LONG-TERM TILLAGE AND POULTRY LITTER APPLICATION IMPACTS ON CROP PRODUCTION IN NORTHEASTERN ALABAMA

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ABSTRACT

Conservation tillage, manure application, and crop rotations are thought to increase yields compared to conventional monoculture (continuous cropping system without rotation) tillage systems. The objective of this study was to evaluate cropping sequences of corn with a wheat cover crop and corn with a wheat cover crop following a soybean rotation in conventional, strip, and no-tillage systems with poultry litter additions to the wheat cover crop. Thus, a field study was conducted at the Sand Mountain Substation in the Appalachian Plateau region of Northeast Alabama, USA, on a Hartselle fine sandy loam (fine-loamy, siliceous, subactive, thermic Typic Hapludults). In 1980, the corn cropping systems were initiated with three different tillage treatments (conventional, strip, and no-tillage). Poultry litter treatments were added in 1991. Poultry litter was applied in the fall of each year to the wheat cover crop at a rate of 50 lb N acre^{-1}. Wheat not receiving poultry litter received an equal amount of inorganic N. The corn crop was fertilized in the spring with 50 lbs N acre^{-1} at planting followed by 150 lbs N acre^{-1} applied approximately 3 weeks following emergence. Corn grain yields were influenced by tillage in 1991, 1992, 1993, 1994, 1996, 1997, 1998, and 2001 with conventional tillage producing the greatest yields except in 1993 (strip tillage) and 2001 (no-till). Increases in grain yield from poultry litter addition were observed in 1991, 1997, and 1998. Crop rotation increased corn grain yield in all years except 2001. Corn crops following soybean rotation provided the most consistent yield increase for the 9 yr study. Thus suggesting, crop rotations should be implemented into corn production systems in order to produce sustainable crop production.

INTRODUCTION

Adoption of conservation tillage systems has increased during the last two decades. These practices can increase surface organic matter (Edwards et al., 1988), which increases the level of macronutrients (Ca, P, K, and Mg) and micronutrients (Mn, Zn, and Cu) (Edwards et al., 1992, Watts et al., 2010) in soil. Also, less soil disturbance under conservation tillage systems improved soil physical properties, which increases water infiltration, water retention, soil aggregates, and decreases bulk density. Conservation tillage has been shown to improve soil structure and fertility while resulting in increases in crop yield (Triplett and Dick, 2008).

Poultry litter utilization has also been shown to increase SOM and yield (Nyakatawa et al., 2000a and Nyakatawa et al., 2000b). Alabama is one of the leading states in the US in broiler production (Reddy et al., 2008). The resulting broiler litter can serve as a relatively inexpensive source of nutrients for row crop production (Nyakatawa and Reddy, 2002).

Crop rotation can also increase yields. For instance, crop rotations can provide better weed control, interrupt insect and disease cycles, and improve crop nutrient use efficiency (Karlen et al., 1994). When grown in rotation, corn grain yields were 10 to 17% greater than under continuous corn (Higgs et al., 1990). Significant yield increases for corn grown in rotation have also been observed in experiments where N, P, and K soil test levels were high and pest populations were managed (Copeland and Crookston, 1992). Thus, crop rotations can have a positive influence on yield.

Few studies have investigated crop rotation and manure/litter application under conservation tillage systems in the southeastern United States. However these studies have typically been evaluated in 2–5-yr studies (Nyakatawa et al., 2001; Balkcom et al., 2005; Tewolde et al., 2008). Evaluation of long-term studies is vital for examining the sustainability of cropping or land management systems (Greenland, 1994). For instance, long-term studies allows for better evaluation of how year to year variability in environmental factors will impact crop yields (Grover et al., 2009). The objectives of this study were to determine the impact of tillage, poultry litter application, and crop rotation has on corn grain yield during 9 growing seasons.

MATERIALS AND METHODS

Site Description

The study was initiated in fall of 1979 at the Sand Mountain Research and Extension Center in the Appalachian Plateau region of northeast Alabama near Crossville, AL (34°18'N, 86°01'W). The soil was a Hartsells fine sandy loam (fine-loamy, siliceous, subactive, thermic Typic Hapludults). Climate in this region is subtropical with no dry season; mean annual rainfall is 52 inches, and mean annual temperature is 61ºF (Shaw, 1982). Prior to initiation of field study in 1980, the site had been under intensive row crop production for more than 50 years.

Experimental Design and Treatments

The experiment was a split-split plot design with a randomized complete block arrangement of three tillage treatments (initiated in 1980), two crop rotations (continuous corn and corn soybean rotation) and two fertilization treatments (initiated in 1991) for which there were four blocks. The main plots were tillage, the split plots were rotations, and the split-split plots were fertilization. The cropping system was a corn (*Zea mays* L.) system. Each plot consisted of four rows with 3ft spacings. The tillage treatments consisted of conventional tillage (CT; moldboard plow and disking followed by rototiller in the spring), no-tillage (NT; planting into crop residue with a double disk-opener planter), and strip tillage (Planting behind a strip till shank to a 1ft depth). Rotation treatments were continuous corn-wheat cover, corn-wheat cover-soybean-wheat cover, and soybean-wheat cover-corn-wheat cover. The rotational treatments alternated each year in order to evaluate the impact crop rotation had on corn yield each year. Corn was planted each year in mid April after the wheat cover and harvested in mid September for grain yield.

At planting in the fall, 50 lbs N acre^{-1} as NH_4NO_3 and poultry litter was applied to wheat. Corn received 50 lbs N acre^{-1} at planting and an additional 150 lbs N acre^{-1} as NH_4NO_3 (no poultry litter was applied to corn) 2 to 3 wk after emergence. No fertilizer was applied to the soybean plots. Both poultry litter and NH_4NO_3 were surface broadcasted by hand. Dolomitic lime and KCL (0-0-60) were applied in the fall according to Auburn University Soil Test recommendations. Lime and K application rates varied across years, but all plots received the same amount when applied. The middle two rows were harvested for grain yield using a combine and moisture adjusted to 150 g kg^{-1}.

Statistics

The experimental design was a split-split plot design with four replications. Tillage was the main plot, rotation was the split plot, and litter vs. no litter was the split-split plot. Corn grain yield analysis was performed using the Mixed procedure of SAS (Littell et al., 1996). A significance level of $P < 0.10$ was established.

RESULTS AND DISCUSSION

Corn grain yields were significantly increased by rotation in all years except 2001. Although, no significant differences we observed in 2001, rotating the crops increased grain yields compared to yields without a rotation. Significant corn grain yield increases in 8 out of the 9 years evaluated which suggests that crop rotations are needed in corn production systems to increase and maintain sustainable yields. Addition of poultry litter to the wheat cover crop significantly influenced corn yields in 1991, 1997, and 1998. Although not significant, poultry litter addition increased grain yields in 7 out of the eight years. Tillage significantly influenced corn yield in 1991, 1992, 1993, 1994, 1996, 1997, 1998, and 2001. In the eight years that tillage was significantly different, conventional tillage produced the highest yields 6 out of the eight and no-tillage and strip tillage both had the highest yield 1 year. There was a significant tillage x litter effect in 1992 and 1998, with conventional tillage with poultry litter producing the highest grain yields. Overall, crop rotation had the greatest impact on corn grain yields as evidenced by a more consist impact on yield compared to tillage and litter application.

CONCLUSIONS

Results from this study show that crop rotations are very important in corn production systems in the Southeast. Corn rotation with soybean had the most consistent increase in yield compared to continuous corn without a rotation. Corn grain yield response was greater with crop rotation compared to tillage and poultry litter application. Although less effective than crop rotation, poultry litter addition had a positive impact on corn grain yield.

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Table 1. Effects of tillage, poultry litter applicaton, and crop rotation on corn yields for 1991 through 2001.

Tillage system	fertilzer treatment	1991	1992	1993	1994	1995	1996	1997	1998	2001	9 yr mean
						Yield of Corn					
						Continuous corn					
No tillage	litter	6627.4	7780.15	3638.24	7528.47	4492.27	5250.91	6565.45	1968.05	12690.25	6282.354
	no litter	4974	9142.28	22997.23	7837.59	5090.97	5114.76	5038.33	2200.03	10894	8143.243
Strip tillage	litter	5039.63	9154.06	4582.75	5946.82	6078.27	6078.27	6519.03	2980.19	10004.76	6264.864
	no litter	4492.17	8308.68	4099.67	6433.32	5651.45	5618.18	5573.15	3071.77	9046.6	5810.554
Conventional tillage	litter	6847.42	9677.79	3354.24	8131.68	6038.03	8148.1	8383.38	6235.43	10749.86	7507.326
	no litter	5558.2	8370.98	3750.81	8104.13	5920.41	8472.99	6750.74	5741.17	11508.44	7130.874
						Corn-soybean rotation					
No tillage	litter	5971.86	6258.57	4701.07	7573.29	6675.01	7880.33	6748.05	6744.79	13152.32	7300.588
	no litter	5636	8833.8	4520.83	7956.37	6560.66	7390.11	6874.99	5877.01	11646.74	7255.168
Strip tillage	litter	6400.72	10894.39	6414.62	8400.26	6788.94	8179.66	8451.15	6867.21	12190.77	8287.524
	no litter	5661.97	11196.8	4884.1	7596.98	7158.51	7358	8511.61	5241.28	10687.86	7588.568
Conventional tillage	litter	7019.04	11082.01	4544.82	9194.6	6407.52	9509.98	8776.9	7594.77	10409.21	8282.094
	no litter	6474.46	10881.15	4240.54	8228.12	6116.94	9317.62	7512.95	7009.61	9393.89	7686.142
LSD (0.10) Tillage (T)		0.0651	0.0050	0.0745	0.0350	0.3518	<0.0001	0.0218	<0.0001	0.1085	
LSD (0.10) Rotation (R)		0.1007	0.0116	0.0082	0.0413	0.1090	<0.0001	0.0041	<0.0001	0.5380	
LSD (0.10) Fertilizer (F)		0.0255	0.4594	0.2719	0.7967	0.9938	0.2052	0.0560	0.1037	0.0156	
LSD (0.10) Cover x Tillage		0.3992	0.1779	0.6036	0.3721	0.9704	0.6892	0.2559	0.1995	0.6280	
LSD (0.10) Cover x Litter		0.3775	0.0060	0.8693	0.2041	0.3518	0.1890	0.2068	0.1000	0.1917	
LSD (0.10) Tillage x Litter		0.9186	0.0275	0.5795	0.6865	0.9001	0.4156	0.6253	0.8858	0.6542	
LSD (0.10) Rotationx Tillage x Litt		0.6988	0.9986	0.8693	0.7689	0.7388	0.8897	0.8360	0.6529	0.8303	