Evaluation of Plant Population Effects on Lint Yield and Fiber Quality

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Abstract

The cotton (Gossypium spp.) plant is a true perennial with perhaps the most complex structure of all the major field crops. Plants can compensate to a large degree for environmental as well as physical conditions. Much research has been conducted to arrive at plant population recommendations that optimize the yield and quality of the crop. Research conducted in the low desert regions of Arizona suggest that optimum plant density lies somewhere between 25,000 and 50,000 plants per acre. However, cotton crops with plant densities outside of this optimal range still have the ability to yield similarly and maintain premium quality. Accordingly, a research project was conducted comparing four separate plant densities. Objectives included determining effects on yield and fiber quality. The study was laid out in a randomized complete block design with target plant populations of approximately 30K, 50K, 70K, and 90K plants per acre as the treatments. All other inputs were equal across treatments. Throughout the course of the season, plant measurements showed no distinct differences among the treatments. Height-to-Node ratios (an indicator of vegetative tendencies) remained above normal throughout the season for all populations. Fruit retention levels remained optimal throughout the season. Lint yield results revealed that treatment four (90K plants per acre) yielded significantly less that the other three treatments. No significant differences in fiber quality were observed among treatments.

Introduction

Arizona cotton growers are faced with many challenges that are unique to the present day. Competition in global marketplaces and overall low prices have motivated many growers to reconsider production management decisions and to look for new practices that will increase their competitiveness in marketing their cotton crop. Establishing a history of premium quality cotton can become a significant marketing tool. Producing a high yielding, quality product is challenging. Cotton is unique among other field crops in its sensitivity to environmental conditions and management decisions.

Extensive research has been conducted to evaluate the effects of plant population on not only yield but also on relationship to physiology of the plant and the allocation of carbohydrates within the plant. Research has shown

that effects on yield are mixed. There are indications that populations above 75,000 plants per acre (ppa) can be detrimental to crop yield (Silvertooth et al., 1994). However, work with extremely high populations in and Ultra Narrow Row system have shown significant increases in lint yield. Recommended populations for Arizona are anywhere from 20 to 70K ppa with optimal populations between 25 and 50K ppa (Silvertooth, 2001). Higher plant populations provide for the possibility of earlier canopy closure than with a conventional population. Eaton and Eargle (1954) demonstrated a correlation between shading due to early canopy closure and increased fiber length and decreased micronaire.

The objectives of this project were to determine the effects of multiple plant populations on two key properties: yield and fiber quality. The assertion that very high plant populations could have a detrimental effect on yield and that increased populations also can provide benefits with fiber quality were the subject of this investigation.

Methods and Materials

A large-scale field trial was established which consisted of four separate target plant populations. The experimental design was a randomized complete block design with treatments representing different plant populations. Plots were eight rows wide by the entire length of the 1,000-foot irrigation run. Deltapine 444BG/RR was planted into moisture on April 15, 2004. Proper seeding rates were established based upon seeds/pound and estimating 70% germination. A John Deere Maxemerge® vacuum planter was utilized to plant the four separate seeding rates. Plant measurements were taken over the course of the season to track vegetative tendencies and fruit retention on the plants. All other management practices and inputs were the same across populations for optimum efficiency. Irrigation was terminated on September 9. The crop was defoliated and prepared for harvest. Plots were harvested on November 17. The entire plots were harvested with a four-row spindle picker. Seed cotton was weighed in a boll buggy equipped with load cells to determine seed cotton yield per acre. Sub-samples were ginned to determine percent lint turnout. Fiber samples were then sent to the USDA Classing Office in Phoenix, AZ for fiber quality analysis. Data for plant population and fiber quality variables were analyzed in accordance with analysis of variance procedures outlined by the SAS Institute (1999).

Results

Plant measurements throughout the season were very much the same across treatments. Height-to-node ratios (Figure 2) were well above baselines throughout most of the growing season. Fruit retention (Figure 3), however, followed expected baselines throughout the season. Plants were very large from a structural standpoint but carried a large fruitload.

Analysis of lint yield results (Table 2) demonstrated a statistically significant reduction of lint yield in the 90K plants per acre plots in comparison to all other populations (247 lbs. of lint/acre lower than the top yielding population, Table 2). All other populations revealed no significant differences in lint yield. Fiber quality variables were also analyzed for any statistical differences. Micronaire, fiber strength, fiber length, and fiber uniformity index demonstrated no significant differences among populations (Table 2).

Summary

One of the key objectives of this study was to determine the effects of plant population on yield, negative or positive. It appeared that yield was reduced in the highest plant population plots. This would follow research findings cited above. In addressing the other key objective, effects on fiber quality, no differences were seen among the treatments. The 2004 season was unique from a weather standpoint with a warm spring and low night temperatures during summer, particularly the monsoon periods (Figure 1). Therefore, we would not have expected some of the quality difficulties that can result from extreme high temperatures, specifically high micronaire. It is difficult to determine whether differences might have been seen if conditions had been more to the average. This study will be duplicated in 2005, also looking at separate varieties.

References

Eaton, F.M. and D.R. Eargle. 1954. Effects of shade and partial defoliation on carbohydrate levels and the growth,
fruiting, and fiber properties of cotton plants. Plant Physiology. 29:39-49.

SAS Institute. 1999. SAS/STAT:Procedures. Release 9.1 ed. SAS Inst., Cary, NC.

Silvertooth, J.C. 2001. Plant population evaluation/management for cotton. Cooperative Extension Bulletin AZ1203. College of Agriculture and Life Sciences. University of Arizona.

Table 1. Agronomic Information, 2004.

Planting Date:	April 15
Variety:	Delta Pine 444BG/RR
Termination Date:	September 9
Harvest Date:	November 17

le 2. ANOVA results for lint yield and fiber quality measurements, 2004.

Treatment	Final Plant Population (plants per acre)	Lint Yield[1] (lbs/acre)	Percent Lint	Fiber Quality			
				Micronaire	Fiber Length (100ths)	Fiber Strength (g/tex)	Uniformity Index
1	26,000	1875 a	35.0 a	4.18 a	1.11 a	29.0 a	81.5 a
2	48,000	1853 a	35.2 a	4.23 a	1.13 a	28.5 a	81.5 a
3	70,000	1923 a	35.2 a	4.15 a	1.18 a	28.5 a	81.5 a
4	90,000	1676 b	33.0 a	4.18 a	1.09 a	28.4 a	81.3 a
$LSD_{0.05}$[2]		136	NS	NS	NS	NS	NS
OSL[3]		0.0166	0.3052	0.8559	0.2438	0.9028	0.6696
CV (%)[4]		4.85	4.30	3.20	1.43	3.80	0.96

[2]LSD: Least Significant Difference
[3]OSL: Observed Significance Level
[4]CV: Coefficient of Variation