NebGuide

University of Nebraska–Lincoln Extension, Institute of Agriculture and Natural Resources

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G1461

Fertilizing Winter Wheat II
Phosphorus

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Soil testing and residual phosphorus application in wheat are discussed. Worksheets to calculate the recommended phosphorus rates for various application methods are included.

Wheat responds to applied phosphorus more than the other major Nebraska grain crops. Soil test levels of phosphorus must be higher for wheat than for corn, grain sorghum, or soybeans. Research results have indicated that phosphorus mainly increases tillering in fall, which increases the number of heads harvested, and thereby, grain yields. To a lesser extent, phosphorus increases seed size and number of kernels in the head.

Because of the effect of phosphorus on wheat rooting, winterkill is often associated with phosphorus deficiency. Phosphorus deficiencies also result in delayed maturity, which is clearly visible on eroded and high pH soils where soil phosphorus availability is low. Areas of green wheat among mature golden wheat also are good indicators of phosphorus deficiency. Such areas can benefit from spot treatment with phosphorus in subsequent years and generally require higher application rates to optimize yields. These areas should be soil sampled separately from other areas to provide a more accurate representation of variations in the field. All soils are not phosphorus deficient for wheat, so good soil sampling and testing are necessary to minimize unnecessary phosphorus applications and to maximize profits. Soils should be sampled for phosphorus and soil pH every three to five years.

Plow-layer samples (0-8 inches) should be taken for phosphorus analysis. Collect composite cores from at least 15 points in the field. More than one set of samples may be necessary from some fields if parts of the field differ in slope or soil characteristics such as color, sandiness or previous crop. For more information on soil sampling see NebGuide G91-1000, *Guidelines for Soil Sampling*.

The optimum phosphorus rate for winter wheat can be calculated according to the following equations or by using *Worksheet 1* for row or dual placement or *Worksheet 2* for broadcast application.

Optimum Phosphorus Rate for Row or Dual Placement

Bray-1 P Test:

P_2O_5 rate (pounds per acre) = (-9.98 - 2.38 x LN Bray-1P + 4.39 x LN YG)/(P PRICE/WHEAT PRICE)

Olsen P Test:

P_2O_5 rate (pounds/acre) = (-9.98 - 2.38 x LN (OlsenP x1.5) + 4.39 x LN YG)/(P PRICE/WHEAT PRICE)

Optimum Phosphorus Rate for Broadcast Application

Bray-1 P Test:

P_2O_5 rate (pounds/acre) = (17.13 - 3.21 x LN (Bray-1P) + 2.89 x LN YG - 9.81 x LN pH)/(P PRICE/WHEAT PRICE)

Olsen P Test:

P_2O_5 rate (pounds/acre) = (17.13 - 3.21 x LN (OlsenP x1.5) + 2.89 x LN YG - 9.81 x LN pH)/(P PRICE/WHEAT PRICE)

Where LN is the natural logarithm,

Bray-1P is the soil phosphorus test (ppm) for use in acid or neutral pH soils,

OlsenP is the soil phosphorus test (ppm) for use in alkaline soils,

YG stands for yield goal in bushels per acre,

pH is soil pH,

P PRICE is dollars per pound P_2O_5,

WHEAT PRICE is in dollars per bushel of wheat (includes actual selling price and yield-bound government subsidies).

Phosphorus Application Methods

Three basic methods of phosphorus application can be used for wheat: applying directly with the seed; broadcasting and incorporating prior to seeding; or dual placement which is applying liquid phosphorus (ammonium polyphosphate 10-34-0) together with anhydrous ammonia prior to seeding.

With new air seeders and air distribution fertilizer, many variations of these three application schemes are now available. For example, a producer using different kinds of tillage and placement shovels or sweeps or a no-till seeding system can place nitrogen and phosphorus fertilizers either under or slightly to the side of the seed row. Seed rows also may vary greatly in width, where the seed may be spread out over several inches under a sweep or seeded in a narrow slot. These variations greatly influence fertilizer-seed contact which may affect seed germination. The normal superphosphates and ammonium phosphates generally have a negligible effect on wheat stands because of the low salt content of phosphorus fertilizers compared to nitrogen fertilizer, the low concentration associated with the narrow rows (7 to 12 inches), and the generally high rates of seeding used with present wheat varieties. The seeding mechanism for applying phosphorus fertilizer with the seed (or in bands) is not critical unless the producer applies additional nitrogen at the same time. If a producer applies large amounts of nitrogen (over 15 to 20 pounds of nitrogen per acre), fertilizer nitrogen must be separated from the seed or stand losses may result.

Experiments in Nebraska have shown that dual placement, where phosphorus is knifed in with anhydrous ammonia, performs similarly to seed-applied phosphorus. Therefore, the recommendation for phosphorus is the same for both application methods. Dual placement knife spacing should be no greater than 15 inches. Wider spacing of nitrogen and phosphorus bands can result in variable plant height and may reduce yield. The normal ammonia application depth of 4 to 6 inches is also a good depth for phosphorus application.

While dual-placed phosphorus often results in somewhat less uniform wheat growth than seed-applied phosphorus, harvest yields have been similar for the two application methods. Greater wheat growth variability associated with dual-placed phosphorus is the result of delayed root contact because of the greater distance that phosphorus is placed from the row compared to seed application. This difference in time of root-to-phosphorus contact normally does not affect yield when wheat is seeded at the optimum seeding date; however, if wheat is seeded late without time for adequate root growth, the seed application method is superior.

Standard ammonia applicators equipped to dispense liquid phosphorus fertilizer (10-34-0) can readily apply dual-placed phosphorus. Double tubes for ammonia delivery and liquid fertilizer phosphorus are required.

Residual Phosphorus

When fertilizer phosphorus is applied, only 10 percent to 30 percent (broadcast compared to seed-applied) is absorbed by the wheat. The remaining 70 percent to 90 percent of the applied phosphorus remains in the soil as residual phosphorus. However, less than 25 percent of residual phosphorus is generally found in the following year's soil tests for phosphorus when the phosphorus is broadcasted and mixed with the soil. Studies have shown that residual phosphorus availability can increase significantly when it is knifed-in below tillage depth. Such bands may provide some soluble phosphorus for several years, but the primary effect occurs during the following year. Therefore, residual phosphorus from banding is most effective in continuous cropping systems and less effective in fallow and ecofallow systems because of the longer time between phosphorus application and seeding of the next crop.

Worksheet 1: Phosphate Fertilizer Requirement for Dual or Row Application

1) Soil test value: Bray-P1 ________ ppm..........................Factor 1 (from *Table I*): __________
   OR
   Olsen ________ ppm..........................Factor 1 (from *Table I*): __________

2) Yield Goal: ________ bu/acre ....Factor 2 (from *Table II*): __________

3) Add Factor 1 and Factor 2 __________
   If result is negative, STOP, NO fertilization is required.

4) Price per bushel of wheat $__________

5) Price per pound of P_2O_6 $__________

6) Divide Line 4 by Line 5 __________

7) Multiply result of Line 3 by the result of Line 6. __________

Result of Line 7 is the amount of fertilizer (pounds of P_2O_5/acre) required.

Table I. Conversion factor for soil text value.

Bray-P1	*Olsen P*	*Factor 1*	*Bray-P1*	*Olsen P*	*Factor 1*
1.5	1.0	-10.95	16.0	10.7	-16.58
2.0	1.3	-11.63	17.0	11.3	-16.72
3.0	2.0	-12.59	18.0	12.0	-16.86
4.0	2.7	-13.28	19.0	12.7	-16.99
5.0	3.3	-13.81	20.0	13.3	-17.11
6.0	4.0	-14.24	21.0	14.0	-17.23
7.0	4.7	-14.61	22.0	14.7	-17.34
8.0	5.3	-14.93	23.0	15.3	-17.44
9.0	6.0	-15.21	24.0	16.0	-17.54
10.0	6.7	-15.46	25.0	16.7	-17.64
11.0	7.3	-15.69	26.0	17.3	-17.73
12.0	8.0	-15.89	27.0	18.0	-17.82
13.0	8.7	-16.08	28.0	18.7	-17.91
14.0	9.3	-16.26	29.0	19.3	-17.99
15.0	10.0	-16.43	30.0	20.0	-18.07

Table II. Conversion factor for yield goal.

Yield goal	*Factor 2*	*Yield goal*	*Factor 2*
30	14.93	80	19.24
35	15.61	85	19.50
40	16.19	90	19.75
45	16.71	95	19.99
50	17.17	100	20.22
55	17.59	105	20.43
60	17.97	110	20.64
65	18.33	115	20.83
70	18.65	120	21.02
75	18.95		

Worksheet 2: Phosphate Fertilizer Requirement for Broadcast Application

1) Soil test value: Bray-P1 ________ ppm..........................Factor 3 (from *Table III*): __________
OR
Olsen ________ ppm..........................Factor 3 (from *Table III*): __________

2) Yield Goal: ________ bu/acre ....Factor 4 (from *Table IV*): __________

3) Soil pH ________ Factor 5 (from *Table V*): __________

4) Add Factor 3 and Factor 4 and Factor 5 __________
If result is negative, STOP, NO fertilization is required.

5) Price per bushel of wheat $__________

6) Price per pound of P_2O_5 $__________

7) Divide Line 5 by Line 6 __________

8) Multiply result of Line 4 by the result of Line 7 __________

Result of Line 8 is the amount of fertilizer (pounds of P_2O_5/acre) required.

Table III: Conversion factor for soil test value.

Bray-P1	*Olsen*	*Factor 3*	*Bray-P1*	*Olsen*	*Factor 3*
1.1	0.7	16.82	16.0	10.7	8.23
2.0	1.3	14.90	17.0	11.3	8.04
3.0	2.0	14.60	18.0	12.0	7.85
4.0	2.7	12.68	19.0	12.7	7.68
5.0	3.3	11.96	20.0	13.3	7.51
6.0	4.0	11.38	21.0	14.0	7.36
7.0	4.7	10.88	22.0	14.7	7.21
8.0	5.3	10.45	23.0	15.3	7.07
9.0	6.0	10.08	24.0	16.0	6.93
10.0	6.7	9.75	25.0	16.7	6.80
11.0	7.3	9.43	26.0	17.3	6.67
12.0	8.0	9.15	27.0	18.0	6.55
13.0	8.7	8.90	28.0	18.7	6.43
14.0	9.3	8.66	29.0	19.3	6.32
15.0	10.0	8.44	30.0	20.0	6.21

Table IV: Conversion factor for yield goal.

Yield goal	*Factor 4*	*Yield goal*	*Factor 4*
30	9.83	80	12.66
35	10.27	85	12.84
40	10.66	90	13.00
45	11.00	95	13.16
50	11.31	100	13.31
55	11.58	105	13.45
60	11.83	110	13.58
65	12.06	115	13.71
70	12.28	120	13.84
75	12.48		

Table V: Conversion factor for soil pH

pH	*Factor 5*
6	-17.58
6.2	-17.90
6.4	-18.21
6.6	-18.51
6.8	-18.81
7	-19.09
7.2	-19.37
7.4	-19.63
7.6	-19.90
7.8	-20.15
8	-20.40
8.2	-20.64
8.4	-20.88
8.6	-21.11

Example for
Worksheet 1: Phosphate Fertilizer Requirement for Dual or Row Application

A grower has a field with the following soil test value: Bray-P1: 4.0 ppm. His yield goal is 50 bushels per acre. He will pay \$0.30 per pound of P_2O_5 and plans to sell the wheat crop for \$3.00 per bushel.

1)	Soil test value:	Bray-P1 4.0	ppm	Factor 1 (from *Table I*):	-13.28
		OR	OR		OR
		Olsen ______	ppm	Factor 1 (from *Table I*):	______
2)	Yield Goal:	50	bu/acre	Factor 2 (from *Table II*):	17.17
3)	Add Factor 1 and Factor 2 If result is negative, STOP, NO fertilization is required.				3.89
4)	Price per bushel of wheat				\$ 3.00
5)	Price per pound of P_2O_6				\$ 0.30
6)	Divide Line 4 by Line 5				10
7)	Multiply result of Line 3 by the result of Line 6.				38.9

Result of Line 7 is the amount of fertilizer (pounds of P_2O_5/acre) required.

Example for
Worksheet 2: Phosphate Fertilizer Requirement for Broadcast Application

A grower has a field with the following soil test value: Olsen P: 3.0 ppm, soil pH 7.2. His yield goal is 60 bushels per acre. He will pay \$0.35 per pound of P_2O_5 and plans to sell the wheat crop for \$2.70 per bushel.

1)	Soil test value:	Bray-P1 ______	ppm	Factor 3 (from *Table III*):	______
		OR	OR		OR
		Olsen 3.3	ppm	Factor 3 (from *Table III*):	11.96
2)	Yield Goal:	60	bu/acre	Factor 4 (from *Table IV*):	11.83
3)	Soil pH	7.2	Factor 5 (from *Table V*):		-19.37
4)	Add Factor 3 and Factor 4 and Factor 5 If result is negative, STOP, NO fertilization is required.				4.42
5)	Price per bushel of wheat				\$ 2.70
6)	Price per pound of P_2O_5				\$ 0.35
7)	Divide Line 5 by Line 6				7.71
8)	Multiply result of Line 4 by the result of Line 7				34.1

Result of Line 8 is the amount of fertilizer (pounds of P_2O_5/acre) required.

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Index Field Crops
Small Grains
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