COOPERATIVE EXTENSION SERVICE MSU AG FACTS

No. 127 Extension Bulletin E-1067 April 1977

FERTILIZATION OF WHEAT

BY M.L. VITOSH AND D.D. WARNCKE
Extension Specialists, Crop and Soil Sciences

SIGNIFICANT CHANGES in fertilizer and grain prices in recent years have caused many growers to reassess their fertilizing practices for wheat. The fertilizer shortage of 1973-74 brought about uneven distribution and allocations of fertilizers as well as fewer grades. These changes resulted in less choice of fertilizer materials for the farmer, and in some situations, farmers were forced to use what was available. The information presented here should help growers to make wise and more efficient use of the fertilizers available.

SOIL TESTING

Regardless of the size of farming operation or the crops to be grown, soil testing is still one of the best means of utilizing fertilizer efficiently. By soil testing and following the recommendations, a farmer can virtually eliminate soil fertility as a limiting factor in producing top yields. A test for phosphorus (P) or potassium (K) will help the grower decide which fields need these elements and in what amounts. Some fields may need more fertilizer than others. The soil test report will also indicate whether lime is needed to correct soil acidity. A good soil test should also report the level of exchangeable magnesium (Mg) and whether Mg fertilizer is required. Quite often it will be practical to correct soil acidity and the Mg level with a single application of dolomitic limestone (a limestone containing magnesium carbonate). For optimum growth of wheat, soils should have a pH of 6.5 or better and at least 75 pounds of exchangeable Mg per acre.

MICRONUTRIENTS

Upon special request, many soil test laboratories will do analysis for micronutrients. Soils most likely to show micronutrient deficiencies are alkaline mineral soils (those with a soil pH above 7.0) and "naturally" poorly drained soils of the old lake bed area of Michigan. Manganese (Mn) is the most likely micronutrient to be deficient for wheat. If Mn is needed, the best method of correcting the problem is to use fertilizers containing 2% Mn and applied with the drill at planting time, assuming a rate of 200-300 pounds of fertilizer per acre. For further information on micronutrients, see Extension Bulletin E-486.

YIELD POTENTIAL—YIELD GOAL

Soils vary in their natural inherent ability to grow crops. Thus it can be said that each soil has its own unique yield potential (YP). **Yield potential can be defined as the maximum yield obtainable under existing climate and management where fertilizer is not limiting.** The **yield goal** which is closely related to the yield potential **is a yield selected by the grower as to what he believes is possible to achieve.**

The yield goal is less than the yield potential because economics of fertilization have shown that the most profitable rate of fertilization is something less than the yield obtained with unlimited fertilizer additions. In most situations, the yield goal should be better than the long-time average yield under the present management.

Since yield goal is most often used in making fertilizer recommendations, it is very important that growers select a realistic yield goal. The farmer who tills his soil and harvests the crops is the individual most familiar with his field and is in the best position to select the appropriate yield goal.

NITROGEN

Nitrogen (N) is the most limiting nutrient for wheat. An inadequate N supply can greatly reduce yield and profit. The response of wheat to N fertilizer is similar to that of corn except less N is required to reach the yield potential. Typical response curves for wheat grown on three different soil types are shown in Figure 1. Note that these three soil types have different yield potentials (YP = 30, 50 and 70). Also note that the first increments of N give the largest yield increase and that smaller yield increases are obtained with additional increments of N as the yield potential is approached.

Most Profitable Nitrogen Rate

The most profitable N rate (MPR) can easily be obtained from the yield response curves by calculating the added revenue for each additional increment of

N added. The added revenue (profit over and above the cost of the last 10 pounds of N added) is plotted as a dot-dash line, using the right axis of Figure 1. It decreases with each additional pound of N until the additional yield will no longer pay for the added N. The amount of N applied at this point is the most profitable N rate.

The example in Figure 1 shows that the MPR for the loamy sand soil with a yield potential of 30 bushels per acre (YP = 30) is 40 pounds of N per acre. For the clay soil (YP = 50) it's 68 pounds, and for the loam (YP = 70) it's 90 pounds per acre. Soils which ahve the potential for high yields also require more N fertilizer than soils with a lower yield potential unless the N can be supplied by some other means such as manure or legumes.

How do varying prices of N fertilizer affect the MPR? If wheat price remains at $3.50 per bushel and N decreases to 10 cents per pound, the MPR for the respective yield goals will increase slightly (45, 75, and 100 pounds N per acre for the respective yield potentials of 30, 50, and 70 bushels per acre). If N price increases to 30 cents, the MPR will decrease (36, 62, 82 pounds N per acre, respectively). Note that changes in N price result in relatively small changes (10% or less) in the MPR compared to changes due to yield goal.

Wheat price can also affect the MPR of N fertilization. Higher wheat prices increase the MPR; however, unless wheat prices are doubled ($3.50 to $7.00) changes in the MPR are not likely to exceed 10%.

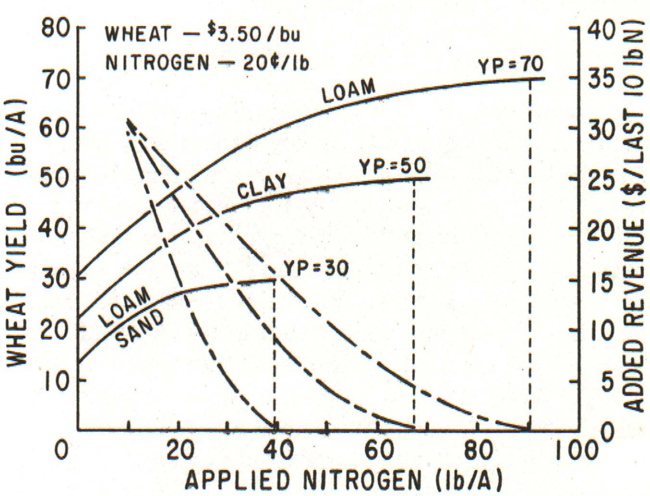

Figure 1 — Yield response of wheat to nitrogen fertilizer on three soils with different yield potentials (YP). The diagonal broken line shows the added revenue for the last 10 pounds of N applied, using the right axis. The vertical dotted line shows the most profitable rate (MPR) of fertilization based on $3.50 wheat and 20-cent nitrogen.

The most important relationship here is the wheat: N price ratio. Higher wheat: N price ratios increase the MPR, while lower wheat: N price ratios decrease the MPR.

We conclude that unless N and wheat prices are drastically changed, they do not greatly affect the most profitable N rate. **Accurately selecting the proper yield goal is more important in determining the rate of N fertilization than changes in wheat or N prices.**

Nitrogen Recommendations

Soil tests for N in Michigan have not been practical because of the rapid changes in the readily available sources of soil N and the wide range of soil types in Michigan. Rapid changes in nitrate N in these soils occur because of the semi-humid climate and sudden changes in soil moisture. On sandy soils, nitrate N is leached by excess moisture moving down through the profile, while on fine-textured soils denitrification of nitrate N can occur during periods of excess moisture.

Nitrogen released from soil organic matter may be the most reliable source of N for wheat, but the procedure for determining organic nitrogen has not been adapted for routine use. In the absence of a reliable soil test, information on soil type, organic matter levels, yield goal and variety are the most useful criteria for predicting the N requirements for wheat. Table 1 gives the N recommendations for the newer short, stiff-strawed varieties such as Abe, Arthur, Tecumseh, and Yorkstar. Other varieties which are more susceptible to lodging caused by too much N should receive reduced rates (see footnote at bottom of Table 1).

Table 1—Nitrogen Fertilizer Recommendations for Short- and Stiff-strawed Wheat Varieties* †

Soil type	*Percent organic matter*	*Wheat yield goal (bu/acre)* 30	40	50	60	70	80
		pounds N/acre					
Sandy soils	0-2%	45	60	75	90	—	—
Medium-fine textured soils	2-4%	30	40	50	60	70	80
Dark colored mineral soils	4-6%	20	25	30	35	40	45

**For varieties susceptible to lodging, do not use more than 60 pounds N per acre on sandy soils, 40 pounds N per acre on medium and fine textured soils and 30 pounds N per acre on dark colored mineral soils.*

†Do not use topdress N where the previous crop was a legume or where more than 20 tons of manure per acre has been recently applied. For smaller application of manure, reduce the N recommendations by 4 pounds for each ton of manure applied.

‡Wheat is not recommended for organic soils (>6% organic matter); however, if it is grown on these soils do not topdress with N.

PHOSPHORUS

Phosphorus (P) fertilizer experiments over the years have been used to correlate wheat yields with soil test P. Typical response curves to soil test P (Figure 2) and to added P fertilizer at various soil test levels (Figure 4) have been developed from these experiments.

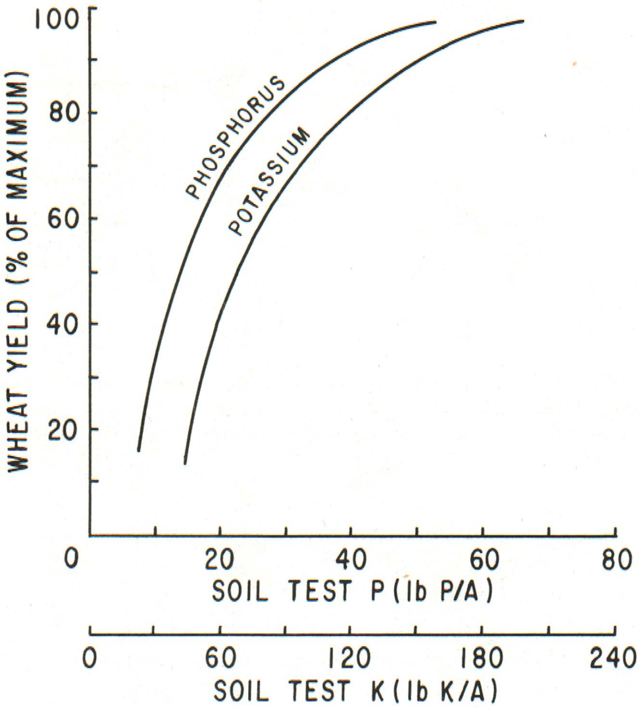

Figure 2—Relationship between expected wheat yield and soil test levels of phosphorus and potassium, assuming no phosphorus or potassium fertilizers are applied (yield potential is 50 bushels per acre).

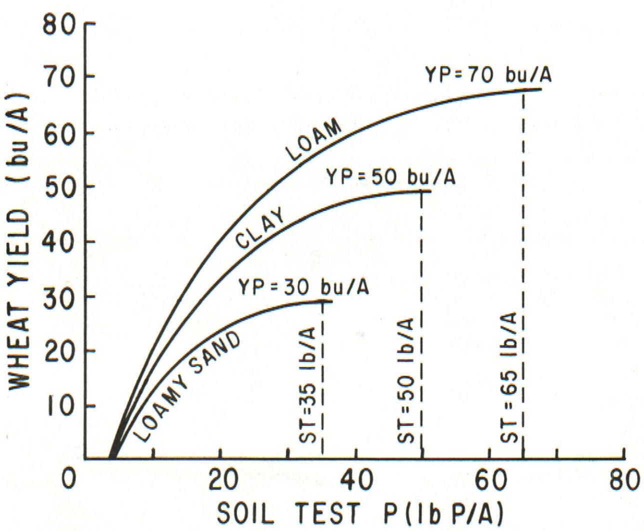

Figure 3—Relationship between expected wheat yield on three soils with varying yield potential (YP) to soil test (ST) levels of phosphorus, assuming no phosphorus fertilizer is applied.

Figure 2 shows that a soil with a yield potential of 50 bushesl per acre (YP = 50) would require a soil test of about 50 pounds P per acre to produce the optimum yield without P fertilizer. Figure 3 shows the response of wheat on soils with varying yield potential. Soils which have the inherent ability to produce large yields require a higher soil test than low-yielding soils to maximize yield.

Figure 4 shows that as the soil test (ST) for P increases from 8 to 38, smaller amounts of P fertilizer are required to reach the 70 bushel yield potential. The loss in yield due to inadequate P fertilizer can also be predicted from these curves. For example, a farmer who has a soil test of 8 and uses only 50 pounds of P_2O_5 would get 62 bushels per acre instead of 69 had he used 90 pounds P_2O_5, or a loss of 7 bushels per acre.

Recommendations for P fertilizer for certain yield goals and P soil tests are given in Table 2. **Soil tests from laboratories which do not use the Bray P_1 extractant with extraction procedures similar to that of the MSU laboratory should not use Table 2.** Laboratories using other extracting solutons or a widely different dilution or shaking time may obtain highly different soil test values.

POTASSIUM

Potassium (K) response curves similar to those for phosphorus have been developed from K fertilizer studies. Figure 2 shows the response of wheat with increasing levels of exchangeable K (soil test K) for a soil with a 50-bushel yield potential. A soil test of

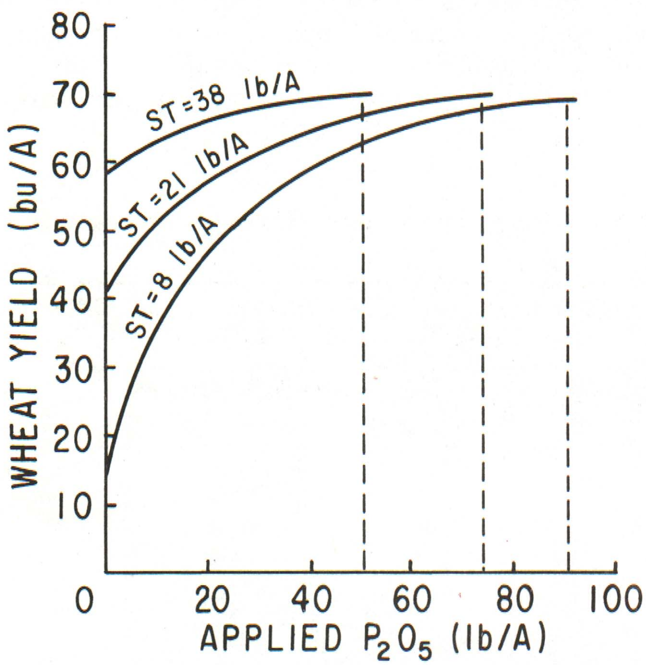

Figure 4—Relationship between expected wheat yield and applied phosphate fertilizer at three phosphorus soil test (ST) levels (yield potential is 70 bushels per acre).

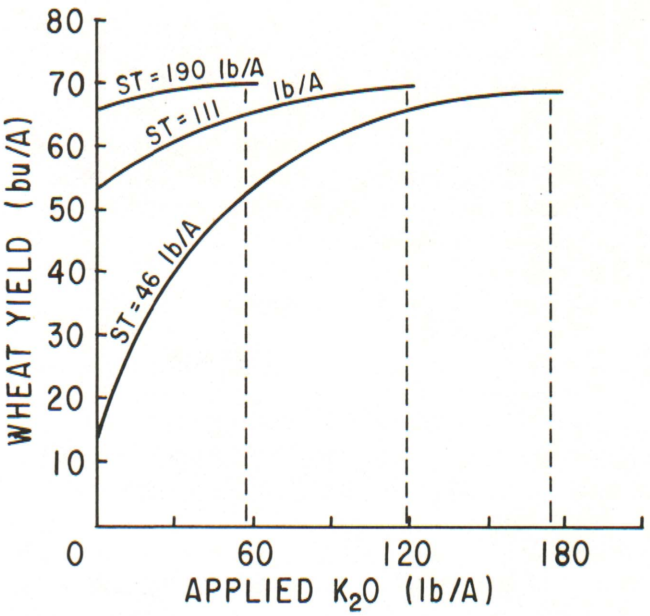

Figure 5—Relationship between expected wheat yield and applied potash fertilizer at three potassium soil test (ST) levels (yield potential is 70 bushels per acre).

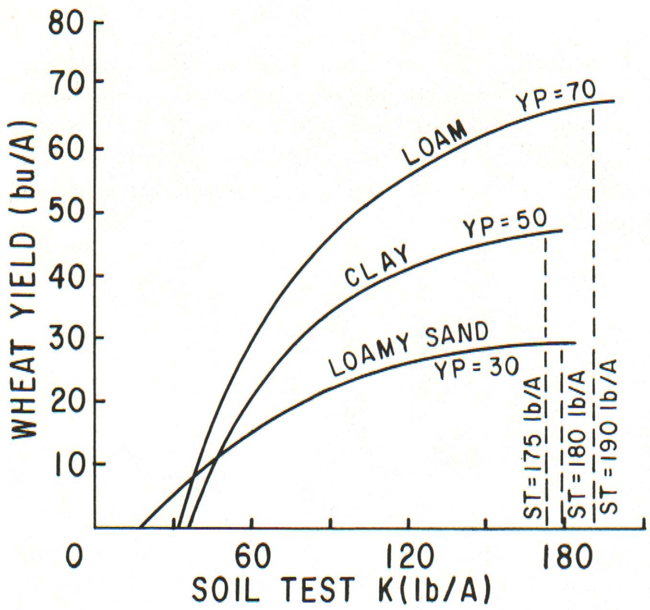

Figure 6—Relationship between expected wheat yield on three soils with varying yield potentials (YP) to soil test (ST) levels of potassium, assuming no potassium fertilizer is applied.

200 pounds of K per acre is required on this soil to maximize yield without adding K fertilizer. Note, however, that the yield potential can also be obtained by adding fertilizer K to soils with lower soil test K levels (Figure 5). Figure 6 shows the response of wheat on soils with varying yield potential. Soils which have the inherent ability to produce large yields require a higher soil test than low-yielding soils, but note that the response to soil test levels are not exactly alike for each soil. Sandy soils, although they do not have a large adsorption capacity, usually contain K which is easily available to plants, particularly at low soil test levels. Fine-textured soils with large amounts of clay have a large adsorption capacity but tend to render K less available than sandy soils. This is particularly noticeable at low soil test levels. Since sandy soils have a much lower adsorption capacity than clay soils, these soils have a lower reserve of K which plants can utilize. For these reasons, more K is recommended on coarse-textured than on fine-textured soils where the soil tests are identical. Potassium recommendations for coarse-textured soils are found in Table 3 and for fine-textured soils in Table 4.

Table 2.—Phosphorus Fertilizer Recommendations for Wheat.*

Soil test† P	*Wheat yield goal (bu/acre)* 30	40	50	60	70	80
(pounds/acre)			—— pounds P_2O_5/acre ——			
10	45	60	70	85	95	110
20	35	45	60	70	85	95
30	20	35	45	60	70	85
40	10	20	35	45	60	70
50	0	10	20	35	45	60
60		0	10	20	35	45
70			0	10	20	35
80				0	10	20
90					0	10
100						0

**Reduce the phosphorus recommendation by 2 pounds for each ton of manure recently applied.*

†Bray No. 1 Soil Extractant.

Table 3.—Potassium Fertilizer Recommendations for What Grown on Loamy Sand and Sandy Loam Soils.*

Soil test K	*Wheat yield goal (bu/acre)* 30	40	50	60
(pounds/acre)		pounds K_2O/acre		
25	95	120	150	175
50	85	110	130	155
75	75	95	115	140
100	60	80	100	120
125	50	70	85	100
150	40	55	70	85
175	30	40	55	70
200	20	30	40	55
225	0	15	25	35
250		0	0	20
275				0

**Reduce the potassium recommendation by 8 pounds for each ton of manure applied.*

PLACEMENT AND TIME OF APPLICATON

Phosphorus and potassium are most efficiently utilized by plants if banded or placed near the seed at planting. Many grain drills today apply the fertilizer directly in contact with the seed. When large amounts of fertilizer are placed in direct contact with the seed, injury to the new germinating seedlings can occur. To avoid injury do not apply more than 100 pounds of plant nutrients ($N + P_2O_5 + K_2O$) in direct contact with the seed on sandy soils and 140 pounds per acre on fine-textured soils. If additional amounts are required according to the soil test information, apply in a separate broadcast operation.

Spring applications of nitrogen are usually more efficient than fall applications. This is especially true on sandy soils and poorly-drained, fine-textured soils. A small amount of N should be applied at planting and the remainder topdressed in the spring. March and April are usually the best months for topdressing N. Whenever possible, avoid topdressing N on frozen soils where slopes are greater than 3% to reduce potential runoff losses. Make nitrogen applications prior to spring growth. Later applications may result in some yield reduction.

SOIL TEST LEVELS

Past attempts to classify soil tests into low, medium and high categories have generally been unsatisfactory. This was especially true where the categories were used for a wide variety of crops because crops vary greatly in their fertility requirements. The fertility requirements also change with changes in yield goal.

Table 4.—Potassium Fertilizer Recommendations for Wheat Grown on Loam, Clay Loam and Clay Soils.*

Soil test K	*Wheat yield goal (bu/acre)* 30	40	50	60	70	80
(pounds/acre)	----- pounds K_2O/acre -----					
25	95	120	150	175	200	225
50	80	105	130	155	175	200
75	70	90	110	135	155	175
100	55	75	95	115	130	150
125	40	60	75	95	110	130
150	25	40	55	75	90	105
175	10	25	40	55	65	80
200	0	10	20	35	45	55
225		0	5	15	25	35
250			0	0	0	10
275						0
300						

Reduce the potassium recommendation by 8 pounds for each ton of manure applied.

Categories, however, can be developed for a specific crop and a specific yield goal, using the relative yield concept and the response curves developed in this bulletin. Table 5 shows what such a classification would look like for wheat at two yield goal levels. The range in soil test for each classification varies with yield goal. Thus each yield goal has its own unique range of soil tests for each soil test category. The system is complex, however, and would require a great deal of training in order to be fully understood by all users of the soil test program. The merits of such a system require further study.

Table 5.—Classification of Soil Tests for Two Wheat Yield Goal Levels.

Soil[1] test level	*Relative yield %*	*Wheat yield goal (bu/acre)* 30 *(All soils) Soil test P*	50	30 *(Coarse-textured soils) Soil test K*	50	30 *(Fine-textured soils) Soil test K*	50
		--- pounds P/acre ---		--- pounds K/acre ---		--- pounds K/acre ---	
L-	< 50	0-11	0-15	0-59	0-68	0-58	0-68
L	51-65	12-15	15-19	60-78	69-89	59-72	69-86
L+	66-75	16-19	20-24	79-98	90-109	73-87	87-104
M-	76-82	20-23	25-29	99-117	110-131	88-101	105-122
M	83-87	24-27	30-34	118-136	132-151	102-116	123-140
M+	88-91	28-31	35-39	137-155	152-172	117-130	141-158
H-	92-94	32-35	40-44	156-175	173-193	131-145	159-176
H	95-97	36-39	45-49	176-194	194-214	146-159	177-194
H+	98-100	40+	50+	195+	215+	160+	195+

[1] *L = Low, M = Medium, and H = High*

RELATED PUBLICATIONS

Additional information on soil testing, liming, fertilization and micronutrients can be found in the following MSU Extension publicatons:

Bulletin No. 937: Understanding the MSU Soil Test Report

Bulletin E-896: Fertilizers: Types, Uses, and Characteristics

Bulletin E-550: Fertlizer Recommendations for Michigan Vegetable and Field Crops

Bulletin E-486: Secondary and Micronutrients for Vegetable and Field Crops

Bulletin E-471: Lime for Michigan Soils

Bulletin E-996: Essential Secondary Elements: Calcium

Bulletin E-994: Essential Secondary Elements: Magnesium

Bulletin E-997: Essential Secondary Elements: Sulfur

Bulletin E-1012: Essential Micronutrients: Zinc

Cooperative Extension Service Programs are open to all without regard to race, color, creed, or national origin. 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. Gordon E. Guyer, Director, Cooperative Extension Service, Michigan State University, E. Lansing, MI 48824. Price 10 cents. Single copy free to Michigan residents.

Michigan State University Printing