RECENT PERSPECTIVES FOR STARTER FERTILIZER USE ON CORN IN MINNESOTA

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Abstract

Application of fertilizer with the seed at planning has been a popular choice for Minnesota corn farmers to get their crop off to a fast start. Traditionally the salt index of a fertilizer has been important in farmers' management decisions. A research study was conducted at six locations on fine and coarse textured soils around Minnesota. Three fertilizer grades, 4-10-10, 10-34-0, and 3-18-18 were compared at two rates and in three placements relative to the seed. Nitrogen (N) and phosphorus (P) applied varied by source; however, potassium (K) rate was constant to limit response to this nutrient. On fine textured soils, neither source, rate, nor placement of fertilizer significantly impacted corn emergence or yield. However, all high fertilizer rates decreased emergence and yield at one coarse textured location and all rates of 10-34-0 reduced stand and yield at all sandy locations. If soils are dry fertilizer salts may be a problem; however, nitrogen rate should be a major consideration when farmers are applying starter fertilizers even in years with normal rainfall, especially on coarse textured soils.

Introduction

It is known from previous experience dating back to the 1950's, that banded application of immobile nutrients such as phosphorus and potassium near the seed at planting can be much more efficient that a broadcast application. Research conducted at Purdue by Barber indicates this is a function of the amount of soil the roots must explore to obtain adequate amounts of the immobile nutrient. For optimum root growth, only 6 % of the soil volume needs to be fertilized. With the price of many fertilizers increasing, farmers have been looking ways, such as banding fertilizers, to do more with less to get the most out of crop nutrients.

Starter fertilizer has become a popular choice for many farmers around Minnesota to band fertilizer. Most farmers like the early growth benefits by getting the plant off to a faster start in the spring, which can be important in the Northern Corn Belt with cooler springs and shorter growing seasons. Most producers are open to using starter fertilizer as long as it can be applied on the seed, and thus they do not need to use additional starter attachments which can add up to considerable costs with larger planters. Also, the availability and ease of handling of liquid fertilizers has made it easy for farmers to supply small amounts of nutrients with the planter.

The major concern with starter placement close to the seed is germination damage from fertilizer. This damage has been attributed to the salt and ammonium content of the fertilizer. Comparing the two issues, fertilizer salt concentrations tend to be indicated as the larger issue by most producers and they tend to forget about effects due to nitrogen. A rule of thumb has typically been used in Minnesota as well as neighboring areas. This states that no more than 10 lbs of N + K_20 be applied near the seed at planting since both contribute largely to the salt content of a fertilizer. However, it has been recognized in Minnesota as well as other areas that damage from fertilizer placed close to the seed can vary by soil types, properties, or conditions (Rehm, 1999). In Minnesota banded fertilizer recommendations are half that of broadcast for corn (Rehm et al., 2001), thus farmers are willing to start banding fertilizers to save on cost. While it is recommended that some soil be put between fertilizer bands and the seed if high rates are used (Rehm, 1999), some farmers still try to increase rates near the seed to supply a majority of the crops nutrient needs to save on trips across the field.

In Minnesota, the use of ammonium polyphosphate, 10-34-0, with the seed has become very popular due to lower prices and greater availability. The common question is, how much can I apply with the seed. Past research has shown on heavy textured soils with moisture at planting time, a grower can put up to 10 gallons/acre without reducing emergence or grain yield (Rehm, 1999). While 10-34-0 is still a popular fertilizer grade, shortages and price increases have caused some producers to consider other sources. Producers have been looking to banding in nitrogen sources including urea-ammonium nitrate solutions and others as a substitute. Also, products like 3-18-18, 9-18-9, 7-21-7, or 4-10-10 (as well as many others) are being looked to since they are commercially available. With shifts being made to other sources questions arise as to; How much fertilizer can I put on?, Does the soil texture make a difference on fertilizer damage to the seed?, Does soil moisture affect the damage?, And is it the ammonium or the salt index of the fertilizer that is most important in evaluating the damage?

While salt index has traditionally been a concern for producers, two studies have been conducted in Minnesota looking at the effect of ammonia and salt injury from seed placed fertilizers in corn. One small study focused on dry fertilizer N source and rate effects on corn emergence and yield in a coarse textured soil. The second study focused on liquid fertilizer source and placement with the objective of evaluating the impact of three fluid fertilizers applied at two rates in three placements relative to the seed on corn emergence and yield.

Effect of N source and Rate on Corn Germination and Yield

Fertilizer sources that liberate ammonium nitrogen can be problematic since ammonia can be detrimental to young plant tissues. Fertilizer sources that liberate large quantities of ammonia can severely impact the germination and overall stand if placed near the corn seed at planting. Because of this it is recommended that no more than 30 lbs of nitrogen be placed in a band with less than 1 inch of soil between the band and the seed furrow (Rehm, 1999). Fertilizers containing urea can be extremely problematic if placed near the seed. Even with the negative impacts that can be seen when using urea and a starter

source, many producers still want to use urea fertilizer sources because of their availability compared to other sources, and belief that early growth can be increased by a banded application of nitrogen.

Trials were established on coarse textured sandy soils at one location in 1999 and 2000. Treatments were a no-starter control and straight- and polymer coated urea applied at rates of 7.5, 15, and 30 lbs of N per acre. Fertilizer was placed on the seed in the seed furrow (with seed) and two inches besides and below the seed furrow (2 X 2) in 1999, and only with seed comparisons were made in 2000. Additional nitrogen, phosphorus, potassium, and sulfur (S) fertilizer was applied according to recommended rates for corn in Minnesota. A single corn hybrid was planted each year of the study.

The application of Urea in contact with the seed decreased corn emergence as the N rate increased in 1999 and 2000. When Urea was placed in a 2 X 2 band, corn emergence in 1999 was not affected. The use of a polymer coating in 1999 did reduce the decrease in emergence from placement with the seed. However, stands were still reduced with polymer coated urea (PCU) compared to the control. Grain yield was increased over the check with the 2 X 2 addition of urea or PCU in 1999 (Table 3.). The placement of urea with the seed reduced grain yield similar to the reduction in emergence in 1999 and 2000. Polycoated urea reduced grain yield only in 2000. The reduction in grain yield was less for PCU than it was for urea applied with the seed at planting. The reduction in emergence and yield are attributed to the ammonium toxicity of urea. It is not recommended to place urea with the seed. Placement of any urea source should be away from the seed to limit the risk of potential stand and yield losses. Dry soils, especially coarse textured soils, may potentially be at more risk than others. However, the overall scope of this study is limited to sandy soils so more research needs to be conducted to examine the effects on fine textures soils.

Effect of Starter Source and Placement on Corn Germination and Yield

Materials and Methods

Research trials were established at 2 locations in 2004, 2005, and 2006 (six sites total). In each year a site was located on a fine textured and coarse textured soil (Table 3). Initial soil samples were collected prior to treatment application. Soil P and K levels were generally high at all locations (Table 3). Treatments were a no-starter control and three commercially available fluid fertilizers applied at two rates with three placements arranged in a complete factorial design with four replications. Fertilizer grades and applications rates were 10-34-0 and 4-10-10 (% N-P_2O_5-K_2O) applied at 5 and 10 gallons per acre, and 3-18-18 applied at 3.4 and 6.8 gallons per acre. The 3-18-18 rate was adjusted to apply the same rate of K_2O per acre as 4-10-10. The primary K source in 3-18-18 was KOH, while KCl was used to manufacture the 4-10-10. Potassium sources manufactured with KOH typically have a lower salt index and are thought to be safer for seed placement (Mortvedt 2001). Fertilizer placements varied by years. In all years, with seed (WS) placement and a single band above (SBA) placement were used. In 2004 dual band above the seed (DBA) was used, but was replaced with a single band below the

seed (BBS) in 2005 and 2006. Placements above and below the seed (SBA, DBA, and BBS) had approximately 0.5 to 0.75 inches of soil between the fertilizer band and the seed. Fertilizer was placed directly on the seed in the WS treatment. Additional nitrogen was applied to plots to achieve a total application rate of 140 lbs of N per acre. Additional nitrogen applied was urea broadcasted and incorporated prior to planting, except for sites with sandy soil textures under irrigation where half the fertilizer was applied at V4 (Ritchie et al., 1986) and the remaining top-dressed at the V8 growth stage. Additional P, K, or S fertilizer was applied based on need as determined by initial soil tests. Corn hybrids and management practices were those chosen by the farmer cooperators.

Measured variables were corn emergence and yield. Corn emergence was determined by counting the number of plants in two adjacent rows 20 feet long at the V4 growth stage. Plots were hand harvested and yields were adjusted to 15.5% moisture content. Data analysis was conducted using the PROC GLM procedure in SAS (SAS Institute, 2000). Data was analyzed across sites to determine interactions between site and main treatments effects. When significant ($P \leq 0.05$) interactions between site and main treatment effects were determined, additional analysis was conducted on individual sites for main treatment effects. Data from 2004 was analyzed separately from 2005 and 2006 due to differences in fertilizer placement.

Results and Discussion

Analysis of variance tests on heavy textured soils found no significant ($P \leq 0.05$) differences in emergence and grain yield from the use of different fertilizer grades (Table 4), fertilizer application rate (Table 5), or placement of the band relative to the seed (Table 6). In all years at these locations April rainfall was at or above normal levels. It is unclear whether similar results would be found if soils were drier than normal at planting. However, Raun et al., (1986) found that high rates of N + K_2O delayed seedling emergence when soils remained dry after planting. From this data it is evident that no significant stand reductions should be seen in heavy textured soils from seed applied starter fertilizers in Minnesota if soils are wet. However, it is unclear if different soil moisture conditions would affect the results.

The results from the sandy textured sites were different. At the 2004 and 2006 sites B04 and B06, the use of a high rate of 10-34-0 significantly reduced corn plant emergence, (Table 7). The placement of the band did not influence this response. This only occurred for 10-34-0. At the D05 site, there was a reduction in plant emergence with the high rate of all starter fertilizer materials and a reduction in plant emergence with the low rate of 10-34-0, (Table 8). Grain yields were affected similarly to the plant emergence. The sandy soils at these locations tended to be drier after planting and most likely caused the starter fertilizers to have more of an injury effect on the plant. The D05 site was the driest of the sandy sites in this study. This would explain why the more drastic effect of the starter fertilizer on plant emergence and grain yield. When examining the results for the B04 and B06 sites, one could make a case that the ammonium in the 10-34-0 had a bigger negative effect on the plant than the salt effect from the other starter fertilizers

since the fertilizer sources containing K, 4-10-10 and 3-18-18, did not affect yields as much as 10-34-0 which applied the highest amounts of N. Also, source of K used in the manufacture of the different fertilizers did not result in any significant reductions in stands or yields even though the salt index for 4-10-10 was higher than 3-18-18.

Conclusions

The effects of different grades of fertilizer applied at two rates in three placements were studied. In fine textured soils when adequate soil moisture was present, fertilizer grade, rate, and placement did not significantly decrease plant stand or yield. In sandy sites, higher nitrogen rates applied in 10-34-0 decreased corn stand and yield and fertilizer salt content did not have a larger impact on stand or yield. If soils remain dry after planting both ammonia and salt content may seriously affect corn emergence. However, farmers should monitor nitrogen rates placed close to the seed to limit stand losses.

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Table 1. The effect of Urea and PCU placed with the seed or 2 inches to the side and 2 inches below the seed on corn emergence in 1999 and 2000, Rehm, 1999.

		N rate (lb/A)			
N source	Placement	0	7.5	15	30
		---------- % ----------			
1999					
Check	None	100	-	-	-
Urea	2 X 2	-	110	101	104
	With seed	-	86	54	19
PCU	2 X 2	-	110	105	101
	With seed	-	103	100	95
2000					
Check	None	100	-	-	-
Urea	With seed	-	80	52	9
PCU	With seed	-	88	62	29

Table 2. The effect of Urea and PCU placed with the seed or 2 inches to the side and 2 inches below the seed on corn yield in 1999 and 2000, Rehm, 1999.

		N rate (lb/A)			
N source	Placement	0	7.5	15	30
		---------- bu/A ----------			
1999					
Check	None	139	-	-	-
Urea	2 X 2	-	166	151	161
	With seed	-	132	84	59
PCU	2 X 2	-	159	160	159
	With seed	-	153	155	150
2000					
Check	None	163	-	-	-
Urea	With seed	-	144	126	32
PCU	With seed	-	171	131	97

Table 3. Site information for the starter placement study.

	pH	Soil test P	Soil test K	Organic matter	Soil texture
Site		-- ppm --		%	
S04	6.6	63	215	4.3	silty clay loam
B04	6.5	133	68	1.0	fine sandy loam
R05	6.4	24	157	4.5	silty clay loam
D05	6.2	24	78	1.4	fine sandy loam
R06	5.4	15	119	3.9	clay loam
B06	6.4	56	112	1.3	fine sandy loam

Table 4. The effect of fertilizer grade on plant population and grain yield on heavy textured soils, 2004, 2005, and 2006.

Fertilizer grade	Plant population	Grain yield
	% of control	bu/A
10-34-0	99	201
4-10-10	99	200
3-18-18	99	201
Check	33,250 plants/A	201

Table 5. The effect of fertilizer rate on plant population and grain yield on heavy textured soils, 2004, 2005, and 2006.

Fertilizer rate	Plant population	Grain yield
	% of control	bu/A
High	99	201
Low	99	200
Check	33,250 plants/A	201

Table 6. The effect of band placement relative to the seed on plant population and grain yield on heavy textured soils, 2004, 2005, and 2006.

Band placement	Plant population	Grain yield
	% of control	bu/A
With seed	99	198
Single band above seed	99	201
Dual band/below seed	99	203
Check	33,250 plants/A	201

Table 7. The effect of band placement, starter fertilizer source, and starter fertilizer rate on plant emergence at B04. The results were similar at B06.

Fertilizer source	Dual band/below seed		With seed		Single band above seed	
	High	Low	High	Low	High	Low
			% of control			
10-34-0	81	99	88	108	84	107
4-10-10	110	107	112	107	111	103
3-18-18	100	109	106	102	114	103

Table 8. The effect of band placement, starter fertilizer source, and starter fertilizer rate on plant emergence at D05.

Fertilizer source	Below seed		With seed		Single band above seed	
	High	Low	High	Low	High	Low
			% of control			
10-34-0	68	85	67	93	69	94
4-10-10	92	102	93	105	90	103
3-18-18	91	104	95	106	102	107

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