Section 5: Phosphorus and Potassium Management Practices

Jason D. Clark (Jason.D.Clark@sdstate.edu)
Péter Kovács (Peter.Kovacs@sdstate.edu)
Jessica D. Ulrich-Schad (Jessica.Schad@usu.edu)
Anthony Bly (Anthony.Bly@sdstate.edu)

April 2023

Introduction

Appropriate management of phosphorus (P) and potassium (K) fertilizers are important to maximizing corn yields as well as reducing the loss of these nutrients that can cause negative environmental effects. The management practices that lead to the maximum use of P and K by the corn crop and lowest chance of loss to the environment are often referred to as the 4Rs of nutrient management—Right: source, rate, timing, and placement. In this chapter, we will evaluate the results from the 2019 nutrient management survey to help us better understand the local factors influencing the use of various P and K management practices. The local factors evaluated include geographic location within South Dakota, tillage type, and farm size. Understanding these factors on farmer's decisions regarding P and K management practices can inform government agencies, extension, and other professionals to identify research, educational resources, and trainings that are needed to help farmers adopt appropriate 4R nutrient management practices.

Phosphorus and Potassium Sources

Phosphorus

Phosphorus fertilizer source used by farmers regardless of application timing was not related to location, tillage, or farm size. This result suggests that fertilizer sources are similarly available to farmers regardless of their location in SD and the associated precipitation amounts along with tillage type were not related to the P fertilizer source decision. Farmers used MAP the most regardless of application timing (67%), followed by DAP (30%) and MESZ or MES (3%) (Table 1).

Potassium

Potassium fertilizer source used by farmers regardless of application timing was related to location, tillage, or farm size. Similar to P fertilizer, this result suggests that fertilizer sources are similarly available to farmers regardless of their location in SD and similarly used regardless of tillage type or farm size. Farmers used K chloride (KCl; potash) the most (70%) regardless of application timing, followed by K sulfate (16%), K thiosulfate (7%), and K-magnesium sulfate (6%) (Table 1).

Table 1. Percentage of surveyed farmers who used various phosphorus and potassium fertilizer sources in the fall, spring or in season along with their use across phosphorus and potassium fertilizer sources and application timings.

Nutrient Source	Application timing			Across timings
	Fall	Spring	In-season	
	---------- % -------			
Phosphorus				
MAP (11-52-0)	19	28	2	67
DAP (18-46-0)	8	13	1	30
MESZ or MES	1	1	0	3
Across phosphorus products	38	58	4	
Potassium				
Potassium chloride (0-0-60)	18	24	1	70
Potassium sulfate (0-0-50)	3	6	1	16
Potassium-magnesium sulfate (0-0-22-22S-11Mg)	1	2	1	6
Potassium thiosulfate (0-0-25-17S)	0	3	1	7
Across potassium products	37	56	7	

Phosphorus and Potassium Rates

Phosphorus

Fertilizer-P rates used in corn production were not related to location, tillage type, or farm size (Table 2). Phosphorus fertilizer rates across categories ranged from 62 to 72 lbs. P_2O_5 ac^{-1} with a mean of 68 lbs. P_2O_5 ac^{-1}. The lack of location, tillage type, or farm size related to P rate decisions shows that these factors were not related to most farmers' choices.

Potassium

Fertilizer-K rates used in corn production were related to tillage type, farm size, but not location within SD (Table 2). Regarding tillage, no-till farmers applied the least amount of K to their corn crop (41 lbs K_2O ac^{-1}) while conventional- and reduced-till farmers applied the most (51-61 lbs K_2O ac^{-1}). These results indicate that in general no-till farmers apply lower amounts of fertilizer-K to corn. For farm size, larger farms (>2,000 ac) applied the lowest amount of K while farms less than 2,000 ac applied K at similar rates. The largest farms in SD are typically in central SD where soil test K levels are normally high enough where farmers do not typically apply K fertilizer. This may be the reason that these larger farms apply less K than smaller farms that are typically in eastern SD where K is more frequently a yield limiting factor.

Table 2. Total fertilizer-P and -K rate in relation to location, tillage system, and farm size.

Variable category	Variables	Fertilizer-P rate (lbs P_2O_5 ac^{-1})	Fertilizer-K use (lbs K_2O ac^{-1})
Location	East	68	46
	Central	68	53
Tillage	No-till	62	41c
	Reduced	67	51b
	Conventional	72	61a
Farm size (ac)	>2000	69	44b
	1,000-1,999	72	53a
	500-1,999	62	56a
	1-499	69	54a

[a] Mean values with different letters within each column for each variable category (i.e. location, tillage, and farm size) are statistically different ($P \leq 0.05$). If no letters are present, then there are no significant differences.

Phosphorus and Potassium Application Time

Approximately ⅓ of P and K fertilizer applications for corn occur in the fall while more than 50% occur in the spring and only 4 to 7% occur during the growing season (Table 1). The greater amount of fall application timings of P and K fertilizer compared to N is likely due to the lower likelihood of P and K loss during typically high spring precipitation events. Further, the lower movement of P and K in the soil compared to N is also likely a reason that minimal P and K applications occur during the growing season. To be most effective P and K fertilizers need to be applied before planting to help it move to where corn roots will be growing so the corn plant can take up these nutrients.

Besides fertilizer application timing within a season, farmers also often have to decide whether they apply fertilizer for one or multiple growing seasons. Overall, farmers in SD choose to apply fertilizer that supplies nutrients for only one growing season (Table 2). However, 13% of farmers that took the survey applies P for the next two or three cropping seasons. For P, the location of the farm in SD, size of the farm, or tillage type was not related to making this fertilizer application rate strategy decision. However, for K fertilization, the location in SD but not farm size or tillage type was related to this decision. For K, farms in eastern SD were more likely than farms in central SD to apply K for one or two growing seasons. Fields in central SD generally have higher K levels in their soils, and this is likely the reason why we see farms in eastern SD applying K for only one or two growing seasons.

Table 3. Percentage of surveyed farmers who applied enough phosphorus or potassium fertilizer for only the current growing season or for two or more growing seasons.

Phosphorus and potassium fertilizer application strategy	Phosphorus	Potassium
	----- % -----	
I apply enough for the current cropping season	80	100
I apply enough for the next two cropping seasons	12	0
I apply enough for the next three cropping seasons	1	0
I apply enough for longer than three cropping seasons	0	0

Table 4. Percentage of surveyed farmers in eastern versus central SD that applied enough potassium for only the current growing season or for two or more growing seasons.

Phosphorus and potassium fertilizer application strategy	Central	East
	----- % -----	
I apply enough for the current cropping season	52b[a]	67a
I apply enough for the next two cropping seasons	5b	19a
I apply enough for the next three cropping seasons	1	0
I apply enough for longer than three cropping seasons	0	0

[a] Numbers in the same row without the same letter are statistically different.

Phosphorus and Potassium Placement

The placement of P and K on the soil surface or incorporating them into the soil can affect their availability to plants and potential loss. In this survey, we evaluated various placement methods of P and K when applied in the fall and spring. When evaluated across application timings, broadcast, incorporated was by far the most common method of application (47%), followed by broadcast without incorporation (28%), banding with strip-till (11%), banding under the row (7%), and all other methods were used 3% or less of the time (Table 5). When P and K fertilizer was applied in the fall, it was close to evenly split whether farmers broadcast the fertilizer and incorporated it or not or used strip-till to band the fertilizer. However, when farmers applied P and K in the spring, broadcast and incorporating (25%) were used 11% more than broadcast and not incorporated (14%), with all others being used less than 5% of cases.

Farm location in SD, farm size, and tillage type were related to farmers' decisions on where P and K fertilizers were placed when banding fertilizer under the row and broadcasting fertilizer (Table 6). No-till farms were more likely to band fertilizer under the row or broadcast without incorporation, whereas conventional and reduced till farms were more likely to broadcast and incorporate the fertilizer with tillage. These differences were likely due to the inherent inability to incorporate broadcast fertilizer with tillage in a no-till farm. In central SD the climate is drier, and farms dominantly use no-till practices and farm more acres compared to eastern SD that typically has smaller farms and uses conventional tillage practices. These reasons likely explain why we found that larger farms and farms in central SD (generally no-till farms) more typically do not incorporate fertilizer after broadcast applications and band fertilizer under the row, while eastern SD farms and smaller farms incorporate fertilizer after broadcasting it. Overall, these results show that most farmers in eastern and central SD use broadcast methods to apply P and K fertilizer. Additionally, in conventional tillage farms, P and K are incorporated and in no-till farms they are banded under the row or unincorporated. The use of these methods by farmers in SD is supported by research as broadcast methods are as effective as banding methods the majority of the time (Bly et al., 2015). The only improvement in yield from banding P next to the corn plant has come from soils with < 8 ppm Olsen soil test P values and when rates applied were < 40 lbs P_2O_5 ac^{-1}.

Table 5. Percentage of surveyed farmers who used various phosphorus and potassium fertilizer application by placement methods along with the percentage of their use across application timings and placement methods.

Placement Method	Fertilizer application timing		Across timings
	Fall	Spring	
	%		
Broadcast: incorporated	12	25	47
Broadcast: not-incorporated	8	14	28
Banding: with strip till	7	1	11
Banding: under the row	1	4	7
Sub-surface banding: next to row	0	2	3
Sub-surface banding: mid row	1	2	3
Surface banding: next to row	0	1	1
Surface banding: mid row	0	<1	<1
Across placement methods	37	63	--

Table 6. Percentage of surveyed farmers who used various phosphorus and potassium fertilizer placement methods of spring applied phosphorus and potassium fertilizer in relation to location, tillage system, and farm size.

Variable category	Variables	Fertilizer placement method		
		Banding Under the row	Broadcast: Not incorporated	Broadcast: Incorporated
		%		
Location	East	2b	15b	46a
	Central	7a	25a	13b
Tillage	No-till	9a	36a	12b
	Reduced	0b	4b	39a
	Conventional	2b	9b	54a
Farm size (ac)	>2000	9	14	16c
	1,000-1,999	6	25	30b
	500-1,999	2	21	39b
	1-499	0	18	64a

[a] Mean values with different letters within each column for each variable category (i.e. location, tillage, and farm size) are statistically different (P ≤ 0.05). If no letters are present, then there are no significant differences.

Acknowledgement

Research funded by the SD Nutrient Research and Education Council and NIFA Hatch projects SD000H676-18 and SD00H733-22. Authors appreciate responses of those farmers who filled out and returned our survey and graduate student Edem Avemegah for assisting in developing and implementing the survey and data cleaning.

References

Bly, A., G. Reiks, and R. Gelderman. 2015. Starter, banding, and broadcasting phosphorus fertilizer for profitable corn production. In: Clay, D., Carlson, C., Clay, S., and Byamukama, E., editors, iGrow Corn: Best Management Practices. SDSU Extension, Brookings, SD. p. 26-1-26–7