Section 3: Corn Starter Fertilizer Practices

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Starter fertilizers are commonly used in the northern part of the US as soils are normally cool and wet or cool and dry during planting. These cold and wet soils also tend to slow root growth and limit uptake of some nutrients. Placing nutrients close to the corn seed can increase early season growth and reduce grain moisture at harvest. Common methods of starter fertilizer application include in-furrow, 2×2, and surface banding. However, soil texture, temperature, soil moisture, and sometimes tillage type can vary the effect of starter fertilizers on corn yield (Vyn and Janovicek, 2001; Wortmann et al., 2006; Rutan and Steinke, 2018). South Dakota (SD) has varying moisture conditions with greater precipitation in the east and decreasing going west. Tillage type used and soil textures also vary across the state. In this chapter we will evaluate the results from the 2019 nutrient management survey to help better understand the local factors and farmer characteristics that influence the use of various starter fertilizer practices. The local factors evaluated include geographic location within SD, tillage type, and farm size, as well as age and education of the farmer respondents. Understanding these factors on farmer's decisions regarding starter fertilizer use practices can give guidance to government agencies, extension, and other professionals regarding needed research, educational resources, and trainings that are needed to help farmers.

Use of Starter Fertilizer (Pop-up or Side-band)

Across central and eastern SD, 60% of farmers applied starter fertilizer using in-furrow or another side banding application method (Table 1). Use of starter fertilizer varied by farm location, tillage type, farms size, age of farmer, but not education level. Farmers in central SD used starter fertilizer more than those in eastern SD. This may be because most farmers in central SD follow no-till practices (Table 2 in Chapter 1), and farmers who use no-till were 15-36% more likely to use starter fertilizer compared to farmers using reduced or conventional tillage. Compared to tilled soils, no-till soils are normally cooler and wetter in the spring; thus, conditions more commonly show positive yield responses to starter fertilizer application (Vyn and Janovicek, 2001; Wortmann et al., 2006; Rutan and Steinke, 2018). Our results also showed that farmers with greater than 1,000 acres and younger farmers (18-40) were more likely to use starter fertilizer. The fact that larger farms in SD are more frequently using no-till practices (Table 2 in Chapter 1) may be one reason for the greater use of starter fertilizer. Larger farms may also have the capital to invest in and maintain starter fertilizer application systems. Younger farmers may use starter fertilizer more frequently due to a greater level of with the computer and software technologies required to operate starter fertilizer systems.

Table 1. Percentage of surveyed farmers that used starter fertilizer, placement methods, and which nutrients were applied in relation to location, tillage, farm size, age, and education level.

Variables	Use of starter fertilizer	Starter Placement			Nutrient application			
		In-furrow	2×2	Other	N	P	K	S
	%							
Overall Location	60	42	6	2	43	41	8	5
Central	78a[a]	84	13	3	80a	79a	11	13a
East	44b	86	9	5	43b	41b	16	6b
Tillage								
No-till	74a	83	13	4	71a	70a	11b	9
Reduced	59b	86	10	4	50b	46b	26a	15
Conventional	38c	84	11	5	35c	35b	10b	5
Farm size (ac)								
>2000	75a	81	15	4	72a	69a	17	11
1,000-1,999	68a	87	8	5	61a	60a	14	6
500-1,999	45b	81	11	8	42b	41b	11	7
1-499	37b	92	0	1	32b	30b	9	9
Age								
18-40	78a	85	11	4	77a	69	28a	32a
41-59	61ab	90	8	2	58b	58	15b	8b
60+	54b	82	12	6	59b	49	9b	3b
Education								
College degree	64	90	7	3	66a	62a	22a	12a
No college degree	56	82	13	5	50b	50b	8b	6b

[a] Percentages with different letters within each column are statistically different (P ≤ .05). If no letters are present, there are no significant differences.

Placement of Starter Fertilizer

Overall, placement of starter fertilizer was applied in-furrow 60% of the time, with 2×2 and other placements (surface band, broadcast, etc.) only being used 2 to 6% of the time (Table 1). This same pattern was true regardless of farm location, tillage type, farm size, age of farmer, or education level. In-furrow is likely most popular as it requires the least amount of equipment added to a planter. However, lower rates of fertilizer must be applied using in-furrow compared to 2×2 to avoid too high of salt concentrations and ammonia toxicity (Niehues et al., 2004; Rehm and Lamb, 2009). On the other hand, a 2×2 system can use greater fertilizer rates, but these systems require adding extra coulters that can slow down planting, are more sensitive to soil moisture conditions, and may bring more soil to the surface (Niehues et al., 2004).

Nutrients Applied in Starter Fertilizer

Across all farmers, N and P were the most common nutrients applied in a starter fertilizer (41-43% of farmers), followed by K and Zn (5-8% of farmers) and lastly Fe, B, Mn, and Cu (1-3%) (Table 2). The close percentage of farmers applying N and P in their starter fertilizer may be due to few P starter fertilizers only containing P. Nutrients applied as starter generally varied by farm location, tillage type, farms size, age of farmer, and education level. Farmers in central compared to eastern SD applied N, P, and S more frequently but there was no difference in the application of K. No-till farmers and farms greater than 1,000 ac normally applied N and P more frequently than conventionally tilled farms and farms smaller than 1,000 ac. Reduced-till farms most frequently applied K in starter fertilizer with no differences found in S usage due to tillage or farm size. Further, younger farmers (18-49) and those with college degrees were generally more likely to apply N, P, K, and S in their starter fertilizer. Overall, these results show that farmers that use no-till (most frequently used in central SD and by larger farms; Table 2 in Chapter 1) are the most likely to apply plant nutrients as starter fertilizer. These results also show that application of S is not related to geographical location or soil management practices but only to the age and education of the farmer. This may be due to S becoming more limiting to crop yields in recent years

for various reasons including less deposition of S from the atmosphere due to reduction in power plant S emissions. It may also be related to older farmers not needing to add S in the past, so they keep following that same nutrient management practice.

Table 2. Percentage of surveyed farmers that applied various nutrients in their starter fertilizer.

Nutrient	Percentage of farmers %
Nitrogen	43
Phosphorus	41
Potassium	8
Sulfur	5
Zinc	3
Iron	2
Boron	1
Manganese	1
Copper	1
Chloride	1
Molybdenum	1

Nutrient Rates Applied as Starter Fertilizer

As part of the 2019 survey, we also asked nutrient application rats. Based on the information received, Table 3 contains the mean rate and the standard deviation of the various nutrients applied in-furrow and as a sideband that includes 2×2, surface band, and any other method that was not applied with the seed. We are only presenting the results for N, P, K, and S as rates were not given for the other nutrients. Generally, rates of side band applications were greater than in-furrow applications. This is likely due to potential salt and ammonia toxicity that can occur from fertilizers placed close to the seed that are not an issue when fertilizer is further from the seed as discussed earlier. For in-furrow applications, P was generally applied at the highest rate (23 lbs ac^{-1}) followed by N and S (12-13 lbs ac^{-1}), and lastly K (4 lbs ac^{-1}). For side banding applications N and P were normally applied at similar rates (43-46 lbs ac^{-1}) followed by S (23 lbs ac^{-1}) and lastly K (2 lbs ac^{-1}). Lower K rates for both in-furrow and side banding are likely due to the most common liquid starter fertilizer products containing no or little K.

Fertilizer placed in contact with the seed (in-furrow) can often be very efficiently used by the plant. However, fertilizer placed in contact with the seed can also cause seed injury or death. To minimize potential injury, fertilizer rates placed with the seed, especially N and K, need to be kept low. It is important to note that the average rates reported by farmers in this survey are above the SDSU guidelines, which if used may cause seed injury and reduce germination. However, it is difficult to predict the exact rate which will cause seed injury since it is dependent on soil and environmental conditions. Injury from any given fertilizer is much more likely when soil is dry or sandy compared to wet or fine textured. Row width also makes a large difference in acceptable rate per acre since narrower rows mean there are more feet of row per acre than wider rows. In general, seed injury is caused by too much "salt" per acre. However, N fertilizers such as urea that form ammonia in soil can cause severe injury, as can thiosulfate. The general guideline for corn in 30-inch rows is for the N plus K_2O applications in contact with the seed to be less than 10 lbs/ac and that N as urea, UAN, and ammonium thiosulfate (12-0-26) should NOT be in contact with the seed. For dry or coarse-textured soils, the rates should be decreased by half. For more information regarding starter fertilizer rate guidelines see chapter 26 (Starter, Banding, and Broadcasting Phosphorus fertilizer for Profitable Corn Production) in Best Management Practices for Corn Production manual and the South Dakota Fertilizer Recommendation Guide

Table 3. Mean nutrient rate (± standard deviation) applied in-furrow or sideband (i.e., 2×2 or surface band) to corn.

Nutrient	Corn	
	In-furrow	Side band
	Nutrient Rate: lbs/ac	
Nitrogen	13 ± 24	46 ± 45
Phosphorus	23 ± 15	43 ± 33
Potassium	4 ± 4	2 ± n/a
Sulfur	12 ± 8	23 ± n/a

[a] If "n/a" is in the place of the standard deviation, it indicates only 1 response was recorded from the survey so no standard deviation could be calculated.

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