

## Southern Idaho Fertilizer Guide

# Irrigated Winter Wheat

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The following fertilizer guidelines are based on University of Idaho research that relates the yield response of irrigated winter wheat to soil test concentrations and fertilizer application rates. The suggested fertilizer rates are designed to produce above average yields if other production factors are not limiting.

The suggested fertilizer rates also assume that soil samples are properly taken and processed, and that they represent the area to be fertilized. Many fields have appreciable variation in residual nutrients or productivity. Areas within fields that differ significantly in residual fertility or productivity should be sampled and treated separately if the areas are large enough that fertilizer application rates can be conveniently adjusted and if the treatment would be cost effective.

Precision ag technology and variable rate applicators provide options for differentially fertilizing these areas as never before. For information on mapping soil variability and variable application technology, contact an extension soil fertility specialist, your local county extension educator, or a fertilizer dealer/consultant.

Representative soil samples are essential. Each soil sample submitted to a soil test laboratory should consist of a composite of at least 20 individual cores from within the area of interest. Collect separate samples from the 0- to 12-inch and 12- to 24-inch depths. Skip areas that do not represent the majority of the field such as gravelly areas, saline or sodic areas, wet spots, and turn rows.

Do not store moist samples under warm conditions because microbial activity can change the extractable nitrogen in the sample. Send samples to the laboratory as quickly as possible if the samples are not air-dried.

## Nitrogen

Adequate nitrogen (N) is necessary for maximum economic production of irrigated winter wheat. The amount of N required depends on many factors that influence irrigated winter wheat production and quality. Estimated yield and available N from all sources (soil test, previous crop, and mineralizable N) should be considered when determining N fertilizer rates.

### **Total N Requirements Based on Estimated Yield**

Fertilizer N rates should correspond to the yield growers can reasonably expect for their soil conditions and management. Historical yields for a specific field or area provide a fair approximation of yield potential, given the grower's traditional crop management. Projected changes in crop management (water management, variety, lodging control, disease, and weed control) designed to appreciably increase production may require adjustment of estimated yield.

Research in western Idaho has shown that the available N from all sources required to produce a bushel (60 lb) of irrigated winter wheat depends on such factors as weed, insect, and disease control as well as irrigation, planting date, and soil type. Results of field trials suggest that two pounds of available N per bushel (bu) are required for irrigated winter wheat yielding up to 120 bu per acre. Nitrogen requirements are less than two pounds per bushel for yields above 120 bu per acre. The total N required for a range of expected yields is given in Table 1.

### **Available Nitrogen**

Available N in the soil includes inorganic N as nitrate ( $\text{NO}_3\text{-N}$ ) and ammonium ( $\text{NH}_4\text{-N}$ ), mineraliz-



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**Table 1. Total available N requirement of irrigated winter wheat based on expected yield**

Expected yield (bu/acre) <sup>1</sup>	80	100	120	140	160	180
Total N (lb/acre)	160	200	240	270	300	330

<sup>1</sup>Based on historical average yield.

able N (N released from organic matter during the growing season), N credits from previous cropping or manures, and N in the irrigation water. Each component of available N must be estimated for accurate determination of optimum fertilizer N rates.

### Inorganic Nitrogen

Residual soil inorganic N (NO<sub>3</sub>, NH<sub>4</sub>) can be evaluated most effectively with a soil test. Soil samples should be collected in one-foot increments to a depth of two feet, unless roots are restricted by dense soil layers or high water tables.

Ammonium N (NH<sub>4</sub>-N) is generally low in preplant soil samples and thus contributes little to available N. However, it can be as high or higher than NO<sub>3</sub>-N. NH<sub>4</sub>-N should be determined along with NO<sub>3</sub>-N, especially when there is reason to expect the presence of appreciable NH<sub>4</sub>-N, such as recent ammonium N fertilizer applications.

To convert soil test NO<sub>3</sub>-N and NH<sub>4</sub>-N concentrations to pounds N per acre, sum the N expressed in ppm for each foot increment of sampling depth and multiply by four. An example is shown in Table 2.

Often, a preplant soil sample is only collected from the first foot of soil. Although this information is not as complete and reliable as would be provided by deeper sampling, residual N measurements from the first foot of soil can be combined with estimates of residual N in the second foot to predict N requirements for irrigated winter wheat.

For fall-planted winter cereals in western Idaho, preplant soil test NO<sub>3</sub>-N in the second foot of the soil is commonly only one-half to two-thirds of that in

**Table 2. Example conversion of inorganic N in ppm to lb per acre**

Soil depth (inches)	Soil Test Results			Multiplier	Total inorganic N (lb/acre)
	NO <sub>3</sub> -N (ppm)	NH <sub>4</sub> -N (ppm)	Total (ppm)		
0 to 12	13	2	15	x4	= 60
12 to 24	6	2	8	x4	= 32
Total	19	4	23	x4	= 92

the first foot of soil. If the residual N value is only available from the first foot of soil, estimate the NO<sub>3</sub>-N in the second foot at 50 to 67 percent of the first value and sum over the two values. However, this estimate may not be accurate after potatoes or other sprinkler-irrigated crops, especially in coarser textured soils or when irrigation has been excessive. Basing N rate recommendations on estimates of residual N in the second foot increases the risk of recommending either too little or too much N. Sampling to a depth of two feet is preferable because wheat will use N from the second foot.

Soil test N can be measured from samples collected in early fall (preplant), late fall, or early spring. The soil test for inorganic N reflects inorganic N only at the time the sample is collected. For example, the early fall test can't possibly account for the subsequent leaching, mineralization, immobilization, or denitrification of N that occurs between the time of fall sampling and the time N is applied in late winter or spring.

In contrast, spring sampling will reflect the net effect of all these processes, as well as the N taken up by the young wheat plant. Soil test N is typically lower in the spring than in the early fall before planting. Research indicates that spring soil test N can provide an accurate estimate of the N required. However, since some N has already been incorporated into the plant by the time spring samples are collected and spring applied N is generally more effective than preplant applied N, the total N required on a per bushel basis should be reduced by about 0.25 lb N/bu.

### Mineralizable Nitrogen

Soils vary in their capacity to release N from organic matter during the growing season. The amount of N released depends on such factors as soil type, soil moisture, soil temperature, previous crop, and the N fertilization history for the field.

Measurements of mineralizable N for winter cereals typically range from 30 to 60 lb per acre. Unless the capacity of a specific soil to release N is known, use a midpoint mineralizable N value of 45 lb N per acre for irrigated winter wheat. Manured soils can be expected to have N mineralization rates that are over twice as high as non-manured soils, depending on the rates, types of manure, and time since the last application.

While soil organic matter content is frequently used to estimate annual mineralizable N contributions, UI research shows it does not accurately

predict N mineralization in southern Idaho irrigated soils.

### Nitrogen from Previous Crop Residues

Nitrogen associated with decomposition of the previous crop residues should also be considered when estimating available N. Residues that require additional N for decomposition include cereal straw and mature corn stalks. Research shows that 15 pounds of additional N are needed per ton of straw returned to the soil, up to a maximum of 50 pounds. For more information on compensating for cereal residues, refer to CIS 825, *Wheat Straw Management and Nitrogen Fertilizer Requirements*.

Row crop residues (potatoes, sugarbeets, onions) generally do not require additional N for decomposition. Consequently, these residues have little effect on the N recommendations for winter wheat.

Legume residues from beans, peas, and alfalfa can release variable amounts of N during the following crop season that may not be reflected by preplant soil test N. Bean and pea residues decompose more rapidly than alfalfa residues. Spring soil test N should more accurately reflect the N contributed by beans and peas incorporated in early fall, and, to a lesser extent, alfalfa (due to woody crowns). Table 3 estimates the net N contribution from the previous crop.

**Table 3. Estimated nitrogen credit based on previous crop**

Previous crop	Nitrogen credit (lb N per acre)
Grain or corn (mature residue returned)	-50
Grain or corn (residue removed)	0
Sweet corn residue returned	0
Row crops (potatoes, onions, sugarbeets)	0
Beans and peas	40
Alfalfa plowed in early fall	60
Alfalfa plowed in late fall	40

### Nitrogen from Manures and Other Sources

Occasionally, animal manures or lagoon wastes are used on soils in which winter wheat is grown. Nutrient contributions from these sources should also be taken into consideration when estimating available N for the next season. Manures can preclude the need for any fertilizer, depending on the rate applied and their nutrient composition.

Nutrient contents of manures can vary appreciably by animal, by how it is processed, and by the kind and amount of bedding material. Manure should be analyzed for its nutrient content to obtain the most accurate estimate of fertilizer equivalent values. For more detailed information on animal manures and their nutrient contributions to soils, refer to PNW Bulletin 239, *How to Calculate Manure Application Rates in the Pacific Northwest*.

Irrigation waters other than lagoon effluents can also contain appreciable N. While most well and surface waters used for irrigation have low N concentrations, irrigation waters that receive appreciable return flows from other districts are likely to be higher in N. To convert the N content of each acre foot of irrigation water applied to the lb N per acre fertilizer equivalent, multiply the ppm, or milligrams per liter (mg/L) of the nitrogen concentration by 2.7.

### Calculation of N Application Rates

To calculate the fertilizer N application rate, several components of the N balance must be estimated: (1) total N needed to produce a given yield, (2) inorganic N ( $\text{NO}_3 + \text{NH}_4$ ) as measured by the soil test, (3) mineralized N, (4) previous crop/residue management influence, and (5) other N sources (i.e., manure N, irrigation N).

A sample calculation is provided in Table 4. This example assumes an expected yield of 140 bu per acre, 45 lb of N per acre mineralized from soil organic matter, soil test inorganic N measuring 92 lb per acre, a previous crop of corn taken as silage, and no manures or other significant available N sources applied.

**Table 4. Sample N requirement calculation**

Available N component	lb N/acre
Total N required (Table 1)	270
Minus inorganic N (Table 2)	-92
Minus mineralizable N	-45
Previous crop factor (Table 3)	0
Manures or other sources	0
Fertilizer N required (sum above)	133

### Timing of Nitrogen Application

Excessive irrigation or heavy winter precipitation can leach  $\text{NO}_3\text{-N}$  beyond root systems. This hazard exists on all soils but particularly on coarse-textured soils such as sands and sandy loams. Spring applied N has always been preferable on soils prone to leaching.

Fall preplant N was once thought to be as good or better than spring topdressed N in calcareous silt loam or clay soils in areas of low rainfall. However, even under these conditions, southern Idaho research shows that N applied as a topdress in late winter or early spring is frequently used more effectively than early fall preplant applied N. Seldom was preplant applied N more effective than spring topdressed N.

Nitrogen fertilizers containing ammonium (ammonium sulfate, anhydrous or aqua ammonia, or urea) are less subject to leaching losses when lower soil temperatures (less than 40°F) inhibit the microbial conversion of ammonium to nitrate. Lower temperatures also reduce the microbial activity responsible for the immobilization of applied N. Late fall, split, or spring applied N is also recommended when residues from previous grain or mature corn crops are returned to the soil in early fall.

### **Nitrogen Impact on Lodging**

Irrigated winter wheat varieties typically have good straw strength. However, lodging can be appreciable in turn-around areas or other areas with excessive N. Lodging can reduce both grain yield and quality as well as increase harvest costs and dockage discounts.

Varieties differ in straw strength, plant height, and susceptibility to lodging. For descriptions of varieties and their susceptibility to lodging, refer to *2001 Certified Seed Selection Guide for Some Varieties of Winter Wheat and Winter Barley*, Progress Report 311.

Ethephon (Cerone®) is a growth regulator commonly used to shorten small grains and to stiffen straw. It can significantly reduce the incidence and severity of lodging in winter wheat.

### **Managing N for High Protein Hard Winter Wheat**

The hard wheat market occasionally pays a premium for high protein. Hard winter wheat varieties differ in their ability to produce high protein grain. The most critical factor for producing high protein irrigated wheat is the amount and timing of N fertilization.

To produce high protein wheat, first determine the total fertilizer N required to maximize yield (see Tables 1-4). High protein generally is not realized unless available N exceeds that required for maximum yield.

Timing is critical. Early fall preplant applied N results in lower protein than N applied in late winter or spring. The total N required for the yield estimate

should be applied during vegetative growth (tillering) or before jointing. Additional N applied between boot and flowering stages may be necessary to increase protein to acceptable levels.

The optimum N rate for increasing protein content to 13 percent may vary, depending on the final yield and variety. The optimal delayed N rate is increased by higher yields and reduced by lower yields.

Flag leaf N testing may be useful for determining the need for later applied N. Research indicates there is little protein increase from subsequent applied N when flag leaf total N concentration at heading is 4.2 to 4.3 percent. The required N rate increases as flag leaf N concentrations decrease below 4.2 percent.

If flag leaf N at heading is above 3.8 percent, no more than 40 lb N per acre should be needed to increase protein to 13 percent. If flag leaf N is below 3.8 percent, higher N rates may be needed.

### **Phosphorus**

Phosphorus (P) deficient winter wheat plants appear stunted but may not otherwise exhibit obvious symptoms. Winter wheat grown in rotation with crops that are fertilized with P such as potatoes, onions, or sugarbeets will often not need additional fertilizer P.

Minimum soil levels of P are necessary for maximum production. Adequate P is sometimes necessary for improved winter hardiness or earlier maturity.

Soil tests can indicate whether soils require P fertilization for maximum winter wheat production. Soil samples are collected before planting from the first foot of soil. Free lime content of the soil interacts with fertilizer P to reduce its effectiveness. Fertilizer P rates should be increased as soil free lime content increases. Table 5 gives phosphorus fertilizer rates based on the soil test P concentration and soil lime content.

**Table 5. Phosphorus application rates based on soil test P and free lime content**

Soil test P <sup>1</sup> (0 to 12 inch)	Free lime content <sup>2</sup> (%)			
	0	5	10	15
(ppm P)	----- (lb/acre P <sub>2</sub> O <sub>5</sub> ) -----			
0	240	280	320	360
5	160	200	240	280
10	80	120	160	200
15	0	40	80	120
20	0	0	0	40

<sup>1</sup>NaHCO<sub>3</sub> extraction

<sup>2</sup>Free lime is determined as calcium carbonate equivalent.

Effective methods of application include broadcasting at plowdown, broadcasting and incorporating during seedbed preparation, or drill banding low rates of P with the seed. Drill banding may reduce the amount of fertilizer required. Drill banding high rates of P with the seed, especially ammonium phosphate fertilizers, can cause seedling damage. For a more detailed discussion of banding, refer to PNW 283, *Fertilizer Band Location for Cereal Root Access*.

## Potassium

Winter wheat has a lower requirement for potassium (K) than sugarbeets, corn, or potatoes. Potassium deficiency in southern Idaho winter wheat is relatively rare, compared to N and P deficiency. Application of K should not be necessary if winter wheat is rotated with other annual crops that receive fertilizer K.

Soil test K is a reasonable indication of available K in southern Idaho soils (Table 6). Incorporate K during seedbed preparation. Consider alternating the use of K fertilizers (potassium sulfate and potassium chloride) depending on the availability of S or Cl in the soil.

**Table 6. Potassium rates based on soil test K**

Soil test K (0 to 12 inches)	Application rate
(ppm)	(lb/acre K <sub>2</sub> O)
0	240
25	160
50	80
75	0

## Sulfur

Sulfur (S) requirements for winter wheat will vary by soil texture, leaching losses, S content of the irrigation water, and the S soil test. Plant available S (sulfate) is mobile so soil samples should be collected to a depth of two feet.

If preplant soil test S for the first two feet is low (a total of less than 10 ppm or 30 lb/acre), 20 to 40 pounds of S per acre should be applied.

In many areas, the S content of the irrigation water is high enough to satisfy the S requirements of winter wheat. Winter wheat irrigated with Snake River water or waters consisting of significant runoff from other fields should not experience S shortages.

Plant analysis can be useful in confirming a sulfur deficiency. Ratios of total N to total S above 17:1 in whole plants indicate a shortage of S.

## Chloride

Winter wheat yield can be limited by a shortage of chloride (Cl). A Cl shortage is associated with increased incidence and severity of root diseases such as take-all and more pronounced physiologic leaf spot.

Available Cl can be measured with a soil test. Since Cl is mobile, soils should be sampled to a depth of two feet. The conversion of soil test Cl concentrations to lb Cl per acre is the same as for nitrate N in Table 2. If soil test Cl is below 30 lb per acre in the first two feet, additional Cl should be considered. Rates of 30 to 40 lb per acre are all that are generally needed to restore productivity.

The most common Cl fertilizer is potassium chloride (0-0-52). The material should either be broadcast and incorporated before planting or topdressed in early spring. It should not be banded with the seed because of its high salt index.

## Micronutrients (Fe, Mn, Zn, Cu, B)

Winter wheat growth response to micronutrients has generally not been observed in irrigated southern Idaho soils. Even in severely scraped or eroded soils, other nutrients tend to be more limiting to yield than micronutrients. Applications of micronutrients are generally not recommended unless need is indicated by a reliable soil or plant tissue test.

## ***For Further Reading***

You may order this and other publications about fertilizers and crops in southern Idaho from the University of Idaho Cooperative Extension offices in your county or Ag Publications, P.O. Box 442240, University of Idaho, Moscow, ID 83844-2240, phone (208) 885-7982, fax (208) 885-7982, email [cking@uidaho.edu](mailto:cking@uidaho.edu), or <http://info.ag.uidaho.edu> on the internet.

CIS 825 *Wheat Straw Management and Nitrogen Fertilizer Requirements*, \$1.00

CIS 828 *Southern Idaho Fertilizer Guide: Irrigated Spring Wheat*, \$0.35

CIS 1082 *Southern Idaho Fertilizer Guide: Irrigated Winter Barley*, \$1.50

PNW 239 *How to Calculate Manure Application Rates in the Pacific Northwest*, \$0.25

PNW 283 *No-Till and Minimum Tillage Farming: Fertilizer Band Location for Cereal Root Access*, \$0.50

PR 311 *2001 Certified Seed Selection Guide for Some Varieties of Winter Wheat and Winter Barley*, free



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