Enhancing Continuous Corn Production

Fluid starter combinations used under high-residue conditions.

J. Vetsch, and Drs. D. Kaiser, and G. Randall

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Summary: *Continuous corn production using conservation tillage 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 residue is slower and soil temperatures are colder. The primary objective of this study was to determine the effects of fluid starter combinations and placements of 10-34-0 (ammonium poly phosphate [AAP]), 28-0-0 (urea ammonium nitrate [UAN]), and 12-0-0-26 (ammonium thiosulfate [ATS]) on continuous corn production in reduced-till/high-residue conditions. Crop response to treatments in 2012 varied between locations. Early plant growth (plant heights and dry matter yields) was enhanced when N, P, and S starter fertilizers as UAN, APP, and ATS were applied at both sites, but to a greater extent at Waseca. At Rochester, grain yields were reduced 6 bu/A with 4 gal/A of APP (16 lbs P2O5/A) applied in-furrow at planting, when averaged across UAN and ATS treatments. No grain yield responses to N, P, and S starter fertilizer treatments were found at Waseca in 2012.*

Crop rotations in the Midwest have changed from a traditional corn-soybean rotation to more corn-intensive rotations. Due to the expanding demand for corn to supply the ethanol industry and the increasing insect and disease challenges facing soybean producers, some farms are switching to a corn-corn-soybean rotation or, for some, continuous corn. These rotations produce large amounts of biomass (corn stover) that often remain on the soil surface with present-day tillage systems. This is good in terms of erosion control, but can be a significant problem from the standpoint of seedbed preparations, early corn growth, and yield.

Corn dominated crop rotations present a huge tillage challenge to corn producers on many poorly drained, colder soils of the northern Corn Belt because corn yields following corn are generally reduced significantly when conservation tillage practices are used.

Our 2010 research (Randall and Vetsch, Early Spring Fluid Journal of 2010) has shown many of the early growth and yield problems associated with corn after corn could be eliminated by using conventional tillage (i.e., moldboard plow) in combination with fluid starter fertilizers. Generally, for most northern Corn Belt farmers, the moldboard plow is not an option, because of increased potential for erosion, lack of equipment, or the labor/time needed to plow large acreages. This research also showed fluid starter fertilizers (APP applied in furrow or APP and UAN dribbled on the soil surface) significantly increased early growth of corn by 13 to 43 percent and corn yield by 5 to 7 bu/A. This study did not address a commonly asked question: would dual placement (APP in furrow and UAN dribbled on the soil surface) further enhance corn production?

Continuous corn generally shows slow early growth, pale spindly plants, and reduced yields with reduced tillage systems. Sulfur deficiency in corn has contributed to some of these pale looking plants. Corn yield responses to sulfur have been reported on medium and fine-textured soils in Minnesota and Iowa. In Minnesota we have very little data on the optimum rate and placement of sulfur-containing fluid starter fertilizers for corn. With increased costs and price volatility of fertilizers, farmers have questions about what products, placements, and rates give them the most “bang for the buck.”

The objectives of this 2012 study were to:

- Determine the effects of the fluid starter combinations and placement

Table 1. Precipitation at Waseca and Rochester and growing degree units (GDUs) at Waseca in 2012

	Waseca		Rochester		Waseca GDU's	
Month	2012	Normal*	2012	Normal	2012	Normal
	---------- inches ----------					
May	5.74	3.93	6.24	3.66	410	332
Jun	4.25	4.69	4.29	4.34	584	538
Jul	2.10	4.42	3.76	4.53	790	655
Aug	1.45	4.75	2.98	4.66	577	597
Sep	0.94	3.67	1.11	3.66	326	348
May - Sep	14.48	21.46	18.38	20.85	2687	2470

**30-year normal, 1971-2010*

Table 2. Corn production parameters as affected by fluid starter fertilizers at Waseca.

				V6	CV of	Whole Plant Samples at V6						Initial	Final
	Fertilizer rate			Plant	Plant		Nutrient uptake			Grain	Grain	Plant	Plant
Trt #	**APP**	**UAN**	**ATS**	**height**	**height**	**Yield**	**N**	**P**	**S**	**H_2O**	**Yield**	**Stand**	**Pop.**
	---- gal/A -----			**inch**	**%**	**---------- lb/A ----------**				**%**	**bu/A**	**plants×10^3/A**	
1	0	0	0	22.3	10.7	291	10.4	1.18	0.66	16.1	206	33.0	33.0
2	0	0	2	20.7	14.3	291	9.6	1.17	0.63	16.3	205	33.5	33.1
3	0	0	4	24.6	11.3	374	11.6	1.53	0.80	16.1	220	33.5	32.9
4	0	8	0	27.3	5.9	412	14.1	1.63	0.85	15.5	216	32.8	32.8
5	0	8	2	27.9	7.4	513	16.1	1.91	0.94	15.4	221	33.1	33.0
6	0	8	4	28.8	5.4	519	15.7	1.94	0.95	15.6	214	33.9	33.5
7	4	0	0	26.9	8.0	393	11.3	1.56	0.75	15.6	213	33.3	33.0
8	4	0	2	26.2	9.1	418	12.3	1.66	0.79	15.6	209	33.1	33.0
9	4	0	4	26.8	10.1	431	12.5	1.76	0.82	15.5	209	33.1	33.1
10	4	8	0	28.4	8.6	513	15.7	1.96	0.97	15.3	213	33.4	33.2
11	4	8	2	29.9	5.6	576	18.4	2.10	1.12	15.1	209	33.0	32.8
12	4	8	4	28.8	7.5	576	18.5	2.09	1.18	15.7	216	33.5	33.3
Treatment main effects													
APP (10-34-0) applied in-furrow													
None				25.3b*	9.2a	400b	12.9b	1.56b	0.80b	15.8a	214a	33.3a	33.1a
4 gal/A				27.8a	8.2a	484a	14.8a	1.85a	0.94a	15.4b	212a	33.3a	33.1a
UAN (28-0-0) applied as a surface dribble band													
None				24.6b	10.6a	366b	11.3b	1.48b	0.74b	15.9a	210a	33.3a	33.0a
8 gal/A				28.5a	6.7b	518a	16.4a	1.94a	1.00a	15.4b	215a	33.3a	33.1a
ATS (12-0-0-26) applied as a surface dribble band													
None				26.2a	8.3a	402b	12.9a	1.58b	0.81b	15.6a	212a	33.1a	33.0a
2 gal/A				26.2a	9.1a	450a	14.1a	1.71ab	0.87ab	15.6a	211a	33.2a	33.0a
4 gal/A				27.3a	8.6a	475a	14.6a	1.83a	0.94a	15.7a	215a	33.5a	33.2a

** Values within a column followed by the same lower-case letter are not significantly different at the probability level = 0.10.*

Table 3. Corn production parameters as affected by fluid starter fertilizers at Rochester.

				V6	CV of	Whole Plant Samples at V6						Initial	Final
	Fertilizer rate			Plant	Plant		Nutrient uptake			Grain	Grain	Plant	Plant
Trt #	APP	UAN	ATS	height	height	Yield	N	P	S	H_2O	Yield	Stand	Pop.
	---- gal/A -----			inch	%	---------- lb/A ----------				%	bu/A	plants×10^3/A	
1	0	0	0	22.8	10.0	247	9.1	0.95	0.59	17.3	239	35.5	34.4
2	0	0	2	23.8	6.8	256	9.6	1.05	0.63	16.4	238	35.4	34.4
3	0	0	4	23.6	8.3	290	10.5	1.11	0.75	16.6	239	35.9	34.4
4	0	8	0	23.9	7.6	290	10.9	1.11	0.69	16.7	238	35.4	34.1
5	0	8	2	26.2	6.8	313	11.6	1.24	0.75	16.1	240	35.0	34.0
6	0	8	4	25.0	6.4	309	11.6	1.19	0.75	16.4	237	34.2	34.0
7	4	0	0	24.8	6.4	323	12.2	1.32	0.81	16.4	234	34.5	34.2
8	4	0	2	24.4	7.7	280	10.8	1.17	0.71	16.9	233	35.5	34.4
9	4	0	4	24.6	6.7	332	12.3	1.33	0.84	15.9	234	34.5	34.0
10	4	8	0	25.0	9.2	332	12.5	1.30	0.81	16.5	231	35.2	34.2
11	4	8	2	24.5	6.6	342	13.1	1.32	0.82	16.3	237	34.0	33.9
12	4	8	4	24.7	7.4	323	12.5	1.30	0.84	16.9	230	34.3	34.0
Treatment main effects													
APP (10-34-0) applied in-furrow													
None				24.2a*	7.6a	284b	10.6b	1.11b	0.69b	16.6a	239a	35.2a	34.2a
4 gal/A				24.7a	7.3a	322a	12.2a	1.29a	0.80a	16.5a	233b	34.6b	34.1a
UAN (28-0-0) applied as a surface dribble band													
None				24.0b	7.6a	288b	10.8b	1.15a	0.72a	16.6a	236a	35.2a	34.3a
8 gal/A				24.9a	7.3a	318a	12.0a	1.24a	0.78a	16.5a	236a	34.7b	34.0b
ATS (12-0-0-26) applied as a surface dribble band													
None				24.1a	8.3a	298a	11.2a	1.17a	0.72a	16.7a	236a	35.1a	34.2a
2 gal/A				24.7a	7.0a	298a	11.3a	1.20a	0.73a	16.4a	237a	35.0a	34.2a
4 gal/A				24.5a	7.2a	313a	11.7a	1.23a	0.80a	16.4a	235a	34.7a	34.1a

** Values within a column followed by the same lower-case letter are not significantly different at the probability level = 0.10.*

of APP, UAN, and ATS on continuous corn production in reduced tillage/high-residue conditions

- Provide management guidelines on placement and rates of UAN, APP, and ATS combined as a starter 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.

Waseca results

Weather data characterizing the growing season are presented in Table 1. These data were taken form the SROC weather station located 0.5 miles from the research site. A record warm March and warmer-than-normal April and May resulted in early planting, warm soil temperatures, and very rapid early growth and development of corn. May precipitation was 1.81 inches greater than normal, which aided soil moisture recharge following a dry 2011 fall. On June 15th, 2.55 inches of precipitation were recorded at the SROC weather station. Another inch fell on June 21. The remainder of the growing season from June 22 through September 30 was very dry. Only 4.51 inches of precipitation fell during the period. Growing season (May to September) rainfall totaled 14.48 inches or 6.98 inches less than normal. Air temperatures from May to July were greater than normal and growing degree units (GDUs) for the season were 8 percent more than normal. The drought reduced yields somewhat and dramatically increased variability in the data. Data from one replication were discarded prior to statistical analysis because of variability. Yields in that rep ranged from 152 to 216 bu/A. The yield variability was not treatment related, it was related to moisture stress from subtle differences in elevation and soil type.

Early growth. Effects on plant height, coefficient of variation (CV) of plant height and whole plant dry matter yield are presented in Table 2. Plant height was increased about 10 percent when APP was applied in-furrow and about 16 percent when UAN was applied as a surface band. Plant height CV, a measure of variability in plant height (lower CV = less variable plant height), was greatly reduced with UAN application. A significant APP×UAN interaction for plant height (data not shown) showed UAN increased plant height more than APP. These data show how nitrogen in starter fertilizer enhanced early growth and plant uniformity in continuous corn grown with conservation tillage practices.

Whole plant dry matter yields were increased 21, 42, and 12 to 18 percent by the main effects of APP, UAN, and ATS applications, respectively. Greatest dry matter yields were obtained when all three starter fertilizers were applied (treatments numbers 11 and 12). Dry matter yields of V6 corn plants that received a starter containing APP, UAN, and ATS were nearly double the yield of the control treatment. The application of fluid fertilizers at planting resulted in dramatic visual differences (greater early growth and plant uniformity and a darker green color) in May and June of 2012.

Nutrient uptake. Generally, all starter treatments (APP, UAN and ATS) increased nutrient uptake of V6 corn plants at Waseca (Table 2). Nitrogen uptake increased about 15 percent when APP was applied in-furrow and about 45 percent when UAN was applied as a surface band. Moreover, P uptake increased about 19 percent when APP was applied in-furrow and about 31 percent when UAN was applied as a surface band. Numerically, the greatest N, P and S uptakes occurred when all fluid starters (APP, UAN and ATS) were applied (treatment numbers 11 and 12). These data show how fluid starter fertilizer application can dramatically increase early growth and nutrient uptake of corn.

Grain moisture & yield. Treatment effects on grain moisture, grain yield, initial plant stand and final plant population are presented in Table 2. The summer drought resulted in grain that was very dry at harvest, especially considering the early harvest date (September 19). Grain moisture was reduced about 0.5 percentage points by the main effects of APP and UAN application at planting. Corn grain yields ranged from 205 to 216 bu/A. However, grain yields were not affected by APP, UAN, and ATS application at planting. The dramatic differences in early growth that occurred early in the growing season did not result in increased yields in this warm and dry growing season. Initial plant stand and final plant population (after thinning) were not affected by any of the treatments at this location in 2012.

Rochester results

Weather. The 2012 growing season, similar to Waseca, was considerably warmer than normal. Unlike Waseca, Rochester received significantly greater rainfall in July and August, which resulted in excellent crop growth and development (Table 1). Growing season precipitation totaled only 2.47 inches less than normal for the period May through September.

Early growth of corn as measured by V6 plant heights and whole plant dry matter yields was affected by two of the main effects in the factorial analysis of treatments (Table 3). When averaged across APP and ATS main effects, heights and yields of V6 corn plants were increased slightly with UAN application. Dry matter yields were only 13 percent greater with APP application when averaged across UAN and ATS

"Crop response to treatments varied."

rates. Moreover, these data showed early growth of corn at the Rochester location, a well drained silt loam soil, was less responsive to starter fertilizers compared with the Waseca location, a poorly drained clay loam soil. Plant height CV was not affected by the main effects at Rochester. However, a significant APP×UAN interaction (interaction statistics not shown) for CV showed CV was numerically greatest (heights were more variable) when APP and UAN were not applied.

Nutrient uptake. Nitrogen, P, and S uptakes increased about 15 percent with APP applied in-furrow, when averaged across UAN and ATS main effects (Table 3). Nitrogen uptake increased only 11 percent when UAN was applied as a surface band. Increases in nutrient uptake were primarily a result of small increases in dry matter yield as concentrations were not affected by treatments (concentration data not shown). These data are contrary to what was observed at Waseca and result from smaller differences in dry matter yield at Rochester.

Grain moisture & yield. Treatment effects on grain moisture, grain yield, initial plant stand and final plant population are presented in Table 3. Corn grain was very dry at harvest. It ranged from 15.9 to 17.3 percent among treatments. A significant APP×UAN interaction (interaction statistics not shown) for grain moisture showed moisture was greatest when APP and UAN were not applied and less when either or both were applied. Corn grain yield decreased 6 bu/A with 4 gal/A of APP compared with 0 gal/A of APP, when averaged across UAN and ATS treatments. Initial plant stand was reduced 500 to 600 plants/A with UAN and APP application and after thinning final plant populations were slightly (300 plants/A) less with UAN application. It is unlikely that small final plant population differences reduced yields at this location. However, the combination of initial stand and grain yield reductions with APP suggests some negative effect of in-furrow placement on this silt loam soil. Non-uniform rainfall distribution early in the growing season may have contributed to these responses. About 3.5 inches of precipitation fell in the 14-day period after planting, while the next 18 days brought only 0.1 inches. Then 3.3 inches of precipitation were recorded in 3 days, followed by a 19-day period with only 0.5 inches. It's possible the 6 bu/A yield reduction with APP and the plant stand reduction with APP and UAN application could be a result of salt injury during these extended dry periods.

Plant stand. Significant UAN×ATS and APP×UAN×ATS interactions (interaction statistics not shown) for plant stand showed stand was reduced about 1,000 plants/A when two (UAN and ATS) or all three starter fertilizers were applied at planting. These data suggest the distance from the row to the location of the surface dribble band should be greater than the 2-inch distance used in this study.

Summing up

A record warm spring produced rapid early growth and development of corn in 2012. A summer drought resulted in increased yield variability at Waseca. Early growth responses to starter fertilizer treatment varied between locations, while yield responses were similar. At Waseca, early growth and plant-to-plant uniformity of corn were greatly enhanced with fluid starter fertilizers but grain yields were not affected, whereas at Rochester early growth responses were smaller, less frequent, and positive yield responses were not observed.

Mr. Vetsch is an Assistant Scientist and Dr. Randall is Professor Emeritus at the Southern Research and Outreach Center, University of Minnesota, in Waseca, MN, and Dr. Kaiser is an Extension Nutrient Management Specialist and Assistant Professor in the Department of Soil, Water, and Climate at the University of Minnesota, Twin Cities.