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COTTON YIELD AND PLANT GROWTH ACROSS ROW SPACINGS, TILLAGE SYSTEMS, AND HERBICIDE TECHNOLOGIES

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Abstract

Cotton producers are faced with a myriad of choices including cotton varieties, herbicide systems, tillage systems, and row spacings. A study was conducted to compare a conventional variety, a glyphosate tolerant variety, and a glufosinate tolerant variety in both conventional tillage and conservation tillage systems for standard row (40-inch) and narrow row (15-inch) cotton planting patterns. The experiment was conducted during the 2004-2006 growing seasons at the E.V. Smith Research Center, Field Crops Unit near Shorter, AL. Data collection included plant populations, lint yields, and plant biomass at 1st square and mid-bloom. Plant populations were 22% higher for 15-inch cotton compared to 40-inch cotton, reflecting a 35% higher seeding rate in 15-inch cotton plots. Lint yields were influenced more by the growing season than row spacing, variety, or tillage system. Plant biomass measured at 1st square and mid-bloom was also affected by growing season with 15-inch cotton plant biomass averaging 34% greater in 2004 and 2005, however, the effect of tillage system was contradictory during the same growing seasons. The 15-inch lint yields were equivalent to 40-inch cotton lint yields, while plant biomass was greater for 15-inch cotton at both growth stages. An extensive economic analysis is required to account for differing plant populations, technology fees, tillage systems, and herbicide systems to determine if a 15-inch system is more profitable than a traditional cotton system with wider row spacings.

Introduction

Cotton producers have many choices in cotton varieties. Producers can choose among varieties with different herbicide technologies based upon both agronomic considerations and weed management. Decisions related to specific varieties or herbicide technologies may be influenced by a grower's tillage and/or planting pattern. For example, conservation tillage will likely eliminate mechanical weed control as a control option and dictate the use of a broad spectrum over-the-top herbicide application. Complex economics are also involved in choosing varieties and subsequent herbicide systems due to the availability of both conventional and herbicide resistant varieties. Typically, herbicide resistant varieties include technology fees that substantially increase seed costs. Conventional varieties may have cheaper seed costs, but may require multiple herbicide applications utilizing more expensive herbicides, which may offset the initial seed cost savings.

Historically cotton has been grown in 36 to 40 inch rows due to equipment considerations. An alternative narrow row production system consisting of planting rows 15 inches apart is being adopted by limited numbers of cotton growers. Potential advantages associated with this system are moisture conservation and weed suppression, due to the faster canopy closure. Plant populations in narrow row cotton production systems are higher, but more plants/acre could increase cotton yields, especially on poorer soils. Jost and Cothren (2000) reported a yield increase for cotton grown in narrow rows during a dry growing season, while Boquet (2005) reported no yield advantage for narrow row cotton production.

Growers have not been able to capitalize on the potential yield advantage offered by narrow row production because narrow row cotton has been traditionally harvested with a stripper harvester, which can increase trash content. Growers are substantially penalized for the trash content, eliminating the economic incentive of narrow row production. The type of harvester required and the trash contents associated with a stripper harvester have suppressed the adoption of narrow row cotton.

John Deere® has recently begun marketing a spindle harvester capable of harvesting 15-inch cotton rows. This equipment advancement addresses two major limitations of narrow row cotton production; however, the performance of narrow row cotton production across tillage systems remains unknown. Thus, an experiment was conducted to compare three cotton varieties with different herbicide technologies, planted in standard 40-inch rows and 15-inch row patterns in both conventional and conservation tillage systems.

Materials and Methods

This experiment was initiated in the fall of 2003 at the E.V. Smith Research Center, Field Crops Unit near Shorter, AL on a Compass sandy loam (coarse-loamy, siliceous, subactive, thermic Plinthic Paleudults). The experiment remained in the same location for three years with no re-randomization of the treatments. The experimental area utilized for this study contained conventional tillage and conservation tillage plots that were originally established over 15 years ago. These plots allowed a comparison of treatments among mature tillage systems and eliminated any concern associated with transition effects into conservation tillage.

The experimental design contained a split-split plot treatment restriction in a randomized complete block design with four replicates. The main plots consisted of row spacings (15-inch vs. 40-inch row spacing), the subplots were varieties represented by different herbicide technologies (conventional variety - FM966®, glyphosate tolerant variety - FM960 RR®, and a glufosinate tolerant variety - FM966 LL®), and the sub-subplots were tillage systems (conventional and conservation tillage). A rye cover crop was drilled across the experimental area each fall at 90 lb ac^{-1}. All plots were paratilled (complete disruption) immediately following the cover crop planting operation to eliminate any subsurface soil compaction with the exception of fall 2003. During the first year of the study, no deep tillage was performed in any of the plots, and only surface tillage associated with the conventional tillage plots was performed where appropriate. Surface tillage in the conventional tillage plots consisted of multiple spring disk operations and level. In the conservation tillage plots, no additional tillage was performed after the fall paratill operation. Typical spring in-row subsoiling prior to planting could not be administered to standard row (40-inch) cotton, because it would create a potential bias against 15-inch cotton.

In early spring, 20-30 lb N ac^{-1}, as NH_4NO_3, was applied to the cover crop to enhance biomass production. Biomass samples were collected from each plot approximately 3 weeks before anticipated planting date and immediately preceding chemical termination. The average biomass production across the experimental site was 3520, 3060, and 4470 lb ac^{-1} for 2004, 2005, and 2006, respectively. All plots received 42 lb N ac^{-1} as a starter in the form of NH_4NO_3, prior to planting. An additional 60 lb N ac^{-1} was sidedressed as urea-ammonium nitrate (UAN). All cotton varieties were Cruiser® treated and planted with an in-furrow application of Temik® (5 lb/A) and Terraclor® (10 lb/ac). All plots were planted on May 25, 2004, May 17, 2005, and May 17, 2006, respectively. The 15-inch cotton was planted with a precision drill at 105,000 plants/A, while the 40-inch cotton utilized an air planter at 80,000 plants/A. Prowl® (32 oz/A) was applied pre-emergence to all conventional tillage plots and conventional varieties immediately following planting. Two over-the-top applications of Roundup Weathermax® (23 oz/A), Ignite® (32 oz/A), and Staple® (1.2 oz/A) were applied to corresponding herbicide tolerant and conventional varieties at the 2- and 4-leaf stages. A layby application of Envoke® (0.15 oz/A) or Staple® (1.2 oz/A), depending on the year, was applied to all 15-inch cotton, while a layby application of Caparol® (32 oz/A) and MSMA® (42.6 oz/A) was applied on the same day to the 40-inch cotton. Each year, all cotton in the experiment was defoliated with Def 6® (1 pt/A), Prep (1.5 pt/A), and Dropp® (0.2 lb/A). Unfortunately, access to a 15-inch spindle picker was not feasible, but cotton from two 2-m^2 sections within each plot was hand-harvested on October 4, 2004, October 11, 2005, and October 11, 2006, respectively. A sub-sample of seed cotton from each plot was ginned in a 20-saw tabletop micro-gin to determine ginning percentage. Lint yields were determined by weighting lint and seed collected from each plot and multiplying corresponding seed cotton by the ginning percentage of each plot. The values obtained from a tabletop gin can be used for comparative purposes but may not necessarily coincide with values obtained by a grower from a full-scale gin. Values obtained for lint percentage and quality will likely be above typical averages, but any differences between treatments should be detectable. Initial plant populations were recorded approximately 3 weeks after planting by counting all the plants from 3 equal areas within each plot. Whole plant biomass (1 m^2) samples were collected from each plot during 1st square and mid-bloom.

All response variables were analyzed using the MIXED procedure (Littell et al., 2006) and the LSMEANS PDIFF option to distinguish between treatment means (release 9.1; SAS Institute Inc.; Cary, NC). Data were analyzed with rep, year, variety, spacing, tillage, and the interactions among year, variety, spacing, and tillage as fixed effects in the model, while replication X variety and replication X variety X spacing were considered random. Treatment differences were considered significant if $P \leq 0.05$.

Results and Discussion

Plant Populations

A three-way interaction was observed between Year X Spacing X Tillage ($Pr > F = 0.0434$) (Fig. 1). Higher plant populations were generally measured for the 15-inch cotton, regardless of the tillage system. Across the three significant conventional tillage comparisons and the one no-tillage comparison, 15-inch cotton plant populations were 22% higher than 40-inch cotton plant populations. However, due to differences between the drill for 15-inch cotton and traditional planter units utilized for 40-inch cotton, initial seeding rates were 35% higher for the 15-inch cotton. The high seed costs associated with using a drill in 15-inch cotton production will require a significant yield increase to offset this key production expense. However, other cost savings, such as benefits associated with weed suppression should also be considered.

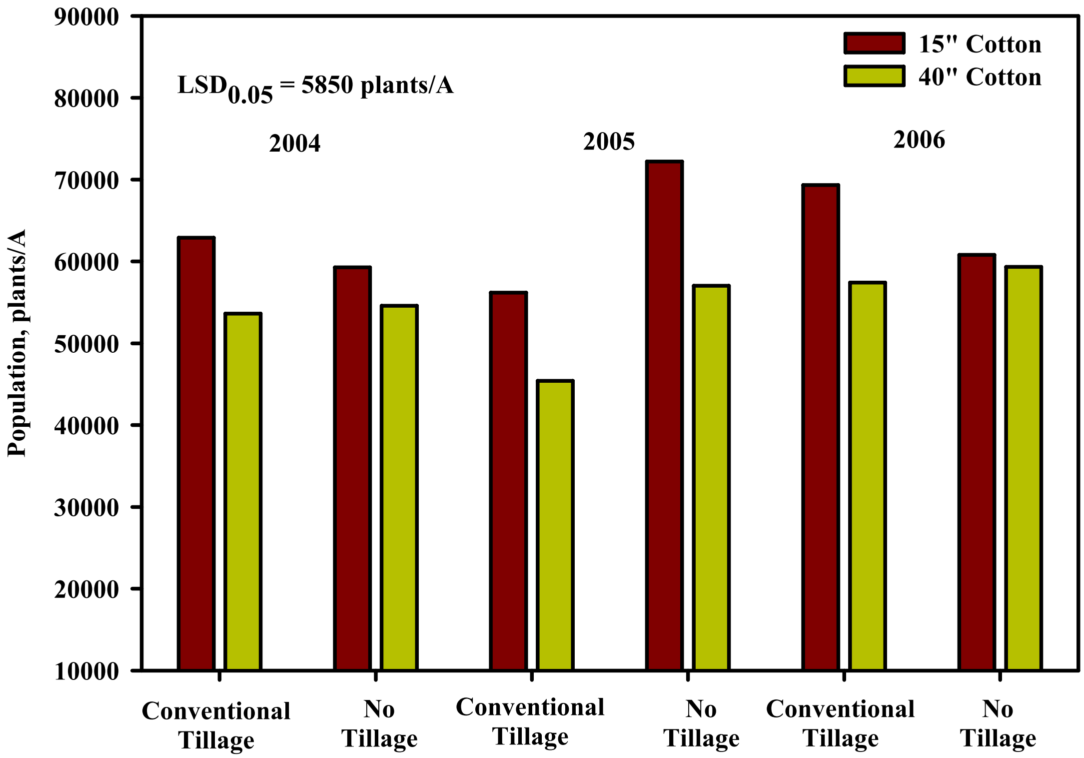

Figure 1. Plant populations measured across 15-inch and 40-inch cotton within conventional and no-tillage systems during the 2004-2006 growing seasons at the Field Crops Unit of the E.V. Smith Research Center near Shorter, AL.

Lint Yields

Lint yields were influenced by year as indicated by three interactions that included year. A Year X Spacing interaction ($Pr > F = 0.0127$) indicated that 2005 produced superior lint yields compared to the other two growing seasons (Fig. 2A). However, within growing seasons, 15-inch cotton yields were equivalent to 40-inch cotton yields. The increase in seed costs associated with 15-inch cotton may require an additional yield increase for growers to justify the additional costs. A Year X Variety interaction ($Pr > F = 0.0150$) also showed that 2005 produced the best yields, but the conventional and glyphosate-tolerant variety produced higher yields compared to the glufosinate-tolerant variety (Fig. 2B). In 2005, conventional cotton produced 12% greater yields, while glyphosate-tolerant cotton produced 13% greater yields compared to glufosinate-tolerant cotton. In 2006, glyphosate-tolerant cotton was superior to both conventional and glufosinate-tolerant cotton by 29%. No lint yield differences were observed between varieties in 2004. A Year X Tillage interaction (Pr > F = 0.0005) highlighted a 21% yield increase for conventional tillage cotton compared to no-tillage cotton during the 2004 growing season (Fig. 2C). However, this yield increase can be attributed to the lack of deep tillage during the first year of the experiment. Typically, Coastal Plain soils require some form of deep tillage to eliminate subsurface soil compaction, which will enhance root growth and subsequent nutrient and water uptake (Busscher et al., 1988; Schwab et al., 2002).

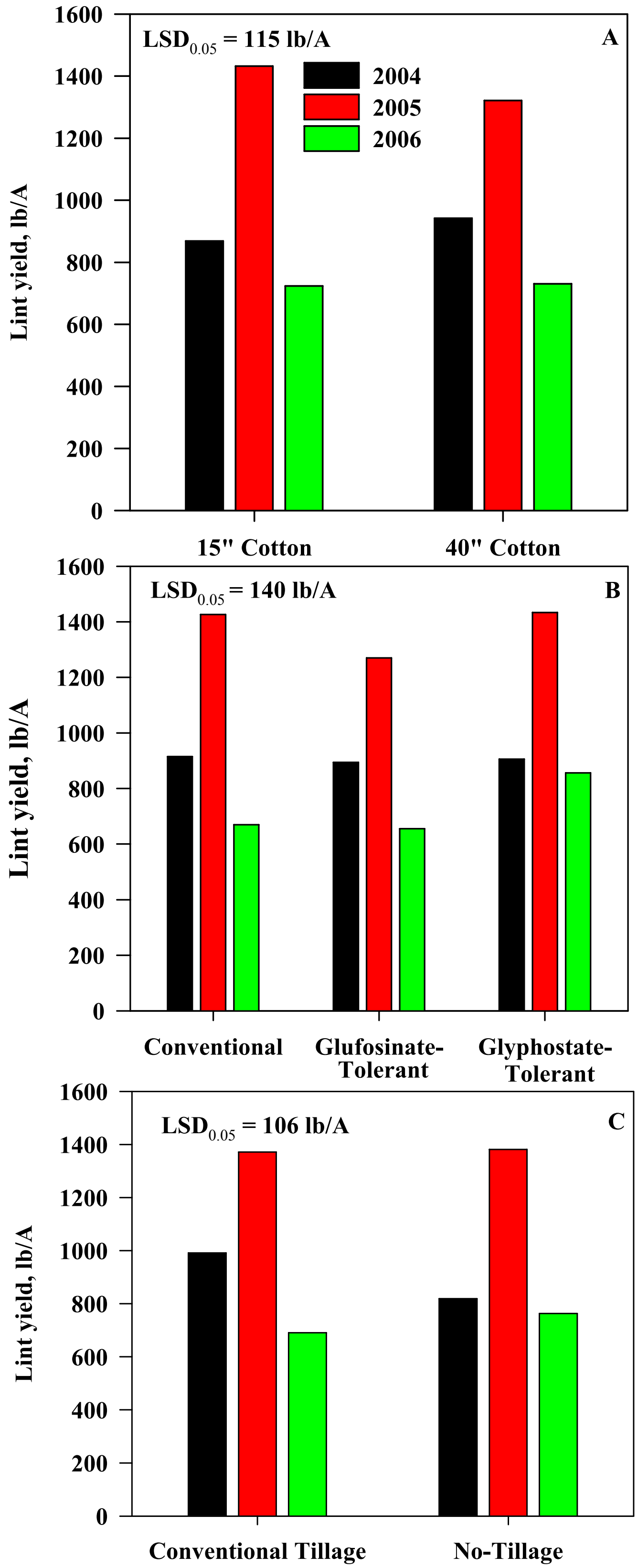

Figure 2. Lint yields measured during the 2004-2006 growing seasons across row spacings (A), cotton varieties (B), and tillage systems (C) at the Field Crops Unit of the E.V. Smith Research Center near Shorter, AL.

1st Square Plant Biomass
Three interactions were also observed for early season plant biomass measured at 1st square. A Year X Spacing interaction (Pr > F = <0.0001) indicated that 15-inch cotton produced larger plants at 1st square the first two growing seasons, however no difference was observed the last year (Fig. 3A). The 15-inch cotton produced 51% and 17% heavier plants at 1st square compared to 40-inch cotton during 2004 and 2005, respectively. The 2004 40-inch cotton also produced less plant biomass than 40-inch cotton produced in 2005 or any 15-inch cotton produced in 2004 or 2005. A Year X Tillage interaction (Pr > F = <0.0001) showed conflicting results that depended on the growing season (Fig. 3B). In 2004, plant biomass measured at 1st square was lower from no-tillage plots, but as with the yields, that can be attributed to the lack of deep tillage. The biomass observed in the no-tillage plots for the 2004 growing season were also lower than plant biomass measured during the 2005 growing season. In 2005, the best growing season of the experiment, plant biomass was 16% greater in the no-tillage plots. In 2006, a very dry growing season, no differences were observed, but no-tillage plant biomass was numerically lower. A Spacing X Tillage interaction (Pr > F = 0.0464) illustrated that 15-inch cotton produced 28% more 1st square plant biomass than 40-inch cotton averaged across tillage systems (Fig. 3C). The 40-inch conventional tillage cotton also produced 20% greater 1st square plant biomass than 40-inch no-tillage cotton. This difference is probably attributed to the lack of deep tillage performed in 2004.

Mid-Bloom Plant Biomass
Mid-bloom plant biomass was significant across years, row spacings and tillage systems (Table 1). The most mid-bloom plant biomass was measured during the 2005 growing season followed by the 2004 growing season. The lowest mid-bloom plant biomass was recorded in the very dry 2006 growing season. The 2006 mid-bloom plant biomass was 55% and 78% lower than the 2004 and 2005 growing season, respectively. The 40-inch cotton produced 21% less plant biomass at mid-bloom compared to 15-inch cotton, while no-tillage plots produced 14% less plant biomass at mid-bloom when averaged over varieties, row spacings, and all three years of the experiment (Table 1).

Table 1. Mid-bloom plant biomass measured across years, row spacings, and tillage systems during the 2004-2006 growing seasons at the Field Crops Unit of the E.V. Smith Research Center near Shorter, AL.

	Crop year			Row spacing		Tillage system†	
Variable	2004	2005	2006	15”	40”	CT	NT
	--------------------	--------------------	--------------------	----------lb ac^{-1}	--------------------	--------------------	--------------------
Mid-bloom plant biomass	3567	7233	1609	4534	3738	4408	3865
Pr > F		< 0.0001		0.0004		0.0007	
$LSD_{0.05}$		374		377		287	

† CT = Conventional tillage; NT = No-tillage.

Conclusions

The effects of row spacing, cotton variety, and tillage system were examined across three growing seasons at the Field Crops Unit of the E.V. Smith Research Center near Shorter, AL. The variables examined included plant populations, lint yields, and plant biomass at 1st square and mid-bloom. Measured plant populations were generally greater for 15-inch cotton across tillage systems, reflecting a higher seeding rate utilized in the 15-inch cotton. Lint yields were influenced by the growing season more than row spacings, cotton varieties, or tillage systems. The growing season also influenced plant biomass at 1st square and mid-bloom, but 15-inch cotton generally produced more plant biomass, while tillage systems showed more erratic effects. Although 15-inch lint yields were equivalent to 40-inch cotton lint yields, an extensive economic analysis is required to account for differing plant populations, technology fees, tillage systems, and herbicide systems to determine if a 15-inch system is more profitable than a traditional cotton system with wider row spacings.

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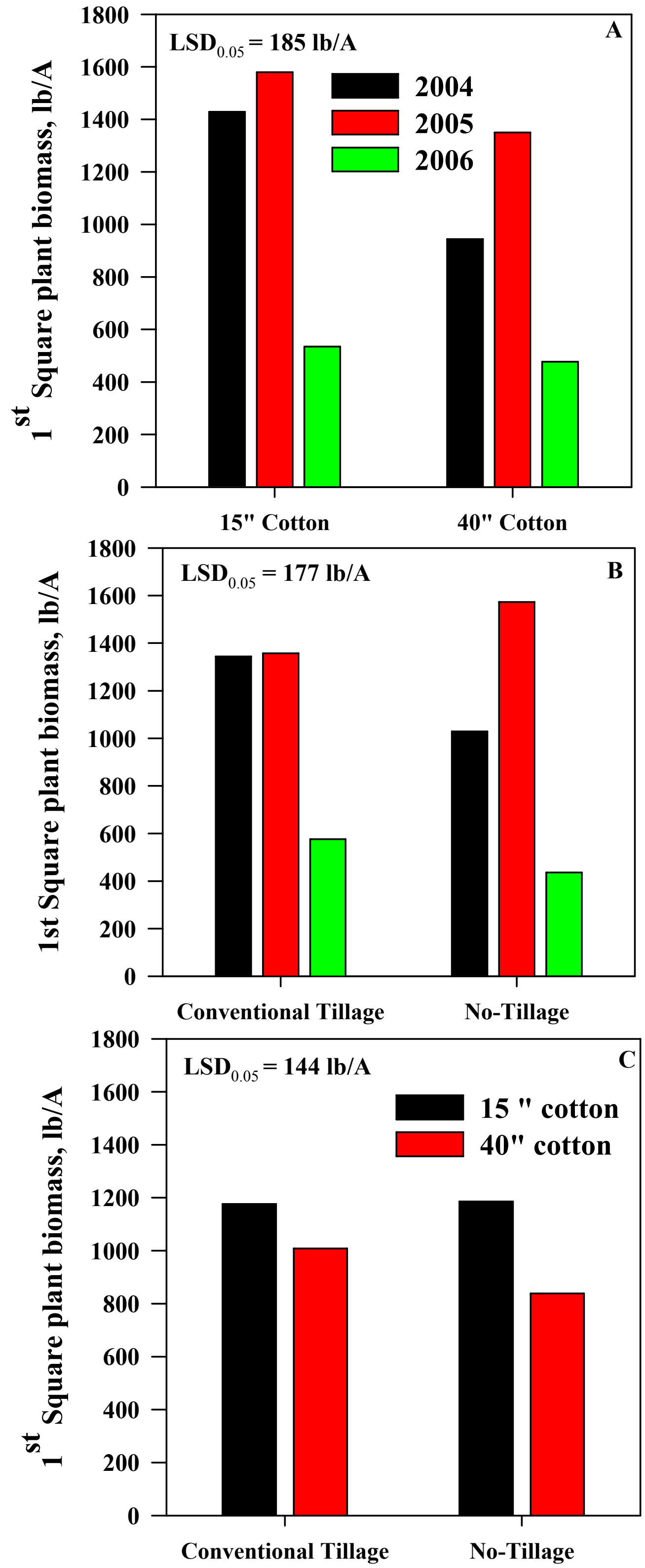

Figure 3. Plant biomass measured at 1st square during the 2004-2006 growing seasons across row spacings (A), tillage systems (B), and row spacings and tillage systems (C) at the Field Crops Unit of the E.V. Smith Research Center near Shorter, AL.

References

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

Busscher, W.J., D.L. Karlen, R.E. Sojka, and K.P. Burnham. 1988. Soil and plant response to three subsoiling implements. Soil Sci. Soc. Am. J. 52:804-809.

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.

Littell, R.C., G.A. Milliken, W.W. Stroup, R.D. Wolfinger, O. Schabenberger. 2006. SAS system for mixed models. 2nd Edition. SAS Institute, Cary, NC.

Schwab, E.B., D.W. Reeves, C.H. Burmester, and R.L. Raper. 2002. Conservation tillage systems for cotton in the Tennessee Valley. Soil Sci. Soc. Am. J. 66:569-577.