The *Journal of Cotton Science 19:319–327 (2015)*
http://journal.cotton.org, © The Cotton Foundation 2015

MOLECULAR BIOLOGY AND PHYSIOLOGY

Twin-Row Production of Cotton Genotypes Varying in Leaf Shape

William T. Pettigrew*

ABSTRACT

Twin-row planting for soybean and maize has proliferated in Mid-South production systems during the past decade. Knowledge of cotton production with twin-row planting is limited. The objective of this research was to determine how cotton leaf-type isolines (varying in size and the degree of lobing) performed in both twin-row and single-row planting patterns. Field studies were conducted in 2011 and 2012. Four genotypes (MD 65-11 normal, MD 65-11 okra, MD 65-11 super okra, and ST 4554B2RF) were grown in both twin-row and single-row planting patterns. Dry matter partitioning, leaf area index, light interception, nodes above white bloom, lint yield, and fiber quality data were collected. The response to twin-row planting when compared to single-row planting was consistent across all the cotton genotypes evaluated in this study. Twin-row canopies produced a greater early season leaf area index that intercepted more sunlight than the single-row pattern, but these differences diminished as the season progressed. Twin-row plots reached cutout approximately two days earlier than the single-row plots. Despite increased early season leaf area production and sunlight interception, no differences between planting patterns were detected for lint yield, the yield components, or fiber quality traits. Convenience of using a standard planting configuration across multiple crops may be the only justification for twin-row planting in cotton because neither lint yield nor fiber quality were impacted.

Many of the historical cotton hectares in the Mississippi Delta have in recent years shifted production among cotton (*Gossypium hirsutum* L.), soybean (*Glycine max* L.), and maize (*Zea mays* L.), in response to changing commodity prices and the relaxing of United States Department of Agriculture (USDA) farm program regulations. Improved profitability is the driving force behind most of land usage decisions. One of the ways to improve profitability is to become more efficient with equipment usage.

Many regional maize and soybean producers have begun adapting twin-row planting patterns (two rows spaced 18 to 38 cm apart on 92 to 102 cm beds) for their production systems. Although the underlying assumption is that yields can be improved in these twin-row production systems, documentation of the yield responses to twin-row production for maize and soybean has proven inconsistent in Mid-south research trials (Bruns, 2011a; 2011b; 2012; Mascagni et al., 2008). Nonetheless, many Mid-south producers have rapidly adapted twin-row production as a preferred production technique. Having purchased new planting equipment or adapted existing planters for twin-row planting, producers are interested in planting as many of their crops (including cotton) with this twin-row planter as possible, to make the most efficient use of that piece of equipment.

Inconsistent lint yield response for cotton to twin-row planting has also been reported. Mascagni et al. (2008), Reddy et al. (2009), and Stephenson et al. (2011) all reported no significant yield differences between twin-row planted cotton and single-row planted cotton. However, Stephenson and Brecke (2010) and Reddy and Boykin (2010) reported instance when cotton grown in a twin-row planting pattern yielded significantly greater than single-row cotton. No yield differences were observed between planting patterns at the higher plant densities of 13 and 26 plants m^{-2} (Stephenson and Brecke, 2010). These yield inconsistencies occurred despite increased early season light interception (Stephenson and Brecke, 2010) and earlier canopy closure (Reddy et al., 2009; Reddy and Boykin, 2010) from the twin-row planning pattern.

While all the aforementioned twin-row studies utilized normal leaf-type cotton, variation in leaf shape exists among genotypes within the *hirsutum* germplasm pool (Wells et al., 1986). These leaf shape variations lead to differences in canopy architecture and light interception (Wells et al., 1986; Heitholt et al., 1992; Riar et al., 2013). Okra and Super okra leaf types had less leaf area index and intercepted

W.T. Pettigrew*, USDA-ARS, Crop Production Systems Research Unit, P.O. Box 350, Stoneville, MS 38776
*Corresponding author: bill.pettigrew@ars.usda.gov

less sunlight than the normal leaf type lines (Wells et al., 1986). Peng and Krieg (1991) reported that an okra leaf type cotton line had greater canopy apparent photosynthesis per unit leaf area than did the normal leaf type line, but when expressed on a per unit ground area, the normal leaf type line exhibited greater late season canopy apparent photosynthesis. Single leaf photosynthesis of okra and super okra leaf type isolines were also demonstrated to be greater than the normal leaf type counterpart (Pettigrew et al., 1993), complimenting the Peng and Krieg (1991) research. The limited leaf area index of okra leaf cotton compromises canopy photosynthesis, as highlighted by the Wells et al. (1986) and Peng and Krieg (1991) research, and limits yield production in cotton's traditional wide row planting configuration.

Studies to mitigate the leaf area limitation and alter the canopy architecture in okra leaf cotton through changing the planting width have produced inconsistent yield results. Planting in a narrower row configuration (50 cm width) improved the yield production of okra leaf cotton over that produced in wide rows (100 cm width), but it still did not yield more than normal leaf cotton, whose yield response didn't differ between row spacings (Heitholt et al., 1992; 1993). Other studies did not find an interaction between leaf morphology and row spacing for lint yield production (Heitholt, 1995; Heitholt et al., 1996; Riar et al., 2013).

The earlier cotton twin-row vs. wide-row planting comparison produced inconsistent results (Mascagni et al., 2008; Reddy et al., 2009; Stephenson and Brecke, 2010; and Stephenson et al., 2011) but only evaluated normal leaf type cotton in production systems. Evaluations of okra vs. normal leaf type lines in narrower row widths vs. the more traditional planting widths indicate the potential for yield improvements (although inconsistent) from growing okra leaf type cotton in narrow row planting patterns. The objectives of this research were to investigate the crop physiological and agronomic performance of cotton isolines varying in leaf shape morphology when grown in twin-row and wide-row planting patterns.

MATERIALS AND METHODS

Field studies were conducted near Stoneville, MS during the years 2011 and 2012. The soil type of the experimental area was a Dundee silt loam (fine-silty, mixed, active, thermic Typic Endoaqualfs). Four cotton genotypes (3 leaf type isolines and one commercial variety) were grown in two different planting patterns each year of the study. Three cotton leaf type isolines of MD 65-11ne were provided by W.R. Meredith, Jr. They were the normal leaf type (Normal), okra leaf type (Okra), and super okra leaf type (Super) isolines of MD 65-11ne that varied in the degree of leaf lobbing (Wells et al, 1986). ST 4554B2RF was the fourth genotype included in the study (a normal leaf type variety), and was provided by Bayer CropScience, Research Triangle Park, NC. The two planting patterns were a single-row centered on a 1-m bed (single-row) and two rows spaced 23 cm apart and centered on a 1-m bed (twin-row). A JD 7300 vacuum planter (John Deere, East Moline, IL) was utilized to plant the single-row planting pattern. A Monosem NG+3 twin-row vacuum planter (A.T.I., Inc. Monosem, Lenexa, KS) was used to plant the twin-row pattern. Both planters were set to achieve a similar overall plant population density of approximately 100,000 plants ha^{-1}. The genotypes and planting patterns were arranged factorially in a randomized complete block design with six replicates.

Cotton was planted on 29 April, 2011 and 26 April, 2012. Plots consisted of four 1-m beds (one row per bed in the single-row configuration and two rows per bed for the twin-row configuration) and were 12 m long. Fluometuron at 1.12 kg ai ha^{-1}, pendimethalin at 1.12 kg ai ha^{-1}, and glyphosate at 2.24 kg ai ha^{-1} were applied pre-emergence for weed control. Later- emerging weeds were controlled by hand-weeding the plots. Prior to planting each year, 112 kg N ha^{-1} were knifed into the experimental area as a urea-ammonium nitrate solution. Furrow irrigations were applied as needed each growing season to minimize moisture deficit stress. Two irrigations of approximately 2.54 cm each were applied in both 2011 and 2012. Recommended insect control measures were utilized each growing season as needed.

Early season dry matter harvests were collected from all plots on 38-40 days after planting (DAP) in 2011 and 39-40 DAP in 2012. Above ground biomass was harvested from a 0.3 m^{-2} section of bed from each plot, avoiding the row ends. These bed sections were 0.3-m long and 1-m wide with one row sampled for the single-row pattern and two rows sampled for the twin-row pattern. Height and the number of main stem nodes on each plant were determined. Plants were then separated into leaves, stems and petioles, squares, and blooms and bolls. Leaves were passed through an LI-3100 area meter

(LI-COR, Lincoln, NE) to determine leaf area index (LAI). Samples were dried for at least 48 h at 60^0C and the dry weights recorded. Specific leaf weight (SLW) was calculated from the leaf area and leaf dry weight. Harvest index was calculated from the reproductive dry weight/total dry weight.

In addition to the leaf area index determined through destructive sampling, LAI was also determined non-destructively utilizing the LI-2200 plant canopy analyzer (LI-COR) during the periods 59-61 DAP, 73-75 DAP, and 87-89 DAP in 2011. Readings were collected between 60-62 DAP and 74-76 DAP in 2012. Detailed methodologies used in quantifying LAI with the LI-2200 have been previously documented (Pettigrew and Johnson, 2005). A total of 16 readings were collected throughout the entire plot area of each plot between 8:00 to 10:00 am Central Daylight Time (CDT).

Canopy photosynthetic photon flux density (PPFD) interception was determined by placing a 1-m-long LI 191SB line quantum sensor (LI-COR) on the ground perpendicular to and centered on the rows, and by positioning a LI 190SB point quantum sensor (LI-COR) above the canopy. Measurements were collected on generally clear skies between 11:00 and 14:00 CDT with the incoming PPFD levels at least 1600 µmols m^{-2} s^{-1}. Two measurements were collected per plot from the inner rows, avoiding the row ends. The mean of these two measurements was used for the later statistical analyses. Canopy light extinction coefficients were estimated according to Beer's law as a function of the leaf area index and canopy intercepted PPFD, as previously described (Constable, 1986; Sadras and Wilson, 1997; Pettigrew and Meredith, 2012).

The number of white blooms (blooms at anthesis) produced per plot was counted on a weekly basis beginning with the onset of early blooming. These counts were continued until the rate of blooming had essentially ceased. Counts were taken on a 6.1-m^2 section of bed from one of the inner plot rows, avoiding the ends. These bed sections were 6.1-m long and 1-m wide with blooms on one row counted for the single-row pattern and blooms from two rows counted for the twin-row pattern. The number of main stem nodes above a sympodial branch occupying the first branch fruiting position (NAWB) were also determined weekly on three randomly selected plants per plot.

During early-to-mid September each year, the cotton was defoliated using a two-step process. The first step involved applying a mixture of 0.035 kg thidiazuron ha^{-1} and 0.0175 kg diuron ha^{-1} to the canopy. One week later a second treatment, a mixture of 0.035 kg thidiazuron ha^{-1}, 0.0175 kg diuron ha^{-1}, and 1.68 kg ethephon ha^{-1} was applied to complete the defoliation and also open most of the remaining unopened bolls. Defoliation was initiated when approximately 60% of the bolls had opened. Approximately two weeks after the second defoliant application, the center two rows of the plot were mechanically harvested with a spindle-picker equipped with an automated weighing system. Yield components were determined from a 50-boll sample that was hand-harvested after defoliation but before the mechanical harvest occurred. These boll samples were subsequently ginned on a 10-saw laboratory gin, saving and weighing the lint and seed. Boll mass was calculated from the 50 boll samples by dividing the sample seed cotton weight by the number of bolls harvested. The lint percentage was determined from the ginned samples and then was used to calculate the total lint yield from the total of the mechanically harvested and hand-harvested seed cotton. The boll mass and total seed cotton weights were used to calculate the number of bolls produced per area. Average seed mass was determined from 100 non-delinted seed per sample and reported as weight per individual seed. Ginned lint from each plot was sent to Starlab Inc. (Knoxville, TN) for fiber quality determination. High volume instrument (HVI) was used to quantify staple length, length uniformity, fiber strength, fiber elongation, and fiber micronaire.

Statistical analyses were performed by analysis of variance (PROC MIXED, SAS Institute, 1996). When statistically significant interactions were not detected, planting pattern means were averaged across genotypes and genotype means were averaged across planting patterns. Overall planting pattern means or genotype means were separated using a LSD $P \leq 0.05$.

RESULTS AND DISCUSSION

The weather during the two growing seasons was dramatically different (Table 1). The period of reproductive growth and boll filling (June-August) during 2011 was much warmer, drier, and had more cumulative solar radiation. In contrast, 2012 had an abundance of rainfall with cooler temperatures and less solar radiation during the same period. Despite these two different growing seasons, years did not significantly interact with either row pattern or genotype for most traits. Therefore, row pattern and genotype means were averaged across years for most traits measured. The exception being the traits of non-destructively measured LAI and canopy extinction coefficients, whose response to either row pattern or genotype varied across the years. For these traits, the row pattern or genotype means are presented by year. Similarly, row patterns and genotypes did not interact significantly for any of the traits measured. Therefore, row pattern means were averaged across genotypes and genotype means were averaged across row patterns.

Table 1. Monthly weather summary for 2011 to 2012 at Stoneville, MS.[z]

Month	2011	2012
	Precipitation (cm)	
April	16.0	10.6
May	7.0	5.2
June	4.0	16.2
July	5.0	11.6
August	6.1	10.9
September	10.1	8.3
October	2.7	14.7
	Thermal Units [y]	
April	159	137
May	224	293
June	404	316
July	436	409
August	425	370
September	228	264
October	101	68
	Solar Radiation (MJ m^{-2})	
April	626	638
May	748	688
June	743	751
July	723	700
August	689	634
September	530	528
October	523	462

[z] All observations made by NOAA, Mid-South Agric. Weather Service, and Delta Research and Extension Center Weather, Stoneville, MS.

[y] [(Max. temp + Min. temp.)/2] – 15.5

Only a few differences were detected between row patterns and genotypes for the dry matter partitioning data collected during an early squaring period dry matter harvest (Table 2). During this early period, the twin-row planting pattern had produced 44% more total dry matter per unit ground area, with a 43% greater leaf area index that intercepted 35% more of the incoming solar radiation than the single-row pattern. These row pattern differences in leaf area index and solar radiation interception match the early season differences also reported by Stephenson and Brecke (2010) and Reddy et al. (2009). The two normal leaf cotton lines (MD 65-11 normal and ST 4554B2RF) both produced a greater leaf area index than either the MD 65-11 okra or MD 65-11 super okra isolines. ST 4554B2RF also produced the greatest total dry matter and intercepted the most incoming solar radiation. These leaf-type differences in light interception were similar to those reported earlier for normal and okra leaf cottons (Heitholt et al., 1992; Heitholt, 1994; Heitholt et al., 1996)

LAI differences between the planting patterns, as quantified by non-destructive methods, diminished as the cotton crop further developed, although the twin-row planting pattern demonstrated a 5% greater LAI than the single-row during the 2011 growing season (Table 3). No LAI differences were detected between row patterns in 2012. Canopy solar radiation interception data collected during similar periods as the non-destructive LAI determinations, also demonstrated that twin-row plots intercepted more sunlight than the single-row plots, but that difference became smaller or non-existent later in the growing season, as the canopies further developed and closed. Canopy extinction coefficients, developed by pairing the non-destructively quantified LAI with the solar radiation interception data, demonstrate that canopies planted in the twin-row pattern were more efficient at intercepting sunlight for a given amount of leaf area than a canopy with a single-row planting pattern. This difference diminished as the canopies reached closure.

The MD 65-11 super-okra isoline demonstrated the lowest non-destructively determined LAI of any of the genotypes both years of the study (Table 3). It also intercepted the least solar radiation of any of the genotypes. Other than ST 4554B2RF having the largest extinction coefficient of any of the genotypes during one measurement period in 2012, no other genotypic differences were detected in canopy extinction coefficients.

Table 2. Early season cotton dry matter partitioning, canopy photosynthetic photon flux density interception, and canopy extinction coefficients as affected by planting patterns and genotype averaged across the years 2011-2012.

Row Pattern	Genotype	Plant Height	Main Stem Nodes	Leaf Area Index	Specific Leaf Weight	Total Dry Weight	Harvest Index	PPFD Interception	Extinction Coefficient
		Cm	nodes plant^{-1}		g m^{-2}	g m^{-2}		%	
Single-row		19.1	9.1	0.28	69.2	28.9	0.0011	23.7	1.071
Twin-row		18.6	9.4	0.40	71.2	41.6	0.0011	32.0	0.973
LSD 0.05		1.4 (ns) ^{z}	0.4 (ns)	0.04	4.0 (ns)	4.5	0.001 (ns)	4.1	0.244 (ns)
	Normal	19.4	9.6	0.38	68.1	37.4	0.0018	28.4	0.935
	Okra	17.2	9.0	0.31	68.9	30.7	0.0001	24.9	0.966
	Super Okra	19.6	9.3	0.30	71.1	32.5	0.0009	26.9	1.122
	ST 4554B2RF	19.1	9.2	0.38	72.6	40.3	0.0016	31.2	1.065
	LSD 0.05	2.0 (ns)	0.6 (ns)	0.06	5.7 (ns)	6.4	0.0015 (ns)	5.9	0.344 (ns)

^{z} ns = Not significantly different at the $P \leq 0.05$ level.

Table 3. Cotton leaf area index (LAI), photosynthetic photon flux density interception (PPFD) and canopy extinction coefficients at varying times during the growing season as affected by planting pattern and genotypes for the years 2011-2012.

Year	Row Pattern	Genotype	1st LAI	2nd LAI	3rd LAI	1st PPFD Interception	2nd PPFD Interception	1st Extinction Coefficient	2nd Extinction Coefficient
						%	%		
2011	Single-row		2.77	3.53	4.31	76.8	90.5	0.564	0.710
	Twin-row		2.88	3.75	4.53	87.9	93.3	0.793	0.854
	LSD 0.05		0.15 (ns) ^{z}	0.18	0.21	3.0	2.7	0.083	0.099
		Normal	3.29	3.97	4.90	86.4	94.7	0.676	0.867
		Okra	2.67	3.67	4.47	80.5	92.9	0.673	0.788
		Super Okra	2.23	3.01	3.44	77.1	87.5	0.703	0.732
		ST 4554B2RF	3.11	3.92	4.87	85.3	92.5	0.662	0.740
		LSD 0.05	0.21	0.26	0.30	4.2	3.9	0.118 (ns)	0.140 (ns)
2012	Single-row		3.16	5.02	-	91.8	97.9	0.830	0.862
	Twin-row		3.14	5.21	-	96.7	98.5	1.181	0.874
	LSD 0.05		0.19 (ns)	0.21 (ns)	-	1.4	0.7 (ns)	0.089	0.050 (ns)
		Normal	3.56	5.86	-	96.6	99.2	1.032	0.857
		Okra	3.17	4.98	-	94.6	98.4	0.990	0.866
		Super Okra	2.63	4.21	-	90.7	95.9	0.958	0.795
		ST 4554B2RF	3.24	5.40	-	95.2	99.3	1.043	0.955
		LSD 0.05	0.28	0.30	-	2.0	1.0	0.125 (ns)	0.071

^{z} ns = Not significantly different at the $P \leq 0.05$ level.

Reproductive growth was not consistently impacted by the planting row pattern across both years of the study. The single-row pattern had a 15% greater blooming rate at 83 DAP and a 26% greater blooming rate at 96 DAP in 2011 than the twin-row pattern (Figure 1). However, no significant blooming rate differences were detected between planting patterns in 2012. In contrast, the maturity of the crop, as measured by the progression of a first sympodial position white bloom up the main stem, was slightly earlier for the twin-row compared to the single-row (Figure 2). At 76, 83, and 88 DAP in 2011, the single-row pattern had a greater nodes above white bloom (NAWB) count than the twin-row pattern. This difference was also observed at 78 DAP in 2012. Based upon these NAWB data, the canopies planted in the twin-row pattern reached cutout or NAWB=5 (Bourland et al., 1992) approximately two days earlier than the single-row pattern canopies in 2011. This minor cutout difference between row patterns was not evident in 2012.

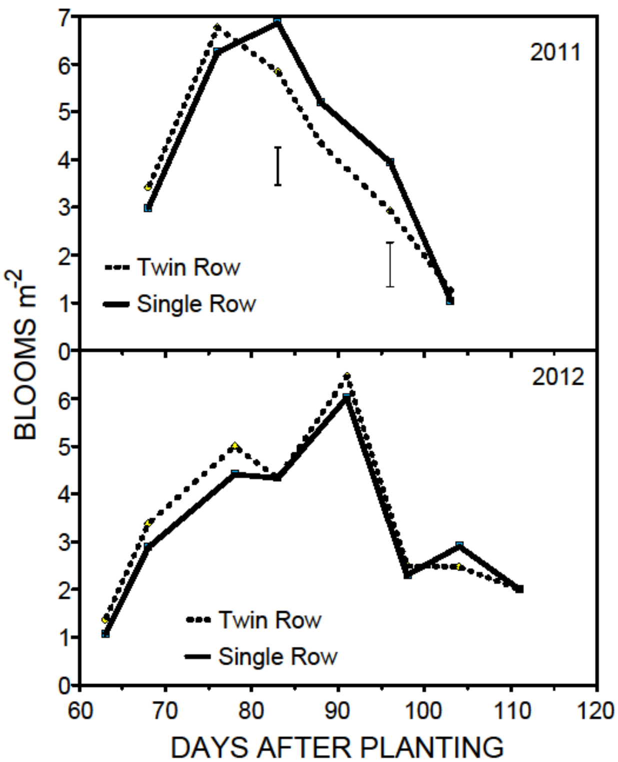

Figure 1. White blooms (blooms at anthesis) m^{-2} of ground area at various times throughout the 2011 and 2012 growing seasons as impacted by planting a single-row on a one-m bed (Single-row) or planting twin-rows spaced 23 cm apart on a one-m bed (Twin-row). Vertical bars denote LSD values at the 0.05 level and are present only when the planting pattern means for that date are statistically different at the 0.05 level.

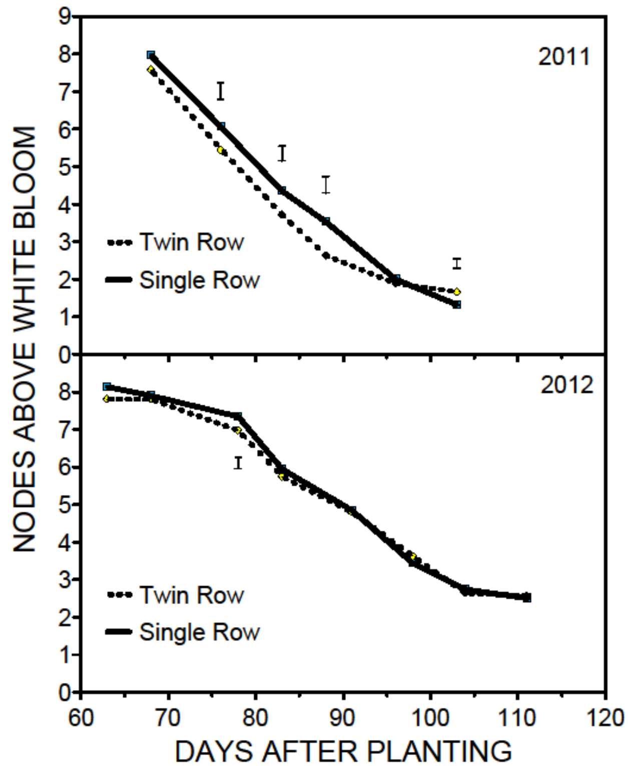

Figure 2. Number of main stem nodes of cotton above a sympodial branch with a first position white bloom (blooms at anthesis) at various times throughout the 2011 and 2012 growing seasons as impacted by planting a single-row on a one-m bed (Single-row) or planting twin-rows spaced 23 cm apart on a one-m bed (Twin-row). Vertical bars denote LSD values at the 0.05 level and are present only when the planting pattern means for that date are statistically different at the 0.05 level.

Despite minor row pattern differences for some of the early reproductive growth traits, ultimately no lint yield differences were detected between the row patterns (Table 4). Similarly, no row pattern differences were detected for any of the yield component traits. This lack of a lint yield response to the twin-row planting pattern was consistent with that demonstrated in prior cotton twin-row research (Mascagni et al., 2008; Reddy et al., 2009; and Stephenson et al., 2011). In contrast, instances of higher yields with twin-row production were reported by Stephenson and Brecke (2010) and Reddy and Boykin (2010) when compared to the single-row pattern at the same density. Not only were row pattern differences not detected in the amount of lint produced, but also no row pattern differences were detected among the various fiber quality traits quantified in this research (Table 5). This lack of an effect on fiber quality from the twin-row production is similar to that reported by Boykin and Reddy (2010).

Strong differences were detected among the genotypes for lint yield production (Table 4). The modern commercial variety ST 4554B2RF yielded on average 58% more than any of the MD 65-11 ne leaf type isolines. The production of 41% more bolls per unit ground area is the principal yield component responsible for the higher yield of ST 4554B2RF. ST 4554B2RF also produced on average a 10% larger lint percentage and 11% greater lint index than the MD 65-11 isolines. In contrast, ST 4554B2RF had a lower seed index than either MD 65-11 normal or okra, the two largest seed index genotypes.

Genotypic differences were also detected in the fiber quality traits measured in this research (Table 5). In general, fiber from MD 65-11 normal leaf type was superior in quality to that obtained from any of the other genotypes in this study. The MD 65-11 normal fiber was longer with greater length uniformity than the other genotypes. The two normal leaf-type genotypes (MD 65-11 normal and ST 4554B2RF) produced stronger fiber with a greater fiber elongation than the other genotypes. The two normal leaf-type lines diverged in their micronaire production as MD 65-11 normal produced the lowest fiber micronaire and ST 4554B2RF produced the highest micronaire (an estimate of the fiber maturity and fineness). This greater micronaire for ST 4554B2RF contributed to its greater yield.

Despite the manner in which a twin-row planting pattern optimized the interception of early season solar radiation, no improvement in lint yield production or in fiber quality was detected with a twin-row pattern. The earlier canopy closure with twin-row systems might help deter late season weed seed germination and establishment, and possibly eliminate the need for a post-emergence herbicide application (Reddy et al. 2009). However, cultivation of the fields planted in a twin-row pattern could be problematic for producers that employ cultivation as a component of their weed control strategies. The twin-row canopies were slightly earlier in maturity, but this minor difference (two days until cutout) would probably be of little consequence in determining production strategies for a cotton crop.

Increasing the leaf area index of the super okra and okra leaf canopies through use of a twin-row planting pattern also did not improve yields. Our hypothesis was that yields could be improved for the super okra and okra leaf-type genotypes by growing them in twin-rows. This technique would have increased the amount of leaf area produced per unit ground area for these genotypes. Both of those genotypes had higher leaf photosynthetic rates than the normal genotypes but did not produce sufficient leaf area for maximal yields (Heitholt et al., 1992; Pettigrew et al., 1993). Twin-row planting did increase the early season LAI but did not improve yields for these lines, so the hypothesis proved to be false.

Table 4. Cotton lint yield and yield components as affected by planting pattern and genotype averaged across the years 2011-2012.

Row Pattern	Genotype	Lint Yield	Boll Number	Boll Mass	Lint Percentage	Seed Mass	Seed Number	Lint Index
		kg ha^{-1}	bolls m^{-2}	g boll^{-1}	%	mg seed^{-1}	seed boll^{-1}	mg seed^{-1}
Single-row		1202	76	4.15	38.1	101	25.5	62.1
Twin-row		1190	75	4.16	38.3	101	25.5	62.6
LSD 0.05		150 (ns) [z]	10 (ns)	0.12 (ns)	0.8 (ns)	2 (ns)	1.1 (ns)	1.8 (ns)
	Normal	1011	68	4.19	36.2	108	24.8	61.3
	Okra	1099	68	4.19	38.4	97	26.7	60.4
	Super Okra	1023	68	4.05	37.3	101	25.1	60.2
	ST 4554B2RF	1652	96	4.20	40.9	97	25.5	67.5
	LSD 0.05	213	14	0.16 (ns)	1.1	3	1.6 (ns)	2.5

[z] ns = Not significantly different at the $P \leq 0.05$ level.

Table 5. Cotton high volume instrument (HVI) fiber quality traits as affected by planting pattern and genotype averaged across the years 2011-2012.

Row Pattern	Genotype	Fiber Length	Length Uniformity	Fiber Strength	Fiber Elongation	Micronaire	Rd	+b
		cm	%	cN tex^{-1}	%		%	
Single-row		2.88	83.3	30.4	6.3	3.99	75.5	8.0
Twin-row		2.87	83.1	30.0	6.3	4.00	75.0	8.0
LSD 0.05		0.02 (ns) [z]	0.3 (ns)	1.1 (ns)	0.2 (ns)	0.15 (ns)	0.6 (ns)	0.2 (ns)
	Normal	2.94	83.8	32.2	6.4	3.72	76.2	8.2
	Okra	2.87	83.2	28.9	5.9	3.98	76.5	7.8
	Super Okra	2.84	82.4	28.3	5.8	3.92	75.0	7.4
	ST 4554B2RF	2.86	83.3	31.5	7.0	4.36	73.3	8.5
	LSD 0.05	0.03	0.4	1.5	0.2	0.21	0.9	0.3

[z] ns = Not significantly different at the $P \leq 0.05$ level.

Although the twin-row planting pattern did not improve yields or fiber quality, it also didn't hurt those traits. Therefore, there might not be a need for producers to change the row pattern on planters previously set up to plant other crops (i.e. soybean or corn) in twin-rows to a single-row pattern for the expressed purpose of planting cotton. The cotton yields should be the same. However, the different canopy architecture of the twin-row canopies compared to the single-row canopies could cause other complications (altered insecticide penetration or decreased harvest efficiency for spindle pickers) that have not been addressed by this research. These issues may need to be resolved before wide spread adoption of twin-row cotton production.

DISCLAIMER

Trade names are necessary to report factually on available data, however, the USDA neither guarantees nor warrants the standard of the product or service, and the use of the name by USDA implies no approval of the product or service to the exclusion of others that may also be suitable.

REFERENCES

Bruns, H.A. 2011a. Comparisons of single-row and twin-row soybean in the Mid-south. Agron. J. 103:702-708.

Bruns, H.A. 2011b. Planting date, rate, and twin-row vs. single-row soybean in the Mid-south. Agron. J. 103:1308-1313.

Bruns, H.A. 2012. Comparing single-row and twin-row corn production in the Mid-south. Crop Management doi:10.1094/CM-2012-0404-01-RS.

Bourland, F.M., D.M. Oosterhuis, and N.P. Tugwell. 1992. Concept for monitoring growth and development of cotton plants using main stem counts. J. Prod. Agric. 5:532-538.

Boykin, J.C., and K.N. Reddy. 2010. The effects of narrow-row and twin-row cotton on fiber properties. J. Cotton. Sci. 14:205-211.

Constable, G.A. 1986. Growth and light receipt by mainstem cotton leaves in relation to plant densities in the field. Agric. For. Meteorol. 37:279-292.

Heitholt, J.J., W.T. Pettigrew, and W.R. Meredith, Jr. 1992. Light interception and lint yield of narrow-row cotton. Crop Sci. 32:728-733.

Heitholt, J.J., W.T. Pettigrew, and W.R. Meredith, Jr. 1993. Growth, boll opening rate, and fiber properties of narrow-row cotton. Agron. J. 85:590-594.

Heitholt, J.J. 1994. Canopy characteristics associated with deficient and excessive cotton plant population densities. Crop Sci. 34:1291-1297.

Heitholt, J.J. 1995. Cotton flowering and boll retention in different planting configurations and leaf shapes. Agon. J. 87:994-998.

Heitholt, J.J., W.R. Meredith, Jr., and J.R. Williford. 1996. Comparison of cotton genotypes varying in canopy characteristics in 76-cm vs. 102-cm rows. Crop Sci. 36:955-960.

Mascagni, H.J., E. Clawson, D. Lanclos, D. Boquet, and R. Ferguson. 2008. Comparing single-row, twin-row configurations for Louisiana crop production. Louisiana Agric. Magazine. Baton Rouge, LA. Available at http://lsuagcenter.com/en/communications/publications/agmag/Archive/2008/Summer/Comparing+SingleRow+TwinRow+Configurations+for+Louisiana+Crop+Production.htm (verified 4 April, 2014). LSU AgCenter Res. And Ext., St. Joseph, LA

Peng, S. and D.R. Krieg. 1991. Single leaf and canopy photosynthesis response to plant age in cotton. Agron. J.83:704-708.

Pettigrew, W.T., J.J. Heitholt, and K.C. Vaughn. 1993. Gas exchange differences and comparative anatomy among cotton leaf-type isolines. Crop Sci. 33:1295-1299.

Pettigrew, W.T. and J.T. Johnson. 2005. Effects of different seeding rates and plant growth regulators on early-planted cotton. J. Cotton. Sci. 10:128-135.

Pettigrew, W.T. and W.R. Meredith, Jr. 2012. Genotypic variation in physiological strategies for attaining cotton lint yield production. J. Cotton Sci. 16:179-189.

Riar, R., R. Wells, K. Edimisten, D. Jordan, and J. Bacheler. 2013. Cotton yield and canopy closure in North Carolina as influenced by row width, plant population, and leaf morphology. Crop Sci. 53:1704-1711.

Reddy, K.N., I.C. Burke, J.C. Boykin, and J.R. Williford. 2009. Narrow-row cotton production under irrigated and non-irrigated environment: Plant population and lint yield. J. Cotton Sci. 13:48-55.

Reddy, K.N. and J.C. Boykin. 2010. Weed control and yield comparisons of twin- and single-row glyphosate-resistant cotton production systems. Weed Tech 24:95-101.

Sadras, V.O. and L.J. Wilson. 1997. Growth analysis of cotton crops infested with spider mites: I. Light interception and radiation-use efficiency. Crop Sci. 37:481-491.

SAS Institute. 1996. SAS systems for mixed models. SAS Inst. Cary, NC.

Stephenson IV, D.O. and B.J. Brecke. 2010. Weed management in single- vs. twin-row cotton (*Gossypium hirsutum*). Weed Technology 24:275-280.

Stephenson IV, D.O., L.T. Barber, and F.M. Bourland. 2011. Effect of twin-row planting pattern and plant density on cotton growth, yield, and fiber quality. J. Cotton Sci. 15:243-250.

Wells, R., W.R. Meredith, Jr., and J.R. Williford. 1986. Canopy photosynthesis and its relationship to plant productivity in near-isogenic cotton lines differing in leaf morphology. Plant Physiol. 82:635-640.