



# DRYLAND WINTER WHEAT

## Eastern Washington Nutrient Management Guide

Nutrient management is essential to the economical production of high-yielding, high-quality crops, and to preserving soil, air, and water quality. As the term implies, nutrient *management* includes activities such as sampling to monitor soil nutrient levels and adjust application rates; altering practices such as the placement, application timing, and source of nutrients to maximize plant availability and uptake; and conducting a post-harvest assessment of yield, grain protein levels, and nutrient use efficiency.

Eastern Washington is unique in that diverse environment, soil, and topography result in variations in crop yield across the region as well as across farms and individual fields within farms. Due to the inherent variability associated with eastern Washington dryland crop production, a one-size-fits-all recommendation for the management of any one nutrient is of little value. Recommendations must be based on individual grower practices, achievable yields, and current soil test data. This document presents guidelines for managing major nutrients in eastern Washington dryland winter wheat and emphasizes how producers can tailor recommendations to their own production systems. It also identifies opportunities where information such as crop yield and protein and soil test nutrient levels can help refine and improve nutrient management practices.

### Nutrient uptake and removal by dryland wheat

High-yielding wheat absorbs large quantities of nutrients from soil. Box A shows average values for nutrient uptake and removal in the grain and straw of wheat. This table can be used as a guide to forecast nutrient removal from the field with the grain and straw portions of the crop. Note that the majority of nitrogen and sulfur in straw is lost if a field is burned; other nutrients generally remain in the ash.

### Box A Average Nutrient Content in Dryland Wheat: Total Uptake and Removal in Grain and Straw.<sup>1</sup>

Nutrient	Total uptake	Removal in grain	Removal in straw
—lbs per bushel of yield—			
Nitrogen (N)			
9.0% protein (soft white)	1.35	0.95	.40 <sup>2</sup>
11.5% protein (hard red)	1.50	1.20	0.30
12.5% protein (hard white)	1.65	1.32	0.33
Phosphorus (P <sub>2</sub> O <sub>5</sub> ) <sup>3</sup>	0.62	0.5	0.12
Potassium (K <sub>2</sub> O) <sup>4</sup>	1.55	0.35	1.2
Sulfur (S)	0.30	0.13	0.17
Chloride (Cl)	0.20	0.0	0.20

<sup>1</sup> Source: USDA-NRCS and the International Plant Nutrition Institute.

<sup>2</sup> Based on a N harvest index of 0.7 for soft white and 0.8 for hard red and hard white.

<sup>3</sup> To convert to lbs of elemental P multiply values by 0.44.

<sup>4</sup> To convert to lbs of elemental K multiply values by 0.83.

### Nitrogen (N) recommendations

Nitrogen recommendations are based on the potential yield for a site, the amount of N required to achieve yield and protein goals for a desired wheat class, and an inventory of soil N contributions. A worksheet is included in this guide to aid in developing an N recommendation and as a record-keeping tool. The following paragraphs refer to specific sections of the worksheet. A separate Microsoft Excel® spreadsheet is also available to make these calculations electronically.

**Yield potential and N supply needed (Block A of the worksheet).** The amount of N required to achieve yield and protein goals is a function of the yield potential of the site and class of wheat grown.

**A1.** An accurate yield goal is essential to develop an accurate N recommendation; however, yield varies within a field and from year to year in response to weather, and rotation, seeding date, and other management variables. Acceptable methods of estimating potential yield for a site are based on: 1) grower practices and experience with the field; 2) measured historic averages; and 3) pre-plant soil moisture and rainfall expected during the growing season.

**A2.** Different wheat classes require different amounts of N to achieve quality goals. The number of pounds of N required per bushel (lb N/bu) for different wheat classes is summarized in a footnote on Block A2 as a single value +/- 0.2 to reflect variations in N use efficiency among years and landscape positions. Actual values may vary by more than +/- 0.2 lb N/bu. Methods of calculating the actual lb N/bu required to produce wheat in the field are included in Block E. Note that the N supply calculated in Block A2 is the total amount of N that must be supplied from fertilizer and soil sources, not the N fertilizer recommendation.

**Soil N Inventory (Block B of the worksheet).** The soil N inventory is a combination of inorganic N in the profile prior to fertilizer application, N released by decomposing residue from a previous legume crop and soil organic matter (mineralization), N tied up by decomposing straw (immobilization), and other credits such as manure applied.

<b>Box B</b>	
<b>Credit From Previous Grain and Forage Legume Crops</b>	
<b>Preceding crop and yield</b>	<b>Credit (lb N/acre)</b>
Peas > 2500 lb/acre	20
Peas 1500 to 2500 lb/acre	15
Peas < 1500 lb/acre	10
Lentils >1000 lb/acre	10
Alfalfa	50

**B1.** Soil test N should be measured using appropriate sampling practices (see Box C). For winter wheat, samples should be collected in one-foot increments to a minimum depth of four feet or a restrictive layer. Analyze surface foot samples for nitrate (NO<sub>3</sub>) and ammonium (NH<sub>4</sub>) forms of N, as well as other

nutrients described later in this guide. Analyze the remaining depths for NO<sub>3</sub>. Most labs report soil test N in units of pounds per acre (lb/acre). If values are reported in parts per million (ppm) N, sum all values across one-foot depth intervals and multiply by 3.5 to estimate pounds of N per acre in the soil test.

**B2.** Nitrogen released from decomposing legume residue is considered a credit to the soil N inventory. Box B summarizes these credits.

**B3.** Soil organic matter releases N as it decomposes. Credit the soil N inventory for soil test organic matter in the surface foot according to the following guidelines:

*Conventional tillage:* credit 20 lb N for each 1% organic matter;

*No-tillage/direct seeding:* credit 17 lb N for each 1% organic matter up to 3% organic matter. Organic matter may release less N during the transition to direct seeding, and in high elevation environments with low soil temperatures.

**B4.** A debit is taken for N immobilized by decomposing residue from a preceding cereal crop in annual cropping systems. No debit is taken in summer fallow situations. Subtract 35 lb N/acre if winter wheat was the preceding crop, 30 lb N/acre if spring wheat was the preceding crop, and 25 lb N/acre if barley was the preceding crop.

**B5.** Other credits may come in the form of manure or other sources of nutrients applied to the field. If applicable, enter the N available to the plant during the first year after application on line B5.

**B6.** Total the soil N inventory and enter the total on line B6.

**Nitrogen to apply (Block C of the worksheet).** Calculate the amount of N to apply by subtracting the total soil N inventory (line B6) from the N supply requirement (line A2).

**Nitrogen application, yield, and protein record (Block D of the worksheet).** Enter dates, rates and methods of N application, yield and protein data, and any other special notes in Block D.

**Post-harvest N efficiency estimates (Block E of the worksheet).** Average yield per acre and grain protein concentration can be used to estimate N uptake by the crop. Nitrogen uptake and N supply are used to estimate N uptake efficiency in Block E of the worksheet. Post-season estimates of the lb N supply per bushel produced (lb N/bu) and the lb N/

## Box C

### Soil Sampling—Composite or Management Unit Approach?

Soils in eastern Washington dryland areas are inherently variable and difficult to sample accurately. If a field will be fertilized as one unit, collect cores from several representative locations throughout the field and combine these together for the sample. Don't sample unusual or unrepresentative areas, or sample these areas separately. This composite sampling technique provides a field average measure of soil properties.

An alternative sampling approach is to divide fields into management units based on knowledge of variability in soil properties and yield potential. A typical field in eastern Washington may be divided into 2 to 3 management units based on slope, aspect, and drainage. Sample each management unit separately by collecting cores from several representative locations within the unit. Fertilize each unit separately according to the soil test results and a management unit-based yield potential. This approach is only warranted if growers have the ability to manage units within a field separately.

acre potentially left in the field (lb N/ac left) are also described at the bottom of Block E. These measures of N efficiency can be used to refine future N management practices for the field or a management unit within a field. See "Additional considerations" at the end of this guide for more information.

### Phosphorus (P) recommendations

Phosphorus recommendations are based on soil test values in a surface one-foot sample (Table 1). Note that winter wheat may respond to starter applications of P even if soil test levels are considered adequate. Placement of P is important; subsurface banding below, below and beside, or with the seed are all efficient placement methods to maximize P availability to the plant.

### Potassium (K) recommendations

Soils in the dryland areas of Washington generally contain adequate levels of K. If a soil test report shows less than 75 ppm K in the surface foot based on a sodium acetate extract, or less than 90 ppm K based on a bicarbonate extract, applications of 50 to 100 lb K<sub>2</sub>O/acre may be warranted.

### Sulfur (S) recommendations

The soil test for S is less reliable than for other nutrients. When soil test S in the top two feet of soil is below 8 ppm or 30 lb/acre, trial applications of 10 to 20 lb S/acre are warranted. Higher rates may be needed if a legume will follow the wheat crop. Another tool is to analyze grain for nitrogen:sulfur (N:S) ratio. Ratios above 15:1 indicate a need for S fertilization. For hard red wheat production, a common practice is to apply 1 lb S for each 5 lb N applied, up to 25 lb S/acre.

### Chloride (Cl) and micronutrients

Responses to Cl have been obtained with dryland winter wheat, particularly in annual cropping areas. Chloride reduces the incidence of leaf spot and the severity of certain diseases in wheat. When soil test Cl in the top two feet of soil is below 8 ppm or 30 lb/acre, a response to 10 to 20 lb Cl/acre is possible. Limited research has been done on micronutrient fertilization of dryland wheat in Washington, so specific recommendations are not available at this time.

**Table 1**  
**Phosphorous Fertilizer Recommendations for Dryland Winter Wheat**

Soil Test P (ppm) 0 to 12-inch depth		Application rate lb P <sub>2</sub> O <sub>5</sub> /acre <sup>1</sup>
Acetate method	Bicarbonate (Olsen) method	
0 to 2	0 to 4	40
2 to 4	4 to 8	30
4 to 6	8 to 12	20 <sup>2</sup>
6 to 8	12 to 16	10 <sup>2</sup>
> 8	> 16	0 <sup>2</sup>

<sup>1</sup> These recommendations assume fertilizer is banded below the soil surface. For broadcast or broadcast-incorporated applications multiply Table 1 rates by 2.

<sup>2</sup> Higher rates of P may be applied to build soil test levels for subsequent crops in the rotation. If desired, apply up to 1/2 crop removal rates in the categories indicated. Use the yield potential established earlier and estimates of P removal from Box A. Removal rates must be based on the grain only, unless straw is also removed from the field.

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## Additional considerations

- Soil testing is an important tool to evaluate the effectiveness of a fertility program. Over time, changes in soil test nutrient levels can be used to revise fertilizer application rates. For example, if soil test P levels are declining, increase the rate applied to maintain adequate levels. If levels are increasing over time, reduce application rates once soil test levels are adequate.
- High soil test N levels at the beginning of a crop year indicate the previous crop did not use all of the available N. If soil test N in the profile is above 50 lb/acre, consider whether the yield potential of the previous crop was too high, whether calculations involved an error in the soil N inventory, or if some other factor reduced yield below the season goal. As necessary, adjust the fertilizer program to reduce N in future soil tests.
- Large amounts of N at or below 4 feet in a soil profile are subject to leaching below the plant root zone. This deep N also contributes to undesirably high grain protein in soft white wheat. Modifying N application timing and making split applications are two ways to improve N availability and uptake by plants. If the majority of N in a preplant soil test is at or below 4 feet, consider splitting the timing of N application between fall and spring to promote more efficient use of N.
- The lb N/bushel needed for wheat classes described in Block A2 of the worksheet depends in part on wheat achieving an N uptake efficiency of 50% or higher. If the N uptake efficiency calculated in Block E is below 50%, this could mean N was unavailable to the plant due to leaching or denitrification losses, excessive immobilization by residue, or stranding in dry regions of the soil profile. Nitrogen management practices such as fall-spring split applications and placement below the residue layer can improve N availability and uptake by wheat. Precision N management strategies such as dividing fields into management units and treating each unit separately is another way to improve overall N efficiency.
- The lb N supply/bushel produced as calculated in block E should be compared to the N requirement (lb N/bu) used in Block A2 of the worksheet. If the calculated value is substantially higher than the standard, improvements in N uptake using management practices such as those mentioned above are needed. If the calculated values are substantially lower than the value used in Block A2 and yield and protein goals were met, consider using the calculated value in Block E in place of the standard value in Block A2 for future calculations of the N supply needed to produce wheat in this field. Finally, pounds of residual N/ac as calculated at the bottom of Block E is an estimate of the potential amount of N remaining in the soil after this crop was harvested. A high value may indicate a lower N fertilizer requirement for the next crop, but this should be verified through a soil test.



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# Washington State University Dryland Winter Wheat Nitrogen Needs Worksheet and Application Record\*

<b>Grower:</b>	<b>Rainfall zone:</b>	<b>Assisted by:</b>	
<b>Tract:</b>	<b>Crop class:</b>	<b>Field description:</b>	
<b>Date:</b>	<b>Soil type:</b>	<b>Field size:</b>	acres

<b>A N supply needed by the crop to meet yield and quality goals</b>	(N supply needed)
1. Yield goal	
<input type="checkbox"/> Estimated based on grower practices and experience: _____ bu/ac <input type="checkbox"/> Estimated based on soil moisture + expected rainfall (in inches): (_____ soil moisture + _____ expected rainfall - 4) x _____ bu/inch <sup>1</sup> = _____ bu/ac <small><sup>1</sup>bushel yield per inch available moisture (bu/inch): soft white winter wheat = 7; all other winter wheat = 6</small>	
2. N supply needed _____ bu/acre (line A1 above) x _____ lbs N/bu <sup>2</sup> = _____ lb N/ac →→ <small><sup>2</sup> lbs of N per bushel yield: soft white winter and club = 2.7 +/- 0.2; hard red and hard white winter = 3.0 +/- 0.2</small>	
<b>B Soil N inventory</b>	
1. Current soil test N (nitrate + ammonium) (see text) + _____ lb/acre	(Soil N) =
2. Credit from previous legume crop (see text) + _____ lb/acre	
3. Credit from organic matter release (see text) + _____ lb/acre	
4. Debit for residue decomposition (see text) - _____ lb/acre	
5. Other credit (source: _____) + _____ lb/acre	
6. Total soil N inventory (lines 1 through 5) = _____ lb/acre →→	
<b>C N to apply (fertilizer recommendation)</b>	
1. Line A2 _____ - line B6 _____ = _____ lb N/acre →→	(lb N/acre to apply)

<b>D N application, yield, and protein record</b>	<b>E Post-harvest N efficiency calculation</b>																												
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Date</th> <th>Form</th> <th>Method</th> <th>Rate (lb N/ac)</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td><td> </td></tr> <tr> <td colspan="3">Total N applied (lb/acre):</td> <td> </td> </tr> <tr> <td>Yield: _____ bu/acre</td> <td colspan="3">Protein: _____ %</td> </tr> <tr> <td colspan="4">Notes:</td> </tr> </tbody> </table>	Date	Form	Method	Rate (lb N/ac)													Total N applied (lb/acre):				Yield: _____ bu/acre	Protein: _____ %			Notes:				$\frac{\text{yield, bu/ac} \times \text{\% protein}}{\text{factor}^1} = \text{N uptake lb/ac}$ $\frac{\text{Total N applied (left)} + \text{Soil N inventory (line B6)}}{\text{N supply}} = \text{N supply lb/ac}$ $(\text{N uptake} \div \text{N supply}) \times 100 = \text{\% N uptake efficiency}$ <small><sup>1</sup>Factor to convert yield from bu to lbs, % grain protein to %N, and grain N to whole-plant N. Use 0.15 for soft white and club; use 0.13 for hard red and hard white.</small> $\frac{\text{lb/ac N supply}}{\text{yield, bu/ac}} = \text{lb N/bu}$ $\text{N supply} - \text{N uptake} = \text{lb N/ac}$
Date	Form	Method	Rate (lb N/ac)																										
Total N applied (lb/acre):																													
Yield: _____ bu/acre	Protein: _____ %																												
Notes:																													

\* Attach this form to the current soil test report and archive as part of the field record.