	660	23 Apr	3 May
1st square (2nd planting)	670	24 Apr	5 May
End spring emergence	1225	13 Jun	20 Jun
F_1 generation (peak)	1104	5 Jun	10 Jun
F_2 generation (peak)	1548	6 Jul	10 Jul
F_3 generation (peak)	1992	3 Jul	6 Aug
F_4 generation (peak)	2436	30 Aug	4 Sep
F_5 generation (peak)	2880	2 Oct	5 Oct

[a] Based on 12.8/30.0°C lower/upper threshold models, generation time based on 444 degree days predictions (Cotton 1984).

Table 3. Number of pink bollworm larvae per m at harvest, Yuma Valley, 1989.

Treatment Planting	Term.	Squares % infested	Squares # per m	Bolls % infested	Bolls # per m	Estimated no. larvae per m
			PIMA S-6			
Early	Early	5.3a	14.5a	49b	23.1a	26.2b
Early	Late	6.3a	12.0ab	79a	25.8a	46.5a
Late	Early	5.8a	8.8b	51ab	21.3a	24.9b
Late	Late	2.3a	15.3a	48b	26.8a	29.0b
			DPL 90			
Early	Early	12.8a	5.1b	35b	16.3b	13.6b
Early	Late	11.3a	6.2b	57a	24.8a	32.4a
Late	Early	16.3a	8.5b	52a	25.3a	31.1a
Late	Late	8.5a	12.0a	49ab	18.3ab	21.4ab

[a] Means within the same cotton variety and column which are followed by the same letter are not significantly different (α=0.05 Scheffé).

Table 4. Number of pink bollworm larvae per m found at harvest for each treatment, Yuma Valley tests, 1990.[a]

	EE	EM	LM	LL[b]
		DPL 90		
# squares/m	6.4b	5.2b	8.4b	13.7a
% infested	1.3c	12.9b	6.1b	69.0a
# larvae/m	0.08c	0.67b	0.5b	11.9a
# bolls/m	37.6ab	44.7a	25.0b	16.3b
% infested	8.6b	27.0b	18.9b	91.7a
# larvae/m	3.9b	15.8ab	5.0b	44.8a
Total insects/m	4.0c	16.5b	5.5b	56.7a
# overwinter/m	0c	1.6b	0.5b	51.0a
		Pima S-6		
# squares/m	3.7a	2.6a	4.1a	1.6a
% infested	3.6b	4.1b	7.7b	82.9a
# larvae/m	0.13b	0.11b	0.32b	1.8a
# bolls/m	43.8a	22.1b	17.9b	14.0b
% infested	8.5c	31.0bc	44.0b	94.3a
# larvae/m	4.5c	11.3b	11.9b	30.6a
Total larvae/m	4.6c	11.4b	12.2b	32.4a
# overwinter/m	0c	1.1b	1.1b	29.2a

[a] Means in the same row followed by the same letter are not significantly different, (α=0.05, Sheffé).
[b] EE=Early planted, early terminated; EM=Early planted, mid termination; LM=Late planted, mid termination; LL=Late planted, late terminated.

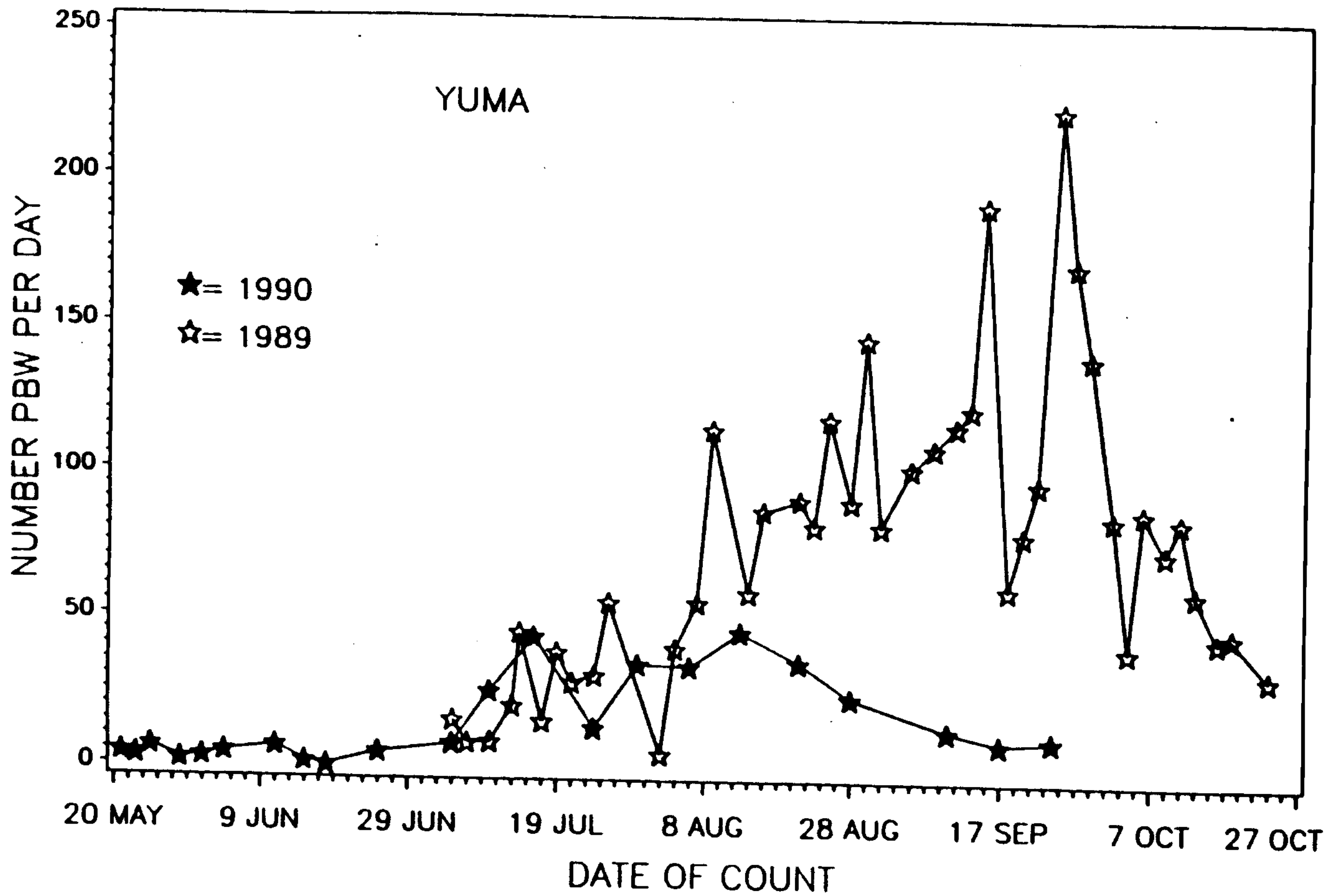


Fig. 1. Number of pink bollworm adult males per trap per night, 1989 and 1990.

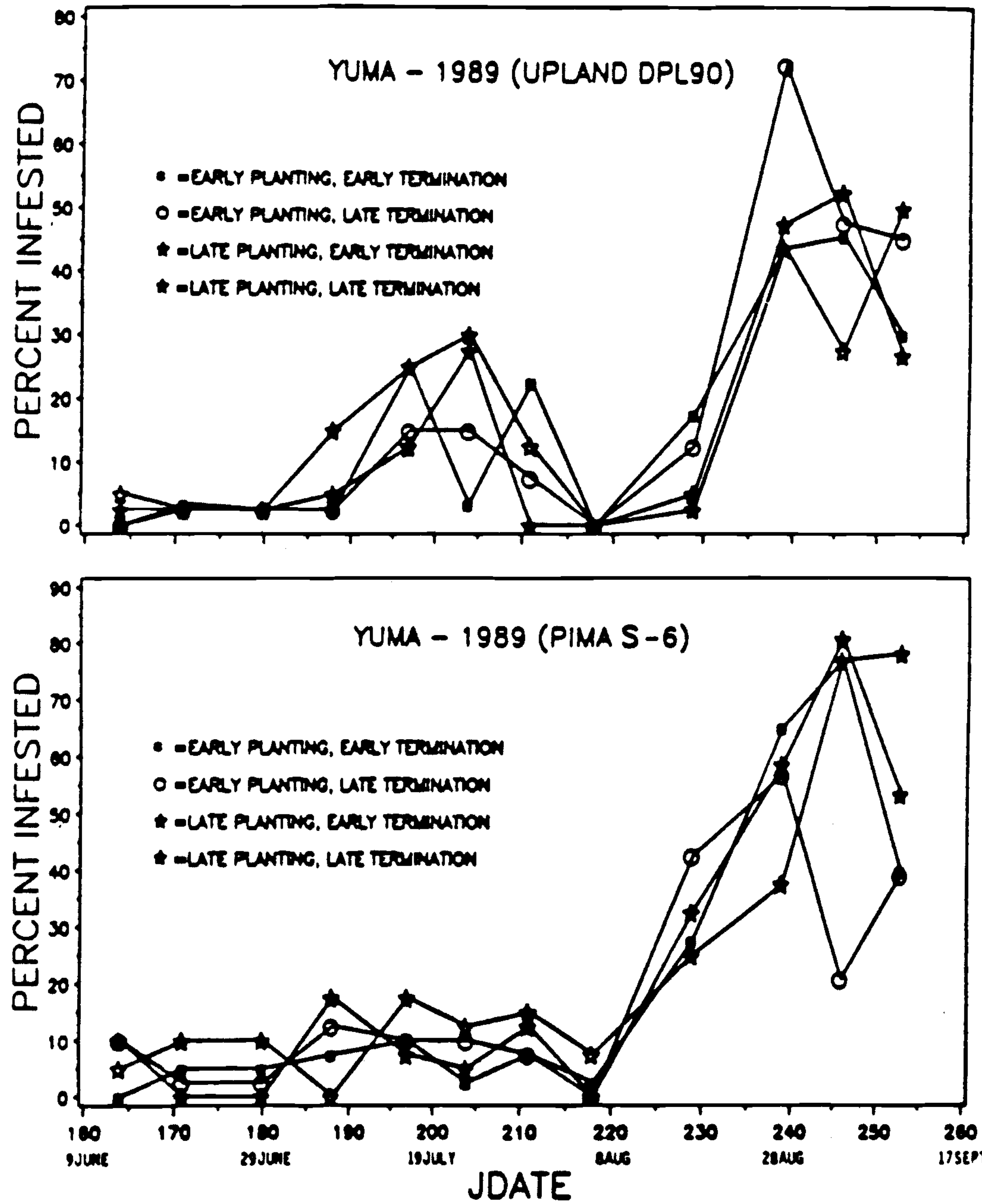
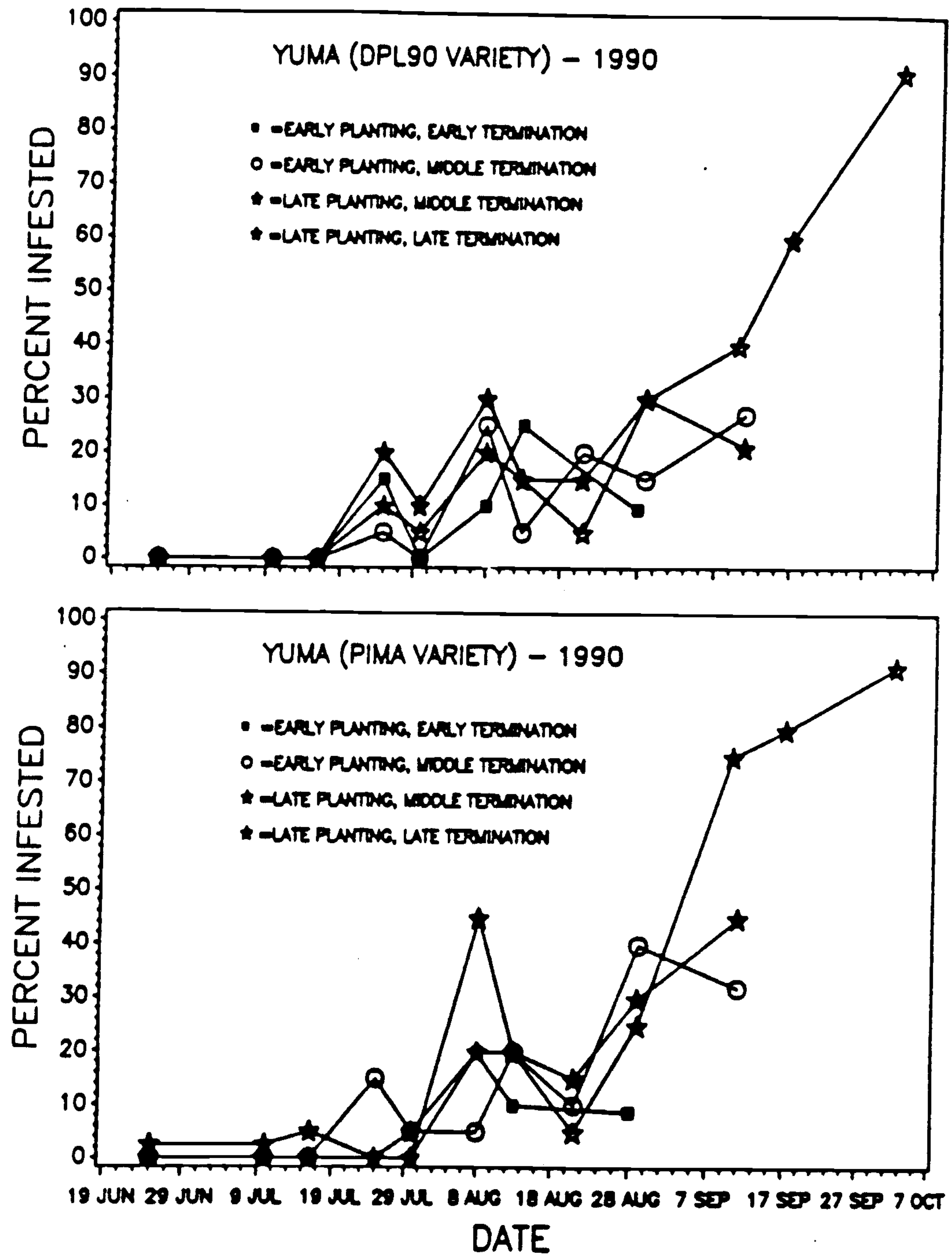


Fig. 2. Percent bolls infested with pink bollworm larvae.



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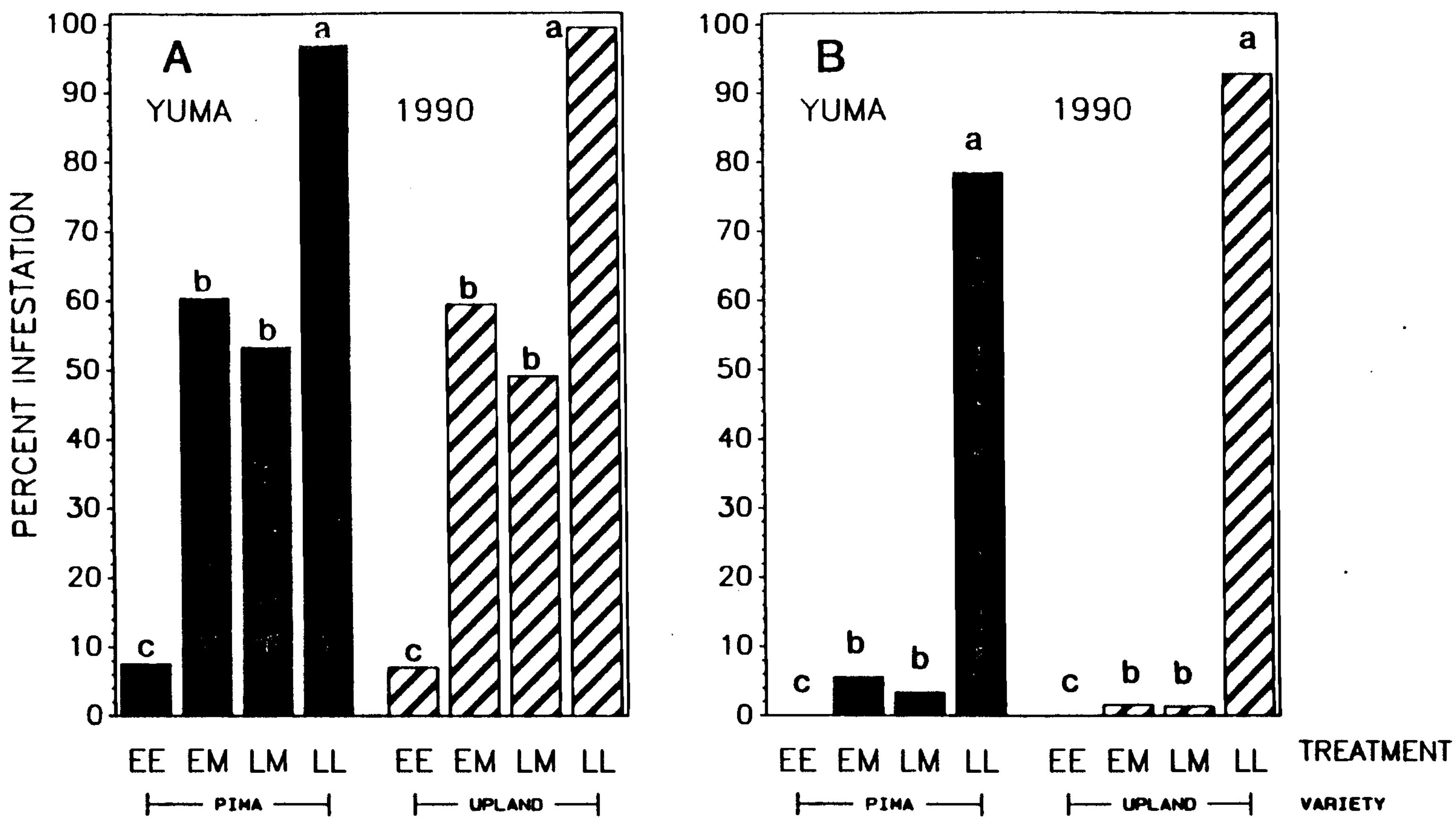

Fig. 4. Percent infested bolls comparing treatments and cotton varieties for (A) diapausing plus non-diapausing larvae and (B) diapausing larvae only. Means within a variety, which are followed by the same letter are not significantly different ($\alpha=0.05$ scheffe). Treatment codes: EE= early planted, early terminated; EM= early planted, mid termination; LM= late planted, mid termination; LL= late planted, late terminated.