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# AGRONOMY AND SOILS

## Comparison of Growth and Yield Components of Conventional and Ultra-narrow Row Cotton

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### ABTRACT

**The introduction of transgenic cotton (*Gossypium hirsutum* L.) cultivars with resistance to certain herbicides has increased the interest in ultra-narrow-row production systems. A field study was conducted on Sharkey silty clay soil (very-fine, smectitic, thermic Chromic Epiaquerts) from 1995 through 1997 to evaluate the effects of ultra-narrow-row (UNR) and conventional wide-row (CONV) production systems on plant growth and yield components. Cotton grown in 19-cm rows with 530 000 seed ha$^{-1}$ and harvested with a stripper was compared with cotton grown in 97-cm rows with 155 000 seed ha$^{-1}$ and harvested with a spindle picker. Percentage of first position boll retention was higher in CONV than UNR in two of three years and averaged 30% in CONV and 27% in UNR across the three years. An average of 8.5% of the second position bolls were retained with UNR compared with 15% in CONV. The UNR plants were shorter, had fewer nodes, and had fewer total sympodia than the CONV plants. The UNR plants had fewer bolls than CONV plants, with a higher percentage of the total boll number in the first sympodial position and a lower percentage in the second position. Higher seed cotton yield of UNR cotton in 1995 and 1997 appeared to result from the higher plant populations, although the findings indicated that seeding rates lower than the one used in this study could have been used for UNR. Plant populations were also higher for UNR in 1996, but the low rainfall during fruiting appeared to impact the UNR more than CONV, possibly due to the high plant density.**

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Cotton (*Gossypium hirsutum* L.) in the United States is usually grown with a row spacing of 76 cm or more. In the past, weed control was often cited as an obstacle to narrow-row cotton production. For years, problems with weed control seriously limited adoption of any row spacing too narrow to plow; however, new herbicides and transgenic cultivars with herbicide resistance have increased interest in production systems commonly referred to as ultra-narrow row (UNR), even though questions concerning harvest methods and fiber quality remain. While there is no standard definition, the term “ultra-narrow row” cotton has generally referred to cotton grown on a row spacing of 38 cm or less without post-plant cultivation and harvested with a stripper.

Planting was another factor limiting adoption of narrow-row cotton. Some systems tried to take advantage of narrow rows and still receive the benefits of soil beds. Parish et al. (1973) evaluated multiple rows (33 to 81 cm) planted on a 2.4-m-wide raised bed. Another method employed two 18-cm rows centered on standard beds (Waddle and Pennington, 1974). Narrow rows are often planted on unbedded soil, which miss the drainage and soil-warming benefits of raised beds. Allen et al. (1998) reported that UNR showed promise as a way to produce cotton with reduced inputs on marginal soils, but one of the major challenges was achieving an adequate stand without beds. Burmester (1996) indicated that the best fit for UNR in the Southeast was on heavier textured soils, where the drainage benefits of beds would be needed.

Another major limiting factor to UNR production has been harvesting. Perkins and Atwell (1996) pointed out problems with harvesting UNR cotton and presented some available options. Perkins (1998) indicated that a better harvest system was the hurdle to widespread adoption of UNR cotton. New picker technology allows spindle picking of cotton produced on 38-cm rows, which could relieve the marketing concerns for UNR cotton in the mid-South.

In recent years, studies investigating a UNR cotton production system have been conducted in almost every cotton-producing state. UNR cotton systems produced substantially higher yields (15% to 113%) in the central Texas Blacklands (Gerik et al., 1999). Gwathmey et al. (1999) reported an additional 325 kg/ha of lint with UNR cotton in Tennessee, even though the lint turnout was lower. Without mepiquat chloride applications, yields decreased for cotton in 25-cm and 38-cm rows (Atwell, 1996). Vories et al. (2001) reported that lower turnout offset part of the higher seedcotton yields observed with UNR cotton in Arkansas, so that three-year-average lint yields were not significantly different between UNR and wide-row systems. Boquet (2005) reported different responses to irrigated and rain-fed UNR cotton in Louisiana, but consistently higher yields for wide-row cotton. Yields were usually equal or higher for UNR cotton in Mississippi (Nichols et al., 2004). In Texas, yields were higher for narrower row spacings in a dryer year (1998), but yields were not different among row spacings in a wetter year (1999); however, the soil type was different each year (Jost and Cothren, 2001).

In an effort to explain the different yield responses among various studies, many researchers looked at growth characteristics, boll sizes and numbers, and yield distribution on the plant. Guinn et al. (1981) showed how boll retention was affected by water stress, and Krieg (1996) suggested that UNR cotton could reduce bare-soil evaporation and thereby increase yield without additional water. Heitholt (1995) reported that the total number of flowers produced, rather than boll retention, explained the yield increase in narrow-row production. Bednarz et al. (1999) reported more fruit per acre, but boll weight was 0.5 g lower for UNR cotton in Georgia. Plant height, number of sympodia, total nodes, and total bolls per plant were usually reduced for UNR cotton in Mississippi (Nichols et al., 2004). In Texas, plant heights and total mainstem nodes were lower for narrower row spacings in a dry year (1998) but were not different among row spacings in a wetter year (1999), although the soil type was different between the two years (Jost and Cothren, 2001). In an irrigated study, final plant height and total nodes were lowest for a 19-cm row spacing in both years of the study (Jost and Cothren, 2000). Atwell (1996) observed little effect of row spacing on either plant height or number of mainstem nodes.

In cotton not treated with mepiquat chloride, Atwell (1996) reported finding 87% first-position fruit for 25-cm rows and 61% for 102-cm rows. Jost and Cothren (2000) reported similar boll retention for 19-cm rows (85%), but lower boll retention for 102-cm rows (42%). Bednarz and Nichols (2005) reported that even though the vertical flowering interval is not always half the horizontal interval as commonly assumed, flowering does progress up the plant faster than it progresses out from the mainstem. Having more of the bolls in the first sympodial position should favor an earlier crop for UNR cotton.

As cotton producers pursue ways to cut production costs and increase yields, UNR cotton may be a possible alternative production system. The development of herbicide-resistant cultivars has solved many of the weed-control problems, but also led to higher seed costs and technology fees that actually increase planting costs of UNR cotton compared with CONV cotton. Harvest problems still exist, but new picker technology may reduce those problems. The objective of this research was to compare cotton production in a UNR system and in a conventional system. Yield and detailed fiber quality results from the study have previously been reported (Vories et al., 2001). Comparisons of plant structure, fruiting patterns, and yield components between the systems are presented in this report to improve the understanding of the UNR production system and how it contrasts with conventional production.

## MATERIALS AND METHODS

A three-year field study of UNR cotton production was conducted at the University of Arkansas Northeast Research and Extension Center (NEREC) at Keiser during the 1995 through 1997 growing seasons. The study compared cotton produced in 19-cm rows and harvested with a stripper (UNR) with cotton produced in 97-cm rows and harvested with a spindle picker (CONV). The soil in the study area was Sharkey silty clay soil (very-fine, smectitic, thermic Chromic Epiaquerts) that was fallowed in 1994.

The UNR plots were seeded with a Great Plains (Great Plains Manufacturing; Salina, KS) no-till grain drill in 1995 and John Deere (Deere & Company; Moline, IL) 750 grain drill in 1996 and 1997. Both grain drills had 19-cm drill spacing and were set for approximately 10 seeds $m^{-1}$ (520 000 seeds $ha^{-1}$). The CONV plots were seeded with a John Deere 7100 planter at approximately 15 seeds $m^{-1}$ (155 000 seeds $ha^{-1}$), a common rate for the Sharkey soil in NE Arkansas. The cotton was not irrigated.

In 1995, the cultivar SG 404 (Sure-Grow Cotton Seed Co.; Maricopa, AZ) was seeded 17 May. Aldicarb (Temik 15G; Bayer CropScience; Research Triangle Park, NC) was applied in-furrow at 3.9 kg a.i. ha$^{-1}$. A grass-seeder attachment to the grain drill was used to apply the aldicarb to the UNR plots at the same rate per hectare as the conventional plots, resulting in a linear rate approximately one-fifth that of the CONV plots. To insure against excessive vegetative growth, two applications of 0.025 kg a.i. ha$^{-1}$ mepiquat chloride (Pix; BASF Corp.; Research Triangle Park, NC) were applied to the UNR plots and one application was made to CONV plots. Harvest aids were applied on 7 October and consisted of a tank mix of 0.84 kg a.i. ha$^{-1}$ tribufos (Def; Bayer CropScience; Research Triangle Park, NC), 0.06 kg a.i. ha$^{-1}$ thidiazuron (Dropp; Bayer CropScience) and 2.24 kg a.i. ha$^{-1}$ ethephon (Prep; Bayer CropScience) and on 21 October with paraquat at 0.42 kg a.i. ha$^{-1}$ (Starfire; Syngenta Corporation; Greensboro, NC). Cotton was harvested 25 October.

In 1996, the cultivar SG 125 (Sure-Grow Cotton Seed Co.) was seeded 21 May. Because of dissatisfaction with the aldicarb application method in 1995, seed treated with imidacloprid (Gaucho; Bayer CropScience) was used in place of an in-furrow treatment. No mepiquat chloride was applied. Harvest aids were applied 9 October [tank mix of 0.84 kg a.i. ha$^{-1}$ tribufos (Def) and 2.24 kg a.i. ha$^{-1}$ ethephon (Prep)] and 20 October [0.70 kg a.i. ha$^{-1}$ paraquat (Starfire), mistakenly at a rate greater than intended]. Frequent rains after the desiccant application delayed harvest until 19 December, when the soil was frozen solid enough to support the harvest equipment.

In 1997, the cultivar SG 125 (Sure-Grow Cotton Seed Co.) was seeded 6 May. Seed treated with imidacloprid was again used in place of an in-furrow insecticide treatment. No mepiquat chloride was applied. Harvest aids were applied 4 October [tank mix of 0.84 kg a.i. ha$^{-1}$ tribufos (Def) and 2.24 kg a.i. ha$^{-1}$ ethephon (Prep)] and 15 October [0.42 kg a.i. ha$^{-1}$ paraquat (Starfire)]. Plots were harvested 20 October.

A total of 140 kg ha$^{-1}$ N was applied, split between early season (84 kg ha$^{-1}$ N) and first flower (56 kg ha$^{-1}$ N) aerial applications of ammonium nitrate. Soil tests indicated that no other fertilizers were required. University of Arkansas Cooperative Extension Service recommendations for 97-cm row spacing were followed for weed and insect control (Bonner, 1995). Because there were no recommendations for UNR cotton, standard recommendations were adapted where appropriate. In most cases, the whole field (i.e., both production systems) was treated with the same herbicide or insecticide; however, the CONV plots were cultivated and post-directed herbicides were applied as needed.

The number of plants per 3 m of row were made at 10 locations per plot in June or early July each year. Just prior to harvest, boll samples were collected from each plot to determine an average boll weight. In 1995 and 1996, every boll in 3 m of row was hand picked. In 1997, a total of 100 bolls were collected, rather than a specific length of row. Plant populations were calculated from the stand counts made early in the season. At high plant populations with any row spacing, plants tend emerge that never develop to any significant size and do not contribute to yield; therefore, a "fruiting plant population" was estimated by dividing the seed cotton yield by the product of total bolls per plant and average boll weight.

At harvest, 20 plants per plot (10 plants per plot in 1996) were collected and mapped to determine plant structure and yield components using the COTMAP procedure (Bourland and Watson, 1990). All plots were approximately 0.5 ha, with all of the plot area harvested and no border area between plots. Once-over harvest was employed for both systems. The CONV plots were harvested with a John Deere 9930 (Deere & Co.), two-row cotton picker. The UNR plots were harvested with an Allis Chalmers 880 stripper (AGCO Corporation; Duluth, GA) with a platform header and on-board cleaning. Seed cotton weights were determined for each plot with wheel scales in 1995 and with an instrumented boll buggy in 1996 and 1997.

The experimental design was as a randomized complete block with three replications. Treatments were randomized before the study began; however, because minimum tillage production systems were employed, the same plots were used each year. Since there was not a new randomization each year, the resulting data were analyzed as a split plot in time, with years as a fixed effect. The data were analyzed using SAS (SAS for Windows version 9.1, SAS Institute Inc.; Cary, NC), and Fisher's least significant difference (LSD) was used to compare treatment means whenever significant ($P \leq 0.05$) treatment effects were observed. In cases of a significant production system by year interaction, separate analyses were conducted for each year of the study. Finally, each of the growth and yield component variables was correlated to seed cotton yield using the CORR procedure of SAS. Separate correlations were conducted for the two systems, to identify whether any of the factors affected yield differently in the two systems.

## RESULTS AND DISCUSSION

Air temperatures at NEREC did not vary greatly among the three years of the study or from the average of the 30 yr from 1963 through 1992, as indicated by the growing degree-days based on 15.6 °C (Table 1). The largest monthly difference from the 30-year average was an additional 68 growing degree days in August 1995. The six-month total growing degree-days for the growing seasons ranged from 1354 in 1997 to 1429 in 1996, which in not very different from the 30-year average of 1394. More variability was observed for rainfall than for temperature (Table 1). The largest monthly rainfall departure from the 30-year average was an increase of 151 mm in July 1995. Six-month totals ranged from 595 mm (1997) to 688 mm (1996), which is not very different from the 30-year average of 570 mm.

The fairly late planting into warm soils followed by rain the first two seasons led to excellent seedling emergence and high plant populations (Table 2). Less favorable conditions in 1997 led to lower populations in both CONV and UNR plots. The bedded soil was expected to favor seedling emergence in the wide rows, but both systems had reduced populations.

The UNR plants were consistently shorter than CONV plants, an average of 17 cm less, which is an advantage for stripper harvesting. Wanjura and Brashears (1983) reported the percentage of sticks

**Table 1. Monthly growing degree-days, based on 15.6 °C, and rainfall from weather data collected at NEREC, Keiser, Arkansas**

| Month | Growing degree-days | | | |
|---|---|---|---|---|
| | 1995 | 1996 | 1997 | 30-year mean[z] |
| May | 175 | 222 | 125 | 167 |
| June | 276 | 299 | 254 | 295 |
| July | 338 | 352 | 384 | 355 |
| August | 380 | 319 | 307 | 312 |
| September | 167 | 181 | 195 | 196 |
| October | 61 | 55 | 89 | 70 |
| Six-month total | 1397 | 1429 | 1354 | 1394 |
| | Rainfall (mm) | | | |
| May | 114 | 109 | 108 | 138 |
| June | 75 | 176 | 118 | 91 |
| July | 239 | 118 | 73 | 88 |
| August | 74 | 36 | 103 | 76 |
| September | 33 | 153 | 99 | 101 |
| October | 95 | 95 | 94 | 76 |
| Six-month total | 630 | 688 | 595 | 570 |

[z] Mean values from 1963 through 1992.

**Table 2. Plant population and plant structure for ultra-narrow row row and conventional cotton production**

| Production system[z] | 1995 | 1996 | 1997 | 3-year mean[y] |
|---|---|---|---|---|
| | Plant population (plants/ha)[w,x] | | | |
| CONV | 102,000 i | 121,000 i | 68,000 i | 97,000 b |
| UNR | 370,000 h | 369,000 h | 202,000 h | 314,000 a |
| | Plant height (cm)[x] | | | |
| CONV | 73.9 | 62.4 | 62.0 | 66.1 a |
| UNR | 54.4 | 50.8 | 40.4 | 48.5 b |
| | Total nodes per plant | | | |
| CONV | 19.6 | 18.7 | 22.0 | 20.1 a |
| UNR | 17.5 | 15.5 | 17.2 | 16.7 b |
| | Average internode length (cm) | | | |
| CONV | 3.8 | 3.3 | 2.8 | 3.3 a |
| UNR | 3.1 | 3.3 | 2.4 | 2.9 b |
| | Monopodia per plant | | | |
| CONV | 1.9 | 1.1 | 0.4 | 1.2 a |
| UNR | 2.6 | 0.4 | 0.0 | 1.0 a |
| | First fruiting node | | | |
| CONV | 7.9 | 7.3 | 6.8 | 7.3 a |
| UNR | 8.8 | 6.9 | 7.4 | 7.7 a |
| | Total sympodia per plant[w] | | | |
| CONV | 12.7 h | 12.5 h | 16.2 h | 13.8 a |
| UNR | 9.7 i | 9.6 i | 10.8 i | 10.1 b |
| | Effective sympodia[v] | | | |
| CONV | 7.7 | 3.9 | 7.6 | 6.4 a |
| UNR | 4.8 | 1.8 | 5.5 | 4.1 b |

[z] Production system: CONV = cotton produced in 97-cm rows and harvested with a spindle picker; UNR = cotton produced in 19-cm rows and harvested with a stripper.

[y] Means for each variable followed by the same letter are not significantly different ($P = 0.05$).

[x] Data from Vories et al., 2001.

[w] The year by system interaction was significant. Means within a column followed by the same letter are not significantly different ($P = 0.05$).

[v] Uppermost sympodia on the plant that contained fruit as described by Bourland and Watson, 1990.

in stripped cotton increased with plant size. Total number of nodes was significantly different each year. The UNR plants averaged 3.4 fewer nodes than CONV; however, even with the reduction in numbers of nodes, the average internode length averaged 4 mm less for UNR. In 1998, which was a dry year, Jost and Cothren (2001) observed differences in height (18 cm) and nodes (5) between a 102-cm row spacing with a conventional plant density and a 19-cm row spacing with a high plant density. In 1999, which was a wetter year, height or nodes were not different between row spacings. Plant heights were greatest in this study in 1995, the only year with mepiquat chloride applications. The reduction in plant height and number of total nodes was consistent with the findings of Nichols et al. (2004) and Jost and Cothren (2000).

Monopodia per plant were few, and there was little to no effect of the row spacing on number of monopodia per plant (Table 2). Few monopodia are typically observed for cotton grown on this soil, even with conventional row spacings. There was no significant effect of row spacing on location of the first fruiting node.

The primary difference in plant structure between the systems was in total sympodia. The UNR plants consistently averaged 3.7 fewer sympodia per plant than CONV plants (Table 2), which is consistent with the observations of Nichols et al. (2004). More sympodia were observed in 1997, which is consistent with the highest number of total nodes, but not all sympodia produced fruit. The effective sympodia, or the sympodia that contained fruit (Bourland and Watson, 1990), averaged 2.3 fewer in UNR than CONV. Fewer effective sympodia were observed in 1996, even though the total sympodia were the same in 1995 and 1996.

The average boll weight was not significantly different between systems in this study (Table 3). This is different from the findings of Bednarz et al. (1999), who reported smaller bolls for UNR cotton in Georgia. Larger bolls were observed in 1997, the year with the lowest plant populations, than in 1995 and 1996 (Table 2). The total bolls per plant, however, averaged 3.1 fewer for UNR. Jost and Cothren (2000) observed an even greater difference, with 6.6 fewer bolls in 19-cm rows than in 102-cm rows. The boll number per plant varied by year, with the fewest observed in 1996, the year with the lowest seed cotton yield (Table 3).

**Table 3. Boll weight and distribution and seed cotton yield from ultra-narrow row and conventional cotton production**

| Production system[z] | 1995 | 1996 | 1997 | 3-year mean [y] |
|---|---|---|---|---|
| | Average boll weight (g seedcotton/boll) | | | |
| CONV | 3.8 | 3.7 | 4.3 | 3.9 a |
| UNR | 3.4 | 3.6 | 4.0 | 3.7 a |
| | Total bolls per plant | | | |
| CONV | 6.6 | 3.4 | 8.9 | 6.3 a |
| UNR | 3.1 | 1.5 | 5.0 | 3.2 b |
| | Seed cotton yield (kg/ha) [w,x] | | | |
| CONV | 2690 i | 1610 h | 2350 i | 2220 b |
| UNR | 3100 h | 1240 i | 3130 h | 2490 a |
| | Fruiting plant population (plants/ha) [v] | | | |
| CONV | 111,000 | 134,000 | 62,000 | 102,000 b |
| UNR | 292,000 | 238,000 | 156,000 | 228,000 a |
| | Bolls in first sympodial position (%) | | | |
| CONV | 70.8 | 73.5 | 65.4 | 69.9 b |
| UNR | 88.3 | 89.0 | 84.7 | 87.3 a |
| | Bolls in second sympodial position (%) [w] | | | |
| CONV | 20.7 h | 10.2 h | 24.8 h | 18.6 a |
| UNR | 10.8 i | 2.1 i | 14.7 i | 9.2 b |
| | Bolls beyond second sympodial position (%) | | | |
| CONV | 8.1 | 2.1 | 5.8 | 5.4 a |
| UNR | 1.0 | 0.0 | 0.3 | 0.4 a |
| | Bolls on monopodia (%) | | | |
| CONV | 0.4 | 14.2 | 4.0 | 6.2 a |
| UNR | 0.0 | 9.0 | 0.3 | 3.1 a |

[z] Production system: CONV = cotton produced in 97-cm rows and harvested with a spindle picker; UNR = cotton produced in 19-cm rows and harvested with a stripper.

[y] Means for each variable followed by the same letter are not significantly different ($P = 0.05$).

[x] Data from Vories et al., 2001

[w] The year by system interaction was significant. Means within a column followed by the same letter are not significantly different ($P = 0.05$).

[v] Estimated from seed cotton yield, total bolls per plant, and average boll weight.

Fruiting plant populations for CONV were similar to the total population, even numerically higher in two of the years due to round off errors and cumulative errors in the measurements used to calculate fruiting plant population. Large differences between fruiting and total plant populations were observed for UNR, indicating that many of the plants counted early in the season were not included when samples were collected for COTMAP analysis. In fact, the estimated population at the end of season averaged 26% fewer plants than the early-season population for UNR (228 000 versus 314 000 plants ha$^{-1}$). With included seed costs and technology fees, the cost of excessive seeding rates that foster "cotton weeds", plants that don't develop fully and contribute to yield, is high. Fruiting plant population was lower in 1997 than in the other two years, similar to the total plant population (Table 2). The large differences between plant population (Table 2) and fruiting plant population (Table 3) indicate that lower seeding rates could be used for UNR than the rates used in this study. The fact that Jost and Cothren (2001) and Boquet (2005) did not observe significant yield differences among three plant densities in UNR in any year of their studies supports that observation.

Most of the bolls in both systems were located on the first sympodial position. UNR plants averaged 87% and CONV 70% of the total bolls at first position (Table 3). Atwell (1996) reported similar findings in cotton not treated with mepiquat chloride, with 87% first-position fruit for 25-cm rows and 61% for 102-cm rows. Jost and Cothren (2000) reported a similar value for 19-cm rows (85%), but a lower value for 102-cm rows (42%). Since the vertical flowering rate is shorter than the horizontal flowering rate (Bednarz and Nichols, 2005), more bolls in the first sympodial position should have resulted in an earlier crop for the UNR cotton. Since harvest aids were applied to all plots at the same time, it was not possible to take advantage of any maturity differences.

In contrast with results for first-position bolls, UNR cotton averaged fewer bolls than CONV on the second sympodial position (Table 3). Atwell (1996) reported similar findings of 14% fewer second position bolls for 25-cm rows than 102-cm rows. Although a significant year by system interaction was observed for the second position, UNR had a consistently lower percentage of bolls in the second position each year. In 1996, the year with the lowest yields (Table 3), there was a significantly lower percentage of bolls in the second position than for the other two years. No significant differences were observed between systems or among years for bolls located beyond the second sympodial position or on monopodia. Those locations typically make up a small portion of the bolls for cotton plants on the Sharkey silty clay soils at NEREC.

The percentage boll retention on the first sympodial position varied by year, with retention significantly higher for CONV in 1995 and for UNR in 1997 (Table 4). The difference was not significant in 1996. Retention in the second position was consistently higher for CONV, with an average difference of 6% more second position bolls retained. The lowest retention was observed for both positions in 1996, the year with the lowest yields (Table 3).

**Table 4. Boll retention findings from ultra-narrow row and conventional cotton production**

| Production system[z] | 1995 | 1996 | 1997 | 3-year mean [y] |
|---|---|---|---|---|
| | First sympodial position boll retention (%) [x] | | | |
| CONV | 35.7 h | 19.7 h | 35.8 i | 30.4 a |
| UNR | 28.1 i | 13.6 h | 39.9 h | 27.2 a |
| | Second sympodial position boll retention (%) | | | |
| CONV | 15.0 | 4.9 | 23.8 | 14.6 a |
| UNR | 5.0 | 1.2 | 19.2 | 8.5 b |

[z] Production systems: CONV = cotton produced in 97-cm rows and harvested with a spindle picker; UNR = cotton produced in 19-cm rows and harvested with a stripper.

[y] Means for each variable followed by the same letter are not significantly different (*P* = 0.05). Means in the same row followed by the same letter are not significantly different according to Fisher's least significant difference (*P* = 0.05).

[x] The year by system interaction was significant. System means within a column followed by the same letter are not significantly different (*P* = 0.05).

The number of effective sympodia, total bolls per plant, and boll retention in the first sympodial position were all significantly correlated to seed cotton yield for both production systems (Table 5). The total number of nodes per plant and the percentage of bolls in the second sympodial position were significantly correlated to yield for UNR; but they were not significant for CONV. The positive correlation for percentage of bolls in the second sympodial position is probably reflective of the low yield in 1996; a high percentage of the total boll load in the second position would not normally be associated with high yield. Similarly, the average internode length and percentage of bolls located on monopodia were inversely correlated to yield for UNR, but not significantly correlated for CONV. The inverse correlation for percentage of bolls located on monopodia was expected, since monopodial bolls are generally later and rarely make up much of the total yield.

**Table 5. Correlations between seedcotton yield and plant structure and yield component factors from ultra-narrow and conventional cotton**

| Factor | CONV [z] | | UNR [z] | |
|---|---|---|---|---|
| | Pearson r | *P* [y] | Pearson r | *P* |
| Seed cotton yield | 1.0 | 0.0 | 1.0 | 0.0 |
| Plant population | -0.508 | 0.163 | -0.473 | 0.198 |
| Plant height | 0.603 | 0.086 | -0.239 | 0.536 |
| Total nodes per plant | 0.502 | 0.168 | 0.881 | 0.002 |
| Average internode length | 0.249 | 0.518 | -0.593 | 0.029 |
| Monopodia per plant | 0.395 | 0.293 | 0.346 | 0.362 |
| First fruiting node | 0.303 | 0.429 | 0.642 | 0.060 |
| Sympodia per plant | 0.310 | 0.417 | 0.446 | 0.229 |
| Effective sympodia | 0.914 | 0.001 | 0.972 | 0.000 |
| Average boll weight | 0.405 | 0.279 | 0.194 | 0.618 |
| Total bolls per plant | 0.726 | 0.027 | 0.847 | 0.004 |
| Fruiting plant population | -0.510 | 0.161 | -0.116 | 0.766 |
| Bolls in first position (%) | -0.346 | 0.361 | -0.318 | 0.404 |
| Bolls in second position (%) | 0.664 | 0.051 | 0.853 | 0.004 |
| Bolls beyond second position (%) | 0.572 | 0.108 | 0.453 | 0.221 |
| Bolls on monopodia (%) | -0.542 | 0.132 | -0.927 | 0.000 |
| First sympodial position boll retention | 0.894 | 0.001 | 0.887 | 0.001 |
| Second sympodial position boll retention | 0.637 | 0.065 | 0.655 | 0.056 |

[z] Production systems: CONV = cotton produced in 97-cm rows and harvested with a spindle picker; UNR = cotton produced in 19-cm rows and harvested with a stripper.

[y] *P* = probability > |r| under H0: Rho=0; 7 df.

The low yields in 1996 were the result of a combination of factors. The planting date (21 May) was latest of the three years; however, the date was not late enough to explain the low yields. Although some of the cotton was lost between harvest aid application (9 October) and harvest (19 December), the primary cause was probably insufficient rainfall. The driest August of the three years was recorded in 1996, with only 36 mm of rainfall (Table 1). The total rainfall from 31 July through 15 September was 45 mm, an average of less than 1 mm per day. The low number of effective sympodia (Table 2) suggests that drought stress affected the crop before much fruit was set. Similarly, the higher percentage of monopodial bolls (Table 3), even though not significant, would support the idea that fruiting was interrupted, since they are generally later bolls. The yield was impacted more severely for UNR than CONV, perhaps because the high plant population used the available soil moisture more quickly.

## CONCLUSIONS

Several differences were observed between the plants in the two production systems. The UNR system with its high plant density had consistently smaller plants that averaged 17 cm shorter in height with 3.4 fewer nodes and 3.7 fewer total sympodia than the plants in the CONV system. For plants that must be harvested with a stripper, like the 19-cm row spacings in this study, the smaller plants should be beneficial. In addition to fewer total sympodia, the UNR plants also averaged 2.3 fewer effective sympodia and 3.1 fewer bolls, although boll weight wasn't significantly different between systems. With the higher plant population, however, UNR produced higher yields in two of the three years. The UNR plants had 17% more bolls than CONV plants in the first sympodial position and 9% fewer in the second position, which indicates an earlier maturing crop in UNR.

About 25% of the UNR plants that emerged were not counted at the end of the season when whole-plant samples were collected, indicating that seeding rates for the UNR treatment could have been reduced without causing yield loss. Seeding rate should be an important consideration with high seed costs and technology fees. Boll retention was low in all cases, and an average of fewer than 10% of the second position bolls were retained in UNR cotton. The number of effective sympodia, total bolls per plant, and boll retention in the first sympodial position were all significantly correlated to seed cotton yield for both production systems. The total number of nodes per plant and percentage of bolls in the second sympodial position were positively correlated with yield for UNR, but not significantly correlated for CONV. The average internode length and percentage of bolls located on monopodia were inversely correlated with yield for UNR, but not significantly correlated for CONV.

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## DISCLAIMER

Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture or the University of Arkansas.

## REFERENCES

Allen, C.T., C. Kennedy, B. Robertson, M. Kharboutli, K. Bryant, C. Capps, and L. Earnest. 1998. Potential of ultra-narrow row cotton in Southeast Arkansas. p. 1403-1406. *In* Proc. Beltwide Cotton Conf., San Diego, CA. 5-9 Jan. 1998. Natl. Cotton Counc. Am., Memphis, TN.

Atwell, S.D. 1996. Influence of ultra narrow row on cotton growth and development. p. 1187-1188. *In* Proc. Beltwide Cotton Conf., Nashville, TN. 9-12 Jan. 1996. Natl. Cotton Counc. Am., Memphis, TN.

Bednarz, C.W., and R.L. Nichols. 2005. Phenological and morphological components of cotton crop maturity. Crop Sci. 45:1497-1503.

Bednarz, C.W., S.M. Brown, and M.J. Bader. 1999. Ultra narrow row cotton research in Georgia. p. 580. *In* Proc. Beltwide Cotton Conf., Orlando, FL. 3-7 Jan. 1999. Natl. Cotton Counc. Am., Memphis, TN.

Bonner, C.M. 1995. 1995 cotton production recommendations. Publ. AG422-4-95. Univ. Arkansas Coop. Ext. Serv., Little Rock, AR.

Boquet, D.J. 2005. Cotton in ultra-narrow row spacing: plant density and nitrogen fertilizer rates. Agron. J. 97(1):279-287.

Bourland, F.M., and C.E. Watson. 1990. COTMAP, a technique for evaluating structure and yield of cotton. Crop Sci. 30(1):224-226.

Burmester, C.H. 1996. Status of ultra-narrow row research in the Southeast. p. 67-68. *In* Proc. Beltwide Cotton Conf., Nashville, TN. 9-12 Jan. 1996. Natl. Cotton Counc. Am., Memphis, TN.

Gerik, T.J., R.G. Lemon, and E.M. Steglich. 1999. Ultra-narrow row cotton performance under drought conditions. p. 581. *In* Proc. Beltwide Cotton Conf., Orlando, FL. 3-7 Jan. 1999. Natl. Cotton Counc. Am., Memphis, TN.

Guinn, G., J.R. Mauney, and K.E. Fry. 1981. Irrigation scheduling and plant population effects on growth, bloom rates, boll abscission, and yield of cotton. Agron. J. 73:529-534.

Gwathmey, C.O., C.E. Michaud, R.D. Cossar, and S.H. Crowe. 1999. Development and cutout curves for ultra-narrow and wide-row cotton in Tennessee. p. 630-632. *In* Proc. Beltwide Cotton Conf., Orlando, FL. 3-7 Jan. 1999. Natl. Cotton Counc. Am., Memphis, TN.

Heitholt, J.J. 1995. Cotton flowering and boll retention in different planting configurations and leaf shapes. Agron. J. 85:590-594.

Jost, P.H., and J.T. Cothren. 2001. Phenotypic alterations and crop maturity differences in ultra-narrow row and conventionally spaced cotton. Crop Sci. 41:1150-1159.

Jost, P.H., and J.T. Cothren. 2000. Growth and yield comparisons of cotton planted in conventional and ultra-narrow row spacings. Crop Sci. 40:430-435.

Krieg, D.R. 1996. Physiological aspects of ultra-narrow row cotton production. p. 66. *In* Proc. Beltwide Cotton Conf., Nashville, TN. 9-12 Jan. 1996. Natl. Cotton Counc. Am., Memphis, TN.

Nichols, S.P., C.E. Snipes, and M.A. Jones. 2004. Cotton growth, lint yield, and fiber quality as affected by row spacing and cultivar. J. Cotton Sci. 8(1):1-12 [Online]. Available at http://www.cotton.org/journal/2004-08/1/1.cfm

Parish, R. L., S. M. Brister, and D. E. Mermoud. 1973. Wide-bed, narrow-row cotton: preliminary research results. Ark. Farm Res. 22(2):4.

Perkins, W.R. 1998. Three-year overview of UNRC vs. conventional cotton. p. 91. *In* Proc. Beltwide Cotton Conf., Nashville, TN. 9-12 Jan. 1996. Natl. Cotton Counc. Am., Memphis, TN.

Perkins, W.R., and S.D. Atwell. 1996. Ultra-narrow row harvesting approaches. p. 69-70. *In* Proc. Beltwide Cotton Conf., Nashville, TN. 9-12 Jan. 1996. Natl. Cotton Counc. Am., Memphis, TN.

Vories, E.D., T.D. Valco, K.J. Bryant, and R.E. Glover. 2001. Three-year comparison of conventional and ultra narrow row cotton production systems. Appl. Engr. Agric. 17(5):583-589.

Waddle, B. A., and J. Pennington. 1974. Results of twin-drill planting comparisons in cotton, 1973. Ser. No. 222. Ark. Agric. Exp. Stn. Mimeo, Fayetteville, AR.

Wanjura, D.F., and A.D. Brashears. 1983. Factors influencing cotton stripper performance. Trans. ASAE 26(1): 54-58.