INFLUENCE OF ROW SPACING AND NITROGEN RATE ON EARLINESS COMPONENTS AND YIELD OF COTTON

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Abstract

Data was taken on yield and several indicators of earliness in cotton at 7.5, 15, and 30" row spacings fertilized with 0, 45, 90, and 135 lb N/A. In 2000, averaged across 90 and 135 lb N/A, the 7.5" spacing was estimated to be 3.2 days earlier to 60% seedcotton harvest than the 30" spacing. In 2001, rain interfered with data collection and days to 60% seedcotton harvest could not be estimated, but indications from available data show that without adverse weather similar patterns may have occurred. The nitrogen effects on earliness were contributed to by significant differences in date of bloom of bolls harvested from specific fruiting sites in 2000, and by significant differences in boll maturation period (dd60s from bloom to boll opening for an individual boll) in 2001. Row spacing effects on earliness were contributed to by significant differences in boll distribution in both years, as well as significant differences in date of bloom of specific fruiting sites in 2000. Lint yield differences were not significant by row spacing in either year.

Introduction

In many areas, it can be important to produce an early maturing, although still high yielding, cotton crop (Edmisten, 2001; Metzer; Silvertooth 2001). Benefits of an early maturing crop can include better weather as fiber matures and defoliation and harvest operations are performed, and decreases in water or insecticide expenses due to a shorter fruiting period (Metzer). Ultra-narrow row cotton (UNRC) has shown indications of earlier maturity than wide row. Cawley et al. found earlier cutout in UNRC (1999), and Jost and Cothren found that UNRC, at a high plant density, reached 60% harvest earlier in one of two years measured (2001). Nitrogen fertilization rate can also influence earliness of the crop (Weir et al., 1996). This study compares ultra-narrow row cotton with wider rows for earliness and yield, under a variety of nitrogen rates. Several different components of earliness were investigated to better explain differences. Yield responses to nitrogen fertilizer rate and row spacing were also examined.

Materials and Methods

The location of the experiment was the Texas A&M University Experimental Farm in Burleson County, TX. Row spacings were 7.5, 15, and 30", and nitrogen rates were 0, 45, 90, and 135 lb N/A. Based on pre-season soil tests, the recommended nitrogen fertilizer rate in 2000 was 90 lb/A. The experimental design was a split plot, with nitrogen rates as the whole plots and row spacings as split plots. The fertilizer material was UAN-32, surface applied with flood nozzles (TeeJet Flow Regulators 4916-48 with Fertilizer Stream Caps) and then incorporated. The variety was DP 422 B/RR. Averaged over the two years, end-of-season populations were approximately 120,000, 77,000, and 53,000 plants per acre for the 7.5, 15, and 30" rows, respectively. The cotton was grown under sprinkler irrigation.

All data was taken from the center five feet of the plot width, between tire tracks from planting. Yield was measured as the sum of several sequential pickings of a 5 by 15' area in each plot. The seedcotton yield obtained from each individual harvest was added to those preceding it. This amount was then divided by the total of all harvest dates to find the cumulative percent seedcotton harvested (CSH) by that date. The estimated days after planting required to reach 60% seedcotton harvested were obtained by interpolation between the CSH at the two picking dates bracketing 60% for a given treatment. The interpolated value was used as an estimate of 60% open boll, to compare how early harvest aids could have been applied in each treatment. Eight sequential harvests were performed in 2000. However, due to excessive rainfall as bolls opened in 2001, only three sequential harvests could be made. One harvest was very early in the boll-opening period, and the final two were very late. Because none were close to the time the plots would have reached 60% harvest, the days to reach this level were not estimated in 2001.

Data was taken on individual bolls by tagging all bolls in one meter of row per plot with the date of white bloom, and on the day they opened, noting the date of harvest, node, and position. For first position fruit at nodes 6, 8, and 10, treatment comparisons were made for date of bloom of harvested bolls and for the boll maturation period (dd60s from bloom to boll opening for an individual boll). Boll maturation period was also analyzed as an average of all bolls within the meter. Comparisons for boll distribution were made from the tagged meter in 2000, and from mapping six representative plants per plot in 2001.

Treatment means were separated with Duncan's New Multiple Range Test at α = .05. Because of unequal numbers of bolls in the tagged meter, approximate f tests using Satterthwaite's procedure were performed for analysis of date of bloom and boll maturation period, and Duncan's mean separations are approximate for these two measures (Lentner and Bishop, 1993). For total lint yield, heterogeneity of variance between years was rejected, using methods outlined in Gomez and Gomez (1984), for only one of the two error terms at α=.05. However, heterogeneity of variance could be rejected for both error terms at α =.025. Thus, although total lint yields were combined over years, the validity of hypothesis tests for the combined lint yield data may be slightly compromised.

The GLM procedure of SAS (SAS Institute, 2000) was used to analyze all data, with the exception of the mean separations for date of bloom and boll maturation period, and the test of homogeneity of variance. All data were analyzed without transformation.

Results and Discussion

Nitrogen Effects on Earliness

In 2000, there were significant nitrogen effects on CSH at all picking dates except the eighth. In addition, a significant nitrogen by row spacing interaction was seen at picking dates 3, 4, and 6 (Fig. 1). For pickings 1, 2, 5, and 7, there were no significant differences among the three highest nitrogen levels except at picking 5, when 45 lb N/A was significantly lower than 90 and 135 lb N/A. The treatments were usually ordered with 90 having the highest CSH, followed by 135, 45 and 0 lb N/A. At each of these picking dates (1, 2, 5, and 7) the differences between the 0-lb N/A and the other treatments were significant. At picking dates 3, 4, and 6, where a significant interaction was present, the direction of the nitrogen effect was similar over part of the nitrogen treatment range. As the nitrogen level moved from 90 to 0 lb/A, CSH decreased in each row spacing.

In 2001, significant nitrogen effects on CSH were limited to picking 1, which was also the only picking to show a significant nitrogen by row spacing interaction (Fig. 2). In 7.5 and 15" row spacings, CSH decreased as nitrogen went from 90 to 0, much like 2000. In the 30" spacing, CSH increased as the nitrogen moved from 90 to 45 lb/A, but decreased to a level below both of these at 0 lb N/A. For both years, the general effect of nitrogen rates below 90 lb/A, especially 0 lb N/A, appeared to be a decrease in the CSH at specific picking dates.

Because most pairs of picking dates used to estimate days to 60% seedcotton harvested in 2000 included at least one date with a significant nitrogen by row spacing interaction, nitrogen effects on this value are reported separately for each row spacing. For the 30" row spacing, 60% seedcotton harvest was estimated at 112.1, 109.6, 108.2 and 108.3 days after planting for 0, 45, 90, and 135 lb N/A respectively. Listed in the same nitrogen order, these values were 110.0, 107.1, 106.3 and 107.6 days after planting for the 15" spacing and 112.0, 109.0, 104.9 and 105.1 days after planting for the 7.5" spacing.

There were no significant differences in either year in boll distribution by nitrogen treatments, as measured by the percent of total bolls at nodes 6-10 or nodes 11-15. Although nonsignificant, there were trends of limited increases in the percent of bolls within nodes 6-10, and limited decreases in the percent of bolls within nodes 11-15, with most decreases in nitrogen. There were no significant differences by nitrogen in the percent first position bolls (at all nodes) in either year.

Examination of the date of bloom of first position harvested bolls in 2000 showed significant differences by nitrogen at nodes 6, 8, and 10. The zero nitrogen treatment was the latest to bloom at each node, with significantly higher days after planting than any other treatment. At all three nodes, the difference between 90 and 135 lb N/A was insignificant. Either 90 or 135 lb N/A was numerically the first to bloom at each node. The range of time between the nitrogen means with the greatest separation was approximately 4.9 days at node 6, 5.8 days at node 8, and 6.5 days at node 10. In 2001, there were no significant differences by nitrogen for date of first position bloom at nodes 6, 8, or 10.

Significant differences were not found for boll maturation period in 2000. In 2001 significant differences by nitrogen existed in the average maturation period of all bolls as well as first position bolls at node 6, with the zero nitrogen treatment numerically requiring the longest time to boll opening in both cases. Differences between the means of the 0 and 135-lb/A treatments were 37.5 dd60s for the average of all bolls and 90.2 dd60s for first position bolls at node 6.

The later crop maturity at lower nitrogen rates may be due to nitrogen deficiency, which has a negative impact on growth (Taiz and Zeiger, 1998). This is supported by the later date of bloom of bolls harvested at specific sites in 2000 in the zero nitrogen treatment. In 2001, visual deficiency symptoms were not as obvious in the field, and date of bloom effects were not significant at the nodes analyzed. However, at node 10, the date of bloom means sorted numerically in order of decreasing nitrogen, with the zero nitrogen being the latest. Perhaps slower growth did not occur until later in the season in 2001, and nodes above 10 would have showed significant differences in date of first position bloom. Although very high nitrogen fertilizer rates have been implicated in reducing crop earliness (Weir et al., 1996), this response was not observed to any appreciable extent at the nitrogen levels utilized in this study. The rates utilized were probably not high enough to cause this effect.

Row Spacing Effects on Earliness

Significant row spacing effects were present for CSH, with the exception of dates 1 and 8 in 2000. As mentioned above, a nitrogen by row spacing interaction was found at pickings 3, 4, and 6 (Fig. 1). For picking dates 2, 5, and 7, the 30" spacings had a significantly lower CSH than the other two spacings, but no significant differences were found between 7.5 and 15" spacings. Because of the significant interaction between the nitrogen and row spacing on some picking dates, CSH for 2000 is shown in summary graphs as the average of 0 and 45 lb N/A, both of which had treatment mean order 15", 7.5", and 30" from greatest to least CSH (Fig. 3), and as the average of 90 and 135 lb N/A, both of which had treatment order 7.5, 15, and 30" from greatest to least CSH (Fig. 4).

In 2001, significant row spacing effects on CSH were found only at picking date 2, when, similar to the previous year, the 30" spacing was significantly lower than the 7.5 and 15" spacings, and the two narrower spacings were not significantly different. There was a significant interaction between row spacing and nitrogen rate at picking date 1 (Fig. 2).

In 2000, row spacing effects on days to 60% seedcotton harvest appeared to differ by nitrogen treatment, possibly due to the significant interaction found in CSH. For 0 lb N/A, 60% seedcotton harvest was attained an estimated 112.0, 110.0, and 112.1 days after planting for the 7.5, 15, and 30" spacings, respectively. The same respective spacing means were 109.0, 107.1, and 109.6 days after planting for 45 lb N/A; 104.9, 106.3, and 108.2 days after planting for 90 lb N/A; and 105.1, 107.6, and 108.3 days after planting for 135 lb N/A. For 90 and 135 lb N/A, the two rates that could be used in production, any reduction in row spacing decreased the days to 60% seedcotton harvest. Based on this data and the CSH information from both years, the 7.5 row spacing appears to be earlier than the 30" row spacing at rates of nitrogen applicable to production.

Significant differences were present each year in boll distribution by row spacings. In each year, more than 85% of the total bolls were within nodes 6-15. In comparison to 30" rows, 7.5" rows had a significantly higher percentage of total bolls at nodes 6-10 and a significantly lower percentage at nodes 11-15 in both years. Likewise, in both years the 7.5" row spacing had a significantly higher percentage of total bolls (all nodes) at position one than the 30" spacing.

Row spacing had a significant effect, as shown by the ANOVA f test, on the date of bloom of first position fruit at nodes 8 and 10 in 2000, but not at node 6. The means could not be separated by Duncan's New Multiple Range Test at node 8. At node 10, the first position fruit bloomed significantly earlier in the 7.5 than in the 15 or 30" spacings. The range between the 7.5 and 30" means at that node was approximately 2.9 days. In 2001, there were no significant row spacing effects on date of bloom of first position fruit at nodes 6, 8, or 10.

Row spacing affected neither the overall boll maturation period nor the boll maturation period for first position bolls at nodes 6, 8, or 10 in either year.

Thus the factor that contributed most consistently to the effects of row spacing on earliness was the boll distribution. The only other significant effect was seen in date of bloom at specific sites in 2000, contributing to increased earliness in 7.5" rows.

Nitrogen and Row Spacing Interaction

Significant row spacing by nitrogen interactions existed in the percent of total seedcotton harvested by picking dates 3, 4, and 6 in 2000 (Fig. 1). This was also seen in the first picking in 2001 (Fig. 2). When these interactions were examined as the response of each spacing to increases in nitrogen fertilizer, the most consistent difference present in both years was between the 7.5 and 30" rows. For each year the 30" row spacing began to decrease or level off in percent yield harvested at lower nitrogen than the 7.5" spacing. The differences between 7.5 and 30" spacings were larger at the two higher nitrogen rates.

One explanation for the interactions seen is that nitrogen deficiency is probably the limiting factor at lower nitrogen rates. The smaller plants may not compete strongly enough to be as constrained by row spacing. Supporting this, at the lower two nitrogen rates, the treatment means did not sort in order of row spacing. At 90 or 135 lb N/A, when plants were more competitive, the typical effect of any reduction in row spacing was an increase in CSH. Therefore a larger CSH difference between 7.5 and 30" row spacings was evident at 90 and 135 lb N/A. These two N levels showed increased CSH as spacing decreased (Figs. 1-4).

In 2000, the increase in percent seedcotton harvested of 7.5" rows at nitrogen rate increases for which the 30" rows stayed the same or dropped had the effect of creating a larger separation in earliness at the higher nitrogen treatments. This did not translate into a large effect on earliness, however. The difference between 7.5 and 30" row spacings in estimated days to 60% seedcotton harvested was 2.0 days if averaged across all nitrogen treatments, and 3.2 days if only the 90 and 135-lb N/A treatments were included. The practical implications of an earliness difference of this size are limited. If conditions had been more conducive to rank growth, perhaps the constraints of closer row spacing would have had a greater effect, and earliness differences between the spacings might have been larger.

No significant interactions were seen between nitrogen and row spacing for date of bloom at specific sites, boll maturation period, or boll distribution.

Nitrogen Effects on Lint Yield

In 2000, lint yields by nitrogen fertilization level were 847, 1011, 1196, and 1320 lb/A, for 0, 45, 90, and 135-lb N/A treatments, respectively (Fig. 5). In 2001, lint yields were 483, 764, 859, and 902 lb/A for the respective nitrogen treatments. Within each year, all differences were statistically significant except those between the 90 and 135 lb/A treatments. When combined over years, the year by nitrogen interaction was not significant. Combined lint yields were 647, 882, 1020, and 1132 lb/A for 0, 45, 90, and 135 lb N/A treatments. Combined lint yield differences between treatments were statistically significant with the exception of the differences between 135 and 90 lb N/A and between 90 and 45 lb N/A.

Row Spacing Effects on Lint Yield

In 2000, lint yields for the three row spacings were 1006, 1167, and 1153 lb/A for the 7.5, 15, and 30" spacings respectively (Fig. 6). In 2001, the lint yields were 793, 713, and 737 lb/A for the same respective spacings. In neither year was there a significant difference among row spacing treatments. Combined total lint yields are not listed because the year by row spacing interaction was significant. This interaction was evident in the yield of the 7.5" rows, which was numerically the least in 2000 but the greatest in 2001.

There was no significant interaction between nitrogen and row spacing on total lint yield in 2000, 2001, or in the combined data.

Conclusions

The potential for increased earliness with ultra-narrow row cotton appears to be real, but limited in magnitude under the conditions of this study. An interaction between nitrogen and row spacing on CSH caused earliness advantages (in days to 60% seedcotton harvest) of 7.5 over 30" rows to be evident mainly at the two highest nitrogen rates. Although not as marked as in 7.5" rows, the 30" rows had a high percentage of bolls at lower fruiting nodes and in the first position. Perhaps under conditions encouraging more rank growth, differences in boll distribution between row spacings would be larger and greater earliness differences would be seen. Nitrogen differences in measures of earliness were seen in large part from including low levels of nitrogen in the study, and would probably not play a role in production situations.

Lint yield increased with higher nitrogen, as expected, but was not significantly impacted by row spacing. Due to the lack of interaction between nitrogen and row spacing on lint yield, the same levels of nitrogen fertilization should probably be used for UNRC and wider spacings.

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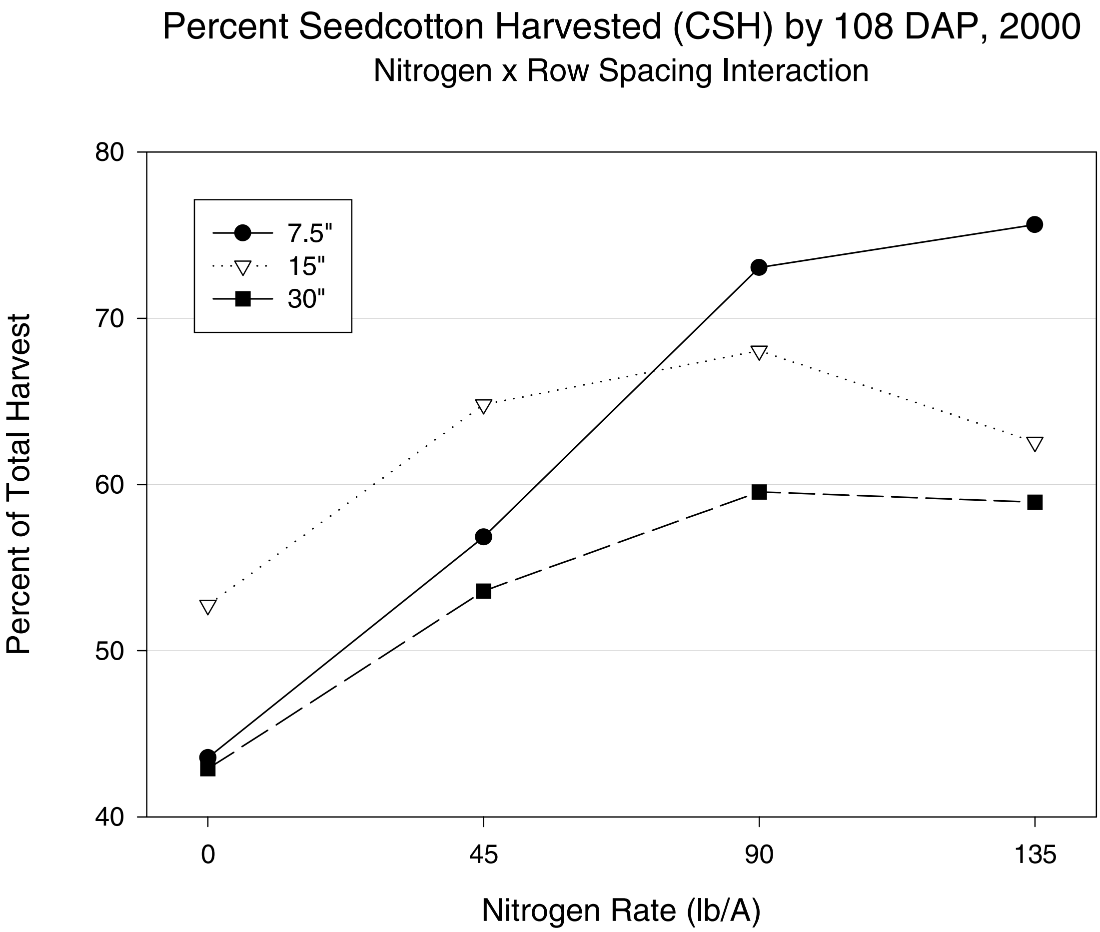

Figure 1: Interaction between nitrogen rate and row spacing on CSH, picking 4 (108 days after planting), 2000. Typical of all interactions on CSH in 2000.

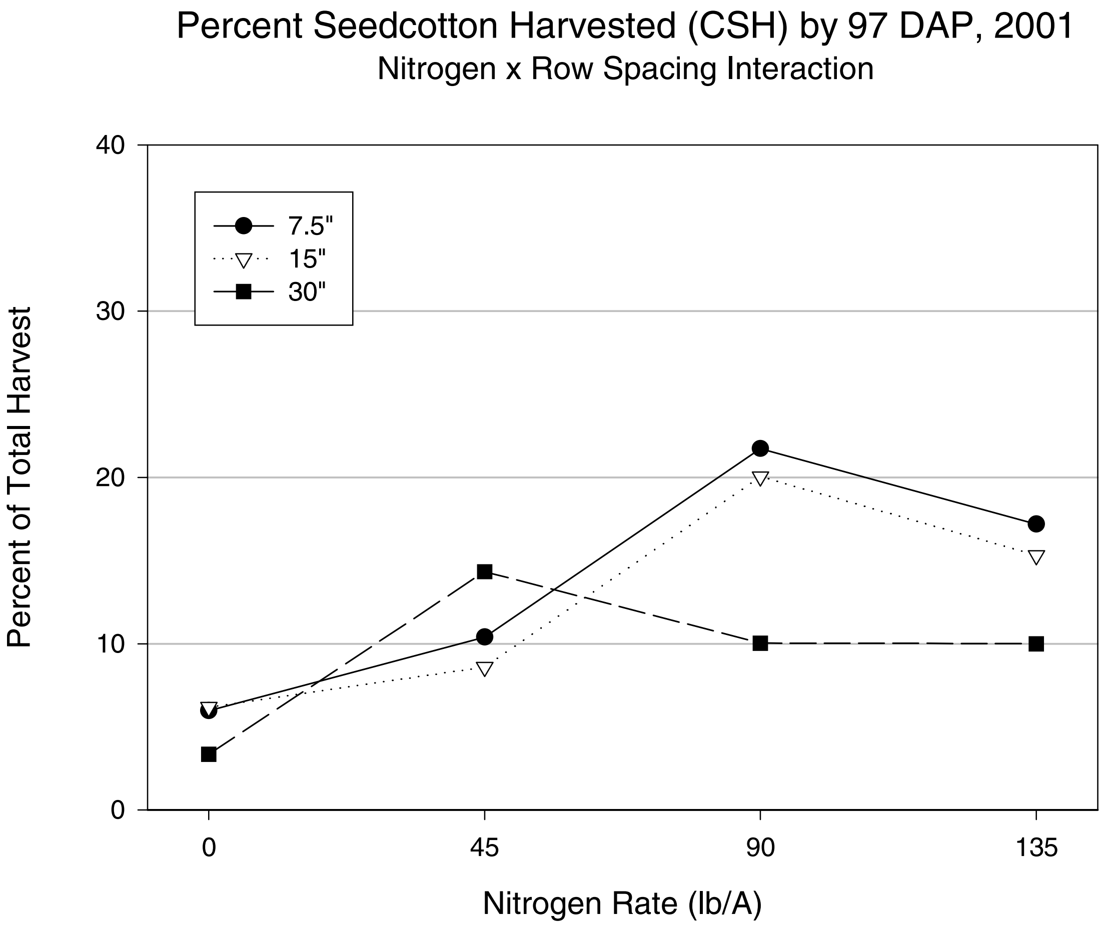

Figure 2. Interaction between nitrogen rate and row spacing on CSH, picking 1 (97 days after planting), 2001

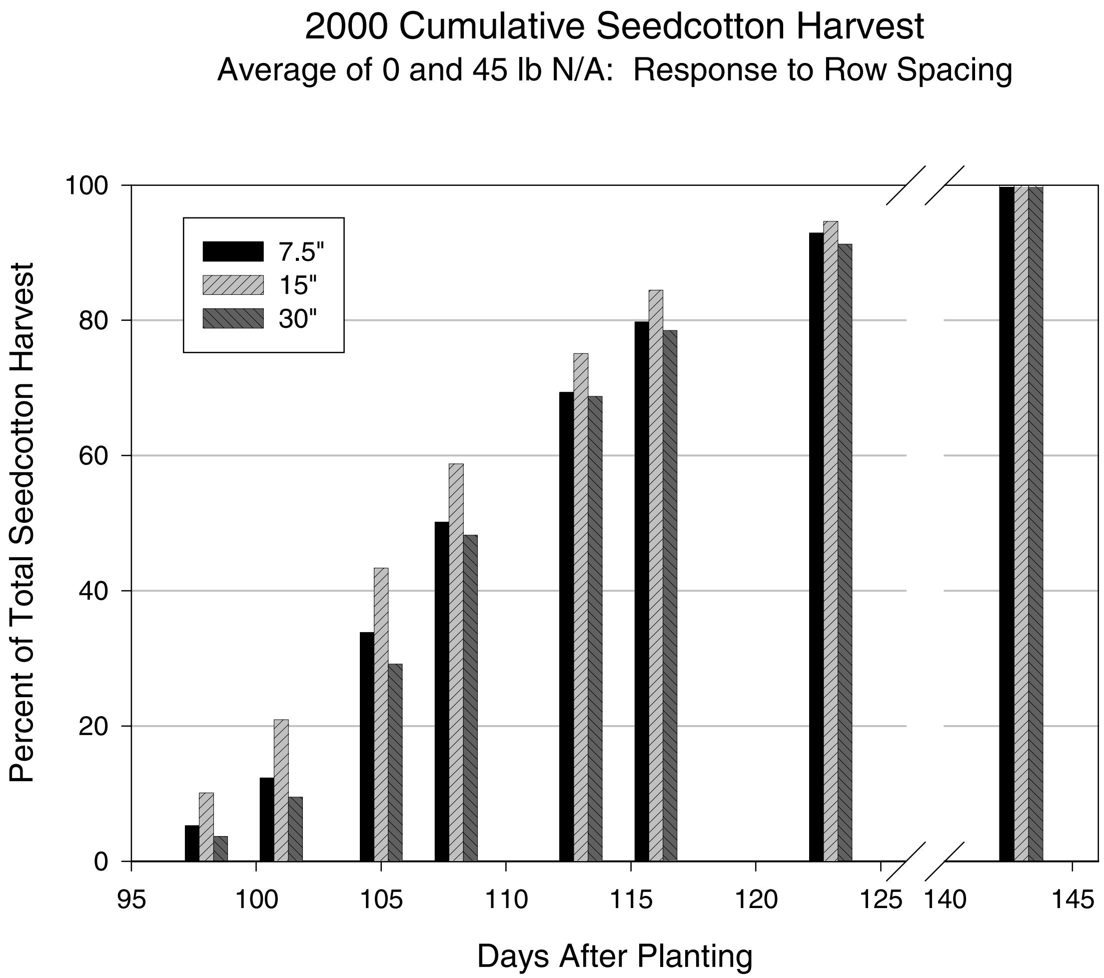

Figure 3. Cumulative seedcotton harvest (CSH), at each picking date, 2000. Average of 0 and 45 lb N/A treatments only.

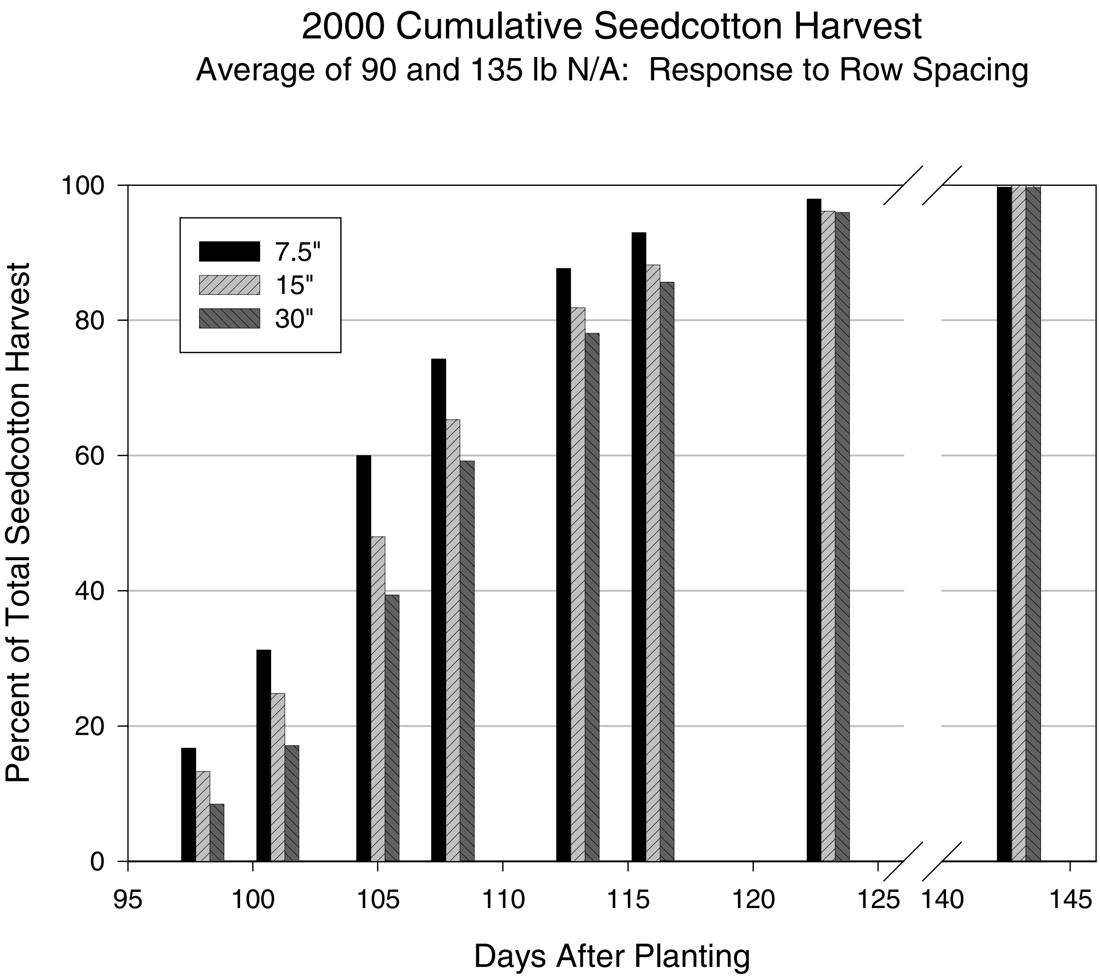

Figure 4. Cumulative seedcotton harvest (CSH), at each picking date, 2000. Average of 90 and 135 lb N/A treatments only.

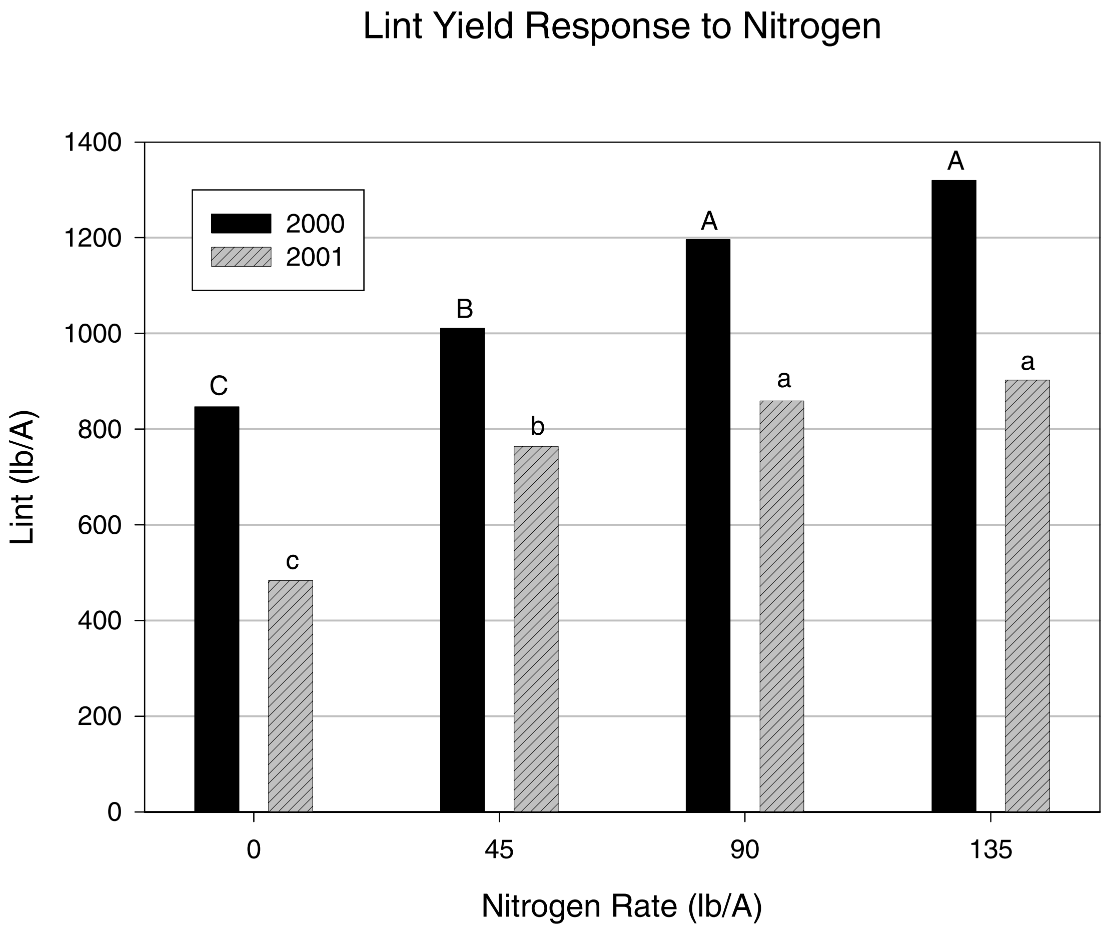

Figure 5. 2000 and 2001 overall mean lint yields by nitrogen rate. Treatment means within a year marked by the same letter are not significantly different.

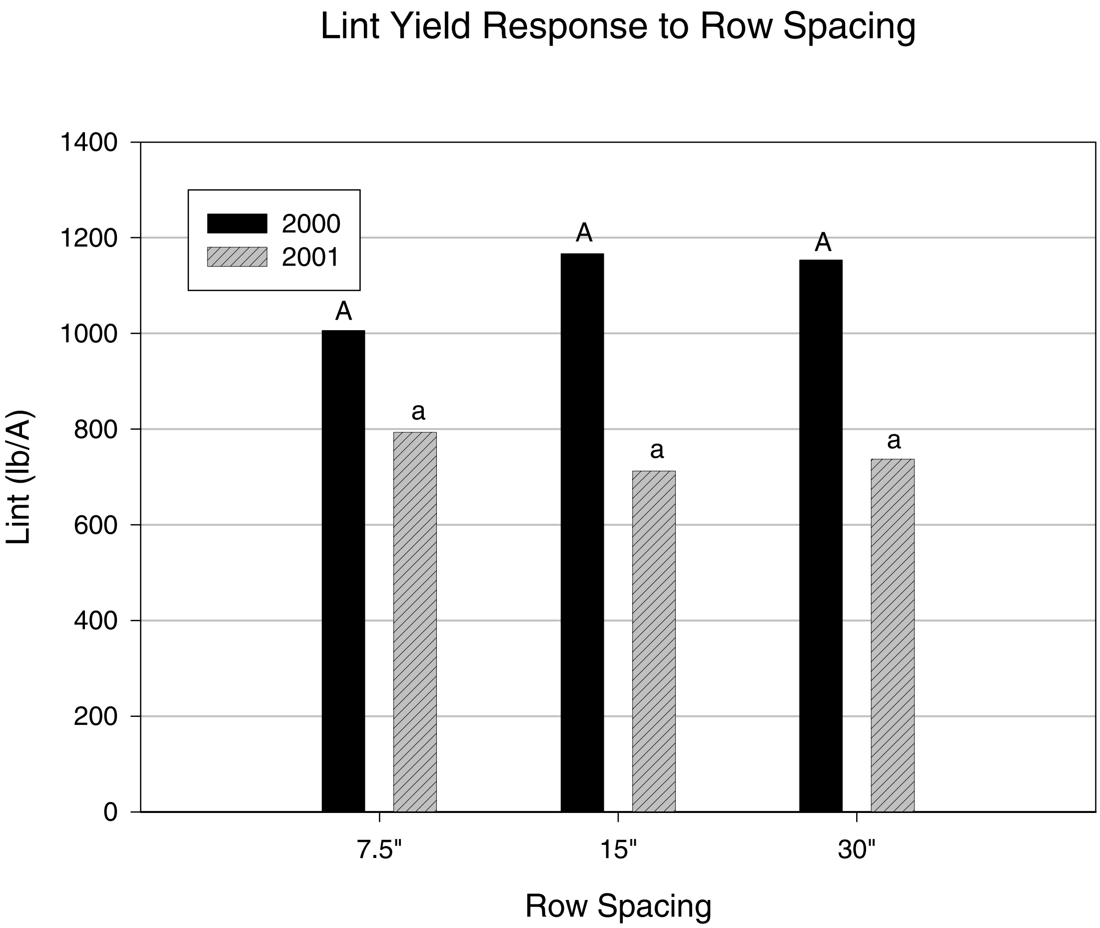

Figure 6. 2000 and 2001 overall mean lint yields by row spacing. Treatment means within a year marked by the same letter are not significantly different.