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AGRONOMY AND SOILS

Narrow-row Cotton Response to Mepiquat Chloride

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ABSTRACT

Transgenic, herbicide-resistant cotton and recently commercialized equipment to spindle-pick 38-cm rows have renewed interest in narrow-row cotton production. Published research relative to mepiquat chloride (MC) use requirements for cotton in 38-cm rows is limited. An experiment was conducted at five locations in North Carolina during 2004 and 2005 to determine if MC application strategies currently recommended for wide-row cotton are valid for cotton planted in 38-cm rows. Cotton planted in 38- and 97-cm rows received MC in three application strategies. The low rate multiple (LRM) strategy consisted of MC at 12 g a.i. ha^{-1} applied three times at 2-wk intervals beginning at the first square stage. The modified early bloom (MEB) strategy consisted of MC at 24 g ha^{-1} applied 2 wk prior to early bloom (EB) and repeated at EB. The EB strategy consisted of MC at 24 g ha^{-1} applied at EB and repeated 2 wk later. Cotton in 38- and 97-cm rows responded similarly to MC, as indicated by lack of a significant MC application strategy by row spacing interaction for plant height, fruiting characteristics, fruit retention, lint yield, and fiber quality. Cotton in 38-cm rows was shorter, produced more bolls per unit area, had greater boll retention on first position sympodial sites, and produced 10% more yield than cotton in wide rows. Except for plant height, which was reduced more by MC in the LRM and MEB strategies than in the EB strategy, cotton response was similar with each MC application strategy. Averaged across row spacings, MC increased lint yield 5%. Minor increases in fiber length were noted in cotton treated with MC, but MC did not affect micronaire, fiber strength, or fiber length uniformity. The results indicate current MC recommendations for wide-row cotton in North Carolina are appropriate for cotton in 38-cm rows. The LRM or MEB strategies would be preferred.

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Cotton production in narrow rows is not a new concept. Researchers began evaluating the utility of narrow-row cotton production during the 1950s (Waddle et al., 1956), and work continued until the early 1970s (Hawkins and Peacock, 1973). Although yield responses were often noted, narrow-row production was considered impractical with the technology available at the time, and research efforts were all but abandoned. Interest in narrow-row cotton was renewed in the 1990s with technological advances, such as herbicide-resistant cotton, plant growth regulators, and more precise planting equipment (Atwell et al., 1996; Brown et al. 1998; Culpepper and York, 2000). The practice that developed, termed ultra-narrow-row (UNR) production, consisted of seeding cotton with a grain drill in 19- to 25-cm rows and harvesting with a finger-stripper harvester. High plant populations and growth regulators were used to create compact plants with short limbs that could be harvested with a finger stripper (Atwell et al., 1996; Gwathmey and Hayes, 1996; Jones, 2001; Nichols et al., 2003).

One of the attractions of UNR cotton is that finger strippers are more economical to own and operate than spindle-type pickers (Larson et al., 1997; Parvin et al., 2000; Vories et al., 2001). Greater yields and net returns have sometimes been obtained with UNR cotton relative to cotton in the typical 76- to 101-cm rows, especially on less productive land (Bullen and Brown, 2000; Gwathmey and Hayes, 1996; Jost and Cothren, 2000; Nichols et al., 2004; Parvin et al., 2000; Vories et al., 2001). At least two equipment-related problems are associated with UNR cotton. First, erratic stands are sometimes achieved with grain drills. Although there have been significant improvements in grain drills in recent years, precise control of seed placement and coverage is still less with a drill than with unit planters. Second, there have been ginning and fiber quality concerns associated with finger-stripper harvesting. Excess foreign matter, such as carpel walls, peduncles, and limbs from the cotton plant, can reduce gin efficiency and increase ginning costs (Anthony et al., 2000). Fiber quality may also be compromised in finger-stripped cotton (McAllister and Rogers, 2005; Vories et al., 2001). Additionally, there seems to be a stigma associated with UNR cotton. Regardless of grade, buyers pay less for UNR cotton.

The plant growth regulator MC has been widely used on cotton since the 1980s, and its ability to create a more compact plant has been well documented (Kerby, 1985; Stuart et al., 1984; York, 1983a, b). Other responses to MC include increased cotton leaf density, chlorophyll content, and seed weight (Fernandez et al., 1991; Reddy et al., 1996; York, 1983b), but yield response to MC has been inconsistent (Biles and Cothren, 2001; Cathey and Meredith, 1988; Kerby, 1985; York, 1983a, b). Earlier research with MC used high rates applied once at EB (Kerby, 1985; York, 1983a, b). More recent research has focused on MC application rates and timings, with emphases on multiple applications at lower rates beginning earlier in the season. Weir et al. (1991) and Biles and Cothren (2001) reported greater cotton yield responses with multiple, lower-dosage applications of MC compared with single applications at the EB stage. Cultivars with a more indeterminate growth habit have responded more positively to MC applied before EB (Craig and Gwathmey, 2005). Other research indicates MC applications can be scheduled using plant monitoring techniques rather than basing applications exclusively on crop growth stage (Edmisten, 1994; Landivar, 1998; Landivar et al., 1996). Edmisten (1994) used plant height, height-to-node ratio, and square retention as guidelines for MC application. Less MC was needed when applications were based on plant monitoring techniques, and cotton yield response to MC applied based on plant monitoring techniques was equal to or greater than when applications were based on growth stage.

A harvester capable of spindle-picking cotton planted in 38-cm rows has recently been commercialized (Karnei, 2005). This equipment will facilitate harvest of narrow-row cotton without the foreign matter and other fiber quality concerns associated with finger-stripped cotton (McAllister and Rogers, 2005; Vories et al., 2001). Cotton can be planted in 38-cm rows using unit planters which produce consistently better stands than grain drills (Wiatrak et al., 1998). The production system eliminates the need for high plant populations, a significant expense in transgenic, UNR cotton. Research in North Carolina (Wilson, 2006) has demonstrated that optimum plant populations for cotton in 38-cm rows are similar to optimum populations in wide-row cotton.

Published information relative to MC use requirements for cotton in 38-cm rows is limited. The objective of this study was to determine if MC application strategies currently recommended for wide-row cotton are valid for cotton planted in 38-cm rows.

MATERIALS AND METHODS

The experiment was conducted at five locations in North Carolina during 2004 and 2005. Soil types and locations included the following: Dothan loamy sand (fine-loamy, kaolinitic, thermic Plinthic Kandiudults) in 2004 and Johns sandy loam (fine-loamy, siliceous, semiactive, thermic Aquic Hapludults) in 2005 on the Central Crops Research Station at Clayton; Norfolk loamy sand (fine-loamy, kaolinitic, thermic Typic Kandiudults) on the Upper Coastal Plain Research at Rocky Mount in 2004 and 2005; and Roanoke sandy loam (fine, mixed, semiactive, thermic Typic Endoaquults) on a private farm at Belhaven in 2005. Soil humic matter content was 0.5, 0.2, 0.6, 0.4, and 1.0% at Clayton in 2004, Clayton in 2005, Rocky Mount in 2004, Rocky Mount in 2005, and Belhaven, respectively.

Glyphosate-tolerant cotton cultivar Stoneville 5599BR (Monsanto Co.; St. Louis, MO) was planted into 38- and 97-cm rows in conventionally prepared seedbeds on 11 May 2004 and 11 May 2005 at Clayton, 10 May 2004 and 12 May 2005 at Rocky Mount, and 16 May 2005 at Belhaven. This cultivar, commonly planted in the southeastern and Mid-south regions of the United States (USDA-AMS, 2007), was chosen for its high plant vigor and vegetative tendencies. Final plant populations, determined by stand counts at the end of the season, averaged 156,100 and 120,650 plants ha^{-1} in the 38- and 97-cm rows, respectively. Plots were 9 m long by six 38-cm rows or four 97-cm rows.

Ninety and 110 kg ha^{-1} of N, as ammonium nitrate, was broadcast prior to planting at Clayton and Rocky Mount, respectively, in 2004. No additional nitrogen was applied during the season. In 2005, ammonium nitrate at 45 kg ha^{-1} of N at Clayton and Rocky Mount or urea ammonium nitrate at 45 kg ha^{-1} of N at Belhaven was broadcast at the pinhead square stage of cotton and repeated 3 wk later. Phosphorus, potassium, and boron were applied according to soil test recommendations. Aldicarb (Temik; Bayer CropScience; Research Triangle Park, NC) was applied in the seed furrow at 0.07 g a.i. m^{-1} of row in 2004 to control thrips (*Frankliniella* spp.) and other early season insects. Seed were treated with imidacloprid (Gaucho Grande; Bayer CropScience) in 2005 at the rate of 0.375 mg a.i. $seed^{-1}$. Acephate (Orthene 97S; Valent Agricultural Products; Walnut Creek, CA) was applied postemergence as needed for additional early season insect control. Mid- and late-season insect management was standard for cotton production in North Carolina. Cotton was kept weed-free during the growing season by pendimethalin (Prowl 3.3 EC; BASF Ag Products; Research Triangle Park, NC) at 1110 g a.i. ha^{-1} plus fluometuron (Cotoran 4L; Griffin LLC; Valdosta, GA) at 1120 g a.i. ha^{-1} applied preemergence, glyphosate potassium salt (Roundup WeatherMAX; Monsanto Co.; St Louis, MO) at 865 g a.e. ha^{-1} applied to one-leaf cotton, and glyphosate at 865 g a.e. ha^{-1} plus *S*-metolachlor (Dual Magnum; Syngenta Crop Protection; Greensboro, NC) at 1390 g a.i. ha^{-1} applied to four-leaf cotton in both row spacings. Cotton in 97-cm rows also received a postemergence-directed application of glyphosate at 865 g a.e. ha^{-1} plus diuron (Direx 4L; Griffin LLC; Valdosta, GA) at 575 g a.i. ha^{-1} when the crop was 46 cm tall. Harvest preparation consisted of defoliation by a mixture of tribufos (DEF 6; Bayer CropScience) plus thiadiazuron (DROPP SC; Bayer CropScience) plus ethephon (Prep; Bayer CropScience) at 840, 110, and 1120 g a.i. ha^{-1}, respectively.

Treatments, arranged in a randomized complete block and replicated four times, included a factorial arrangement of four MC application strategies by the two row spacings previously mentioned. Mepiquat chloride (Pix Plus; BASF Ag Products) was applied according to the low rate multiple (LRM), modified early bloom (MEB), and early bloom (EB) strategies described by Edmisten (2006). A check not treated with MC also was included. The LRM strategy consisted of MC at 12 g a.i. ha^{-1} applied three times at 2-wk intervals beginning at the first square stage. The MEB strategy consisted of MC at 24 g a.i. ha^{-1} applied 2 wk prior to the EB stage and repeated at the EB stage (defined as one white bloom per m of row). The EB strategy consisted of MC at 24 g a.i. ha^{-1} applied at the EB stage and repeated 2 wk later. The MC was applied using a CO_2-pressurized backpack sprayer equipped with flat-fan nozzles (TeeJet XR11002 nozzles; Spraying Systems Co.; Wheaton, IL) and calibrated to deliver 140 L ha^{-1} at 160 kPa.

After defoliation and prior to mechanical harvest, the variables were recorded from 10 consecutive plants per plot as follows: plant height, total number of main-stem nodes, number of sympodia with one or more bolls (hereafter referred to as effective sympodia), node number of the first effective sympodium, total number of bolls and aborted positions on sympodial branches, and number of bolls on monopodial branches. Total bolls and aborted positions on sympodial branches were summed for total sympodial fruiting sites. Sympodial and monopodial bolls were summed for presentation and expressed as number per m^2. Percentage sympodial boll retention was calculated from the total number of sympodial bolls and the total number of sympodial fruiting sites. Percentage first position boll retention on sympodial branches was similarly calculated from the total number of first position bolls and the total number of first position fruiting sites.

The center four 38-cm rows and the center two 97-cm rows were harvested using a spindle-type picker modified to harvest multiple row spacings (Lanier et al., 2005). An approximate 200-g sample of mechanically harvested seed cotton was collected from each plot and used to determine lint percentage and fiber quality. Seed cotton was ginned on a laboratory gin without lint cleaning, hence cotton grades are not presented, because they would not be representative of cotton ginned commercially. Fiber upper half mean length, fiber length uniformity index, fiber strength, and micronaire were determined by high volume instrumentation testing (Sasser, 1981).

Data were subjected to analysis of variance using the MIXED procedure in SAS (version 9.1; SAS Institute Inc.; Cary, NC) with treatment sums of squares partitioned to reflect the factorial treatment arrangement. Locations were considered as random effects (McIntosh, 1983). Means of significant main effects and interactions were separated using Fisher's Protected LSD at $P = 0.05$ (Saxton, 1998).

RESULTS AND DISCUSSION

Data were pooled across the five locations, because there was no significant treatment by location interaction for any variable examined (Tables 1 and 2). The row spacing by MC interaction also was not significant. The main effects of row spacing and MC application strategies were significant for some variables.

Table 1. Analysis of variance for vegetative and fruiting characteristics of cotton as affected by row spacing and mepiquat chloride application strategies

Source[y]	df	Height		Number of main-stem nodes		Node of first effective sympodium		Number of effective sympodia		Percentage boll retention		Number of total bolls		Percentage first position bolls	
		MS[z]	P > F	MS	P > F	MS	P > F	MS	P > F	MS	P > F	MS	P > F	MS	P > F
Loc	4	197.61	<0.0001	63.09	<0.0001	43.4	<0.0001	16.49	<0.0001	6941.61	<0.0001	8982.85	<0.0001	1684.91	<0.0001
Rep(loc)	14	3.16	0.0004	1.93	0.0001	0.47	0.0004	2.16	<0.0001	295.26	<0.0001	647.25	0.0126	58.36	0.0879
RS	1	58.06	<0.0001	28.92	<0.0001	0.56	0.0198	37.40	<0.0001	27.94	0.2980	4498.25	<0.0001	1660.40	<0.0001
Loc*RS	4	2.41	0.0639	5.11	0.0712	0.71	0.0646	4.62	0.0712	239.76	0.1827	601.35	0.0693	188.05	0.0810
MC	3	28.76	<0.0001	11.18	<0.0001	0.40	0.0302	7.41	<0.0001	71.42	0.0458	1071.83	0.0052	33.84	0.3216
Loc*MC	12	5.05	0.0651	1.44	0.0641	0.22	0.1411	1.33	0.4047	33.87	0.1881	463.62	0.7420	51.65	0.1650
RS*MC	3	0.13	0.9680	0.37	0.7076	0.03	0.7538	0.40	0.5264	9.88	0.7587	290.42	0.3407	12.95	0.8577
Loc*RS*MC	12	1.01	0.4447	0.58	0.3917	0.30	0.0785	0.41	0.6360	26.31	0.3914	309.82	0.3743	38.17	0.4045
Error	98	11.39		0.54		0.15		0.51		24.54		293.00		36.10	

[y] Source: Loc=locations; Rep=replications; RS=row spacing; MC=mepiquat chloride strategies.

[z] MS=mean square.

Table 2. Analysis of variance for lint yield, lint percentage, and fiber quality characteristics as affected by row spacing and mepiquat chloride application strategies

Source[y]	df	Lint yield		Lint percentage		Micronaire		UHM length		Uniformity		Fiber strength	
		MS[z]	P > F	MS	P > F	MS	P > F	MS	P > F	MS	P > F	MS	P > F
Loc	4	2352995	<.0001	19.53	<.0001	1.93	<.0001	0.02	<.0001	22.20	<.0001	89.9	<.0001
Rep(loc)	14	112561	<.0001	0.81	0.5278	0.14	0.0062	0.01	0.1060	1.34	0.0636	1.24	0.6742
RS	1	1153060	<.0001	0.10	0.7180	0.10	0.2310	0.01	0.8049	0.02	0.8158	1.09	0.5506
Loc*RS	4	184120	0.1014	1.28	0.2164	0.20	0.1052	0.01	0.1597	0.92	0.3251	3.33	0.0820
MC	3	89818	0.1027	3.80	0.0038	0.08	0.2685	0.01	0.0011	1.71	0.2514	1.50	0.5093
Loc*MC	12	14926	0.0601	0.95	0.3735	0.05	0.6421	0.01	0.2197	1.51	0.3826	0.99	0.8032
RS*MC	3	6940	0.6088	0.54	0.5286	0.08	0.3334	0.01	0.8230	1.32	0.0794	1.29	0.3590
Loc*RS*MC	12	34421	0.0740	1.15	0.2208	0.08	0.1888	0.01	0.0739	1.88	0.0921	1.91	0.2750
Error	98	28144		0.87		0.05				0.78		1.56	

[y] Source: Loc=locations; Rep=replications; RS=row spacing; MC=mepiquat chloride strategies.

[z] MS=mean square.

Vegetative and fruiting characteristics. Cotton in 38-cm rows was 11% shorter than cotton in 97-cm rows (Table 3). The narrow-row cotton had almost one less main-stem node per plant and almost two less effective sympodia per plant. Shorter plants, fewer main-stem nodes, and fewer effective sympodia have been observed in 38-cm rows in other studies (Clawson et al., 2006; Nichols et al., 2003, 2004; Wilson, 2006). The first effective sympodium was 0.2 nodes higher on plants in the 38-cm rows compared with plants in the 97-cm rows. Fowler and Ray (1977) noted that the node of the first effective sympodium increased as plant population increased; however, Nichols et al. (2004) did not observe differences between plants in 38- and 101-cm rows with respect to the lowest effective sympodium. In this study, there were no differences in overall boll retention between row spacings, but cotton in 38-cm rows had more total bolls per m^2 and a higher percentage of first position sympodial bolls than cotton in 97-cm rows. A greater percentage of first position sympodial bolls in 38-cm rows, compared with 97-cm rows, has been observed in other studies in North Carolina with similar plant populations (Wilson, 2006). The greater number of bolls per m^2 in 38-cm rows was primarily because of the higher plant population.

Table 3. Main effects of row spacing and mepiquat chloride application strategies on vegetative and fruiting characteristics of cotton

Main effect[x]	Height (cm)	Main-stem nodes (no. plant^{-1})	Node of first effective sympodium	Effective sympodia (no. plant^{-1})	Boll retention (%)[y]	Total bolls (no. m^{-2})	First position bolls (% of total)
Row spacing (cm)							
38	84 b	16.3 b	6.3 a	9.1 b	49 a	119 a	77 a
97	95 a	17.1 a	6.1 b	10.9 a	50 a	107 b	70 b
MC strategy[z]							
LRM	81 d	16.4 b	6.1 b	10.1 b	50 ab	111 b	73 a
MEB	85 c	16.3 b	6.2 ab	10.1 b	51 a	112 b	74 a
EB	88 b	16.6 b	6.2 ab	10.2 b	49 b	109 b	73 a
Untreated	100 a	17.5 a	6.3 a	11.0 a	49 b	122 a	72 a

[x] Data for row spacing averaged across years, locations, and mepiquat application strategies; data for mepiquat chloride application strategies averaged across years, locations, and row spacings. Means within a column and main effect followed by the same letter are not significantly different according to Fisher's Protected LSD ($P = 0.05$).

[y] Percentage boll retention is based on all sympodial positions.

[z] Mepiquat chloride (MC) application strategies are low rate multiple (LRM), modified early bloom (MEB), and early bloom (EB).

Regardless of application strategy, MC reduced plant height (Table 3). Height was reduced to a greater extent with the LRM and MEB strategies (20 and 15%, respectively) than with the EB strategy (12.5%). In other studies with the same cultivar, MC applied before EB also caused greater reductions in plant height than MC applied at the EB stage (Craig and Gwathmey, 2005). Regardless of application strategy, MC similarly reduced the number of main-stem nodes per plant (5 to 7%), effective sympodia per plant (7 to 8%), and total bolls per m^2 (8 to 11%). The first effective sympodium was 0.2 node lower on plants where MC was applied according to the LRM strategy compared with plants that did not receive MC. Mepiquat chloride applied according to the MEB and EB strategies did not lower the node of the first effective sympodium. This is likely because of the earlier initial MC application with the LRM strategy. Mepiquat chloride had no effect on the percentage of first position sympodial bolls and only minor effects on percentage boll retention. With little to no difference in percentage boll retention, the reduction in total number of bolls in this experiment was primarily because of fewer effective sympodia per plant. It has been widely documented that MC decreases the number of main-stem nodes in both wide- and narrow-row cotton (Kerby, 1985; Nichols et al., 2003; York 1983a, b). It follows that the total number of effective sympodia could also be reduced.

Lint yield and fiber quality. Lint yield was 10% greater in 38-cm rows relative to 97-cm rows (Table 4). Greater yield also has been noted in other studies with narrow rows (Jost and Cothren, 2000; Nichols et al., 2004; Wilson, 2006), but the response was inconsistent in some studies (Nichols et al., 2003; Vories et al., 2001). Clawson et al. (2006) observed similar yields in 38- and 76-cm rows. Boll weight was not determined in this study; however, the greater yield with 38-cm rows was likely because of the greater number of bolls per m^2 (Table 3) rather than an effect on boll weight. Boll weight generally decreases as plant population increases (Buxton et al., 1978; Wilson, 2006), and the population was 29% greater in the 38-cm rows. Worley et al. (1974) observed that bolls per m^2 is the primary component that determines yield potential of cotton. Heitholt et al. (1992) attributed cotton yield increases with narrow rows to greater light interception by the crop canopy on a land area basis. In their work with okra-leaf cultivars, a greater number of bolls per unit land area correlated with greater light interception by plants in narrow rows. It was concluded that the yield increase was because of the greater number of bolls and because of heavier bolls. In other studies in North Carolina (Wilson, 2006), greater light interception was observed in 38-cm rows relative to 97-cm rows.

Row spacing did not affect lint percentage or fiber micronaire, length, length uniformity, or strength (Table 4). Other researchers have reported a similar lack of effect of row spacing on these fiber quality parameters (Baker, 1976; Clawson et al., 2006; Hawkins and Peacock, 1973; Jost and Cothren, 2000; Nichols et al., 2004; Smith et al., 1979).

Mepiquat chloride increased cotton lint yield 5% regardless of application strategy (Table 4). It also caused a minor decrease in lint percentage. A similar effect on lint percentage has been observed previously (Cathey and Meredith, 1988; Pettigrew and Johnson, 2005; Stewart et al., 2001), and it has been attributed to a larger seed fraction (McCarty and Hedin, 1994; York 1983a,b). Yield responses to MC have varied in previous studies; yield increases were noted in some studies (Biles and Cothren, 2001; York, 1983a), while no yield response was noted in others (Jones., 2001; Pettigrew and Johnson, 2005; Prince et al., 1998; Stewart et al., 2001). In a few cases, MC has decreased yield (Monks et al., 1996; York, 1983b). Prince et al. (1998) and Nichols et al. (2003) did not observe a yield response to MC with cotton in 38- or 97-cm rows and 38- or 76-cm rows, respectively.

Mepiquat chloride did not affect fiber micronaire, fiber length uniformity, or fiber strength but increased fiber length 1.1 to 1.8% (Tables 2 and 4). Minor increases in fiber length have sometimes been observed previously in MC-treated cotton (York, 1983a), but mepiquat chloride typically has no effect on fiber length uniformity (Nichols et al., 2003; Nuti et al., 2006). Fiber strength responses to MC treatment have been inconsistent (Baker, 1976; Clawson et al., 2006; Nichols et al., 2003; Nuti et al., 2006). Mepiquat chloride has increased micronaire (Kerby, 1985; York 1983a), decreased micronaire (York 1983b), and had no effect on micronaire (Cathey and Meredith, 1988; Clawson et al., 2006; Jost and Cothren, 2000, 2001; Nichols et al., 2003; Pettigrew and Johnson, 2005).

Lack of significant interaction between row spacing and MC application strategies indicates cotton in 38-cm rows responds to MC similarly to cotton in traditional wide rows, so current MC recommendations for wide-row cotton in North Carolina (Edmisten, 2006) are appropriate for cotton in 38-cm rows. Regardless of row spacing, MC increased lint yields 5%. The LRM and MEB strategies controlled plant height more effectively than the EB strategy, but cotton yields were similar with all MC application strategies. Averaged across MC application strategies, a 10% yield increase was noted with 38-cm rows. Yield increases of 6 and 10% in 38-cm rows were noted in two other North Carolina studies (Wilson, 2006). Increased harvesting costs, primarily because of fewer hectares covered by a picker equipped to harvest 38-cm rows compared with 97- to 102-cm rows, may negate any economic benefits associated with 38-cm rows (Spurlock et al., 2006).

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Table 4. Main effects of row spacing and mepiquat chloride application strategies on lint yield, lint percentage, and fiber quality characteristics of cotton

Main effect[x]	Lint yield (kg ha^{-1})	Lint percentage (%)	Micronaire	UHM[y] length (cm)	Uniformity index (%)	Strength (kN mg kg^{-1})
Row spacing (cm)						
38	**1880 a**	**44.1 a**	**4.9 a**	**2.81 a**	**82.5 a**	**299 a**
97	**1710 b**	**44.1 a**	**4.8 a**	**2.81 a**	**82.5 a**	**301 a**
MC strategy[z]						
LRM	**1820 a**	**44.0 b**	**4.8 a**	**2.82 a**	**82.5 a**	**300 a**
MEB	**1820 a**	**43.9 b**	**4.9 a**	**2.84 a**	**82.6 a**	**302 a**
EB	**1820 a**	**44.0 b**	**4.8 a**	**2.82 a**	**82.7 a**	**300 a**
Non-treated	**1730 b**	**44.6 a**	**4.9 a**	**2.79 b**	**82.5 a**	**298 a**

[x] Data for row spacing averaged across years, locations, and mepiquat chloride application strategies; data for mepiquat chloride application strategies averaged across years, locations, and row spacings. Means within a column and main effect followed by the same letter are not significantly different according to Fisher's Protected LSD (*P* = 0.05).

[y] UHM=upper half mean.

[z] Mepiquat chloride (MC) application strategies are low rate multiple (LRM), modified early bloom (MEB), and early bloom (EB).

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