TWIN-LINE PER BED PLANT POPULATION AND VARIETY EVALUATION

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Abstract

Two experiments were conducted at the University of Arizona Maricopa Agricultural Center in 2002 designed to evaluate cotton yield and fiber quality at various plant populations and to test cotton variety performance in a twin-line per bed cotton production system. The plant population experiment consisted of four target populations which included 60, 80, 100, and 120,000 plants per acre (PPA) and two varieties, Stoneville 4892BR and AG3601. The resulting plant populations were 52800, 69200, 82800 and 96200 for ST4892BR and 54800, 70800, 90500 and 104500 for AG3601. The two lowest plant populations resulted in the highest lint yields for both varieties and were similar but there was a significant linear of decreasing yield with increasing plant population. The highest lint yields in the twin line variety experiment were DP449BR (1743 lb/acre) and DP5415R (1702 lb/acre) which were not statistically different.

Introduction

Profitable cotton production has become increasingly challenging in Arizona in recent years. Rising production costs, continued market depression, and fiber quality based discounts, particularly for high micronaire have increased producer motivation to explore any practical production changes which may ultimately improve profit margins.

Ultra Narrow Row (UNR) cotton production research conducted in 1999 - 2000 compared yield, fiber quality, and production costs of 10 inch UNR systems on the flat (no beds) and conventional 40 inch row system on beds (Husman et al., 2001; Husman et al., 2000; McCloskey et al., 2000). The UNR system produced 3 to 9 percent more lint while reducing variable costs by 5 to 12 percent. In addition, the fiber micronaire produced by the UNR system was 10 to 18 percent lower than the conventional system. High fiber micronaire is the fiber quality property most responsible for discounts experienced in Arizona. While these results were encouraging, commercial interest or adoption has been minimal due to consistent challenges related to stand establishment, weed control, plant height control, and dessication for stripper harvest. In addition, the perceived quality stigma associated with stripper cotton and potential additional discounts this posed resulted in unacceptable risks for Arizona producers.

Researchers at the University of California (UC) have recently been experimenting with a modified UNR approach where two seed-lines (twin-line) are planted on a single bed with a target plant population of approximately 80,000 PPA. Their research found the twin-line system increased yield 5 to 9 percent compared to conventional single-line production and resulted in a $40 to $60 production cost decrease primarily in weed control. The twin-line system is a less radical departure from conventional production than UNR systems and may be of more commercial interest if results are consistent. A major advantage of the twin-line system is that the crop is harvested with a conventional spindle picker, equipment producers currently own. In addition, stand establishment, weed control, and plant height management are similar in conventional and twin-line systems again increasing potential adoption by producers.

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In 2001, Arizona researchers followed the lead of researchers at UC and conducted 3 experiments comparing single and twin-line production systems in terms of yield, fiber micronaire, and production costs (Husman et al., 2002). In general, yields were comparable in both the single- and twin-line configurations at all locations. However, in all 3 experiments there fiber micronaire was reduced in the twin-line system compared to the conventional single-line system. There were no differences in production costs between the single- and twin-line systems. The twin-line system required one less cultivation due to earlier canopy closure but seed costs were increased and the two expenses effectively canceled each other for no net change in costs.

The reduction in fiber micronaire in the twin-line system compared to the conventional single-line was consistent with previous UNR results. This fiber micronaire reduction is thought to occur due to changes in light interception, photosynthesis rates, and carbohydrate production on a per plant or per unit area basis. Fiber micronaire discounts have been costly to many low elevation producers in recent years. If simple changes in plant population and stand geometry can be used to lower micronaire, producer's interest in adoption the system should increase.

Research was continued in 2002 at multiple test locations evaluating yield, fiber quality, and cost comparisons between the twin-line and single-line conventional production systems (see an accompanying report in the 2003 Beltwide Cotton Conference Proceedings). When a producer is considering the adoption of a system change such as twin-line, generally the first couple questions will center around plant population and variety choice. Therefore, two studies were initiated in 2002; the first evaluated two phenologically different varieties at four plant populations, and the second evaluated six popular commercially available Upland cotton varieties in the twin-line configuration.

Materials and Methods

Two separate experiments were conducted in 2002 at the University of Arizona Maricopa Agricultural Center designed to evaluate twin-line system yield and fiber quality response to plant population and variety.

Twin-Line Variety

The twin line variety experiment consisted of six commercially available Upland cotton varieties including DeltaPine 451BR, 449BR, 5415R, Stoneville 4892BR, 4793R, and Arizona Growers 3601. Plots were 6 rows wide and 80 feet long replicated 5 times resulting in a randomized complete block design. Prior to planting, the beds were shaped to facilitate planting the twin-line configuration. The variety evaluation experiment was dry planted on April 3, 2002, irrigated up on April 4, 2002 and harvested on November 8, 2002. The experiment was planted using a Monosem twin line vacuum planter with planter units spaced 7.25 inches apart. Plots were harvested by picking the center two rows from each six row plot using a Case-IH 1822 picker equipped with a bag attachment for small plot harvesting. Seed cotton from each plot was weighed using an electronic digital platform scale. Prior to harvest, 50 bolls were hand harvested uniformly from lower, middle, and upper portions of plants from each plot. Those samples were ginned with the average of the 5 replicates used for lint turnout. A sub-sample of fiber was then submitted to the USDA Cotton Classing Office, Phoenix, Az. for HVI classing.

Twin-Line Plant Population

The plant population experiment consisted of four target plant populations of 60, 80, 100, and 120,000 PPA and two varieties, Stoneville 4892BR and AG3601. The varieties were chosen based on their distinctly different growth characteristics. Stoneville 4892BR has a branching bush type characteristic with multiple fruiting sites per fruiting branch while AG3601 has a columnar cluster type growth characteristic. Plots were 6 rows wide and 550 feet long, replicated 4 times resulting in a randomized complete block split-plot design. Prior to planting, the beds were shaped to facilitate planting the twin-line configuration. The plant population experiment was dry planted on April 3, 2002, irrigated up on April 5, 2002 and harvested on October 24, 2002. The experiment was planted using a 6 row (12 planter units) Monosem twin-line vacuum planter with planter units spaced 7.25 inches apart. Seed drop changes were made to accomplish the targeted plant populations by changing the driver and driven sprockets according to the planter operations manual. Plots were harvested by picking the center four rows of each six row plot with a 4 row Case-IH 2155. The seed cotton from each plot was weighed using a boll buggy equipped with load cells. Sub-samples of approximately 15 pounds of seed cotton were taken from each plot and ginned for lint turnout. A sub-sample of fiber was then submitted to the USDA Cotton Classing Office, Phoenix, Az. for HVI classing.

Canopy closure measurements were made by selecting three subplots in each plot, one area near each end of a plot and one area in the middle of the plot. These areas were then flagged (one flag on each side of the furrow) so that repeated measurements were made in the same locations for the rest of the season. Canopy closure was determined by measuring the distance between the edges of the canopies of two adjacent rows. The edge of each canopy was determined by sighting down the edge of a canopy and measuring from an approximate average location of leaf edges at the edge of the canopy. Subplot measurements were averaged to determine the mean percent canopy closure. Canopy closure measurements were taken approximately every two weeks at the selected locations. Percent groundcover measurements were made by analyzing digital images. An Olympus Camedia C3030 digital camera mounted 2 m above the ground on a pole was used to take pictures in three subplots per plot in all treatments in the Maricopa and Marana experiments. A software package, SigmaScan from SPSS Science Software, was used to digitally analyze and calculate the ratio of green image pixels to non-green pixels which was used to calculate percent ground cover. To determine percent canopy closure from the pictures, three lines were drawn between the outside leaf edges of adjacent rows in each picture. The length of each line was measured and an average distance between rows was calculated to determine the degree of canopy closure at different dates.

Results and Discussion

Twin-Line Variety Evaluation

DP449BR and DP5415R produced the highest and statistically similar lint yields of 1743 and 1702 lb/acre, respectively (Table 1). AG3601 resulted in the lowest lint yield of 1324 lb/acre. In general, varietal performance in the twin-line planting configuration was consistent with performance expectations of the varieties in a conventional single-line system. Surprisingly, five of the six tested varieties had micronaire values greater than 5.0, the discount threshold. It is not clear as to the cause, since the results from previous twin-line research suggested that micronaire values might be reduced by using the twin-line system configuration. Fiber samples were taken by hand harvesting a 50 boll sample that was ginned and submitted to the USDA Cotton Classing Office, Phoenix, Az. The results of this experiment represent a single site-year and should be considered accordingly.

Twin-Line Plant Population

The target plant populations were 60, 80, 100, and 120,000 PPA in the population density experiment. The average final stand counts were 52.8, 69.2, 82.8, and 96,200 PPA for the ST4892BR variety and 54.8, 70.8, 90.5, and 104,500 PPA for the AG3601 variety (Table 2). The highest and statistically similar lint yields were obtained at the lowest populations of each variety (Table 2). There was a significant linear trend of decreasing lint yield with increasing density or plant population for both the ST4892BR and AG3601 varieties (Figure 1). There were only small, mostly non-significant, differences in canopy development measured as percent ground cover or percent canopy closure between the different densities (Table 3). Only on the first measurement date, June 4th, was there a statistically significant linear increase in percent ground cover or canopy closure with increasing density possibly indicating that there were differences in canopy development earlier in the season prior to the initiation of canopy measurements. Increased shading within the canopy with increasing plant density would be expected to result in reduced carbohydrate supply in the lower canopy (Ergle and Eaton, 1954) which might partially explain the declining yield with increasing density. Alternatively, resources, particularly water, may have been more limiting at the higher densities thereby reducing yield. In retrospect, it appears likely that the optimum planting density for the twin-line configuration may be similar to the optimum planting density in a conventional single-line system or perhaps even lower given the more optimal geometric arrangement of plants in the twin-line configuration. Continued research in 2003 will include a range of densities between 15,000 and 80,000 PPA so that a regression curve can be used to describe the density yield data and facilitate prediction of the optimum twin-line planting density.

Conclusions

Variety selection is always one of the first critical decisions a cotton producer makes and ultimately tends to have a significant bottom line impact. While logic may suggest that cotton varieties that exhibit more columnar and cluster type fruiting growth characteristics may be more suitable to the higher plant population twin-line production system, the results of this experiment did not support that rationale. At this time, it is thought that in general, varieties with consistently high performance records should be the producer choice in both a conventional single-line as well as twin-line configurations.

The plant population experiment results were consistent across two varieties with distinctly different growth characteristics. ST4892BR is a branching bush type plant with multiple fruiting sites per branch while AG3601 exhibits an upright, columnar tight cluster fruiting pattern. The target plant populations which resulted in the greatest yield were 60,000 to 80,000 plants per acre which resulted in field populations of 52,800 to 70,800 plants per acre. Further research on twin-line planting densities is required before a recommendation can be made regarding planting density. However, based on one site-year of data, only target densities that will result in a field population of 60,000 plants per acre or less should be contemplated for the twin-line production system.

References

Husman, S.H., W.B. McCloskey, T. Teegerstrom, P. Clay, R. Norton, and K. White. 2002. Yield, quality, and economic comparison of single and double seed line per bed cotton production. *In* Proc. Beltwide Cotton Conference, Atlanta, Ga., Jan. 2002. Natl Cotton Council. Am., Memphis, TN. 6 pages.

Husman, S.H., W.B. McCloskey, T. Teegerstrom, and P. Clay. 2001. Agronomic and economic evaluation of ultra narrow row cotton production in Arizona 1999-2000. Pp. 469-470. *In* Proc. Beltwide Cotton Conference, Anaheim, CA, Jan. 2001. Natl Cotton Council. Am., Memphis, TN.

Husman, S.H., W. B. McCloskey, T.Teegerstrom, and P.A. Clay. 2000. Agronomic and economic evaluation of ultra narrow row cotton production in Arizona in 1999. Pp. 653-657. *In* Proc. Beltwide Cotton Conference., San Antonio, TX., Jan. 2000. Natl Cotton Council. Am., Memphis, TN.

McCloskey, W.B., P.A. Clay, and S.H. Husman. 2000. Weed control in Arizona ultra narrow row cotton: 1999 preliminary results. Pp. 1492-1495. *In* Proc. Beltwide Cotton Conf., San Antonio, TX. January 2000. Natl Cotton Council. Am., Memphis, TN.

Eaton, F.M., and Ergle, D.R. 1954. Effects of Shade and Partial Defoliation on Carbohydrate Levels and the Growth, Fruiting, and Fiber Properties of Cotton Plants. Plant Physiol. 29: 39-49.

Table 1. Yield and fiber quality of six upland cotton varieties planting in a twin-line per bed planting configuration at the Maricopa Agricultural Center in 2002.

Variety	Density x 10^{-3}	Lint Yield	Micronaire	Staple	Strength
	(plants/A)	(lb/A)			
DP449BR	67	1743 a	5.33 a	35.8 ab	29.9 ab
DP5415R	65	1702 ab	4.97 b	36.3 ab	29.2 ab
ST4892BR	67	1544 abc	5.48 a	34.5 b	27.7 b
DP451BR	63	1527 abc	5.48 a	35.4 ab	28.1 ab
ST4793R	72	1489 bc	5.4 a	35.0 b	28.2 ab
AG3601	63	1324 c	4.83 b	37.0 a	31.4 a
P		0.0007	0.0002	0.013	0.0499
CV		8.30	2.99	2.36	5.36

Values are means; means within a column followed by the same letter are not significantly different at a P=0.05 according to the Ryan-Einot-Gabriel-Welsch multiple range test (PROC GLM, SAS Institute).

Table 2. Yield and fiber quality of ST4892BR planted at various densities in a twin-line per bed planting configuration on 40 inch rows at the Maricopa Agricultural Center in 2002.

Variety	Density x 10^{-3}	Lint	Micronaire	Staple	Strength	Uniformity
	(plants/A)	(lb/A)				
ST4892BR	52.8	1743 a	5.3 a	37	29.7	83
ST4892BR	69.2	1672 ab	5.2 a	36	28.5	83
ST4892BR	82.8	1583 bc	5.1 a	36	30.0	83
ST4892BR	96.2	1533 c	5.0 a	36	28.4	82
P		0.004	>0.05			
%CV		3.75				
LSD		97.6				
AG3601	54.8	1299 a	4.4 a	38	32.3	81
AG3601	70.8	1275 a	4.2 ab	38	33.5	82
AG3601	90.5	1131 b	3.9 b	38	33.7	82
AG3601	104.5	1079 b	3.9 b	38	33.9	82
P		0.0001	<0.01			
%CV		3.36				
LSD		60.8				

Values are measns (SAS PROC GLM (ANOVA); means within a column followed by the same letter are not significantly different at P=0.05 level according to the Waller mean separation test.

Table 3. Percent cotton ground cover and canopy closure of double-seed line per bed cotton planting configurations at the Maricopa Agricultural Center Plant Population Study.

Density (plants/A)	Date	Ground Cover (%)	Canopy Closure (%)
53.5K	6/4/02	30.4	52.3
69.3K	6/4/02	30.7	52.2
82.8K	6/4/02	32.6	53.5
98.3K	6/4/02	37.2*	56.8*
53.5K	6/17/02	41.2	62.9
69.3K	6/17/02	43.5	63.5
82.8K	6/17/02	41.9	63.2
98.3K	6/17/02	44.6	65.4
53.5K	6/24/02	52.0	70.7
69.36K	6/24/02	50.6	69.6
82.8K	6/24/02	50.8	68.3
98.3K	6/24/02	54.1	71.6

*Values are means (SAS PROC GLM (ANOVA); means within a column followed by the same letter are not significantly different at P=0.05 level according to the Waller mean separation test.

Figure 1. Relationship of lint yield with increasing density for two varieties, ST4892BR and AG3601, in the twin-line cotton production system at the Maricopa Agricultural Center experiment in 2002. The regression equation for ST4892BR was Yield = 1987 - (0.00467 * Density) with P = 0.0002 and $R^2 = 0.6335$. The regression equation for AG3601 was Yield = 1576 - (0.00474 * Density) with P<0.0001 and $R^2 = 0.8016$.