University of Idaho
College of Agricultural and Life Sciences

CIS 1101

Northern Idaho Fertilizer Guide

Soft White Spring Wheat

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The following fertilizer guidelines were developed through research conducted by the University of Idaho and Washington State University. The guidelines are based on relationships between soil test data and yields of spring wheat. The suggested fertilizer rates are designed to produce above-average yields if other factors such as pests, soil moisture, planting date, and stand are not limiting production. Thus, the fertilizer guidelines assume the use of sound management practices.

The suggested fertilizer rates will be accurate for your field if (1) soil samples are properly taken and represent the area to be fertilized and (2) the crop history you supply is complete and accurate. For assistance in obtaining a good soil sample, refer to University of Idaho bulletin 704, *Soil Sampling*.

Nitrogen

The amount of nitrogen (N) fertilizer required on any field depends on the following:

- The spring wheat variety, its market class, and its potential yield in the field. The suggested rates in this publication were developed over many years based on several varieties of soft white spring wheat. Modern varieties require high levels of available soil nutrients and superior management to achieve their high yield potentials.
- The potential yield of the selected variety based on its historical yield in the particular location and good management. Research in northern Idaho and eastern Washington has shown that 2.3 pounds available N per acre are required to produce 1 bushel of soft white spring wheat in the 16- to 21-inch annual precipitation zone. In areas receiving 22 to 24 inches of annual precipitation, 2.4 pounds N per acre are required to produce 1 bushel of soft white spring wheat, while 2.5 pounds N per acre are required when annual precipitation exceeds 24 inches.
- The amount of usable N in the soil profile. This includes mineralizable N (N released by decomposing organic matter during the growing season) and inorganic N in the forms of nitrate (NO_3) and ammonium (NH_4).
- Actual total annual precipitation and other climatic factors.
- The density and vigor of the plant stand.
- The type and yield of the previous crop.

In areas of low precipitation (18 inches or less), determine soil moisture in the profile. In these low-moisture areas and in areas with shallow soils (2 to 3 feet maximum depth), adjust the recommended N fertilizer rate based on the yield potential as limited by available soil moisture. Contact the extension educator in your county for more information on determining crop yield based on soil-profile moisture.

Nitrtogen fertilizer based on soil testing—Use the following equation to determine the amount of fertilizer N to apply to meet your crop's need:

$$\text{Fertilizer } N \text{ needed} = \left(\underset{\text{(Table 1)}}{\text{N needed based on potential yield}} + \underset{\text{(Table 2)}}{\text{N needed for residue breakdown}} \right) - \left(\underset{\text{(Tables 3 \& 4)}}{\text{Mineralizable } N} + \underset{\text{(Table 5)}}{\text{Soil test } N} \right)$$

Note: The amounts of N needed to attain the desirable high-protein hard red spring wheats are about 40 percent greater than those needed for soft white spring wheats. The values in this guide are for soft white spring wheats. Increase N fertilizer rates by 40 percent for hard red spring wheat production.

Nitrogen needed based on potential yield—Estimates of N needed to produce a crop of soft white spring wheat in a particular field should be based on potential yield—the field's long-term average yield. Multiply the potential yield in bushels per acre by 2.3, 2.4, or 2.5 pounds N per bushel, depending on annual precipitation, to arrive at total N needed (Table 1). If, for example, annual precipitation in your area is 19 inches and potential yield is 60 bushels per acre, then you would need 138 pounds N per acre (2.3 x 60).

Table 1. Total N needed by soft white spring wheat based on precipitation and potential yield.

Annual precipitation	N
(inches)	(lb/acre)
21 or fewer	2.3 x potential yield (bu/acre)
22 to 24	2.4 x potential yield (bu/acre)
More than 24	2.5 x potential yield (bu/acre)

Note: Initial research has shown that hard red spring wheats (14% protein) require between 3.1 and 3.5 pounds N per bushel of wheat.

Nitrogen needed for residue breakdown—Nitrogen is needed to break down straw from the previous cereal crop. Apply 15 pounds available N for each ton of straw incorporated into the soil up to 50 pounds N per acre (Table 2). Remember, 1 ton of residue is produced for each 20 bushels of wheat or 1,400 pounds of barley grain produced.

Table 2. Nitrogen needed for cereal straw (residue) breakdown.

Residue	N to add
(tons)	(lb/acre)
0	0
0.5	7.5
1	15
2	30
3	45
4	50
More than 4	50

Note: One ton of residue is produced for each 20 bu of wheat or 1,400 pounds of barley grain produced.

Nitrogen credit from previous legume crop—If the previous crop was a legume (peas, chickpeas, alfalfa, clover, birdsfoot trefoil, or lentils), the residue constitutes a small nitrogen credit. This credit is much smaller for a spring-seeded crop such as spring wheat because at least 60 percent of the legume residue has already broken down and the resulting plant-available N will be accounted for in a soil test. The N credit value for the previous legume crop can be obtained in Table 3. This value should be subtracted from the total N needed to produce the spring barley crop.

Table 3. Nitrogen credit for legume straw (residue) breakdown.

Residue	N credit
(tons)	(lb/acre)
0	0
0.5	3
1	6
1.5	9
2	12
3	18
4	24

Note: One ton of legume residue is produced from 1,000 pounds of lentil or pea grain produced.

Mineralizable nitrogen—Soils vary in their capacities to release N from organic matter during the growing season. The rate or amount of N released depends on factors such as the amount of soil organic matter, soil erosion, available soil moisture, tillage practice, and soil temperature during the growing season.

Estimated mineralization values for N release are shown in Table 4. Soils that are farmed using reduced tillage systems are often colder in the spring than conventionally tilled soils. Consequently, N mineralization rates are slightly higher in conventionally tilled fields.

Table 4. Mineralizable nitrogen release rates for northern Idaho soils.

	Tillage	
Organic matter content	Conventional	Reduced
(%)	------------------(lb N/acre/year)-----------------	
< 1.0	20	17
1.0	20	17
1.1	22	19
1.2	24	20
1.3	26	22
1.4	28	24
1.5	30	26
1.6	32	27
1.7	34	29
1.8	36	31
1.9	38	32
2.0	40	34
2.1	42	36
2.2	44	37
2.3	46	39
2.4	48	41
2.5	50	43
2.6	52	44
2.7	54	46
2.8	56	48
2.9	58	49
3.0 +	60	51

Soil test nitrogen—The amount of available N in the soil can be evaluated most effectively with a soil test. The soil samples should represent the rooting depth of the crop because nitrate-nitrogen (NO_3-N) is mobile in soil. Spring wheat is capable of removing N to a depth of 3 feet.

Soil test values include both NO_3-N and ammonium-nitrogen (NH_4-N) in the first foot of the soil profile. NO_3-N should be sampled in 1-foot increments to the crop's effective rooting depth. To convert soil test NO_3-N and NH_4-N values in parts per million (ppm) to pounds per acre, add the N values (ppm) for each foot of sampling depth and multiply by 3.5 (Table 5).

Table 5. Example of calculation to convert N soil test results in ppm to pounds per acre.

Depth	Soil test results NO_3-N	NH_4-N[1]	Total	Factor		Total N[2]
(inches)	(ppm)	(ppm)	(ppm)			(lb/acre)
0 to 12	1	1	2	x 3.5	=	7
12 to 24	2	–	2	x 3.5	=	7
24 to 36	2	–	2	x 3.5	=	7
Total	5	1	6	x 3.5		21

[1] Ammonium (NH_4-N) content is usually low and is often not included in soil test analyses.
[2] ppm x 3.5 = lb/acre

Nitrogen fertilizer needed—Again, the calculation for N fertilizer needed is:

Total N needed (lb/acre) (Table 1 + Table 2)		______
Minus mineralizable N (lb/acre) (Table 3 + Table 4)	–	______
Minus soil test N (lb/acre) (Table 5)	–	______
Equals N fertilizer needed (lb/acre)	=	______

Example: With a potential yield of 60 bushels per acre, annual precipitation of 23 inches, 2.3 percent organic matter, conventional tillage, 80 bu/A winter wheat straw = 4 tons/A straw residue, no legume residue, and soil test values from the example in Table 5, you would need 127 pounds N per acre:

Total N needed (lb/acre) (Table 1 + Table 2)	(144 + 50)		194
Minus mineralizable N (lb/acre) (Table 3 + Table 4)	(0 + 46)	–	46
Minus soil test N (lb/acre) (Table 5)		–	21
Equals N fertilizer needed		=	127*

* 7 lb/acre more fertilizer N would be needed if this were a reduced-tillage system.

Phosphorus

Spring wheat has a relatively low phosphorus (P) demand, but an adequate amount must be available for use by the plant (Table 6). Thus, if the soil level of P is low, the crop will respond to applied P.

If your soil contains more than 4 ppm based on the NaOAc soil test method (or > 40 ppm using the Bray I method or > 12 ppm using the $NaHCO_3$ method) additional fertilizer P is not needed. However, if you are using reduced tillage you may apply up to 30 pounds P_2O_5 in a band. This band containing P should be placed either below or with the seed at planting.

Phosphorus should be either banded or incorporated into the seedbed before or at planting. Broadcast-plowdown, broadcast-seedbed incorporated, and drill banding are commonly used methods of application. Drill banding is usually the most efficient application method, allowing placement with, below, or to the side of the seed. Choose whichever application method is most convenient. *Note:* If the P material banded with the seed contains N, do not apply more than 20 pounds N per acre.

Table 6. Phosphorus fertilizer rates for spring wheat based on a soil test.

Soil test P (0 to 12 inches)[1] NaOAc	Bray I	$NaHCO_3$	Application rate[2] P_2O_5	P
(ppm)	(ppm)	(ppm)	(lb/acre)	(lb/acre)
0 to 2	0 to 20	0 to 8	60	26
2 to 3	20 to 30	8 to 10	40	18
3 to 4	30 to 40	10 to 12	20[3]	9
over 4	over 40	over 12	0[3]	0

[1] Soil test P can be determined by three different procedures: sodium acetate (NaOAc), Bray I method, or sodium bicarbonate ($NaHCO_3$). Sodium bicarbonate should not be used on soils with pH values less than 6.2. Use the column indicated by your soil test report.
[2] P_2O_5 x 0.44 = P, or P x 2.29 = P_2O_5.
[3] Under reduced tillage you can apply up to 30 lb P_2O_5 per acre in a band either with or below the seed at planting, regardless of P soil test level.

Potassium

Spring wheat has a relatively low demand for potassium (K). Few soil samples have soil test values low enough to warrant the use of K fertilizer. Those that do are usually from eroded areas of hilltops, clay knobs, or both. Apply K fertilizer as needed according to a soil test (Table 7).

Table 7. Potassium fertilizer rates for soft white and hard red spring wheats based on a soil test.

Soil test K (0 to 12 inches)[1]	Application rate[2] K_2O	K
(ppm)	(lb/acre)	(lb/acre)
0 to 35	80	66
35 to 75	60	50
more than 75	0	0

[1] Sodium acetate extractable K.
[2] K_2O x 0.83 = K, or K x 1.20 = K_2O.

K should be incorporated into the seedbed before or at planting. Broadcast-plowdown, broadcast-seedbed incorporated, and drill banding are effective methods of application. Drill-banded fertilizer can be placed with, below, or to the side of the seed. Choose whichever application method is most convenient. The total of N plus K (as K_2O) applied with the seed should not exceed 20 pounds per acre due to potential harm to the seed.

Sulfur

Sulfur (S) requirements for spring wheat are influenced by soil texture, soil organic matter, the previous crop, and fertilizer history. A soil testing less than 10 ppm SO_4-S should receive 15 to 20 pounds S per acre. Avoid using elemental S. Use a material containing sulfate. Sulfur deficiency appears as a yellowing of the plant early in the growing season and is impossible to distinguish visually from N deficiency. Have the soil tested if you suspect a deficiency. Sulfur needs of spring wheat based on a soil test are shown in Table 8.

Table 8. Sulfur fertilizer needs of spring wheat based on a soil test.

Soil test S (0 to 12 inches)		S application rate
(ppm SO_4-S)	(ppm S)	(lb/acre)
0 to 10	0 to 4	20
over 10	over 4	0

Micronutrients and lime

Spring wheat responses to micronutrients have been uncommon in northern Idaho. If you are in doubt about your soil's micronutrient needs, have the soil tested and consult the extension educator in your county.

Soil pH values in northern Idaho have declined dramatically over the past 40 years. This steep decline has led to a reduction in yields of several crops. Research conducted in the 1980s showed that wheat yields are unaffected as long as soil pH values (in the surface foot of the soil profile) remain at or above pH 5.3. Research shows that wheat yield reductions of 5, 12, 20, 25, and 40 percent can be expected at soil pH values of 5.2, 5.1, 5.0, 4.9, and 4.8, respectively.

Try experimental lime applications on strongly acid soils (pH less than 5.1) to determine whether the crop gives an economical response. Apply needed lime at a rate of 1 to 2 tons per acre and mix it thoroughly into the soil. For additional information see CIS 811, *The Relationship of Soil pH and Crop Yields in Northern Idaho*.

Agronomy/Water quality considerations

- Fall N fertilization for spring cereal crop production is acceptable as long as the risk of groundwater contamination is not high based on the USDA-NRCS Idaho Nutrient Transport Risk Assessment (INTRA) model.
- Weeds, insects, diseases, and environmental stress can influence the effectiveness of a fertilizer program and reduce yields.
- Early planting of spring wheat has been shown to result in the highest yields.
- Poor N management can result in excessive nitrate leaching and groundwater pollution under certain conditions. Poor management practices can cause excessive erosion and contamination of surface waters with P.
- The ammoniacal forms of N (ammonium and ammonia) do not leach as readily as nitrate. When temperature and moisture are favorable for plant growth, however, ammoniacal N and urea are quickly converted to the nitrate form at temperatures above 50ºF. Thus, N applied in the spring, regardless of its form, is subject to leaching in areas of heavy precipitation.
- Soil sampling is an essential component of nutrient management. To learn more about soil sampling procedures, the correct soil sampling tools, and the handling of your soil sample refer to University of Idaho Bulletin 704, *Soil Sampling*.
- Starter, or pop-up, fertilizers have limited success. Starter fertilizers have been most effective when soils were cold and root growth could be stimulated by a readily available supply of both P and N.
- Avoid banding high amounts of fertilizer close to the seed. High amounts of N and K can result in salt damage during germination. Wheat is especially sensitive to excess salts during germination.
- Banding fertilizer improves N and P use efficiency. Consequently, if applying N, P, or both in a band, cut the recommended fertilizer application rates by 10 to 15 percent.
- Lower soil disturbance in reduced tillage systems results in lower soil temperatures, which in turn reduces organic matter mineralization rates. Consequently, N fertilization rates are often slightly higher in reduced tillage systems.

Further reading

BUL 704, *Soil Sampling*, $2.00

CIS 811, *The Relationship of Soil pH and Crop Yields in Northern Idaho,* 35 cents.

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CIS 1101, *Soft White Spring Wheat*

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