IRRIGATION TIMING AND TARNISHED PLANT BUG MANAGEMENT – IMPLICATIONS FOR LATE SEASON SUSCEPTIBILITY TO TARNISHED PLANT BUG AND CROP TERMINATION DECISIONS-YEAR III

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Abstract

In the final year of a three-year study, effects of early and late season feeding injury by tarnished plant bug (*Lygus lineolaris* (Palisot de Beauvois)) were evaluated across 5 different irrigation timing regimes. One aim of this study was to determine if the COTMAN termination guides should be revised to take into account late season crop growth anomalies following pre-flower water deficit stress and early season feeding injury from insects. Results in 2010 were similar to 2008 and 2009 findings. Irrigation starting at first flowers resulted in a 26% increase in yield compared to rainfed cotton, but early irrigation initiation resulted in a 61% increase in yield compared to rainfed cotton. Waiting until first flowers to start irrigation also resulted in crop delay. Number of days to physiological cutout was 9 days longer if irrigation was delayed compared to early initiation. Rainfed cotton was water stressed much of 2010, and plants reached cutout at 68 days after planting - 28 days earlier than early irrigated cotton. Irrigation timing to avoid pre-flower water deficits is critical in Arkansas cotton to manage for high and early yields. Providing an extra week of irrigation in late season did not compensate for the early water deficit stress; such late season, post cutout irrigations may not contribute to yield and can delay maturity extending the time the crop is attractive and vulnerable to late season insect pests.

Plant bug feeding damage resulted in significant reductions in yield in 2010 in the untreated check. Highest yields were observed when cotton was protected from plant bugs from the first week of flower through cutout, but an additional application made in late season (seasonal cutout +330 DD60s) did not affect yield. The COTMAN termination endpoint for boll protection of cutout + 250 DD60 appears valid for tarnished plant bug control termination. Adjustments in defining the cutout date - when to start heat unit accumulation - may be required when a crop has suffered pre-flower stress. If the crop maturity is delayed past the latest possible cutout date, seasonal cutout guides should be employed, and heat unit accumulations started at that time.

Introduction

Termination timing for insect control based on decision guides in the COTMAN system has become a standard recommended practice in Arkansas cotton production (Danforth and O'Leary 1998, Oosterhuis and Bourland, 2008). Decision makers first determine the flowering date of the last effective boll population, that last cohort of flowers that produce bolls that contribute to economic yield. This is called cutout. If a field reaches physiological cutout (average number of nodes above white flower=5 (NAWF=5)) (Bourland et al 1992) in late July or early August in Arkansas, then heat units (DD60s) are accumulated from the NAWF=5 date. Otherwise, DD60s are accumulated from a seasonal cutout date based on historical weather for that production region. Typically a boll needs 850 DD60s to mature with acceptable size and quality. The weather-restricted, seasonal cutout date is the calendar date on which there is a 50% probability that the crop will have the benefit of late season temperatures sufficient to develop a mature boll. Seasonal cutout dates range across the state from late July in the north to late August in the south. When that last effective boll population has accumulated 350 DD60s the crop has been shown to be safe from new infestations of the most significant boll feeding insect pests in Midsouth history: boll weevil, tobacco budworm and bollworm. The protection endpoint for new infestations of tarnished plant bug is slightly earlier, cutout + 250 DD60s.

When metabolic stress from boll loading is reduced because of loss of fruiting forms -- small bolls because of physiological stress or squares because of insect feeding --- crop maturity is delayed. Terminal growth continues in late season, with NAWF values "hovering" around 5. Values may dip below 5 earlier than expected and then increase again later in the season. Such late season "rank growth" produces highly attractive squares just in time for the season's highest population densities of plant bugs. Crop advisors may be uncertain on when to define cutout for the field – when to start the clock for heat unit accumulation for late-season decision-making. It is a familiar dilemma for managers of this perennial crop….. When to quit?

The aim of this Cotton Incorporated Arkansas State Support Committee sponsored study was to determine if the COTMAN guides should be revised to take into account late season crop growth anomalies following stress. In this final year of a 3-year study, field trials in 2010 were established in Lee County in the central Delta region and in Mississippi County, in the northeast. The Mississippi County results are summarized in this report.

Materials and Methods

The experiment was conducted in a commercial cotton field at Wildy Farms located in Northeast Arkansas near Leachville. The growing season is May through October. The latest possible cutout date in 2010 (that date with an 85% probability of attaining 850 DD60s) for this production area based on 49 years of historical weather data was 2 Aug (Zhang et al. 1994 and Danforth and O'Leary 1998). The cultivar Stoneville 5458 B2RF was planted 30 April 2010. Plant population density was ca. 3 to 4 plants per ft of row on raised beds spaced at 38 inches. The grower's practices for fertility, weed control, plant growth regulator application and defoliation were followed through the season; only irrigation and insecticide inputs were varied for the study. Treatments were re-randomized after the 2009 season. The sandy soil was a Routon-Dundee-Crevasse Complex.

Two factors were evaluated: furrow irrigation timing (5 levels) and timing of plant bug induced injury (5 levels). The 5*5 split-plot factorial experiment was arranged in a randomized complete block design. There were 3 replications. Bug induced crop injury treatments were considered subplots within irrigation main plots. Plots were 75 ft long, 8 rows wide with 4 row buffers. Fifteen ft alleys separated plots. Irrigation treatments were: 1) early initiation followed by early termination (Early-Early), 2) early initiation followed by late termination (Early-Late), 3) late initiation and early termination (Late-Early), 4) late initiation and late termination (Late-Late) and 5) no supplemental irrigation (Rainfed). Timing details are listed in Table 1

The five levels of plant bug induced injury were accomplished by manipulating plant bug numbers either by manually releasing bugs, ("B"), leaving plots untreated ("O") or applying insecticide sprays ("S"). Plant bug treatments were: 1) Plant bugs early (manually applied pre-flower), mid-season sprays and plant bugs late (field population of plant bugs allowed to feed) (B-S-O); 2) Plant bugs released early followed by mid and late season insecticide sprays (B-S-S); 3) early, mid and late sprays (S-S-S); 4) early and mid sprays but no late spray (S-S-O); and 5) no manually applied bugs or insecticide sprays applied season long (O-O-O). Timing details and product selection are listed in Tables 1 and 2.

In the center portion of each plot, a 10 ft section of 2 adjacent rows was selected for all plant sampling, yield assessments and, where appropriate, for pre-flower plant bug releases to supplement native populations. Plant bug nymphs were released in the first week of squaring (Table 1). Third and fourth instar plant bug nymphs were applied at 1 to 2 bugs per row foot. Confetti-sized strips of shredded white copy paper (0.5 cm wide and 10 to 20 cm long) on which the nymphs were resting were laid across the terminal leaves of plants to be infested. The paper strips lined the rearing containers, and the nymphs clinging to these paper strips crawled onto the plants. Bugs were released during the cool period of the morning just after dew had dried. Nymphs had been collected from weedy field borders near cotton fields in neighboring Craighead and Poinsett Counties 3 to 7 days prior to release. Insects were held in the ASU laboratory in plastic rearing cages and provided ears of sweet corn for food.

Table 1. Designations and timing (days after planting) of different irrigation and plant bug release and insecticide spray treatments at Wildy Farms, 2010, Leachville, AR.

Treatment Designation	Treatment timing (Days after planting) Pre-Flower	Mid-season thru cutout	Late
Irrigation Timing[1]			
Early-Early	17, 21, 24 June (48, 52, 55)	30 June, 8, 20 July, 4, 11 Aug (61, 69, 81, 96, 103)	None
Early-Late	17, 21, 24 June (48, 52, 55)	30 June, 8, 20 July, 4, 11 Aug (61, 69, 81, 96, 103)	19 Aug (111)
Late-Early	None	30 June, 8, 20 July, 4, 11 Aug (61, 69, 81, 96, 103)	None
Late-Late	None	30 June, 8, 20 July, 4, 11 Aug (61, 69, 81, 96, 103)	19 Aug (111)
Rainfed	None	None	None
Bugs[2] and Sprays[3]			
B-S-O	Bugs released 18, 23 June (49, 56)	Spray 15, 23, 30 July (76, 84, 91)	None
B-S-S	Bugs released 18, 25 June (49, 56)	Spray 15, 23, 30 July (76, 84, 91)	Spray 13 Aug (105)
S-S-O	Spray 6 July (63)	Spray 15, 23, 30 July (76, 84, 91)	None
S-S-S	Spray 6 July (63)	Spray 15, 23, 30 July (76, 84, 91)60)	Spray 13 Aug (105)
O-O-O	None	None	None

[1]Early and late initiation was followed by either early or late termination timing.
[2]Plant bug nymphs were released at levels of 1 to 2 bugs per foot of row at 49 and 56 DAP in bug ("B") designated treatments.
[3]Plots received insecticide sprays ("S") or were untreated ("O"). The native, field population densities of bugs increased in August. Bugs were allowed to feed ("O") or were controlled with insecticides ("S").

Table 2. Application timing and products for insecticide sprays in insect treatment plots – Wildy Farms, 2010.

Application date[1]	Days after planting	Product (rate/acre)	Plant bug treatment
2-July	63	Centric (2 oz/ac)	S-S-S, S-S-O
15-July	76	Orthene (0.5 lb/ac)	S-S-S, S-S-O, B-S-S, B-S-O
23-July	84	Bidrin 8 (6 oz/ac)	S-S-S, S-S-O, B-S-S, B-S-O
30-July	91	Diamond (9 oz/ac) + Orthene (0.75 lb/ac)	S-S-S, S-S-O, B-S-S, B-S-O
13-August	105	Diamond (8 oz/ac) + Orthene (0.75 lb/ac)	S-S-S, B-S-S

[1] A back pack sprayer with 4-row hand held boom was used for the 2 July application. All other insecticide applications were made with a high clearance tractor mounted sprayer with 8 row boom.

Plant bug field population numbers were monitored season long using drop cloth sampling in treatment plots outside the 2 row plant sampling area. Variation in average number of collected nymphs and adults per drop was analyzed using AOV separately for each date.

Plant monitoring with COTMAN was carried out weekly from the early squaring period through cutout. Two sets of five consecutive plants were monitored weekly using the standard Squaremap sampling procedure. This includes measurement of plant height, number of main-stem sympodia, and presence or absence of first position squares and bolls. Care was taken to minimize handling sampled plants.

Defoliant was applied 2 September, which was 789 DD60s after seasonal cutout. Final plant mapping was performed 13 to 16 September using COTMAP sampling protocol (Bourland and Watson 1990). Plants 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 main-stem sympodia 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. Total numbers of bolls per plant displaying boll rot symptoms including "dry lock" also were recorded.

Commercial production fields across the region had early harvests in 2010; defoliant was applied on the commercial field surrounding this experiment on 26 August. In this study, weekly hand harvests in a single row, 10 ft long, in each plot sample area were made beginning 26 August and continued through 22 September. Cumulative seedcotton yield was determined. Lint yield was calculated based on 39% turn-out across all treatments to eliminate any turnout bias associated with the laboratory gin. An additional seedcotton sample was made on 23 September for fiber quality assessments. Fifty consecutive bolls, hand-picked from adjacent whole plants in the plot sample row, were collected, ginned on the laboratory gin and submitted to the Fiber and Biopolymer Research Institute at Texas Tech University for HVI fiber quality determinations. Additional yield component calculations were made using methods employed in the University of Arkansas variety testing program (Bourland et al. 2008). All plant monitoring and yield and quality data were analyzed using AOV with mean separation using LSD.

Results

Summer weather was hot and dry and conducive for inducing water deficit stress. Comparisons of 2010 temperatures and rainfall accumulations to a 47 year average for the region indicate in June through October heat units were 632 DD60s above average and rainfall amounts was 7.93 inches below average (Table 3).

Table 3. Average monthly heat unit (DD60s) and precipitation accumulation, 1960-2007 for NE Arkansas[1] compared to 2010 on-farm measurements at Wildy Farms.

	Heat Units (DD60s)		Rain (inches)		2010 Deviation from Average	
Month	Average	2010	Average	2010	Heat Units	Rainfall
June	532	768	3.89	0.63	236	-3.26
July	644	736	3.67	4.50	92	0.83
August	583	771	2.85	0.30	188	-2.55
September	363	479	3.73	0.78	116	-2.95
				Total	632	-7.93

[1]Source: NOAA National Climatic Data Center, daily surface data for Keiser, AR

Results from COTMAN crop monitoring indicate initial development of squaring nodes was early relative to the days after planting, when compared to standard target development curve (Figure 1). Significantly fewer total main-stem sympodia were observed at first flowers (56 days after planting (DAP)) on late-initiated and non-irrigated treatments compared to the early irrigated treatment (P=0.001, LSD=0.61). Mean no. of squaring nodes for the early irrigation was 8.0 compared to the COTMAN standard of 9.25 squaring nodes, but mean squaring nodes were 6.7 and 6.6 for late start and for non-irrigated treatments, respectively.

The only significant rain events of the season were at 64 (3 July, 0.3 inches), 74 (13 July, 1.4 inches), 77 (16 July, 1 inch), 87 (26 July, 0.5 inches) and 88 (27 July, 1.6 inches) days after planting. No irrigations were applied in those weeks. The COTMAN growth curves show renewed terminal growth in the rainfed plots following rains. Physiological cutout (mean NAWF = 5) was observed in rainfed cotton 68 DAP. Physiological cutout was observed at 96 DAP in early irrigated cotton. When irrigation start time was delayed, cutout was delayed until 105 DAP.

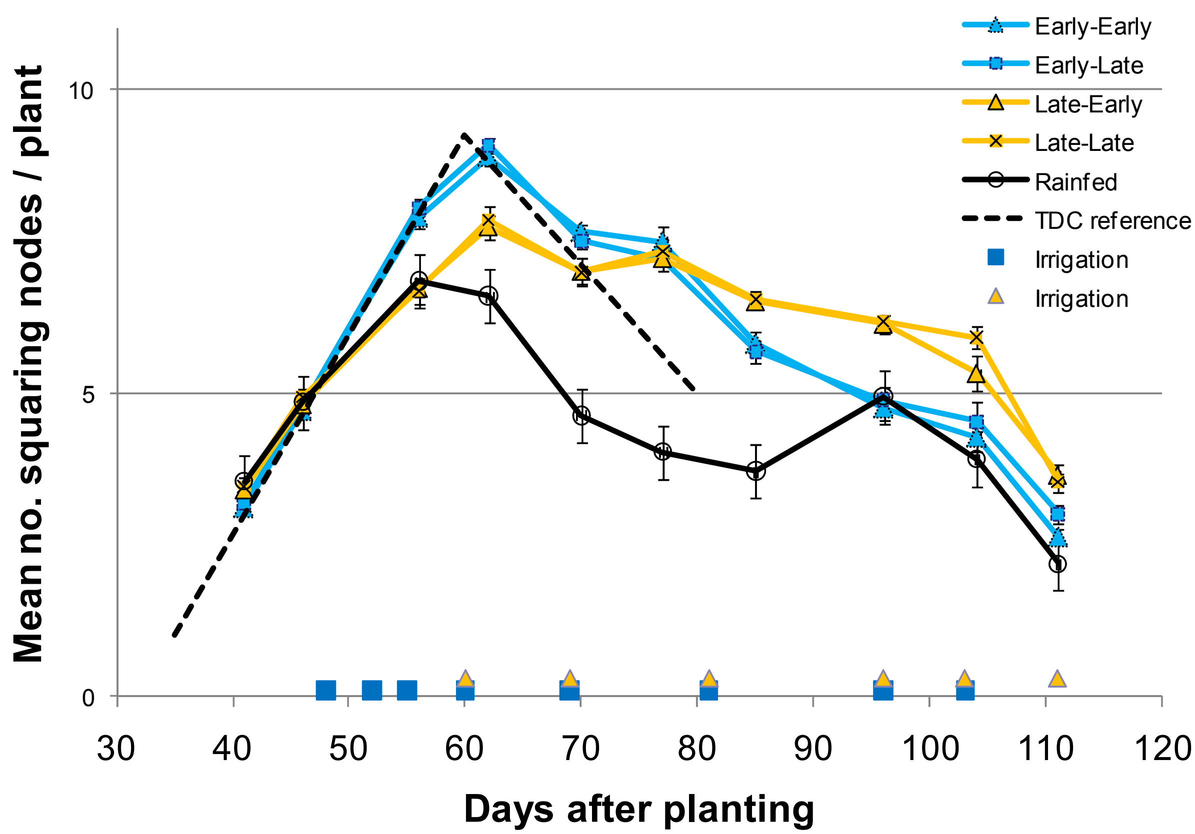

Figure 1. The COTMAN target development curve (reference), is presented along with the actual growth curves of plants in irrigation timing main plots shown as mean no. of squaring nodes (±SEM) per plant. Irrigation dates are indicated by blue squares on the x-axis for early irrigation start (48, 52, 55 DAP) and yellow triangles that show timing for late irrigation termination (111 DAP).

Between 70 and 91 DAP, squaring node counts for plants from rainfed or delayed irrigation plots did not decline at a similar pace as that observed for plants receiving early irrigation. A NAWF growth curve that "flattens" out rather than following the slope of the COTMAN target development curve can be interpreted an indication that plants are undergoing low levels of "metabolic stress", and boll filling may not be at a desirable level (Bourland et al 2008). Results from other COTMAN measurements from this same period, indicated significant differences in small boll retention among irrigation treatments (Figure 2.). Using the Squaremap portion of COTMAN, presence or absence of the first position bolls in the uppermost three mainstem sympodia is used for monitoring % small boll shed. Mean % small boll shed was 11.7% for early irrigated cotton at 77 DAP compared to 30 to 35% shed in rainfed or delayed irrigation cotton (P=0.001). Small boll retention differences were considered to be associated primarily with physiological boll shed. Differences in shed levels among irrigation treatments were observed in both protected (sprayed) and non-protected cotton, with only slightly higher levels of shed where plant bugs had been released. Mean small boll shed at 77 DAP in untreated, sprayed and manually infested cotton was 22, 21 and 27%, respectively (P=0.07).

The hot, dry conditions during and following plant bug manual releases was not conducive to insect survival. Sentinel plots located outside the experimental area were used to provide a gauge of plant bug survival, and at 24 hrs after the initial release, drop cloth sampling in the sentinel plots indicated less than 1 plant bug nymph per 3 ft of row. In previous years using the same methodology, plant bug recovery has ranged from 8 to 11 nymphs per sample. With few exceptions, the low survival resulted in low levels of square shed; retention levels were similar among sprayed and untreated plants (Figure 3). Natural field populations likely had greater overall impact on fruit retention and plant response observed in late season (Figure 4)

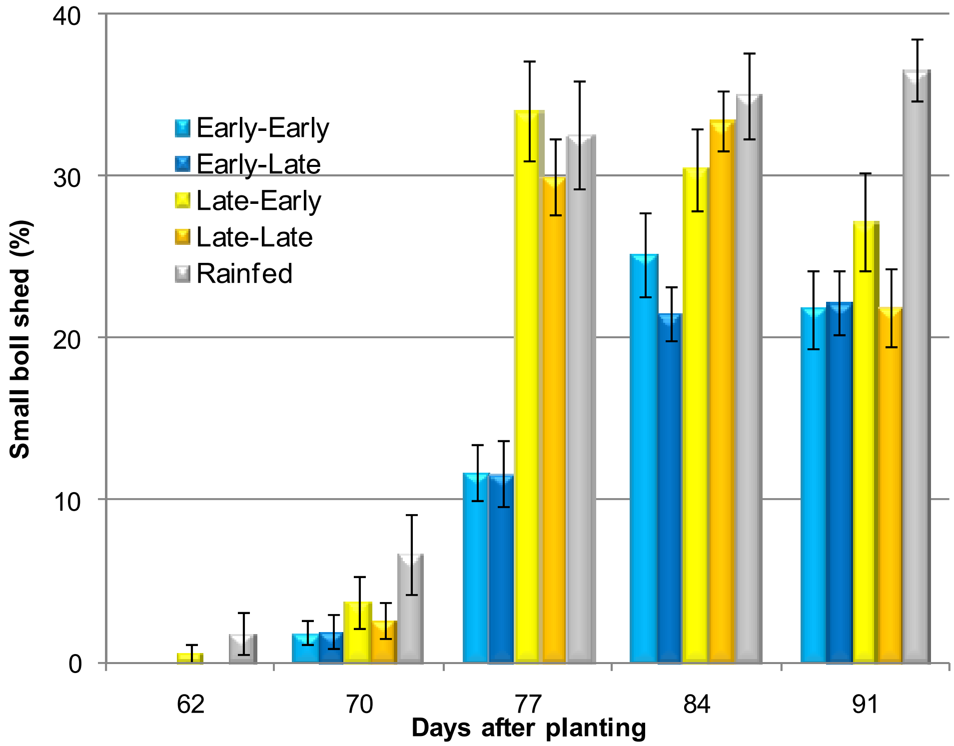

Figure 2. Mean % shed of "top three" 1st position small bolls (±SEM) for the five irrigation timing main effects. Small boll shed was significantly reduced on 77 DAP sample date (P=0.001) where irrigation was applied starting at 48 DAP rather than waiting until 60 DAP and thereby reducing pre-flower water deficits**.**

Tarnished plant bug field population numbers were low through most of the early season (Figure 4). Action levels for plant bugs (3 bugs/drop cloth sample) were exceeded by 69 DAP. Numbers continued to increase in the untreated check (O-O-O), but insecticide applications at 84 and 91 DAP were sufficient to keep bug numbers low in protected treatments. After 91 DAP, no further sprays were made in the early termination treatments (B-S-O and S-S-O). A late season increase in bug numbers that occurred after cutout +250 DD60s created an opportunity for validating the COTMAN insect control termination guide. At 105 DAP (cutout + 330 DD60s), an additional application of insecticide was made in treatments B-S-S and S-S-S. Plant bug numbers by 118 DAP ranged from 4 to 5 nymphs per drop cloth sample where no sprays were applied compared to 0 to 1.2 bugs where cotton had received the additional insecticide spray.

For main plot irrigation effects, plant bug sampling data in 2010 was quite variable in late season. There were no significant differences in numbers of plant bug associated with irrigation timing nor were there significant bug treatment*irrigation interactions.

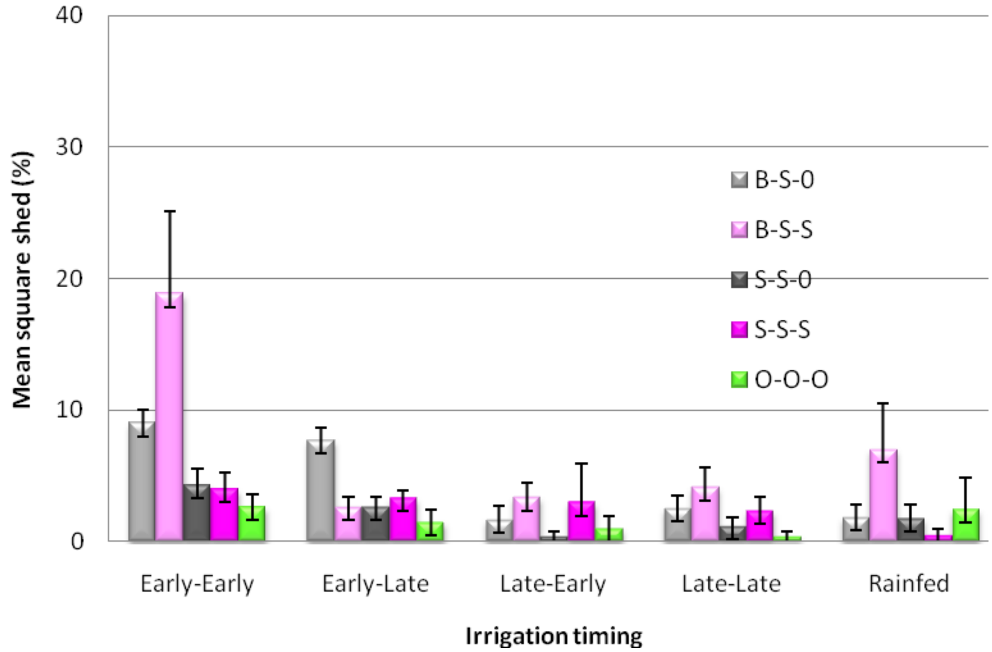

Figure 3. Mean % shed of 1st position squares (±SEM) at 62 DAP, first week of flowers. Plant bugs were released (B-S-O and B-S-S) at 49 and 56 DAP, but survival was reduced due to hot, dry conditions.

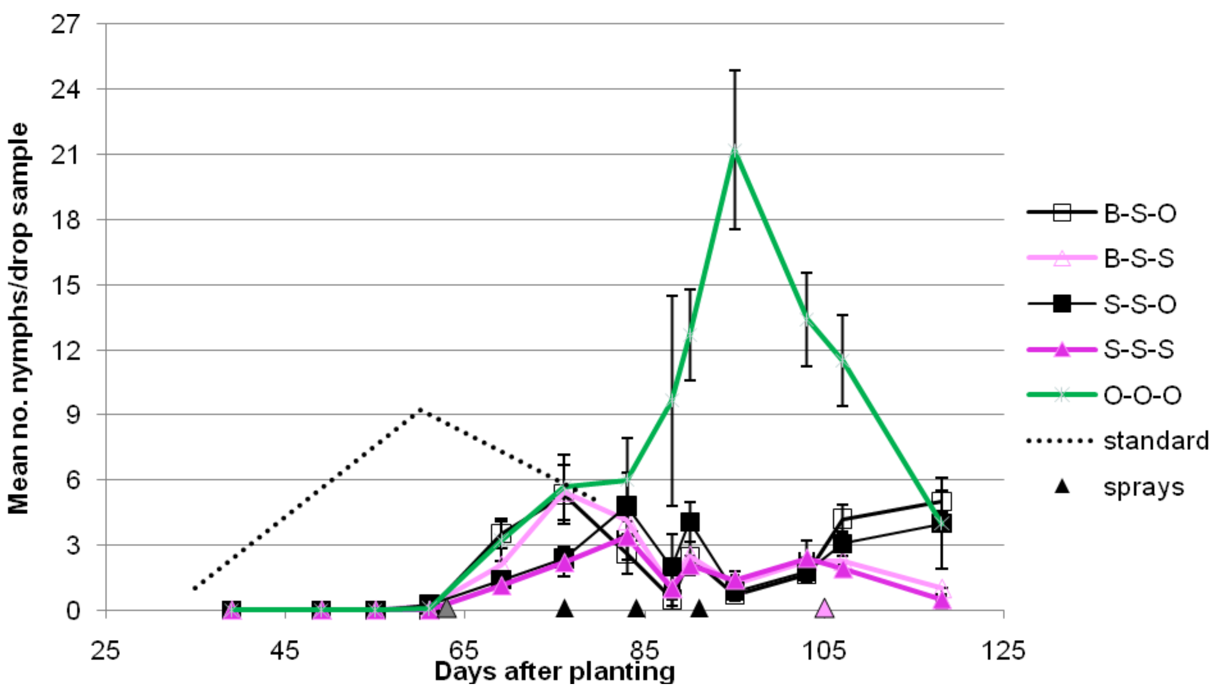

Figure 4. Mean no. tarnished plant bug adults and nymphs (±SEM) observed per drop cloth sampled by beating plants over a 2.5 ft black cloth positioned in rows outside the plant sample/bug release rows. The final spray was made at 105 DAP, seasonal cutout + 330 DD60s, and that application reduced numbers in B-S-S and S-S-S treatments to below the recommended threshold of 3 bugs/sample threshold.

Table 4. Results from final end-of-season plant mapping using COTMAP for irrigation timing treatment main plot effects – 2010 Leachville[1].

Category	Mean per plant for irrigation treatment						
	Early – Early	Early – Late	Late - Early	Late - Late	Rainfed	*P>F*	*LSD_{05}*
1st Sympodial Node	5.9	5.8	5.8	5.7	5.7	*0.39*	
No. Monopodia	1.6	1.3	1.4	1.3	1.3	*0.09*	
Highest Sympodia with 2 nodes	14.0	14.9	15.2	16.0	10.2	*0.001*	*1.5*
Plant Height (inches)	37.7	38.7	42.0	42.1	21.7	*0.001*	*6.3*
No. Effective Sympodia	11.3	10.9	10.9	10.6	7.4	*0.001*	*1.2*
No. Sympodia	17.9	19.1	19.4	20.4	14.6	*0.001*	*1.6*
No. Sympodia with 1st Position Bolls	5.3	5.0	4.7	4.8	3.8	*0.01*	*0.7*
No. Sympodia with 2nd Position Bolls	1.2	1.2	1.4	1.3	0.7	*0.09*	
No. Sympodia with 1st & 2nd Bolls	1.3	1.1	0.7	0.7	0.7	*0.08*	
Total Bolls/Plant	11.0	9.8	8.8	8.6	6.7	*0.04*	*1.7*
% Total Bolls in 1st Position	61.8	64.1	62.0	64.3	69.3	*0.38*	
% Total Bolls in 2nd Position	22.7	22.8	22.8	22.9	18.0	*0.28*	
% Total Bolls in Outer Position	5.1	5.4	6.4	7.6	4.4	*0.21*	
% Total Bolls on Monopodia	10.3	7.5	8.8	5.2	8.1	*0.36*	
% Total Bolls on Extra – Axillary	0.1	0.2	0.0	0.0	0.2	*0.37*	
% Boll Retention - 1st Position	37.3	32.5	27.6	27.5	30.3	*0.03*	*6.1*
% Boll Retention - 2nd Position	17.8	15.6	13.4	12.6	12.7	*0.28*	
% Early Boll Retention	46.1	46.3	34.3	38.2	38.1	*0.19*	
Total Nodes/Plant	22.8	23.9	24.2	25.1	19.4	*0.001*	*1.8*
Internode Length (inches)	1.7	1.6	1.7	1.7	1.1	*0.001*	*0.2*

[1] means of 10 plants per plot

Table 5. Results from final end-of-season plant mapping using COTMAP for plant bug treatment sub-plot effects – 2010 Leachville[1].

Category	Mean per plant for insecticide treatment						
	B-S-O	B-S-S	S-S-O	S-S-S	O-O-O	*P>F*	*LSD_{05}*
1st Sympodial Node	5.8	5.8	5.8	5.8	5.8	*0.86*	
No. Monopodia	1.5	1.4	1.3	1.4	1.3	*0.28*	
Highest Sympodia with 2 nodes	13.9	14.5	14.0	13.6	14.4	*0.46*	
Plant Height (inches)	36.5	37.8	35.6	36.1	36.1	*0.59*	
No. Effective Sympodia	10.1	11.3	11.2	10.6	8.0	*0.001*	*1.3*
No. Sympodia	18.0	18.6	18.1	17.8	19.0	*0.21*	
No. Sympodia with 1st Position Bolls	4.5	4.6	5.6	4.9	4.0	*0.001*	*0.7*
No. Sympodia with 2nd Position Bolls	1.2	1.3	1.2	1.2	0.9	*0.12*	
No. Sympodia with 1st & 2nd Bolls	0.6	0.8	1.1	1.1	0.9	*0.05*	*0.4*
Total Bolls/Plant	8.4	8.9	10.4	9.5	7.7	*0.04*	*2.5*
% Total Bolls in 1st Position	61.9	63.3	66.0	65.8	64.5	*0.67*	
% Total Bolls in 2nd Position	21.2	21.7	22.3	22.7	21.4	*0.94*	
% Total Bolls in Outer Position	6.6	7.2	4.6	4.3	6.2	*0.19*	
% Total Bolls on Monopodia	10.3	7.8	7.1	7.2	7.6	*0.39*	
% Total Bolls on Extra – Axillary	0.0	0.1	0.0	0.0	0.4	*0.02*	*0.3*
% Boll Retention - 1st Position	28.6	28.7	37.6	34.0	26.4	*0.001*	*5.0*
% Boll Retention - 2nd Position	13.0	14.3	16.8	15.9	12.1	*0.17*	
% Early Boll Retention	35.3	34.7	47.8	42.7	42.5	*0.002*	*6.9*
Total Nodes/Plant	22.8	23.3	22.8	22.6	23.8	*0.21*	
Internode Length (inches)	1.6	1.6	1.5	1.6	1.5	*0.15*	

[1] means of 10 plants per plot

Significant irrigation effects as well as plant bug treatment effects on final plant structure were measured in final, end-of-season plant mapping using COTMAP (Tables 4, 5). Rainfed plants were shorter with fewer mainstem sympodia and bolls (Table 4). Late initiation and late termination of irrigation resulted in taller plants with more sympodia, but these plants had fewer sympodia with first position bolls and fewer total bolls per plant compared to plants receiving early irrigation. Late initiation of irrigation resulted in plants with reduced % early boll retention compared to plants with early irrigation or to non-irrigated, rainfed plants.

For plant bug effects measured using COTMAP, significant reductions in % early boll retention were observed where plant bugs were released in the second and third week of squaring (Table 5). Total bolls per plant were lowest in the untreated check; this treatment also had significantly fewer effective sympodia. Very little boll rot was observed in 2010, and plant bug treatments had no effect on counts of bolls with hard lock or boll rot (data not shown).

Irrigation timing significantly affected lint yield (Fig 6). Lowest yield was observed in the rainfed cotton. If cotton was irrigated starting at first flower mean yields were increased by almost 274 lbs. With early irrigation initiation yields were an additional 356 lbs higher – an increase of 27%. Providing an extra week of irrigation after cutout did not compensate for the early water deficit stress.

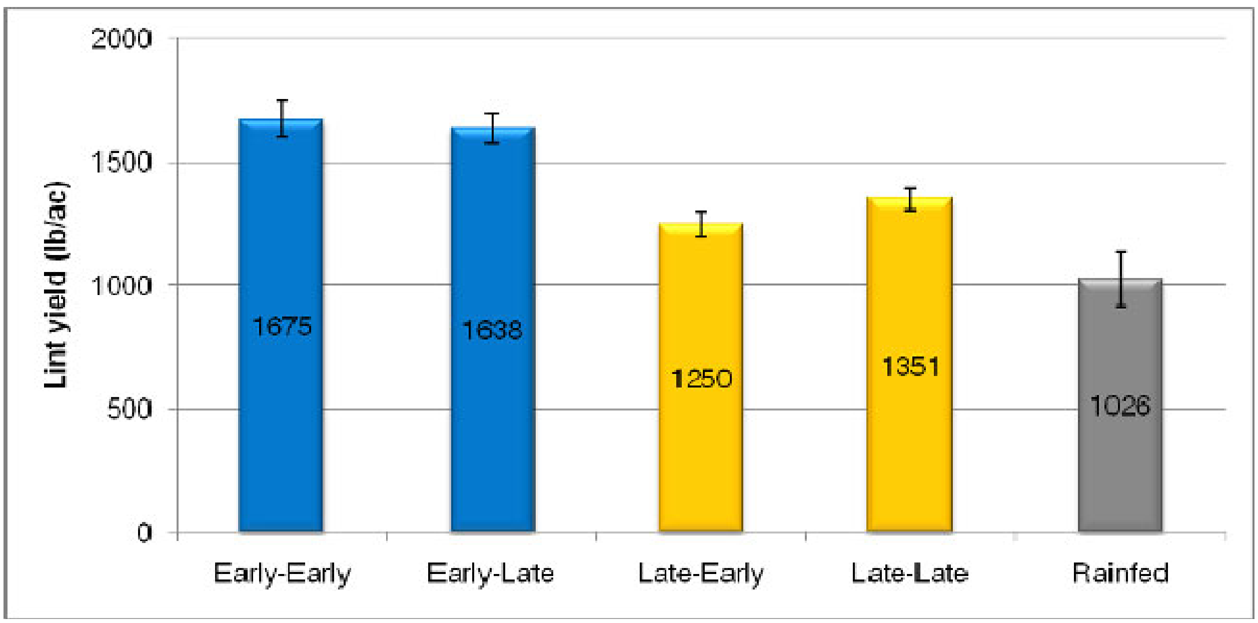

Figure 5. Irrigation timing significantly impacted mean lint (±SEM) (AOV, P=0.005; LSD_{05}= 207) for 5 different irrigation timing treatments for 2010 Leachville. There were no significant irrigation*bug interactions.

Plant bug feeding damage resulted in significant reductions in yield in 2010 in the untreated check (O-O-O) under all irrigation regimes (Fig 5). Highest yields were observed when cotton was protected from plant bugs from the first week of flower through cutout (S-S-O). The post cutout (+330 DD60s) insecticide spray did not protect fruiting forms that contributed to yield; that spray appeared to suppress yields. This occurred for plants in both the S-S-S and B-S-S treatments. Early bug infested plants that did not receive the late spray (B-S-O) produced yields comparable to plants that had received season long protection (S-S-S). There were no significant irrigation*bug interactions.

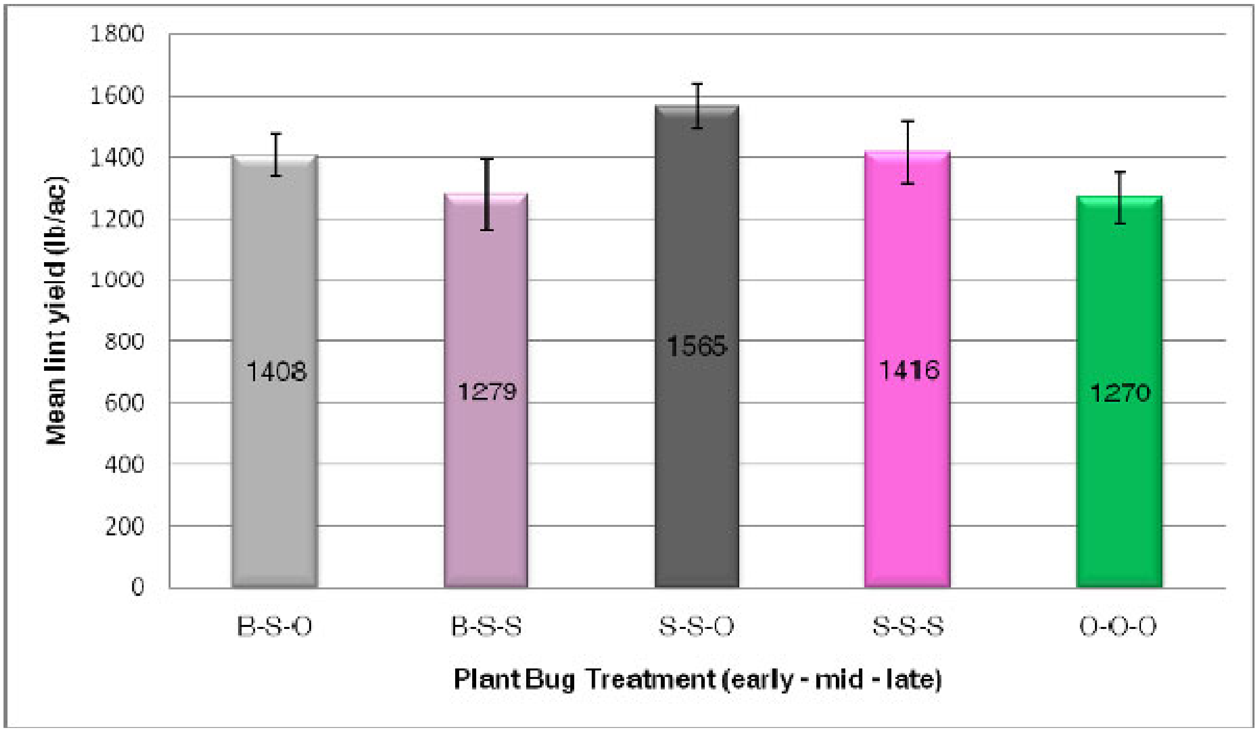

Figure 6. Mean lint (±SEM) yields for five plant bug treatments in the 2010 Leachville irrigation*plant bug trial (AOV; P=0.02, LSD_{05} = 190).

Table 6. Means for seed cotton and lint yields along with yield component information for plant bug control and irrigation interaction study, Leachville, 2010.

Treatment Timing	% Lint	Weight per Boll (g)	Seedcotton per acre (lbs)[1]	Seed per acre (* 10^6)	Fibers per seed	Fiber density
Irrigation Timing[1]						
Early-Early	39.9	5.12	4294	10.5	15391	23.4
Early-Late	38.9	5.03	4200	9.9	15343	22.7
Late-Early	39.2	4.98	3204	7.7	15756	23.3
Late-Late	38.8	5.00	3463	8.2	16052	23.2
Rainfed	40.5	3.99	2630	6.8	16223	27.0
Bugs and Sprays						
B-S-O	40.2	4.8	3611	8.8	15469	23.2
B-S-S	38.8	4.6	3279	8.2	15472	24.4
S-S-O	39.1	5.1	4013	9.8	15755	24.1
S-S-S	39.3	4.8	3630	8.8	15802	23.7
O-O-O	39.8	4.8	3257	7.6	16266	24.0
P>F						
irrigation (I)	*0.48*	*0.0001*	*0.006*	*0.01*	*0.54*	*0.02*
spray (S)	*0.14*	*0.12*	*0.02*	*0.02*	*0.52*	*0.69*
*I*S*	*0.85*	*0.68*	*0.89*	*0.79*	*0.77*	*0.26*

[1]Yield component calculations were derived from fiber data from 50 boll samples

Table 7. Means for HVI classing data[1] from 50 boll hand-picked samples collected in plots from consecutive plants for plant bug * irrigation interaction study, Leachville 2010.

Treatment Timing	Micronaire	Length	Uniformity	Strength	Elongation	Rd	+b
Irrigation Timing[1]							
Early-Early	5.02	1.16	82.72	31.25	6.23	75.17	8.11
Early-Late	5.00	1.18	83.19	31.86	6.23	75.62	8.25
Late-Early	4.87	1.18	82.85	31.92	6.23	75.66	8.33
Late-Late	4.84	1.17	82.57	31.79	6.34	76.52	8.15
Rainfed	4.73	1.12	82.18	30.92	6.29	70.71	7.81
Bugs and Sprays							
B-S-O	4.86	1.16	82.74	31.52	6.42	74.81	8.08
B-S-S	4.80	1.16	82.63	31.99	6.21	75.03	8.42
S-S-O	4.94	1.17	83.00	31.60	6.14	74.53	7.98
S-S-S	4.83	1.17	82.59	31.91	6.38	75.03	8.01
O-O-O	5.01	1.15	82.55	30.72	6.17	74.28	8.15
P>F							
irrigation (I)	*0.07*	*0.01*	*0.35*	*0.59*	*0.92*	*0.0003*	*0.225*
spray (S)	*0.23*	*0.19*	*0.79*	*0.2*	*0.1*	*0.62*	*0.2*
*I*S*	*0.98*	*0.01*	*0.62*	*0.55*	*0.82*	*86*	*0.78*

[1] HVI evaluations made at Fiber and Biopolymer Research Institute at Texas Tech University.

Results from fiber quality and yield component analysis of 50 boll samples indicate significant reduction in boll size in rainfed compared to irrigated cotton in 2010 (Table 6). Seedcotton, seed per acre and fiber density were all impacted by irrigation and plant bug treatments. Laboratory gin turnout (% lint) was similar among irrigation and plant bug treatments. No differences among treatments were noted for calculations of fibers per seed. Smaller boll size was associated with the late season spray.

Fiber quality was impacted by irrigation. Length was significantly reduced in rainfed compared to irrigated cotton (Table 7). Rd values also were reduced. No fiber quality differences were noted in response to plant bug treatments.

Conclusions

In this final season of a three year study, yields were significantly higher in cotton grown with an early irrigation start compared to delayed start or no irrigation. Providing an extra week of irrigation after cutout did not compensate for the early water deficit stress. Delayed irrigation resulted in maturity delay with the number of days to physiological cutout extended 9 days. Similar crop response to pre-flower water stress and irrigation termination timing has been noted in previous work (Monge et al 2007, Teague et al 1999, 2005a, b, 2006). Comparable results also were observed in 2008 and 2009 in the first and second years of this study in work in Lee County (Teague and Danforth 2009) and at Wildy Farms (Teague and Danforth 2010).

A consequence of pre-flower water deficits arising from delayed start-up of irrigation is the decreased retention of small bolls after the stress is “relieved”. After the crop begins to flower, and the delayed irrigation (or rain) finally occurs, small boll shed typically will increase. Terminal growth, which had stalled because of moisture stress, is triggered to restart. Boll shed and terminal regrowth results in crop delay and rank growth late season all of which translates into availability of highly attractive squares just in time for highest population densities of tarnished plant bugs. Late season rank growth will make defoliation more costly and can increase likelihood of reduced harvest efficiency, variable fiber quality and increased leaf trash. Under such conditions, production costs rise but yields do not. The principle conclusion from this three year study ….. Irrigation timing to avoid pre-flower water deficits is critical in Arkansas cotton to manage for high and early yields.

Producers should time irrigation applications to avoid pre-flower water deficits that can delay the crop and reduce yields. Late season, post cutout irrigations may not contribute to yield and can delay maturity. COTMAN growth curves are useful in monitoring effects on pre-flower crop development pace as well as late season crop maturity following pre-flower water deficits. Growth curves aid in interpreting causes of late season crop growth (Bourland et al 2008).

Conclusions regarding plant bug management are more difficult to summarize for 2010. It is unknown why yields of the treatments B-S-S and S-S-S tended to be lower following the late season insecticide application. Smaller boll size was associated with the late season spray, and perhaps differences in bolls size may account for a portion of the yield penalty. Cotton compensation researchers have reported that when late season feeding removes upper canopy fruiting forms, the cotton plant can redirect photosynthetic resources to the remaining undamaged bolls making them bigger (Hearn and Room 1978). Cotton is vulnerable to insects such as tarnished plant bug from early season through cutout, but there is a point in the season when the last effective boll population is no longer susceptible to damage from this pest. Protective sprays after that point are unnecessary.

Using COTMAN decision guides, producers know when the crop remains susceptible and can make necessary insecticide applications to protect vulnerable bolls from late season infestations …. But they also can save money by avoiding unnecessary applications when bolls are safe. The cutout + 250 DD60 endpoint for boll protection appears valid for plant bug control termination. Adjustments in defining the cutout date - when to start heat unit accumulation - may be required when a crop has suffered pre-flower stress. If the crop maturity is delayed, seasonal cutout guides should be employed, and heat unit accumulations started at that date. Seasonal dates for each US cotton production region are published in annual COTMAN releases.

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