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AGRONOMY AND SOILS

Cotton Growth, Lint Yield, and Fiber Quality as Affected by Row Spacing and Cultivar

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ABSTRACT

Modern transgenic cotton (*Gossypium hirsutum* L.) cultivars with herbicide resistance have rejuvenated an interest in ultra-narrow row cotton production, primarily because of the reduction of weed control problems encountered in the past with ultra-narrow row systems. While the primary goal of ultra-narrow row cotton is to reduce production costs, an agronomic and physiological evaluation of this cropping system is also needed. The objectives of this study were to determine the feasibility of using modern transgenic cotton cultivars in ultra-narrow rows (<38 cm) for cotton production in the Mississippi Delta and to assess the effect of these various systems on cotton growth, lint yield, and fiber quality. Plant height and number of sympodia, total nodes, and total bolls per plant were reduced in cotton grown in ultra-narrow row spacings. In most cases, cotton grown in ultra-narrow rows had lint yields equal to or higher than those attained in the 101-cm spacing. In 2 of 3 yr, row spacing and cultivar interacted to significantly affect mean lint yield. In ultra-narrow rows, glyphosate-resistant transgenic cultivars produced yields equal to or better than conventional cultivars in 2 of 3 yr. Okra-leaf cultivars in narrow row cotton production did not improve lint yield. No conclusions could be made regarding the impact of plant stature on lint yield. Row spacing had little impact on fiber quality. Ultra-narrow row cotton appeared to be a viable agronomic cotton production practice for the Mississippi Delta compared with conventionally-grown cotton based upon lint yield and fiber quality.

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Cultivar selection, a key management component in any cropping system, is even more critical in ultra-narrow row cotton production. While high yield potential is a predominant consideration, maturity, plant size, the transgenes present, and fiber properties are also major factors to consider. Limited data are available regarding performance of cultivars grown in ultra-narrow rows.

Past decisions on cultivar selection for ultra-narrow row production have largely been based on yield potential in conventional cropping systems for a given area, but the recent genetic technology for incorporating insect resistance (i.e., Bt cotton) and herbicide resistance to glyphosate (Roundup Ready cotton) or to bromoxynil (BXN cotton) provides new choices in cultivar selection for cotton grown in ultra-narrow rows. In a study of eight transgenic cultivars, yields for cotton planted in ultra-narrow rows were higher than conventional row spacings (Witten and Cothren, 2000). In a 2-yr study in South Carolina, seed cotton yield, lint yield, and gin turnout were different among row spacings and cultivars (Jones, 2001). A significant row spacing by cultivar interaction was reported for seed cotton yield. In 1999, SureGrow 125BR and Stoneville BXN47 grown in 19-cm rows had higher seed cotton yields compared with 38- and 97-cm rows. In 2000, Stoneville 474 and Fibermax 832 grown in 19-cm rows had higher seed cotton yields than with 38- and 97-cm rows. Conversely, Deltapine NuCotn 35B produced more seed cotton when grown in 97-cm rows compared with 19- and 38-cm rows in 2000. Gin turnout was approximately 37% and 41% for cotton planted in ultra-narrow rows and 97-cm rows, respectively.

Wright et al. (2000) indicated that most cultivars planted at high density form a columnar shape aiding in efficient harvest. Extremely early maturing cultivars planted at high densities did not perform well in limited testing. Most cotton cultivars grown commercially possess the normal-leaf type. Leaf shapes of okra-leaf cultivars can greatly alter canopy structure and light interception characteristics (Wells et al., 1986). Okra-leaf cultivars are characterized by moderately cleft leaves and relatively small leaf area. They typically have less vegetative growth (Wells and Meredith, 1986), earlier maturity (Jones, 1982), greater flower production (Kerby and Buxton, 1976), and less boll rot (Jones, 1982) than normal leaf cotton. Despite these apparent advantages, okra-leaf cultivars often produce lower lint yields than their normal-leaf isolines (Wilson, 1986). A major disadvantage of okra-leaf cotton is lower leaf area index in the early stages of development (Wells and Meredith, 1986); however, reducing row spacing can minimize this disadvantage. Lint yields of okra-leaf genotypes were greater in narrow rows (0.5 m) than in wide rows (1.0 m) (Heitholt et al., 1992).

Stripper harvesting of narrow-row cotton typically increases the trash and bark content of harvested seed cotton. Strippers remove the entire boll including the burs, as well as some of the peduncles and short limbs from the cotton plant. Leaves remaining on the plant may also be harvested with the cotton. In a comparison of cultivars planted across the Southeast, up to 111 kg more trash and foreign matter were removed from ultra-narrow row seed cotton in order to produce a 218-kg bale compared with seed cotton produced in a wide-row spacing (Anthony et al., 1999). In an evaluation of 11 cultivars of cotton in ultra-narrow rows, Anthony and Molin (2000) suggested cultivars differ in desirable fiber content and nep characteristics, but in a study where cotton planted in 76- and 101-cm rows was harvested with a spindle picker and cotton planted in 19- and 38-cm rows was harvested with a stripper equipped with a finger-type head, lint quality was not influenced by cultivar, and HVI analysis indicated all fiber characteristics were in acceptable ranges (Witten and Cothren, 2000). Vories et al. (1999) reported that micronaire, consistently lower for ultra-narrow rows, was the only fiber trait affected when comparing fiber quality in ultra-narrow row cotton with conventional row spacings.

The objectives of this study were to determine the feasibility of using modern transgenic cotton cultivars in ultra-narrow rows (<38 cm) for cotton production in the Mississippi Delta and to assess the effect of these various systems on cotton growth, lint yield, and fiber quality.

MATERIALS AND METHODS

Field experiments were conducted from 1998 to 2000 to evaluate six genotypes of cotton grown under three row spacings. In 1998, cotton isolines MD 51ne normal-leaf and MD 51ne okra-leaf (USDA-ARS, Stoneville, MS), and cultivars Stoneville (ST) 474, ST BXN47 (Stoneville Pedigree Seed Company, Stoneville, MS), Paymaster (PM) 1220RR (Delta and Pine Land Company, Scott, MS), and Deltapine (DP) NuCotn35B (Delta and Pine Land Company, Scott, MS), were evaluated in row spacings of 19-, 38-, and 101-cm. In 1999 and 2000, the cultivars evaluated were revised to reflect cultivars common in the Mississippi Delta and included Fibermax (FM) 832 okra-leaf (Aventis Crop Science, Bridgewater, N.J.), ST 474, ST BXN47, Suregrow (SG) 125BR (Delta and Pine Land Company, Scott, MS), PM 1220RR, and DP Nucotn35B. The narrowest row spacing was 25 cm in 1999 and 2000 because of available equipment. Plots were located at the Delta Research and Extension Center near Stoneville, MS on a Bosket very-fine sandy loam (fine-loamy, mixed, active, thermic Mollic Hapludalfs) soil. Soil test results indicated high levels of phosphorus and potassium and adequate levels of micronutrients. Nitrogen was applied prior to planting at the rate of 112.2 kg ha^{-1} in the form of 32% UAN (urea and ammonium nitrate solution). Treatments were arranged as split plots in a randomized complete block design with main plots consisting of row spacings and subplots consisting of cultivars. There were four replications. Main plots were approximately 15.2 m long and 24.4 m wide. Subplots were 15.2 m long and 4.0 m wide, so that the number of rows varied depending on row spacing treatment.

In all years, cotton was planted in a flat row profile into adequate soil moisture. Planting dates were 7 May 1998, 25 May 1999, and 18 May 2000. Seeding rates were held constant over the course of the study for each row spacing and cultivar. Plant populations were approximately 240,000 plants ha^{-1} in the ultra-narrow-row plots and approximately 95,000 plants ha^{-1} in the conventional plots based upon stand counts taken approximately 3 wk after planting. In 1999 and 2000, 25-cm rows were planted with a Monosem precision vacuum planter, and 38-cm rows were planted with a John Deere 1730 Max Emerge equipped with a vacuum meter. Weed control practices included pre-plant incorporated, pre-emergence, post-emergence over-the-top, and hand-rogued treatments to maintain weed-free plots. All treatments were blanket applications to all plots. Herbicide resistance of the cultivars was not used. Mepiquat chloride (Pix; BASF, Research Triangle

Park, NC) applications at 0.58 L ha^{-1}, 0.44 L ha^{-1}, and 1.46 L ha^{-1} were made during mid-bloom stage to manage crop height and uniformity during 1998, 1999, and 2000, respectively. The decision to apply mepiquat chloride to all plots was based on the idea that the risk of excess vegetative growth (especially in the narrow rows) was greater than the risk of growth suppression. Previous research with mepiquat chloride suggests that this strategy was sound (Nichols et al., 2003). Other standard cultural inputs were conducted to optimize yields for each particular system and were consistent with local agronomic practices. The studies were conducted under non-irrigated conditions for all years. Rainfall data are shown in Table 1.

Data collected in 1999 and 2000 included plant mapping at the end of the season to assess changes in fruiting patterns and earliness. Growth parameters were documented by mapping ten plants per plot and data were analyzed by a modified Windows-based version of CotMap (Univ. of Arkansas, 1998). Plant mapping variables reported include plant height, node number of the lowest sympodial branch, number of sympodia per plant, total main stem nodes, internode length, total bolls per plant, number of sympodia with bolls in first position, number of sympodia with bolls in second position, percentage of total bolls in first position, and percentage retention of first position bolls. Height measurements were taken from the soil surface to the terminal of the plant, and node counts were made from the cotyledonary node to the terminal with the cotyledonary node counted as zero.

Yield variables evaluated were seed cotton yield, gin turnout, and lint yield after harvesting the entire subplot. Ultra-narrow row plots were harvested utilizing a John Deere (Deere & Company, Moline, IL) 7455 stripper with a four meter broadcast, "finger header" spaced to handle any row width. The harvester was equipped with a bur extractor and modified for harvesting small plots. Conventional row spacings were harvested with a 2-row John Deere spindle-type picker customized for plot harvesting. A 25.4-cm saw microgin was used to separate seed cotton samples into lint and seed with no pre-cleaning or lint cleaning. Gin turnout, which takes into account trash typical in stripper harvested cotton, was calculated in 1999 and 2000 by dividing weight of the lint of a given sample by the total weight of the sample and expressed as a percentage. Lint quality measurements were determined by subjecting fiber samples to high volume instrument (HVI) testing at Starlab (Starlab, Inc., Knoxville, TN). Fiber characteristics reported include micronaire, length, uniformity, strength, and color.

All data were subjected to an analysis of variance (SAS Institute, Inc. Cary, NC). Means were separated using Fisher's Protected Least Significant Difference (LSD) test. All statistical determinations were made at $P \leq 0.05$. LSD values presented in the tables are for main effect means, unless otherwise noted. Statistical analysis was performed initially across years. Due to the degree of unbalanced data and the presence of year by treatment interactions, data from each year of the study were analyzed separately.

Table 1. Average minimum and maximum air temperature and monthly precipitation from 1998 through 2000 at Stoneville, MS

	1998			1999			2000		
	Air Temperature (°C)		Precipitation (cm)	Air Temperature (°C)		Precipitation (cm)	Air Temperature (°C)		Precipitation (cm)
	Min.	Max.		Min.	Max.		Min.	Max.	
April	11.2	23.4	11.0	14.9	25.7	16.1	11.1	22.4	28.2
May	19.1	30.5	11.7	17.1	29.1	14.5	18.9	29.4	17.6
June	22.8	33.2	4.0	21.5	31.8	7.1	21.1	32.0	15.6
July	24.0	34.3	14.5	22.9	34.1	2.6	22.2	34.6	1.6
August	22.4	34.2	1.8	21.2	35.7	0.6	22.2	36.7	0.0
September	20.2	33.4	7.4	16.2	31.7	4.4	17.4	31.2	6.6
Average	20.0	31.5	13.6	19.0	31.4	7.5	18.8	31.1	11.6

RESULTS AND DISCUSSION

Plant mapping. In 1999, cotton height prior to harvest was approximately 11 cm less in the 25- and 38-cm row spacings than the 101-cm row spacing (Table 2). These results are similar to those reported by Fowler and Ray (1977), who observed a decrease in plant height on cotton grown on 12.7-cm rows compared with 50.8-cm rows. In 2000, row spacing had no effect on crop height prior to harvest. These findings are different from those observed in 1999, but in agreement with other studies that reported no effect of ultra-narrow row spacing on plant height (Atwell, 1996; Gerik et al., 1998; Gwathmey, 1996). Cultivars also affected height. FM 832 and ST BXN47 were taller than SG 125BR and DP NuCotn35B in both years (Table 3). Shorter, compact cultivars are typically more desirable in ultra-narrow row systems to facilitate harvest.

Lowest sympodial branch on the main axis was not affected by row spacing in either year (Table 2), but there were differences among cultivars (Table 3). FM 832 produced fruit higher on the plant than the other cultivars in 1999 and 2000. In 1999, SG 125BR produced a lower first fruiting node than the other cultivars except PM 1220RR. The number of sympodia was higher in 101-cm rows compared with the narrow-row spacings in 1999 (Table 2). In 2000, neither cultivar nor row spacing significantly affected the number of sympodia. Number of sympodia averaged over 2 yr was 10.7, 10.4, and 11.1 for 25-, 38-, and 101-cm rows, respectively.

Cotton planted in 101-cm rows averaged approximately 2 more total nodes per plant compared with 25- and 38-cm rows in 1999 (Table 2). Jost (2000) reported 2.5 fewer nodes for cotton in 19-cm rows compared with 37-, 76-, and 101-cm rows. Another study found that plants grown in ultra-narrow rows had 5 fewer main stem nodes than wide row spacings (Kerby, 1998). Cultivar had a significant effect on total nodes. SG 125BR produced fewer nodes than all other cultivars in 1999 (Table 3). Similarly, SG 125BR and DP NuCotn35B had fewer nodes than FM 832 and ST 474 in 2000. Internode length (data not shown) was shortest for DP NuCotn35B and averaged 4.5 cm in 1999; however, internode length was not different among cultivars in 2000. Row spacing had no effect on internode length in either year.

Table 2. Effect of row spacing on plant height, node number of lowest sympodial branch, number of sympodia, and number of total nodes at the end of the season

Row spacing	1999				2000			
	Height (cm)	Lowest sympodia node	No. sympodia	No. total nodes	Height (cm)	Lowest sympodial node	No. sympodia	No. total nodes
25 cm	83	6.7	11.1	16.8	84	7.8	10.3	17.1
38 cm	82	7.0	11.2	17.2	83	7.7	9.5	16.1
101 cm	94	7.0	13.0	19.0	88	7.7	11.1	17.8
LSD (*P*=0.05)	8	NS	0.8	1.2	NS	NS	NS	NS

Table 3. Effect of cultivar on plant height, node number of lowest sympodial branch, number of sympodia, and number of total nodes at the end of the season

Cultivar	1999				2000			
	Height (cm)	Lowest sympodial node	No. sympodia	No. total nodes	Height (cm)	Lowest sympodial node	No. sympodia	No. total nodes
ST BXN47	88	6.8	12.2	18.0	87	8.0	10.4	17.4
FM 832	93	7.8	11.6	18.4	89	9.0	9.7	17.7
NuCotn35B	80	7.1	11.6	17.7	79	7.4	10.0	16.3
PM 1220RR	86	6.5	12.3	17.8	87	7.1	10.6	16.7
SG 125BR	81	6.3	10.9	16.2	81	6.9	10.2	16.0
ST 474	90	7.0	12.0	18.0	86	7.8	10.9	17.7
LSD (*P*=0.05)	6	0.3	0.8	0.7	6	0.5	NS	0.9

The number of bolls per plant, fruiting positions, and percentage boll retention among treatments were different at the end-of-season. All cultivars grown in 101-cm rows produced more bolls per plant (data not shown), which is attributed primarily to plant densities of the various row spacings. Cotton planted in 101-cm rows produced a greater number of sympodia with bolls in the first fruiting position in 2000 (Table 4). The number of sympodia with bolls in the second fruiting position was not significantly different among row spacings and cultivars in 2000. In 1999, FM 832 retained fewer bolls in the first position per plant and had fewer sympodia with bolls in the first fruiting position than the other cultivars (Table 5). Similarly, FM 832 had fewer sympodia with first-position bolls compared with the other cultivars, excluding ST 474, in 2000, while PM 1220RR and SG 125BR had more first position bolls than the other cultivars.

In 1999, cotton planted in narrow rows had a higher percentage (73%) of bolls located in the first fruiting position than cotton grown in 101-cm rows (54%) (Table 4). Total percentage of bolls in the first position was not different among row spacings in 2000. Cultivar effect on the total percentage of bolls in the first position was variable and inconclusive over the 2-yr period. The percentage retention of first-position bolls was not different among row spacings in 1999, but was highest for cotton grown in 101-cm rows in 2000 (Table 4). FM 832 retained fewer first-position bolls than the other cultivars in 1999 and 2000 (Table 5). PM 1220RR and SG 125BR retained more first-position bolls than the other cultivars in 2000.

Lint yield and gin turnout. Row spacing had no effect on seed cotton yields in 2 of 3 yr of the study (Table 6). In 1998, cotton grown in 19-cm rows produced significantly more seed cotton than in 38-cm rows. Highest seed cotton yields were observed for DP NuCotn35B, ST 474, and ST BXN47 in 1998. SG 125BR and FM 832 produced higher seed cotton yields than ST 474 and PM 1220RR in 1999; while PM 1220RR and SG 125BR had higher seed cotton yields than the other cultivars in 2000 (Table 7). The

Table 4. Effect of row spacing on number of sympodia with bolls in first fruiting position, number of sympodia with bolls in second fruiting position, percentage of total bolls in first fruiting position, and percentage retention of first fruiting position bolls at the end of the season

Row spacing	1999				2000			
	No. first position	No. second position	Total bolls first position (%)	Retention first position (%)	No. first position	No. second position	Total bolls first position (%)	Retention first position (%)
25 cm	2.6	0.8	73	26	1.6	0.8	56	18
38 cm	2.8	0.6	73	28	1.5	0.6	63	16
101 cm	3.0	1.3	54	30	2.4	0.5	55	30
LSD (P=0.05)	NS	NS	12.3	NS	0.4	NS	NS	4.5

Table 5. Effect of cultivar on number of sympodia with bolls in first fruiting position, number of sympodia with bolls in second fruiting position, percentage of total bolls in first fruiting position, and percentage retention of first fruiting position bolls at the end of the season

Cultivar	1999				2000			
	No. first position	No. second position	Total bolls first position (%)	Retention first position (%)	No. first position	No. second position	Total bolls first position (%)	Retention first position (%)
ST BXN 47	3.2	0.7	75	30	1.8	0.7	54	20
FM 832	1.8	0.9	59	17	1.3	0.5	58	13
NuCotn35B	2.7	1.1	64	27	1.7	0.7	57	21
PM 1220RR	2.9	1.2	62	31	2.4	0.5	70	28
SG 125BR	3.0	0.8	67	34	2.2	0.6	61	27
ST 474	3.0	0.8	72	29	1.6	0.9	48	19
LSD(P=0.05)	0.5	0.3	7.5	4.2	0.4	NS	NS	4.5

influence of cultivar on seed cotton yield appeared to be related to environmental conditions for a given year. More than 15 cm of rainfall was received from June to August in 1998, but less than 5.0 and 2.5 cm was received in July and August in 1999,and 2000, respectively (Table 1). Average day and night air temperatures were similar for all years. Comparison of seed cotton yields between narrow- and wide-row spacings should take into account differences in method of harvest. The initial foreign matter of seed cotton is typically higher for ultra-narrow row cotton in comparison to cotton in wide rows, averaging 20 and 8%, respectively, for stripper and spindle harvested cotton (Valco et al., 2001).

Gin turnout, which was evaluated in 1999 and 2000, takes into account weight due to trash and is usually several percentage points below lint percentage from spindle-picked samples. Gin turnout for cotton grown in 101-cm rows were on average approximately 4% higher than cotton grown in ultra-narrow rows (Table 6). These results are similar to those of Atwell et al. (1996) who reported an average of 28 and 32% gin turnout for ultra-narrow row cotton and conventional cotton, respectively. In this study, differences in gin turnout between narrow rows and wide rows were most likely due to the effect of machine efficiency of the stripper versus the spindle-picker used for harvest. In a study across the Cotton Belt, ultra-narrow row cotton had over three times the foreign matter of cotton grown conventionally and 5% reduction in gin turnout because of different harvest methods (Valco et al., 2001). When cotton was hand-harvested, thus removing the effect of machine efficiency and reducing the possibility of introducing bark and leaf trash in the samples, lint percentage was greater in narrow rows than conventional row spacings (Jost and Cothren, 2001). Engineering advances in harvest and ginning machinery are likely to continue improvements in harvest efficiency and gin turnout of ultra-narrow row cotton. ST 474 had a higher gin turnout than FM 832 and DP NuCotn35B in 1999 and 2000 (Table 7).

In 1998 and 1999, the row spacing by cultivar interaction was significant for lint yield, but the results were inconsistent for these 2 yr, particularly for the 38-cm row spacing (Table 8). In 1998, ST 474 produced more lint than the other cultivars in 101-cm rows. In 38-cm rows, DP NuCotn35B and ST 474 produced more lint than MD51neN, MD51neO, and PM 1220RR, and in 19-cm rows DP NuCotn35B and

Table 6. Effect of row spacing on seed cotton yield and gin turnout in cotton

	1998		1999		2000	
Row spacing[z]	Seed cotton (kg ha^{-1})	Gin turnout (%)	Seed cotton (kg ha^{-1})	Gin turnout (%)	Seed cotton (kg ha^{-1})	Gin turnout (%)
25 cm	2671	na	2641	34.2	1689	29.7
38 cm	2267	na	2669	34.8	1874	30.0
101 cm	2514	na	2120	38.4	1495	34.3
LSD(P=0.05)	277		NS	1.6	NS	1.2

[z]Lowest row spacing in 1998 was 19 cm.

Table 7. Effect of cultivar on seed cotton yield and gin turnout

1998			1999			2000		
Cultivar	Seed cotton (kg ha^{-1})	Gin turnout (%)	Cultivar	Seed cotton (kg ha^{-1})	Gin turnout (%)	Cultivar	Seed cotton (kg ha^{-1})	Gin turnout (%)
ST BXN47	2663	na	ST BXN47	2539	37.1	ST BXN47	1638	31.9
MD51neN	2210	na	FM 832	2651	34.8	FM 832	1395	30.7
MD51neO	2002	na	SG 125BR	2667	36.1	SG 125BR	1988	30.9
NuCotn35B	2911	na	NuCotn35B	2483	34.5	NuCotn35B	1486	31.0
PM 1220RR	2304	na	PM 1220RR	2205	35.3	PM 1220RR	1996	31.4
ST 474	2716	na	ST 474	2316	37.0	ST 474	1613	32.1
LSD (*P*=0.05)	275			254	1.8		228	1.0

ST BXN47 produced more lint than PM 1220RR, MD51neN, and MD51neO. ST 474 produced higher lint yields in 101-cm rows than in 19- and 38-cm rows. In 1999, PM 1220RR had the lowest lint yield compared with the other cultivars in 101-cm rows. In 38-cm rows, SG 125BR and FM 832 produced more lint than ST 474. ST BXN47 produced more lint than PM 1220RR in 25-cm rows. In 2000, lint yields for each cultivar were similar for each of the row spacings (Table 8). In 25-cm rows, PM 1220RR produced more lint than the other cultivars. PM 1220RR and SG 125BR produced more lint than FM 832 and NuCotn35B in 38-cm rows and SG 125BR produced more lint than FM 832 and NuCotn35B in 101-cm rows. Environmental conditions discussed earlier, regarding seed cotton yields, likely contributed to differences in row spacing and cultivar effects over the 3 yr. Collectively, transgenic cultivars in narrow rows produced yields equal to or better than conventional cultivars 2 of the 3 yr in most cases. Okra-leaf cultivars did not improve yields in narrow row cotton production. Additionally, no definitive conclusions were determined regarding plant stature in ultra-narrow row cotton as related to lint yield, but short, compact cotton plants are desirable for efficient harvest of ultra-narrow row cotton.

Lint quality. In 1998 and 1999, there was a significant interaction between row spacing and cultivar on mean micronaire readings (Table 9). In 1999, DP NuCotn35B, SG 125BR, and ST 474 attained higher micronaire readings in 101-cm rows than the narrow-row spacings, and these cultivars were in the discount range for micronaire in this row spacing. All other treatments had micronaire readings in the base range of 3.5 to 4.9. These results are similar to those of Vories et al. (1999) who reported a decrease in micronaire in 2 of 3 yr for cotton grown in ultra-narrow rows compared to conventionally-grown cotton. In 2000, micronaire values for a given cultivar were similar for each of the row spacings. The range of micronaire readings was similar for 1998 and 1999, but much lower for all row spacings and cultivars in 2000. Jost and Cothren (2000) reported no differences in micronaire due to row spacing.

In 2 of 3 yr, row spacing had no effect on fiber length (Table 9). Other studies (Baker, 1976; Vories et al., 1999; Howard et al., 2001) reported similar results, but Jost (2000) reported cotton planted in ultra-narrow rows at high plant densities had reduced fiber length compared with conventional row spacing in 2 out of 3 yr. FM 832 had the greatest fiber length in 2 of 3 yr, while fiber length of SG 125BR was among the shortest in 2 of 3 yr.

In 1999, SG 125BR had higher fiber uniformity in 101-cm rows than 25- and 38-cm rows. In 2000, FM 832 and PM 1220RR had higher fiber uniformity in 101-cm rows compared with narrow row spacings (Table 10). Cotton grown in 101-cm rows had higher

Table 8. Effect of row spacing (RS) and cultivar (CULT) on lint yield

Cultivar	Lint yield (kg ha^{-1})[x]								
	Row Spacing (cm)[y]								
	25			38			101		
	1998	1999	2000	1998	1999	2000	1998	1999	2000
ST BXN47	1001	993	548	775	894	581	926	929	511
MD51neN	723	-	-	633	-	-	754	-	-
FM 832	-[z]	884	412	-	1021	486	-	829	463
MD51neO	643	-	-	616	-	-	642	-	-
SG 125BR	-	953	567	-	1087	729	-	826	631
NuCotn35B	1023	828	473	853	878	475	957	855	491
PM 1220RR	828	809	712	514	894	674	947	606	574
ST 474	931	915	477	852	809	632	1144	844	531

[x] For 1998, the LSDs for comparing RS (same CULT) and for comparing CULT (same RS) are 157 and 152, respectively. For 1999, the LSDs for comparing RS (same CULT) and for comparing CULT (same RS) are 236 and 157, respectively. For 2000, the LSDs for comparing RS (same CULT) and for comparing CULT (same RS) are 168 and 136, respectively.

[y] In 1998, the lowest row spacing was 19 cm.

[z] Not included in the test.

fiber uniformity ratio than narrow rows in 2 out of 3 yr, but means for all row spacings and cultivars were in the average (80 to 82) to high (83 to 85) range. These findings differ from those of Valco et al. (2001) who reported no differences in fiber uniformity due to row spacing.

Row spacing did not affect fiber strength in 1998 or 1999 (Table 10). Similarly, Heitholt et al. (1993) reported no differences in fiber strength when comparing 102-cm versus 51-cm rows. The interaction between row spacing and cultivar was significant for mean fiber strength in 2000. In 25-cm rows in 2000, DP NuCotn35B had higher strength values than PM 1220RR, ST 474, ST BXN47, and SG 125BR. FM 832, an okra-leaf cultivar, had high fiber strength in 1999 and 2000 averaging 33.2 and 31.9 gf tex^{-1}, respectively. ST 474, ST BXN47, and SG 125BR tended to have lower fiber strengths. More importantly, readings for fiber strength for each year were in the base to premium range of loan values

Table 9. Effect of row spacing (RS) and cultivar (CULT) on micronaire and fiber length (upper half mean length) from 1998 through 2000.

Cultivar	Row Spacing (cm)[w]					
	25		38		101	
	Micronaire	Length (cm fiber^{-1})	Micronaire	Length (cm fiber^{-1})	Micronaire	Length (cm fiber^{-1})
1998[x]						
ST BXN47	4.65	2.79	4.50	2.79	4.50	2.82
MD51neN	4.48	2.90	4.60	2.87	4.43	2.95
MD51neO	4.85	2.87	4.38	2.79	4.58	2.95
NuCotn35B	4.60	2.87	4.30	2.82	4.55	2.82
PM 1220RR	4.60	2.90	4.25	2.82	4.93	2.90
ST 474	4.65	2.79	4.68	2.77	4.75	2.84
1999[y]						
ST BXN47	4.85	2.77	4.50	2.79	4.88	2.77
FM 832	4.48	2.95	4.55	2.95	4.50	2.95
NuCotn35B	4.48	2.77	4.53	2.82	5.18	2.82
PM 1220RR	4.43	2.79	4.08	2.77	4.73	2.77
SG 125BR	4.68	2.69	4.70	2.69	5.13	2.69
ST 474	4.83	2.77	4.83	2.74	5.30	2.74
2000[z]						
ST BXN47	3.93	2.77	3.98	2.72	4.05	2.77
FM 832	3.95	2.90	4.15	2.90	4.15	2.95
NuCotn35B	4.05	2.79	4.03	2.74	4.18	2.77
PM 1220RR	3.65	2.72	3.95	2.67	3.88	2.79
SG 125BR	3.95	2.72	4.13	2.72	4.30	2.72
ST 474	3.93	2.74	4.20	2.74	4.23	2.77

[w] In 1998, the lowest row spacing was 19 cm.

[x] In 1998, the LSDs for micronaire and fiber length for comparing RS (same CULT) are 0.33 and 0.030, respectively. The LSDs for mircronaire and fiber length for comparing CULT (same RS) are 0.28 and 0.029, respectively.

[y] In 1999, the LSDs for micronaire and fiber length for comparing RS (same CULT) are 0.37 and 0.024, respectively. The LSDs for micronaire and fiber length for comparing CULT (same RS) are 0.33 and 0.024, respectively .

[z] In 2000, the LSDs for micronaire and fiber length for comparing RS (same CULT) are 0.35 and 0.075, respectively. The LSDs for micronaire and fiber length for comparing CULT (same RS) are 0.33 and 0.029, respectively.

regardless of row spacing or cultivar. Cultivar is a major factor contributing to fiber strength and those with the highest strength tend to produce longer cellulose molecules, thus providing fewer break points in the lint and greater cross linkages between fibers (Jordan, 2001).

Color of the fiber was evaluated by measuring the HVI color Rd (Table 11) and HVI color +b (Table 11), which indicates the degree of reflectance or grayness and yellowness in the sample, respectively. Row spacing had no effect on reflectance in 2 out of 3 yr and had no effect on yellowness in all 3 yr. Differences in color measurements due to cultivar were not consistent. All treatments produced lint in the typical ranges for reflectance and yellowness in all years. Discolored cotton is generally associated with weathering, storage, and modules with high moisture content (Curley et al., 1990). Production systems that minimize exposure to open lint prior to harvest typically improve color grade.

Table 10. Effect of row spacing (RS) and cultivar (CULT) on fiber uniformity and fiber strength from 1998 through 2000

Cultivar	Row Spacing (cm)[w]					
	25		38		101	
	Uniformity (%)	Strength (gf tex^{-1})	Uniformity (%)	Strength (gf tex^{-1})	Uniformity (%)	Strength (gf tex^{-1})
1998[x]						
ST BXN47	83.4	27.8	82.8	28.7	83.1	28.8
MD51neN	83.0	31.9	83.7	32.1	84.0	32.3
MD51neO	83.5	31.5	82.7	30.3	83.2	32.8
NuCotn35B	81.7	30.8	82.0	30.8	82.5	30.0
PM 1220RR	84.3	30.2	83.0	29.2	85.4	29.8
ST 474	83.9	27.8	83.7	29.0	84.0	28.7
1999[y]						
ST BXN47	83.4	29.0	83.5	30.6	84.3	29.1
FM 832	84.5	32.2	84.7	33.8	85.0	33.6
NuCotn35B	83.5	33.9	84.2	32.5	84.0	32.8
PM 1220RR	84.1	32.6	83.7	32.1	84.4	31.4
SG 125BR	82.8	28.9	83.3	28.4	84.2	28.8
ST 474	84.3	28.6	83.4	28.2	83.9	28.1
2000[z]						
ST BXN47	83.0	27.2	82.4	27.5	82.9	28.8
FM 832	82.9	30.4	82.9	31.4	84.2	33.8
NuCotn35B	82.6	31.2	82.1	30.2	82.6	30.6
PM 1220RR	82.0	28.1	82.2	28.4	83.7	29.5
SG 125BR	81.7	27.0	81.9	27.9	82.5	28.0
ST 474	82.5	27.6	82.3	27.5	82.8	27.2

[w] In 1998, the lowest row spacing was 19 cm.

[x] In 1998, the LSDs for fiber uniformity and fiber strength for comparing RS (same CULT) are 1.10 and 2.1, respectively. The LSDs for fiber uniformity and fiber strength for comparing CULT (same RS) are 1.01 and 1.8, respectively.

[y] In 1999, the LSDs for fiber uniformity and fiber strength for comparing RS (same CULT) are 0.90 and 3.0, respectively. The LSDs for fiber uniformity and fiber strength for comparing CULT (same RS) are 0.93 and 2.3, respectively.

[z] In 2000, the LSDs for fiber uniformity and fiber strength for comparing RS (same CULT) are 1.19 and 1.7, respectively. The LSDs for fiber uniformity and fiber strength for comparing CULT (same RS) are 1.16 and 1.6, respectively.

CONCLUSIONS

Cultivars, and to a lesser extent, row spacing were associated with differences in plant growth characteristics. Based on plant mapping data, earliness was not enhanced by ultra-narrow row cotton. Cotton grown in ultra-narrow rows had fewer bolls per plant compared with cotton grown in 101-cm rows, but lint yield comparisons between the two production methods were similar due to the higher plant populations of the ultra-narrow row systems. Row spacing had no effect on seed cotton yield in 2 of 3 yr of the study. Gin turnout was reduced approximately 4% in ultra-narrow row cotton most likely due to reduced efficiency of the finger-stripper harvester versus the spindle-picker used for harvest of cotton grown in 101-cm rows. The interaction between row spacing and cultivar affected lint yield in 2 of 3 yr. Transgenic cultivars produced similar yields to conventional cultivars in most instances. No

Table 11. Effect of row spacing (RS) and cultivar (CULT) on fiber reflectance and fiber yellowness from 1998 through 2000

Cultivar	Row Spacing (cm)[w]					
	25		38		101	
	Reflectance (Rd)	Yellowness (+b)	Reflectance (Rd)	Yellowness (+b)	Reflectance (Rd)	Yellowness (+b)
			1998[x]			
ST BXN47	62.9	7.80	62.3	8.03	63.1	8.08
MD51neN	63.2	8.25	61.3	8.15	63.6	7.93
MD51neO	60.8	7.65	62.0	7.88	62.1	7.75
NuCotn35B	64.6	7.50	66.3	7.35	66.3	7.65
PM 1220RR	64.1	8.03	63.6	8.25	66.2	7.90
ST 474	61.6	7.53	62.3	8.10	63.4	7.68
			1999[y]			
ST BXN47	62.8	8.28	64.3	8.43	61.8	7.93
FM 832	66.7	8.15	63.7	7.60	63.9	7.78
NuCotn35B	65.7	8.43	64.7	8.45	66.5	8.38
PM 1220RR	65.0	7.98	63.0	7.33	64.7	7.78
SG 125BR	64.1	8.18	64.6	8.08	63.0	7.70
ST 474	61.1	7.98	61.8	8.10	61.3	8.50
			2000[z]			
ST BXN47	59.1	8.03	60.2	8.00	60.3	7.98
FM 832	60.8	7.05	61.9	6.48	62.0	6.33
NuCotn35B	62.2	7.43	62.6	7.08	60.5	6.83
PM 1220RR	62.3	7.70	60.4	7.33	64.3	7.90
SG 125BR	59.8	7.08	61.0	7.48	64.6	7.50
ST 474	59.6	7.83	60.0	7.80	61.5	8.40

[w] In 1998, the lowest row spacing was 19 cm.

[x] In 1998, the LSDs for fiber reflectance and yellowness for comparing RS (same CULT) are 2.7 and 0.69, respectively. The LSDs for fiber reflectance and yellowness for comparing CULT (same RS) are 2.5 and 0.66, respectively.

[y] In 1999, the LSDs for fiber reflectance and yellowness for comparing RS (same CULT) are 2.3 and 0.75, respectively. The LSDs for fiber reflectance and yellowness for comparing CULT (same RS) are 2.3 and 0.73, respectively .

[z] In 2000, the LSDs for fiber reflectance and yellowness for comparing RS (same CULT) are 3.2 and 0.77, respectively. The LSDs for fiber reflectance and yellowness for comparing CULT (same RS) are 2.6 and 0.79, respectively.

advantage was observed for the okra-leaf cultivars or short stature cultivars grown in ultra-narrow rows. Cultivar performance in ultra-narrow row systems appears to fluctuate with environmental conditions of a growing season with the advantage for ultra-narrow row systems during drier seasons for the cultivars evaluated. Cultivar selection for ultra-narrow row cotton should be based on recent cultivar trials similar to selection for conventionally grown cotton. HVI analysis data suggests row spacing had little effect on fiber quality even though more gin trash was removed. Ultra-narrow row cotton appears to be a viable agronomic cotton production practice for the Mississippi Delta based upon lint yield and fiber quality. Economic comparison between these two crop cultures might be warranted if accurate estimates of seed, weed control, and other production costs can be attained.

DISCLAIMER

Mention of a trademark, warranty, proprietary product or vendor does not constitute a guarantee by Mississippi State University and does not imply approval or recommendation of the product to the exclusion of others that may be suitable.

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