SF1448
(Revised)

Fertilizing Winter Wheat

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Winter wheat fertilization recommendations in North Dakota previously were similar to spring wheat and durum. As a larger research base was developed for spring wheat and durum, separating winter wheat from other wheats became necessary due to their unique nutrient requirements.

Nitrogen

Nitrogen Timing

Winter wheat can be fertilized with the entire nitrogen amount in the fall, but studies in many winter wheat-growing areas show a consistently better yield response and greater nitrogen use efficiency when the bulk of N is applied in the spring at green-up.

In addition, fertilizing on frozen soils that have a low chance of thaw before spring is a very poor fertilizing strategy. Frozen soil does not allow N to move into soil, so the N is free to move during snowmelt. Very large N losses are common when fertilizing onto frozen ground.

A spring application is sometimes difficult due to uneven snowmelt and potentially wet soil conditions, but morning frosts once snow melts usually enable a timely application.

The use of UAN (28-0-0) liquid fertilizer with stream-bars is a preferred application method. Broadcast UAN applications **should not** be used due to leaf burn that will result. Stream-bars should be monitored during application so that the stream pattern is not broken apart by wind. If the pattern is broken by wind, the stream-bar application will result in a broadcast-like application and severe leaf burning will result.

Urea granules may be used, but potential ammonia volatility is a concern if rain does not fall within a couple of days. Urea surface-applied in no-till is particularly at risk for volatility due to the high concentration of urease enzyme in residue, compared with bare soil. Ammonia loss from urea breakdown due to urease activity is greatest when soil/residue is moist, temperatures are above freezing and a wind is blowing.

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The urease inhibitor Agrotain® (NBPT) may be used on urea to extend urea effectiveness through reduced ammonia volatilization for about 10 days. No other products have been shown to inhibit urease activity consistently enough to be recommended in North Dakota. See the NDSU publication "Nitrogen Extenders and Additives" at *www.ndsu.edu/fileadmin/soils/pdfs/Nitrogen_Extenders_and_Additive_for_Field_Crops_2017.pdf* for more details.

Nitrogen Rates

Nitrogen rate cannot predict yield. Previous recommendation formulas forced a grower to predict a yield and then apply the yield prediction to a formula. This strategy resulted in underfertilization in some years due to less than ideal growing conditions at the time of fertilization.

Weather in the region is unpredictable, and growing conditions can improve and better yields are possible than those planned for initially. Recent N-rate research on several crops indicate that no relationship exists between yield and N-rate and the environment.

A similar optimum N rate is appropriate in a low-yielding environment as in a high-yielding environment due to differences in N mineralization release from the soil, probability of N loss due to leaching and/or denitrification, and N uptake efficiency of roots in different soil moisture environments. In wheats, some consideration of historic soil productivity is necessary due to the economics of the application, and not necessarily the yield response of the application itself.

Our research indicates that the following productivity ranges are appropriate for consideration of optimum economic N rate for winter wheat:

- **Low** – yields below 40 bushel per acre
- **Medium** – yields between 40 and 70 bushels per acre
- **High** – yields greater than 70 bushels per acre

For areas of **low** productivity,
total available N (fertilizer + soil test nitrate 2 feet) = 100 pounds of N/acre

For areas of **medium** productivity,
total available N (fertilizer + soil test nitrate 2 feet) = 150 pounds of N/acre

For areas of **high** productivity,
total available N (fertilizer + soil test nitrate 2 feet) = 200 pounds of N/acre

Adjustments to N Rate

Previous crop N credits – see **Table 1**.

Table 1. Previous crop N credits.

Previous crop	Credit
Soybean	40 lb N/acre
Edible bean	40 lb N/acre
Pea and lentil	40 lb N/acre
Chickpea	40 lb N/acre
Sweet clover that was harvested	40 lb N/acre
Alfalfa that was harvested and unharvested sweet clover:	
>5 plants/sq ft	150 lb N/acre
34 plants/sq ft	100 lb N/acre
12 plants/sq ft	50 lb N/acre
<1 plant /sq ft	0 lb N/acre
Sugarbeet	
Yellow leaves	0 lb N/acre
Yellow/green leaves	30 lb N/acre
Dark green leaves	80 lb N/acre

Second-year N Credits

Half of credit given for the first year for sweet clover and alfalfa; none for other crops.

Reductions in N Rate Due to Location in the Langdon Region

See **Figure 1** for the agri-climatology zone referred to as the Langdon region. If growing winter wheat in this region, reduce N rates 40 pounds/acre. This reduction is due to the unique climatic and soil conditions in this area that promote increased soil and residue mineralization and release of N to growing crops.

The soils in the Langdon region contain small pieces of shale bedrock, which contain large amounts of mineralizable ammonium in the shale. This is probably the reason why the N rate studies in this region resulted in a lower optimum N rate, compared with the rest of eastern North Dakota.

Phosphate

Applying banded phosphate (P) to winter wheat at seeding is extremely important. Phosphate helps the plants establish good root systems and crowns going into winter and helps winter survival. Broadcast P may be better than no P, but the difference in efficiency between the two applications in winter wheat is very pronounced.

When banding granular or liquid fertilizer with the seed, do not exceed rates of N + K_2O as provided in **Tables 3 and 4**. If fertilizer must be applied at rates exceeding those in the tables, some

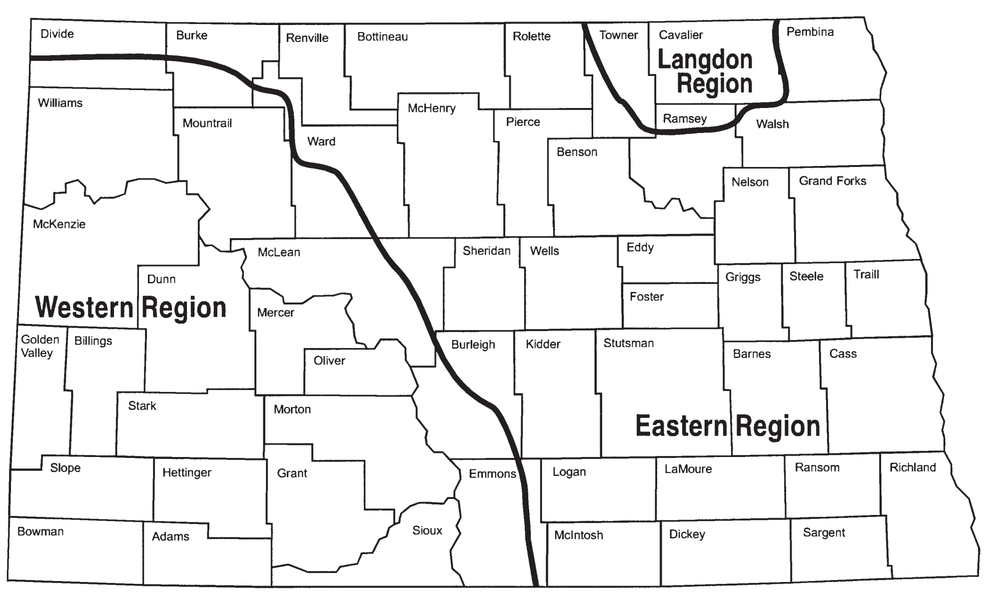

Figure 1. Agri-climatology zones in North Dakota for consideration of N rates.

Table 2. Banded fertilizer phosphate recommendations for North Dakota for winter wheat based on soil test and productivity level.

Olsen Soil Test Phosphorus, ppm				
VL 0-3	L 4-7	M 8-11	H 12-15	VH 16+
Pounds P_2O_5/acre				
75	50	30	25	15*

* Always include a small amount of starter P fertilizer in a band regardless of soil test. If starter fertilizer banding is not used, rates in H and VH categories should be zero.

change in fertilizer delivery must be made on the seeder so that the seed and fertilizer application is separated by at least 1 inch, and preferably 2 inches.

Potassium

The potassium (K) recommendations have been changed. Finding responses to K is difficult when soil test K levels are greater than 100 ppm. Nearly all of the higher soil test K responses are related to a chloride response.

Most soils in North Dakota have high enough potassium (K) levels to support excellent wheat production. Exceptions might be sandier soils or soils with a history of many years of continuous soybean.

Current K fertilizer recommendations are displayed below. If chloride levels are adequate and other crops in the rotation regularly receive K fertilizer, then fertilizer rates in the high range of soil tests may not be needed.

- **Soils with smectite-to-illite ratio greater than 3.5 (Figure 2)**

  Soil test K > 150 ppm, no additional K required. KCl (0-0-60-50Cl) may be applied if Cl levels are low.

  Soil test K 150 ppm or less, apply 50 pounds/acre KCl (30 pounds/acre K_2O)

- **Soils with smectite-to-illite ratio 3.5 or less (Figure 2)**

  Soil test K > 100 ppm, no additional K required. KCl (0-0-60-50Cl) may be applied if Cl levels are low.

  Soil test K 100 ppm or less, apply 50 pounds/acre KCl (30 pounds/acre K_2O)

Table 3. Maximum N + K_2O fertilizer rates with wheat seed at planting based on row spacing, planter opener type and seedbed utilization. SU = seedbed utilization (from Franzen, 2015).

		Row Spacing, inches							
		6		7.5		10		12	
Planter Opener Type	Seed Spread	SU	lb N+K_2O/acre	SU	lb N+K_2O/acre	SU	lb N+K_2O/acre	SU	lb N+K_2O/acre
	inches								
Double-disc	1	17%	20-30	13%	19-28	10%	17-23	8%	15-20
Hoe	2	33%	32-44	27%	27-38	20%	23-31	17%	20-27
	3	50%	44-58	40%	37-48	30%	30-40	25%	26-34
Sweep	4	66%	56-72	53%	46-58	40%	37-48	33%	32-42
	5	83%	68-86	68%	56-68	50%	44-57	44%	38-49
	6	100%	80-100	80%	66-79	60%	51-55	50%	44-56
	7			94%	76-90	70%	58-74	58%	50-64
	8					80%	66-83	67%	56-71
	9					90%	73-92	75%	62-78
	10					100%	80-100	83%	68-86
	11							92%	74-93
	12							100%	80-100

Table 4. Maximum N + K_2O fertilizer rates with wheat at planting based on soil texture and seedbed utilization (from Franzen, 2015).

				Percent Seedbed Utilization		
Soil Texture	— Particle Size — Sand	Silt	Clay	10-20 Double-disc 1 inch	30-50 Hoe 2-3 inches	60-100 Sweep 4-12 inches
	Percent			lb N + K_2O /acre		
Loamy sand	80	10	10	5	10-20	25-40
Sandy loam	60	35	15	10	15-25	30-45
Sandy clay loam	55	15	30	15	20-30	35-50
Loam	40	40	20	20	25-35	40-55
Silt loam	20	65	15	25	30-40	45-60
Silty clay loam	10	55	35	30	35-45	50-70
Clay loam	30	30	40	35	40-50	55-80
Clay	20	20	60	40	45-55	60-100

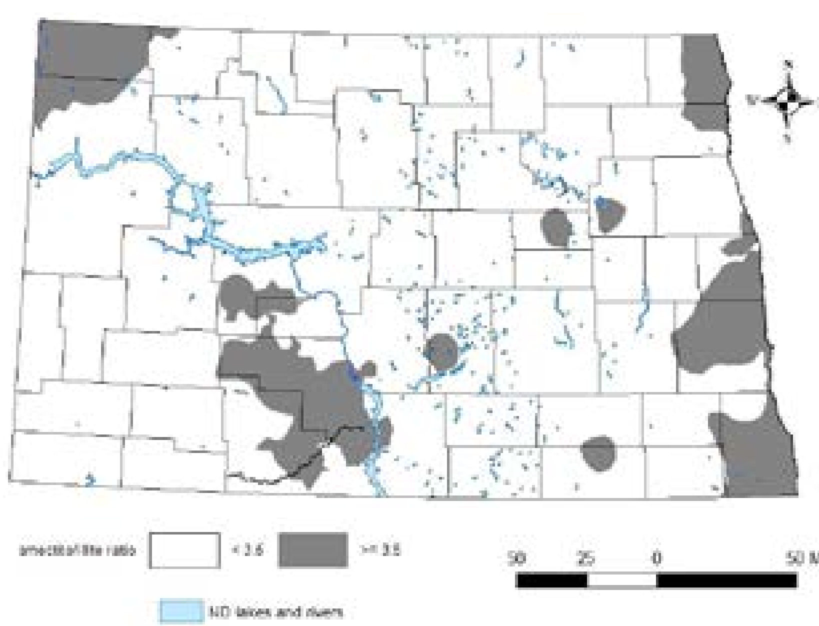

Figure 2. Smectite-to-illite clay chemistry for soils in North Dakota from a soil sampling survey conducted in 2017.

Sulfur

Sulfur is becoming more important than potassium or chloride in the state as a third major nutrient. Environmental regulations on fossil fuel emissions have put more stringent restrictions on sulfur emissions in recent years. This has resulted in less sulfur through rainfall.

The sulfur soil test is not a good predictor of possible sulfur deficiency. Sulfur deficiency has become so prevalent in small grains and corn that for spring wheat/durum, a base application of 10 pounds of S/acre would be prudent, particularly if the fall, winter or early spring before seeding has received normal to above normal precipitation. Soils with sandy loam or coarser textures, and less than 3 percent organic matter on higher landscape positions are most at risk, but most soils are at risk in wetter seasons.

Sulfur fertilizer application is a spring operation. The spring fertilizer application should consist of a soluble sulfur fertilizer. Ammonium sulfate at rates of about 10 pounds of S/acre or gypsum at 20 pounds of S/acre would be excellent sources of sulfur. Elemental sulfur, even premium bentonite-blended forms, would not be nearly as useful in correcting a deficiency.

Composite blended granules of phosphate fertilizers that include sulfur could be used, but rates need to be high enough to supply the 10 pounds of S/acre needed as the ammonium sulfate portion of the fertilizer, or the application should be supplemented with a sulfate containing fertilizer. Gypsum or ammonium sulfate may be blended with a urea top-dress application, while ammonium sulfate solutions or ammonium thiosulfate may be applied with stream-bars (not broadcast nozzles), along with 28-0-0.

Copper

Increases in yield and decreases in fusarium head blight (scab) have been documented in North Dakota with the application of copper (Franzen et al., 2008). The responses to copper were seen mostly on low-organic matter, sandy soils. However, only about 15 percent of the sites that fit these criteria in the study responded.

Predicting whether wheat grown on these soils would respond to copper would be difficult. Copper application is a site-specific nutrient at best. Applying it on loam or heavier soils, or in soils with between 3 and 8 percent organic matter, would provide no benefit. An application of copper sulfate at a rate of 5 pounds of Cu/acre would last many years.

Chloride

Chloride responses are well-documented in wheat. In studies in the state and the region, wheat tends to respond positively to chloride about half the time, with yield increases in the 2- to 5-bushel/acre range. Studies in consecutive years that investigated varietal responses to chloride provided inconsistent results. Yield increases from chloride arise from increased resistance to certain root and leaf diseases and an increase in kernel size. The critical level of chloride is 40 pounds/acre in the surface 2 feet of soil. If the soil test is less than 40 pounds pf Cl/acre, fertilizing with 5 to10 pounds of Cl/acre with or near the seed at planting should sufficiently supply the crop for the year.

The most common source of Cl is KCl (potash, 0-0-60). When adding Cl to fertilizer, refer to **Tables 3 and 4** so critical levels of N + K_2O are not exceeded.

Other Nutrients

No evidence indicates that supplemental zinc, iron, manganese and boron are needed in North Dakota. Although numerous reports exist in the US and around the world of these nutrients being required as fertilizer, our soils apparently supply enough and our wheat is adapted to our soils enough that these nutrients do not need to be supplied artificially.

References

Franzen, D.W., 2015. Fertilizer application with small grain seed at planting. NDSU publication SF1751.

Franzen, D.W., M. McMullen and D.S. Mossett. 2008. Spring wheat and durum yield and disease responses to copper fertilization of mineral soils. Agronomy Journal 100:371-375.

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