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RESEARCH ARTICLE

Response of cotton genotypes to planting date and plant spacing

Muhammad IQBAL, Mueen Alam KHAN (✉)

Department of Plant Breeding & Genetics, College of Agriculture & Environmental Sciences, The Islamia University of Bahawalpur, Pakistan

Abstract **Cotton growers face a problem of low cotton yield in late planting (after sunflower and maize). The objective of our study was to determine the effects of planting date, plant spacing (plant density), and genotypes on seed cotton yield and its components, ginning outturn (GOT%), and fiber quality traits (fiber length and fiber fineness). Five planting dates (May 1, May 15, May 30, June 15, and June 30), three plant spacings (15, 30, and 45 cm), and three cotton genotypes (CRS-6070, CRS-738, and CIM-496) were evaluated for seed cotton yield with its components and fiber quality traits. The results showed that monopodial branches/plant, sympodial branches/plant, number of bolls/plant, and seed cotton yield differed significantly among different planting dates, plant spacing, and genotypes. While the boll weight was significantly different among genotypes only. GOT%, fiber length, and fiber fineness were different significantly among planting time and cotton genotypes, which were not significantly affected by plant spacing. Cotton grown in early planting dates had higher seed cotton yield (4874 and 4653 kg/hm^2) at the highest plant spacing (45 cm). While late sown cotton (June 15 onward) gave higher seed cotton yields (2068 and 1889 kg/hm^2) at the lowest plant spacing (15 cm). GOT%, fiber length, and fiber fineness improved significantly in late planting and not affected from plant spacing. From our present study, it is concluded that high seed cotton yield can be achieved at high plant spacing in early planting while at low plant spacing in late planting.**

Keywords planting date, plant spacing, cotton genotypes, seed cotton yield and fiber traits

Introduction

Cotton (*Gossypium hirsutum* L.) is the most important cash and fiber crop that plays an important role in the economy of Pakistan, because cotton not only provides the raw material to the entire textile industry but also earns valuable foreign exchanges for the country. Cotton yield is greatly affected by environmental conditions and applied cultural practices. The sowing date and plant density are the most important management factors in cotton. The seed cotton yield and lint quality can be maximized by suitable planting dates. Muhammad (2001) reported variable response among genotypes of cotton for environmental adoptability for yield, lint percentage, and fiber quality.

To make a decision, cotton growers need information regarding planting dates, plant spacing, and genotypes along with their effects on seed cotton yield and lint quality. Early planted cotton produced high seed cotton yield as compared to late planting. Delaney et al. (1999) reported that cotton sown later than May 30 in Alabama, USA, lowered the seed cotton yield significantly. They also found significant interactions between planting time and plant density for seed cotton yield. Sowing date in Pima cotton is more important than that of upland cotton (Kittock et al., 1981).

The effect of cotton planting date and plant density interaction on seed cotton yield and lint quality is not known, which is needed to help the growers for planting cotton in late season. The objective of this study was to determine the planting time and plant spacing and their interaction on seed cotton yield and lint quality on different cotton genotypes.

Materials and methods

Field experiments were conducted in 2008 at the Cotton Research Station (CRS) Multan, Pakistan, to determine the planting time and plant population density effects on seed cotton yield and its components and lint quality. Prior to

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Correspondence: Mueen Alam KHAN
E-mail: mueen_1981@yahoo.com

planting, the field was disked and rotavated before using the bed shaper to prepare flat-top ridges. The experiment included five planting dates (May 1, May 15, May 30, June 15, and June 30), three plant spacings (15 cm, 30 cm and 45 cm), and three genotypes of cotton (CRS-6070, CRS-738, and CIM-496).

Treatments were arranged in split plot in randomized complete block design, keeping the sowing dates in main plots, plant spacing in subplots, and genotypes in sub-sub plots. Sowing was done by dibbling method. All other cultural practices were performed in standard fashion to optimize the seed cotton yield. Data were recorded on monopodial branches/plant, sympodial branches/plant, number of bolls/plant, boll weight (g), seed cotton yield (kg/hm^2), ginning outturn (GOT%), fiber length (mm), and fiber fineness (micronaire).

In the experiment, the sub-sub plot size was 10 m long with four rows. Plots were harvested at maturity for seed cotton yield, GOT%, and fiber quality traits. Data for monopodial branches/plant and sympodial branches/plant were recorded from 10 guarded plants of central two rows. Boll weight was recorded by picking and counting the bolls from five plants. All the fiber traits were analyzed by HVI (High Volume Instrument by Uster).

The data were subjected to analysis of variance using the computer program M-STAT C software. Means were separated using Fisher's Protected Least Significant Difference (LSD) test ($P \leqslant 0.05$).

Results and discussion

Using analysis of variance (Table 1), it is indicated that effects due to planting date and genotypes were significant for monopodial branches, sympodial branches, number of bolls per plant, seed cotton yield, and fiber traits. While for boll weight, it remained insignificant in planting date. From the analysis of variance, it is also indicated that plant spacing had nonsignificant effect on GOT%, fiber length, and fiber fineness but significantly affected seed cotton yield and its components. The interaction of planting date and plant spacing was significant for all the traits under study except for boll weight, GOT%, fiber length, and fiber fineness. The interaction of planting date with genotypes was also significant for all the traits studied. Similarly, the interaction effect of plant spacing and genotypes was significant except for boll weight and fiber fineness, while the interaction effect of planting date, plant spacing, and genotypes were only significant for monopodial branches, sympodial branches, number of bolls per plant, GOT%, and fiber length and seed cotton yield (Table 1).

Seed cotton yield for early planting at the lowest plant population was significantly greater than the highest plant population (Table 2). Seed cotton yield in the latest planting at the highest plant density was significantly higher than the lowest plant density, as evident in Table 3. Similar results have been found by other researchers (Jones and Wells, 1998; Siebert et al., 2006; Wrather et al., 2008).

Highest seed cotton yield 4328.3 kg/hm^2 was obtained from May 1 planting date, and lowest seed cotton yield 1274.6 kg/hm^2 was obtained from June 30 planting date. Significant differences in GOT%, fiber length, and fiber fineness came to a conclusion that planting time affected these three traits significantly (Table 2). The yield components, monopodial branches, sympodial branches, and number of bolls per plant were also affected significantly by planting time, plant spacing, genotypes, and their interactions. These yield components reduced in late planting were compensated under low plant spacing (Tables 2, 3, 4, and 8), whereas differences within genotypes for these agronomic traits are due to different growth habits. Similar findings were reported by Iqbal et al. (2007) and Wrather et al. (2008).

Seed cotton yield was also reduced in late sown cotton under normal recommended plant spacing (30 cm) and increased under high plant population (15 cm), as indicated in Tables 2 and 3. The yield differences in genotypes were due

Table 1 Mean squares of analysis of variance for monopodial branches per plant, sympodial branches per plant, number of bolls per plant, boll weight, seed cotton yield, and fiber traits

SOV	*df*	MNO	SYMP	B/P	Boll weight (g)	Yield (kg/hm^2)	GOT%	Fiber length (mm)	Fiber fineness (μg/inch)
Replications	2	0.107	4.896	68.289*	0.003	188986.06*	0.353	0.046	0.021
SD	4	3.891*	1466.585*	1225.3*	0.231	17401503.9*	9.924*	8.366*	0.881*
Error a	8	0.045	1.480	2.557	0.104	2613.372	0.162	0.031	0.023
S	2	3.371*	94.719*	5565.62*	0.068*	60424.067*	0.099	0.465	0.061
SD × S	8	0.161*	6.609*	92.03*	0.020	422987.56*	0.319	0.227	0.031
Error b	20	0.022	0.974	3.248	0.011	4014.011	0.037	0.239	0.24
V	2	17.646*	273.607*	928.067*	0.430*	4851292.4*	69.239*	34.145*	3.378*
SD × V	8	0.675*	15.469*	70.585*	0.016*	468924.38*	0.857*	1.893*	0.062*
S × V	4	0.804*	2.641*	41.756*	0.003	13875.4*	0.187*	1.047*	0.014
SD × S × V	16	0.156*	4.057*	14.135*	0.007	34124.775*	0.407*	0.514*	0.027
Error c	60	0.037	1.270	1.022	0.005	15113.767	0.028	0.024	0.196

* = significant at 0.05, SD = sowing date, S = plant spacing, V = genotypes, MNO = monopodial branches per plant, SYMP = sympodial branches per plant, B/P = number of bolls per plant.

Table 2 Effect of sowing date on yield and fiber components

Planting dates	MNO	SYMP	B/P	Boll weight (g)	Yield (kg/hm^2)	GOT%	Fiber length (mm)	Fiber fineness (μg/inch)
May 1	1.35	26.85	33.51	3.27	4328.3	38.94	27.19	5.39
May 15	1.19	27.29	34.74	3.29	3991.4	39.44	28.04	5.17
May 30	0.82	21.74	29.18	3.30	3334.4	39.84	28.45	4.98
June 15	0.65	13.00	23.70	3.36	2090.5	40.20	28.55	5.02
June 30	0.43	11.92	18.70	3.12	1274.6	40.46	28.37	4.95
CD ($P \leqslant 0.05$)	0.134	0.76	1.006	0.203	32.08	0.251	0.11	0.095

Table 3 Effect of spacing on yield and fiber components

Plant spacing (cm)	MNO	SYMP	B/P	Boll weight (g)	Yield (kg/hm^2)	GOT%	Fiber length (mm)	Fiber fineness (μg/inch)
15	0.59	21.46	15.44	3.24	3514.2	39.82	28.01	5.12
30	0.96	20.42	31.82	3.38	3414.1	39.78	28.13	5.13
45	1.12	18.60	36.66	3.18	3283.2	39.73	28.21	5.06
CD ($P \leqslant 0.05$)	0.065	0.433	0.74	0.045	27.87	0.086	0.215	0.215

Table 4 Effect of genotypes on yield and fiber traits

Genotypes	MNO	SYMP	B/P	Boll weight (g)	Yield (kg/hm^2)	GOT%	Fiber length (mm)	Fiber fineness (μg/inch)
CRS-6070	0.48	21.16	28.29	3.23	3559.7	40.88	27.14	5.18
CRS-738	0.59	21.98	32.35	3.38	3625.2	38.43	28.81	4.80
CIM-496	1.61	17.35	23.29	3.19	3026.6	40.02	28.42	5.33
CD ($P \leqslant 0.05$)	0.182	1.08	0.96	0.066	115.9	0.156	0.146	0.418

Table 5 Mean performance under interaction of sowing date and plant spacing for different traits

Sowing date	Plant spacing (cm)	MNO	SYMP	B/P	Boll weight (g)	Yield (kg/hm^2)	GOT%	Fiber length (mm)	Fiber fineness (μg/inch)
May 1	15	0.83	27.22	18.56	3.29	4116.1	39.15	27.10	5.47
	30	1.52	27.44	37.22	3.31	4321.5	39.03	27.16	5.41
	45	1.71	25.89	44.78	3.21	4547.2	38.62	27.31	5.29
May 15	15	0.82	28.12	18.78	3.25	3982.9	39.51	27.93	5.22
	30	1.31	27.45	39.11	3.36	4023.3	39.42	28.12	5.20
	45	1.46	26.34	46.32	3.27	3968.1	39.40	28.07	5.10
May 30	15	0.56	23.89	15.67	3.26	3618.1	39.98	28.34	5.01
	30	0.88	21.78	33.77	3.34	3315.8	39.78	28.53	4.96
	45	1.04	19.56	38.10	3.27	3069.4	39.77	28.50	4.98
June 15	15	0.43	15.32	13.34	3.29	3356.3	40.18	28.64	5.03
	30	0.65	13.31	28.32	3.38	2098.1	40.04	28.31	5.02
	45	0.87	10.32	29.45	3.43	1217.1	40.38	28.70	5.02
June 30	15	0.31	12.77	10.89	3.04	2497.7	40.29	28.05	4.88
	30	0.46	12.12	20.67	3.15	1512.2	40.63	28.25	5.04
	45	0.54	10.89	24.66	3.16	1014.0	40.47	28.51	4.92
CD ($P \leqslant 0.05$)		0.144	0.97	1.77	0.102	62.31	0.189	0.479	0.48

to their different genetic makeup (Table 4). The GOT% and fiber length increased in late planting, while plant spacing had no effect on these traits. Difference in genotypes for these traits was again due to their different genetic constitution (Tables 2, 4). Among lint quality variables, the fiber fineness (micronaire) was significantly greater in early planting than late planting (Table 2). Our results are in accordance with the findings of Bilbro and Ray (1973) and Wrather et al. (2008). Their results showed that the fiber fineness improved in late sowing significantly (Tables 2 and 3).

The interaction of planting time, plant spacing, and genotypes had a significant effect on seed cotton yield (Table 8). The lowest seed cotton yields of 913.6, 1064.6, and 1263.7 kg/hm^2 were recorded from genotypes CIM-496, CRS-738, and CRS-6070, which were all planted on June 30, with plant spacing of 45 cm, respectively, while the

Table 6 Mean performance for different traits under interaction of sowing date and genotypes

Sowing date	Genotypes	MNO	SYMP	B/P	Boll weight (g)	Yield (kg/hm^2)	GOT%	Fiber length (mm)	Fiber fineness (μg/inch)
May 1	CRS-6070	0.70	27.33	32.00	3.20	4256.7	39.73	25.52	5.46
	CRS-738	0.86	29.67	40.00	3.37	4630.4	37.89	28.37	5.12
	CIM-496	2.51	23.56	28.56	3.24	4097.7	39.19	27.68	5.59
May 15	CRS-6070	0.66	27.00	33.10	3.22	3970.3	40.45	27.10	5.23
	CRS-738	0.83	29.45	42.77	3.42	4140.7	38.44	28.80	4.92
	CIM-496	2.10	25.44	28.45	3.23	3863.4	39.34	28.23	5.37
May 30	CRS-6070	0.51	23.01	28.89	3.28	3718.5	41.02	27.57	5.01
	CRS-738	0.56	23.67	33.88	3.40	3485.7	38.51	29.23	4.68
	CIM-496	1.42	18.56	24.78	3.19	2799.2	40.00	28.57	5.27
June 15	CRS-6070	0.29	14.22	25.55	3.36	2655.8	41.32	27.75	5.16
	CRS-738	0.41	13.12	26.22	3.50	2493.2	38.64	29.29	4.68
	CIM-496	1.26	11.67	19.32	3.24	2022.6	40.62	28.61	5.23
June 30	CRS-6070	0.23	14.22	20.12	3.13	1697.5	41.85	27.75	5.03
	CRS-738	0.31	14.01	18.89	3.18	1476.1	38.68	28.34	4.61
	CIM-496	0.78	7.55	15.34	3.02	1750.3	40.86	29.02	5.20
CD ($P \leqslant 0.05$)		0.182	1.06	0.45	0.066	115.9	0.158	0.146	0.418

Table 7 Mean performance for different traits under interaction of spacing and genotypes

Plant spacing	Genotypes	MNO	SYMP	B/P	Boll weight (g)	Yield (kg/hm^2)	GOT%	Fiber length (mm)	Fiber fineness (μg/inch)
15 cm	CRS-6070	0.36	22.60	16.22	3.18	3688.7	41.01	26.94	5.22
	CRS-738	0.41	23.61	17.93	3.34	3713.6	38.52	28.66	4.79
	CIM-496	1.00	18.21	12.21	3.16	3140.3	39.93	28.45	5.35
30 cm	CRS-6070	0.48	21.66	31.07	3.29	3584.4	40.89	27.31	5.21
	CRS-738	0.59	22.36	37.32	3.41	3648.5	38.38	28.56	4.81
	CIM-496	1.82	17.67	27.07	3.21	3009.6	40.08	28.53	5.37
45 cm	CRS-6070	0.59	19.27	37.66	3.25	3406.1	40.73	27.17	5.11
	CRS-738	0.77	20.34	41.81	3.37	3513.5	38.40	29.20	4.79
	CIM-496	2.01	16.21	30.62	3.19	2929.9	40.05	28.28	5.28
CD ($P \leqslant 0.05$)		0.14	0.822	0.738	0.052	89.78	0.122	0.114	0.324

highest seed cotton yields of 4874, 4653, and 4445 kg/hm^2 were recorded from genotypes CRS-738, CIM-496, and CRS-6070, which were planted on May 1, with plant spacing of 45 cm, respectively (Table 8). Our results were in accordance with the findings of Bozbek et al. (2006), Iqbal et al. (2007), and Wrather et al. (2008). The highest seed cotton yield was obtained in early sown cotton with plant-to-plant distance of 45 cm (Table 5).

The cotton plant is indeterminate and acropetal in nature and continues its growth even in reproductive phase (squares, buds, flowers, and bolls), and if the environment remains favorable, the cotton plant accommodates the available space in a better way due to its indeterminate growth habit under a long growing season. Early sown cotton increased in terms of its growth period, which led to an increase in dry matter accumulation due to longer favorable photosynthesis period. Similar findings were reported by Kerby et al. (1990) and Samani et al. (1999) that the early sown cotton under low plant spacing did not perform well for seed cotton production due to high foliage and fruit shedding, as reported by Iqbal et al. (2007). The lowest seed cotton yield was obtained when planted on June 30, with plant spacing of 45 cm (Tables 5 and 8). However, the seed cotton yield of cotton planted on June 30 varied significantly with different plant spacing for all genotypes under study, with the highest seed cotton yield obtained under plant spacing of 15 cm (Tables 5 and 8). As for the late sown cotton, the growth period was reduced as compared to that of the early sown cotton, and therefore, less dry matter was accumulated. By reducing the plant spacing to 15 cm, the plant population increased two and three times higher than that of 30 cm and 45 cm plant spacing, respectively. Therefore, it is concluded that for the late sown cotton crop (after May 30), the plant population can double the normal plant population by reducing plant-to-plant distance.

The fiber quality traits, fiber length, and fiber fineness were affected significantly by planting date and genotypes, of which the fiber fineness was also affected by plant spacing (Table 2). These findings are again in accordance with the findings of Wrather et al. (2008).

Table 8 Mean performance for different traits under interaction of sowing date, plant spacing, and genotypes

Sowing date	Plant spacing (cm)	Genotypes	MNO	SYMP	B/P	Boll weight (g)	Yield (kg/hm^2)	GOT%	Fiber length (mm)	Fiber fineness (μg/inch)
May 1	15	CRS-6070	0.50	29.0	19.0	3.2	4053	40.2	25.5	5.7
		CRS-738	0.60	31.0	21.6	3.4	4364	38.2	28.2	5.0
		CIM-496	1.40	21.6	15.1	3.3	3930	39.1	27.6	5.6
	30	CRS-6070	0.60	27.3	34.6	3.2	4271	40.3	25.5	5.4
		CRS-738	0.70	30.7	45.3	3.4	4253	37.7	28.4	5.2
		CIM-496	3.20	24.3	31.6	3.2	4040	39.2	27.6	5.6
	45	CRS-6070	0.96	25.7	42.3	3.2	4445	38.7	25.6	5.3
		CRS-738	1.26	27.3	53.0	3.3	4874	37.9	28.5	5.1
		CIM-496	2.90	24.6	39.1	3.2	4653	39.3	27.8	5.5
May 15	15	CRS-6070	0.56	26.7	19.0	3.2	3980	40.6	26.8	5.3
		CRS-738	0.53	31.3	22.3	3.4	4178	38.5	28.8	4.9
		CIM-496	1.36	26.7	15.1	3.2	3789	39.6	28.2	5.4
	30	CRS-6070	0.67	28.0	36.7	3.3	4058	40.4	27.2	5.2
		CRS-738	0.86	29.1	48.6	3.5	4165	38.5	28.8	4.9
		CIM-496	2.40	25.4	32.1	3.3	3847	39.4	28.3	5.4
	45	CRS-6070	0.73	26.7	43.3	3.2	3872	40.3	27.2	5.2
		CRS-738	1.10	28.0	57.3	3.4	4078	38.4	28.8	4.8
		CIM-496	2.53	24.3	38.3	3.2	3953	39.5	28.2	5.3
May 30	15	CRS-6070	0.33	25.4	15.6	3.2	3959	41.1	27.5	5.1
		CRS-738	0.43	25.7	18.3	3.3	3653	38.7	28.9	4.7
		CIM-496	0.90	20.6	13.0	3.2	3241	40.1	28.6	5.2
	30	CRS-6070	0.53	23.3	33.0	3.4	3737	40.6	27.6	5.0
		CRS-738	0.60	23.4	40.6	3.5	3439	38.4	29.4	4.6
		CIM-496	1.50	18.6	27.7	3.2	2770	40.2	28.7	5.3
	45	CRS-6070	0.63	20.4	38.1	3.2	3458	41.3	27.6	4.9
		CRS-738	0.62	22.0	32.7	3.5	3364	38.4	29.4	4.7
		CIM-496	1.86	16.3	33.6	3.1	2386	39.7	28.5	5.3
June 15	15	CRS-6070	0.23	17.2	14.3	3.2	3389	41.5	27.7	5.2
		CRS-738	0.33	15.4	16.1	3.4	3797	38.7	29.6	4.7
		CIM-496	0.73	13.3	9.7	3.2	2882	40.4	28.6	5.3
	30	CRS-6070	0.34	14.6	28.7	3.4	3187	41.2	27.8	5.2
		CRS-738	0.46	12.7	32.1	3.5	3496	38.6	28.5	4.6
		CIM-496	1.17	12.6	24.3	3.2	2611	40.2	28.7	5.3
	45	CRS-6070	0.30	10.7	33.6	3.5	2291	41.2	27.8	5.2
		CRS-738	0.43	11.3	30.7	3.6	2186	28.6	29.8	4.7
		CIM-496	1.87	9.1	24.1	3.3	1974	41.3	28.5	5.1
June 30	15	CRS-6070	0.17	15.0	13.1	3.1	2068	41.7	27.2	4.9
		CRS-738	0.13	14.6	11.3	3.1	1889	38.6	27.7	4.6
		CIM-496	0.63	8.7	8.4	2.9	1558	40.5	29.2	5.2
	30	CRS-6070	0.23	14.7	22.4	3.1	1860	41.8	28.5	5.3
		CRS-738	0.34	14.3	20.1	3.2	1574	38.6	27.7	4.7
		CIM-496	0.80	7.2	19.6	3.1	1479	41.4	29.4	5.2
	45	CRS-6070	0.30	13.0	13.7	3.2	1263	42.1	27.6	5.0
		CRS-738	0.43	13.1	25.4	3.2	1064	38.7	29.5	4.6
		CIM-496	0.90	6.6	18.1	3.1	913	40.6	28.4	5.2
CD ($P \leqslant 0.05$)			0.163	1.84	1.65	0.116	200.76	0.274	0.252	0.722

Conclusion

From the present study, it is concluded that plant population density should be increased in late planting by reducing plant spacing to achieve optimum seed cotton yield. However, in early planting, the plant population density should be normally kept at a plant-to-plant distance of 30 cm, which is also recommended in cotton growing areas during the normal sowing season.

References

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

Bozbek T, Sezener V, Unay A (2006). The effect of sowing date and plant density on cotton yield. J Agron, 5: 122–125

Delaney D P, Monks C D, Reeves D W, Bannon J S, Durbin R M (1999). Planting dates and populations for UNR cotton in Central Alabama. Proc. The Beltwide Cotton Conference, 2: 1278–1279

Iqbal M, Hayat K, Islam N (2007). Cotton response to mepiquat chloride and nitrogen under ultra narrow plant spacing. Asian J Plant Sci, 6: 87–92

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

Kerby T A, Cassman K G, Keely M (1990). Genotypes and plant densities for narrow- row cotton systems. II. Leaf area and dry matter partitioning. Crop Sci, 30: 649–653

Kittock D L, Hennebery T J, Bariola L A (1981). Fruiting of upland and pima cotton with different planting dates. Agron J, 73: 711–715

Muhammad J B (2001). Stability and adaptability analysis of some quantitative traits in upland cotton varieties. Pak J Sci & Indust Res, 44: 105–108.

Samani M R K, Khajehpour M R, Ghavaland A (1999). Effects of row spacing and plant density on growth and dry matter accumulation in cotton in Isfahan. Iran J Agric Sci, 29: 667–679

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

Wrather J A, Phillips B J, Stevens W E, Phillips A S, Vories E D (2008). Cotton planting date and plant population effects on yield and fiber quality in the Mississippi Delta. The Journal of Cotton Sci, 12: 1–7