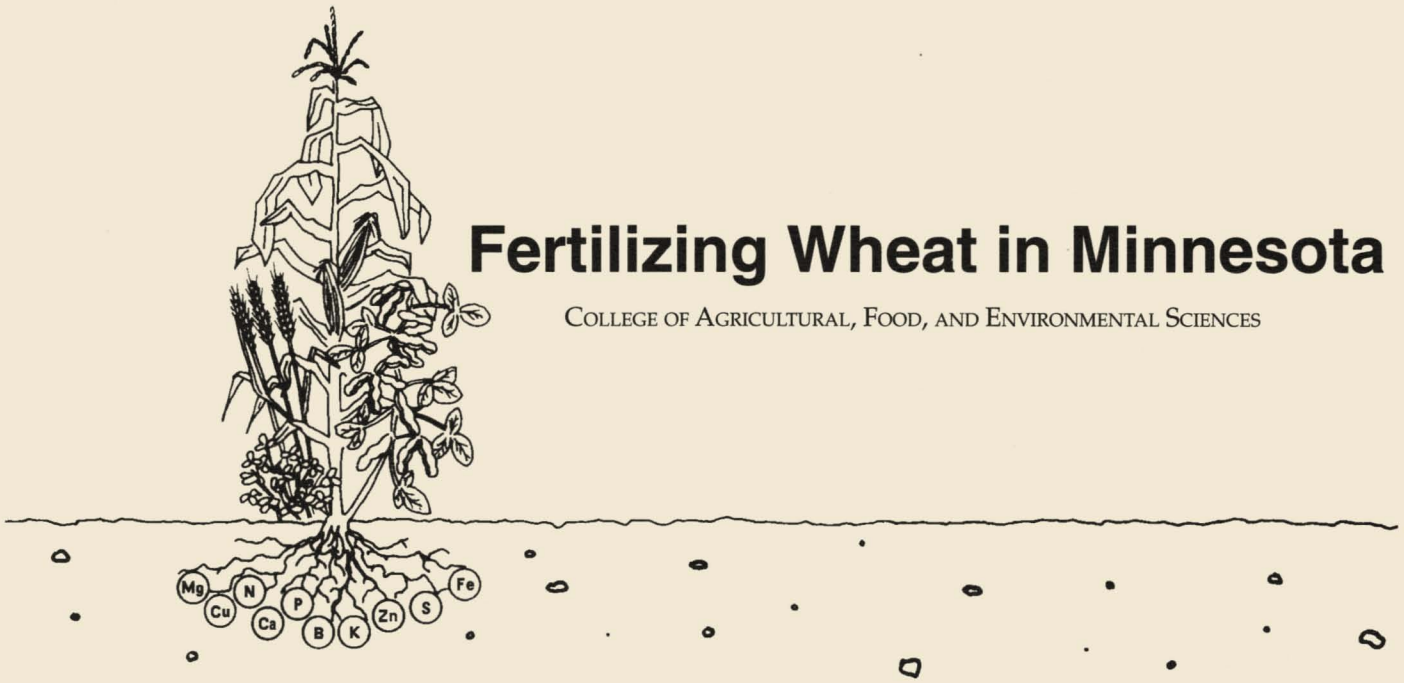

Fertilizing Wheat in Minnesota

College of Agricultural, Food, and Environmental Sciences

George Rehm and *Michael Schmitt*, *Extension Soil Scientists, Soil Fertility*
Roger Eliason, *Soil Scientist*
Department of Soil, Water and Climate

With 2 to 3 million acres planted annually, wheat is a major crop in Minnesota's agriculture. When diseases and other crop pests are not limiting, average yields continue to increase slowly with time. Adequate and efficient use of fertilizer has been a major contributor to this increase.

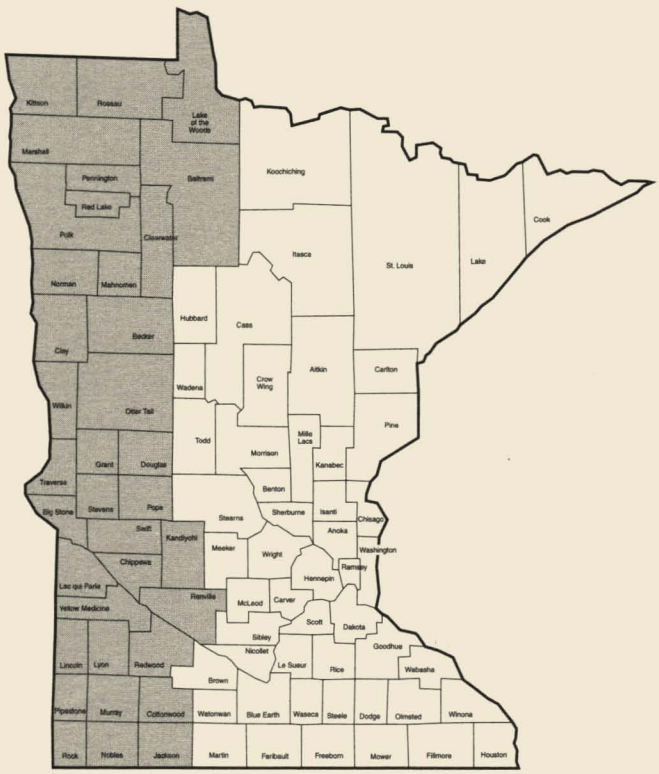

Figure 1. The soil nitrate test should be used for nitrogen recommendations in the counties that are shaded.

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 strategies 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 the amount of fertilizer N to use. This soil test is recommended if wheat is grown in the shaded area of the state shown in **Figure 1**.

If the soil nitrate test is used, the amount of fertilizer N required 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 this equation.

YG = yield goal, bu. per acre

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

N_{PC} = amount of N supplied by the previous crop, lb. per acre (see **Table 1**)

University of Minnesota Extension Service

Table 1. Nitrogen credits for various crops that might precede wheat in a crop rotation. Use these credits when the soil nitrate test is used.

Previous Crop	1st Year Nitrogen Credit lb. N/acre
soybeans	20
edible beans, field peas	10
harvested sweet clover	10
harvested alfalfa[1/] or non-harvested sweet clover	
4-5 plants/ft²	75
2-3 plants/ft²	50
1-2 plants/ft²	25
1 or fewer plants/ft²	0
harvested red clover	35
sugar beet	
yellow leaves	0
yellow-green leaves	15 to 20
dark-green leaves	60 to 70

[1/] If 3rd or 4th cutting was not harvested, add 20 lb. N per acre to the N credits listed.

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

Previous Legume Crop	Nitrogen Credit for 2nd year lb. N/acre
alfalfa (4+ plants/ft²), non-harvested sweet clover	35
alfalfa (2-3 plants/ft²), birdsfoot trefoil	25
red clover	20

If wheat is grown in the second year following any of the crops in **Table 1** use the N credit listed in **Table 2**.

For situations where the soil nitrate test is not used, suggestions for fertilizer N are based on a consideration of previous crop, yield goal, and soil organic matter content. The soil nitrate test is not used for making nitrogen fertilizer recommendations for wheat grown in eastern and southern Minnesota (the area which is not shaded in **Figure 1**). Nitrogen fertilizer recommendations for these situations are summarized in **Table 3**. Use the fertilizer N recommendations for soils having a high organic matter content when wheat is grown in southeast Minnesota. This recommendation applies in Goodhue, Wabasha, Olmsted, 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 N recommendations that are listed for crops in Group 2 (**Table 3**) when wheat is planted 2 years after a legume crop.

Nitrogen from the decomposing tops of a previous crop of sugar beet can be used by the wheat crop

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

Crop Grown Last Year	Organic* Matter Level	Yield Goal (lb./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 sweet clover	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
sugarbeet
sunflowers
sweet corn
triticale
wheat
vegetables

when it follows in a rotation. These N credits are based on the overall color of the sugar beet tops at harvest and are listed in **Table 1**. If the soil nitrate test is used for nitrogen recommendations, the value for the appropriate color should be used as the nitrogen credit from the previous crop (N_{PC}) in the N recommendation equation. If the N recommendations are taken from **Table 3**, subtract the value for the appropriate color from the appropriate N recommendation listed in the table.

Nitrogen recommendations, whether calculated from the equation or obtained from **Table 3,** should also be used for **winter wheat** production. For this crop, 15 to 30 lb. N per 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.

Managing Nitrogen

Researchers have found that the majority of the total amount of essential nutrients used by wheat is absorbed from the soil between the growth stages of tillering and heading. Therefore, it is 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 is 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, south-central, and central 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 followed by the remainder between tillering and jointing.

In northwest and western Minnesota, N 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 good 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 within 48 hours of application 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. Foliar applications should be limited to approximately 40 lb. N per acre. This rate of foliar applied N may cause some leaf burning which will not harm yields. Considerable research has been conducted to evaluate the effect of foliar applications of 28-0-0 at anthesis on protein content of the grain. Results were not encouraging. This practice did not routinely produce economical increases in grain protein. The fall application of 28-0-0 is not considered to be a best management practice and should be discouraged.

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

		Phosphorus (P) Soil Test (ppm)									
		v. low		low		med		high		v. high	
Yield	Bray:	0-5		6-10		11-15		16-20		21+	
Goal	Olsen:	0-3		4-7		8-11		12-15		16+	
		Bdcst	Drill	Bdcst	Drill	Bdcst	Drill	Bdcst	Drill	Bdcst	Drill
bu./acre		P_2O_5 to apply (lb./acre)[1/]									
less than 40		40	20	30	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

[1/] 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, ppm)] (Yield Goal)*

= *[1.071 - (.067) (Olsen P, 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.

Phosphate Suggestions

Suggestions for phosphate use are summarized in **Table 4**. The phosphorus (P) 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 fertilizer 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 the time of 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 P = 16 to 20 ppm; Olsen P = 12 to 15 ppm). A small amount of P_2O_5 applied with the seed is suggested for these situations. No phosphate will be needed when the soil test for P is in the very high range (Bray P = 21+ ppm; Olsen P = 16+ ppm) unless soils are cold and wet at planting time. Even though the soil test for P is high or very high, some phosphate fertilizer (10 lb. P_2O_5 per acre) placed in a band with or near the seed at planting may improve wheat yields.

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

Yield Goal	Potassium (K) Soil Test (ppm)									
	v. low 0-40		low 41-80		med 81-120		high 121-160		v. high 161+	
	Bdcst	Drill	Bdcst	Drill	Bdcst	Drill	Bdcst	Drill	Bdcst	Drill
bu./acre	K_2O to apply (lb./acre)[1/]									
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

[1/] 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.

Potash Suggestions

Suggestions for potash use are summarized in **Table 5**. As with phosphate, application rates 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 fertilizer (either drilled 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. When low rates are suggested for a broadcast application, 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 an established stand. Application prior to a primary tillage operation is preferred.

Fertilizer in Contact with the Seed

Since most of the wheat acreage in Minnesota is usually planted in early spring when soil conditions are cold and wet, the application of some fertilizer with the drill should be a routine management practice. **CAUTION! 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.

Damage from urea (46-0-0) placed in contact with the seed is dependent on the moisture content of the soil at planting. Damage can be substantial if soils are dry at planting. If soils are dry at the time of planting, keep the amount of N as urea in contact with the seed to 10 lb. per acre or less. Higher rates can be used if the soil is wet at planting. The suggested rates for this use, however, are not well defined.

High rates of potash in contact with the seed can cause problems if soils are dry at planting. Under typical moisture conditions, rates of K_2O up to 60 lb. per acre in contact with the seed should not cause problems with emergence.

Phosphate has no negative effect on seed germination and seedling growth. Therefore, ample amounts of phosphate can be applied in contact with the seed.

Fertilizer Applied with Air Seeders

The use of air seeders has increased in popularity in recent years. Many seeders are equipped to apply a mixture of seed and dry fertilizer at the time of planting. There are, however, no firm guidelines for the amount of fertilizer that can be applied with the seed with this planting equipment.

The amount of urea that can be used with the air seeder is related to soil moisture content at planting. Recent trials showed that N rates in excess of 25 lb. per acre as urea can reduce germination if applied with the wheat using an air seeder when soils are dry. By contrast, 75 lb. N per acre as urea caused no emergence problems when soils were wet. Further research is being conducted to determine the amount of N as urea that can safely be mixed with wheat using an air seeder.

Recent trials have shown that rates of phosphate of 92 lb. P_2O_5 per acre or less have not hindered germination if mixed with wheat seed planted with an air seeder. The amount of K_2O that can be applied in contact with the seed using an air seeder is not known at this time.

Table 6. Suggestions for use of copper for wheat grown on an organic soil.

	Method of Application			
Copper	Broadcast		Foliar Spray	
Soil Test	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 (S) and copper (Cu) can be important in limited situations. These special cases are described in the paragraphs that follow.

Sulfur

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

The broadcast application of 25 lb. S per acre in the sulfate form will be adequate for growing wheat on sandy soils. For more efficient applications, use 10 to 15 lb. S per 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**.

The suggestions in **Table 6** are for organic (peat) soils only. The use of Cu in a fertilizer program is not currently suggested when wheat is grown on mineral soils. Research is now being conducted to provide a more thorough evaluation of the use of this nutrient.

Other Micronutrients

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 to a high-yielding wheat crop.

Related Publications

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

FO-6790 *Copper for Crop Production*

FO-0792 *Understanding Phosphorus in Minnesota Soils*

FO-0636 *Fertilizer Urea*

FO-0725 *Magnesium for Crop Production in Minnesota*

FO-3073 *Using Anhydrous Ammonia in Minnesota*

FO-6288 *Understanding Phosphate Fertilizer*

FO-0794 *Sulfur for Minnesota Soils*

FO-6794 *Potassium for Crop Production*

FO-0720 *Zinc for Crop Production*

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

FO-3772-C
Revised 1998

www.extension.umn.edu

Additional copies of this item can be ordered from the University of Minnesota Extension Service Distribution Center, 20 Coffey Hall, 1420 Eckles Avenue, St. Paul, MN 55108-6069, e-mail: order@extension.umn.edu or credit card orders at 800-876-8636 or (612) 624-4900 (local calls).

Produced by Communication and Educational Technology Services, University of Minnesota Extension Service.

In accordance with the Americans with Disabilities Act, this material is available in alternative formats upon request. Please contact your University of Minnesota county extension office or, outside of Minnesota, contact the Distribution Center at (612) 625-8173.

The University of Minnesota Extension Service is an equal opportunity educator and employer. Printed on recycled paper with minimum 10% postconsumer waste.