HYBRID, ROW PATTERN, AND PLANT POPULATION COMPARISONS FOR CONSERVATION TILLAGE CORN PRODUCTION

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ABSTRACT

Corn (*Zea mays* L.) produced in narrow rows can increase yields and result in a quicker canopy closure. Costly equipment modifications make narrow rows impractical, but a twin row configuration may boost production with fewer equipment modifications. We compared yield, leaf area index, and weed biomass, for a conventional and a glyphosate-tolerant hybrid across three plant populations (low 16,000-18,000; medium 24,000-26,000; high 32,000-34,000 plants ac^{-1}) in two row patterns (single vs. twin) at four locations during the 2005 growing season. The experimental design was a RCB (r = 4) with a split-split plot restriction on randomization, where hybrids were assigned to main plots, row patterns to subplots and plant populations to sub-subplots. There was a noticeable and statistically significant interaction between hybrid and population at three out of four locations. The conventional hybrid yielded 15% (138 vs. 117 bu ac^{-1}), 12% (158 vs. 139 bu ac^{-1}), and 16% (138 vs. 117 bu ac^{-1}) higher than the glyphosate-tolerant hybrid at the medium population. Row spacing had little effect on yields. Corn yields did not always increase with increased populations. Row spacing had no effect on weed biomass; however populations had a small effect. At two locations leaf area index values of the twin row pattern were 13% (3.1 vs. 2.7 ft^2 ft^{-2}) and 10% (3.3 vs. 3.0 ft^2 ft^{-2}) higher than the standard row pattern. Leaf area index generally increased with increased plant populations and twin row configurations. Twin row corn resulted in a faster canopy closure, but corn yields were not increased by row pattern.

INTRODUCTION

Weeds compete with crops for moisture, light, and nutrients, which can lead to poor crop development and reduced yields (Dalley et al., 2004). The acreage of transgenic crops, including glyphosate-resistant technology, has increased in recent years (Padgette et al., 1995). Glyphosate allows producers to control broadleaf weeds, and annual and perennial grasses, which eliminates the need for multiple herbicide applications. This technology provides a window for postemergence application, but correct timing is essential to prevent yield loss (Krausz et al., 2001).

In addition to the use of herbicides, narrow row crop production might increase yields and reduce weed populations. Farmers in many areas of the southeastern United States are already using narrow rows for corn, cotton (*Gossypium hirsutum* L.), and soybeans (*Glycine max* L.) (Karlen et al., 1987). Decreased space between rows allows the crop to utilize sunlight more efficiently (Bullock et al., 1998). Yield increases in soybeans have been attributed to more efficient interception of sunlight and increased rates of photosynthesis attributable to an increased leaf area index (Lambert and Lowenberg-DeBoer, 2001).

While yields may increase, some cases have shown that the increase is insignificant compared to the cost of conversion (Lambert and Lowenberg-DeBoer, 2001). An alternative to planting narrow rows, while maintaining many of the benefits, is twin rows. Unlike narrow rows, which are planted in uniform spaces, twin rows are 7.5" to 8" rows centered on traditional row spacings (Hurt et al., 2003). A wide variety of crops, including corn, cotton, and peanuts (*Arachis hypogea* L.) are now under research in twin-row production systems (Lanier et al., 2004). While increased leaf area index in twin rows may not occur as quickly as narrow rows, they do provide more rapid canopy closure than conventional single spaced rows (Hauser and Buchanan, 1981). From an economical standpoint, twin rows may provide a decrease in cost per acre, since they can be harvested with the same equipment used to harvest conventional rows. The objective of this study was to examine the effects of hybrid, row pattern, and plant population on leaf area index, weed biomass, and corn grain yield.

MATERIALS AND METHODS

This study was conducted during the 2005 growing season at the Gulf Coast Research and Extension Center (GCS) in Fairhope, AL on a Malbis sandy loam (fine-loamy, kaolinitic, thermic Typic Kandiudult); the West Florida Research and Education Center (JAY) in Jay, FL on a Red Bay sandy loam (fine-loamy, kaolinitic, thermic, Rhodic Kandiudult); the Tennessee Valley Research and Extension Center (TVS) in Belle Mina, AL on a Decatur silt loam (fine, kaolinitic, thermic Rhodic Paleudult); and the Wiregrass Research and Extension Center (WGS) in Headland, AL on a Dothan sandy loam (fine-loamy, kaolinitic, thermic Plinthic Kandiudult). The experimental design was a RCB (r=4) with a split-split plot restriction on randomization. Conventional (CN) or glyphosate tolerant (GT) hybrids were assigned to main plots, twin or single row pattern to sub plots, and low (16,000-18,000 plants ac^{-1}), medium (24,000-2,6000 plants ac^{-1}), or high (32,000-34,000 plants ac^{-1}) population to sub-sub plots. Sub-sub plot dimensions for GCS and TVS were 50' long by 10' wide. Single rows were spaced 30" apart and twin rows were spaced 7.5" apart on 30" in centers. Plot dimensions for JAY and WGS were 50' long by 12' wide. Single rows were spaced 36" apart and twin row were spaced 7.5" apart on 36" centers.

All four locations utilized a conservation system that included a rye (*Secale cereale* L.) cover crop planted in October or November of 2004. Cover crops were terminated with glyphosate prior to planting and plots in-row sub-soiled. Dates that correspond to specific planting, spraying, harvesting, and sampling times for each location are summarized in Table 1. Atrazine and metolachlor were applied to CN treatments prior to plant emergence. Post-emergence applications of atrazine for the CN variety were used as needed until theV7 growth stage. Glyphosate was applied to GT plots within three weeks of planting at GCS and WGS, and approximately 6 weeks after planting at JAY and TVS.

Weed biomass samples were taken prior to any post-emergent herbicide applications at all locations. Three samples were randomly collected from each plot under yield rows using a 2.69 ft^2 square. Samples were grouped by plot and oven dried at 131°F for 48 hours, prior to weighing. Leaf area index readings were taken at three different times prior to canopy closure. Samples were taken using a LI-COR 2000 Plant Canopy Analyzer (LI-COR, Inc., Lincoln, Nebraska). Corn was harvested during August or September of 2005 using a mechanical combine except for Jay, FL, where 10 ft sections were harvested at 2 different locations within each plot due to severe lodging damage caused by Hurricane Dennis.

Leaf area index, weed biomass, and grain yield were subjected to mixed models analysis of variance as implemented in the SAS® procedure MIXED (http://support.sas.com/onlinedoc/913/docMainpage.jsp). Data were analyzed with location as a fixed effect in the model, and there were significant location × treatment interactions for all response variables. Therefore, data were analyzed by location. Fixed effects, and interactions were considered different if $P > F$ was equal to or less than 0.1.

RESULTS AND DISCUSSION

No difference was observed between hybrids for leaf area index when averaged across row patterns and plant populations. At WGS and TVS, the twin row pattern provided a greater leaf area than the single row pattern when averaged across hybrids and plant populations (Figure 1). At all four locations, leaf area was highest in the highest plant populations when averaged across hybrids and row patterns (Table 2). A significant interaction between row pattern and plant population was observed at WGS, when averaged across hybrids. The twin row pattern produced a higher leaf area (3.67 vs. 3.28 ft^2 ft^{-2}) at the high plant population compared to the single row pattern. This supports previous research stating that a decrease between row widths and increased populations allow the crop to utilize sunlight more efficiently (Bullock et al., 1998).

Significant differences among weed populations were observed across hybrids, when averaged across row patterns and plant populations. At JAY and TVS, less weed biomass was observed in the CN hybrid plots compared to the GT hybrid. Reduced weed biomass can be attributed to the pre-emerge addition of metolachlor on all CN treatments. While some studies have shown effective control of weeds with narrow rows (Forcella, et al. 1992; Teasdale, 1995), no significant differences were observed between row patterns in our study. Previous studies attributed weed control to quicker canopy closure; however, seeding plants in twin row patterns may not provide canopy closure fast enough for effective control during the critical period for weed control. Our study may also underestimate the effect of twin rows since weed populations were very low at all locations during the early growing season.

A significant difference was observed for weed biomass across plant populations. At GCS, the medium population resulted in a lower weed biomass (38.48 vs. 62.08 lbs ac^{-1}) compared to the low population. No difference was observed between the medium and high plant population. Results for plant populations appeared similar at other locations, though not significant. This suggests that planting at low populations increases competition between corn and early season weeds.

At TVS, the CN hybrid yielded (141 vs. 135 bu ac^{-1}) significantly higher than the GT hybrid. Though not significant at other locations, the CN hybrid also yielded higher than the GT hybrid. While weed biomass was reduced during the critical period of control for the CN hybrid, it is doubtful that weed populations affected grain yields.

Grain yield was affected by row pattern at one location when averaged across hybrids and plant populations (Table 3). At JAY, the single rows yielded (128 vs. 119 bu ac^{-1}) significantly higher than twin rows. Grain yields between the twin and single rows varied among the other locations. An interaction was also observed at JAY between row patterns plant population (Table 3). Single rows produced significantly higher yields (143 vs. 117 bu ac^{-1}) than twin rows at the high plant population. A significant interaction between row pattern and plant population was observed at WGS where the twin row pattern yielded higher (145 vs. 125 bu ac^{-1}) than the single row pattern at the high plant population (Table 3).

Grain yields were different across plant populations at all four locations, but the high population did not always result in the highest yields. At TVS, JAY, and GCS differences were only observed between the low and medium populations (Table 4). At WGS, differences were observed between the low and medium, as well as the medium and high plant populations (Table 4). The WGS location was the only location where plots were irrigated (4.5 inches of water over the growing season). This supports previous results indicating available moisture may support higher yields in high plant densities and populations (Lambert and Lowenberg-DeBoer, 2001).

Significant interactions between hybrid and row pattern were observed at two locations when grain yields were averaged across populations (Table 3). At JAY and WGS, the CN hybrid yielded higher than GT hybrid across single rows (Figure 2). No differences were observed between hybrids across twin rows. A significant interaction was also observed between hybrid and plant population at three locations when grain yields were averaged across row patterns. At JAY, TVS, and WGS, the CN hybrid yielded 15% (138 vs. 117 bu ac^{-1}), 12% (158 vs. 139 bu ac^{-1}), and 16% (138 vs. 117 bu ac^{-1}) higher than the GT hybrid at the medium population (Table 5). At WGS, the CN hybrid was significantly higher than the GT hybrid at low plant populations. These reductions in yield associated with the GT hybrid support the yield drag previously reported for transgenic crops (Carey and Kells, 1995).

CONCLUSIONS

The CN hybrid tended to yield as well or higher than the GT hybrid across all four locations. There was some evidence that twin row patterns increase leaf area index; however there was little evidence to support any effect on weed populations or grain yield. It was noted that available moisture might be the controlling factor for increasing grain yield in twin row patterns. Plants seeded at high rates (32,000-34,000 plants ac^{-1}) have the highest leaf area index, while plants seeded at medium rates (24,000-26,000 plants ac^{-1}) appear to have an optimal effect on grain yield. Since early season weed populations were so low, more research is needed to determine if twin row patterns might have more effect on early season weed populations.

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Table1. Dates corresponding to planting, spraying, harvesting, and sampling times for weed biomass and leaf area index measurements during the 2005 growing season at four experimental locations.

		Herbicides				LAI†			
Location	Planting	Date	Application	Rate	Weed biomass	Time 1	Time 2	Time 3	Harvest
GCS	3/24/05	3/25/05	Metolaclor (CN)‡	1.5 pt ac^{-1}	4/14/05	5/16/05	5/25/05	6/10/05	8/19/05
		4/15/05	Glyphosate (GT)§	24 oz ac^{-1}					
		5/13/05	Atrazine (CN)	2.0 qt ac^{-1}					
JAY	3/16/05	3/17/05	Metolaclor (CN)	1.0 pt ac^{-1}	4/14/05	5/19/05	5/25/05	6/10/05	8/1/05
		4/15/05	Atrazine (CN)	1.5 qt ac^{-1}					
		5/16/05	Glyphosate (GT)	22 oz ac^{-1}					
TVS	4/15/05	4/15/05	Metolaclor (CN)	1.0 pt ac^{-1}	5/27/05	5/29/05	6/15/05	6/25/05	9/22/05
		4/15/05	Atrazine (CN)	1.8 qt ac^{-1}					
		6/9/05	Glyphosate (GT)	22 oz ac^{-1}					
WGS	3/21/05	3/22/05	Metolaclor (CN)	1.5 pt ac^{-1}	4/11/05	6/1/05	6/6/05	6/13/05	9/12/05
		4/11/05	Atrazine (CN)	2.0 qt ac^{-1}					
		4/15/05	Glyphosate (GT)	32 oz ac^{-1}					

†LAI; Leaf area index
‡CN; Conventional variety
§GT; Glyphosate-tolerant variety

Table 2. Population effect on leaf area index when averaged across hybrid and row pattern for all four locations during the 2005 growing season.

Population	GCS	JAY	TVS	WGS
	----------------------	ft^2 ft^{-2}	----------------------	
Low	1.38c†	1.65c	2.89c	2.15c
Medium	1.78b	1.95b	3.26b	2.41b
High	2.04a	2.15a	3.48a	2.86a

†Means within a location followed by the same letter are not significantly different according to Fisher's Protected LSD at $p \leq 0.10$.

Table 3. Analysis of variance on fixed effects and interactions for grain yield at all locations during the 2005 growing season.

		Analysis of Variance (P>F)			
Fixed effect	df	GCS	JAY	TVS	WGS
Hybrid	1	0.9300†	0.1073	0.0709	0.1081
Row pattern	1	0.1174	0.0820	0.5515	0.2560
Hybrid×Row pattern	1	0.5130	0.0059	0.1308	0.0631
Population	2	0.0004	0.0017	0.0002	0.0001
Hybrid×Population	2	0.6713	0.0561	0.0062	0.0341
Row pattern×Population	2	0.2953	0.0020	0.1932	0.0281
Hybrid×Row pattern×Population	2	0.7166	0.1160	0.7560	0.5667

†Fixed effects and interactions were considered different if P>F was equal to or less than 0.1

Table 4. Population effect on grain yield when averaged across hybrid and row pattern for all four locations during the 2005 season.

Population	GCS	JAY	TVS	WGS
	----------	bu ac^{-1}	----------	----------
Low	105b†	114b	118b	113c
Medium	135a	127a	149a	128b
High	134a	129a	148a	150a

†Means within a location followed by the same letter are not significantly different according to Fisher's Protected LSD at $p \leq 0.10$.

Table 5. Grain yields measured for each hybrid and plant population for all four locations during the 2005 growing season.

Population	Hybrid	GCS	JAY	TVS	WGS
		----------	bu ac^{-1}	----------	----------
Low	CN†	107a‡	114a	121a	124a
	GT§	103a	114a	115a	101b
Medium	CN	135a	138a	158a	138a
	GT	134a	117b	139b	117b
High	CN	132a	131a	145a	142a
	GT	137a	127a	152a	152a

†CN; conventional variety
§GT; glyphosate-tolerant variety
‡Means within location and population followed by the same letter are not significantly different according to Fisher's Protected LSD at $p \leq 0.10$.

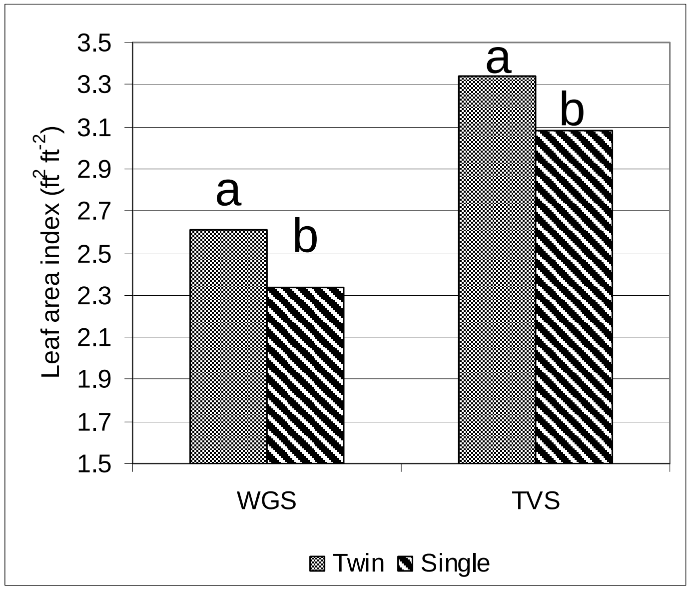

Figure 1. Leaf area index for row patterns at two locations.

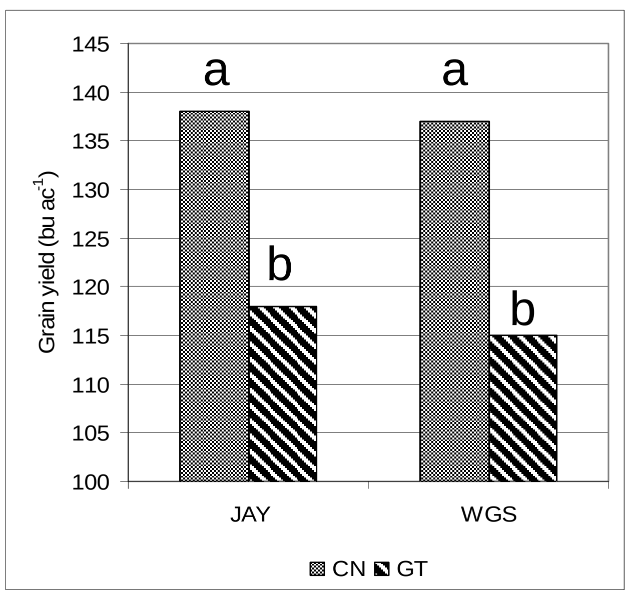

Figure 2. Grain yield for hybrids in single row patterns when averaged across populations at two locations.