



# Winter Wheat in Summer-Fallow Systems

*(Intermediate precipitation zone)*

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**R**ecommendations in this fertilizer guide apply to tillage fallow-winter wheat and chemical fallow-winter wheat cropping systems. This guide is one of a set of publications that address the nutritional requirements of nonirrigated cereal crops in north-central and eastern Oregon (Table 1).

Recommendations for nitrogen, phosphorus, potassium, sulfur, chloride, and zinc are covered in this guide. Soils in the region supply sufficient amounts of other nutrients for optimum production of high-quality grain.

## Nitrogen

Calculate nitrogen (N) application rates by subtracting soil test nitrogen from crop demand for nitrogen. Adjust for excessive straw and/or soil sampling in the spring of the summer-fallow year. Evaluate application rates by reviewing the protein content of harvested grain. A detailed explanation is provided on pages 2–4.



### Growing conditions

**Annual precipitation:** 12 to 18 inches

**Soil:** Silt loam

**Soil organic matter content:** 1 to 2 percent

### Expected yield

50 to 80 bu/acre

Table 1.—Fertilizer guides for nonirrigated cereal production in low, intermediate, and high precipitation zones of Oregon.\*

Publication #	Title	Precipitation zone
FG 80	Winter Wheat in Summer-Fallow Systems	Low
FG 81	Winter Wheat and Spring Grains in Continuous Cropping Systems	Low
FG 82	Winter Wheat in Summer-Fallow Systems	Intermediate
FG 83	Winter Wheat in Continuous Cropping Systems	Intermediate
FG 84	Winter Wheat in Continuous Cropping Systems	High

\*This set of publications replaces FG 54, *Winter Wheat, Non-irrigated, Columbia Plateau*. Precipitation zones are based on average annual precipitation and are defined as follows: Low = less than 12 inches; Intermediate = 12 to 18 inches; High = more than 18 inches.

## Crop demand for nitrogen

Multiply expected yield by the nitrogen requirement to get crop demand for nitrogen. The nitrogen requirement, *which is the amount of nitrogen required to produce 1 bushel of wheat*, is based on a grain protein goal (Table 2).

Table 2.— Grain protein goal and corresponding nitrogen requirements (per bushel) for wheat.

Grain protein goal (%)	Nitrogen requirement	
	Average (lb N/bu)	Range (lb N/bu)
9	2.2	2.0–2.4
10	2.4	2.2–2.6
11	2.7	2.4–2.9
12	3.0	2.6–3.2
13	3.3	2.8–3.5

### Nitrogen requirement

Average nitrogen requirements are suitable for most situations. The ranges given in Table 2 can be used to compensate for growing conditions or varieties that are genetically predisposed to having lower or higher grain protein contents.

A grain protein content of 10 percent is optimum for soft white wheat. Desired grain protein concentrations for hard wheat range from 11 to 13 percent.

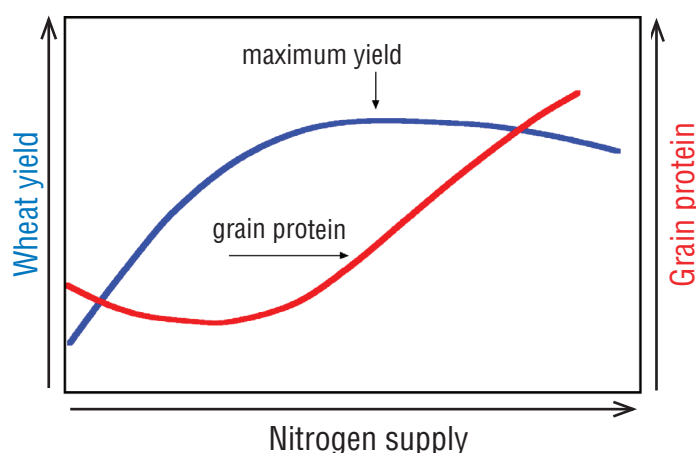


Figure 1.— Generalized relationship of wheat grain yield and grain protein to nitrogen supply.

Nitrogen requirements for high-protein hard wheat are greater than those for low-protein soft wheat. The extra protein in hard wheat accumulates in grain when plant uptake of nitrogen exceeds that required for maximum yield (Figure 1).

### Subtract soil test nitrogen

Laboratory methods are used to test soil samples for plant-available nitrogen (soil test nitrogen). Collect samples from the effective root zone (usually 4 feet) in 1-foot increments and have them analyzed for nitrate nitrogen (NO<sub>3</sub>-N). Samples from the surface foot also should be analyzed for ammonium nitrogen (NH<sub>4</sub>-N). Add reported values for all depths to get total soil test nitrogen (Table 3).

Table 3.— Soil test nitrogen for samples collected in 1-foot increments. Values are used for the application rate calculations on page 3.

Soil depth (inches)	Ammonium nitrogen (NH <sub>4</sub> -N) (lb/acre)	Nitrate nitrogen (NO <sub>3</sub> -N) (lb/acre)	Total soil test nitrogen (NH <sub>4</sub> -N + NO <sub>3</sub> -N) (lb/acre)	Amount to subtract (lb/acre)
0–12	5	30	35	35
13–24	—	25	25	25
25–36	—	15	15	15
37–48	—	5	5	5
<b>Profile*</b>	<b>5</b>	<b>75</b>	<b>80</b>	<b>80</b>
49–60**	—	12	12	—
61–72**	—	10	10	—

\* Calculation of the nitrogen application rate should be based on soil test results from the top 4 feet or the effective root zone.

\*\* Nitrogen in the fifth and sixth foot usually does not contribute to yield, but may increase grain protein.

Periodic assessment of nitrate concentration in the fifth and sixth foot can be used to fine-tune nitrogen management. If nitrate concentrations are high or increase over time, consider adjusting the application rate or the time of application. Split applications may improve nitrogen use efficiency.

**Example 1. A nitrogen application rate calculation for soft white common and club-type winter wheat (10% protein).**

**Assumptions include:**

- Expected yield of 60 bu/acre
- Soil test nitrogen = 80 lb N/acre
- Effective rooting depth of 4 feet

(lb N/acre)

**Crop demand for nitrogen\***

(Expected yield) x (per-bushel N requirement) at desired protein  
 (60 bu/acre) x (2.4 lb N/bu) @ 10% protein ..... **145**

**Subtract soil test nitrogen**

0–12" .....35  
 13–24" .....25  
 25–36" .....15  
 37–48" .....5

**Total soil test nitrogen.....80**

**Nitrogen application rate.....65**

\*Crop demand for nitrogen rounded to nearest 5 lb.

**Example 2. A nitrogen application rate calculation for hard red winter wheat (12% protein).**

**Assumptions include:**

- Expected yield of 60 bu/acre
- Soil test nitrogen = 80 lb N/acre
- Effective rooting depth of 4 feet

(lb N/acre)

**Crop demand for nitrogen**

(Expected yield) x (per-bushel N requirement) at desired protein  
 (60 bu/acre) x (3.0 lb N/bu) @ 12% protein ..... **180**

**Subtract soil test nitrogen\***

0–12" .....35  
 13–24" .....25  
 25–36" .....15  
 37–48" .....5

**Total soil test nitrogen.....80**

**Nitrogen application rate.....100**

\*Crop demand for nitrogen rounded to nearest 5 lb.

**Example 3. A nitrogen application rate calculation for hard white winter wheat (13% protein).**

**Assumptions include:**

- Expected yield of 60 bu/acre
- Soil test nitrogen = 80 lb N/acre
- Effective rooting depth of 4 feet

(lb N/acre)

**Crop demand for nitrogen\***

(Expected yield) x (per-bushel N requirement) at desired protein  
 (60 bu/acre) x (3.3 lb N/bu) @ 13% protein ..... **200**

**Subtract soil test nitrogen**

0–12" .....35  
 13–24" .....25  
 25–36" .....15  
 37–48" .....5

**Total soil test nitrogen.....80**

**Nitrogen application rate.....120**

\*Crop demand for nitrogen rounded to nearest 5 lb.

**Adjust for excessive straw**

Nitrogen “tie-up” in crop residue (immobilization) temporarily reduces the amount of available nitrogen in the soil; immobilization can be a problem when greater-than-average quantities of straw are present in the field.

Grain yield can be used to estimate the quantity of straw. Straw loads increase by about 100 lb/acre for each bushel increase in yield. Adjust the calculated nitrogen application rate as shown in Table 4 if grain yield from the previous wheat crop exceeded the **long-term field average** by 10 bu/acre or more.

Table 4.—Nitrogen application rate adjustments for wheat yield (*straw production*) that is greater than the long-term field average.

Greater-than-average wheat yield (previous crop) (bu/acre)	Corresponding increase in straw production (lb/acre)	Increase application rate by (lb N/acre)
+10	1,000	10
+20	2,000	20
+30	3,000	30

### Adjust for soil sampling (spring of summer-fallow year)

Decrease the calculated application rate by 15 to 25 lb N/acre if fields are sampled in the spring of the summer-fallow year. This adjustment will compensate for mineralization. Mineralization is a biological process that increases the supply of available nitrogen in the soil; it is favored by moist or wet soils and warm temperatures.

Mineralization may increase the supply of available nitrogen by more than 15 or 25 lb/acre when average or above-average precipitation follows a prolonged drought. **Adjustment of the nitrogen application rate is not necessary if fields are sampled within 6 weeks of fall seeding.**

### Review protein content of harvested grain

A postharvest review of grain protein can be a good way to evaluate application rates. Higher-than-desired protein indicates overfertilization—if growing conditions were normal or about average. High protein also can be caused by unusually dry conditions or nitrogen that is positioned deep in the soil profile.

Lower-than-desired protein may be due to an insufficient application rate. Low protein also can be a problem when late-season rainfall results in an above-average yield or when nitrogen losses occur during or after application. Examples of nitrogen losses include “escape” of anhydrous ammonia from dry soil or an unsealed soil surface, volatilization of surface-applied urea, and nitrate leaching below the root zone.

## Phosphorus

Application of 25 to 35 lb P<sub>2</sub>O<sub>5</sub>/acre should increase yield if soil test phosphorus (P) levels are 5 ppm or less (Table 5). A phosphorus application is not recommended when soil test values are greater than 15 ppm.

Phosphorus response in fields with soil test values of 6 to 15 ppm is highly variable. Yield increases from fertilization seem to be associated

with: (1) high yield potentials, (2) late seeding dates, or (3) root diseases that limit plant growth and development. In fields with soil test levels between 6 and 15 ppm, effects of fertilization are best evaluated through on-farm experiments.

Table 5.—Recommended phosphorus fertilizer application rates for a range of soil test values.

Soil test phosphorus (P) (ppm)*	Plant-available index	Amount of phosphate (P <sub>2</sub> O <sub>5</sub> ) to apply (lb/acre)**
0–5	Very low	25–35
<b>6–10***</b>	<b>Low</b>	<b>15–25</b>
<b>11–15***</b>	<b>Moderate</b>	<b>5–15</b>
Over 15	High	0

\* Plant-available index is correlated to sodium bicarbonate-extractable phosphorus only and does not apply to other test methods.

\*\* Recommended application rates apply to banded or subsurface shank applications.

\*\*\* Phosphorus response in fields with soil test values between 6 and 15 ppm is highly variable.

Optimum efficiency is achieved by banding phosphorus. Placement of either liquid or dry material with the seed, below the seed, or below and to the side of seed is recommended. Sub-surface shank applications also are effective. Broadcast applications are not recommended.

### Soil sampling for phosphorus

Collect soil samples for phosphorus testing from the surface foot. Reported values are best thought of as an index of availability. The test cannot be used to calculate the pounds of plant-available P<sub>2</sub>O<sub>5</sub> per acre.

## Potassium

Soil potassium (K) concentrations in the region generally are high or very high (>100 ppm extractable K). Fertilizer applications are not recommended.



## Sulfur

Sulfur (S) is one of the most limiting nutrients for wheat production—second only to nitrogen in importance. The sulfur requirement of the wheat plant is about one-tenth the nitrogen requirement. Sulfur is necessary for optimum yield and high-quality baking flour.

Sulfur deficiencies in wheat are fairly common in the spring after a wet winter. Above-average precipitation moves sulfate-sulfur (SO<sub>4</sub>-S), *the form of sulfur available to plants*, below the root zone. Deficiency symptoms often disappear later in the season as root growth extends to deeper layers of the soil profile.

The soil sulfur (SO<sub>4</sub>-S) test is not definitive. Low or moderate soil test values (Table 6) are a first indication that fertilization might be warranted. Other factors need to be considered. Yield responses are more likely if one or more of the following situations apply: (1) winter wheat is seeded late in the fall, (2) more than 5 years have passed since the last application of sulfur, and/or (3) greater-than-average quantities of straw are present in the field. Field experience, observation, and on-farm experimentation provide valuable information about the need for sulfur.

Table 6.—Plant-available sulfate-sulfur and recommended fertilizer application rates for a range of soil test values.

Soil test sulfate-sulfur (SO <sub>4</sub> -S) (ppm)	Plant-available index	Amount of sulfur (S) to apply (lb/acre)*
0–5	Low	15–20
6–10	Moderate	10
Over 10	High	0

\*A decision to apply sulfur should not be based on soil test results alone. Sulfur may be beneficial if SO<sub>4</sub>-S soil test values are low or moderate and if: (1) winter wheat is seeded late in the fall, (2) more than 5 years have passed since the last application of sulfur, and/or (3) greater-than-average quantities of straw are present in the field.

Optimum efficiency is achieved by banding sulfur. Placement of either liquid or dry material with the seed, below the seed, or below and to the side

### Soil sampling for sulfur

Collect soil samples for sulfur (SO<sub>4</sub>-S) testing from the surface foot. The test is not definitive, and reported values are best thought of as an index of availability. Field experience, observation, and on-farm experimentation provide valuable information about the need for sulfur.

of seed is recommended. Subsurface shank applications also are effective.

Ammonium thiosulfate liquid (Thiosul, 12-0-0-26) is an effective source of sulfur, but it can injure or kill seedlings when placed with the seed. Avoid this problem by placing the product below and to the side of seed.

Elemental sulfur should be used with caution because it is not immediately plant-available. Microorganisms oxidize elemental sulfur to plant-available sulfate, but conversion occurs slowly and is regulated by the moisture status and temperature of the soil. Most of the elemental sulfur will not be available until 2 or 3 years after application. Rates of 100 lb elemental S/acre may be necessary to ensure that adequate sulfate is available during the first growing season.

## Chloride

Research shows that application of chloride (Cl) may increase grain yield, test weight, and/or kernel size. It is important to note, however, that these responses occur only some of the time.

Chloride applications are known to increase yield of winter wheat suffering from “Take-all” root rot, and they reduce the severity of physiological leaf spot. Yield responses in the absence of disease also have been observed and may be a consequence of improved plant–water relations.

Consider applying chloride if soil test concentrations in the surface foot are less than 10 ppm. The recommended application rate for chloride is 10 to 30 lb/acre. Benefits from fertilization may last for several years.

Yield increases, when they occur, usually range from 2 to 5 bu/acre. Responses are most often associated with above-average yield. Growers are advised to experiment with chloride on small acreages.

Do not apply chloride with the seed; it is a soluble salt that can delay germination or injure or kill germinating seeds. Rain is required after application to move surface-broadcast chloride into the root zone.

Potassium chloride (KCl) is the most readily available source of chloride.

## Zinc

Zinc (Zn) fertilization of dryland wheat has not been economical in research trials. On-farm experiments with fertilization should be limited to small acreages. A zinc application rate of 5 lb/acre is appropriate. A 10 lb/acre application should last for several years.

The potential for a grain yield response increases when DTPA-extractable soil test zinc values (surface foot) are less than 0.3 ppm, soil phosphorus levels are moderate to high, the soil pH is greater than 7.5, and yield potential exceeds 50 bu/acre.

## For more information

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### **\*Oregon State University and Pacific Northwest Extension publications**

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Revised November 2006. Reprinted April 2007.