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FINAL IRRIGATION TIMING AND LATE SEASON CROP SUSCEPTIBILITY TO TARNISHED PLANT BUG (LYGUS LINEOLARIS PALISOT DE BEAUVOIS) 2005 – USING COTMAN TO MAKE CROP TERMINATION DECISIONS

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Abstract

Research is underway in Arkansas to establish and validate end-of-season crop management guides for timing final furrow irrigation and for terminating insecticide applications for tarnished plant bug (*Lygus lineolaris* (Palisot de Beauvois)). In the 2nd year of a planned 3-year study, we have examined interactions of late season irrigation and insect control in a field trial on the University of Arkansas Lon Mann Cotton Research Station in Marianna. With rains in late August, termination of irrigation prior to physiological cutout (mean NAWF =5) did not result in significant yield penalties compared to later termination dates. Late irrigations did delay boll opening. Plant bug numbers late season were at low to moderate levels but exceeded some state action thresholds (a range of 3 to 8 bugs/3 ft of row in drop cloth samples). Late season insecticide sprays extending out to NAWF=5+413 DD60s reduced bug numbers in protected treatments but did not result in significant yield differences compared to early terminated (NAWF=7) treatments. There were no significant irrigation*insecticide interactions observed with lint yield. Results from the 2004 and 2005 seasons of research in the Central Eastern Arkansas production region coupled with data from previous studies in NE Arkansas indicate that the insect control termination guide in COTMAN that has been in use for heliothine caterpillars and boll weevils (NAWF=5 +350 DD60s) is more than sufficient for late season plant bug management, and timing of final furrow irrigation also may be appropriate at this same crop stage.

Introduction

Cotton Incorporated has supported research efforts that have yielded a simple crop monitoring procedure and crop termination guide, the COTMAN™ system (Danforth and O'Leary 1998). It allows the user to determine the flowering date of the last effective boll population and to define when those bolls have reached the final stage of susceptibility for major fruit feeding insects (bollworms, tobacco budworms and boll weevil) (Cochran et al 1999). There currently is a regional Cotton Incorporated funded project focused on using crop monitoring with COTMAN to time the final irrigation (Vories et al 2000, 2001, 2002, 2003, 2004).

Ongoing research in Arkansas is focused on evaluating interactions of timing for final furrow irrigation and insecticide applications for tarnished plant bug (Teague and Danforth 2005). Limiting late season irrigation may reduce lush fall crop growth which in turn may affect movement of migrating insect pests such as plant bugs, stink bugs and bollworms/tobacco budworms attracted to high quality food in rank growth. Movement of resident populations of insect pests out of the field may be encouraged by early irrigation termination. Just the presence of insect pests in rank cotton in late season may give the perception that they are damaging the crop even when their effect may be unimportant. The result is added anxiety in deciding to terminate insecticide applications. Timely irrigation termination may help growers feel confident in eliminating unnecessary and expensive late season insecticide sprays.

In this 2nd year of a 3 year project, our focus was to address the following questions….Does the final stage of crop susceptibility (insecticide termination) and the timing for the final irrigation occur at a similar crop stage --- Cutout + 350 DD60s? Does prolonging irrigation delay the onset of final stage of crop susceptibility for plant bugs? Will earlier cessation of irrigation affect movement of insects into or out of a field and reduce the need (or perceived need) for late season insecticide inputs? Will prolonged irrigation and insecticide application produce higher yields?

Materials and Methods

The experiment was conducted on the University of Arkansas Lon Mann Cotton Research Station in Marianna. The growing season in the study area is May through October. The latest possible cutout dates for this production area – those dates with a 50% or 85% probability of attaining 850 DD60s from cutout are August 14 and August 9, respectively (Danforth and O'Leary 1998). Cultivar Stoneville 4892 RBG was seeded on 11 May at a seeding rate of 3 to 4 Cruiser treated seeds/ft in rows spaced 38 inches apart. The soil was a Calloway silt loam. Furrow irrigation timing was based on University of Arkansas Irrigation Scheduler Program and was initiated at a 1 inch deficit until mid-July. The experiment originally was designed as a 4 * 5 factorial with 3 replications with insect control termination (4 factors) and irrigation termination (5 factors) arranged in a split plot with irrigation as main plots. Late season rains confounded the final 2 irrigations, and those treatments were dropped. Treatments dates are listed in Tables 1&2 and Fig 1. Plots were 60 ft long, and 8 rows wide. Fifteen ft alleys separated plots. Sampling for tarnished plant bugs was performed weekly for five weeks using drop cloth samples across 2 adjacent rows (1.5 ft samples per row). Number of nymphs and adults were recorded, and variation in average number of collected insects per 3 ft was analyzed using AOV separately for each date. Plants were monitored in each plot from the early squaring period through cutout using the COTMAN™ crop monitoring system (Danforth and O'Leary 1998). Two sets of five consecutive plants in the center rows were monitored weekly using the Squaremap sampling procedure which includes measurement of plant height, number of main stem sympodia, and presence or absence of first position squares and bolls. After 1st flowers, Bollman sampling was used to monitor nodes above white flower (NAWF) (only plants with mainstem 1st position white flowers are inspected). Squaremap sampling of consecutive plants was continued to monitor square and boll retention and sympodial growth. Additional assessments to evaluate treatment effects on crop maturity included Nodes above Cracked Boll (NACB) determinations made on 26 Aug. Ten plants were inspected per plot. Defoliant and boll opener were applied 7 Sep. Final plant mapping was performed 14 Sep using COTMAP protocol (Bourland and Watson 1990). Ten plants in 2 interior rows per plot were examined for node number of first (lowest) sympodial branch on the main axis, number of monopodia, and number of bolls on sympodia arising from monopodia. Bolls located on main stem sympodia (1st and 2nd position) were recorded, as well as bolls located on the outer positions on sympodial nodes (>2nd position). The highest sympodium with 2 nodal positions and number of bolls on sympodia located on secondary axillary positions were also noted. Plant height was measured as distance from soil to apex. Boll samples were collected for HVI quality assessments on 16 Sep. Fifty consecutive bolls from adjacent plants were collected in each treatment plot; samples were ginned and submitted to the International Textile Center at Texas Tech University for HVI fiber quality determinations. Rows 3&4 of each plot were machine harvested 21 Sep. All plant monitoring and yield data were analyzed using AOV with mean separation using LSD.

Results and Discussion

The 2005 crop season featured moderate summer temperatures with sporadic rainfall in July and August (Figs 1, 2). Rainfall accumulations in May, June, July, Aug, and Sep (until harvest) were 1.01, 1.34, 3.79, 4.22, 0.29 inches, respectively. Because of Aug rainfall, the late irrigation termination treatments were confounded, and treatments 3, 4 and 5 received equal irrigations. Only data from designated treatment 3 were used in analyses – treatments 4 and 5 were dropped.

Sympodial development in the 2005 experiment was comparable to the COTMAN target development curve (TDC) through the season; plant structure at 1st flowers for all plots was slightly lower than the TDC (mean 1st NAWF = 8.6) (Figs 3, 4). Plants in all treatments reached physiological cutout (mean NAWF=5) on 30 July, 80 days after planting. Neither irrigation nor insecticide termination timing affected days to cutout. Effects of irrigation termination were not apparent in COTMAN measures until 90 days after planting (DAP) when there was significantly higher % square shed associated with early irrigation termination (P>F=0.01). Final end-of-season plant mapping results showed no significant irrigation effects (Table 4). The later irrigation did tend to delay crop maturity as measured by NACB (Fig 6). Mean yields were numerically higher where irrigation was continued through cutout in 2005 (P>F=0.07) (Fig 7). Fiber quality measures (HVI analysis of 50 boll samples) indicate significant differences in fiber elongation related to irrigation termination; no significant insecticide effects were noted (Table 6 and Fig 9).

There were low numbers of tarnished plant bugs pre-flower and low to moderate numbers after 1st flowers (Table 3). Numbers increased in August, and late season population densities exceeded action thresholds recommended in some Midsouth states. By 90 DAP, % shed of 1st position fruiting forms (squares + bolls) were numerically higher in the early insecticide termination treatment compared to treatment plots where additional sprays were made

(P>F=0.08). There were no significant insecticide or insecticide*irrigation interaction effects on square, boll or total 1st position shed (Figs 4&5). End of season mapping results indicate that significantly fewer 2nd position bolls were retained where insecticide applications were terminated just after 1st flowers (Table 5). Insecticide applications to eliminate late season bugs provided no significant yield response (Fig 8), although mean yield from plots receiving sprays terminated at NAWF=5+95 and NAWF=5+413 DD60s were numerically higher (P>F=0.44) than from early termination treatments. There also was no significant insecticide*irrigation interaction (P>F=0.15).

The first year of this study in 2004, unlike 2005, was characterized by high population densities of plant bugs season-long and dry conditions in late season. Termination of insecticide and irrigation in 2004 prior to physiological cutout resulted in significant yield penalties compared to later termination dates (Teague et al 2005). There was a point in 2004 when late season applications were no longer beneficial. Extending insecticide sprays past 240 DD60s after physiological cutout (NAWF=5) or irrigation beyond 350 DD60s after NAWF=5 did not significantly improve yields. These results and other previous research (Danforth et al 2004, Greene et al. 2002, Horn et al. 1999, Teague et al 2002) indicate that the insect control termination guide in COTMAN that has been in use for heliothine caterpillars and boll weevils (NAWF=5 +350 DD60s) is more than sufficient for late season plant bug management. Timing of the final furrow irrigation also may be appropriate at this same crop stage (Vories et al 2000, 2001, 2002, 2003, 2004). No results from replicated research trials from annual Marianna studies begun in 2001 or from northeast Arkansas (Mississippi County) since 1999 indicate that prolonging irrigation or insecticide sprays for TPB after 350 DD60s increased yields.

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Table 1. Mean number of days after planting and calendar dates at which plants reached physiological cutout (mean NAWF=5) in irrigation main effects and insecticide termination sub- plot effects (Marianna 2005).

Treatment [1]	Date of final application	Days after planting	Crop maturity status at final application	Mean date of physiological cutout[2]	Mean no. days to cutout[3]
Irrigation	19-Jul	69	NAWF = 7.1	31-Jul	80.9
	31-Jul	81	NAWF = 5	31-Jul	80.8
	14-Aug	95	NAWF = 5 + 300 DD60s	31-Jul	81.0
Insecticide	8-Jul	58	NAWF = 8.6	31-Jul	81.0
	23-Jul	73	NAWF = 7.1	31-Jul	81.0
	4-Aug	85	NAWF = 5 + 95 DD60s	31-Jul	80.9
	19-Aug	100	NAWF = 5 + 413 DD60s	31-Jul	80.7

[1]Irrigation dates: 5, 17, 26, 30 June, 19, 24, 31, 05, 14 Aug; insecticide application dates: 16 June, 8, 23 Jul, 4 12, 19 Aug.

[2]Mean date at which treatments reached mean NAWF = 5.

[3]No significant main, subplot effects or interactions .

Table 2. Application timing, products and crop status at the time of final application in insecticide termination sub-plots.

Application Date	Product (rate/acre)	Termination Treatment (crop status)
16-Jun	Centric (2 oz)	
08-Jul	Orthene 90S (0.5 lb)	Treatment 1 final spray (NAWF =8.6)
23-Jul	Trimax (3.75 oz)	Treatment 2 final spray (NAWF =7.1)
04-Aug	Bidrin (8 oz)	Treatment 3 final spray (NAWF = 5 +95 DD60s)
12-Aug	Orthene 90S (0.5 lb)	
19-Aug	Orthene 90S (0.6 lb)	Treatment 4 final spray (NAWF = 5 + 413 DD60s)

Table 3. Mean no. of tarnished plant bugs observed for each sample date following initiation of insecticide termination test (no significant irrigation effects were noted and are not shown).[1]

Insecticide Termination Date			Mean no. bugs/3ft on each sample date (DAP)				
Date	**DAP**	**Crop Phenology**	**26-Jul (76)**	**03-Aug (84)**	**09-Aug (90)**	**16-Aug (97)**	**26-Aug (107)**
08-Jul	58	NAWF= 8.6	4.7	5.4	8.7	6.0	0.53
23-Jul	73	NAWF= 7.1	2.7	3.2	4.9	6.3	0.27
04-Aug	85	NAWF= 5 + 95 DD60s	2.1	3.4	2.7	3.0	0.20
19-Aug	100	NAWF= 5 + 413 DD60s	3.0	2.1	2.1	0.8	0.47
		P>F	*0.02*	*0.02*	*0.001*	*0.04*	*0.40*
		LSD_{05}	*1.2*	*1.4*	*2.1*	*3.8*	

[1]One drop cloth sample was taken per plot (1.5 ft on 2 adjacent rows = 3 ft of row).

Table 4. Results from 2005 final end-of-season plant mapping using COTMAP following defoliation for irrigation termination main plot treatment effects1.

	Mean per plant for each irrigation termination treatment				
Category	**NAWF =7.1**	**NAWF = 5**	**NAWF = 5 +300 DD60s**	**P>F**	**LSD_{05}**
1st Sympodial Node	6.1	6.1	6.1	0.89	
No. Monopodia	2.5	2.2	2.2	0.45	
Highest Sympodia with 2 nodes	10.6	11.0	10.9	0.29	
Plant Height (inches)	45.4	45.3	46.0	0.45	
No. Effective Sympodia	10.0	9.8	10.4	0.07	
No. Sympodia	14.6	15.1	14.9	0.37	
No. Sympodia with 1st Position Bolls	4.7	4.7	4.8	0.85	
No. Sympodia with 2nd Position Bolls	1.6	1.5	1.5	0.88	
No. Sympodia with 1st & 2nd Bolls	2.5	2.4	2.6	0.67	
Total Bolls/Plant	15.0	14.3	15.2	0.58	
% Total Bolls in 1st Position	48.9	50.4	49.9	0.77	
% Total Bolls in 2nd Position	27.0	26.9	27.4	0.87	
% Total Bolls in Outer Position	8.3	9.0	9.5	0.53	
% Total Bolls on Monopodia	14.5	12.0	11.6	0.21	
% Total Bolls on Extra – Axillary	1.3	1.6	1.6	0.81	
% Boll Retention - 1st Position	49.1	46.9	50.0	0.53	
% Boll Retention - 2nd Position	38.0	35.0	38.0	0.28	
% Early Boll Retention	56.8	56.8	55.3	0.84	
Total Nodes/Plant	19.7	20.1	20.1	0.56	
Internode Length (inches)	2.3	2.3	2.3	0.61	

[1] means of 10 plants per plot

Table 5. Results from 2005 final end-of-season plant mapping using COTMAP following defoliation for insecticide termination sub-plot treatment effects[1].

	Mean per plant for each insecticide termination treatment					
Category	**NAWF =8.6**	**NAWF = 7.1**	**NAWF = 5 +95 DD60s**	**NAWF = 5 +413 DD60s**	**P>F**	**LSD_{05}**
1st Sympodial Node	6.2	6.1	6.2	5.9	0.21	
No. Monopodia	2.3	2.2	2.1	2.3	0.25	
Highest Sympodia with 2 nodes	10.8	10.8	11.1	10.9	0.87	
Plant Height (inches)	45.0	45.5	45.8	45.5	0.85	
No. Effective Sympodia	9.7	10.2	10.2	10.3	0.15	
No. Sympodia	14.9	14.8	15.1	14.9	0.92	
No. Sympodia with 1st Position Bolls	4.7	4.8	4.9	4.8	0.95	
No. Sympodia with 2nd Position Bolls	1.4	1.5	1.5	1.6	0.45	
No. Sympodia with 1st & 2nd Bolls	2.2	2.6	2.5	2.6	0.34	
Total Bolls/Plant	13.4	14.9	15.0	15.7	0.11	
% Total Bolls in 1st Position	52.4	49.5	50.8	47.9	0.31	
% Total Bolls in 2nd Position	26.4	27.5	27.1	27.2	0.84	
% Total Bolls in Outer Position	8.7	9.0	8.5	9.9	0.77	
% Total Bolls on Monopodia	10.7	12.3	12.0	13.5	0.55	
% Total Bolls on Extra – Axillary	1.7	1.7	1.5	1.6	0.93	
% Boll Retention - 1st Position	46.3	49.7	49.1	49.6	0.14	
% Boll Retention - 2nd Position	33.0	37.7	36.4	39.0	0.03	4.1
% Early Boll Retention	54.9	56.8	55.6	57.1	0.74	
Total Nodes/Plant	20.1	19.9	20.2	19.9	0.76	
Internode Length (inches)	2.2	2.3	2.3	2.3	0.43	

[1] means of 10 plants per plot

Table 6. Means for HVI classing data for 50 boll samples collected throughout consecutive plants on consecutive fruiting sites, Marianna AR 2005 – irrigation main effects.

Final Irrigation Timing	**Micronaire**	**Length**	**Uniformity**	**Strength**	**Elongation**	**Leaf**
NAWF = 7.1	4.17	1.06	82.18	28.35	4.37	1.75
NAWF = 5	4.07	1.09	82.66	29.03	4.64	1.75
NAWF = 5 + 300 DD60s	4.51	1.08	82.75	28.86	4.82	1.50
P>F Irrigation(I)	*0.07*	*0.098*	*0.07*	*0.64*	*0.001*	*0.16*
P>F Insecticide (B)	*0.65*	*0.65*	*0.31*	*0.94*	*0.9*	*0.11*
*P>F I*B*	*0.96*	*0.11*	*0.5*	*0.14*	*0.86*	*0.07*

[1] Determinations made at International Textile Center, Texas Tech University, Lubbock.

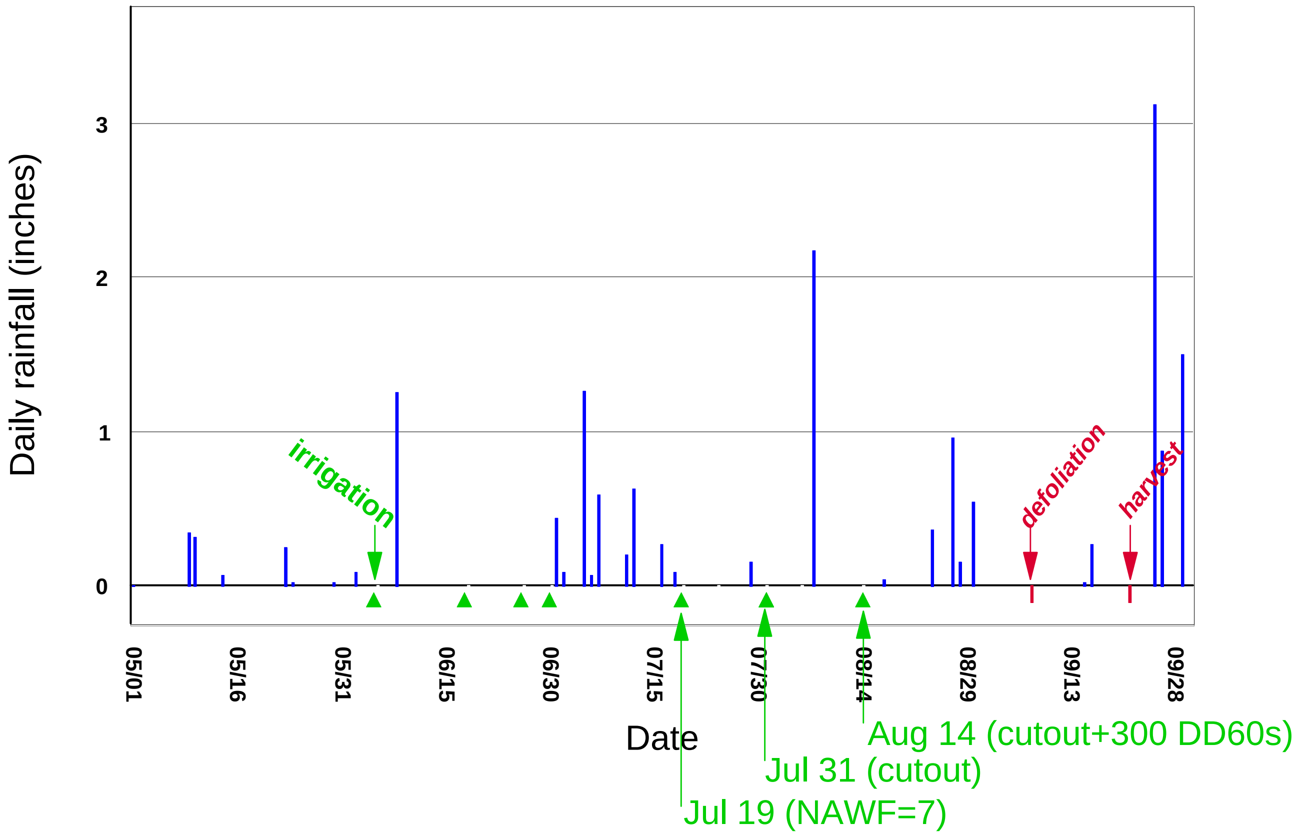

Figure 1. Rainfall accumulations for Cotton Branch Station summer 2005 with dates of irrigation and final irrigation treatments (19 July, 31 July and 14 August). The experiment was designed with 5 irrigation termination treatments, but late season rains forced abandonment of 2 late treatments. Application of harvest aid defoliant/boll openers was made 7 Sept, and plots were picked 21 Sept.

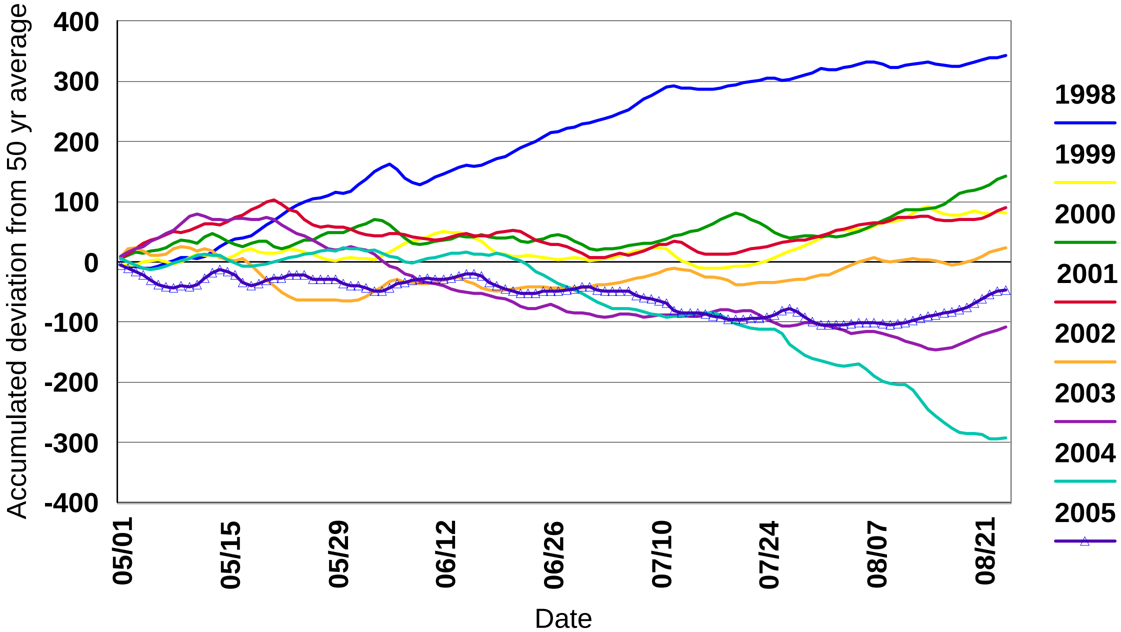

Figure 2. When compared to the 50 year average DD60 accumulation (presented as the standard (zero)), the graph of cumulative deviations that the 2005 temperatures in Mariana were slightly cooler with summer temperature trends similar to those observed in 2003 and 2004. The 2005 crop in NE Arkansas was one of the best on record; the 2004 crop is ranked as historical best.

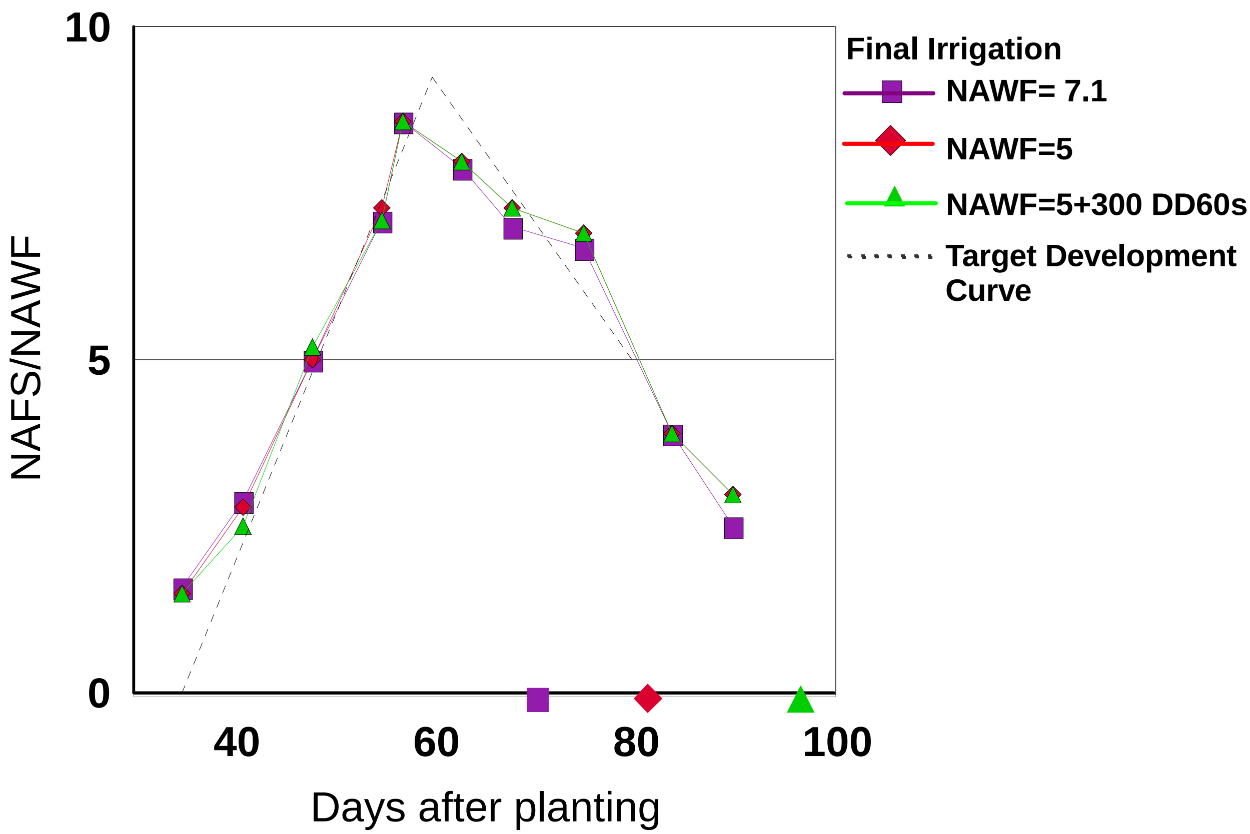

Figure 3. The COTMAN target development curve (TDC) and COTMAN growth curves of plants for irrigation termination main effects. Final irrigation dates are indicated for each termination date on x-axis. Nodes above first square (NAFS) measures were made with Squaremap sampling prior to first flowers, and nodes above white flower (NAWF) measures were taken from Bollman sampling that began 56 days after planting.

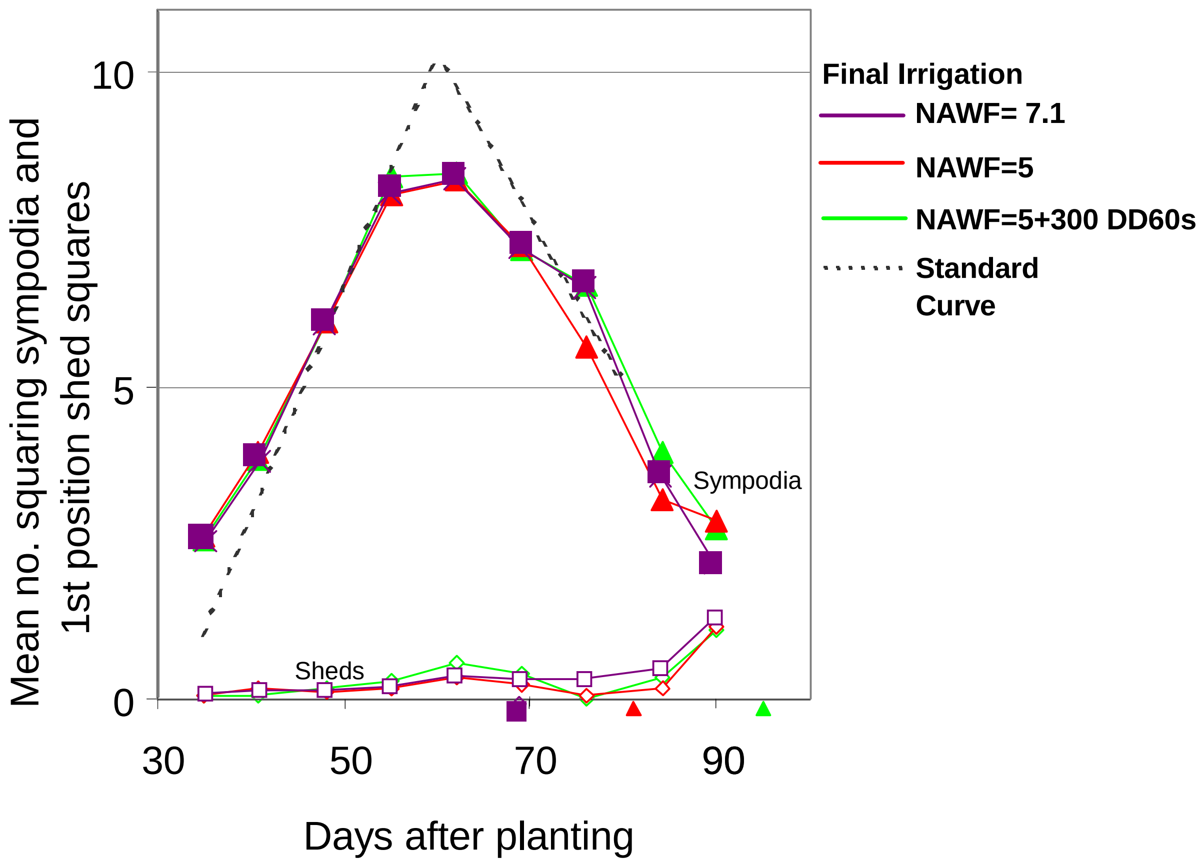

Figure 4. Mean number of squaring sympodia and shed 1st position squares for 3 irrigation termination treatments. Growth curves represent season-long Squaremap monitoring of consecutive plants; standard curve represents actual squaring nodes season-long rather than nodes above first square. There were no differences associated with insecticide or insecticide*irrigation interactions for square shed levels. Irrigation main plot effects for % square shed were significant only at 90 days after planting where significantly higher shed levels were observed in the early termination treatment compared to the 2 later termination dates (P=0.002).

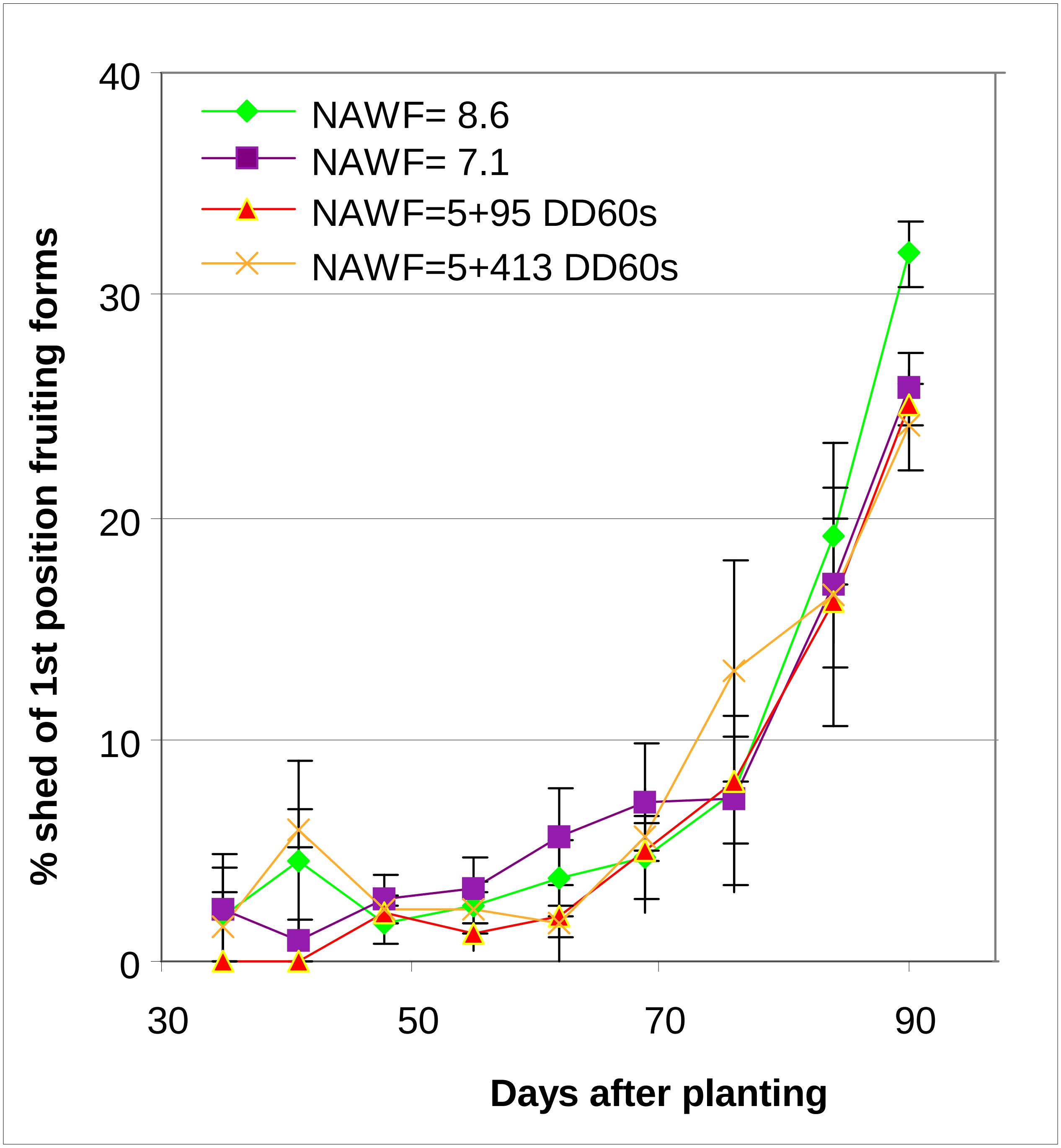

Figure 5. Mean % shed (±SE) of 1st position fruiting forms season long for insecticide sub-plot effects. Pre-flower square shed levels were low; shed rates of small bolls and squares increased in late season as plants reached physiological cutout.

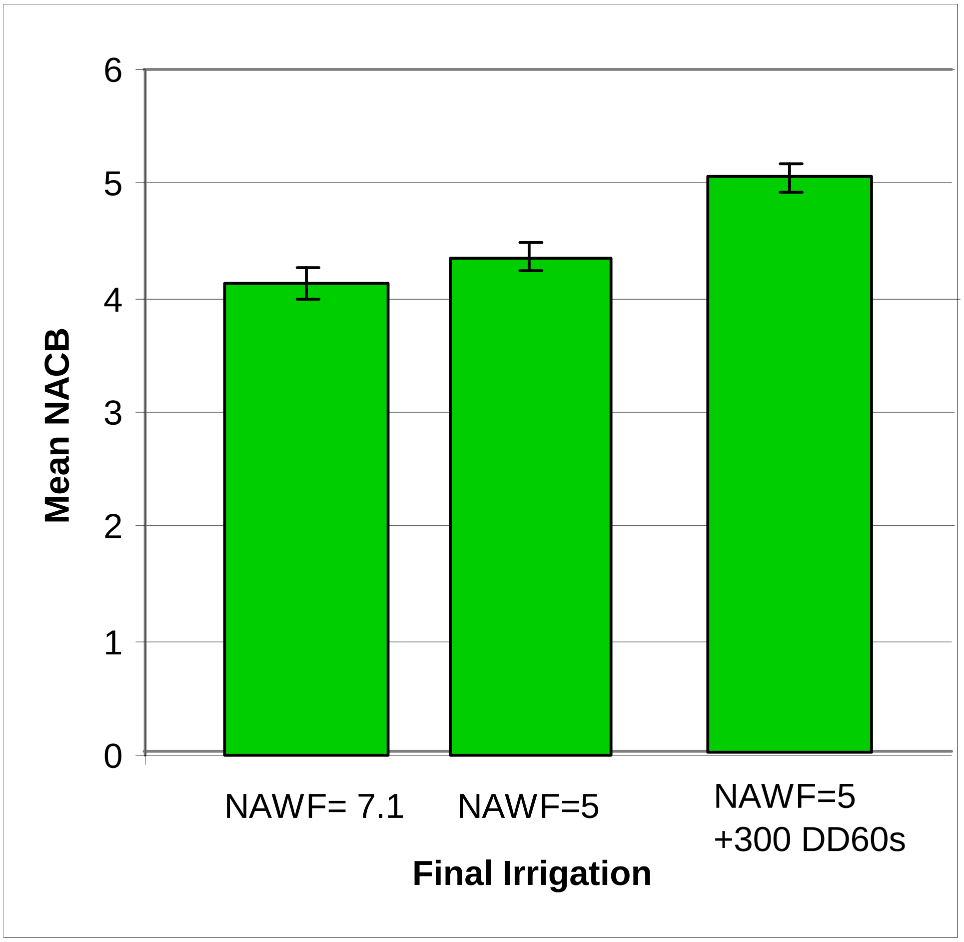

Figure 6. Mean nodes above cracked boll (NACB) values observed 26 Aug for irrigation main effects (P>F=0.02). There were no significant insecticide or irrigation*insecticide interactions.

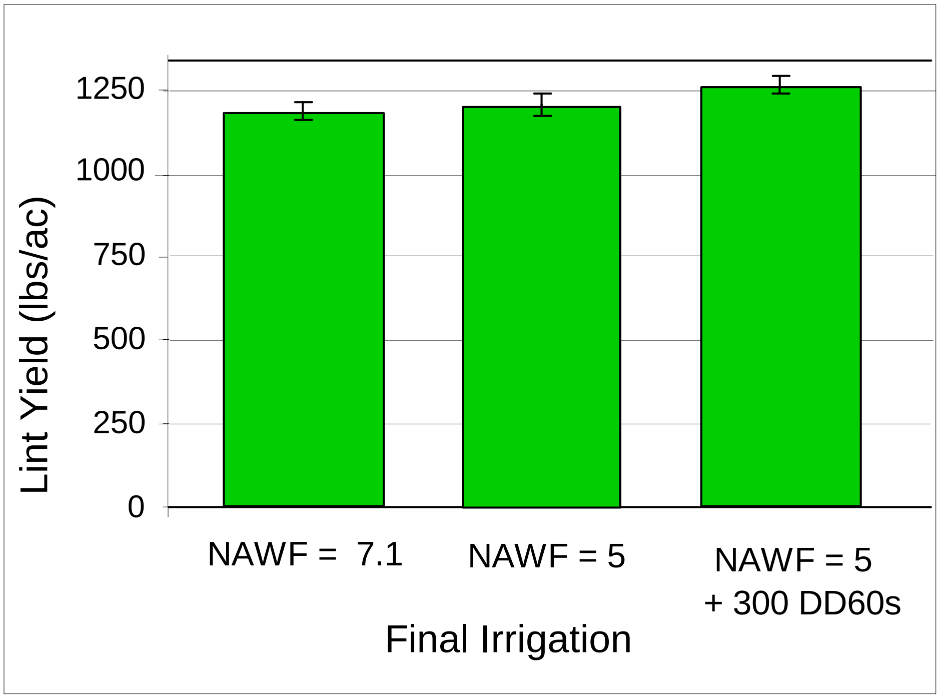

Figure 7. Mean lint yields for Irrigation main plot effects ((AOV, P>F=0.07) for 3 different final irrigation dates).

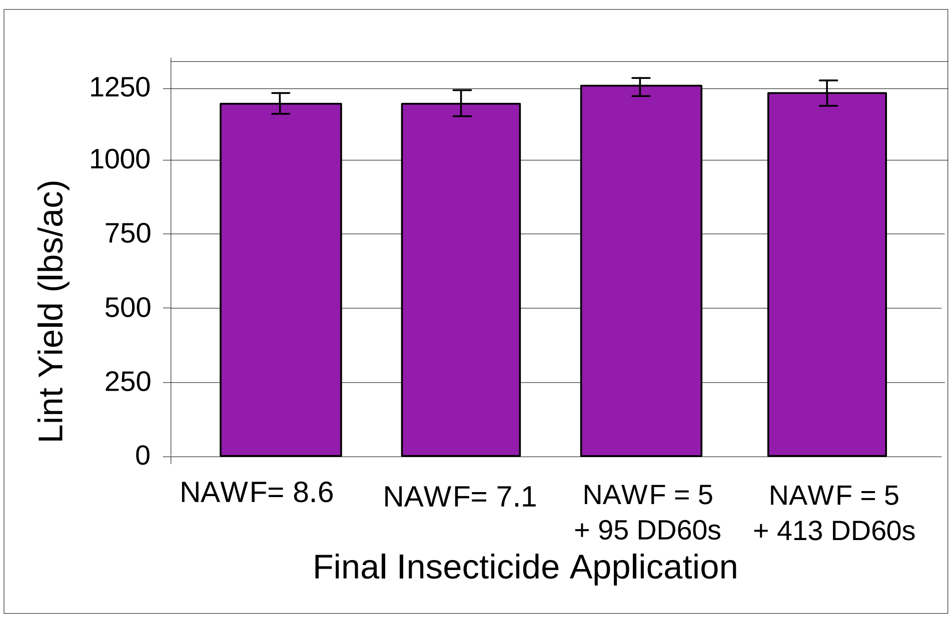

Figure 8. Mean lint yield following termination of insecticide applications for tarnished plant bug at 4 different dates in 2005 (Insecticide sub-plot effects (AOV; P>F=0.44)).

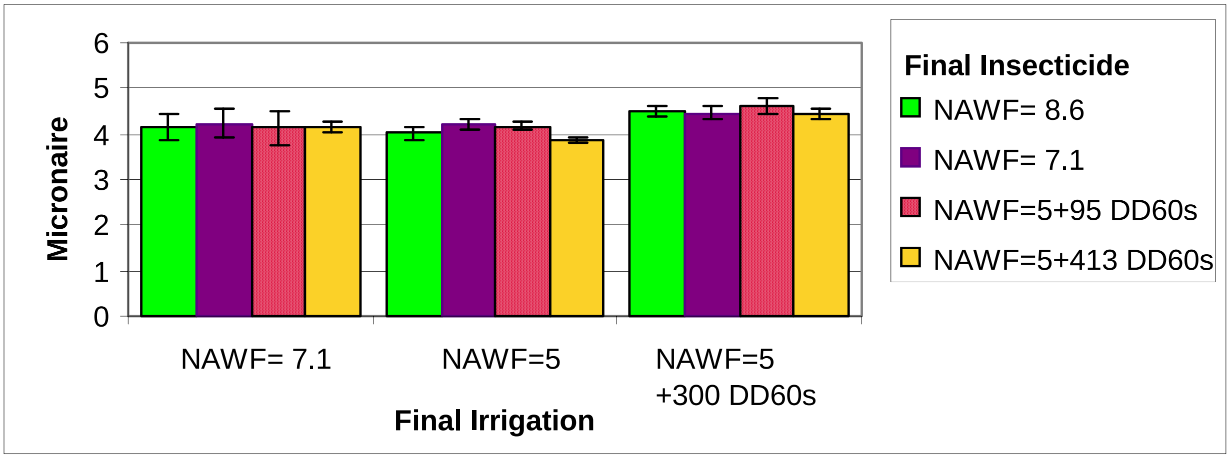

Figure 9. Mean micronaire values (±SEM) from HVI testing of 50- boll samples taken from consecutive plants and fruiting sites just prior to harvest from each plot (AOV; Pr>F=0.08 for irrigation main effects; there were no significant insecticide or irrigation*insecticide interactions).