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Cotton Variety Lint Yield and Fiber Quality Responses to Seeding Rates

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Abstract

Since the introduction of new transgenic varieties in recent years, technology and seed costs have increased dramatically. Vacuum-planter technology offers the opportunity to lower plant populations and achieve uniform plant populations, which can result in reduced seed and technology costs. This study was conducted to determine the optimum cotton plant population for drill-seeded and hill-drop planting methods. A drill-seeded study was conducted in 2003–2005 at Stoneville, Mississippi, on a Bosket fine sandy loam and at Verona, Mississippi, on a Leeper silty clay loam. The objective was to determine the optimum plant population for ST 4892BR, ST 5599BR, and DP 555BG/RR cotton varieties. Varieties showed no differences in response to seeding rates. Across varieties, five seeding rates resulted in various 3-year (2003–2005) average populations: (1) 13,000 seeds per acre — 12,480 plants per acre at Verona and 11,800 plants per acre at Stoneville; (2) 26,000 seeds — 23,620 plants at Verona and 21,900 plants at Stoneville; (3) 39,000 seeds — 33,650 plants at Verona and 31,500 plants at Stoneville; (4) 52,000 seeds — 44,250 plants at Verona and 41,700 plants at Stoneville; and (5) 65,000 seeds — 50,990 plants at Verona and 53,100 plants at Stoneville. Several of these plant populations demonstrated no differences in lint yield or gross returns at either location: 21,900, 31,500, 41,700, and 53,100 plants per acre at Stoneville; and 33,650, 44,250 and 50,990 plants per acre at Verona. However, yields and gross returns for these plant populations were higher than those seen in the 12,480- and 23,620-plant populations at Verona and the 11,800-plant population at Stoneville. The choice of varieties did not affect lint yield or gross return, and it had little or no effect on fiber micronaire, length, uniformity, and strength. At both locations, DP 555BG/RR showed higher percent lint turnout than both ST 4892BR and ST 5599BR. With two-seed/hill-drop and drill-seeded planting systems, DP 555BG/RR and ST 4892BR varieties showed no yield response differences to seeding rates that resulted in populations ranging from 19,600–39,900 plants per acre. However, the trend was for higher yields with 27,100–39,900 plants per acre than with 19,600–22,000 plants per acre.

These results indicated that with good-quality seed, good soil conditions, and good environmental conditions at planting, seeding rates might be lowered from 52,000 seeds per acre to 34,000–39,000 seeds per acre (approximately 30,000 plants per acre) without a negative impact on yield. However, one should evaluate the risk for possible stand failure when reducing the seeding rate below the recommended 52,000 seeds per acre, especially when planting seeds with less-than-optimum seedling vigor and/or when soil or environmental conditions are less than optimum.

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Introduction

Technology and seed costs for transgenic varieties have created a renewed interest in determining the optimum plant population for cotton production. Research from the 1950s through the 1970s with full-season varieties indicated similar yields for plant populations from 13,000–75,000 plants per acre (Burch 1970; Dick and Lund 1955; Douglas et al. 1964; Hawkins and Peacock 1970; Leding and Cotton 1953; Ray et al. 1959; Tugwell and Waddle 1964). However, Bridge et al. (1973) reported that yields for a full-season variety decreased with more than 48,000 plants per acre. In contrast, earlier-maturing varieties showed no effect on lint yield for populations of 52,000–104,000 plants per acre, but yields were higher than those for a 26,000-plant population (Bridge and Miller 1989). Bednarz et al. (2005) reported that 51,056 plants per acre had the highest lint yields and net returns above seed costs, but that population level was not different from 36,469 plants per acre. Pettigrew et al. (2005) reported yields similar to Bednarz. Baugh and Brown (2006) reported that two to three plants per foot of row provided the best yield potential in dryland cotton for the Texas High Plains. Halfmann et al. (2005) reported that populations from 30,000–90,000 plants per acre showed no yield differences. Seibert et al. (2006) reported maximum yields with populations between 13,755 and 61,851 plants per acre in a drill-seeded configuration with hill-drop spacing not to exceed 16 inches.

Since the introduction of BT and Roundup Ready technology in the 1990s, seed costs have increased dramatically. Vacuum planters achieve more equally distant seed spacings and have potential for using lower seeding rates without having a negative effect on lint yield and fiber quality. Lower seeding rates reduce input costs and improve net returns. The objective of the study was to use vacuum-planter technology to determine the optimum seeding rates for transgenic cotton varieties in drill-seeded and hill-drop systems as related to lint turnout, lint yield, fiber quality, and gross returns.

Materials and Methods

Drill-seeded studies were conducted in 2003–2005 on a Leeper silty clay loam soil at Verona, Mississippi, and a Bosket very fine sandy loam soil at Stoneville, Mississippi. The experimental design for each location was a split-split plot in a randomized complete block design with varieties (DP 555BG/RR, ST 4892BR, and ST 5599BR) as main plot and seeding rates as the subplot with four replications. Plot size was four rows (38-inch rows at Verona and 40-inch rows at Stoneville), each 50 feet long. Cotton was planted April 30, 2003, April 29, 2004, and May 3, 2005, at Stoneville and May 28, 2003, May 4, 2004, and May 6, 2005, at Verona. Both studies were planted with vacuum planters.

We also conducted a seeding rate comparison study using a drill-seeded, vacuum-planter system and a two-seed/hill-drop, vacuum-planter system on a Leeper silty clay loam soil in 2004–2005 at Verona. The hill-drop planter dropped two seeds per hill, and the drill-seeded planter placed one seed per drop with a vacuum planter. The hill-drop planter spaced seed approximately 15, 13, 10, 8, and 7 inches apart for seeding rates of 22,000, 26,000, 33,000, 39,000, and 52,000 seeds per acre, respectively. The experimental design was a split-split plot with variety as main plot, planter system (drill-seeded and two-seed/hill-drop) as subplot, and seeding rates as sub-subplot with four replications. Plot size was four rows, 38 inches wide and 50 feet long. DP 555BG/RR and ST 4892BR varieties were planted in early May of each year. The center two rows of each plot were harvested with a spindle picker. Seed cotton from each plot was weighed, and grab samples from each plot were ginned with a small 10-saw sample gin without lint cleaners to determine gin turnout and lint yield.

Treatment gross returns were based on gin turnout, lint yield, and the 2004 USDA National Commodity Credit Corporation South Delta base loan price of $0.52 per pound with adjustments for HVI fiber quality (fiber length, micronaire, strength, and uniformity) for each plot. *The Classification of Cotton* (USDA Agricultural Handbook 566, revised 2001) was used to determine whether differences in fiber characteristics among treatments were within the same market classification category. All data were analyzed with the SAS Mixed Procedure analysis (Littell et al. 1996). When there were no interactions, the data were pooled and reanalyzed. Treatment means were separated using Fisher's Protected LSD calculated at the 5% significance level.

Results and Discussion

Verona

Variety — The analysis indicated varieties showed differences in lint turnout, uniformity, and boll weight (data not shown). ST 5599BR boll weight was higher than either ST 4892BR or DP 555BG/RR with no significant differences between ST 4892BR and DP 555BG/RR. DP 555BG/RR had the highest lint turnout (42.47%). This was higher than both ST 5599BR (41.33%) and ST 4892BR (41.07%), which were not different. However, varieties showed no yield difference. Although varieties showed differences in micronaire and uniformity, the values were in the same cotton market classification category (USDA Agricultural Handbook 566).

Seeding Rate — Seeding rates influenced plant population, lint yield, gross returns, and boll weight (Table 1), but they had no effect on micronaire, uniformity, fiber length, and strength (data not shown). With the exception of micronaire, most studies have found that plant populations had little effect on fiber quality (Hawkins and Peacock 1971; Bridge et al. 1973; Baker 1976; Fowler and Ray 1977; Buxton et al. 1979). High plant populations have shown reduced micronaire (Hawkins and Peacock 1971; Bridge et al. 1973; Baker 1976; Fowler and Ray 1971; Buxton et al. 1979; Bednarz et al. 2005).

Averaged over varieties and 3 years (2003–2005), the five seeding rates resulted in various plant populations: (1) 13,000 seeds per acre, 12,480 plants per acre; (2) 26,000 seeds, 23,620 plants; (3) 39,000 seeds, 33,650 plants; (4) 52,000 seeds, 44,250 plants; and (5) 65,000 seeds, 50,990 plants. Plant populations were determined 4 weeks after planting. Boll weights for populations of 12,480 and 23,620 plants per acre were higher than those for 50,990 plants per acre. The 50,990-plant population produced the lowest boll weight (5.27 grams per boll), but this population was not different from the 33,650- and 44,250-plant populations. Lint yield ranged from 1,061 pounds per acre for the 12,480-plant population to 1,176 pounds per acre for the 44,250-plant population. The 33,650-plant population yielded 1,165 pounds per acre and earned gross returns of $636; the 44,250-plant population, 1,176 pounds and $629; and the 50,990-plant population, 1,163 pounds and $629. There were no yield and gross return differences between these populations. These plant populations had higher yields and gross returns than the 12,480- and 23,620-plant populations. Results were similar to those reported by Bednarz et al. (2005), who found that lint yields and gross returns were the same for plant populations of 36,469 and 51,056 per acre, and both populations were higher than 14,588 plants per acre. However, early research with full-season varieties showed no yield differences, with populations ranging from 13,000–75,000 per acre (Burch 1970; Dick and Lund 1955; Douglas et al. 1964; Hawkins and Peacock 1970; Leding and Cotton 1953; Ray et al. 1959; Tugwell and Waddle 1964).

Seeding Method — The soil environmental conditions both years were ideal for seedling emergence. Conditions resulted in 77–89% emergence, averaged over years, varieties, and seeding method. Since variety, seeding method, seeding rate, and years showed no interactions and had no effect on lint yield, lint turnout, boll weight, fiber strength, uniformity, length, micronaire,

Table 1. Seeding rate influence on lint yield, gross returns, micronaire, and boll size, averaged over varieties in 2003–2005, Verona, Mississippi.

Seed per acre X 1000	Plants per acre[1] X 1000	Lint	GRT[2]	Boll weight
		lb/A	*$/A*	*g*
13	12.48	1,061	566	5.68
26	23.62	1,121	600	5.48
39	33.65	1,165	636	5.43
52	44.25	1,176	629	5.39
65	50.99	1,163	629	5.27
LSD (0.05)	2.7	38	26	0.17

[1]Plants per acre at 4 weeks after planting.
[2]Gross returns based on net loan price and lint yield.

Table 2. Seeding rate influence on plant population and lint yield, averaged over varieties, seeding method, and years, 2004–2005, Verona, Mississippi.

Seed per acre X 1000	Hill-drop (two per hill)[1]	Single drill[1]	Plants per acre X 1000	Yield
	in	*in*		*lb/A*
22	15.0	7.5	19.6	1204
26	13.8	6.9	22.0	1267
34	9.8	4.9	27.1	1288
40	8.2	4.1	31.3	1308
52	6.4	3.2	39.9	1298
LSD (0.05)	—	—	—	NS

[1]Approximate seed spacing.

net loan price, and gross returns, the data was pooled and reanalyzed. Averaged over years, seeding method, and varieties, plant densities ranged from 19,600 plants per acre for 22,000 seeds per acre to 39,900 plants per acre for 52,000 seeds per acre (Table 2). Lint yield ranged from 1,204 pounds per acre for the 19,600-plant population to 1,308 pounds per acre for the 31,300-plant population. These results were similar to Seibert et al. (2006), who found that plant populations for drill-seeded or hill-dropped cotton should be no lower than 13,755 plants per acre and hill-dropped spaces no more than 16 inches apart.

Stoneville

Variety — Varieties only affected lint turnout and uniformity. Lint turnout was higher for DP 555BG/RR than for ST 4892BR and ST 5599BR, but there were no variety effects on lint yield (data not shown). ST 4892BR had greater uniformity than ST 5599BR and DP 555BG/RR. However, according to the classification category (USDA Agricultural Handbook 566), the uniformity values for ST 4892BR and ST 5599BR were in the high range and DP 555BG/RR was in the intermediate range.

Seeding Rate — Seeding rate had no effect on micronaire, fiber uniformity, and fiber strength (data not shown). These results are the same as reported by Bednarz et al. (2005). However, seeding rate did influence plant population, lint yield, fiber length, and gross returns (Table 3). Averaged over varieties, the five seeding rates resulted in various plant populations: (1) 13,000 seeds per acre, 11,800 plants per acre; (2) 26,000 seeds, 21,900 plants; (3) 39,000 seeds, 31,500 plants; (4) 52,000 seeds, 41,700 plants; and (5) 65,000 seeds, 53,100 plants. Plant populations were determined 7 weeks after planting. Populations and yield trends were similar to those at Verona. The 53,100-plant population produced the highest yield (1,402 pounds per acre), but this was not different from yields seen in the 31,500- or 41,700-plant populations. The 11,800-plant density yield (1,262 pounds per acre) was not different from the 21,900-plant density yield, but it was lower than yields for the 31,500-, 41,700-, and 53,100-plant populations. This finding contrasted with early research on full-season varieties that showed no yield differences from 13,000–75,000 plants per acre (Burch 1970; Dick and Lund 1955; Douglas et al. 1964; Hawkins and Peacock 1970; Leding and Cotton 1953; Ray et al. 1959; Tugwell and Waddle 1964). Fiber length ranged from 1.12 inches for the 11,800-plant population to 1.14 inches for the 53,100-plant population. Fiber length was greater for the 53,100-plant density than for the 11,800-plant density but not different from the 21,900-, 31,500-, and 41,700-plant densities. Several populations had gross returns that were not different: 31,500 plants per acre, $742 per acre; 41,700 plants, $745; and 53,100 plants, $756. However, these gross returns were greater than returns from the 11,800-plant population. These results are similar to Bednarz et al. (2005), who reported that lint yield and returns above seed cost for populations of 36,469 and 51,056 plants per acre were not different but were higher than those measurements seen in a 14,588-plant population. These results also were similar to Seibert et al. (2006), who reported that 61,851 plants per acre had the highest yield and that yields were not reduced until the population was reduced to 13,755 plants.

Table 3. Seeding rate influence on plant population, lint yield, fiber length, and gross returns averaged over varieties and years in 2003–2005, Stoneville, Mississippi.

Seed per acre X 1000	Plants per acre[1] X 1000	Lint	Fiber length	GRT[2]
		lb/A	*in*	*$/A*
13	11.80	1,262	1.12	673
26	21.90	1,326	1.13	712
39	31.50	1,388	1.13	742
52	41.70	1,383	1.13	745
65	53.10	1,402	1.14	756
LSD (0.05)	3.4	69	.01	34

[1]Plants per acre at 7 weeks after planting
[2]Gross returns based on net loan price and lint yield.

CONCLUSIONS

Varieties showed no yield and fiber quality differences in response to plant populations or seeding method. Varieties and seeding rates also showed no interactions for gin turnout, lint yield, fiber length, fiber strength, micronaire, uniformity, gross returns, and plant population at either location. Varieties and seeding rates either had minor or no effect on fiber micronaire, length, uniformity, and strength. However, when differences occurred, they were usually in the same cotton market classification category. Drill-seeded or hill-dropped (two-seed/hill-drop) plant densities of 31,500–53,100 plants per acre showed no yield or gross return differences, but their yield trends were higher than those for the 11,800- and 22,000-plant populations. With uniform seed spacing, good-quality seed, good seedbed, and good environmental growing conditions for achieving a good stand, seeding rates may be reduced from the recommended four seeds per foot of row to three seeds. But under less-than-optimum conditions, one should consider the risk for stand failure when using a seeding rate of three seeds per foot of row.

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