Extension Folder 254—Revised 1983

Fertilizer for WHEAT

in Minnesota's Red River Basin

William E. Fenster
Marlin O. Johnson
J. Grava

AGRICULTURAL EXTENSION SERVICE
UNIVERSITY OF MINNESOTA

Hard red spring and durum wheats are well adapted to Red River Basin soils, which generally contain good supplies of organic matter, calcium, magnesium, and potassium. Under certain conditions these soils can be deficient in available nitrogen for wheat. Phosphorus deficiency has been widespread in the past. For top yields, an application of nitrogen and phosphorus fertilizer is usually necessary.

Soil Management in Wheat Production

Perhaps there is no area in the world where crop yields are more dependent on soil management and seasonal climatic conditions than the Minnesota and North Dakota Red River Valley.

Fertilizer applications will generally greatly enhance the farmer's opportunity to obtain greater wheat yields only when soils are managed carefully. Good surface drainage is a must. Rotational and tillage practices, which promote good soil structure, will increase fertilizer's effectiveness on wheat. Soil management which permits the early seeding of wheat is often the key to efficient fertilizer use and profitable crop production. Wheat can usually be seeded early on land which was cultivated to sugar beets the previous year.

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.

Wheat Fertilizer Response in the Red River Basin

For many years farmers have recognized the need for nitrogen-phosphorus fertilizer in wheat production. Phosphorus deficiency has been common and small grain producers usually apply phosphorus and some nitrogen fertilizer at seeding time with the grain drill. This practice is very important in obtaining good wheat yields. Under the cool and perhaps wet soil conditions often present in the Red River Basin, little soil nitrogen or phosphorus is available to plants when soil temperatures are below 50° F.

The response of wheat to nitrogen fertilizer in the Red River Basin depends mainly on weather conditions and the cropping pattern prior to wheat seeding. Many of these soils are high in organic matter and will, with good moisture and temperature conditions, release considerable nitrogen. With warm spring temperatures and good rainfall distribution, some soils may furnish sufficient nitrogen for wheat yields exceeding 50 bushels per acre. In cool, wet seasons the wheat crop will depend more on applied fertilizer for plant growth.

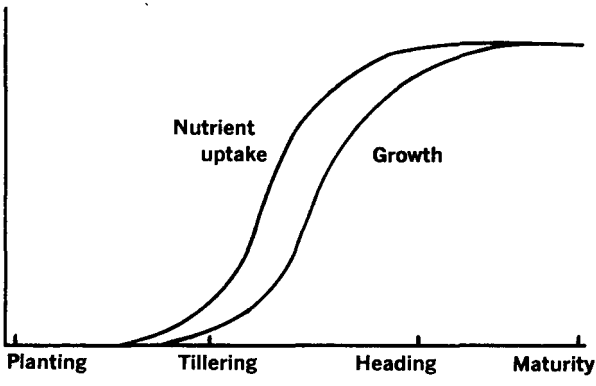
Most fine textured soils of the Red River Basin are generally quite high in available potassium and can furnish sufficient potassium for high wheat yields. Coarse textured or sandy soils can be low in available potassium. The application of potassium fertilizer can result in economic increases in wheat yields on these soils.

Nutrient Requirements of Wheat

High wheat yields require adequate amounts of all plant nutrients at the proper time. 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 of 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 and 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 the soil and plant.

Approximately two thirds of the plant's phosphorus 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 3 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 50 percent. There is a direct relationship between protein content of the grain and the nitrogen removed 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. In the Red River Basin soil properties and climatic conditions experienced at seeding time favor the use of the more water soluble forms of phosphorus. Ordinary super phosphate (20 percent P_2O_5) concentrated super phosphate (46 percent P_2O_5) and high analysis super phosphate (54 percent P_2O_5) as well as the highly water soluble ammonium phosphates and liquid phosphoric acid solutions have proven to be good phosphorus sources for wheat in Minnesota. Phosphate materials which contain less than 50 percent water soluble phosphorus may be less effective in furnishing phosphorus for wheat than more water soluble forms.

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, and ammonium nitrate fertilizers are good sources of nitrogen fertilizer for wheat and should be incorporated into the soil at or near seeding time.

Surface applications of urea (45-0-0), ammonium sulfate (21.5-0-0), and ammonium nitrate (33.5-0-0) in either dry or solution form may result in minor losses of nitrogen under certain conditions. In the Red River Basin high soil pH, high temperature, and dry surfaces may cause losses of ammonia nitrogen from surface applied nitrogen. Under these conditions highest losses come from surface applications of urea, medium losses from ammonium sulfate, and lowest losses from ammonium nitrate. 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.

Nitrogen Fertilizer for Wheat

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

Farmers in the Red River Basin of Minnesota have the opportunity to take advantage of a soil test to determine the nitrogen supplying power of their soil and 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. Table 2 shows the University of Minnesota recommendations based on NO_3-N levels.

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

Expected yield (bu/A)	Soil nitrate N (0-2 ft) + fertilizer N, lb/A*
70 or more	150
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.

The nitrogen supplying power of soils of the Red River Basin is closely associated with the previous management and cropping pattern. Research has shown that there is little need for nitrogen applications if land has just previously been cultivated to a good legume crop. On the other hand, land which was devoted to sugar beet production is usually quite deficient in available nitrogen. Table 3 shows a guide to nitrogen fertilizer use when no test for NO_3-N has been made.

Table 3. Nitrogen recommendations based on previous cropping history for the Red River Valley, Minnesota

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

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 materials are used 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 on coarse textured soils due to leaching and on fine textured soils subject to flooding or ponding by denitrification.

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 appreciable weeds. In dry years nitrogen top dressing is likely to be ineffective in increasing wheat yields.

Phosphorus and Potassium Recommendation 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 phosphorus fertilizer to apply with the grain drill at seeding time ranges from 20 to 40 pounds of P_2O_5 per acre. Table 4 shows the amount of fertilizer phosphorus to apply with the grain drill at seeding time or as a broadcast application.

Table 4. Phosphorus recommendations for wheat

Expected yield (bu/A)	Phosphorus (P) test (lb/A*)			
	0-10	11-20	21-30	More than 30
	P_2O_5 to apply (lb/A†)			
70 or more	60	50	30	0‡
60-69	50	40	30	0‡
50-59	40	30	20	0‡
40-49	30	20	20	0‡
Less than 40	30	20	0‡	0‡

*Some labs report P and K soil test results in ppm (ppm × 2 = lb/A).
†Recommended rates are for total amount to apply broadcast plus drill.
‡None recommended at high soil test levels. A small amount of drill fertilizer may, however, be beneficial under certain conditions.

Table 5. Potassium recommendations for wheat

Expected yield (bu/A)	Potassium (K) test (lb/A*)			
	0-100	101-200	201-300	More than 300
	K_2O to apply (lb/A†)			
70 or more	120	70	40	0‡
60-69	100	60	30	0‡
50-59	80	50	30	0‡
40-49	60	40	20	0‡
Less than 40	40	40	0‡	0‡

*Some labs report P and K soil test results in ppm (ppm × 2 = lb/A).
†Recommended rates are for total amount to apply broadcast plus drill.
‡None recommended at high soil test levels. A small amount of drill fertilizer may, however, be beneficial under certain conditions.

An application of 20 pounds P_2O_5 at seeding time with the grain drill is recommended on soils high in soil test phosphorus. A source of readily available phosphorus is

necessary to initiate early growth in the wheat crop.

Research findings from the Department of Soil Science, University of Minnesota, indicate little or no response to use of potassium fertilizer in wheat production in the Red River Basin. Wheat grown on soils with more than 300 pounds per acre of exchangeable potassium (K) produced yields of wheat of more than 70 bushels per acre without additions of potassium fertilizer. Soils with less than 300 pounds of potassium (K) per acre should receive applications of potassium fertilizer for good wheat production. Table 5 shows the quantity of potassium fertilizer recommended for various soil test levels.

When the soil test indicates a low level of potassium (0-100 pounds per acre), it is usually desirable to apply 10-20 pounds K_2O with the grain drill at planting time. The remaining potassium can be applied as a broadcast treatment prior to wheat seeding.

Application of Fertilizer to Wheat

Wheat growth and production in most cropping seasons, is benefited by drill row placed 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 phosphorus fertilizer is always recommended even though soil tests indicate that a soil is high in these nutrients.

Phosphorus fertilizer materials should, if possible, be applied on the drill row or as a band application. Studies in the Red River Basin 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.

William E. Fenster is professor and extension specialist, soil science; Marlin O. Johnson is professor and area extension agent, Agricultural Extension Service; and J. Grava is professor of soil science, University of Minnesota.

Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Norman A. Brown, Director of Agricultural Extension Service, University of Minnesota, St. Paul, Minnesota 55108. The University of Minnesota, including the Agricultural Extension Service, is committed to the policy that all persons shall have equal access to its programs and facilities without regard to race, creed, color, sex, national origin, or handicap.

20 cents