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COMPARISON OF TWIN AND SINGLE LINE COTTON PRODUCTION SYSTEMS

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Abstract

Twin line (two seed lines 7.25 in apart per bed) and conventional single seed line per bed cotton production systems were compared at 18 sites across Arizona and the Palo Verde Valley near Blythe, Ca. in 2002 and 7 sites in 2003. Three experiments at the Chaffin site in 2002 compared twin line plant populations of 57,000 (57K), 75,000 (75K), and 90,000 (90k) plants per acre (ppa). In 2002, the twin line system produced more lint than the conventional single line system at 4 of 18 locations; the yields of the twin line and single line systems were 1273 and 1186 lb/acre, 1572 and 1461 lb/acre, 1478 and 1290 lb/acre, and 1309 and 1210 lb/acre, respectively, at the Grasty, Ramona, Rovey, and Wells sites, respectively. In 2003, none of the experiments resulted in higher twin line system lint yields. In 2002, there were no significant differences in yield or fiber micronaire in 7 of the 18 experiments. In 2003, there were no significant differences in yield in 3 of the 7 experiments. In 2002, the twin line system produced less lint than the conventional system at 5 of 18 locations; yields of the twin line and single line systems were 2019 and 2189 lb/acre, 1400 and 1489 lb/acre, 1537 and 1845 lb/acre, 1065 and 1200 lb/acre, and 1271 and 1431 lb/acre, respectively, at the Chaffin (75K), Cooley, Hull, Papago, and Wakimoto sites, respectively. In 2003, the twin line system resulted in less yield in 4 of the 7 experiments; yields of the twin line and single line systems were 1906 and 2109 lb./acre, 1797 and 1938 lb./acre, 878 and 1114 lb./acre, and 1230 and 1404 lb./acre, respectively, at the Marlatt 1, 2, 3, and the University of Arizona (UA) Marana Agricultural Center sites respectively. In 2002, fiber micronaire was reduced in five experiments; the micronaire values were 4.25 and 4.73, 4.46 and 4.78, 4.60 and 4.85, 4.76 and 4.98, and 4.93 and 5.15, in the twin line and single line systems, respectively, at the Rogers, Papago, Grasty, Hull, and Perry sites, respectively. In 2003, there were no significant differences in fiber micronaire at all 7 test locations. In 2003, visual observations suggested that the spindle pickers were unable to effectively harvest the lowest bolls primarily below the cross-over point of the two mainstems in the twin line system. Hand harvest comparisons of the twin and single line system resulted in yields of 1776 and 1661 lb./acre respectively, a 6% difference at the Maricopa Agricultural Center. It was concluded that the inability to effectively harvest twin line cotton is the most significant problem with this production system.

Introduction

Cotton production in Arizona is characterized by high input costs and high yield potential. Low cotton prices and increasing input costs are forcing producers to explore opportunities to reduce costs, increase yield or both to be profitable. In addition, significant low desert cotton acreage has produced lint with high fiber micronaire in recent years resulting in price discounts that have further eroded profit margins.

Ultra Narrow Row (UNR) cotton production research conducted in Arizona from 1999 to 2000 compared yield, fiber quality, and production costs of a 10 inch UNR system on the flat (no beds) and a conventional 40 inch row system on beds (Husman et al., 2001, Husman et al., 2000; McCloskey et al., 2000). The results were encouraging in that UNR systems produced 3 to 9 percent more lint while reducing variable costs by 5 to 12 percent. In addition, the micronaire of the lint produced by the UNR system was 10 to 18 percent lower than the fiber micronaire of the lint produced in the conventional system. Although these results appear to encourage adoption of the UNR production system, there has been little commercial interest in or adoption of the system in Arizona due to its challenging and unforgiving nature. The most serious problems associated with the UNR system were establishing a high density, uniform plant population, obtaining adequate weed control, controlling cotton plant height, and obtaining adequate defoliation and dessication in preparation for stripper harvest. There was also a perceived quality stigma associated with stripper picked cotton and the potential discounts resulted in unacceptable risks for Arizona producers.

While UNR system research was being conducted at the University of Arizona (UA) , University of California (UC) researchers were experimenting with a system where two seed lines (twin line) were planted on a bed with a target population of 80,000 plants per acre which they referred to as a modified UNR cotton production system. In some of their experiments, they found that the twin line system increased yield 5 to 8 percent compared to a conventional single line system and reduced production costs $40 to $60 per acre, primarily by reducing weed control costs. The twin line production system is a less radical departure from conventional cotton production than the UNR system because it can be harvest with a conventional spindle picker. In addition, stand establishment, weed control, and management of plant height are similar in conventional and twin line systems. Thus, the twin line system is more likely to be adopted by growers than the UNR system if consistent advantages are associated with the twin line system.

During the 2001 cotton season, the research focus at the University of Arizona shifted away from the UNR system and towards the twin line system. Three experiments were conducted to compare twin line and conventional single line production systems in terms of yield, fiber micronaire, and production costs (Husman, et al., 2002). Lint yields in the single and twin line configurations were similar but fiber micronaire was significantly lower in the twin line system in all 2001 experiments. The twin line system plantings had double the seeding rate of the single line systems but required one less cultivation due to earlier canopy closure. Since these cost were similar, there were no differences in total production costs between the single and twin line systems. In contrast, University of California researchers report that twin line costs are less than single line system costs due to lower weed control costs primarily due to rapid canopy closure and shading. The 2001 Arizona test sites had relatively low weed pressures and therefore weed control costs were the same for both systems.

The lower fiber micronaire associated with the twin line system in 2001 was encouraging since Arizona producers have suffered significant price discounts due to high fiber micronaire. If a relatively simple change in stand geometry and plant population could consistently reduce micronaire, there might be significant interest in adopting the twin line system. Yield increases or reduced costs, of course, would provide additional incentive for growers to adopt the twin line system. Thus, a statewide, multi-site, research program was conducted in 2002 and 2003 to compare the yield and fiber quality of lint produced by the twin line and single seed line per bed production systems on commercial farms and University of Arizona experiment stations.

Materials and Methods

Eighteen experiments were conducted in 2002 and seven in 2003 to compare yield, fiber micronaire, and canopy development of conventional compared to the twin line production system. In 2002, fifteen experiments were located on commercial farms, three on UA experiment stations. In 2003, five experiments were located on commercial farms, two on UA experiment stations. The experiments were located across the entire cotton production region of Arizona as well as the Palo Verde Valley near Blythe, California in an effort to comprehensively evaluate the twin line production system (Table 1).

The experiments consisted of alternating plots of single line and twin line cotton with a minimum of four blocks at each site. Plots ranged from 4 to 16 rows wide and were the length of the field; field lengths ranged from 600 to 1500 feet long across all experimental sites. Prior to planting, the beds were shaped to result in a wide, flat bed top to facilitate the twin line planting geometry. Twin line plots were planted using a Monosem twin line vacuum planter with pairs of planter units spaced 7.25 inches apart centered on the beds. In 2002, the target plant population for the twin line plots was 80,000 plants per acre. In 2003, the target plant populations were similar to those of the compared single line conventional system as a result of twin line plant population research conduced by authors in 2002 (Husman et al., 2003b). Conventional single line plots were planted using the cooperator's planter. All experiments were dry planted and irrigated to germinate the seed and obtain a stand. Row spacings evaluated were 40, 38, and 36 in depending on the cooperating grower's standard row spacing (Table 1). The cotton varieties evaluated in this report were chosen by the cooperating growers (Table 1).

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. Leaf area index was measured using a LiCor LAI2000 Canopy Analyzer.

Production inputs and cultural practices were managed by the cooperating growers based on their standard farm practices. A goal of this research effort was to implement on- farm experiments and to collect data from commercially managed fields. Plots were harvested using the cooperator's spindle pickers which were 2, 4 and 6 row machines manufactured by either Case-IH or John Deere. Harvest dates ranged from mid-September to mid-November. The seed cotton from each plot was weighed using a boll buggy equipped with weighing load cells. Subsamples of approximately 6 to 9 pounds of seed cotton were taken from each plot and ginned at the University of Arizona short staple gin at the Maricopa Agricultural Center. The percent of lint in each seed cotton sample from each plot for a single field were averaged and used for calculation of the percent lint in both the single line and twin line systems in that field. A subsample of each plot's lint was submitted to the USDA Cotton Classing Office in Phoenix, Arizona for HVI fiber quality analysis.

Results and Discussion

In the 2003 experiments, the twin line system did not produce more lint than the conventional single line system at any location. There were no yield differences between the two systems at 3 of 7 locations in 2003 and the twin line system yielded less than the single line system at 4 of 7 locations. Lint yields of the twin line and single line systems were 1906 and 2091 lb/acre, 1797 and 1938 lb/acre, 878 and 1114 lb/acre, and 1230and 1404 lb/acre, respectively, at the Marlatt 1, Marlatt 2, Marlatt 3, and UA Marana Agricultural Center sites, respectively (Table 2).

In the 2002 experiments, the twin line system's yield was greater than the conventional single line system at 4 of 18 locations; the yields of the twin line and single line systems were 1273 and 1186 lb/acre, 1572 and 1461 lb/acre, 1478 and 1290 lb/acre, and 1309 and 1210 lb/acre, respectively, at the Grasty, Ramona, Rovey, and Wells sites, respectively (Table 3). There were no significant differences in yield between the two systems in 7 of the 18 experiments. The twin line system's yield was less than the conventional system at 5 of 18 locations; yields of the twin line and single line systems were 2019 and 2189 lb/acre, 1400 and 1489 lb/acre, 1537 and 1845 lb/acre, 1065 and 1200 lb/acre, and 1271 and 1431 lb/acre, respectively, at the Chaffin (75K), Cooley, Hull, Papago, and Wakimoto sites, respectively (Table 3).

Three 2001 experiments that compared twin line and single line systems on 40 and 38 inch beds were inconsistent with respect to system yield differences. An experiment at the UA Maricopa Agricultural resulted in a significant yield increase for the twin line system compared to the single line system, 1476 and 1396 lb/acre respectively. However, experiments in 2001 at the UA Marana Agricultural Center and at a commercial farm in Glendale, Az. found no significant yield differences between systems (Husman et al., 2002).

Three years (2001 to 2003) of system comparison experiments in over 28 fields has not demonstrated a consistent yield advantage of the twin line system over the conventional single line system. In the 2002 experiments where twin line yields were less than the single line system, it was observed that a substantial amount of cotton was not harvested from the lowest mainstem fruiting branches. Similar visual observations were made in 2003 at several sites. When boll set was low on the mainstem in the twin line system, the ability of a spindle picker to efficiently harvest the bottom crop, particularly below the crossing over point of the 2 mainstems, was severely challenged. This observation was verified at the 2003 UA Maricopa Agricultural Center site by hand harvesting at 2 locations within each of the 4 replicates of both planting configurations. Hand harvested yields were 1776 and 1661 lb./acre for the twin and single line systems respectively, a 6% twin line system advantage. While limited to one location, this data confirms the visual observations and suggests that the twin line system may frequently produce more lint/acre than the single line systems but spindle harvesters are unable to harvest low boll set effectively.

In 2003 there were no differences in fiber micronaire between the twin line and single line systems (Table 2). Fiber micronaire was reduced in only five of the eighteen 2002 experiments; the micronaire values in the twin line and single line systems were 4.25 compared to 4.73, 4.46 compared to 4.78, 4.60 compared to 4.85, 4.76 compared to 4.98, and 4.93 compared to 5.15, at the Rogers, Papago, Grasty, Hull, and Perry sites, respectively (Table 3). Fiber micronaire was below the discount threshold of 5.0 in both systems at the Rogers, Papago, Grasty, and Hull sites. At 11 of the 18 experimental sites, there were no significant differences in fiber micronaire between twin line and single line systems. This contrasted markedly with the 2001 experiments where fiber micronaire was lower in the twin line system compared to the conventional single line systems in all three experiments (Husman et al., 2002).

The micronaire reductions measured in 2001 were attributed to earlier canopy closure and shading in the twin line system compared to the single line system. Similar to the 2001 experiments, percent ground cover and canopy closure (Table 4) were greater in the twin line system compared to the single line system on several dates at several sites in 2002 (Husman et al., 2003). This suggested that incident solar radiation was reduced on a per plant basis resulting in reduced carbohydrate production and allocation to bolls, particularly those at the base of the plant. Shading has been shown to increase fiber length and reduce micronaire (Eaton and Ergle, 1954). Percent ground cover (measured photographically) and leaf area index (measured with a LiCor 2000 Canopy Analyzer) were also greater in the twin line system compared to the single line system on some measurement dates in 2003 but not others at the Maricopa and Marana Agricultural Centers (Table 5). Given the variability in fiber micronaire and canopy development, it is not clear that canopy development exerts much effect on fiber micronaire compared to environmental conditions such as heat stress or interactions of environment conditions and planting configuration. For example, in 2002, commercial production of high micronaire cotton was much less prevalent than in recent previous years and there were fewer heat stress incidents. Good fruit set and uniform retention on mainstem fruiting branches resulted in strong carbohydrate demand that may have reduced the potential for high mirconaire in a manner similar to shading. In contrast, 2003 was characterized by several severe heat stress episodes but there were no differences in fiber micronaire at any of the experimental sites.

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Table 1. Arizona 2002 and 2003 twin line testing program: cooperators, planting dates, varieties, and row widths.

Region	Grower	Planting date	Variety	Row width in.
Blythe, Ca.	Grant Chaffin (57K)	3/26/02	DP5415R	40
	Grant Chaffin (75K)	3/26/02	DP5415R	40
	Grant Chaffin (90K)	3/26/02	DP5415R	40
	Bob Hull	3/21/02	DP451BR	40
	Jack Seiler	3/22/02	DP451BR	40
Western Az.	Larry Hancock	3/27/02	DP422BR	40
	Nathan Rovey	3/27/02	DP428BR	40
	Del Wakimoto	3/28/02	STBXN47	40
	Earl Marlatt 1	3/21/03	ST 5599BR	40
	Earl Marlatt 2	3/21/03	ST 5599BR	40
	Earl Marlatt 3	3/21/03	DP 449BR	40
	Roger Muphy	3/27/03	DP 436R	40
	Nathan Rovey	3/25/03	DP 449BR	40
Central Az.	Mike Cooley	4/18/02	DP33B	38
	Paul Grasty	4/10/02	ST4892BR	38
	Papago - Cecil Borboa	4/19/02	DP388	38
	Bill Perry	4/17/02	DP655BR	38
	Ramona - Karl Button	4/11/02	ST4892BR	38
	Kevin Rogers	4/12/02	DP655BR	38
	Dean Wells	4/10/02	ST4892BR	38
	Univ. of AZ Maricopa Ag. Center	4/2/02	DP451BR	40
	Univ. of AZ Maricopa Ag. Center	4/9/03	DP 449BR	40
Eastern	Steve Daley	4/23/02	SG 215BR	36
	Univ. of AZ Marana Ag. Center	4/8/02	DP 451BR	40
	Univ. of AZ Marana Ag. Center	4/10/03	DP 449BR	40

Table 2. Cotton yield from conventional and twin line planting configurations in 2003 (values are means). Means within rows followed a * are not significantly different at the P=0.05 level of significance (i.e., between conventional and twin line systems at the same location).

		Lint Yield (lb/A)		Fiber Micronaire	
Farm	Location	Conventional	Twin-Line	Conventional	Twin-Line
Marlatt 1	Wellton, AZ	2091*	1906*	4.4	4.5
Marlatt 2	Wellton, AZ	1938*	1797*	4.5	4.3
Marlatt 3	Wellton, AZ	1114*	878*	4.4	4.9
Murphy	Cibola, AZ	662	637	5.2	5.2
Rovey	Parker Valley, AZ	1077	1034	--	--
UA Maricopa Ag. Center	Maricopa, AZ	1651	1572	4.6	4.5
UA Marana Ag. Center	Marana, AZ	1404*	1230*	5.4	5.5

Table 3. Cotton yield and fiber micronaire from conventional and twin line planting configurations in 2002. Values are means; * or ** indicates a significant difference at P=0.5 or P=0.01, respectively, between single and double seed line per bed means within a row (i.e., at a location).

		Lint Yield (lb/A)		Fiber Micronaire	
Farm	Location	Conventional	Twin Line	Conventional	Twin Line
Chaffin (57K)	Blythe, Ca.	2154	2021	4.63	4.53
Chaffin (75K)	Blythe, Ca.	2189	2019**	4.80	4.73
Chaffin (90K)	Blythe, Ca.	2430	2274	4.65	4.73
Cooley	Maricopa, Az.	1489	1400**	4.65	4.68
Daley	Safford, Az.	940	812	4.6	4.75
Grasty	Casa Grande, Az.	1186	1273*	4.85	4.60*
Hancock	Parker Valley, Az.	1530	1509	4.85	4.78
Hull	Blythe, Ca.	1845	1537**	4.98	4.76*
UA Maricopa Ag. Center	Maricopa, Az.	1411	1499	4.98	4.85
UA Marana Ag. Center	Marana, Az.	1185	1166	4.98	5.0
Papago	Eloy, Az.	1200	1065**	4.78	4.46*
Perry	Gila Bend, Az.	1114	1168	5.15	4.93*
Ramona	Sacaton, Az.	1461	1572*	5.38	5.38
Rogers	Scottsdale, Az.	912	919	4.73	4.25*
Rovey	Parker Valley, Az.	1290	1478*	4.90	5.23
Seiler	Blyth, Ca.	1701	1668	4.68	4.45
Wakimoto	Ft. Mohave, Az.	1431	1271**	5.10	4.95
Wells	Casa Grande, Az.	1210	1309**	5.08	4.6

Table 4. Percent cotton ground cover and canopy closure of conventional and twin line per bed cotton planting configurations at the Maricopa and Marana Agricultural Centers of the University of Arizona in 2002. Values are means; * or ** indicates a significant difference at P=0.5 or P=0.01, respectively, between single and double seed line per bed means within a row (i.e., for a particular days after planting [DAP] at a location).

			Ground Cover (%)		Canopy Closure (%)	
Farm	Row Spacing (in)	DAP	Conventional	Twin Line	Conventional	Twin Line
Maricopa	40	63	19.6	24.1**	30.9	46.2**
		76	30.6	38.3**	42.8	58.5**
		83	38.8	46.3*	52.1	64.1**
		91	51.6	61.9**	63.6	73.7**
Marana	40	51	6.2	12.9**	15.3	31.4**
		77	38.9	49.1**	55.2	68.5**
		91	60.4	63.8	73.6	79.6**

Table 5. Percent cotton ground cover and canopy closure of conventional and twin line per bed cotton planting configurations at the Maricopa and Marana Agricultural Centers of the University of Arizona in 2003. Values are means; * or ** indicates a significant difference at P=0.5 or P=0.01, respectively, between single and double seed line per bed means within a row (i.e., for a particular days after planting [DAP] at a location).

			Ground Cover (%)		Leaf Area Index	
Farm	**Row Spacing (in)**	**DAP**	**Conventional**	**Twin Line**	**Conventional**	**Twin Line**
Maricopa	40	51	8.1	9.0	-	-
		62	27.2	32.8	-	-
		71	36.4	42.8**	-	-
		99	-	-	4.92	6.12**
		113	-	-	5.95	7.13**
Marana	40	48	4.7	4.64	-	-
		63	21.8	24.0*	-	-
		74	48.0	55.1**	-	-
		92	-	-	3.43	3.90*
		119	-	-	5.20	5.04