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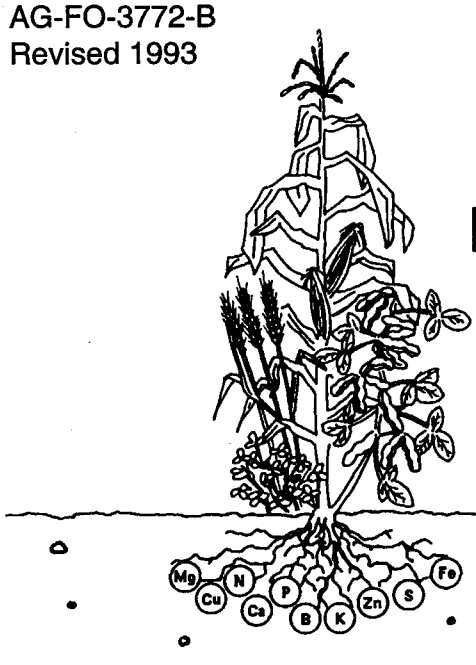

Fertilizing Wheat in Minnesota

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With 2 to 3 million acres planted annually, wheat is a major crop in Minnesota agriculture. Today, production and average yields continue to increase slowly with time. Adequate and efficient use of fertilizer has been a major contributor to this increase.

Nitrogen Suggestions

The modern wheat grower receives more return for money spent on nitrogen (N) than any other nutrient. It is important to focus on using this nutrient as efficiently as possible.

Two methods are used for making suggestions for the amount of fertilizer N to use for wheat production in Minnesota. For the western portion of the state, where most of the wheat is grown, the soil nitrate test (soil samples collected to 2 feet) is the best and most accurate management tool for predicting N fertilizer needs. This soil test is recommended if wheat is grown in the shaded area in **Figure 1.**

If the soil nitrate test is used, the amount of fertilize N needed to meet the yield goal is calculated from the following equation.

$$N_{Rec} = (2.5)\ YG - STN_{(0\text{-}24\ in.)} - N_{pc}$$

The following abbreviations are used in these equations.

YG = yield goal, bu./acre

STN = nitrate-nitrogen (NO_3-N) measured to a depth of 2 feet, lb./acre

N_{pc} = amount of N supplied by the previous crop, lb/acre (**Table 1**)

If wheat is grown in the second year following any of the crops in this table, use the N credit listed in **Table 2.**

Suggestions for fertilizer N are based on previous crop, yield goal, and soil organic matter content when the soil nitrate test is not used. Nitrogen recommendations for wheat are not based on the soil nitrate test in eastern and southern Minnesota (area that is not shaded in **Figure 1.** Suggestions for these situations are summarized in **Table 3.** Use the fertilizer N suggestions for soils having a high organic matter content when wheat is grown in southeast Minnesota. This suggestion applies in Goodhue, Wabasha, Olmstead, Winona, Fillmore, and Houston Counties.

The nitrogen supplied by legume crops can also be utilized by the wheat crop if it is planted 2 years after the legume. The nitrogen credits for these situations are summarized in **Table 2.** Subtract these values from the nitrogen recommendations that are listed for crops in Group 2 for the appropriate yield goal (see **Table 3).**

The nitrogen rates, calculated from the equation and listed in **Table 3,** should also be used for *winter wheat* production. For this crop, 15 to 30 lb. N/acre should be applied in the fall either before or at the time of seeding. The remainder of the amount of fertilizer N needed should be topdressed early in the following spring.

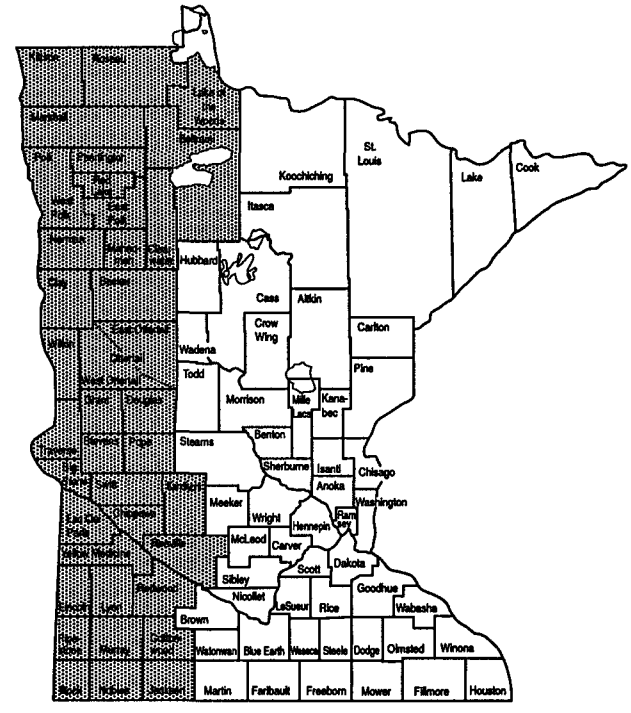

Figure 1. The soil nitrate test should be used for nitrogen recommendations in the counties that are shaded.

Table 1. Nitrogen credits for various crops that might precede wheat in a crop rotation.

Previous Crop	1st Year Nitrogen Credit
soybeans	20 lb. N/acre
edible beans, field peas	10 lb. N/acre
non-harvested **sweet clover**	10 lb. N/acre
harvested **alfalfa*** or non-harvested **sweet clover**	
4-5 plants/ft²	75 lb. N/acre
2-3 plants/ft²	50 lb. N/acre
1 or fewer plants/ft²	none
harvested **red clover**	35 lb. N/acre

** If 3rd or 4th cutting was not harvested, add 20 lb. N/acre to the N credits that are listed.*

Table 2. Nitrogen credits when wheat is grown 2 years after a legume crop.

Previous Legume Crop	Nitrogen Credit for 2nd Year
	- - lb./acre - -
alfalfa (4+ plants/ft²), non-harvested **sweet clover**	35
alfalfa (2-3 plants/ft²), **alsike clover, birdsfoot trefoil, grass/legume hay, grass/legume pasture, fallow**	25
red clover	20

Table 3. Nitrogen recommendations for wheat for situations where the soil nitrate test *is not used.*

Crop Grown Last Year	Organic* Matter Level	Yield Goal (bu./acre) Less than 40	40-49	50-59	60-69	70-79	80+
		N to apply (lb./acre)					
alfalfa, (4+ plants/ft²) non-harvested sweet clover	low	0	0	30	55	80	95
"	medium and high	0	0	0	35	60	75
soybeans	low	35	60	85	110	135	150
"	medium and high	0	40	65	90	115	130
edible beans, field peas, harvested sweetclover	low	45	70	95	120	145	160
"	medium and high	25	50	75	100	125	140
any crop in Group 1	low	0	30	55	80	105	120
"	medium and high	0	0	35	60	85	100
any crop in Group 2	low	55	80	105	130	155	170
"	medium and high	35	60	85	110	135	150
organic soil	—	0	0	0	0	30	35

** Low = less than 3.0%; medium and high = 3.0% or more*

CROPS IN GROUP 1

alfalfa (2-3 plants/ft²)
alsike clover
birdsfoot trefoil
grass/legume hay
grass/legume pasture
fallow
red clover

CROPS IN GROUP 2

alfalfa (0-1 plants/ft²)
barley
buckwheat
canola
corn
flax
grass/hay
grass/pasture
millet
mustard
oats
potatoes
rye
sorghum-sudan
sugarbeets
sunflowers
sweet corn
triticale
wheat
vegetables

Managing Nitrogen

Researchers have found that the majority of the total amount of essential nutrients used by wheat is absorbed from the soil between tillering and heading. Therefore, it's important to have an adequate supply of all nutrients in the root zone early in the growing season.

Since N is mobile in soils and can move to the roots with soil moisture, there can be considerable flexibility in the management of this nutrient. For wheat production in most of Minnesota, fertilizer N can be applied in the fall. In southeast Minnesota, fertilizer N should be applied in the spring and incorporated before planting. Because of the potential for losses due to leaching, fertilizer N should be applied in the spring when soils are sandy. Split N applications are encouraged for very sandy soils. For these situations, the first application can be made before planting. The remainder should be applied between tillering and jointing.

Nitrogen applications at tillering may be justified if loss of previously applied N from leaching or denitrification is suspected. Application of N at this time would also be appropriate where a yield goal established in the fall was conservative and projected weather plus available soil moisture suggest that there is a high probability for a higher yield. For these situations, added N at tillering may also increase the protein content of hard red spring wheat.

If applied properly, all of the popular N fertilizers will have an equal effect on wheat yields. Some precautions in the application of some N sources are necessary. With anhydrous ammonia (82-0-0), there is concern for loss during application. If white ammonia fumes are easily detected, some change in application technique is needed. There is also a potential for N loss if urea (46-0-0) or urea-ammonium nitrate (28-0-0) is broadcast on the soil surface without incorporation when soil pH is higher than 7.3, air temperatures are high, and there is residue on the soil surface. Shallow incorporation of urea or fertilizers containing urea is encouraged when these N sources are used for wheat production.

Urea-ammonium nitrate solution (28-0-0) can be applied before planting or as a foliar treatment. The foliar application may cause some leaf burning which will not harm yields. The fall application of 28-0-0 is not considered to be a best management practice and should be discouraged.

Phosphate Suggestions

Suggestions for phosphate use are summarized in **Table 4.** The phosphorus status of Minnesota soils is determined by using either the Bray or the Olsen analytical procedure. In general, the Olsen test provides more accurate recommendations if the soil pH is 7.4 or higher.

The phosphate suggestions change with soil test level and placement. At very low, low, and medium soil test levels, the needed phosphate can be broadcast and incorporated before planting or applied with the drill at planting. Rates can be reduced substantially if the phosphate is applied with the drill.

No broadcast phosphate is suggested when the soil test for P is high (Bray = 16-20 ppm P; Olsen = 12-15 ppm P). A small amount of P_2O_5 applied with the drill is suggested for these situations. No phosphate fertilizer will be needed when the soil test for P is in the very high range (Bray = 21+ ppm; Olsen = 16+ ppm) unless soils are cold and wet at planting. In north-central Minnesota, soils may be cold and wet at planting time. Even though the soil test for P may be high, some phosphate fertilizer (10 lb. P_2O_5/acre) placed in a band near the seed at planting may improve wheat yields on these soils.

Potash Suggestions

Suggestions for potash use are summarized in **Table 5.** As with phosphate, suggestions vary with placement and soil test level for K. No broadcast potash will be needed when the soil test for K is 121 ppm or higher. No potash (either banded or broadcast) is suggested when the soil test for K is 161 ppm or higher.

It may not be practical to broadcast some of the low rates of suggested phosphate and potash. For these situations, it may be more practical to double the suggested broadcast rate and apply in alternate years if the grain drill is not equipped to apply fertilizer with the seed.

Any phosphate and/or potash that is broadcast should be incorporated before seeding. These nutrients do not move in most soils and will have very little effect on production if they are topdressed to established stand. Application before a primary tillage operation is preferred.

Table 4. Phosphate fertilizer suggestions for wheat production in Minnesota.*

		Phosphorus (P) Soil Test (ppm)									
		v. low		low		med		high		v. high	
Yield Goal	Bray(P-1): / Olsen:	0 - 5 / 0 - 3		6 - 10 / 4 - 7		11 - 15 / 8 - 11		16 - 20 / 12 - 15		21+ / 16+	
		Bdcst	Drill	Bdcst	Drill	Bdcst	Drill	Bdcst	Drill	Bdcst	Drill
bu./acre		*lb. P_2O_5 / acre to apply*									
less than 40		40	20	3	15	15	10	0	10-15	0	0
40 - 49		40	20	30	15	15	10	0	10-15	0	0
50 - 59		50	25	35	20	20	15	0	10-15	0	0
60 - 69		60	30	45	25	20	15	0	10-15	0	0
70 - 79		70	35	50	25	25	20	0	10-15	0	0
80 or more		80	40	55	30	25	20	0	10-15	0	0

* *Use one of the following equations if a phosphate recommendation for a specific soil test and a specific yield goal is desired.*

$P_2O_{5\,Rec}$ = [1.071 - (.054) (Bray P soil test, ppm)] (yield goal)
= [1.071 - (.067) (Olsen P soil test, ppm)] (yield goal)

No phosphate fertilizer is suggested when the Bray P test is 21 ppm or higher or the Olsen P test is 16 ppm or higher.

Table 5. Potash fertilizer suggestions for wheat production in Minnesota.*

Yield Goal	Potassium (K) Soil Test (ppm) v. low 0 - 40 Bdcst or Drill		low 41 - 80 Bdcst or Drill		med. 81 - 120 Bdcst or Drill		high 121 - 160 Bdcst or Drill		v. high 161+ Bdcst or Drill	
bu./acre	*lb. K_2O/ acre to apply*									
less than 40	95	50	70	35	40	20	0	15-20	0	0
40 - 49	105	55	75	40	45	25	0	15-20	0	0
50 - 59	130	65	95	50	55	30	0	15-20	0	0
60 - 69	155	80	110	55	65	35	0	15-20	0	0
70 - 79	180	90	125	65	75	40	0	15-20	0	0
80 or more	190	95	135	70	80	40	0	15-20	0	0

** Use the following equation if a potash recommendation for a specific soil test and a specific yield goal is desired.*

K_2O_{Rec} = [2.710 - .017 (K soil test, ppm)] (yield goal)

No potash fertilizer is suggested when the K test is 161 ppm or higher.

Fertilizer With The Drill

Since most of the small grain acreage in Minnesota is usually planted in early spring when soil conditions are cold and wet, the application of fertilizer with the drill should be a standard management practice. **CAUTION! Do not** apply more than 5 lb. N/acre as urea in contact with the seed (in the row). If the soil is dry at planting time do not apply more than 40 lb. N plus K_2O per acre with the drill. Higher rates can be applied if the soil is wet at planting time. **Do not** place ammonium thiosulfate (12-0-0-26) in direct contact with the seed. **Do not** place boron fertilizers in direct contact with the seed. Phosphate has no negative effect on seed germination and seedling growth. Therefore, ample amounts of phosphate can be applied in contact with the seed.

Table 6. Suggestions for use of copper in a fertilizer program when wheat is grown on an organic soil.

Copper Soil Test	Method of Application Broadcast		Foliar Spray	
	Copper	Copper Sulfate	Copper	Copper Sulfate
ppm	*lb./acre to apply*			
0-2.5 (low)	6-12	24-48	0.3	1.2
2.6-5.0 (marginal)		trial only	0.3	1.2
more than 5.0 (adequate)	0	0	0	0

Other Nutrients Needed

Major emphasis in wheat production should be directed to efficient and effective management of nitrogen, phosphate, and potash fertilizers. Sulfur and copper can be important in limited situations. These special cases are described in the paragraphs that follow.

Sulfur: Sulfur (S) can increase wheat yields when the crop is grown on sandy soils. Research trials have shown that there is no need to add to a fertilizer program when wheat is grown on fine-textured soils in Minnesota.

The broadcast application of 25 lb. S/acre in the sulfate form will be adequate for growing wheat on sandy soils. For more efficient applications, use 10-15 lb. S/acre with the drill at planting.

Copper: Copper (Cu) may be required in a fertilizer program when wheat is grown on organic soils. Suggestions for Cu use are summarized in **Table 6.**

These suggestions are for organic soils only. The use of Cu in a fertilizer program is not suggested when wheat is grown on mineral soils.

Research from throughout Minnesota has shown that magnesium, calcium, iron, boron, zinc, and manganese are not needed in fertilizer programs. Most soils are able to supply ample amounts of these nutrients for crop production.

Related Publications

The following publications provide more details for fertilizer management. They are available in the local county extension office.

AG-FO-0648 *Copper for Organic Soils*
AG-FO-2774 *Using the Soil Nitrate Test for Corn in Minnesota*
AG-FO-0792 *Phosphorus for Minnesota Soils*
AG-FO-0636 *Fertilizer Urea*
AG-FO-3073 *Using Anhydrous Ammonia in Minnesota*
AG-FO-0794 *Sulfur for Minnesota Soils*

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