

Wheat Nutrient Management Practices

Section 2: Nitrogen Management Practices

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Introduction

Nitrogen is the most common nutrient that limits wheat growth and yield. The management practices that lead to the highest chance of N use by the wheat crop and lowest chance of loss to the environment is often referred to as the 4Rs of nutrient management—Right: source, rate, timing, and placement. In this section we will evaluate the results from the 2019 nutrient management survey to help us better understand the local factors that influence the use of various N management practices. The local factors evaluated include geographic location within South Dakota (SD), tillage type, and farm size. Understanding these factors on farmer's decisions regarding N management practices can give guidance to government agencies, extension, and other professionals regarding needed research, educational resources, and trainings that are needed to help farmers adopt appropriate 4R nutrient management practices.

Nitrogen Sources

Nitrogen fertilizer source used by farmers regardless of application timing was not affected by location, tillage, or farm size. This result suggests that fertilizer sources are similarly available to farmers regardless of their location in SD and its associated precipitation amounts. Tillage type also did not affect the fertilizer-N source decision. Farmers used urea the most (68%) followed by urea ammonium nitrate (UAN) 28% (24%), manure (6%) and anhydrous ammonia (3%) (Table1). Urea was the N source of choice in the fall and spring, but once N applications hit mid/late season then UAN 28% was most common at 14% and then urea at 5%.

Table 1. Percentage use of N fertilizer source by application timing along with percentage use across N fertilizer sources and application timings.

Nitrogen Fertilizer Source ^a						
Application Timing	Urea	UAN 28%	UAN 32%	AA 82%	Manure	Across Products
Fall	33	5	0	5	10	21
Spring	67	14	0	0	0	6
Early Season	5	5	0	0	0	50
Mid/Late Season	5	14	0	0	0	24
Across timings	68	24	0	3	6	-
Note. Percentages may not add up to 100 as individuals could input data in multiple categories.						
^a UAN, Urea ammonium nitrate; AA, Anhydrous ammonia						

Liquid N Product Use

The use of liquid-N fertilizer (common products are UAN 28%) as a source for N is becoming more used and similar to urea use once farmers planted wheat (Table 1). In this survey we polled farmers to see the percentage of their land where liquid-N fertilizer was applied. The percentage of land where liquid-N was applied was not impacted by location, tillage type, or farm size. Liquid N use regardless of location, tillage type, or locations was used in 7-23% of farmers' wheat acres each year (Table 3).

Enhanced Efficiency Fertilizer Use

Enhanced efficiency fertilizers—fertilizers with urease or nitrification inhibitors or a slow-release fertilizer—were minimally used by farmers in SD ($\leq 15\%$) (Table 2). Because of the low use of these EEFs an analysis related to the influence of location, tillage, and farm size was not completed. Therefore, we examined the use of EEFs across all surveyed farmers. Urease inhibitors delay the conversion of urea to ammonia to lengthen the time urea can be on the soil surface before it is incorporated with precipitation. Using a urease inhibitor lowers the probability of N loss through ammonia volatilization and was the most used EEF by SD farmers (15%). Slow-release fertilizers were the second most used EEF (10%). These fertilizers are encapsulated or coated with a material that slowly releases N throughout the growing season. Nitrification inhibitors were used 9% of the time. These inhibitors interfere with the bacteria that converts ammonium into nitrite and then nitrate, which are highly mobile in the soil and more susceptible to loss through leaching and denitrification.

When EEFs were used by SD farmers when growing wheat they were most used in the spring (11%) and in-season (4%) with minimal use in the fall (1%) (Table 2). These results coincide with our other fertilizer application timing results where synthetic N fertilizers were most applied in the spring and in-season (Table 3). The low use of these EEFs may be due to the effectiveness of nitrification inhibitors being greatest when applied in the fall (Randall et al., 2003; Randall and Vetsch, 2005; Burzaco et al., 2014). However, most N applications in SD occur in the spring and in-season.

Table 2. Percentage use of various enhanced efficiency fertilizers and their application timings across all enhanced efficiency fertilizers.

Variables	Percentage Use (%)
Enhanced Efficiency Fertilizer categories	
Urease inhibitors	15
Nitrification inhibitors	9
Both urease and nitrification inhibitors	6
Yes inhibitor, unsure of category	7
Slow-release fertilizer	10
Enhanced Efficiency Fertilizer application timing	
Fall	1
Spring	11
In-season	4

Nitrogen Rates

Fertilizer-N rates for wheat across evaluated categories ranged between 116 and 163 lbs N ac⁻¹ (Table 3). These fertilizer-N rates were influenced by tillage type and not by location or farm size ($\alpha = 0.05$). However, there was a trend that farmers in central compared to eastern SD applied more N to their wheat crop (130 vs 116 lbs N ac⁻¹) (Table 4). Regarding tillage, no-till and conventional till farmers applied the least amount of N to their wheat crop (112-121 lbs N ac⁻¹) while reduced-till farmers applied the most (163 lbs N ac⁻¹). The higher rate applied in reduced till may be skewed by the lower number of farmers using reduced-till (N=9) compared to no-till (N=73) and conventional tillage (N=112). Therefore, more reduced till farmers would need to be surveyed to better show if this higher rate of N applied to wheat is indeed true. The fact that farm size did not affect fertilizer-N rates among farmers indicates that these rates applied are not likely being changed based on number of acres operated, equipment availability, or ability to absorb financial risk.

Table 3. Total fertilizer-N rate and proportion of land liquid-N is used as the primary N source as affected by location, tillage system, and farm size.

Variables	Fertilizer-N (lbs N ac ⁻¹)	Liquid-N Use (% of land)
Location		
East	116	16
Central	130	15
Tillage		
No-till	121b	16
Reduced	163a	21
Conventional	112b	13
Farm size (ac)		
>2000	126	15
1,000-1,999	123	7
500-1,999	116	23
1-499	126	23
^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.		

Nitrogen Application Time

Minimal fertilizer-N applications were applied in the fall except for manure (Table 1). This is important because N fertilizer applied in the fall has a large window where loss can occur before wheat starts utilizing it the following spring. This result is important as it shows farmers in SD are generally choosing to apply N closer to crop use by applying it in the spring. Across N sources and among the four synthetic N sources (not including manure), spring or early season N fertilizer applications were the most common (56%) followed by mid/late growing season applications (24%). These results suggest that the primary time for synthetic N fertilizer application is the spring and early season, and that mid/late in-season applications are less used. Some studies have suggested that splitting N fertilizer applications can improve wheat yield and protein content. However, the use of split applications by SD farmers was only 32% opposed to single applications being used 68% of the time (Table 4). Farm location, tillage type, and farm size were not related ($P \leq .05$) to the use of single- and split-N applications.

Table 4. Percentage of respondents that use single- and split-N application strategies as affected by location, tillage system, and farm size.

Variables	Single-N application (%)	Split-N application (%)
Overall	68	32
Location		
Central	68	32
East	62	38
Tillage		
No-till	71	30
Reduced	63	38
Conventional	33	68
Farm size (ac)		
>2000	52	48
1,000-1,999	83	17
500-1,999	80	20
1-499	80	20
^a Percentages with different letters within each column are statistically different ($P \leq .05$). If no letters are present, there are no significant differences.		

Nitrogen Placement

Placing nutrients on or below the soil surface can influence the availability of N to crops and its susceptibility to loss. For example, urea left on the soil surface can lead to ammonia volatilization loss, reducing the total N available to the crop. In this survey, we evaluated various placement methods both when N was single and split applied. For single-N applications, broadcast application of N in the spring or early growing season was by far the most common placement method (Table 5). Broadcasting without incorporation was generally more common before planting (36 vs 17%). This result is likely due to approximately 50% of SD farmers using no-till practices that would inhibit them from using tillage to incorporate a broadcast application of N fertilizer (USDA-NRCS, 2019; Wang, 2019). All other fertilizer placement methods and application timing combinations were minimally used ($\leq 3\%$).

For farmers that split up their N applications, broadcast placement and spring and early season timing compared to the other options were still the dominant placement by timing combinations (13-33% vs 3-23%) (Table 5). However, likely due to the nature of splitting up the applications, the percent use of mid/late season and top dress applications increased from 0-3% to 13-23%. Additionally, when split applying N compared to single-N applications, application methods that place the fertilizer below the soil surface during in-season applications was also more frequently used (3-13% vs. 1-3%). This greater use of below the surface application with in-season applications is likely due to some of the fertilizer being put on with the planter. However, the use of placement methods that place fertilizer below the surface are still minimally used ($\leq 13\%$). This low usage is likely due to the specialized equipment that is often needed to place fertilizer below the soil surface. These types of applications also frequently require the use of liquid-N sources that are commonly more expensive than dry-N sources. Additionally, many farmers hire co-ops to apply fertilizer for them. These co-ops most frequently broadcast fertilizer on the soil surface as this method can be used to apply N to more acres each day compared to methods that place fertilizer below the soil surface. To change any of these practices it will take research results and educational programs geared to farmers and fertilizer applicators, showing a combination of improved yields and profits with the use of placement methods that place fertilizer below the soil surface or applications completed in-season.

Table 5. Percentage use of N fertilizer application timing by placement method along with percentage use across application timings and placement methods.

Placement Method	N fertilizer application timing				
	Fall	Spring, Preplant	Early Season	Mid/Late Season	Across Timings
Using Single-N Application					
Broadcast: incorporated	8	17	11	0	36
Broadcast: not-incorporated	3	36	17	0	56
Banding: under the row	0	3	0	0	3
Sub-surface banding: mid row	1	3	0	0	4
Top dress: foliar feed	0	0	0	0	0
Across placement methods	12	59	29	0	-
Using Split-N Application					
Broadcast: incorporated	17	17	13	3	24
Broadcast: not-incorporated	20	33	23	10	42
Banding: under the row	7	7	0	0	6
Sub-surface banding: mid row	3	13	0	0	8
Top dress: foliar feed	0	0	13	23	18
Across placement methods	22	34	24	19	-
Note. Percentages may not add up to 100 as individuals could input data in multiple categories.					

Nitrogen Placement with Split-N Applications

For those farmers who split up their total N application among two or more application times, we wanted to understand what percent of their total N rate they applied at each timing and placement method combination. Before planting, the mean percent of fertilizer applied ranged from 4-73% of the total N application (Table 6). After planting, the mean percent of the total N application had a smaller range of 21-58% with early season applications generally receiving more of the N at 40-58% compared to mid/late season that received only 21-31%. Banding and top-dress applications had the lowest mean percent (36-42%) where broadcast methods had the greatest mean percentage (46-48%).

Table 6. Mean percentage $\pm$ standard deviation of total fertilizer-N rate when splitting up the N applications for each application timing and placement method combination.

Placement method	N Fertilizer Application Timing (% of total N rate $\pm$ standard deviation)				
	Fall	Spring, Preplant	Early Season	Mid/Late Season	Across Timings
Broadcast: incorporated	4 $\pm$ 14	64 $\pm$ 12	58 $\pm$ 22	29 $\pm$ n/a	48 $\pm$ 12
Broadcast: not-incorporated	32 $\pm$ 40	73 $\pm$ 15	58 $\pm$ 12	21 $\pm$ 7	46 $\pm$ 18
Sub-surface banding: mid row	n/a	42 $\pm$ 11	n/a	n/a	42 $\pm$ 11
Top dress: foliar feed	n/a	n/a	40 $\pm$ 1	31 $\pm$ 16	36 $\pm$ 8
Across placement methods	18 $\pm$ 27	60 $\pm$ 13	52 $\pm$ 12	27 $\pm$ 12	
^a “n/a” indicates that no response was recorded from the survey for that placement and timing combination. If “n/a” is in the place of the standard deviation, it indicates only 1 response was recorded from the survey for that placement and timing combination so no standard deviation could be calculated.					

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