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Fertilizer for Wheat in Minnesota

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Introduction

Hard red spring and durum wheats are well adapted to the valley soils of northwest Minnesota. These soils generally contain high organic matter and adequate calcium, magnesium, sulfur, and potassium. Weather conditions such as coldness or unusual wetness during early growth can increase the chances of some deficiencies. Nitrogen and phosphorus are the two most important nutrient deficiencies that have been quite general in this area. On some years, however, when ideal temperatures and moisture prevail, responses from these nutrients, especially nitrogen, are not as apparent.

Wheat grows well in the southern corn areas of Minnesota as well. Smaller rates of annual nitrogen and phosphorus might be recommended in this area because soils tend to warm faster in the spring, and there is also the possibility of carryover from liberal applications on corn.

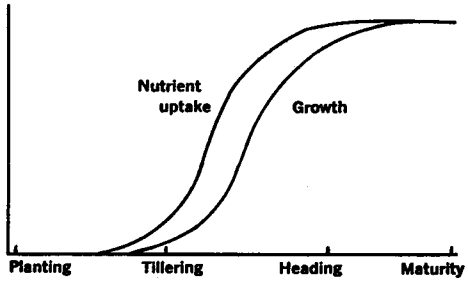
Nitrogen management is slightly different for winter wheat than spring wheat. Other than some specific paragraphs for winter wheat, emphasis in this publication is placed on the spring seeded crop since it has the largest acreage in the state.

Nutrient Requirements of Wheat

High wheat yields require adequate amounts of all plant nutrients. Most Minnesota soils supply adequate amounts of the micronutrients as well as calcium, magnesium, and sulfur for good wheat yields. In general, fertilizer use in Minnesota is geared to nitrogen, phosphorus, and potassium needs.

Investigators have found that a major portion of the plant food is taken up by the wheat plant during the stage from tillering to heading. Figure 1 illustrates growth and nutrient uptake by wheat from seeding to maturity.

Figure 1. Growth and nutrient uptake by wheat.



Uptake of most nutrients usually proceeds more rapidly than top growth. The patterns of uptake for nitrogen, phosphorus, and potassium are similar.

In the early growth stages, uptake of a particular nutrient proceeds at a relatively faster rate than growth. Nearly all the phosphorus used by the wheat plant is taken up by heading time. Wheat accumulates nutrients in its leaves and stems until grain formation begins when a portion of the nutrients are translocated into the grain. The amount of translocation varies greatly with different nutrients. For any one nutrient, it may vary considerably, depending on weather, soil conditions, and nutrient level in both soil and plant.

Approximately two-thirds of the phosphorus absorbed by the wheat plant is moved into the grain. Three-fourths of the nitrogen also moves into the grain, where it becomes part of the grain protein. Only about one-fourth of the potassium taken up by the wheat plant is found in the grain. Table 1 shows typical amounts of plant nutrients removed in wheat grain and straw.

Table 1. Plant food removed by wheat crop.

	Pounds		
	N	P_2O_5	K_2O
One bushel grain and straw	1.8	.75	1.0

Nitrogen is removed in largest amounts. Research has shown that under nonirrigated conditions approximately 2.5 pounds nitrogen is required for each bushel of wheat produced.

Total nitrogen in the wheat grain and straw is normally 1.8 pounds for each bushel produced, but the efficiency of fertilizer nitrogen uptake from the soil is roughly 60 percent. There is a direct relationship between protein content of the grain and the nitrogen removed from the soil, since 5.7 times grain nitrogen equals grain protein.

Forms of Fertilizer for Wheat

Most of the commonly used sources of phosphorus and potassium fertilizer are satisfactory for use in wheat production. Concentrated super phosphate (46 percent P_2O_5), as well as the highly water soluble ammonium phosphates and liquid ammonium polyphosphates, have proven to be good phosphorus sources for wheat in Minnesota.

Nearly all sources for nitrogen fertilizer can be used in wheat production under appropriate conditions. Farmers utilizing volatile sources of nitrogen such as anhydrous ammonia and aqua ammonia must place the materials in the soil so that free ammonia gas cannot escape into the atmosphere. Urea, ammonium sulfate, ammonium nitrate, and urea-ammonium nitrate fertilizers are good sources of nitrogen for wheat and should be incorporated into the soil at or near seeding time.

Surface applications of urea (46-0-0), ammonium sulfate (21.5-0-0), urea-ammonium nitrate (28-0-0), and ammonium nitrate (33.5-0-0) may result in minor losses of nitrogen under certain conditions. High soil pH, high temperature, and dry surfaces may cause losses of ammonia nitrogen with surface applied 46-0-0 and 28-0-0. If these materials are incorporated soon after application, little loss due to volatilization will occur.

Fall applied nitrogen is less likely to be lost due to leaching or denitrification if applied in the ammonium form. Field experiments generally show equivalent yields from different nitrogen fertilizers if the materials are applied properly.

Nitrogen Fertilizer Needed for Wheat

The introduction of semidwarf wheat varieties greatly enhanced the opportunity for growers to obtain high yields and to utilize nitrogen fertilizer more fully. Yield goals with normal height varieties are generally restricted to 50 bushels or less per acre, whereas the semidwarf varieties have potentials of more than 70 bushels per acre. This higher yield potential requires a higher rate of fertilizer use.

Farmers in the western half of Minnesota have the opportunity to take advantage of a nitrate soil test to accurately determine the needs for nitrogen fertilizer.

A composite sample taken from a depth of 0-24 inches in 10 to 15 locations within a field can be submitted to a soil testing laboratory for determining nitrate nitrogen (NO_3-N). Table 2 shows University of Minnesota recommendations based on NO_3-N levels as measured by the soil nitrate test.

Table 2. Nitrogen recommendations based on nitrate-nitrogen (NO_3-N) soil test. See Map 1.

Expected yield bu/A	Soil nitrate N (0-2 ft) + fertilizer N, lb/A*
80 or more	170
70-79	140
60-69	120
50-59	100
40-49	80
Less than 40	60

*Subtract nitrate N from this value to determine lb/A of N to apply. See Map 1.

The nitrogen supplying power of soils is closely associated with the previous management and cropping pattern. Research has shown that there is a need for nitrogen applications if land has just previously been planted to a good legume crop. On the other hand, land which was previously devoted to sugar beet production is usually quite deficient in available nitrogen. Tables 3 and 4 present a guide to nitrogen fertilizer use when no soil nitrate test has been made.

Table 3. Nitrogen recommendations based on previous cropping history for the Red River Valley, Minn. (see Area I, Map 2).

Expected yield (bu/A)	Previous crop: Corn sugar beet potatoes	Previous crop: Small grains soybeans sunflowers	Previous crop: Black fallow alfalfa, sweet clover fallow
80 or more	140	120	40
70-79	120	100	30
60-69	100	80	30
50-59	80	60	20
40-49	60	40	0
Less than 40	40	30	0

Table 4. Nitrogen recommendations for Area II based on cropping history (see Map 2).

	Corn, sugar beets, potatoes, small grain, sunflowers	Soybeans			Black fallow, alfalfa, sweet clover, organic soil
	Organic Matter Level				
Yield Goal	Low to Medium	High	Low to Medium	High	—
(bu./acre)	N to apply (lb./acre)[1]				
80 or more	110	90	90	70	40
70-79	100	80	80	60	30
60-69	90	70	70	50	30
50-59	80	60	60	40	30
40-49	60	50	50	30	20
less than 40	40	30	40	30	20

[1]This is general recommendation based on cropping history. Analysis of a soil sample collected from 0 to 2 feet for nitrate -N is needed before a more accurate N recommendation can be made in western Minnesota.

Nitrogen can be applied broadcast before or after seed bed preparation, at planting time, and/or top dressed after the crop has been planted. Nitrogen rates up to 60 pounds nitrogen per acre can be applied by drill attachment at seeding time if there is adequate moisture for germination.

If urea is applied with the fertilizer attachment on the grain drill, limit the application rate to 20 pounds nitrogen per acre. Nitrogen rates higher than those that can be safely applied with the grain drill attachment should be applied in the fall or spring as a broadcast application.

In years of heavy winter or spring precipitation, losses of fall applied nitrogen may occur because of leaching with coarse textured soils and denitrification on fine textured soils subject to flooding.

Winter Wheat

Where winter wheat is grown only about 15 to 30 pounds per acre of nitrogen is recommended at seeding time. This can be applied with phosphorus or phosphorus and potassium with the grain drill. A commonly used drill applied fertilizer is 18-46-0 or 10-34-0.

It is recommended that additional nitrogen, if necessary, be applied the following spring. Rates for winter wheat would be the same as for spring wheat as shown in tables 2, 3, and 4. The spring application should be made as early as is practical.

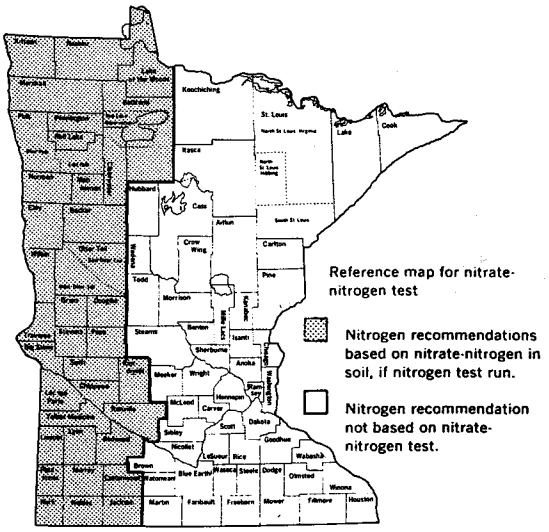
Nitrogen Applied to Wheat After the Crop is Up

Nitrogen can be top dressed after the wheat crop has been planted. A profitable yield increase is more likely to be obtained when the nitrogen is applied before the plants reach 4 inches in height. Top dressing of nitrogen is not recommended on fields infested with weeds. In dry years, nitrogen top dressing is likely to be ineffective in increasing wheat yields.

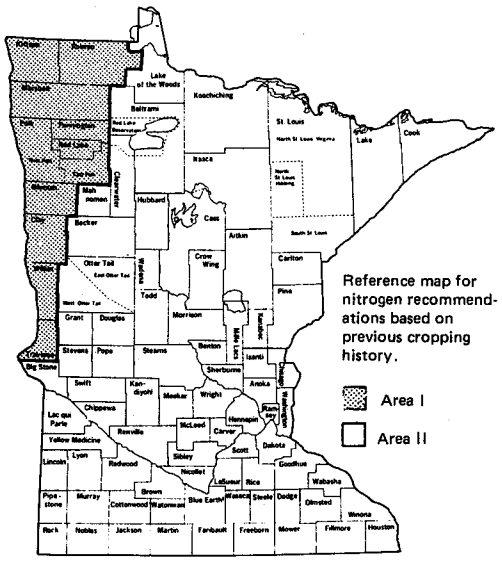
Adding dry material such as urea or ammonium nitrate will not cause leaf damage unless these materials are applied to wet leaves. Liquid nitrogen will give a temporary burn at rates above 25 pounds of nitrogen per acre. Leaf burn and yield loss may not mean the same thing, however. Rates considerably above 25 pounds per acre in some years have resulted in excellent yields. Higher rates without burn can be applied during cool weather when heavy dew is on the leaves, which dilutes the nitrogen concentration. Timing just ahead of irrigation, or even rain, allows the use of rates of liquid nitrogen equal to that of preplant.

Topdressing after tillering can result in higher protein in the grain but is not effective in increasing yields. Application after jointing with other than aerial treatments can result in rundown plants that may not recover very well.

The general recommendation is "the earlier the better" and that preplant is favored if possible.



Map 1. Reference map for using the soil nitrate test.



Map 2. Reference map to be used for making nitrogen recommendations for small grain crops based on cropping history.

Nitrogen and Wheat Protein

Forty pounds per acre of nitrogen fertilizer added to spring wheat could be profitable if the present pricing advantage for protein holds.

In a three-year study with preplant nitrogen at the Northwest Experiment Station, Crookston, with a semidwarf variety, the first 80 pounds of nitrogen resulted in a 21-bushel per acre yield increase with only a small increase in grain protein. The next 40-pound increment of nitrogen fertilizer increased protein from 12 to 13.2 percent which, at current pricing, increased the value of the wheat 43 cents per bushel, hence, improved profit without increase in yield.

	N Applied (lb./acre)			
	0	40	80	120
Yield (bu./A)	48	61	69	66.1
Protein (%)	11.3	11.1	12.0	13.2

On fine textured soils, preplant nitrogen treatments higher than needed for best yield will usually give extra protein benefits. Nitrogen treatments after boot stage may be effective in increasing protein, but not if liberal rates have been added at seeding time.

Phosphorus and Potassium Recommendations for Wheat

The best way to obtain information on phosphorus or potassium fertilizer needs is through laboratory analysis of carefully taken soil samples. The quantity of phosphate fertilizer to apply with the grain drill at seeding time ranges from 20 to 30 pounds of P_2O_5 per acre. Table 5 shows the amount of fertilizer phosphate to apply either with the grain drill at seeding time or as a broadcast application. Potassium recommendations are summarized in Table 6.

An application of 10 pounds P_2O_5 at seeding time with the grain drill is recommended on soils high in soil test phosphorus. A supply of readily available phosphorus is necessary to initiate early growth in the wheat crop.

Table 5. Phosphorus recommendations.

	Phosphorus (P) Soil Test (lb./acre)[1]							
	0-11		11-20		21-30		30+	
Yield Goal	Bdcst/Drill		Bdcst/Drill		Bdcst/Drill		Bdcst/Drill	
bu./acre	---------- P_2O_5 to apply (lb./acre) ----------							
80 or more	90	30[2]	70	30[2]	50	25	0	10[3]
70-79	80	30[2]	60	30	40	20	0	10[3]
60-69	70	30[2]	50	25	30	15	0	10[3]
50-59	60	30[2]	40	20	20*	10	0	10[3]
40-49	50	25[2]	30	15	20*	10	0	10[3]
less than 40	40	20[2]	20*	10	20*	10	0	10[3]

[1]Some labs report P and K soil test results in ppm. (ppm × 2 lb/acre)
[2]Application of phosphorus fertilizer with the drill is a very efficient way to supply needed potash at this soil test level. It is desirable, however, to increase the soil test value to a higher level. To do this, subtract the rate suggested for drill application from the corresponding broadcast suggestion. Broadcast and incorporate the remainder before seeding.
[3]This rate of phosphate is suggested for application with the drill under conditions of limited drainage, cool spring soil temperatures, or when conservation tillage systems are used. For other conditions at planting, the probability of a response to drill applied phosphate is not high when the soil test for P is higher than 30 lb/acre. A small amount of N is suggested for use in all drill-applied fertilizer.
*It may not be practical to broadcast these low rates each year. An alternative would be to double the suggested rate and broadcast on alternative years.

Table 6. Potassium recommendations.

	Potassium (K) Soil Test (lb./acre)[1]							
	0-100		101-200		201-300		300+	
Yield Goal	Bdcst/Drill		Bdcst/Drill		Bdcst/Drill		Bdcst/Drill	
bu./acre	---------- K_2O to apply (lb./acre)[1] ----------							
80 or more	140	30[2]	80	30[2]	50	25	0	0
70-79	120	30[2]	70	30	40	20	0	0
60-69	100	30[2]	60	30	30*	15	0	0
50-59	80	30[2]	50	25	20*	10	0	0
40-49	60	30[2]	40	20	20*	10	0	0
less than 40	40	30[2]	30*	20	0	10	0	0

[1]Some labs report P and K soil test results in ppm. (ppm × 2 = lb/acre)
[2]Application of potash fertilizer with the drill is a very efficient way to supply needed potash at this soil test level. It is desirable, however, to increase the soil test value to a higher level. To do this, subtract the rate suggested for drill application from the corresponding broadcast suggestion. Broadcast and incorporate the remainder before seeding.
*It may not be practical to broadcast these low rates each year. An alternative would be to double the suggested rate and broadcast on alternative years.

When the soil test indicates a low level of potassium (0-100 pounds per acre), it is usually desirable to apply 30 pounds of K_2O with the grain drill at planting time. The remaining K_2O needed can be applied as a broadcast treatment and incorporated prior to wheat seeding.

Other Possible Nutrients Needs

Except for sulfur for small grain production on sandy soils and copper for wheat production on organic soils, small grain crops in Minnesota have not responded to the application of nutrients other than N, P, and K.

Application Methods for Wheat

Wheat growth and production in most cropping seasons, is benefited by drill applied fertilizer. Cool, wet conditions reduce the availability and uptake of soil nutrients making it essential that young wheat plants have a readily available source of plant food. A small quantity of nitrogen and phosphate fertilizer is always recommended, even though soil tests indicate that a soil is high in these nutrients.

Phosphate fertilizer materials should, if possible, be applied in the drill row or as a band application when needed. Studies show that 20 pounds of P_2O_5 drilled with the wheat seed is generally more effective than 40 pounds of P_2O_5 broadcast on the soil surface.

Soil Management

In addition to knowledge of fertilizer use, practices such as surface drainage and proper tillage are also important in soil management. Tillage used correctly promotes good soil structure. Desirable soil structure improves internal drainage and also increases the effectiveness of fertilizers. Good structure permits earlier seeding and along with fertilizer gets the crop off to an earlier start resulting in good yields. It has been observed that wheat after sugar beets can usually be planted earlier than after other crops. Fields on which alfalfa or sweet clover have been grown the previous year are usually ready for seed bed preparation several days earlier than land which has been either black fallowed or cultivated to a small grain crop the previous year.

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