CROP RESPONSE FOLLOWING A TALL FESCUE SOD AND AGRONOMIC CROPS IN REDUCED TILLAGE

W. L. Drake, D. L. Jordan, M. Schroeder-Moreno, Y. J. Cardoza, and J. L. Heitman, North Carolina State University, Raleigh

Abstract

Sod-based production systems have been successful in the southeastern and mid-Atlantic regions of the United States as an alternative to conventional tillage systems. However, research comparing these systems in North Carolina is limited. Therefore, research was conducted at four locations in North Carolina to compare corn, cotton, peanut, and soybean yield when these crops were strip tilled following four years of continuous tall fescue versus four years of either corn or cotton grown in no tillage or strip tillage. Cotton yield was higher following tall fescue compared with yield following agronomic crops. In contrast, yield of corn was lower following tall fescue compared with agronomic crops while peanut and soybean yields were not affected by previous cropping history. Additional treatments in peanut included conventional tillage following both cropping systems, and pod yield was lower when peanut was strip tilled into either tall fescue or residue from corn or cotton compared with conventional tillage systems. No major differences in soil bulk density at depths of 0 to 8 cm or 8 to 16 cm were noted when comparing tall fescue or agronomic crops either in strip tillage or non-tilled zones. Populations of soil parasitic nematodes were often lower in peanut following tall fescue than when following agronomic crops. These experiments indicate that sod-based systems may be an effective alternative to reduced tillage systems, especially for cotton. Yield benefits in 2009 were not observed for peanut or soybean and corn was negatively affected by tall fescue. However, in 2010 when corn was the only crop planted (in 2 of the 4 sites,) corn yield was higher following tall fescue sod (and one year of agronomic crops in 2009) compared with agronomic crops from 2005-2009.

Introduction

The need to incorporate environmentally sustainable and economically feasible practices into crop production systems in the southern United States has increased interest in developing best management practices that include effective crop rotations and reduced tillage systems. Crop rotation is effective in managing pests in a variety of crops (Anderson et al., 2006). Additionally, crop rotation is important in maintaining long-term soil productivity. Although economic feasibility of sod-based cropping systems is limited in some regions, including one or more years of an appropriate sod can reduce peanut disease (Bowen et al., 1996 *Peanut Sci.*; Hagan et al., 2003 *Proc. Sod-Based Cropping Sys.*; Siri-Prieto et al., 2009 *Agron. J.*). Sod can also improve soil physical and biological characteristics and subsequent crop yield, especially when compared with conventional tillage systems (Hagan et al., 2003; Reeves 1997 *Soil Tillage Res.*; Varvel, 1994 *Agron. J.*; Siri-Prieto et al., 2009). Most research in the southern United States has focused on cotton and peanut response to sod-based rotation systems, while information on the response of corn and soybean to these systems is limited. One experiment with sod-based rotation was conducted in southeastern Virginia in 2004-2007 using orchardgrass and tall fescue as sod treatments (Weeks, 2008 *VPI&SU MS Thesis*). Eight different crop rotation combinations including tall fescue, orchardgrass, cotton, peanut, corn, and soybean were established in 2004 and yields were recorded in subsequent years. Yields of cotton and peanut were higher following either orchardgrass or tall fescue than following agronomic crops in the final year of the experiment (Weeks, 2008). Implementation of sod-based systems could provide a more sustainable alternative to current production systems. Perennial grasses such as tall fescue grow relatively well in the coastal plain of North Carolina and have potential to be a good source of forage or hay for livestock. However, documentation of the positive and negative attributes of these crops in agronomic production systems is limited in North Carolina. Therefore, research was conducted to compare yield response of corn, cotton, peanut, and soybean planted after four years of continuous tall fescue versus cropping systems that included corn and cotton and to determine if changes in soil bulk density and soil parasitic nematode populations occurred as a result of previous cropping system and tillage in peanut.

Table 1. Crops planted in trials conducted at Edenton, Lewiston-Woodville, Rocky Hock, and Rocky Mount from 2004 through 2010. Tall fescue sod was present in adjacent plots from fall 2004 through fall 2008.

Location	2004	2005	2006	2007	2008	2009*	2010
Edenton	Peanut	F. corn	Cotton	S. corn	Cotton	Multiple	-
Lewiston-Woodville	F. Corn	Cotton	Corn	Cotton	Cotton	Multiple	F. Corn
Rocky Hock	Peanut	S. corn	Cotton	Cotton	S. corn	Multiple	-
Rocky Mount	Peanut	F. Corn	Cotton	F. Corn	Cotton	Multiple	F. Corn

*Corn, cotton, peanut, and soybean planted at Edenton, Lewiston-Woodville, and Rocky Mount. Cotton and peanut planted at Rocky Hock.

Materials and Methods

The experiment was conducted at four locations in eastern North Carolina in fields typical for cotton and peanut production. From 2004-2008, cropping system treatments consisted of continuous tall fescue compared with reduced tillage production of cotton, field corn, or sweet corn depending upon location and year (Table 1, see photographs for examples). In 2009, corn, cotton, peanut, and soybean were planted following both cropping systems depending on location (see bottom photograph for example). Soil at the Peanut Belt Research Station located near Lewiston-Woodville was Norfolk loamy sand. At the Upper Coastal Plain Research Station located near Rocky Mount, soil consisted of a mix of Rains loamy sand and Goldsboro loamy sand. Soil near Edenton was Perquimans silt loam while soil near Rocky Hock was a Valhalla fine sand. Plot size at all locations was at least 16 rows wide (91-cm spacing) by 23 to 32 m long. These plots included either tall fescue (Kentucky 31, endophyte-free) established in the fall of 2004 in four randomly assigned areas of the field at Edenton, Rocky Hock, and Rocky Mount and in three areas of the field at Lewiston-Woodville. A similar number of plots were established without tall fescue and were planted with agronomic crops (Table 1). Nitrogen at 110 kg ha^{-1} as ammonium nitrate was applied to tall fescue in April of each year at all locations. Nitrogen for corn (170 kg ha^{-1}) and cotton (70 kg ha^{-1}) was applied each year within three weeks after planting. A broadcast application of 350 kg ha^{-1} ($N\text{-}P_2O_5\text{-}K_2O$) was included each year to corn and cotton. No fertilizer was applied to tall fescue other than N during the duration of the experiment. In fall 2008, glyphosate was applied at 0.84 kg ae ha^{-1} to kill the tall fescue. In mid March 2009, a repeat application of glyphosate was made to ensure tall fescue was killed and to control existing winter vegetation in crop stubble from corn or cotton. Glyphosate was also applied within two weeks of planting all summer crops at each location. Crops were not irrigated. In 2010, corn was planted in all plots at Lewiston-Woodville and Rocky Mount. On-farm locations were not continued after 2009.

Data for corn, cotton, peanut, and soybean yield from 2009 and corn yield from 2010 were subjected to ANOVA for a three or four (location) by two (cropping system) factorial arrangement of treatments. Means for significant main effects and interactions were separated using Fisher's Protected LSD Test at $p \leq 0.05$ using the general linear model procedure of SAS V 9.1 with locations considered random effects and cropping system and tillage considered fixed effects (SAS, 2006 *GLM Procedure*).

Results and Discussion

Corn and cotton yield in 2009 were affected by the main effect of cropping system but not the interaction of location by cropping system (Table 2). Soybean and peanut yields were not affected by the main effect of cropping system or the interaction of location by cropping system (Table 2). Corn yield was lower following tall fescue compared with planting following agronomic crops (Table 2). In contrast, cotton yield was higher following tall fescue compared with planting behind other agronomic crops (Table 2). Weeks (2008) and Katsvario et al. (2006, 2007 *Agron. J.*) both found yield increases in cotton and peanut following sod-based systems. Corn yield could have been decreased due to immobilization of nitrogen by microbial organisms (Panikov, 1999 *Applied Soil Ecol.*). A higher amount of residue from the four years of tall fescue most likely was present compared with the strip tillage into stubble from agronomic crops. Even though the tall fescue was killed in the fall or winter of the previous year, microbial activity is driven by temperature and moisture (Panikov, 1999), and cooler temperatures may have minimized decomposition. Subsequently, in the spring when the temperature increased and rainfall was adequate, N intended for corn was immobilized by microorganisms resulting in less than optimum soil N for corn. In other research corn yield was lower when planted the year following bahiagrass with the lower yield attributed to immobilization of N (Wright, D. L., personal communication, University of Florida). However, the same N rate was applied to cotton in both tall fescue and agronomic crop systems, and a yield increase was noted for cotton only following tall fescue. Although not substantiated in this research, cotton has a tap root that can access nutritional resources deeper in the soil than corn or tall fescue which both possess fibrous root systems. This may have helped cotton overcome any potential negative effects of immobilization of N on crop yield. In contrast to results in 2009, corn yield was higher when corn followed tall fescue (2004-2008) and one year of agronomic crops (2009) compared to yield following agronomic crops from 2004-2009 (Table 2). These data suggest that issues associated with lower yield of corn following tall fescue in 2009 did not have an impact in 2010. The positive response of corn to the previous tall fescue crop could have been associated with crop rotation (advantage of tall fescue reducing plant parasitic nematode populations, data not presented) or improvements in water holding capacity following 4 years of tall fescue under the dry conditions experienced at both locations during 2010. In contrast, rainfall was generally adequate for good crop growth during 2009 .

Data presented here indicate that tall fescue sod may be an effective alternative to reduced tillage systems, especially for cotton. However, benefits were not observed for peanut or soybean and corn was negatively affected by tall fescue sod, at least the year immediately following sod termination. Additionally, the economic value of the having agronomic crops versus tall fescue must be considered to determine the full potential of a tall fescue sod in North Carolina.

Note: With the exception of results from 2010, a more complete listing of citations and details of this study and results will be published in *Agronomy Journal* in the final issue of 2010. Additional results include comparisons of bulk density and populations of soil parasitic nematodes as well as comparison of pest reaction and yield of peanut in conventional versus reduced tillage systems following both agronomic crops and tall fescue.

Acknowledgements

The North Carolina Peanut Growers Association, Inc., the National Peanut Board, and the USAID Peanut CRSP (grant LAG-G-00-96-0013-00) provided financial support. Dewayne Johnson, Michael Williams, and staff at the Peanut Belt Research Station and the Upper Coastal Plain Research Station provided technical assistance. Appreciation is expressed to Lin and Ed Jordan for allowing one experiment to be conducted on their farm and to the facility manager at the Chowan County Learning Center for allowing the experiment to be conducted on their property. Appreciation is also expressed to Joseph E. Harrell, Robert Harrell, C. Y. Parrish, III, Russell Byrum, and Adam Bunch for performing tillage and production operations during the course of the on-farm experiments.

Table 2. Influence of prior cropping system on lint yield of cotton, grain yield of corn and soybean, and pod yield of peanut in 2009 after four years of agronomic crops vs. four years of tall fescue sod (2009) and corn yield in 2010 after four years of tall fescue and one year of agronomic crops vs. agronomic crops for five years.

	2009			Corn	
Crops (2004-2008)	Cotton	Peanut	Soybean	2009	2010
	kg ha^{-1}				
Agronomic crops	750	4530	2630	9710	4260
Tall fescue sod	910	4680	3000	8220	5500
P > F	0.003	0.379	0.081	0.027	0.001

*Data for cotton and peanut are pooled over four locations in 2009. Data for corn and soybean are pooled over three locations in 2009. Data for corn in 2010 are pooled over two locations.