2020 Compensation Capacity of High and Low Vigor Cotton Plants in Response to Pre-Flower Injury by Tarnished Plant Bug (Heteroptera: Miridae)

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ABSTRACT

Crop tolerance of feeding injury by tarnished plant bug (*Lygus lineolaris* Palisot de Beauvois) (Heteroptera: Miridae) was investigated in field trials conducted in a highly variable field in Northeast Arkansas in 2005 and 2006. Plant biomass assessments were used to classify crop areas of high and low plant vigor. In a split plot design, field plots were positioned across these variable plant types with main plot irrigated and non irrigated blocks. Insect induced injury was manipulated by augmenting natural field populations of plant bugs with lab reared nymphs and by application of insecticides. Crop response was measured using the COTMAN crop monitoring system and in end-of-season plant mapping as well as in measures of lint yield and fiber quality. First position square retention varied from 98% down to 71% at first flowers across treatments; total no. of main stem sympodia ranged from 3.4 up to 10 nodes per plant in non-irrigated low vigor plants and irrigated, high vigor plants. Irrigation significantly affected yield and fiber quality in 2005, but insect induced injury was not a limiting factor. Greater levels of injury were observed with high vigor plants, but that injury failed to significantly reduce yield. In 2006. irrigation did not affect lint yield, but insect feeding did result in economic damage in plants in the low vigor classification. Managers considering site specific approaches for insect control should consider variability in compensation capacity and tolerance for pest injury when planning adjustments in action thresholds.

KEY WORDS: COTMAN, crop monitoring, irrigation, *Lygus lineolaris,* vigor classification

INTRODUCTION

With increasing interest in use of site-specific, variable rate application technology in cotton production, decision makers question whether crop protection tactics should be modified across variable fields among areas of high and low yield potential. Sensor systems can measure spatial variability in soil types, elevation, and drainage patterns in variable fields as well as some crop development responses to these physical factors. There is evidence that spatial distribution in tarnished plant bug abundance can be associated with these patterns (Willers et al 1999, Willers et al 2005, Subrink et al 2001).

Cotton research efforts in Arkansas have been focused on refinement of the COTMAN™ crop monitoring system to incorporate plant-based decision guides for managing an array of abiotic and biotic stress factors. In 2003 and 2004, we examined response of non-stressed plants and plants under pre-flower water deficit stress to square loss following feeding by tarnished plant bug (*Lygus lineolaris* Palisot de Beauvois) (Teague et al 2005). Water stress was induced by delaying or withholding irrigation, and insect induced injury was manipulated by augmenting natural field populations of plant bugs with lab reared nymphs and by application of insecticides. Our objective was to compare crop response and compensation with and without pre-flower water deficits coupled with square loss resulting from plant bug feeding. These studies were expanded in 2005 and 2006 to include a crop "vigor" component to determine if adjustments in crop protection are needed for site specific management.

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, and the latest possible cutout date (that date with a 50% or 85% probability of attaining 850 DD60s from cutout) for this production area is 9 Aug or 31 July, respectively (Zhang et al. 1994 and Danforth and O'Leary 1998). The cultivar, Stoneville 4575BR was planted 8 May 2005 and 6 May 2006. Plant population density in both years was ca. 9 plants/m of row. Standard grower 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. The soil was a Routon-Dundee-Crevasse Complex, and as is common across that production region, there were, interlaced through the field, easily identifiable inclusions of coarse-textured soils associated with sand blows related to the 1812 New Madrid earthquake (Saucier 1989).

Three factors were evaluated: irrigation (2 levels), plant "vigor" classification (2 levels) and insect induced injury (4 levels). The 2*2*4 split-plot factorial experiment was arranged in a randomized complete block design. Irrigation treatments were considered main plots. The subplots were comprised of 8 treatment combinations where each combination was one of the 2 vigor classes and 4 plant bug injury treatments. Three blocks were used, and each treatment combination occurred only once in each block; treatments were re-randomized in each year. Plots were 8 rows wide, 13m long with 4 row buffers. Row spacing was 0.97 m (38 inches).Within each plot, 2 adjacent rows, 4 m long were selected for all plant sampling and when applicable, for plant bug releases.

Irrigation treatments were: 1) weekly (as needed) furrow irrigations, 2) no supplemental irrigation. Plant vigor treatments were: 1) high vigor 2) low vigor. Only 2 vigor classes were designated to keep the design simple and these represented a low level of yield potential and high end of yield potential. Vigor designations were made ca. 30 days after planting and were based on plant growth (biomass) responding to soil variability that extended through the field plot area. Biomass classifications were considered indicators of crop vigor with the high biomass classification reflecting our estimate of greatest vigor and our estimate of highest yield potential. Plant bug treatments were 1) manual infestation of 3 plant bug nymphs per m of row in week 1 and 2 of squaring; 2) 9 bugs per m of row in week 1 and 2 of squaring; 3) untreated, natural populations; 4) sprayed with insecticide. Plant bug nymphs were released in appropriate treatments on 17 and 24 June 2005 (40 and 47 days after planting (DAP)) and 14 June and 21 June 2006 (39 and 46 DAP). A single 3rd or 4th instar nymph was aspirated from rearing containers into a 3 cm long tube (opaque 1 cm ID automotive radiator hose). Release tubes were placed at the base of each plant's main stem, and bugs were allowed to crawl out of the tube and up the plant. Plant bug nymphs were collected from wild plant hosts in NE Arkansas and had been held for 1 to 2 days in the laboratory on ears of fresh sweet corn.

Pre-flower applications of insecticides were made using a CO_2 charged backpack sprayer equipped with a 2 row boom and calibrated to deliver 12 GPA; all 8 rows of each insecticide treatment plot was sprayed. In 2005, the insecticide Trimax® (imidacloprid 0.042 kg a.i. /ha) was applied on 25 June. Bidrin® (dicrotophos 0.36 kg a.i. ha) was applied across the entire field on 28 July 2005. In 2006, Trimax (imidacloprid 0.042 kg a.i. /ha) was applied on 16 June 2006, and the entire field received a blanket application of Centric (thiamethoxam 0.04 kg a.i./ha) on 26 June. Whole field insecticide applications were made by the cooperating grower using a John Deere 4710 sprayer equipped with a 28 m boom. Other insecticides applied during the seasons were: Temik® 15G (aldicarb 4.2 kg a.i./ha) at planting, and Bidrin (dicrotohos 0.22 kg a.i/ha) on 31 May 2005 and 25 May 2006. Native plant bug population densities were monitored in the field area outside the experimental plots season-long using weekly drop cloth sampling. In addition, the professional crop advisors employed by the cooperating producers, monitored insect infestations weekly in the field.

Plants were monitored in each plot from the early squaring period through cutout using the Squaremap procedure in the COTMAN system (Danforth and O'Leary 1998). Five consecutive plants in 2 treatment rows were monitored weekly. Sampling included measurement of plant height from soil to plant apex, number of sympodia on the main plant axis, and retention of first position fruiting forms on those branches (Bourland et al 1992). Care was taken to minimize touching the plants.

Crop injury assessments using COTMAN were used to monitor injury by plant bugs following the manual infestations. In 2006, an additional gauge of nymph survival used sentinel plots that were installed in the field adjacent to the experiment. Because of limited numbers of nymphs, sentinel plots were established only with high vigor, irrigated plants. Corresponding with timing of infestations in the experiment, nymphs were released in sentinel plots at 0, 3 and 9 bugs/m. There were 3 replications per infestation level. After 24 hours, plants were sampled using drop cloths (1 m beat sheets), and numbers of nymphs recovered were recorded.

Final plant mapping was performed after defoliation using COTMAP (Bourland and Watson 1990). Ten plants in one row 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 was also noted. Plant height was measured as distance from soil to apex.

Defoliant and boll openers were applied 21 and 27 Sept 2005 and 20 and 29 Sept 2006. Seed cotton yields were determined with hand harvests conducted in 3 m of row within 1 row of each sample plot on 8, 13, 20 and 3 Oct. 2005 and on 26 Sept and 5 Oct 2006. Fifty boll samples were taken on 3 Oct 2005 and 5 Oct 2006 in the center portion of the 2nd sample row of each plot. Bolls were collected from consecutive plants on consecutive fruiting positions. Seed cotton was ginned on a laboratory gin, and lint samples sent to the International Textile Center at Texas Tech University, Lubbock, TX, for fiber quality determinations using HVI analysis. All crop monitoring and yield data were subjected to analysis of variance (ANOVA) using PROC GLM for each date and year, and treatment means were separated using least significant difference (LSD) following a significant ($P \leq 0.05$) F test (SAS Institute 1985).

RESULTS

Temperature and rainfall patterns generally were favorable in NE Arkansas for cotton production in 2005 and 2006; however, there were dry periods in May and June 2005 that created potential for water deficits in pre-flower development period in non-irrigated treatments (Table 1). Rainfall variation between years resulted in significant differences in plant and insect related results, and data for each year are therefore presented separately.

Visual differences in plant stature between high vigor and low vigor plants were easily discernable by 40 DAP (Fig 1). The pace and range of plant development in both years among vigor classes and in response to injury and irrigation are apparent in COTMAN based growth curves (Fig. 2 and 3). Squares appeared on high vigor plants by the COTMAN target date of 35 days after planting; squaring was delayed in the low vigor classes. For high vigor plants, pre-flower water deficit stress in non-irrigated plants in 2005 resulted in reduced level and pace of sympodial development pre-flower (no. of main stem sympodia produced/unit of time) compared to irrigated (Fig 2.). Flowers were first observed by 55 DAP in 2005 for the high vigor classed plants. By 65 DAP, flowers were observed in every treatment plot. In the Squaremap sample taken at 60 DAP, mean no. of main stem sympodia per plant ranged from 3.4 to 9.0 depending on irrigation and vigor class (Fig. 2 and Table 2). Growth curves for the irrigated, non-infested, high vigor plants generally followed the pattern of the COTMAN target curve. Growth curves for irrigated, high vigor plants which were inoculated with 9 bugs/m were similar to growth curves observed in our previous compensation studies (Teague et al 2001, 2002, 2004). Loss of early squares and the resulting reduced early boll retention lead to higher squaring node counts after the onset of flowering (=nodes above white flower (NAWF)). Mean no. of squaring nodes at 68 and 73 DAP were at highest levels where early square shed was highest in irrigated, high vigor plants (Fig 2). In the non-irrigated plots, sympodial development pre-flower was slowed because of water deficits, but growth resumed with rains and cool, cloudy conditions that came in July. All treatments reached physiological cutout (mean NAWF=5) prior to 8 Aug, and there were no significant differences among treatments on number of days to cutout (Bourland et al 2000).

In 2006, rains in June, July and August made irrigation effects less pronounced compared to 2005, and variation in plant structure among irrigation and vigor treatments were not as apparent in the field or in COTMAN growth curves (Fig. 3). Squares appeared on plants classed in the high and low vigor categories just after the COTMAN target date of 35 DAP. Flowers were first observed by the 5 July sampling date, 60 DAP, across most treatments. In some low vigor, non irrigated plots, flowers were not observed until 20 July. Mean no. of sympodia per plant at 60 DAP ranged from 5.8 to 7.2 (Fig 3 and Table 2). Higher NAWF counts in the first 2 weeks of flowering were noted where early boll retention had been reduced because of plant bug induced square loss, and higher NAWF values were most apparent in irrigated, high vigor plants (Fig 3). All treatments reached physiological cutout prior to 8 Aug. Mean no. days to cutout were significantly affected by irrigation ($P < 0.02$) and biomass ($P < 0.03$). Mean days to cutout was not significantly affected by insect injury. There were no significant interactions.

Native plant bug population densities were very low region-wide in both years. In our research plots, first position square shed recorded in unsprayed, non-inoculated, natural plots was less than 10% for the entire pre-flower period (Fig 4 and 5). There were no significant differences in first position square shed between untreated (natural) or the insecticide (spray) treatments season-long, and at no time, season long, did plant bug numbers in field sampling exceed state recommended action thresholds (**http://www.uaex.edu/Other_Areas/publications/HTML/MP-144.asp**). Field wide insecticide applications were made as "preventative" sprays. Square shed in pre-flower plants was attributed to insect injury; post flower boll shed likely was related to physiological processes, not direct insect feeding.

Following release of nymphs during the first 2 wks of squaring, square shed levels recorded during Squaremap sampling were significantly higher in treatment plots infested with 9 nymphs/m. Percent square shed in 2005 recorded at the time of first flowers ranged from highs of nearly 30% in irrigated, high vigor plants compared to 15% in dryland, low vigor plants (Fig 4). There were no significant differences in 1st position square shed associated with 1 bug/ft treatments in 2005 compared to natural or sprayed treatments, but square loss was numerically higher where bugs were released. Square retention in response to insect injury was lower in irrigated compared to non-irrigated plants (P=0.08) (Table 2). Low levels of square shed in non-irrigated plants following manual infestations, particularly in the low vigor class, was likely due to poor survival of nymphs on the small plants in the dry, sandy portions of the field in 2005.

In 2006, under cool and moist weather conditions more favorable for nymph survival, overall shed levels were much higher following release of bugs. Square shed in manually infested treatments ranged from 7 to 12% where nymphs were released at 3/m and from 19 to 27% where 9 nymphs/m were released (Fig 5). Plant bugs significantly decreased no. of squares retained (P<0.01) measured at first flowers at 60 DAP (Table 2). No significant irrigation effects on pre-flower shed levels were observed in 2006 indicating that nymph survival was similar across irrigation treatments. Square shed levels at first flowers were affected by vigor class. Reduced nymph survival in low vigor plants is one possible reason for this difference. In sentinel plots in 2006, mean no. nymphs recovered in drop cloth sampling 24 hours after release of at 0, 3 and 9 nymphs/m were 0.0, 4.3 and 6.7 nymphs /m (0, 144% and 67% recovery), respectively. Sentinel plots were not established on low vigor plants so no direct comparison of survival rates on different vigor classes is available.

Results from end-of-season plant mapping indicate significant irrigation, vigor and plant bug effects on final plant stature and structure (Tables 3 and 4). COTMAP results reflected the variability observed through the 2 seasons with irrigation having significant effects on plant structure in 2005 and less effect in 2006. In both years, differences in plant structure and boll retention were measured between the 2 vigor classes. Bug effects were minimal in 2005, but the insect treatment had a significant effect on total no. of sympodia and highest sympodia with 2 nodes. These structural differences are indicative of continued terminal growth after flowers where plant bug feeding had reduced early boll retention. Noteworthy effects from plant bug feeding injury were not apparent in end of season mapping results from 2006.

Remarkable variability in cotton yields were observed over both years with seed cotton yields ranging from 650 to 5500 kg /ha in 2005 and from 1700 to 4500 kg /ha in 2006 (Fig 6). In 2005, plant bug effects did not result in significant reductions in final yield, and there were no significant Bug*Irrigation or Bug*Vigor interactions (Table 7). Bug induced square shed was not sufficiently high to result in measurable yield reductions. Irrigated, high vigor plants that received one application of insecticide, produced highest numerical yields, but these were not significantly (P>F=05) higher than yields from other irrigated high vigor plants. Irrigation*Vigor interactions were significant in 2005. Extremely low yields in portions of the field were associated with variations in soil properties including compaction in the sand blow areas (data not shown). Plant bug treatments had no effect on severely stressed plants in these areas.

In 2006, plant bug feeding injury did significantly affect yields; there was a significant bug*vigor interaction (Table 8). Seed cotton yield from plants in the non-irrigated, low vigor class where plant bugs were released at 9 bugs/m had lowest yields. In the high vigor class with the same plant bug treatment, plants were able to compensate for similar levels of bug induced square shed. For the high vigor class treatments, yields were no different among manually infested, sprayed or untreated, natural treatments (Fig. 6).

Results from HVI testing for fiber properties are presented in Tables 9 and 10 . Significant bug * vigor interactions were noted in 2005 in micronaire measures. Irrigation affected length, uniformity, and leaf. Vigor significantly affected strength and elongation. In 2006, HVI testing results indicate that micronaire, length, uniformity and leaf were not significantly affected by treatments. Strength differed significantly among vigor classes, and there was a significant vigor*bug interaction.

DISCUSSION

Small plot research techniques were used in this 2005 and 2006 study to attempt to characterize cotton response to a variety of stress factors. Our research team has worked in this commercial field for 6 years, and in setting up previous experiments, we always avoided the sandy areas that wind throughout the plot areas. Producer interest regarding guidelines for site specific management tactics prompted our inclusion of the marginal areas of the field into the 2005 and 2006 research. One question we hoped to address was whether crop protection costs could be reduced by managing insect pests differently across areas of varying yield potential. In particular, would plant bug injury be tolerated differently by high or low vigor plants such that action levels might be modified across variable fields. For instance, could low yielding areas be ignored when applying insecticides for tarnished plant bug control? In previous work at this site we had found that irrigated plants infested with tarnished plant bugs during the seedling stage were able to recover from moderate injury with no reduction in yield (Coy et al 2003). In 2003 experiments, well watered, non-stressed plants were able to tolerate and/or compensate from manual infestations as high as 30 nymphs/m (>50% square shed at first flowers); yields produced were similar to those produced in cotton receiving weekly applications of insecticide. In 2004, overall yields were at higher levels, and comparable levels of pre-flower plant bug damage significantly reduced yields (Teague et al 2005).

In these studies, crop delay generally was associated with plant bug induced injury regardless of compensation. Hearn and Room (1979) listed 2 types of time-dependent compensatory responses to loss of fruiting structures: 1) time dependent tolerance - when fruiting structures that would have shed physiologically replace those previously damaged or 2) time-dependent compensation – when loss of fruiting structures delays metabolic stress associated with boll loading stress therefore lengthening the time of squaring and allowing some of the additional squares to set bolls.

In our previous compensation studies, response of *high* (or *medium)* vigor plants were evaluated. When bugs were released on low vigor plants in 2005, the insects failed to cause sufficient damage to have measurable effects on yield even under water deficit stress. In 2005, plants in the dryland areas of the sand blows produced very little cotton. It appeared that few bugs survived on those plants after release. Plants were very small, and hot and dry conditions in non-irrigated plots may have reduced survival. Microclimate differences between irrigated, higher biomass plants compared to water stressed smaller plants should be evaluated with regard to plant bug oviposition preferences and survival.

Conditions were favorable for plant bug survival in 2006, and bug feeding injury in non-irrigated, low vigor plants resulted in reduced yield. Irrigated plants and high vigor classed plants infested with plant bugs suffered similar levels of square shed as low vigor plants, but they were able to compensate for the injury. Results from this study indicate that there are differences in compensation capacity of crop plants across variable fields. These results suggest that IF plant bug infestations develop in low vigor areas, those plants may not compensate for injury as well as high vigor classed plants.

Action thresholds in place for management of tarnished plant bug in Midsouth cotton are based on pest insect numbers as well as fruit retention. Current pre-flower action thresholds in Arkansas appear to be sufficiently conservative for lower pest tolerance of low vigor plants. High vigor plants may tolerate higher levels if injury does not result in unacceptable crop delay. Production areas in the northern extremes of the US Cotton Belt typically have less time for compensation because of fewer heat units available in a production season (see Zhang et al. 1994); thus growers in these regions must be concerned with management practices or pests that results in crop delay. Further work should be conducted by field research entomologists to examine and validate any changes in insect pest management recommendations for use in site-specific management approaches.

One goal in this study was to conduct the experiment to compare response of “uniformly” low vigor plants to “uniformly” high vigor plants. Results on the technique are mixed. More complex and elegant experimental designs than employed in this study merit consideration in future work.

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Table 1. Minimum and maximum air temperature and precipitation recorded for 2004 and 2005 at Wildy Farms, Leachville, AR.

	2005			2006		
Month	Air temperature (°C)		Precipitation	Air temperature (°C)		Precipitation
	Min.	Max.	(cm)	Min.	Max.	(cm)
May	10.0	34.4	4.4	8.9	35.6	7.8
June	15.6	37.2	0.1	15	36.7	2
July	17.2	36.7	12.4	15	36.7	12.2
August	17.2	38.3	3.4	15	37.8	4.2
September	7.8	36.1	8.8	6.1	30.6	9.4
October	-0.6	33.3	0.2	-1.1	31.1	9.2
Average	11.2	36.0	4.9	9.8	34.8	7.5

Table 2. Mean no. main stem sympodia and first position squares per plant observed during the first week of flowering at 60 days after planting in 2005 and 2006.

Irrigation, vigor classification & plant bug treatment	2005		2006	
	Sympodia	Squares	Sympodia	Squares
Irrigated, high vigor, bug 3/m	8.4	8.0	7.2	6.3
Irrigated, high vigor, bug 9/m	9.0	6.4	6.8	5.7
Irrigated, high vigor, natural	8.7	8.7	7.0	6.6
Irrigated, high vigor, spray	8.9	8.4	7.6	7.4
Irrigated, low vigor, bug 3/m	7.0	6.8	6.4	6.1
Irrigated, low vigor, bug 9/m	7.2	5.7	6.3	4.1
Irrigated low vigor, natural	6.4	6.4	6.7	6.6
Irrigated, low vigor, spray	6.6	6.6	6.3	6.2
Not Irrigated, high vigor, bug 3/m	7.5	7.2	6.4	5.6
Not Irrigated, high vigor, bug 9/m	7.5	7.0	7.1	5.7
Not Irrigated, high vigor, natural	6.8	6.6	6.8	6.5
Not Irrigated, high vigor, spray	7.0	6.9	7.1	6.8
Not Irrigated, low vigor, bug 3/m	5.5	5.5	6.4	5.8
Not Irrigated, low vigor, bug 9/m	5.4	4.7	5.8	4.9
Not Irrigated, low vigor, natural	3.4	3.4	5.9	5.8
Not Irrigated, low vigor, spray	5.5	5.4	6.5	6.2
Analysis of variance				
P>F Irrigation(I)	0.05	0.04	0.44	0.61
Vigor (V)	<0.001	<0.001	<0.001	0.003
I * V	0.61	0.28	0.95	0.49
Bug (B)	0.28	0.13	0.52	<0.001
I * B	0.53	0.08	0.89	0.31
B * V	0.56	0.42	0.7	0.14
I * B * V	0.72	0.75	0.37	0.45

[1] Determinations made with COTMAN Squaremap procedure; n=10 plants.

Table 3. Results from analysis of variance - *F* test significance - for effects of irrigation, plant vigor classification and plant bug injury on different categories of plant structure from end-of-season final plant mapping using COTMAP - 2005.

Category	Irrigation (I)	Vigor (V)	Bug (B)	I*V	I*B	B*V	I*B*V
1st Sympodial Node	0.5	0.132	0.52	0.12	0.73	0.80	0.45
No. of Monopodia	0.34	0.28	0.03	0.82	0.25	0.49	0.27
Highest Sympodia with 2 nodes	0.39	0.005	0.01	0.48	0.10	0.15	0.51
Plant Height	0.25	0.002	0.34	0.32	0.08	0.34	0.07
No. of Effective Sympodia	0.13	0.01	0.09	0.94	0.16	0.27	0.07
No. of Sympodia	0.91	0.003	0.03	0.14	0.16	0.35	0.34
No. of Sympodia with 1st Position Bolls	0.17	0.006	0.09	0.22	0.25	0.84	0.72
No. of Sympodia with 2nd Position Bolls	0.62	0.005	0.49	0.72	0.09	0.15	0.04
No. of Sympodia with 1st & 2nd Position Bolls	0.08	0.03	0.47	0.85	0.14	0.23	0.19
Total Bolls/Plant	0.03	0.02	0.45	0.62	0.15	0.36	0.13
Total Nodes/Plant	0.37	0.001	0.02	0.19	0.10	0.30	0.39
Internode Length	0.27	0.003	0.31	0.58	0.11	0.50	0.03

Table 4. Results from analysis of variance - *F* test significance - for effects of irrigation, plant vigor classification and plant bug injury on different categories of plant structure from end-of-season final plant mapping using COTMAP - 2006.

Category	Irrigation (I)	Vigor (V)	Bug (B)	I*V	I*B	B*V	I*B*V
1st Sympodial Node	0.03	0.56	0.37	0.81	0.66	0.26	0.77
No. of Monopodia	0.30	0.17	0.55	0.25	0.44	0.43	0.59
Highest Sympodia with 2 nodes	0.12	0.04	0.74	0.79	0.05	0.87	0.80
Plant Height	0.39	0.01	0.31	0.82	0.23	0.37	0.98
No. of Effective Sympodia	0.13	0.01	0.27	0.29	0.05	0.05	0.97
No. of Sympodia	0.09	0.02	0.50	0.99	0.07	0.91	0.60
No. of Sympodia with 1st Position Bolls	0.04	0.01	0.35	0.76	0.77	0.55	0.70
No. of Sympodia with 2nd Position Bolls	0.51	0.01	0.03	0.95	0.29	0.69	0.51
No. of Sympodia with 1st & 2nd Position Bolls	0.43	0.01	0.29	0.02	0.89	0.24	0.95
Total Bolls/Plant	0.76	0.01	0.70	0.07	0.71	0.37	0.51
Total Nodes/Plant	0.36	0.02	0.77	0.93	0.08	0.67	0.67
Internode Length	0.01	0.01	0.42	0.68	0.58	0.39	0.73

Table 5. Results from final end-of-season plant mapping following defoliation using COTMAP^z – plant bug effects, 2005.

Category	Mean per plant for each treatment					
	Bug 3/m	Bug 9/m	Natural	Sprayed	*P*>F	LSD$_{05}$
1st Sympodial Node	6.2	6.3	6.4	6.2	0.52	
No. Monopodia	1.4	1.7	1.9	1.6	0.03	0.31
Highest Sympodia with 2 nodes	9.9	11.4	9.7	10.5	0.01	1.12
Plant Height (cm)	89.7	99.3	86.9	91.2	0.34	
No. Effective Sympodia	8.4	9.1	7.7	8.1	0.09	
No. Sympodia	13.7	15.3	13.7	14.6	0.03	1.15
No. Sympodia with 1st Position Bolls	4.0	3.9	3.2	3.8	0.09	
No. Sympodia with 2nd Position Bolls	1.3	1.4	1.3	1.2	0.49	
No. Sympodia with 1st & 2nd Bolls	1.4	1.7	1.8	1.3	0.47	
Total Bolls/Plant	9.7	11.5	9.9	9.6	0.45	
Total Nodes/Plant	18.9	20.6	19.1	19.8	0.02	1.1
Internode Length (cm)	4.8	4.8	4.6	4.6	0.31	

^{z} means of 10 plants per plot

Table 6. Results from final end-of-season plant mapping following defoliation using COTMAP^z – plant bug effects, 2006.

Category	Mean per plant for each treatment					
	Bug 3/m	Bug 9/m	Natural	Sprayed	*P*>F	LSD$_{05}$
1st Sympodial Node	7.0	7.1	6.7	6.8	0.37	
No. of Monopodia	2.4	2.1	2.2	2.3	0.55	
Highest Sympodia with 2 nodes	11.1	10.8	11.1	11.5	0.74	
Plant Height (cm)	74.2	73.2	73.9	74.8	0.31	
No. of Effective Sympodia	8.2	8.5	8.0	8.8	0.27	
No. of Sympodia	14.9	14.5	15.0	15.5	0.50	
No. Sympodia with 1st Position Bolls	4.1	3.8	4.1	4.2	0.35	
No. Sympodia with 2nd Position Bolls	1.1	1.1	0.8	1.3	0.03	0.32
No. Sympodia with 1st & 2nd Bolls	1.2	1.0	1.4	1.6	0.29	
Total Bolls/Plant	10.9	10.1	10.7	11.4	0.70	
Total Nodes/Plant	20.9	20.6	20.8	21.3	0.77	
Internode Length (cm)	3.6	3.6	3.6	3.8	0.42	

^{z} means of 10 plants per plot

Table 7. Results of analysis of variance for seed cotton as influenced by irrigation, plant vigor and bug treatment, 2005.

Source[z]	df	*F*	*P>F*
Irrigation	1	20.3	0.046
Vigor	1	170.43	0.0002
Irrigation * Vigor	1	20.31	0.010
Bug	3	0.27	0.848
Bug * Irrigation	3	1.03	0.398
Bug * Vigor	3	1.61	0.212
Bug * Irrigation * Vigor	3	1.75	0.183

[z] Irrigation = Irrigated, not-irrigated; Vigor = High or Low; Bug= 3 bugs/m, 9 bugs/m, untreated and sprayed with insecticide.

Table 8. Results of analysis of variance for seed cotton yield as influenced by irrigation, plant vigor and bug treatment, 2006.

Source[z]	df	*F*	*P>F*
Irrigation	1	0.10	0.78
Vigor	1	15.34	0.001
Irrigation * Vigor	1	1.70	0.20
Bug	3	1.02	0.40
Bug * Irrigation	3	0.67	0.58
Bug * Vigor	3	3.00	0.05
Bug * Irrigation * Vigor	3	0.39	0.76

[z] Irrigation = Irrigated, not-irrigated; Vigor = High or Low; Bug= 3 bugs/m, 9 bugs/m, untreated and sprayed with insecticide.

Table 9. Results of HVI classing data for 50 boll samples collected in hand-harvested plots throughout consecutive plants, 2005.

Mepiquat chloride treatment & biomass classification	Micronaire	Length	Uniformity	Strength	Elongation	Leaf
Irrigated, high vigor, bug 3/m	4.57	1.08	83.00	30.20	4.80	2.67
Irrigated, high vigor, bug 9/m	4.83	1.08	82.27	29.23	4.63	2.00
Irrigated, high vigor, natural	4.77	1.09	83.70	29.23	4.97	3.00
Irrigated, high vigor, spray	4.93	1.10	83.17	29.50	5.10	2.67
Irrigated, low vigor, bug 3/m	5.13	1.07	82.90	27.57	4.53	2.67
Irrigated, low vigor, bug 9/m	4.70	1.10	83.33	29.00	4.90	3.00
Irrigated low vigor, natural	5.13	1.08	83.13	28.47	4.77	2.33
Irrigated, low vigor, spray	5.57	1.06	83.10	26.47	4.07	3.00
Not Irrigated, high vigor, bug 3/m	4.53	1.11	83.23	29.23	4.90	2.33
Not Irrigated, high vigor, bug 9/m	5.10	1.09	83.13	30.33	5.17	2.00
Not Irrigated, high vigor, natural	4.27	1.07	81.20	28.77	4.73	2.33
Not Irrigated, high vigor, spray	4.73	1.05	82.47	28.80	4.67	2.00
Not Irrigated, low vigor, bug 3/m	5.07	1.05	81.53	27.83	4.37	2.33
Not Irrigated, low vigor, bug 9/m	4.50	1.09	82.87	29.53	4.43	1.33
Not Irrigated, low vigor, natural	5.03	1.07	82.67	29.17	4.57	3.00
Not Irrigated, low vigor, spray	4.60	1.02	80.10	27.13	4.13	2.00
Analysis of Variance						
P>F Irrigation(I)	0.23	0.04	0.008	0.66	0.45	0.001
Vigor (V)	0.11	0.15	0.36	0.04	0.006	0.72
Bug (B)	0.77	0.19	0..57	0.33	0.38	0.39
I * V	0.43	0.56	0.27	0.41	0.09	0.72
I * B	0.39	0.75	0.42	0.84	0.98	0.40
B * V	0.05	0.62	0.25	0.40	0.44	0.92
I * B * V	0.59	0.85	0.51	0.85	0.45	0.18

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

Table 10. Means for HVI classing data for 50 boll samples collected in hand-harvested plots throughout consecutive plants, 2006.

Irrigation, vigor classification and plant bug treatment	Micronaire	Length	Uniformity	Strength	Elongation	Leaf
Irrigated, high vigor, bug 3/m	4.53	1.11	82.77	30.37	7.40	2.67
Irrigated, high vigor, bug 9/m	4.23	1.12	83.50	31.63	7.10	2.33
Irrigated, high vigor, natural	4.13	1.09	82.10	28.03	7.10	3.33
Irrigated, high vigor, spray	4.80	1.10	82.53	30.03	7.07	3.67
Irrigated, low vigor, bug 3/m	4.23	1.11	83.23	30.37	7.33	3.67
Irrigated, low vigor, bug 9/m	4.13	1.08	82.47	30.30	7.27	3.33
Irrigated low vigor, natural	4.63	1.10	82.67	28.90	7.27	3.67
Irrigated, low vigor, spray	4.17	1.07	81.23	27.73	7.30	3.33
Not Irrigated, high vigor, bug 3/m	4.83	1.12	82.77	30.73	6.93	3.33
Not Irrigated, high vigor, bug 9/m	4.77	1.13	82.80	31.70	7.13	3.00
Not Irrigated, high vigor, natural	4.40	1.13	83.37	32.43	6.97	2.00
Not Irrigated, high vigor, spray	4.40	1.10	82.50	30.13	6.80	3.00
Not Irrigated, low vigor, bug 3/m	4.87	1.13	84.03	31.93	7.17	3.33
Not Irrigated, low vigor, bug 9/m	4.50	1.10	82.20	29.80	6.93	3.33
Not Irrigated, low vigor, natural	4.53	1.14	83.57	34.83	6.60	3.00
Not Irrigated, low vigor, spray	5.00	1.11	83.30	31.37	6.53	3.00
Analysis of Variance						
P>F Irrigation(I)	0.06	0.06	0.30	0.01	0.27	0.44
Vigor (V)	0.97	0.35	0.90	0.97	0.93	0.02
Bug (B)	0.48	0.15	0.49	0.28	0.48	0.53
I * V	0.29	0.24	0.33	0.15	0.33	0.62
I * B	0.61	0.57	0.43	0.01	0.82	0.03
B * V	0.45	0.08	0.42	0.12	0.97	0.26
I * B * V	0.11	0.67	0.70	0.53	0.69	0.26

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