STARTER FERTILIZER FOR ROW CROP PRODUCTION UNDER NO-TILL CONDITIONS IN EASTERN NEBRASKA

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Abstract

Starter fertilizer application often results in increased corn and sorghum yield under no-till conditions, probably due to lower soil temperatures as compared to tilled soil. Five dryland and 5 irrigated corn trials, and 12 dryland grain sorghum trials were established after soybean in 2002 and 2003 on rolling land in eastern Nebraska with different soil types and topographic positions. Three placement positions were compared: in the seed furrow, over the row, and 2" to the side and 2" deep (2x2). Starter fertilizer treatments applied as liquid contained N+P and N+P+S at the rates of 20 lb/A each for N and P_2O_5, and 10 lb/A for S, but half rates were applied in-furrow. Ammonium sulfate was the S source and was compared to in-furrow ammonium thio-sulfate (ATS). Sorghum response to starter fertilizer occurred but the responses were infrequent and small. Corn response was more frequent. In-furrow application was better than other placements, especially for corn, and gave a 7.7 and a 4.8 bu/A mean corn yield increase if 3 severely drought affected trials are excluded or included, respectively. Including S in the starter fertilizer did not result in increased corn or sorghum yields.

Introduction

The benefits of starter fertilizer need to justify application and product costs, while avoiding seedling damage. Results from various studies show a higher probability of crop response to N, P, and S in starter fertilizer under no-till as compared to tilled conditions. Some studies, but not all, find method of placement of starter fertilizer to be important. Soil type and topographic position may be important to response. Varieties may differ in response to starter fertilizer. The objective of this research was to evaluate the effectiveness of starter fertilizers for improving no-till corn and sorghum yield in eastern Nebraska.

Materials and Methods

In 2002-3, 12 grain sorghum and 15 corn trials with 4 replications were conducted on farmers' fields and research stations across diverse topographic positions/soil types in Dixon, Gage, Lancaster, Saunders, and Washington counties of eastern Nebraska. The sorghum trials and most of the corn trials were installed in sets of three per location, with each trial on a different soil type/topographic position. All sites had a history of continuous no-till. In all trials but one, the previous crop was soybean. Six of the corn trials were irrigated. The eight treatments were: no starter applied; N+P_2O applied 2x2 at 20 + 20 lb; N+ P_2O applied over the row at 20 + 20 lb; N+ P_2O applied in the furrow at 10 + 10 lb; N+P_2O+S applied 2x2 at 20 + 20 + 10 lb; N+ P_2O+S applied over the row at 20 + 20 + 10 lb; N+ P_2O+S applied in the furrow at 10 + 10 + 5 lb: and N+ P_2O+S in-furrow application with S supplied from ATS rather than ammonium sulfate.

The fertilizer products were liquid formulations composed, as appropriate, of: 10-34-0, 32-0-0, 12-0-0-26 and 21-0-0-24. Ammonium sulfate was the main S source and was dissolved before mixing with other fertilizers. A total of 5 sorghum varieties and 8 corn varieties were used in the trials. The plot sizes were 40 by 10 ft, but split in 2003 to have 2 varieties per plot in 9 trials. An area of 5 x 20 ft, or 2.5 x 20 ft for trials with 2 varieties, was harvested for grain yield determination.

Basal fertilizer application was uniform for the trial sites and adequate to achieve expected yields. We planted and applied starter fertilizer with a 4-row planter. The farmers performed all other operations at their preference.

Results and Discussion

Sorghum. Soil type/topographic positions included one bottomland soil, 3 hilltop, and 8 hillside positions, including 2, 3 and 3 with east, south and north aspects, respectively. Soils of all upland sites were loess derived with clay loam or silty clay loam textures. The surface soil (0 to 8") pH values for these sites ranged from 5.3 to 6.1 (Table 1). Soil organic matter was generally more than 3%. Bray 1 P ranged from low to very high and overall was nearly 3 times as high in the 0 to 2" depth (median = 15.2 ppm) as compared to the 2 to 8" depth (median = 5.5 ppm). Potassium levels were high at all sites.

Soil type, topographic position, and soil test values were not determinants of sorghum response to starter fertilizer as the interaction of starter fertilizer treatment by trial effects were not significant. Also, there was no variety difference in responsiveness as indicated by non-significant effects of the variety by starter fertilizer treatment interaction.

Plant population with starter fertilizer placed in the planting furrow was a mean of 9.8% less in both years than with other placements (Tables 2 and 3). The other placements had similar stands to the no starter treatment. Plant stand was greater with S applied for the 2003 Lancaster trials, but not for the other trials. Plant stand was less with ATS than with ammonium sulfate applied in-furrow for the 2003 Lancaster trials, only.

Mean early sorghum plant weight was similar with and without starter fertilizer applied at all locations. Early plant growth was more with in-furrow placement than with other placements in the 2003 Gage Co. trials, but placement did not affect early growth elsewhere. Sulfur in starter fertilizer did not affect plant growth, and growth was similar for ammonium sulfate and ATS.

Sorghum grain yield results are available for the 2002 trials only, but the effects were inconsistent. Mean yields with and without starter fertilizer were not different. Yield was similar for all placements. The effect of S in the starter fertilizer on yield was not significant, and grain yield was similar for ammonium sulfate and ATS applied in-furrow.

Corn. Soil type/topographic positions included 3 bottomland, 2 hilltop, and 10 hillside positions, and 5, 3, 1 and 1 hillsides had predominately east, south, north and west aspects, respectively. Soil pH ranged from 5.3 to 6.8 (Table 4). Soil organic matter ranged from 1.9 to

3.3%. Bray 1 P ranged from low to very high and was higher in the 0 to 2" depth (median =35 ppm) than in the 2 to 8" depth (median = 9.6 ppm). Potassium levels were high at all sites. Soil type, topographic position, and soil test values were not found to be important to corn response to starter fertilizer.

The mean plant densities with and without starter fertilizer applied were similar (Table 5-7). In 2002, the effects of placement, S in the starter fertilizer, and ammonium sulfate versus ATS were not significant except for one dryland trial where plant stand was less with ATS applied. In the 2003 trials, plant density was greater with in-furrow application. Plant number was reduced in the 2003 trials with S included in the starter fertilizer, but stands were similar for the in-furrow applications of ammonium sulfate and ATS.

Early plant weight was not affected by starter fertilizer in the 2002 dryland trials (Table 5). In the irrigated 2002 Dixon Co. trial, plant weight was increased where starter fertilizer treatments contained S (Table 6), and weights were similar for in-furrow application of ATS versus ammonium sulfate. In 2003, mean early plant weight was more with than without starter fertilizer (Table 7). Placement had no effect on early growth in 2003, but including S in the starter fertilizer resulted in increased growth while growth was less with ATS than with ammonium sulfate.

One 2002 trial was lost in Washington Co. due to a misunderstanding with a cooperating farmer. Three trials in Gage Co. had an overall average corn grain yield of only 46.5 bu/A in 2002 due to severe water deficits and the treatment effects on grain yield were judged to be non-significant.

Mean grain yields were 140 and 111 bu/A for the 2002 dryland trials in Washington Co., 170 bu/A for the irrigated 2002 Dixon Co. trial, and 141 bu/A for the 2003 Lancaster Co. trials (Table 5-7). There were significant treatment effects on corn yield in one dryland trial and in the 2002 irrigated trial. The mean effect of starter fertilizer on yield was not significant in any of the trials. The effects of placement and S were not significant. In-furrow application of S as ATS or as ammonium sulfate resulted in very similar yields in the 2002 trials.

Conclusion

Most of the yield results for 2003 are not yet available and we make these conclusions realizing that they are not final. Sorghum response to starter fertilizer may occur but responses are infrequent and small. Corn response is greater and more frequent, but difficult to predict based on soil properties and topographic position. In-furrow application was better than other placements. Including S in the starter fertilizer did not improved sorghum or corn response. Overall, in-furrow placement of N + P gave a 7.7 and 4.8 bu/A corn yield increase if severely drought affected trials are excluded or included, respectively.

Table 1. Soil test results summarized for 12 trial sites for the evaluation of grain sorghum response to starter fertilizer.

	pH	SOM	K	P, Bray 1, ppm	
		%	ppm	0-2"	2-8"
Minimum	5.3	2.7	201	4.6	3.1
Maximum	6.1	3.4	365	162.6	43.2
Median	5.5	3.1	330	15.2	5.5

Table 2. Grain sorghum performance as affected by starter fertilizer treatments in 2002; means of 6 trials conducted under non-irrigated, no-till conditions in eastern Nebraska.

	Plants/A	Early plant weight, g/plant	Yield, bu/A
No starter	35.1	5.65	98.9
20N,20P_2O_5, 2x2	36.6	5.96	101.7
20N,20P_2O_5, over the row	37.8	6.01	100.5
10N,10P_2O_5, in-furrow	33.9	5.63	99.0
20N,20P_2O_5,10S, 2x2	36.9	6.14	96.7
20N,20P_2O_5,10S, over the row	36.6	5.54	97.9
10N,10P_2O_5,5S, in-furrow	34.9	6.31	97.0
10N,10P_2O_5,5S, in-furrow ATS	35.5	5.89	98.4
LSD 0.10	2.44	0.412	4.68
No starter vs. starter	35.1 vs. 36.1 ns	5.65 vs. 5.93 ns	98.9 vs. 98.8 ns
In-furrow vs. other placements	34.4 vs. 37.0 *	5.97 vs. 5.91 ns	98.0 vs. 99.2 ns
Sulfur vs. no sulfur	36.1 vs. 36.1 ns	6.00 vs. 5.87 ns	97.2 vs. 100.4 ns
NH_4SO_4 vs. ATS, in-furrow	36.6 vs. 34.9 ns	6.31 vs. 5.89 ns	97.0 vs. 98.4 ns

ns, * indicate not significant, and significant at the 0.1 probability level.
NH_4SO_4 and ATS are ammonium sulfate and ammonium thiosulfate, respectively, as the sulfur sources.

Table 3. Grain sorghum performance as affected by starter fertilizer treatments in 2003: means of 3 trials per location conducted under non-irrigated, no-till conditions in eastern Nebraska.

	Plants/ha, '000	Early plant weight, g/plant	Yield, bu/A
	Gage Co., two varieties		
No starter	42.5	11.61	
20N,20P_2O_5, 2x2	44.3	13.22	
20N,20P_2O_5, over the row	43.4	11.50	
10N,10P_2O_5, in-furrow	37.7	14.46	
20N,20P_2O_5,10S, 2x2	45.4	12.00	
20N,20P_2O_5,10S, over the row	44.9	10.65	
10N,10P_2O_5,5S, in-furrow	40.0	13.02	
10N,10P_2O_5,5S, in-furrow ATS	35.4	14.34	
LSD 0.10	2.2	1.781	
No starter vs. starter	ns	11.6 vs 12.5 ns	
In-furrow vs. other placements	38.8 vs 44.5****	13.7 vs 11.8 **	
Sulfur vs. no sulfur	43.4 vs 41.8**	11.9 vs 13.1 *	
NH_4SO_4 vs. ATS, in-furrow	40.0 vs 35.4****	13.0 vs 14.3 ns	
	Lancaster Co., one variety		
No starter	25.7	5.90	
20N,20P_2O_5, 2x2	25.6	6.41	
20N,20P_2O_5, over the row	25.7	6.51	
10N,10P_2O_5, in-furrow	20.0	6.09	
20N,20P_2O_5,10S, 2x2	27.8	6.34	
20N,20P_2O_5,10S, over the row	27.0	6.41	
10N,10P_2O_5,5S, in-furrow	24.0	7.14	
10N,10P_2O_5,5S, in-furrow ATS	24.3	6.70	
LSD 0.10	3.2	ns	
No starter vs. starter	25.7 vs. 25.6 ns	5.90 vs. 6.48 ns	
In-furrow vs. other placements	22.0 vs. 26.5****	6.61 vs. 6.42 ns	
Sulfur vs. no sulfur	26.3 vs. 23.8 ns	6.63 vs. 6.34 ns	
NH_4SO_4 vs. ATS, in-furrow	24.0 vs. 24.3 ns	7.14 vs. 6.70 ns	

The two varieties responded similarly to starter fertilizer as indicated by the lack of significant variety by starter treatment interaction.

The trial x treatment interaction effect was not significant which means that topographic position did not have an effect on response to starter fertilizer.

The 2003 yield results are not yet available.

ns, *, **, ***, **** indicate not significant, and significant at the 0.1, 0.05, 0.01, 0.001 probability levels.

NH_4SO_4 and ATS are ammonium sulfate and ammonium thiosulfate, respectively, as the S sources.

Table 4. Soil test results for 15 trial sites for the evaluation of corn response to starter fertilizer treatments.

	pH	SOM	K	P, Bray 1, ppm	
		%	ppm	0-2"	2-8"
Minimum	5.4	1.9	194	4.5	3.1
Maximum	6.8	3.3	621	78.5	33.6
Median	6.0	2.5	312	35.0	9.6

Table 5. Corn performance as affected by starter fertilizer treatments in 2002 under non-irrigated, no-till conditions in eastern Nebraska.

	Plants/A ('000)		Early plant weight (g/plant) (6 trials)	Yield, bu/A, Anderson trials[1]	
	An1	An3		An1	An3
No starter	22.1	21.5	12.1	136.6	101.7
20N,20P_2O_5, 2x2	21.8	17.3	12.8	144.8	122.2
20N,20P_2O_5, over the row	22.7	19.9	12.0	140.1	124.2
10N,10P_2O_5, in-furrow	21.6	17.9	12.7	147.3	97.5
20N,20P_2O_5,10S, 2x2	20.5	22.1	12.2	134.4	113.7
20N,20P_2O_5,10S, over the row	21.4	19.8	12.6	147.5	106.5
10N,10P_2O_5,5S, in-furrow	20.8	20.1	11.9	136.6	109.1
10N,10P_2O_5,5S, in-furrow ATS	20.3	16.3	12.4	133.5	109.9
LSD 0.1	1.91	3.24	1.36	ns	15.3
No starter vs. starter	22.1 vs. 21.7 ns	21.5 vs. 19.7 ns	12.1 vs 12.4 ns	136.6 vs. 141.8 ns	101.7 vs 111.0 ns
In-furrow vs. other placements	22.0 vs. 21.5 ns	19.8 vs. 19.7 ns	12.3 vs 12.4 ns	143.8 vs. 140.8 ns	115.3 vs 108.8 ns
Sulfur vs. no sulfur	21.2 vs. 22.2 ns	19.9 vs. 19.6 ns	12.5 vs 12.3 ns	140.5 vs. 143.8 ns	105.9 vs 116.0 ns
NH_4SO_4 vs. ATS, in-furrow	20.8 vs. 20.3 ns	20.1 vs. 16.3 *	11.9 vs 12.4 ns	136.6 vs. 133.5 ns	109.1 vs 109.9 ns

[1] Three other trials had very low yield due to severe water deficits. These were not harvested with the assumption that there was not a significant response to the starter fertilizer treatments.
ns, * indicate not significant, and significant at the 0.1 probability level.
NH_4SO_4 and ATS are ammonium sulfate and ammonium thiosulfate, respectively, as the sulfur sources.

Table 6. Corn performance as affected by starter fertilizer treatments in 2002 under irrigated. no-till conditions at Haskell Lab in eastern Nebraska.

	Plants/A ('000)	Early plant weight (g/plant)	Yield, bu/A
No starter	22.4	23.0	165.9
20N,20P_2O_5, 2x2	23.7	25.4	183.3
20N.20P_2O_5, over the row	22.4	23.9	165.7
10N.10P_2O_5, in-furrow	23.7	25.4	186.2
20N,20P_2O_5,10S. 2x2	19.6	29.1	156.6
20N,20P_2O_5,10S, over the row	22.7	25.2	174.9
10N.10P_2O_5,5S, in-furrow	22.4	27.3	165.5
10N,10P_2O_5,5S, in-furrow ATS	20.5	25.8	164.6
LSD 0.10	2.681	3.1	19.1
No starter vs. starter	22.4 vs. 22.4 ns	23.0 vs. 26.1 *	165.9 vs 172.0 ns
In-furrow vs. other placements	23.0 vs. 22.1 ns	26.3 vs. 25.9 ns	175.8 vs 170.1 ns
Sulfur vs no sulfur	21.6 vs. 23.3 ns	27.2 vs. 24.9 *	165.7 vs 178.4 ns
NH_4SO_4 vs ATS, in-furrow	22.4 vs. 20.5 ns	27.3 vs. 25.8 ns	165.5 vs 164.6 ns

ns, *, **, ***, **** indicate not significant, and significant at the 0.1, 0.05, 0.01, 0.001 probability levels.

NH_4SO_4 and ATS are ammonium sulfate and ammonium thiosulfate, respectively, as the sulfur sources.

Table 7. Mean corn performance across seven trials as affected by starter fertilizer treatments in 2003 under no-till conditions in eastern Nebraska.

	Plants/A ('000)	Early plant wt (g/plant)	Yield, bu/A
			Lancaster, 3 trials
No starter	36.1	11.79	140.3
20N,20P_2O_5, 2x2	33.8	13.55	138.0
20N,20P_2O_5, over the row	34.9	13.96	128.8
10N,10P_2O_5, in-furrow	39.2	13.73	144.4
20N,20P_2O_5,10S, 2x2	33.1	14.62	143.7
20N,20P_2O_5,10S, over the row	32.9	14.44	135.7
10N,10P_2O_5,5S, in-furrow	38.8	14.41	145.2
10N,10P_2O_5,5S, in-furrow ATS	38.0	13.60	152.1
LSD 0.10	1.5	0.702	14.09
No starter vs. starter	36.1 vs. 35.4 ns	11.8 vs. 14.1 ***	140.3 vs 139.3 ns
In-furrow vs. other placements	39.0 vs 33.6 ***	14.1 vs. 14.1 ns	144.8 vs 136.5 ns
Sulfur vs no sulfur	34.9 vs. 36.0 *	14.5 vs. 13.7 ***	141.4 vs 137.1 ns
NH_4SO_4 vs ATS, in-furrow	38.8 vs. 38.0	14.4 vs. 13.6 *	145.2 vs 152.1 ns

The trials had two varieties but varieties responded similarly to starter fertilizer as indicated by the lack of significant variety by starter treatment interaction.
Four trials were irrigated and three were dryland, but this did not affect early response as indicated by the lack of significant trial x treatment interaction. This also means that topographic position did not have an effect on response to starter fertilizer.
The 2003 yield results are not yet available for four trials.
ns *, **, *** indicate not significant, and significant at the 0.1, 0.05, 0.01 probability levels.
NH_4SO_4 and ATS are ammonium sulfate and ammonium thiosulfate, respectively, as the sulfur sources.

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