ENHANCING CONTINUOUS CORN PRODUCTION UNDER HIGH-RESIDUE CONDITIONS WITH STARTER FLUID FERTILIZER COMBINATIONS AND PLACEMENTS 2009

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ABSTRACT

Continuous corn production using conservation tillage systems often results in less uniform and smaller early season growth along with lower grain yields and profitability. This is especially true on fine-textured, and poorly drained soils in the northern part of the Corn Belt where decomposition of surface residues is slower and soil temps are colder. The purpose of this study was to determine the effects of fluid starter fertilizer (10-34-0 and 28-0-0, UAN) combinations and placements on second-year corn production under reduced tillage/high residue conditions. When averaged across the six starter fertilizer treatments, yields in 2009 with moldboard plow tillage (209.1 bu/A) were significantly greater than from chisel/rip tillage (197.8 bu/A) when DM yield at the V7 stage averaged 46% larger for the moldboard plowed plots. Late season moisture stress due to greater ET demand for the larger plants on the moldboard plow plots may have limited the yields and kept them from achieving their earlier high potential. When averaged across tillage systems, the starter fertilizer treatments did not produce higher yields than the no-starter control plots on this very high P-testing soil. Small plant (V7) DM was increased 42 to 114% by 10-34-0 placed in the seed furrow or dribbled on the soil surface with UAN. Uptake of N and P in the grain was generally not affected by tillage or starter fertilizer but concentrations were reduced by moldboard plow tillage due to dilution caused by greater yields. Interactions between tillage and starter fertilizer treatment were not observed for any of the measured parameters except grain moisture and plant population.

INTRODUCTION

Crop rotations in the Midwest are changing markedly due to rapid expansion of the bio-fuel industry. Because of increased demand for corn to supply the ethanol industry and increasing insect and disease challenges facing soybean producers, some farmers are switching to a corn-corn-soybean rotation and other corn intensive rotations. These rotations produce large amounts of biomass (corn stover) that often remain on the soil surface with present-day tillage systems.

Farmers who have switched to rotations where corn follows corn are concerned about yield reductions, especially when surface residue levels are high and soil temps are cooler with their current conservation tillage systems. Farmers are facing a dilemma – should they revert back to moldboard plow tillage, which greatly increases the potential for erosion but will lead to greater yields, or can they overcome the yield penalty associated with conservation tillage by using combinations of N & P fluid starter fertilizers?

The objectives of this research were to: (1) determine the effects of fluid starter fertilizer placement and combinations of 10-34-0 and 28-0-0 on second-year corn production under reduced tillage/high-residue conditions and (2) provide management guidelines on placement and rates of UAN and APP combinations for crop consultants,

local advisors, and the fertilizer industry as they serve corn producers trying to meet the growing needs for corn grain by the ethanol industry and livestock producers.

EXPERIMENTAL PROCEDURES

A field experiment was established following first year corn on a Nicollet-Webster clay loam soil complex at the Southern Research and Outreach Center, Waseca, MN in the fall of 2008. A split-plot design with four replications was used. Main plots (60' x 50') were tillage (moldboard plow vs. chisel plow) and the subplots (10' wide x 50' long) were combinations of placements and rates of fluid APP (10-34-0) and UAN (Table 1). The tillage was conducted on Nov. 16 by moldboard plowing about 9" deep and chisel-ripping about 9-10" deep with a DMI Model 2500 Disk Chisel with Tiger-point shanks. Soil tests (0-6") averaged pH = 5.2, OM = 7.0%, Bray P_1 = 21 ppm (VH) and exchangeable K = 157 ppm (H).

Gypsum was broadcast applied at a rate of 15 lb S/A and incorporated by field cultivating on April 10. Corn (DKC 57-43 VT3) was planted at 33,000 seeds/A on April 16. Various combinations of APP and UAN were either applied in the furrow with the seed or dribbled on the soil surface within 2" of the seed row. Good weed control was obtained with a pre-emergence application of Harness + Callisto on April 24. Surface residue accumulation on May 6 averaged 14% and 52% for the moldboard plow and chisel-rip treatments, respectively. Stand counts were taken on the center two rows of each plot on May 26 and were thinned slightly on June 12 to give a uniform plant population across all plots (see Table 2). Supplemental N as UAN was sidedress-injected 3" deep midway between the rows on June 1 to give a total N rate of 180 lb/A on all plots. Roundup WeatherMax was applied on June 12 to eliminate weed escapes from the pre-emergence application. On June 22 (V7-8 stage) 10 random plants from each plot were cut at ground level, dried, weighed to determine dry matter, ground and submitted for N and P analyses. Plant heights of 10 random plants per plot were also taken on June 22. Grain yields and moisture content were determined on October 28 by a combine equipped with a weigh cell and moisture sensor system. Grain samples were also dried, ground, and submitted for N and P analyses.

Growing conditions during the May-September growing season were colder than normal with monthly air temps averaging –0.4, -0.2, -5.2, and –2.5 degrees below normal in May, June, July and August, respectively. Growing degree units (GDUs) were 3%, 10%, 22%, and 11% below normal, respectively. Fortunately, September temps averaged 3.9 degrees above normal and GDUs averaged 38% above normal, bringing the cumulative GDUs for the May-September period to only 8% below normal. Not only was the 2009 growing season cool, it was very dry with a total of 11.00" for the 5-month period (9.42" below normal). This was the second driest growing season in our 95-year record. Available water in the top 5' at the start of the season was 9.05" (82% of FMC) and declined to 2.86" (26% of FMC) on Sept. 16. Eighty three percent of the available water was below 3' at that time. These cool and dry conditions likely contributed to the huge early plant growth differences but minimal grain yield differences among the starter fertilizer treatments. This was particularly true where vegetative plant growth earlier in the season was robust, which led to greater soil water use followed by lower soil water content later in the season to sustain the yield potential associated with the more robust early season vegetative growth.

RESULTS AND DISCUSSION

Early plant growth on June 22 (V7 stage) was affected by both tillage and starter fertilizer placement on this very high P-testing soil in this cool spring (Table 1). Plant height, dry matter and uptake of N and P (due primarily to greater DM) were significantly greater (P = 10% level) for the moldboard plowed plots than for the chisel/ripped plots. Concentrations of N and P in the whole-plant tissue were not affected by tillage.

The in-furrow placed, pop-up treatment (5 gal 10-34-0/A) produced greater plant height, DM yield, and N and P update compared to the no-starter control (Table 1). When APP without UAN was dribbled on the soil surface within 2" of the seed row, early DM yield and uptake of N and P were increased slightly above the no-starter control. Adding UAN at rates of 15, 30, and 45 lb N/A to the surface-applied APP increased plant height, DM, and uptake of N and P with a linear trend related to N rate. These results were quite similar to those obtained in 2008 – another cool spring. Less N was likely mineralized from the soil under the cool conditions in May and June 2009; thus greater plant growth was obtained due to a N response to the larger application rates of starter N. Although, N and P concentrations were not greatly different among the treatments, they tended to be lowest for the treatments producing larger plants, probably due to dilution.

Interactions between tillage and the starter treatments were not significant ($P \leq 0.10$) for any of the early growth parameters, but it is interesting to note that early DM yield, N uptake, and P uptake were increased over the no-starter control by 150, 107, and 144%, respectively, for the in-furrow, pop-up placement of APP when using chisel plow tillage and by 93, 78, and 66%, respectively, when using moldboard plow tillage. This highlights the need for a small amount of pop-up placed APP or other fluid fertilizer even at a very high soil test P level (21 ppm) under reduced tillage if the genetic potential for very high yields is to be realized. Under these conditions, plants without an intimate placement of starter fertilizer would have considerably less early growth and reduced yield potential than those receiving starter fertilizer.

Corn grain yield was affected significantly (P=0.10%) by tillage, with the moldboard-plowed plots yielding 11 bu/A more than the chisel/ripped plots (Table 2). However, corn grain yields were not different between the no-starter control and any of the starter APP and UAN treatments. This was surprising considering that early plant growth at V7 was increased by 42 to 114% by all APP and UAN treatments compared to the no-starter control. Greater growth for the APP and UAN treatments was observed through the R1 stage. Based on these observations, one can argue that the starter fertilizer treatments, which resulted in substantially greater early plant biomass due to the cool conditions, actually became a detriment and stress factor to greater yields because of increased soil water demand in this year when precipitation was minimal. The reservoir of available soil water was consumed to a greater extent by the larger plants, which allowed the smaller, no-starter plants with more soil water to catch up and yield similarly in this year when rainfall was yield-limiting.

Grain moisture at harvest was significantly less (2.2 points) for moldboard tillage compared to chisel/rip tillage (Table 2). However, the significant tillage x starter fertilizer interaction indicated the higher moisture content for chisel/rip tillage was primarily due to the no-starter control treatment (34.8%). Tasseling also occurred about 5 days earlier on the moldboard plowed plots. Initial plant population was reduced about 2800 plants/A (9%) by the in-furrow, pop-up APP treatment for the chisel-rip tillage system compared to no reduction for the moldboard plow system.

Nitrogen and P concentrations in the grain were significantly less for moldboard plow tillage than for chisel/rip tillage but were not affected by the starter APP & UAN treatments (Table 3). Uptake of N and P in the grain was not affected by tillage or starter APP with or without UAN, indicating that the lower concentrations in the moldboard plow treatments were due to dilution.

CONCLUSIONS

The results obtained from this third-year study were somewhat different from the 2008 study and were influenced by: a) the very high soil test P (21 ppm Bray P_1), b) the much cooler soil temps in May, June, and July, c) the relatively wet 14-day period after planting when seven rain events totaled 2.10", and d) the dry 5-month period from May 1 through September 30 when 11.0 inches of rain was received (9.4" less than normal) and stored soil moisture in the top 5' dipped to 2.86" (26% of field moist capacity). The primary conclusions are:

1) Early plant growth and uptake of N and P at the V7 stage were greater for moldboard plow tillage than for chisel/rip tillage.
2) Starter fertilizer (10-34-0, APP) either placed in the seed furrow as a pop-up or combined with UAN and dribbled on the soil surface next to the seed row increased early plant growth and uptake of N and P. Early growth was 51% greater when APP was placed as a pop-up in the furrow compared to dribbled on the surface.
3) Nitrogen and P concentrations in the small plants were correlated negatively with plant size due to dilution.
4) Grain yields were 11 bu/A greater for moldboard plow compared to chisel/rip tillage.
5) Grain yields were not affected by any of the starter fertilizer APP with or without UAN treatments regardless of tillage system.
6) An interaction between tillage system and starter fertilizer treatment did not occur for any of the measured parameters except plant stand where the in-furrow, pop-up treatment reduced stand about 2800 plants/A with chisel/rip tillage and grain moisture.
7) Grain moisture at harvest was 2.2 points drier for moldboard plow tillage compared to chisel-rip tillage, primarily due to higher moisture content of the no-starter, control treatment for chisel/rip tillage.
8) Nitrogen and P uptake in the grain was not affected by the tillage and starter treatments.

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Table 1. Whole plant growth and nutrient uptake by corn at the V7 stage as affected by primary tillage and starter fertilizer placement and rate in 2009.

				Whole Plant Samples at V7 (June 22)					
	Starter Fertilizer Treatments			Plant	DM	Concentration		Uptake	
Tillage	Placement	10-34-0	28-0-0	height	yield	N	P	N	P
		gal/A	lb N/A	inch	lb/A	%	%	--- lb/A ---	
Chisel	None	0	0	23.8	236	3.73	0.378	8.7	0.87
Chisel	Pop-up	5	0	32.7	590	3.05	0.360	18.0	2.12
Chisel	2 x 0	5	0	26.6	346	3.63	0.421	12.5	1.43
Chisel	2 x 0	5	15	30.2	372	3.64	0.348	17.2	1.65
Chisel	2 x 0	5	30	30.7	474	3.69	0.378	17.4	1.77
Chisel	2 x 0	5	45	32.3	554	3.77	0.382	20.7	2.11
Moldboard	None	0	0	30.9	430	3.76	0.401	16.3	1.71
Moldboard	Pop-up	5	0	38.4	832	3.48	0.342	29.0	2.84
Moldboard	2 x 0	5	0	34.2	600	3.73	0.387	22.5	2.33
Moldboard	2 x 0	5	15	34.9	634	3.74	0.373	23.6	2.37
Moldboard	2 x 0	5	30	36.7	708	3.67	0.367	26.0	2.59
Moldboard	2 x 0	5	45	35.1	714	3.96	0.392	28.2	2.83
Stats for RCB Design (All Treatments)									
P>F:				0.001	0.001	0.021	0.004	0.001	0.001
LSD (0.10):				2.7	136	0.33	0.029	5.3	0.54
CV (%):				7.0	20.8	7.7	6.5	22.0	22.2
Stats for Split-Plot Design (All Treatments)									
Tillage									
Chisel				29.4	446	3.58	0.378	15.7	1.66
Moldboard				35.0	652	3.72	0.377	24.3	2.45
P > F:				0.013	0.022	0.463	0.926	0.021	0.040
Starter Treatments									
None				27.4	332	3.75	0.390	12.5	1.29
Popup: 5, 0				35.6	712	3.27	0.351	23.5	2.48
2 x 0: 5, 0				30.4	472	3.68	0.404	17.5	1.88
2 x 0: 5, 15				32.5	552	3.69	0.360	20.4	2.01
2 x 0: 5, 30				33.7	590	3.68	0.372	21.7	2.18
2 x 0: 5, 45				33.7	634	3.86	0.387	24.5	2.47
P > F:				0.001	0.001	0.001	0.002	0.001	0.001
LSD (0.10):				1.7	92	0.19	0.021	3.5	0.35
Interaction Tillage x Starter treatment									
P > F:				0.257	0.901	0.437	0.125	0.871	0.996
CV (%):				6.3	19.6	6.2	6.5	20.5	19.9

Table 2. Corn production as influenced by primary tillage and starter fertilizer placement and rate at Waseca in 2009.

	Starter Fertilizer Treatments			Grain		Initial Plant	Final Plant
Tillage	Placement	10-34-0	28-0-0	Yield	H_2O	Stand	Popl'n
		gal/A	lb N/A	bu/A	%	- - - plants*10^3/A - - -	
Chisel	None	0	0	197.8	34.8	31.7	31.5
Chisel	Pop-up	5	0	199.2	32.5	28.9	28.9
Chisel	2 x 0	5	0	198.9	34.8	31.8	31.6
Chisel	2 x 0	5	15	197.5	31.8	31.2	31.2
Chisel	2 x 0	5	30	195.2	31.9	31.0	30.8
Chisel	2 x 0	5	45	198.3	31.1	32.2	31.8
Moldboard	None	0	0	210.5	31.0	31.7	31.5
Moldboard	Pop-up	5	0	211.9	29.4	31.7	31.5
Moldboard	2 x 0	5	0	209.9	30.0	33.2	32.3
Moldboard	2 x 0	5	15	208.9	30.9	32.8	32.1
Moldboard	2 x 0	5	30	209.5	31.3	33.0	32.2
Moldboard	2 x 0	5	45	203.7	31.0	32.9	32.1
Stats for RCB Design (All Treatments)							
P > F:				0.166	0.001	0.001	0.001
LSD (0.10):				NS	2.0	0.9	0.7
CV (%):				5.0	5.2	2.5	1.9
Stats for Split-Plot Design (All Treatments)							
Tillage							
Chisel				197.8	32.8	31.1	31.0
Moldboard				209.1	30.6	32.5	32.0
P > F:				0.021	0.016	0.025	0.032
Starter Treatments							
None				204.2	32.9	31.7	31.5
Popup: 5, 0				205.5	31.0	30.3	30.2
2 x 0: 5, 0				204.5	32.4	32.5	32.0
2 x 0: 5, 15				203.2	31.3	32.0	31.7
2 x 0: 5, 30				202.3	31.6	32.0	31.5
2 x 0: 5, 45				201.0	31.0	32.6	32.0
P > F:				0.959	0.161	0.001	0.001
LSD (0.10):				NS	NS	0.6	0.5
Interaction Tillage x Starter treatment							
P > F:				0.967	0.046	0.011	0.001
CV (%):				5.0	5.3	2.3	1.8

Table 3. Nitrogen and phosphorus concentration and uptake in corn grain as influenced by primary tillage and starter fertilizer placement and rate at Waseca in 2009.

	Starter Fertilizer Treatments			Grain			
Tillage	Placement	10-34-0	28-0-0	[N]	[P]	N Uptake	P Uptake
		gal/A	lb N/A	- - - - - - % - - - - - -		- - - - - - lb/A - - - - - -	
Chisel	None	0	0	1.23	0.259	115.5	24.4
Chisel	Pop-up	5	0	1.26	0.279	118.7	26.3
Chisel	2 x 0	5	0	1.25	0.260	118.1	24.6
Chisel	2 x 0	5	15	1.22	0.260	114.0	24.4
Chisel	2 x 0	5	30	1.25	0.256	115.7	23.7
Chisel	2 x 0	5	45	1.22	0.253	114.4	23.9
Moldboard	None	0	0	1.20	0.242	119.8	24.2
Moldboard	Pop-up	5	0	1.18	0.236	118.1	23.7
Moldboard	2 x 0	5	0	1.20	0.234	119.7	23.3
Moldboard	2 x 0	5	15	1.18	0.228	116.6	22.7
Moldboard	2 x 0	5	30	1.17	0.236	115.5	23.5
Moldboard	2 x 0	5	45	1.16	0.237	111.8	22.9
Stats for RCB Design (All Treatments)							
P > F:				0.001	0.154	0.838	0.904
LSD (0.10):				0.04	NS	NS	NS
CV (%):				2.6	9.4	5.6	11.6
Stats for Split-Plot Design (All Treatments)							
Tillage							
Chisel				1.24	0.261	116.1	24.6
Moldboard				1.18	0.235	116.9	23.4
P > F:				0.004	0.017	0.664	0.088
Starter Treatments							
None				1.22	0.250	117.7	24.3
Popup: 5, 0				1.22	0.257	118.4	25.0
2 x 0: 5, 0				1.23	0.247	118.9	23.9
2 x 0: 5, 15				1.20	0.244	115.3	23.6
2 x 0: 5, 30				1.21	0.246	115.6	23.6
2 x 0: 5, 45				1.19	0.245	113.1	23.4
P > F:				0.190	0.882	0.482	0.863
LSD (0.10):				NS	NS	NS	NS
Interaction Tillage x Starter treatment							
P > F:				0.488	0.811	0.920	0.955
CV (%):				2.7	9.6	5.6	12.0