

Fertilizing Winter Wheat I Nitrogen, Potassium, and Micronutrients

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Soil testing, recommended rates, and timing for fertilizing winter wheat with nitrogen, potassium, and micronutrients.

Management practices which provide an adequate, but not excessive, supply of plant nutrients are essential for top yields of high quality winter wheat in the High Plains.

Soil Testing

Soil testing is the foundation of nutrient management in winter wheat. The goal of soil testing is to characterize the amount of nutrients in the soil prior to planting. Fertilizers can then be applied to ensure optimal nutritional conditions for the crop.

Soil samples from the surface to a depth of 3 feet are necessary for the most accurate prediction of nutrient needs. These should include a plow-layer sample (0-8 inches) and a sample from 8 to 36 inches. Collect composite cores from at least 15 points in the field for the surface sample and from 8 to 10 points for the deeper samples. More than one set of samples may be necessary from some fields if parts of the field differ in slope or soil characteristics such as color, sandiness or previous crop. For more information on soil sampling refer to NebGuide G1000, *Guidelines for Soil Sampling*.

The plow layer sample should be analyzed for nitrate and all other nutrients, organic matter concentration, and soil pH. The deeper samples should be analyzed for nitrate only. The reasons for this difference in analysis are:

- 1) while most nutrients are not very soluble and are mainly in the top 8 inches of soil, nitrate is very soluble, and rainfall or irrigation may leach it from the plow layer; and
- 2) research and experience has shown that wheat can utilize nitrate-nitrogen from depths of 3 feet or more. Soil samples from the plow layer alone do not accurately predict the amount of nitrogen available to the crop.

Soil testing for nitrate-nitrogen is recommended before planting each wheat crop and soil testing for potassium and micronutrients is recommended every three to five years.

Nitrogen Recommendations

Most winter wheat grown in Nebraska requires additional nitrogen fertilizer for profitable production. This is true for virtually all soils in Nebraska where wheat is commonly grown unless there is a large carryover of fertilizer nitrogen.

Nitrogen is a building block of amino acids and proteins in plants. The most abundant protein in plants, chlorophyll, gives them their green color. It is necessary for photosynthesis — the conversion of carbon dioxide gas and water into sugars with the help of light energy. Plants deficient in nitrogen contain less chlorophyll and appear light green. With increasing severity of nitrogen deficiency, leaves will appear yellow and older leaves will age prematurely. Symptoms of nitrogen deficiency appear first on older leaves.

Residual soil nitrate can be measured effectively with a soil test of the root zone. While the depth of the root zone for wheat is often six feet or more, most available nitrogen affecting yield is in the top two or three feet of soil. The producer can use soil samples less than three feet deep for making nitrogen recommendations, but they are slightly less accurate.

The optimum fertilizer nitrogen rate for winter wheat (with a maximum rate of 100 pounds of nitrogen per acre for dryland, 150 pounds of nitrogen per acre irrigated) can be calculated with the following equation or by using *Table I*.

$$\text{Nitrogen Rate (lbs/acre)} = ((\text{N PRICE} / \text{WHEAT PRICE}) + 0.014558 \times \text{NO}_3\text{-N} - 0.235) / -0.00138$$

Where N PRICE is the price of nitrogen fertilizer in dollars per pound of nitrogen,
WHEAT PRICE is the price of wheat in dollars per bushel (includes actual selling price and yield-bound government subsidies),
NO₃-N is the average parts per million (ppm) nitrate-nitrogen in three feet.

If a soil sample is not taken, a recommendation of 9 ppm of nitrate-nitrogen per acre represents about an average or medium soil nitrate level.

Consider this example: A field has a soil test value of 5 ppm residual nitrate-nitrogen in a 3-foot soil profile. Nitrogen costs \$0.20 a pound and the wheat crop will sell for \$3.00 per bushel.

Table I. Nitrogen fertilizer recommendations for wheat.

Wheat Price (\$/bu)	\$2.50			\$3.00			\$3.50			\$4.00		
Fertilizer Price (\$/lb N)	0.20	0.25	0.30	0.20	0.25	0.30	0.20	0.25	0.30	0.20	0.25	0.30
	Nitrogen Application Rate (Lb N/A)			Nitrogen Application Rate (Lb N/A)			Nitrogen Application Rate (Lb N/A)			Nitrogen Application Rate (Lb N/A)		
Soil Test N (ppm)												
1	102	87	73	111	99	87	118	108	98	124	114	105
2	91	77	62	101	89	77	108	97	87	113	104	95
3	81	66	52	90	78	66	97	87	77	102	93	84
4	70	56	41	80	68	56	87	76	66	92	83	74
5	60	45	31	69	57	45	76	66	55	81	72	63
6	49	35	20	59	47	35	66	55	45	71	62	53
7	38	24	9	48	36	24	55	45	34	60	51	42
8	28	13	0	38	26	13	44	34	24	50	41	32
9	17	3	0	27	15	3	34	24	13	39	30	21
10	7	0	0	16	4	0	23	13	3	29	20	10
11	0	0	0	6	0	0	13	2	0	18	9	0
12	0	0	0	0	0	0	2	0	0	7	0	0

The nitrogen fertilizer requirement is calculated as follows:

$$\text{Nitrogen need (lb N/acre)} = ((0.20/3.00) + 0.014558 \times 5 - 0.235) / -0.00138$$

$$\text{Nitrogen need} = 69 \text{ lb N/acre}$$

While research results have generally shown that high yields require higher nitrogen application rates for most crops, research data for winter wheat in Nebraska does not consistently show any effect of yield level on the optimum nitrogen required for maximizing profits from fertilizer nitrogen. Therefore, one rate is adequate regardless of yield level unless the producer expects yields above 70 bushels per acre; in this case the wheat may require an additional 20 pounds of nitrogen per acre.

When to Apply Nitrogen

Nitrogen applications have a high probability of increasing yield when soil nitrogen availability is low in relation to yield potential; however, studies also have shown yield depression due to nitrogen fertilizer application. Yield depressions have occurred more often with fall applications than with spring topdressing applications. Fall applications tend to stimulate increased fall growth which depletes the soil moisture supply and may increase susceptibility to disease. Yield depressions associated with fall application of nitrogen have been relatively rare and should not be used as a basis for not applying nitrogen to wheat when recommended by soil tests. If yield depression is a concern, especially in western Nebraska, topdressing is highly recommended. Topdressing allows the producer to evaluate yield potential based on stands and soil moisture in the spring. Topdressing has a significant advantage because it can help the producer avoid investing in a wheat crop that has low yield potential. Topdressing should be completed before April 15 or prior to jointing. With later nitrogen applications, yields generally decrease, but grain protein content generally increases.

Yield decreases due to nitrogen application also can occur on soils high in available nitrogen. When available nitrogen is too high, lodging often results, especially with high soil moisture in the spring. This emphasizes the importance of soil tests to determine soil nitrogen availability for high yield management.

Sources of Nitrogen for Wheat

All nitrogen fertilizer sources (ammonium nitrate (33-0-0); urea (45-0-0); urea-ammonium nitrate (28-0-0); anhydrous ammonia (82-0-0)) are generally very effective. Dry and liquid nitrogen sources vary in their susceptibility to volatilization or gaseous loss as ammonia to the atmosphere. Ammonium nitrate is the least susceptible, while urea is usually most susceptible. Therefore, ammonium nitrate is the preferred nitrogen fertilizer for topdressing where incorporation is impossible. With incorporation soon after fertilizer application, all nitrogen sources should be equally effective.

Anhydrous ammonia is the most economical source of nitrogen, especially under normal tillage; however, if applied with standard knife applicators, the increased power requirements add to application costs making the lower ammonia price less advantageous compared to other nitrogen sources. Depending on local pricing, ammonia application rates must be more than 50 pounds of nitrogen per acre to be more economical than other nitrogen sources. It is possible to topdress ammonia, but special applicators equipped with narrow knives are required in order to avoid damaging wheat stands. In western fallow areas, ammonia is generally the best nitrogen source to avoid drying the soil prior to seeding, if it is applied early in the fallow period.

Fertilizing With Nitrogen for Grain Protein

Nebraska wheat has traditionally been high in protein content and quality, desirable characteristics for the baking industry. The amount of nitrogen available to the wheat crop

directly affects grain protein content. Under high soil nitrogen availability, grain protein is often 13 percent or higher, depending on yield levels. If soil nitrogen is low, grain protein tends to decrease as grain yield decreases. Since grain protein reflects soil nitrogen availability, it can reflect when wheat yield will increase with applied nitrogen. A grain protein level of 12 percent to 13 percent with an average yield indicates adequate nitrogen. If grain protein is in the 9 percent to 10 percent range, however, yield response to nitrogen is probable.

A producer relying on University of Nebraska fertilizer recommendations for nitrogen will probably produce grain protein around 12 percent. If the goal is for higher grain protein to obtain premium grain prices, about 20 pounds per acre of additional nitrogen will need to be topdressed in the spring for each 1 percent increase in grain protein.

Fertilizing With Nitrogen Following High Yields

When a producer plants wheat following above average grain yields, increased nitrogen fertilizer may be required because of increased nitrogen removal with the previous crop and because increased straw yields require additional nitrogen for decomposition. Straw yields increase about 0.5 ton for each 10-bushel-per-acre increase in grain yields. Straw contains about 10 pounds of nitrogen per ton. Therefore, wheat following grain yields of 70 bushels per acre (about 20 bushels per acre above normal) may require additional nitrogen before soil organisms can decompose the straw. This can result in a temporary nitrogen deficiency for continuous wheat, but it also may limit straw decomposition during fallow in western areas. Under favorable soil moisture and temperature conditions, straw decomposition is usually quite rapid, releasing nitrogen for wheat growth in the fall. If straw decomposition is not complete, the immobilization of nitrogen in the straw can result in nitrogen deficiency during rapid spring growth. If such conditions exist, an additional 20 pounds of nitrogen per acre may be required for proper straw decomposition to prevent yield limitations to the following wheat crop.

Potassium Recommendations

Most Nebraska soils have enough potassium (K) for maximum wheat production. Potassium is important for the function of the stomata, pore-like openings of the plant leaves, through which transpiration of water and uptake of gaseous carbon dioxide occurs. Adequate potassium nutrition of the plant is necessary to ensure the integrity of the water economy within the plant. Early symptoms of potassium deficiency include uniform chlorosis on older plant parts. Leaves eventually become streaked with yellow or appear scorched, bronzed, or blighted along their edges

Although some experiments have shown that potassium fertilizer has apparently increased wheat yield, such increases have not been predictable and may have been the result of abnormal weather conditions or some indirect effect other than a potassium deficiency.

Potassium recommendations according to soil test are shown in *Table II*. It is rare for potassium to be recommended for Nebraska soils producing wheat because most soils growing wheat contain more than 150 ppm potassium.

Table II. Potassium fertilizer recommendations.

<i>Potassium soil test level (Exchangeable potassium, ppm)</i>	<i>Potash application rate (lb K₂O/A)</i>
0-40	40
40-74	30
75-124	20
125-150	0
>150	0

Micronutrient Recommendations

While some soil test laboratories recommend other nutrients for wheat, especially zinc (Zn) and sulfur (S), there is no experimental evidence substantiating the use of nutrients other than nitrogen and phosphorus in Nebraska. Sulfur on sandy soils probably has the greatest potential. While the acreage of sandy soils growing wheat is quite small, some wheat is irrigated on sandy soils in southwest Nebraska and occasionally in the Sandhill-loess transition areas bordering the Sandhills. Because sulfur soil tests are not very definitive, the decision to apply sulfur should be based on the following criteria: low organic matter, sandy soils, irrigation water that has low sulfur content, and visual symptoms such as a yellow color in the presence of adequate nitrogen.

If a farmer decides to apply sulfur, 20 pounds of sulfur per acre should be adequate. It can be applied as ammonia thiosulfate (11-0-0-26S) through irrigation water as a corrective treatment or broadcast as dry ammonium sulfate (21-0-0-24S). Seed application of ammonium thiosulfate with liquid ammonium phosphate can seriously damage germination and is not recommended.

Yield responses to chloride (Cl) have been observed on spring wheat grown in South Dakota. A series of experiments were conducted in the wheat growing areas of western Nebraska to see if there were benefits to chloride fertilization of winter wheat. Although most of the soils at the experimental sites tested low for chloride, applying fertilizers containing chloride did not result in increased yield or a better quality of winter wheat. Chloride fertilization is currently not recommended for winter wheat grown in Nebraska.

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