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AGRONOMY AND SOILS

Effect of Twin-Row Planting Pattern and Plant Density on Cotton Growth, Yield, and Fiber Quality

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ABSTRACT

Investigation of new cotton (*Gossypium hirsutum*) production strategies such as alternative planting patterns in conjunction with plant density is needed to improve yield and profitability. Field experiments were conducted to evaluate the effect of three cotton planting patterns (19 or 38 cm twin rows and 97 cm single rows) at five plant densities (7, 9, 11, 13, and 15 plants m^{-2}) on cotton growth, yield, and fiber quality. Planting pattern did not influence any plant structure or yield variables, seed cotton or lint yield, lint percentage, lint or seed index, and fiber quality. Plant density did not influence the first sympodial branch on the main axis. Monopodial branch number increased with decreasing plant density. The 7 plants m^{-2} density produced 13.8 sympodia on the main axis and highest first position boll at node 10.5. Total nodes and plant height were greatest for the 7 plants m^{-2} density. As plant density increased, total bolls per plant decreased. First position boll retention was inversely related to plant densities. Seed cotton and lint yield were greatest for the 11 plants m^{-2} plant density, but this only differed from the 7 plants m^{-2} density. Plant density did not influence fiber length, micronaire, strength, or uniformity. Based on these data, seeding cotton in either twin-row planting pattern does not adversely affect cotton growth, yield, or fiber quality. However, cotton plant density had a strong impact on measured variables.

Selecting effective economic and environmental production strategies are critical for cotton producers due to rising production costs and declining returns for their crop. Reducing cotton planting pattern (row spacing) and plant densities, are two strategies producers have manipulated in the past to increase yield and decrease down-the-row production costs. Traditionally, cotton planting patterns have been single rows consistently spaced 97 to 102 cm apart (Reddy et al., 2009). However, interest in seeding cotton in consistently spaced 19 to 25 cm rows (ultra-narrow-row) and harvesting with a finger-stripper increased in the 1990s as a possible way to reduce production costs and increase yields (Atwell, 1996; Culpepper and York, 2000). However, this system was not widely adopted due to increased plant density requirements, cost of ginning, and reduced fiber quality associated with finger-stripper harvested cotton (Brown et al., 1998; Valco et al., 2001). In 2005, a spindle-type cotton harvester capable of harvesting 38 to 102 cm rows (Karnei, 2005) renewed interest in narrow-row cotton production. Numerous researchers observed that cotton seeded in 38 cm rows produced similar or greater yields than 97 to 102 cm wide rows (Buehring et al., 2006; Harrison et al., 2006; Karnei, 2005; Wilson et al., 2007). Additionally, a twin-row planting pattern (two rows spaced 18 to 38 cm apart on 92 to 102 cm centers) has been utilized in corn (*Zea mays* L.), peanut (*Arachis hypogea* L.), and soybean (*Glycine max* L.) production systems (Brecke and Stephenson, 2006; Colvin et al., 1985; Lanier et al., 2004; Nelson, 2007). Others have reported that twin-row peanuts yielded 300 to 500 kg ha^{-1} more than single-row peanuts (Brecke and Stephenson, 2006; Colvin et al., 1985; Lanier et al, 2004). However, seeding corn and soybean in twin-rows offered no yield advantage compared to wide rows (Nelson, 2007). Stephenson and Brecke (2010) reported a slight yield increase when cotton seeded in 19 cm twin rows was compared to 76 cm single rows. No cotton yield differences were observed by Reddy et al. (2009) between 25 cm twin rows and 102 cm single rows.

Another strategy producers have utilized to decrease production cost is reducing the cotton seeding rate or plant densities. Establishing an acceptable stand of cotton seedlings is paramount to obtaining high yields (Christiansen and Rowland,

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1981). Recent studies have shown no differences in cotton yield due to plant density (Bednarz et al., 2000; Franklin et al., 2000; Jones and Wells, 1998; Seibert et al., 2006; Seibert and Stewart 2006). The lack of yield differences can be explained by an increased number of main stem nodes, and location of sympodial and monopodial bolls on plants grown at low densities (Jones and Wells, 1997; Seibert et al., 2006). Current technology allows cotton to be effectively seeded and harvested in alternative planting patterns. In addition, reducing cotton plant densities could be a practical option for producers to decrease production costs. However, no information is available concerning the effect of an alternative cotton planting pattern utilizing reduced plant densities. The objective of this research was to evaluate the effect of three cotton planting patterns across five cotton plant densities to determine the effect on cotton growth, yield, and fiber quality.

MATERIALS AND METHODS

Experiments were conducted to evaluate the effect of three planting patterns and five plant densities on cotton growth, yield, and fiber quality in 2007, 2008, and 2009 at the University of Arkansas Lon Mann Cotton Research Station in Marianna, AR and in 2007 and 2008 at the Northeast Research and Extension Center in Keiser, AR. The soil at Marianna is a Callaway silt loam (fine-silty, mixed, thermic Glossaquic Fragiudalfs) with 11.7% sand, 69.8% silt, 18.5% clay, pH of 5.6, and 1.25% organic matter. Soil at Keiser is a Sharkey silty clay loam (very fine, smectitic, thermic Chromic Epiaquerts) with 20% sand, 49% silt, 31% clay, pH of 6.8, and 2.25% organic matter.

A split-plot experimental design was utilized with treatments arranged in a randomized complete block with four replications. Plots were 3.9 m wide (4, 97 cm raised beds) by 15.3 m long. Main plots consisted of three cotton planting patterns: twin rows spaced 19 cm or 38 cm apart on 97 cm centers, and single rows spaced 97 cm apart (Figure 1). All planting patterns were seeded on a raised bed mechanically prepared with a hipper-roller (W & A Manufacturing Co., Pine Bluff, AR) designed to provide 97 cm raised beds with the crown of each bed rolled flat to a width of 61 cm to facilitate planting. Split-plots consisted of five cotton plant densities: 7, 9, 11, 13, and 15 plants m^{-2}. To achieve the desired plant densities, actual seeding rates were adjusted assuming 80% survival of planted seed. A modified John Deere vacuum planter with a hydraulic-powered variable-rate seed drive (Deere & Company, Moline, IL) was utilized to seed both the 38 cm twin-row and 97 cm single row planting patterns. To seed the 19 cm twin row planting pattern, a Monosem vacuum planter (Monosem Inc., Edwardsville, KS) equipped with a hydraulic variable-rate seed drive (Trimble Navigation Limited, Sonnyvale, CA) was employed. 'Stoneville 4554 B2RF' was seeded in all planting patterns and plant densities between 15 May and 21 May of each year at both locations. Cotton emerged about five days following seeding in all years.

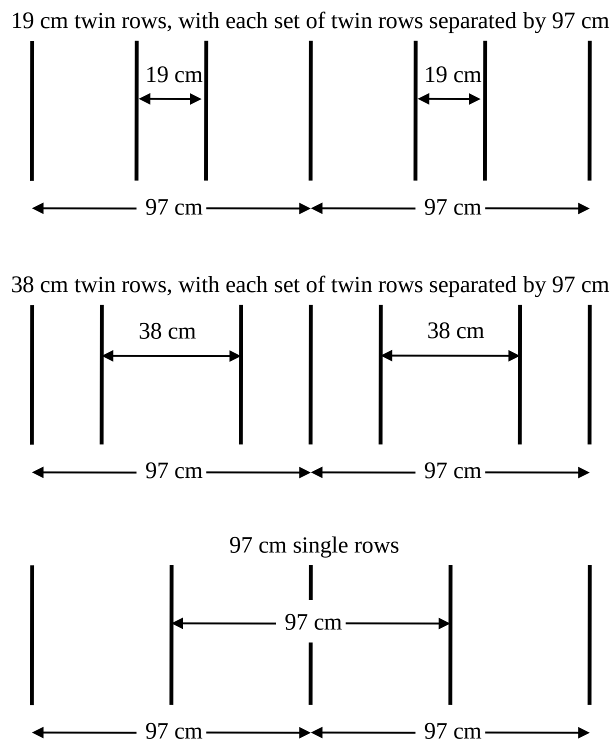

Figure 1. Illustration of 19 and 38 cm twin row and 97 cm single row planting patterns. Solid line represents sides of mechanically-constructed raised beds. Dotted lines represent rows of cotton plants.

To determine if the five targeted plant densities were achieved, plant density 30 d after emergence was collected by counting the number of plants in 12 m of both the center two rows of each plot and data were averaged for each plot. Plant density data were subjected to PROC MIXED in Statistical Analysis System (SAS® version 9.1.3; SAS Institute Inc.; Cary, NC) with replications (nested within year) considered as a random effect and location, plant density, and year considered fixed effects. Analysis indicated considerable variation in plant densities 30 d after emergence compared to the target plant densities at Keiser in all years and at Marianna in 2007. In both years at

Keiser, numerous attempts were made to mechanically prepare a 97 cm raised bed with the crown rolled flat to a width of 61 cm, which was required for seeding cotton in the multiple planting patterns specified for this research. However, formation of a raised bed that allowed proper seed placement and depth was not accomplished, which caused the observed plant densities to be approximately 25-50% less than the desired plant densities shown in Table 1. At Marianna in 2007, heavy rainfall (10 cm) following planting caused soil crusting, which hampered cotton emergence thus reducing observed plant densities 15-30% 30 d after emergence. This variation in plant stand necessitated the need to exclude all Keiser and 2007 Marianna data from analysis because their inclusion would not allow proper evaluation of the effect that planting pattern and plant density may have had on cotton plant structure and boll distribution. Therefore, only data from Marianna in 2008 and 2009 were utilized for analysis. Table 1 shows the actual plant densities at Marianna in 2008 and 2009, which differed among plant density treatments as desired, but not among planting patterns. Plant density data indicates that the desired survival of approximately 80% was achieved (Table 1).

Table 1. Actual plant populations for each planting pattern and plant density 30 d after emergence at Marianna in 2008 and 2009.

	Observed plant density	
	2008	**2009**
Planting pattern[z]	------------- Plants m^{-2} -------------	
19-cm twin row	**11.2 a**	**11.2 a**
38-cm twin row	**10.9 a**	**11.9 a**
97-cm single row	**10.9 a**	**11.2 a**
P-value (0.05)	**0.4817**	**0.3824**
Target plant density[y,x]		
7 plants m^{-2}	**7.1 e**	**6.9 e**
9 plants m^{-2}	**8.2 d**	**8.9 d**
11 plants m^{-2}	**11.6 c**	**11.9 c**
13 plants m^{-2}	**13.3 b**	**13.4 b**
15 plants m^{-2}	**15.0 a**	**15.5 a**
P-value (0.05)	**0.0184**	**0.0098**

[z] Planting pattern data pooled over plant density. Means followed by the same letter for each parameter are not significantly different at $P \leq 0.05$.

[y] Plant density data pooled over planting pattern. Means followed by the same letter for each parameter are not significantly different at $P \leq 0.05$.

[x] To achieve the targeted plant densities, actual seeding rates are adjusted assuming 80% survival of planted seed.

At Marianna in 2008 and 2009, cotton was fertilized with a preplant application of 112, 34, and 67 kg ha^{-1} of N, P, and K, respectively. At first bloom (defined as 50% of plants with a white flower), 49 g ha^{-1} of mepiquat chloride (Mepex®, NuFarm Americas Inc., Burr Ridge, IL) was applied in each year. Herbicides, insecticides, and defoliants were applied uniformly, according to standard management practices for Arkansas.

In addition to plant density data collected 30 d after emergence, 10 plants per plot were randomly chosen just prior to harvest and mapped utilizing the COTMAP plant mapping technique described by Bourland and Watson (1990) to determine if cotton structure and fruiting behavior were influenced by planting pattern and plant density. This plant mapping technique maps the primary fruiting sites (first and second sympodial positions) while the remaining fruiting sites are considered collectively. In addition, total bolls, boll distribution, and boll retention in prime fruiting sites were calculated. Plant structure variables measured included node of first (lowest) sympodial branch on the main axis (FN), number of monopodial (M) and sympodial (S) branches on main axis, node number of the highest sympodium with a boll in the first position (ES), highest sympodium with two nodal positions (H2), total number of nodes on main axis above cotyledonary nodes (TN), plant height in cm (PHT), and average length of main axis internodes (IL). Yield variables include total bolls per plant (TB), percentage of total bolls associated with first (B1), second (B2), outer (i.e. outside first and second positions) (OB), and secondary auxiliary positions (XB), percentage of total bolls with sympodia arising from monopodia (MB). Boll retention variables included retention of all first (BR1) and second (BR2) sympodial boll positions, and boll retention summed over the first two positions of the first (lowest) five sympodia (EBR).

Following plant mapping, seed cotton was mechanically harvested at Marianna in late October 2008 and 2009 with a John Deere spindle-harvester (Deere & Company, Moline, IL) capable of harvesting all three planting patterns. To determine lint percentage, lint yield, lint index (g lint 100 $seed^{-1}$), seed index (g 100 $seed^{-1}$), a 2 kg seed cotton sample was collected from each subplot in two randomly selected replications at harvest followed by processing each seed cotton sample on a 10-saw micro-gin (Continental Eagle Co., Prattville, AL). Additionally, a 30 g lint sub-sample was sent to the Louisiana State University Cotton Fiber Lab in Baton Rouge, LA to determine fiber length, micronaire, strength, and uniformity using high volume instrument analysis.

Data, except plant densities, were subjected to analysis of variance using PROC MIXED in SAS. Years and replications (nested within year) were considered random effects with planting pattern and plant density considered fixed effects (Blouin et al., 2011; Bond et al., 2008; Ottis et al., 2004; Stephenson et al., 2004, 2007; Walker et al., 2006, 2008). Considering years and locations as random effects permits inferences about treatments to be made over a range of environments (Blouin et al., 2011; Carmer et al., 1989). Least square means were calculated and mean separation ($P \leq 0.05$) was produced using PDMIX800 in SAS, which is a macro for converting mean separation output to letter groupings (Saxton, 1998).

RESULTS AND DISCUSSION

The main effect of cotton planting pattern and the planting pattern by planting density interaction was not significant at $P = 0.05$ for any variable measured (Table 2). The main effect of cotton plant density was significant for actual observed plant densities, plant structure variables (M, S, ES, H2, TN, and PHT), yield variables (B1, OB, MB, BR1, and BR2), seed cotton yield, and lint yield (Table 2).

Plant mapping indicated that planting pattern did not influence plant structure variables FN (6.3 – 6.5), M (1.9 – 2.2), S (12.2 – 3.1), ES (8.8 – 9.8), H2 (9.2 – 10.0), PHT (98 – 105 cm), or IL (5.5 – 5.8 cm) (data not shown). However, cotton plant density influenced numerous plant structure and yield variables (Tables 3 and 4). Plant density did not influence FN (Table 3). The number of monopodial branches increased with decreasing plant density with 3, 2.1, 1.9, 1.6, and 1.4 monopodia observed for the 7, 9, 11, 13, and 15 plants m^{-2} plant densities, respectively (Table 3). Similar to our results, Bednarz et al. (2000) and O'Berry et al. (2008) found that decreasing cotton plant densities lead to greater monopodial branches. The effect of cotton plant density for the three variables associated with sympodial branches, S, ES, and H2, was similar. Seven plants m^{-2} density developed 13.8 S, 10.5 ES, and 10.9 H2, which was greater than any other plant density (Table 3). Total nodes and PHT were greatest for the 7 plants m^{-2} density compared to other plant densities, which may be due to increased sympodia produced at the lowest plant density (Table 3). Past research also observed that total nodes per plant were inversely related to plant densities (Bednarz et al., 2000; Jones and Wells, 1997; O'Berry et al., 2008; Seibert and Stewart, 2006; Seibert et al., 2006). Seibert and Stewart (2006) observed that plant density did not influence plant height; however, Seibert et al. (2006) found a positive relationship between plant height and plant density. Average internode length was not influenced by plant density with an overall average of 5.7 cm (Table 3). Pettigrew and Johnson (2005) reported no differences between cotton plant densities of 7, 9, 11, or 13 plants m^{-2} for plant height and total nodes per plant.

Table 2. Significance of the main effects of planting pattern and plant density and interactions among main effects.

Effect[z]	Planting pattern	Plant density	Planting pattern x Plant density
FN	0.8524	0.8505	0.9084
M	0.8884	0.0095	0.0895
S	0.2692	0.0003	0.2963
ES	0.3486	<0.0001	0.0924
H2	0.5120	0.0002	0.1168
TN	0.4612	<0.0001	0.4770
PHT	0.4535	0.0097	0.6241
IL	0.0745	0.6937	0.6737
TB	0.4769	<0.0001	0.1024
B1	0.4314	<0.0001	0.0784
B2	0.4190	0.5359	0.4286
OB	0.5526	0.0466	0.1209
MB	0.2339	0.0114	0.0994
XB	0.1078	0.2151	0.3730
BR1	0.8732	0.0324	0.5122
BR2	0.4828	0.0198	0.0849
EBR	0.2888	0.0246	0.0654
Seed Cotton Yield	0.8352	0.0413	0.9572
Lint Yield	0.8960	0.0428	0.8117
Lint percentage	0.3773	0.5267	0.4271
Lint Index	0.7598	0.7025	0.3639
Seed Index	0.9866	0.8663	0.9316
Fiber length	0.8677	0.8021	0.5797
Fiber micronaire	0.8532	0.7114	0.4455
Fiber strength	0.8378	0.8173	0.5001
Fiber uniformity	0.0978	0.5716	0.8695

[z] Plant structure variables are FN (first sympodia node); M (no. of monopodia), S (no. of sympodia); ES (no. of highest sympodium with a boll in the first position); H2 (highest sympodium with two nodal positions); TN (total main axis nodes); PHT (plant height), and IL (average internode length); TB (total bolls), B1, B2, OB, MB, and XB (proportion of TB associated with first, second, and outer sympodial nodes from main axis, monopodia, and second auxiliary nodes, respectively); BR1 and BR2 (boll retention in first and second sympodial nodes from main axis); and EBR (first and second boll sympodial nodes on lowest five sympodia).

Planting pattern did not influence yield variables TB (9.4 – 10.2), B1 (66.5 – 69.9%), B2 (18.1 – 19.8%), OB (3.0 – 3.4%), MB (9.4 – 12.2%), XB (0.2 – 0.5%), BR1 (45.6 – 46.6%), BR2 (18.3 – 19.7%), or EBR (39.5 – 42.0%) (data not shown). However, TB and other boll distribution variables (B1, B2, OB, MB, and XB) were highly influenced by plant density (Table 4). As plant density increased, TB decreased with 12.9, 9.0, 8.3, 7.8, and 6.8 bolls per plant for the 7, 9, 11, 13, and 15 plants m^{-2} densities, respectively (Table 4). Similarly, Gwathmey and Clement (2010) found that increasing plant density from 8.3 to 17.6 plants m^{-2} decreased total number of bolls. Greater TB associated with 7 plants m^{-2} may be due to a greater percentage of bolls associated with OB (4%) and MB (16.8%) (Table 4). Similarly, others have found that OB increased as plant density decreased (Bednarz et al., 2000; O'Berry et al., 2008; Seibert and Stewart, 2006). Lower cotton plant densities typically produce a greater number of bolls outside the first and second position as well as sympodia arising from monopodial branches that may be due to less interplant competition between cotton plants. The greater number M and S branches for the 7 plants m^{-2} densities detected by plant mapping may be another cause for the observed boll distribution (Table 3).

Percentage of total bolls associated with the first position increased with increasing plant density. A B1 of 75.9% was observed for the 15 plants m^{-2} density, which was greater than the percentage of bolls associated with the first position for a plant density of 7 or 9 plants m^{-2} (Table 4). Increased B1 for higher plant densities may be due to greater interplant competition among cotton plants, but this competition may have caused decreased first position boll retention (BR1) at higher plant densities (Table 4). In other research, O'Berry et al. (2008) found no differences in the number of first and second position bolls per plant between plant densities of 5.3, 8.9, and 12.8 plants m^{-2} in North Carolina and Virginia.

Table 3. Effect of plant density on plant structure variables[z] determined by plant mapping.

	FN	M	S	ES	H2	TN	PHT	IL
Plant density[y]	no.						cm	
7 plants m^{-2}	6.5 a	3.0 a	13.8 a	10.5 a	10.9 a	19.3 a	110.5 a	5.7 a
9 plants m^{-2}	6.4 a	2.1 b	12.5 b	9.2 b	9.5 b	17.9 b	100.0 b	5.6 a
11 plants m^{-2}	6.5 a	1.9 bc	12.2 b	9.0 b	9.5 b	17.7 b	101.8 b	5.8 a
13 plants m^{-2}	6.4 a	1.6 bc	12.2 b	8.9 b	9.1 b	17.6 b	98.8 b	5.6 a
15 plants m^{-2}	6.3 a	1.4 c	11.9 b	8.6 b	8.8 b	17.2 b	98.0 b	5.7 a

[z] Plant structure variables are FN (first sympodia node); M (no. of monopodia), S (no. of sympodia); ES (no. of highest sympodium with a boll in the first position); H2 (highest sympodium with two nodal positions); TN (total main axis nodes); PHT (plant height), and IL (average internode length).

[y] Plant density data pooled over planting pattern. Means followed by the same letter for each parameter are not significantly different at P ≤ 0.05.

Table 4. Effect of plant density on yield variables[z] determined by plant mapping.

	Boll Distribution						Boll Retention		
	TB	B1	B2	OB	MB	XB	BR1	BR2	EBR
Plant density[y]	no.	%					%		
7 plants m^{-2}	12.9 a	58.0 c	20.7 a	4.0 a	16.8 a	0.5 a	49.9 a	24.7 a	47.1 a
9 plants m^{-2}	9.0 b	68.5 b	18.9 a	2.0 b	10.3 b	0.3 a	47.8 a	18.3 b	43.1 b
11 plants m^{-2}	8.3 b	70.5 ab	19.2 a	2.8 b	7.6 bc	0.1 a	46.4 ab	17.0 b	41.2 b
13 plants m^{-2}	7.8 bc	73.5 ab	17.2 a	2.1 b	7.0 bc	0.2 a	44.3 b	15.5 bc	37.0 c
15 plants m^{-2}	6.8 c	75.9 a	17.3 a	1.6 b	5.0 c	0.3 a	42.9 b	14.2 c	35.6 c

[z] Yield variables are TB (total bolls), B1, B2, OB, MB, and XB (proportion of TB associated with first, second, and outer sympodial nodes from main axis, monopodia, and second axilliary nodes, respectively); BR1 and BR2 (boll retention in first and second sympodial nodes from main axis); and EBR (first and second boll sympodial nodes on lowest five sympodia).

[y] Plant density data pooled over planting pattern. Means followed by the same letter for each parameter are not significantly different at P ≤ 0.05.

Plant mapping detected that BR1 was inversely related to plant densities with 7 and 9 plants m^{-2} densities having 49.9 and 47.8% BR1, but 13 and 15 plants m^{-2} densities obtaining only 44.3 and 42.9% BR1 (Table 4). Seibert et al. (2006) found that overall boll retention was decreased as plant density increased. Percentage of total bolls associated with the second position or XB was not influenced by plant density; however, BR2 was 24.7% for 7 plants m^{-2} which was greater than all other densities (Table 4). Greater BR2 at lower plant densities may be a function of less interplant competition among cotton plants resulting in less shading thus increasing retention. Boll retention summed over the first (lowest) five sympodia was correlated to BR1 and BR2 which indicated that lower plant densities were observed with greater EBR (Table 4). These results indicate that plants seeded at low densities were able to maintain lower sympodia fruiting structures due to less interplant competition.

Planting pattern did not influence seed cotton yield (3160 – 3250 kg ha^{-1}) or lint yield (1320 – 1350 kg ha^{-1}) (data not shown). Gwathmey et al. (2008) found that cotton seeded 76 cm rows yielded greater than 25 and 102 cm rows. Reddy et al. (2009) reported no differences between 25 cm twin-row and 102 cm single row cotton. However, differences in seed cotton and lint yield were observed between the 7 and 11 plants m^{-2} densities (Table 5). Eleven plants m^{-2} yielded 370 and 120 kg ha^{-1} more seed cotton and lint, respectively, than the 7 plants m^{-2} planting density, but no other differences among plant densities were observed (Table 5). Stephenson and Brecke (2010) found that cotton seeded at 7 plants m^{-2} in 19 cm twin rows yielded 220 kg ha^{-1} more than 76 cm single row cotton, but differences between planting patterns were not observed at plant densities of 13 and 26 plants m^{-2}. Others found that lint yield was not influenced by plant density when cotton was seeded in 90 or 97 cm rows (Bednarz et al., 2000; Franklin et al., 2000; Seibert and Stewart, 2006; Seibert et al. 2006). Conversely, Bednarz et al. (2005) found that cotton lint yields increased when plant density was increased. O'Berry et al. (2008) reported that plant densities of 8.9 and 12.8 plants m^{-2} resulted in higher yields compared to 5.3 plants m^{-2}.

Planting pattern did not influence lint percentage (40.9 – 42.6%), lint index (6.8 – 7.3 lint 100 $seed^{-1}$), or seed index (9.2 g 100 $seed^{-1}$) (data not shown). Additionally, plant density did not affect lint percentage (40.9 – 42.6%), lint index (6.8 – 7.4 lint 100 $seed^{-1}$), or seed index (9.1 – 9.3 g 100 $seed^{-1}$) (data not shown). O'Berry et al. (2008) observed no effect of plant density on lint percentage, but Bednarz et al. (2005) reported that lint percentage increased with a plant density of 3.6 plants m^{-2} compared to 9.0 – 21.5 plants m^{-2}. Fiber length (28.7 mm), micronaire (4.3), strength (287 – 288 kN m kg^{-1}), or uniformity (83.5 – 84.3%) was not influenced by planting pattern (data not shown). Also, plant density did not affect fiber length (28.5 – 28.7 mm), micronaire (4.2 – 4.4), strength (286 – 290 kN m kg^{-1}), or uniformity (83.6 – 84.2%). Previous work indicated that plant density did not influence fiber strength or uniformity, but micronaire was slightly affected (Pettigrew and Johnson, 2005). Darawsheh et al., (2009) observed decreased fiber micronaire and length when plant densities are increased, but fiber strength and uniformity were not affected.

Results indicate that seeding cotton in 19 or 38 cm twin rows or 97 cm single rows, on a 97 cm bedded row pattern does not influence cotton growth, yield, or fiber quality. However, plant density affects cotton plant structure and yield. Yield was only affected when plant density was less than 9 plants m^{-2}. Results demonstrate the cotton plant's ability to compensate for variation in stands. A greater number of monopodial and sympodial branches, total nodes, taller plants, increased number of total bolls, and increased boll retention on all sympodial and monopodial positions were observed when cotton was seeded to obtain low plant densities (7 plants m^{-2}). Even though a lower plant density provided a greater number of the afore mentioned plant structure and yield variables, seeding cotton to obtain 11 plants m^{-2} was the observed optimum rate for cotton yield potential with 280 and 120 kg ha^{-1}more seed cotton and lint yield, respectively, compared to the 7 plants m^{-2} density. Based on these data, seeding cotton in either twin-row planting pattern on a wide 97 cm bed does not adversely affect cotton growth, yield, or fiber quality as long as adequate plant stand is achieved. However, cotton plant density is quite influential on the observed plant structure and boll distribution variables.

Table 5. Effect of plant density on seed cotton yield and lint yield.

	Seed cotton yield	Lint yield
Plant density[z]	**kg ha^{-1}**	**kg ha^{-1}**
7 plants m^{-2}	**3010 b**	**1280 b**
9 plants m^{-2}	**3250 ab**	**1350 ab**
11 plants m^{-2}	**3380 a**	**1400 a**
13 plants m^{-2}	**3190 ab**	**1350 ab**
15 plants m^{-2}	**3220 ab**	**1330 ab**

[z] **Plant density data pooled over planting pattern. Means followed by the same letter for each parameter are not significantly different at $P \leq 0.05$.**

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