The *Journal of Cotton Science 12:1–7 (2008)*
http://journal.cotton.org, © The Cotton Foundation 2008

AGRONOMY AND SOILS

Cotton Planting Date and Plant Population Effects on Yield and Fiber Quality in the Mississippi Delta

J. A. Wrather*, B. J. Phipps, W. E. Stevens, A. S. Phillips, and E. D. Vories

ABSTRACT

Cotton producers in the Mississippi Delta plant in the early spring, but wet, cold weather often develops that may reduce plant population directly or indirectly. Producers must occasionally decide if replanting is necessary. The objective of these studies was to determine the effects of planting dates and plant populations on cotton yield, lint quality, and crop maturity in the Mississippi Delta. Three separate field experiments were conducted during 2001-2005. For the planting date by plant population experiment, seed cotton yields for the late April plantings were significantly greater than for other planting dates, and seed cotton yields for 33 976, 67 952, and 135 904 plants ha^{-1} were significantly greater than for 16 988 plants ha^{-1}. Yield for late April planted cotton at 16 988 plants ha^{-1} was significantly greater than or equal to yields for mid-May planted cotton at all plant populations. For the planting date experiment, lint yields and percentage lint were significantly greater for early than late plantings three of five years, and micronaire was significantly greater for early than late plantings each year. For the plant population experiment, lint yields were significantly greater for 33 976 to 135 904 plants ha^{-1} than 23 782 plants ha^{-1} in two of four years. There were no plant population effects on lint quality. In all experiments, crop maturity was delayed for late planting dates and low plant populations. Producers in the Mississippi Delta should not replant cotton after mid-May, if the plant population from a late April planting is 16 988 or more plants ha^{-1}.

J. A. Wrather, W. E. Stevens, and A. S. Phillips, University of Missouri-Delta Center, P.O. Box 160, Portageville 63873, MO; B. J. Phipps, P.O. Box 984, 373 CR 2128, Quitman, TX 75783; E. D. Vories, USDA-ARS, P.O. Box 160, Portageville, MO 63873
*Corresponding author: wratherj@missouri.edu

Cotton producers in the Mississippi Delta often plant in early spring. Unfortunately, wet, cold weather often develops in this region at this time and sometimes contributes to reduced plant population directly through flooding or indirectly through increased death because of seedling diseases. Producers must occasionally decide in mid- to late May if a lower than expected cotton plant population is acceptable or if replanting is necessary. To make informed decisions, producers in the Mississippi Delta region need information about planting date and plant population density effects on cotton yield and lint quality. Studies have been conducted in the United States to determine cotton planting date or plant population effects on yield and quality (Bilbro & Ray, 1973; Guthrie, 1991; Jones & Wells, 1998), and some of these studies were reported from the Mississippi Delta region (Cathey & Meredith, 1998; Heitholt, 1994; Micinski et al., 1990; Siebert et al., 2006; Smith et al., 1979). Only one study reported in a refereed journal from Greece in mid-1970 reported on planting date by plant population effects on cotton yield (Galanopulou-Sendouka et al., 1980). The affect of cotton planting date and plant population interaction on yield in the United States is not known but is needed to help producers make replant decisions. The objective of this study was to determine planting date and plant population effects and their corresponding interactions on cotton yield, lint quality, and maturity over years in the Mississippi Delta.

MATERIALS AND METHODS

Three experiments were established to determine planting dates and plant population density effects on cotton yield and lint quality in the Mississippi Delta region of the United States. The soil was a Tiptonville silt loam (fine-silty, mixed, superactive, thermic, oxyaquic Argiudoll), and the fields had been planted to cotton the two previous years. Prior to planting each year, the fields were disked twice, and row beds (96-cm spacing) were formed. The top 10 cm of the beds were dragged just prior to

planting to form a flat-top ridge. University Extension recommended agronomic practices were used for weed control, fertilization, irrigation, and for treatment with plant growth regulators, insecticides, and defoliants. In all experiments, each four-row plot was 10 m long and the ends were trimmed so the plot was 8 m long at first open boll to eliminate end row effects on yield. Plots were defoliated as each reached 60% open boll, and plots were harvested at maturity. The center 2 rows of each plot were harvested by spindle picker. For all experiments, statistical analyses of data were performed using SAS Mixed Model procedures (SAS Institute; Cary, NC). Mean separation was evaluated through a series of protected pairwise contrasts among all treatments (Saxton, 1998).

Planting date by plant population tests. The planting date by population experiment, conducted from 2002 through 2004, was designed to determine planting date and plant population density effects on seed cotton yield. A split-plot experimental design with four replications was employed to evaluate three planting dates (main plots) and four plant populations (subplots). Planting dates were 22 April, 30 April, and 10 May 2002; 21 April, 1 May, and 13 May 2003; and 25 April, 8 May, and 20 May 2004. The plant populations established were 16 988, 33 976, 67 952, and 135 904 plants ha^{-1}. The cultivar Paymaster 1218 BG/RR (Delta Pine and Land Co.; Scott, MS) was planted in 2002, and DPL 451 BG/RR (Delta Pine and Land Co.; Scott, MS) in 2003 and 2004 at 26 seed per meter of row. Plots were thinned by hand when the cotton had developed the third true-leaf (Jones & Wells, 1998). Seed cotton was weighed to determine yield. Samples of seed cotton from each plot were not kept for lint yield and lint quality analysis because of equipment limitations.

Planting date tests. The planting date experiment, conducted from 2001 through 2005, was designed to determine the effect of planting date on cotton lint yield and quality. A randomized complete block experimental design with four replications was employed to evaluate five planting dates**.** The dates were as follows: 3 May, 10 May, 17 May, 24 May, and 31 May 2001; 30 April, 6 May, 16 May, 23 May, and 28 May 2002; 28 April, 13 May, 22 May, 28 May, and 2 June 2003; and 29 April, 5 May, 12 May, 20 May, and 25 May 2004. The cultivar Paymaster 1218 BG/RR was planted each year at 18 seed per meter of row. The plant population at 28 d after emergence each year was 62 000 to 103 000 plants ha^{-1}, depending on seedling emergence. To compare crop maturity among treatments, the percentage of open bolls was recorded during early October each year. Seed cotton was ginned on a 20-saw gin. Lint was weighed to determine yield per plot, and the lint percentage was calculated. One lint sample per plot was analyzed for quality using HVI at the International Textile Center at Texas Tech University. Lint was analyzed for micronaire, fiber length, uniformity index, fiber strength, elongation, leaf trash, percentage reflectance, and yellowness (Ramey, 1999).

Plant population tests. The plant population experiment, conducted from 2001 through 2004, was designed to determine the effects of plant populations on cotton lint yield and quality. A randomized complete block experimental design with four replications was employed to evaluate four plant populations; 23 782, 33 976, 67 952, and 135 904 plants ha^{-1}. The cultivar Paymaster 1218 BG/RR was planted at 26 seed per meter of row. Planting dates were 3 May 2001, 30 April 2002, 28 April 2003, and 29 April 2004. Plots were thinned by hand when the cotton had developed the third true leaf (Jones and Wells, 1998). To compare crop maturity among treatments, the percentage of open bolls was recorded during early October each year. Cotton lint yield and fiber quality were determined as in the planting date experiment.

RESULTS

Planting date by plant population tests. Analysis of variance for seed cotton yield indicated there were significant year, planting date, and plant population effects (Table 1). There was a significant year by planting date interaction, and a year by plant population interaction. The planting date by plant population interaction was significant at $P = 0.09$. The year by planting date by plant population interaction was not significant. Seed cotton yield for the late April planting was significantly greater than for the other plantings each year, and yield for the early May planting was significantly greater than for the mid-May planting two of three years (data not shown). Seed cotton yields for 33 976, 67 952, and 135 904 plants ha^{-1} were significantly greater than for 16 988 plants ha^{-1} each year (data not shown). Seed cotton yield for the late April planting at 16 988 plants ha^{-1} was significantly greater ($P = 0.09$ level) than or equal to yields for the mid-May planting at all plant populations (Table 2).

Table 1. Analysis of variance for seed cotton yield (Mg ha^{-1}) for year, planting date, and plant population

Source of variation[z]	Pr ≥ F
Year (Y)	0.0030
Planting date (PD)	< 0.0001
Y × PD	< 0.0001
Plant population (PP)	< 0.0001
Y × PP	< 0.0001
PD × PP	0.0948
Y × PD × PP	0.2146

[z] Years were 2002, 2003, and 2004. Planting dates were late-Apr., early-May, and mid-May. Plant population was 16 988, 33 976, 67 952, and 135 904 plants ha^{-1}.

Table 2. Planting date and plant population effects on seed cotton yield (Mg ha^{-1}) averaged over years (2002-2004)

Plant date	Plant population (no./ha)[z]			
	16 988	33 976	67 952	135 904
Late April	3.07 cd	3.42 b	3.54 a	3.47 ab
Early May	2.75 ef	3.03 c	3.26 b	3.26 b
Mid-May	2.29 g	2.72 f	2.84 de	2.78 ef

[z] Means within the table followed by the same letter are not significantly different according to (P = 0.09).

Planting date tests. Analysis of variance indicated that year significantly affected cotton lint yield, percentage lint, and all lint quality variables (Table 3). Planting date significantly affected lint yield, percentage lint, all lint quality variables except uniformity and percentage open bolls. There was a year by planting date interaction for yield, percentage lint, and all lint quality variables except leaf trash and lint reflectance. Generally, cotton lint yields were significantly greater for the first two planting dates than for the last two during 2001, 2003, and 2005 (Table 4). These results are different from the results from planting date by plant population tests that showed seed cotton yields were significantly greater for late April than early and mid-May plantings each year. The reason for this difference is not clear. The sites for the experiments were 1 km apart, and the weather was similar, but the cultivars planted were different some years. The percentage coarse sand was greater in the soil where the planting date by plant population study was conducted than where the planting date study was conducted. Generally, percentage lint was significantly greater for the first than the last planting date during 2001, 2003, and 2005 (Table 4). Generally, micronaire decreased as planting was delayed, although the significance of the decline varied each year. Fiber length was significantly shorter for the first than the last planting date during 2004 and 2005. Fiber strength and fiber elongation were similar among planting dates most years. Lint yellowness was significantly lower for the first than the last planting date during 2001, 2003, 2004, and 2005. Leaf trash varied among planting dates and was greater for the last than all other planting dates averaged over years (Table 5). Lint reflectance varied among planting dates averaged over years, and trends were not apparent. Percentage open bolls were similar for the first two planting dates and were significantly greater for the first two than the other planting dates averaged over years.

Table 3. Analysis of variance for cotton lint yield (Mg ha^{-1}) and lint quality variables for years (2001-2005) and planting date

Variables	*Pr > F*		
	Year (Y)	Planting date (PD)[z]	Y * PD
Yield	<0.0001	<0.0001	<0.0001
Percentage lint	<0.0001	<0.0001	<0.0001
Micronaire	<0.0001	<0.0001	<0.0001
Fiber length	<0.0001	0.0003	0.0327
Fiber uniformity index	<0.0001	0.1003	0.0141
Fiber strength	<0.0001	0.0002	0.0263
Fiber elongation	<0.0001	0.0005	0.0325
Leaf trash	<0.0001	0.0001	0.2484
Lint reflectance (Rd)	<0.0001	0.0011	0.3013
Lint yellowness (+ b)	<0.0001	<0.0001	0.0064
Percentage open bolls	0.1197	<0.0001	0.1050

[z] Planting dates were late April to early May, then every 7-10 d after for four subsequent plantings.

Table 4. Year and planting date effects on cotton lint yield, percentage lint, micronaire, length, uniformity index, strength, elongation, and yellowness

Planting date[y]	2001	2002	2003	2004	2005
			Yield (Mg/ha)[z]		
1	1.24 a	1.37 b	1.15 a	1.44 b	1.35 a
2	1.06 b	1.50 ab	1.14 a	1.54 ab	1.32 ab
3	0.86 c	1.53 a	0.86 b	1.47 ab	1.27 b
4	0.73 c	1.53 a	0.74 b	1.60 a	0.88 c
5	0.55 d	1.52 a	0.39 c	1.24 c	0.69 d
			Percentage lint[z]		
1	38 a	38 a	39 a	41 a	40 a
2	35 b	38 a	39 a	40 a	40 a
3	35 b	37 a	37 b	41 a	39 ab
4	36 c	37 a	36 b	41 a	38 bc
5	34 d	37 a	34 c	41 a	37 c
			Lint micronaire[z]		
1	4.95 a	4.73 a	4.90 a	5.20 a	5.30 a
2	4.68 b	4.65 ab	4.65 b	4.80 b	5.28 a
3	4.48 bc	4.48 b	4.33 c	5.13 a	5.33 a
4	4.25 c	4.08 c	4.20 c	4.85 b	5.13 ab
5	4.35 c	4.45 b	3.83 d	4.80 b	5.03 b
			Fiber length (cm)[z]		
1	2.79 b	2.79 a	2.79 ab	2.72 b	2.66 c
2	2.84 ab	2.82 a	2.79 ab	2.76 a	2.69 b
3	2.84 ab	2.79 a	2.82 a	2.79 a	2.69 b
4	2.87 a	2.82 a	2.76 b	2.76 a	2.69 b
5	2.84 ab	2.82 a	2.79 ab	2.79 a	2.79 a
			Fiber strength (cN/tex)[z]		
1	27.56 b	29.12 a	27.78 a	27.56 a	28.04 d
2	28.29 a	29.60 a	27.85 a	28.17 a	28.49 cd
3	27.83 a	29.08 a	28.05 a	27.68 a	29.30 bc
4	28.49 a	29.94 a	27.75 a	28.24 a	30.06 ab
5	28.42 a	29.86 a	27.78 a	27.73 a	30.55 a
			Fiber elongation[z]		
1	6.63 a	5.35 a	4.65 c	4.83 ab	4.63 bc
2	6.63 a	5.25 a	4.85 c	4.88 ab	4.53 c
3	6.58 a	5.38 a	5.10 abc	4.58 b	4.73 bc
4	6.80 a	5.45 a	5.40 a	4.88 ab	4.90 ab
5	6.63 a	5.20 a	5.25 ab	5.03 a	5.05 a
			Lint yellowness[z]		
1	9.3 b	8.9 ab	8.2 b	9.2 b	9.6 c
2	9.5 a	8.9 ab	8.4 b	8.4 c	9.8 bc
3	9.7 a	8.9 ab	8.8 a	9.3 ab	9.9 bc
4	9.8 a	8.7 b	8.9 a	9.1 b	10.2 ab
5	9.9 a	9.1 a	8.9 a	9.6 a	10.3 a

[y] Planting dates were very late April or early May and then every 7 to 10 d after for four subsequent plantings.

[z] Means within a column for each variable followed by the same letter are not significantly different ($P = 0.05$).

Table 5. Planting date effects on leaf trash, reflectance, and percentage open bolls average over years

Planting date[y]	Variable[z]		
	Leaf trash	Lint reflectance	Percentage open bolls
1	1.75 bc	72.18 c	50 a
2	1.40 c	73.01 a	49 a
3	1.75 bc	72.49 bc	18 b
4	1.95 b	72.89 ab	9 c
5	2.35 a	72.39 c	2 c

[y] Planting dates were very late April or early May and then every 7 to 10 d after for four subsequent plantings.

[z] Leaf trash is classers leaf grade. Percentage open bolls was determined early October each year. Means within a column followed by the same letter are not significantly different ($P = 0.05$).

Plant population tests. Analysis of variance indicated that year significantly affected cotton lint yield, percentage lint, and all lint quality variables (Table 6). Plant population significantly affected cotton lint yield, lint yellowness, and percentage open bolls. There was a significant year by plant population interaction for yield. Cotton lint yields were similar among plant populations during 2001 and 2002 and were significantly less for 23 782 plants ha^{-1} than other populations during 2003 and 2004 (Table 7). Averaged over years, lint yellowness was generally greater for the low plant populations than the high, and percentage open bolls was significantly greater for the highest than lowest plant populations (Table 8).

Table 6. Analysis of variance for cotton lint yield (Mg ha^{-1}), lint quality variables, and percentage open bolls for years (2001-2004) and plant population

Variables	Pr ≥ *F*		
	Year (Y)	Plant population (PP)[z]	Y * PP
Yield	<0.0001	<0.0001	0.0008
Percentage lint	0.0020	0.0857	0.6604
Micronaire	<0.0001	0.4991	0.2087
Fiber length	0.0008	0.2368	0.7162
Fiber uniformity index	0.0003	0.1424	0.3597
Fiber strength	0.0001	0.4916	0.7298
Fiber elongation	<0.0001	0.1045	0.1109
Leaf trash	0.0004	0.6444	0.7899
Lint reflectance (Rd)	<0.0001	0.9727	0.0871
Lint yellowness (+ b)	<0.0001	0.0003	0.4468
Percentage open bolls	0.1840	<0.0001	0.5801

[z] Plant populations were 23 782, 33 976, 67 952, and 135 904 plants ha^{-1}.

Table 7. Year and plant population effects on cotton lint yield (Mg ha^{-1})

Plant population (no./ha)	Year[z]			
	2001	2002	2003	2004
23 782	1.36 a	1.57 a	0.85 b	1.34 b
33 976	1.36 a	1.65 a	1.06 a	1.66 a
67 952	1.31 a	1.63 a	1.19 a	1.76 a
135 904	1.25 a	1.63 a	1.14 a	1.65 a

[z] Means within a column followed by the same letter are not significantly different ($P = 0.05$).

Table 8. Effect of plant population on lint yellowness, and percentage open bolls averaged over years (2001-2004)

Plant population (no./ha)	Variable[z]	
	Lint yellowness	Percentage open bolls
23 782	9.43 a	11 c
33 976	9.31 ab	17 b
67 952	9.16 bc	26 a
135 904	9.06 c	28 a

[z] Percentage open bolls was determined early October each year. Means within a column followed by the same letter are not significantly different ($P = 0.05$).

DISCUSSION

This is the first report in the United States of a cotton planting date by plant population interaction effect on yield. Galanopoulou-Sendouka et al. (1980) previously reported no planting date by plant population interaction effects on cotton yield in Greece. The differences between their results and the results of this study may be due to environment and cultivars used. Cotton producers in many areas especially the Mississippi Delta should consider replanting cotton only if the plant population of the early planted cotton is less than 16 988 plants ha^{-1}. This is assuming uniform plant spacing. The impact of irregular plant spacing (ie. skips) on yield was not a factor in these experiments but would probably greatly impact yield.

Guthrie (1991) and Cathey and Meredith (1988) reported lint yields were significantly greater over years for early May than mid- and late May plantings, and Micinski et al. (1990) reported similar cotton yields for mid-April and mid-May plantings over years. The results from these studies did not always agree with theirs. The results from this long-term research involving 8 site years show that yields for late April and very early May planting dates were always greater than or equal to the greatest yields for the other planting dates, but yields may be similar among planting dates some years. The study reported by Cathey and Meredith (1988) and Micinski et al. (1990) were conducted in the Mississippi Delta, but their experiments were conducted over fewer years than those in this study. We speculate that cotton yields may be greater for early than late plantings when the weather is suitable for seedling growth from early plantings, but cool weather after early planting may slow seedling growth resulting in yields similar to other plantings. Cotton producers in the Mississippi Delta should focus on planting as early as possible for optimum yield.

Lint quality variables were expected to be better for late April and very early May plantings than later plantings, but the results do not confirm this. The results showed that percentage lint and micronaire were significantly greater for early than late plantings as shown by Bilbro and Ray (1973), but fiber strength, leaf trash, and lint yellowness were significantly greater for late than for early plantings. Producers in the Mississippi Delta should plant early for the greatest percentage lint and lowest leaf trash, but high micronaire may be a problem for early plantings.

The results on plant population effects on cotton lint yield were similar to those reported by Siebert et al. (2006); however, results from this study did not agree with those reported by Heitholt (1994) that lint yield was greater for 50 000 than 100 000 and 150 000 plants ha^{-1}, by Jones and Wells (1998) that cotton lint yield was similar for 20 000 and 120 000 plants ha^{-1}, and by Smith et al. (1979) that cotton lint yield was similar for 101 573 and 169 841 plants ha^{-1} and significantly greater than for 33 969 plants ha^{-1}. The causes of these differences are not known. Producers in the Mississippi Delta should strive for a plant population of 33 976 to 67 952 plants ha^{-1}. A greater plant population was not beneficial, and a lower population resulted in lower yields some years and later crop maturity. In these studies, plant populations did not affect micronaire, fiber length, and strength, and these results agree with those reported by Siebert et al. (2006).

Late planting dates and low plant population densities delayed crop maturity, which has been observed by others (Jones and Wells 1998; Smith et al., 1979; Siebert et al., 2006). Producers that save a thin stand of early planted cotton rather than replant must manage the crop for late maturity.

Planting dates significantly affected some fiber qualities in some years, but these affects seldom resulted in differences in lint value. The greater micronaire for early than late planting dates resulted in high micronaire discounts only during 2004. The greater fiber length for late than early planting dates in 2004 and 2005 resulted in a slightly greater lint value these years. The greater fiber strength for late than early planting dates resulted in greater lint value only during 2005. The greater leaf trash for late than early planting dates did not result in a change in lint value.

ACKNOWLEDGMENTS

These studies were supported in part by the University of Missouri Agriculture Experiment Station, by the National Cotton Foundation, and the cotton farmer check-off administered through the Cotton Incorporated State Support Committee Projects #02-202MO and 05-623MO.

REFERENCES

Bilbro, J.D. and L.L. Ray. 1973. Effect of planting date on the yield and fiber properties of three cotton cultivars. Agron. J. 65:606-609.

Cathey, G.W. and W.R. Meredith, Jr. 1988. Cotton response to planting date and mepiquat chloride. Agron. J. 80:463-466.

Galanopoulou-Sendouka, S., A.G. Sficas, N.A. Fotiadis, A.A. Gagianas, and P.A. Gerakis. 1980. Effect of population density, planting date, and genotype on plant growth and development of cotton. Agron. J. 72:347-353.

Guthrie, D.S. 1991. Cotton response to starter fertilizer placement and planting dates. Agron. J. 83:836-839.

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

Jones, M.A. and R. Wells. 1998. Fiber yield and quality of cotton grown at two divergent population densities. Crop Sci. 38:1190-1195.

Micinski, S., P.D. Colyer, K.T. Nguyen, and K.L. Koonce. 1990. Effects of planting date and early-season pest control on yield in cotton. J. Prod. Agric. 3:597-602.

Ramey, H.H., Jr. 1999. Classing of fiber. p. 709-727. *In* C.W. Smith & J.T. Cothren (ed.) Cotton: origin, history, technology, and production. John Wiley & Sons, New York.

Saxton, A. M. 1998. A macro for converting mean separation output to letter groupings in proc mixed. p. 1243-1246. *In*: Proc SAS Users Group Inter. Conf., 23rd, SAS Institute, Carey, NC.

Siebert, J. D., A. M. Stewart, and B. R. Leonard. 2006. Comparative growth and yield of cotton planted at various densities and configurations. Agron. J. 98:562-568.

Smith, C.W., B.A. Waddle, and H.H. Ramey, Jr. 1979. Plant spacings with irrigated cotton. Agron. J. 71:858-860.