ENHANCING CONTINUOUS CORN PRODUCTION UNDER HIGH-RESIDUE CONDITIONS WITH STARTER FLUID FERTILIZER COMBINATIONS AND PLACEMENTS 2008

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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 2008 with moldboard plow tillage (185.0 bu/A) were not different from chisel/rip tillage (182.5 bu/A) even though DM yield at the V7 stage averaged 36% 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. All starter fertilizer treatments produced 10-15 bu/A higher yields than the no starter control plots when averaged across tillage systems, but yields were not different among the five starter treatments. Uptake of N into the grain was greater for moldboard plow tillage and was influenced by starter fertilizer treatment. Interactions between tillage and starter fertilizer treatment were not observed for any of the measured parameters.

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 2006. 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. 6 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 = 5.1, OM = 5.8%, Bray P_1 = 26 ppm (VH) and exchangeable K = 200 ppm (VH).

Gypsum was broadcast applied at a rate of 15 lb S/A and incorporated by field cultivating on April 30. Corn (Pioneer 35F44) was planted at 35,000 seeds/A on May 9. 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 May 14. Surface residue accumulation on May 12 averaged 15% and 54% for the moldboard plow and chisel-rip treatments, respectively. Stand counts were taken on the center two rows of each plot on June 10 and were thinned slightly on June 16 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 13 to give a total N rate of 180 lb/A on all plots. Roundup WeatherMax was applied on June 14 to eliminate weed escapes from the pre-emergence application. On June 26 (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 26. Grain yields and moisture content were determined on October 16 by a combine equipped with a weigh cell and moisture sensor system.

Growing conditions during the early season were colder than normal with air temperatures averaging 42.2º in April and 55.5º in May. These were 2.7 and 2.9º cooler than normal. Growing degree units (GDUs) in May and June were 19 and 6%, respectively, below normal. September temps averaged 2.3º warmer than normal, allowing cumulative GDUs for the May-September period to almost catch up to normal (2% below normal). Rainfall for the May through September growing season totaled only 17.01" (3.41" below normal) with poor temporal distribution. Monthly rainfall received in May-July was normal to slightly above normal. In the 10-week period following a 4.2" rain event on July 17, only 4.0" of rain was received. Available soil water in the top 5' ranged from near field moist capacity (11") at silking to 4.5" (78% below 3' deep) on Sept. 16. We saw corn, which showed superb yield potential in early August, suffer moderate to severe (depending on soil type) moisture stress during grain fill in September. This was particularly true for those situations where vegetative plant growth earlier in the season was robust, which in turn required more stored soil water to meet the demand.

RESULTS AND DISCUSSION

Early plant growth on June 26 (V7 stage) was affected by both tillage and starter fertilizer placement on this very high 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 for the moldboard plowed plots than for the chisel/ripped plots. Concentrations of N (P = 10%

level) in the whole-plant tissue were not affected by tillage, but P was significantly lower in the larger plants obtained with moldboard plow 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 the APP rate was dribbled on the soil surface within 2" of the seed row, early DM yield and uptake of N and P were not different from the no-starter control. However, when 15 lb N/A was added to the surface-dribbled APP treatment, plant height, early DM yield, and uptake of N and P were similar to the in-furrow, pop-up treatment. Adding 30 or 45 lb N/A to the surface-dribbled APP treatment increased plant height, early DM yield, and uptake of N and P (due mostly to greater DM) over the 15-lb N rate. This UAN-rate effect was not found in 2007 when May soil temps were warmer. Less N was likely mineralized from the soil under the cool conditions in May 2008; 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 74, 40, and 41%, respectively, for the in-furrow, pop-up placement of APP when using chisel plow tillage and by only 27, 4 and 16%, 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 (26 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 not affected significantly (P=0.10%) by tillage, but was increased 10-15 bu/A across both tillage systems when fluid starter fertilizers were used (Table 2). Yield differences among the starter fertilizer placement positions (pop-up vs 2x0) and starter N rates were not significant, however. The fact that tillage did not affect corn yield and that an interaction between tillage and starter fertilizer was not found is surprising considering observations of the plots during the year. Early in the growing season (June and July), corn grown on the moldboard plow plots was considerably larger (35% larger on June 26) than corn on the chiseled plots. In addition, tasseling occurred about 7 days earlier on the larger, robust corn from the moldboard plots. The yield potential around August 10 was outstanding. It is our opinion that the rainfall shortage (4.15") from mid-August through September placed greater moisture stress on the larger corn because ET to maintain the larger plants was greater, thereby depleting more soil water than for the smaller, less robust corn from the chiseled plots. This stress negated the greater yield potential observed for the moldboard plowed corn, resulting in no yield and grain moisture differences between the two tillage systems. This moisture stress described above may also have penalized the yield potential of the treatments receiving 45 lb N/A with the surface dribbled 2 x 0" band treatment; these were the largest plants on June 26 but yielded 4-5 bu/A less than the lower starter N rate treatments.

Grain moisture at harvest and plant population were not affected meaningfully by either tillage or starter fertilizer (Table 2).

CONCLUSIONS

The results obtained from this second-year study were quire different from the 2007 study and were influenced by: a) the very high soil test P (26 ppm Bray P_1), b) the much cooler soil temps at the 2" depth in the 14-day period following planting (averaged 60.6ºF), c) the relatively dry 14-day period after planting when two rain events totaled 0.52", and d) the dry 75-day period from July 18 through September 30 when 4.0 inches of rain was received (4.15" less than normal) and stored soil moisture in the top 5' dipped to 3.98" (36% 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.
3) Nitrogen and P concentrations in the small plants were correlated negatively with plant size due to dilution.
4) Grain yields were not different between moldboard plow and chisel/rip tillage; probably due to the greater ET and moisture stress associated with the larger plants with moldboard plow tillage.
5) All starter fertilizer treatments, averaged across tillage systems, produced greater corn yields (10-15 bu/A) than the no-starter control treatment. Yields were not significantly different among the placement methods (in-furrow vs. 2x0") and UAN rates (0, 15, 30, and 45 lb N/A).
6) An interaction between tillage system and starter fertilizer treatment did not occur for any of the measured parameters.
7) Grain moisture at harvest and plant population were not affected by tillage or starter fertilizer.

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TWO-YEAR RESULTS

The following significant results are found in Table 3:

- Corn yields averaged across the six starter fertilizer treatments were 4 bu/A greater for moldboard plow tillage. There was no year x tillage interaction.
- Corn yields averaged across the two tillage treatments were greatest for the in-furrow pop-up treatment without starter N as UAN and the 2 x 0 surface dribble treatments that contained either 15 or 30 lb N/A as UAN. Lowest yields occurred with the 2 x surface dribble treatment and the no starter, control treatment.
- There were no tillage x starter fertilizer interactions for any of the parameters.
- Grain moisture at harvest was not affected by tillage system or starter fertilizer.

- Whole plant yield at the V7 stage was 23% greater for moldboard plow tillage and was increased from 14 to 43% by the starter treatments that were placed in-furrow with the seed or dribbled on the surface (2 x 0”) with 15 to 45 lb N/A as UAN.
- Uptake of N and P at the V7 stage was increased 22 and 19% for moldboard plow tillage compared to chisel/rip tillage.
- Year x starter fertilizer interactions occurred for early DM yield and N and P uptake at the V7 stage.

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 2008.

				Whole Plant Samples at V7 (June 26)					
	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	21.8	312	3.15	0.458	9.9	1.43
Chisel	Pop-up	5	0	28.2	542	2.59	0.383	13.9	2.02
Chisel	2 x 0	5	0	25.1	422	2.76	0.408	11.7	1.68
Chisel	2 x 0	5	15	28.3	504	2.49	0.365	12.6	1.83
Chisel	2 x 0	5	30	30.5	610	2.69	0.330	16.4	2.02
Chisel	2 x 0	5	45	31.4	708	2.73	0.333	19.3	2.36
Moldboard	None	0	0	27.6	576	2.97	0.373	17.0	2.15
Moldboard	Pop-up	5	0	32.4	730	2.41	0.343	17.6	2.49
Moldboard	2 x 0	5	0	29.3	580	2.77	0.360	16.1	2.09
Moldboard	2 x 0	5	15	32.2	690	2.63	0.333	18.0	2.29
Moldboard	2 x 0	5	30	33.3	750	2.64	0.318	19.5	2.38
Moldboard	2 x 0	5	45	33.9	852	2.75	0.328	23.3	2.78
Stats for RCB Design (All Treatments)									
P>F:				0.001	0.001	0.001	0.001	0.001	0.001
LSD (0.10):				1.6	122	0.24	0.035	2.9	0.41
CV (%):				4.7	16.8	7.4	8.2	14.6	16.0
Stats for Split-Plot Design (All Treatments)									
Tillage									
Chisel				27.5	516	2.73	0.379	14.0	1.89
Moldboard				31.4	696	2.69	0.342	18.6	2.36
P > F:				0.015	0.042	0.751	0.033	0.018	0.077
Starter Treatments									
None				24.7	444	3.06	0.415	13.5	1.79
Popup: 5, 0				30.3	636	2.50	0.363	15.7	2.25
2 x 0: 5, 0				27.2	500	2.77	0.384	13.9	1.88
2 x 0: 5, 15				30.2	596	2.56	0.349	15.3	2.06
2 x 0: 5, 30				31.9	680	2.66	0.324	18.0	2.20
2 x 0: 5, 45				32.6	780	2.74	0.330	21.3	2.57
P > F:				0.001	0.001	0.001	0.001	0.001	0.001
LSD (0.10):				1.0	76	0.14	0.025	1.9	0.25
Interaction Tillage x Starter treatment									
P > F:				0.108	0.762	0.364	0.118	0.529	0.858
CV (%):				3.9	14.9	6.2	8.0	13.9	14.0

Table 2. Corn production as influenced by primary tillage and starter fertilizer placement and rate at Waseca in 2008.

	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	174.2	23.6	35.9	34.2
Chisel	Pop-up	5	0	183.9	25.4	34.3	33.8
Chisel	2 x 0	5	0	181.5	24.6	35.0	34.0
Chisel	2 x 0	5	15	188.0	24.2	35.2	34.2
Chisel	2 x 0	5	30	187.1	23.8	35.3	34.1
Chisel	2 x 0	5	45	180.5	24.1	34.7	34.0
Moldboard	None	0	0	172.8	23.5	34.9	33.6
Moldboard	Pop-up	5	0	184.4	25.0	35.8	34.2
Moldboard	2 x 0	5	0	186.8	23.2	34.7	33.7
Moldboard	2 x 0	5	15	189.8	23.4	35.2	34.2
Moldboard	2 x 0	5	30	190.4	23.2	35.6	34.0
Moldboard	2 x 0	5	45	186.0	22.4	34.9	34.0
Stats for RCB Design (All Treatments)							
P > F:				0.104	0.294	0.359	0.345
LSD (0.10):				NS	NS	NS	NS
CV (%):				4.7	6.3	2.5	1.0
Stats for Split-Plot Design (All Treatments)							
Tillage							
Chisel				182.5	24.3	35.1	34.0
Moldboard				185.0	23.4	35.2	33.9
P > F:				0.470	0.364	0.557	0.391
Starter Treatments							
None				173.5	23.5	35.4	33.9
Popup: 5, 0				184.1	25.2	35.1	34.0
2 x 0: 5, 0				184.1	23.9	34.9	33.9
2 x 0: 5, 15				188.9	23.8	35.2	34.2
2 x 0: 5, 30				188.8	23.5	35.5	34.0
2 x 0: 5, 45				183.3	23.2	34.8	34.0
P > F:				0.011	0.082	0.630	0.605
LSD (0.10):				7.1	1.1	NS	NS
Interaction Tillage x Starter treatment							
P > F:				0.953	0.838	0.181	0.184
CV (%):				4.5	5.6	2.6	1.0

Table 3. Two-year average grain yields, grain moisture, and early DM yield, N uptake and P uptake.

	Grain		Whole plant at V7		
			DM	Uptake	
	Yield	Moisture	yield	N	P
	bu/A	%	lb/A	- - - - lb/A - - - -	
Year					
2007	177.2	16.2	770	26.9	2.89
2008	183.8	23.9	606	16.3	2.13
P>F:	0.333	0.001	0.001	0.001	0.001
Tillage					
Chisel/rip	178.5	20.2	618	19.5	2.29
Moldboard	182.5	19.8	758	23.7	2.72
P > F:	0.056	0.370	0.002	0.001	0.003
Starter Treatments					
None	174.6	19.8	532	18.6	2.12
pop-up: 5, 0	180.3	20.8	682	19.7	2.41
2x0: 5, 0	174.1	20.4	530	17.3	2.08
2x0: 5, 15	181.1	20.3	602	18.6	2.29
2x0: 5, 30	181.5	20.0	602	18.7	2.15
2x0: 5, 45	179.2	20.1	760	23.9	2.68
P>F:	0.003	0.102	0.001	0.001	0.001
LSD (0.05):	5.9	NS	64	2.0	0.26
LSD (0.10):	4.9	NS	54	1.7	0.22
CV (%):	4.6	1.0	13.1	13.4	14.9
Interactions					
Yr x Till	0.391	0.294	0.216	0.537	0.658
Yr x Starter	0.068	0.053	0.001	0.001	0.039
Till x starter	0.731	0.750	0.328	0.220	0.791
Tr x Till x Starter	0.511	0.893	0.249	0.095	0.767