YIELD, QUALITY AND PROFITABILITY OF COTTON AT VARIOUS PLANT POPULATIONS

Craig W. Bednarz[1], W. Don Shurley[2], W. Stanley Anthony[3] and Robert L. Nichols[4]

[1] Dept. of Crop and Soil Sciences, University of Georgia, Tifton, GA
[2] Dept. of Agricultural and Applied Economics, University of Georgia, Tifton, GA
[3] USDA-ARS Cotton Ginning Research Unit, Stoneville
[4] Cotton Incorporated, Cary, NC

Introduction

Advances in yarn spinning and fabric manufacturing technologies require fibers of exceptional quality to operate at peak efficiency. Quality parameters for Staple, Strength, and fiber length Uniformity are increasingly important. In 2000, quality standards for fiber length Uniformity were added to price premiums and discounts and minimum standards for Strength were increased. Currently, approximately 2 out of every 3 bales of US cotton is exported. US cotton must, therefore, be competitive in both price and quality on the global market.

Unfortunately, during the past five to seven years quality of U.S. cotton has actually declined. Some textile manufacturers have begun to discriminate against cottons produced in certain regions of the U.S. cotton belt due to historical trends of less than desirable quality from these areas. Price discounts and wider basis for cottons of lesser quality places such producers at an economic disadvantage relative to others in the industry.

Georgia, once having an exceptional reputation within the industry for high-quality fiber, has in recent years experienced a decline in quality. Of particular concern, low fiber Uniformity and short Staple appear to be chronic problems. Some textile mills are avoiding purchase of Georgia cotton.

What is causing the problems? Soil type, weather patterns, insect pressure, cultivar selection, defoliation and harvest timing, crop management– it is unknown but each or all of these could play a role.

It has been speculated by some that this deterioration in quality is due to the wide spread adoption of transgenic cotton cultivars that were not adequately tested for yield and fiber quality prior to their release. Others have conjectured the decline in fiber quality has been the result of changes in crop management that arose from adoption of transgenic cotton cultivars. For instance, technology fees associated with transgenic cotton cultivars may act as an economic incentive for the grower to reduce seeding rates.

The objectives of this study were to determine how lint yield, fiber quality and profitability of cotton are impacted by seeding rates (plant population or density).

Materials and Methods

Two cotton cultivars, DPL 458BR and FM 966, were over seeded and hand thinned to 1, 2.5, 3.5, and 6 plants per foot at the University of Georgia Coastal Plain Experiment Station at Tifton in 2001 and at the Southwest Branch Experiment Station at Plains in 2001 and 2002. At Tifton, the study was on a Tifton loamy sand and at Plains on a Greenville sandy clay loam. All plots were 4 rows wide, 36" row spacing, and 120 feet long.

At each location and each year, the cotton was produced with irrigation and using conventional tillage production practices (ripping and bedding). Each variety was produced in accordance with University of Georgia Cooperative Extension Service guidelines (Brown et al., 2001). At each location each year, all inputs (fertility, weed and insect control, and harvest aids) were the same by variety except the seeding rate. Defoliation was at approximately 70% open boll in each study.

All plots were machine (spindle picker) harvested. The seed cotton from each plot was shipped to the USDA/Agricultural Research Service/Cotton Ginning Research Unit in Stoneville, MS for ginning. While ginning, 3 samples were collected per plot which were delivered to Cotton Incorporated (Cary, NC) for fiber quality analyses. Fiber quality was determined using High Volume Instrument (HVI) measurements.

Net returns were determined from yield, quality and seed cost data. Net return above seed costs was calculated for each HVI fiber quality sample. Except for seed, all other inputs and costs were fixed regardless of plant density. The net return for each plant density and variety for each year and location was calculated as:

$$NR^{xyz}_{ijk} = (Y^{xyz}_{ij} \times P^{x}_{k}) - S^{xz}_{i}$$

NR = Net return per acre in year *x*, location *y*, and variety *z* for plant density *i*, yield rep *j*, and quality sample *k*.

Y = Yield (lbs per acre) in year *x*, location *y*, and variety *z* for plant density *i*, yield rep *j*.

P = Loan rate (cents per lb) for year *x* and quality of sample *k*.

S = Seed cost ($ per acre) in year *x* for variety *z* and plant density *i*.

Cotton lint was valued at the loan rate adjusted for fiber quality. Base loan rates (no premiums or discounts for fiber quality) for 2001 and 2002 were $0.5192 per pound and $0.5200 per pound, respectively. (USDA/FSA, 2001, 2002).

Leaf Grade data were unavailable for this study. Therefore, leaf grade was assumed to be in the same proportion to Color Grade as for the state in each year (USDA/AMS, 2003). For example, in 2002 in Georgia the average leaf grade for cotton that graded Color 31 was 3.26. Therefore, for quality samples in the study for 2002 that graded 31 in Color, a Leaf grade of 3 was assumed.

Seed cost per bag, including technology fee if applicable, for each variety and year was obtained from company sales representatives. The price per bag was provided by the company as the typical price paid by Georgia farmers. The seed cost per acre was calculated for each variety and plant density based on 36" row spacing. Final plant density (1.0, 2.5, 3.5, or 6.0 plants per foot) was assumed to be 85% of the actual seeding rate. For example, seed costs for 2.5 plants per foot was based on 2.94 seeds per foot and 3.5 plants per foot was based on 4.1 seeds per foot.

The technology fee for DPL 458BR was capped at a maximum of $41.00 per acre. This is the "exception rate" established by Monsanto. If the technology fee for the entire farm averages more than $41.00 per acre, the fee may be reduced to this level. In this study the technology fee for DPL 458BR was reduced to $41.00 per acre at plant densities of 3.5 (4.1 seed per foot) and 6.0 (7.06 seed per foot).

Results and Discussion

Lint Yield

Several previous studies have shown decreased lint percentage (gin turn-out) with increased plant density. This study illustrated a similar pattern (Table 1). While the exact reasons for this are unknown, it likely results from decreased seed size and lint weight per seed with increased plant density.

Lint yield increased from 1.0 to 3.5 plants per foot but decreased from 3.5 to 6.0 plants per foot. Lint yields were greatest at 3.5 plants per foot. Statistically there was no difference in lint yield at 2.5, 3.5, and 6.0 plants per foot but numerically on average there was a decline in yield of 28 lbs per acre from 3.5 to 2.5 plants per foot and 88 lbs per acre from 2.5 to 1.0 plants per foot. The yield response to plant density in this study was similar to previous studies.

Lint Quality

Color, Staple, and Uniformity were unaffected by plant density. Color grade averaged 31 regardless of plant density. Staple averaged 35 regardless of plant density and fiber length Uniformity averaged 82 (ranged from 81.6 to 81.8 depending on plant density). Fiber Micronaire, Strength, Staple, and Uniformity were, however, greatly influenced by cultivar (Table 2).

In this study, among quality parameters, only Micronaire and Strength were greatly influenced by plant density (Figures 1 and 2). Micronaire increased as plant density decreased. Strength decreased as plant density decreased.

Net Returns

In discussing profitability, it is important to recognize that for some quality factors such as Strength, Micronaire, and Uniformity that numerical and even statistical differences may occur with little or no impact on the price received for lint. This is because the "base" or standard for which there is no premium or discount may range over a wide area. Likewise, for some quality factors such as Color and Staple, numerical averages may not be different but price differences may nevertheless occur.

Price premiums for Color-Leaf/Staple, Strength, and Uniformity numerically increased with higher plant density (Table 3). The price premium for Micronaire statistically increased when plant density increased.

Quality premiums and discounts were statistically different by variety. Total quality premium was .98 cents per lb for DP458BR compared to 3.38 cents per lb for FM966. Variety differences in premium for Strength, Micronaire, and Uniformity were observed.

Net Returns above seed costs were lowest for DP458BR at 1.0 plants per foot (Table 4). Net Returns were highest at 3.5 plants per foot for both varieties.

Summary and Conclusions

Plant density impacts boll size and boll distribution in the plant and, therefore, may impact fiber quality. In this study, small gains in fiber length and strength were made through modifications in plant density, but the greatest improvement in fiber quality was in micronaire. FM966 consistently outperformed DP458BR at all plant densities. This supports the idea that fiber properties are highly genetically influenced. To maximize fiber quality, cultivar selection is of greatest importance while management of plant density to maintain or maximize genetic potential is secondary.

Acknowledgments

The authors would like to thank Benjamin G. Mullinix. Jr. for assistance with the statistical analyses and T. Dudley Cook and Lola C. Sexton for the technical support. The authors also thank the Georgia Agricultural Commodity Commission for Cotton and Cotton Incorporated for financial support.

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Table 1. Yield (Lbs Per Acre) By Plant Density, Year, Location, and Variety

			Plants Per Foot of Row			
Year	**Location**	**Variety**	**1.0**	**2.5**	**3.5**	**6.0**
2001	Tifton	DP458BR	1143	1302	1313	1390
2001	Tifton	FM966	1230	1402	1429	1446
2001	Plains	DP458BR	1072	1231	1266	1284
2001	Plains	FM966	1188	1173	1217	1178
2002	Plains	DP458BR	983	1037	1087	1017
2002	Plains	FM966	1044	1045	1047	972
Average By Plant Density			1110	1198	1226	1214
Average By Variety		**DP458BR**	1066	1190	1222	1231
		FM966	1154	1207	1231	1199

Table 2. Quality Parameters, Average by Variety For All Plant Density

Variety	**Color**	**Staple**	**Strength**	**Micronaire**	**Uniformity**
DP458BR	31	34.2	27.5	4.34	80.9
FM966	31	35.6	31.1	4.16	82.3

Table 3. Lint Quality Premiums and Discounts (Cents Per Lb) Average By Plant Density and Variety

	C-L/S	**Strength**	**Micronaire**	**Uniformity**	**Total**
1.0	1.38	-.09	.06	.04	1.39
2.5	1.97	.07	.08	.04	2.16
3.5	2.20	.18	.10	.08	2.56
6.0	2.18	.20	.14	.05	2.57
DP458BR	1.21	-.30	.07	.00	.98
FM966	2.66	.48	.12	.12	3.38

Table 4. Net Returns ($ Per Acre) By Plant Density, Year, Location, and Variety

			Plants Per Foot of Row			
Year	**Location**	**Variety**	**1.0**	**2.5**	**3.5**	**6.0**
2001	Tifton	DP458BR	$541.53	$618.68	$623.90	$660.72
2001	Tifton	FM966	$673.46	$750.46	$773.74	$770.57
2001	Plains	DP458BR	$541.74	$622.95	$635.50	$643.16
2001	Plains	FM966	$658.02	$642.92	$663.56	$632.44
2002	Plains	DP458BR	$505.08	$522.82	$536.58	$483.53
2002	Plains	FM966	$573.15	$560.67	$559.76	$504.37
Average By Plant Density			$582.17	$619.75	$632.17	$615.80
Average By Variety		**DP458BR**	$529.45	$588.15	$598.66	$595.81
		FM966	$634.88	$651.35	$665.69	$635.79

Figure 1. Micronaire At Various Plant Density

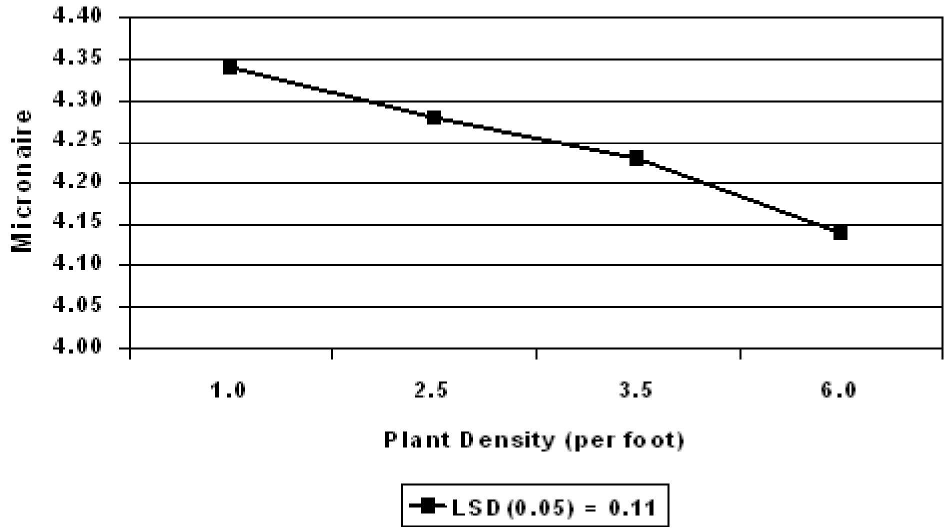

Figure 2. Fiber Strength at Various Plant Density