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# Irrigated Soft White Wheat

*(Eastern Oregon)*

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Soft white wheat is grown in a variety of rotations and landscape positions throughout eastern Oregon. Recommendations in this fertilizer guide apply to spring or winter varieties of soft white wheat grown with irrigation in Baker, Crook, Deschutes, Jefferson, Malheur, Umatilla, Morrow, Wallowa, and Union counties on silt loam, sandy loam, loamy sand, and sand soil textural classes with less than 3 percent organic matter.

The most yield-limiting nutrient for wheat is nitrogen. Recommendations for nitrogen (N), phosphorus (P), potassium (K), sulfur (S), and micronutrients are included in this guide. Amendments for salt-affected, acidic, and alkaline soils are also discussed.

The production area covered by this guide is geographically large and diverse. Soil type, soil depth, crop rotation, management, and climate differ widely across this area. This publication provides information and recommendations suitable for the soil and climatic conditions across the region. Use these recommendations as a guide, rather than a prescription. Take into account your own experience with your fields when making nutrient management decisions.

Recommendations for Washington and Idaho differ from those in this guide. For example, the N recommendations in the *Southern Idaho Fertilizer Guide for Irrigated Winter Wheat* are lower than those in this guide. In some areas of eastern Oregon, conditions are similar to those in Washington or Idaho. If you know from experience that this is the case for your field or farm, use the recommendations for the appropriate area. Use the N rate recommendations from the Idaho guide if your experience and grain protein level show that the lower rates are sufficient for your situation.

Pest-free plants with adequate root systems are required to obtain the greatest return from your fertilizer investment. The nutrient recommendations in this guide assume that weeds, insects, and diseases are controlled. Lack of pest control cannot be overcome by the addition of nutrients.

This guide is organized chronologically for a cropping season. Common fertilizer forms of nitrogen, phosphorus, potassium, and sulfur are 100 percent plant-available at the time of application. For this reason, most nutrients are best applied shortly before they will be needed.

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## Management decisions before planting

### Variety selection

Nutrient recommendations in this guide assume that an appropriate variety is selected for the site. Wheat varieties are available that have agronomic and quality characteristics needed to optimize production for your location. In eastern Oregon irrigated production, growers should consider varieties with high yield potential, suitable milling quality, good disease resistance, and lodging resistance. Information on the performance, agronomic, and quality characteristics of winter and spring wheat varieties in Oregon can be found at http://cropandsoil.oregonstate.edu/wheat/state_performance_data.htm

### Planting date

Winter wheat is typically planted from late September to November. Planting is delayed until this time to reduce the level of aphid infestation and the risk of barley yellow dwarf virus, which is transmitted by aphids. When planting earlier, an insecticidal seed treatment is recommended to reduce the risk of aphid-borne diseases. Wheat planted in November will have reduced fall growth. Late planting can reduce winter kill in some varieties. For late plantings, increase the seeding rate and consider applying a "starter" fertilizer with or near the seed (see pages 4–7).

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In this region, spring wheat is typically planted from February to May. Where barley yellow dwarf virus and Hessian fly are common, consider the use of an insecticidal seed treatment when sowing spring wheat.

Planting outside these recommended times can add stress to wheat plants, thus reducing efficiency of nutrient use.

## Rotation

Wheat is grown in rotation with many crops, including processing vegetables, peppermint, grass seed, legumes, corn, potatoes, and onions. Fertilizer application and nutrient use vary greatly among crops, creating a range of soil nutrient availability. Wheat is well suited for situations where nutrients from a previous crop remain in the soil. With its deep, fibrous root system, wheat efficiently extracts nutrients, especially N. When wheat is planted after potatoes, onions, and many other vegetable crops, sufficient nutrients are usually available for early wheat growth, so a preplant fertilizer application is not needed.

# Fall soil sampling and pH adjustment

## Sampling soil

Sample soil in the fall regardless of whether wheat will be planted in fall or spring. For fall-planted wheat, take samples after tillage is complete.

Sample and analyze soil from a 1-foot depth to estimate lime, phosphorus, and potassium requirements. A single sample should represent no more than 40 acres, a single soil type, or an area in the field with the same management practices. Be careful when comparing soil test results from spring and fall samples, as soil pH can vary more than 1 to 2 units annually, especially in sandy soil.

If you have questions about sampling or testing soil, contact your local Oregon State University Extension office or refer to OSU Extension Service publication PNW 570, *Monitoring Soil Nutrients Using a Management Unit Approach,* http://extension.oregonstate.edu/catalog/pdf/pnw/pnw570-e.pdf

## Summary

***Preplant management***

| | |
|---|---|
| Lime | A soil pH greater than 5.5 is recommended. If the soil pH is below 5.4, apply 1 ton of 100-score lime/a if the field's soil textural class is sandy loam, fine sandy loam, or loamy sand. For fields that are a silt loam soil textural class, increase the lime rate to 1.5 to 2 t/a. See page 3. |
| Nitrogen (N) | If winter wheat will be planted after a crop leaving limited N in the soil, or if wheat is planted later than recommended in the fall, apply 20 to 30 lb N/a. Otherwise, no N is needed at planting. See page 4. When planting spring wheat, up to 25 lb N/a can be banded at planting. |
| Phosphorus (P) | If soil test P is below 20 ppm, apply P according to Table 2. See page 5. |
| Potassium (K) | If soil test K is below 100 ppm, apply K according to Table 6. See page 7. |
| Sulfur (S) | Apply 10 to 30 lb S/a if (1) wheat is seeded late in the fall, (2) a greater-than-average quantity of straw is present in the field, and/or (3) the concentration of S in irrigation water is less than 5 ppm. See page 7. |
| Zinc (Zn) | Application of Zn may be beneficial when DTPA-extractable soil test Zn is less than 0.8 ppm. Apply Zn at a rate of 1 to 5 lb/a. If applying 1 to 2 lb Zn/a, apply in a band. Broadcast application is recommended when higher rates are used. See page 7. |
| Boron (B) | Apply 0.5 to 2 lb B/a when soil test B is below 0.4 ppm. See page 7. |

***Spring nutrient management***

| | |
|---|---|
| Nitrogen (N) | **Winter wheat**: After winter dormancy, sample soil for N analysis. Collect samples from the effective root zone (usually 2 or 3 feet) in 1-foot increments and have them analyzed for nitrate-N ($NO_3$-N). In addition, have samples from the top foot analyzed for ammonium-N ($NH_4$-N). Use Tables 7 and 9 to calculate spring N rate. See pages 9–10. |
| | **Spring wheat**: Before planting, sample soil and have it analyzed for nitrate-N and ammonium-N as described above for winter wheat. Use Table 9 to calculate N rate. See pages 9–10. |

***Postharvest management***

| | |
|---|---|
| Grain protein | Target for grain protein is 8 to 10.5 percent. See page 10 for explanation. |

## Soil pH adjustment

Soil pH indicates the chemical conditions of the soil that roots will experience. A decrease in soil pH is accompanied by increased solubility of iron, zinc, manganese, copper, and aluminum. In acidic soil, the concentration of manganese and aluminum can increase to levels that inhibit root growth.

Acidic soils are prevalent throughout eastern Oregon. The combination of high-quality irrigation water and N fertilizer use has lowered the pH of many soils. Sandy soils are acidified faster than silt loam or finer soil textural classes. Even so, silt loam soils in eastern Oregon can have a soil pH too low for optimal wheat production.

A soil pH above 5.4 is recommended for wheat production. Wheat yields are markedly reduced when soil pH is less than 5.0, as shown in Figure 1. Between pH 5.0 and 5.4, yield varies with variety, field, and year. Figure 1 shows that wheat yield will not be increased by raising the soil pH above 5.7.

The soil pH for some sandy soils may need to be higher than 5.3 at planting because soil pH changes seasonally. In some cases, pH may be adequate in the fall but drop below 5.4 by spring. For example, soil pH can decrease 2 units between January and March. This change in soil pH makes sampling time critical. Sample soil for pH in the fall to determine the need for lime.

### *Increasing soil pH*

Lime application is recommended to raise soil pH when pH is below 5.4. Apply 1 ton of 100-score lime/a when the field has a sandy loam, fine sandy loam, or loamy sand soil textural class. Increase the lime rate to 1.5 to 2 t/a for fields that are a silt loam soil textural class. Incorporating lime in the fall is best for both winter and spring wheat, as lime reacts slowly to raise soil pH.

### *Decreasing soil pH*

Wheat yield can be reduced if the soil pH is above 8.7. A soil pH above 8.5 may be caused by excess sodium in soil. For information about management of alkaline soil, see the sidebar "Decreasing soil pH (alkaline soils)." For information about salt-affected soils, see the sidebar titled "Salt-affected soils" (page 4).

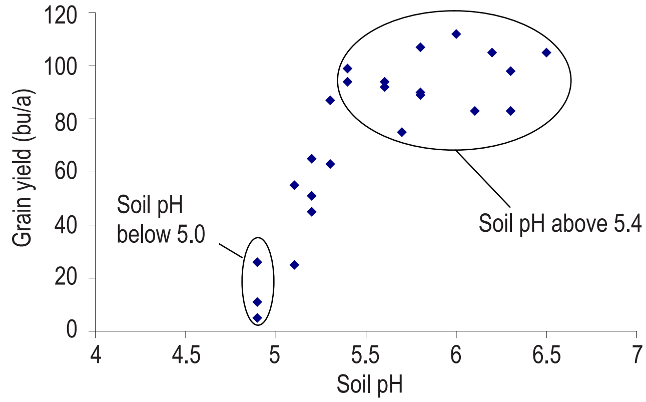


Figure 1.—Grain yield of Nugaines wheat as related to soil pH on an acidic western Oregon field.

## Soil textural class, lime rate, and lime score

Lime application rates are based on soil textural class and lime score. Where soil organic matter content is low, as in eastern Oregon, soil textural class is a good indication of soil pH buffering capacity (resistance to pH change).

Lime score is a relative indication of a product's ability to increase soil pH. Lime rates are based on a lime score of 100, or pure lime (calcium carbonate). The lime application rate is increased as lime score decreases. For example, sugar by-product lime (sugar lime) commonly has a score of 50.

For any lime product, determine the rate needed to achieve the recommended lime rate by dividing the recommended rate (t/a) by the decimal fraction score. For a 1 t/a lime application and a score of 50, the calculation would be: $1 \div 0.5 = 2$. Therefore, if the lime recommendation is 2 t/a of 100-score lime, and you use sugar lime (a score of 50), you will need to apply 4 t sugar lime/a ($2 \div 0.5 = 4$).

## Decreasing soil pH (alkaline soils)

Alkaline soils (high pH) are the product of landscape position, climate, and the chemical characteristics of the soil. High soil pH may also be caused by poor-quality irrigation water. Wheat yield may be reduced when soil pH is greater than 8.7. Micronutrient deficiencies are common in highly alkaline soils. Water penetration can also be a problem in these soils and should be addressed when making crop management decisions.

Soil pH can be reduced by applying high rates (1 or more t/a) of elemental S, but doing so is rarely economical. The use of acid-producing fertilizer products, such as ammonium sulfate or mono-ammonium phosphate, may reduce the detrimental effects of high soil pH. In addition, banding fertilizer will increase the solubility of micronutrients in the seed zone.

For more information about soil pH management and water penetration in alkaline soils, see OSU Extension Service publication PNW 601-E, *Salt-affected Soils for Crop Production*.

## Salt-affected soils

Salt-affected soils can result from a variety of factors—climate, landscape position, poor drainage, poor-quality irrigation water, and/or poor water management. Accumulation of salt in irrigated soils can reduce crop growth and yield, reduce the effectiveness of irrigation, ruin soil structure, and affect other soil properties. The extent to which salts affect soil is determined by measuring electrical conductivity (EC) of both soil and irrigation water. Estimated yield reduction from salt in soil or irrigation water is summarized in Table 1.

Table 1.—Yield reductions for wheat associated with a range of electrical conductivity (EC) values for soil and water of the saturated paste extract.[a,b]

| Electrical conductivity (saturated paste) (mmhos/cm or dS/m) | | Yield reduction (%) |
|---|---|---|
| **Soluble salts in soil** | **Water** | |
| Below 6 | Below 4 | Below 10 |
| 6.0–7.5 | 4–5 | 10 |
| 7.5–9.5 | 4.5–6.5 | 25 |
| 9.5–13 | 6.5–8.5 | 50 |
| 13–20 | 8.5–13 | 50–100 |
| Over 20 | Over 13 | 100 |

[a]Source: Ayers and Westcot. *Water Quality for Agriculture*.

[b]Not all laboratories in the Northwest determine soluble salts from saturated paste. Some laboratories use 2:1 or 1:1 water-to-soil, which does not provide a value that can be related to soluble salts from a saturated paste.

Wheat plants are most susceptible to injury at early growth stages (germination and emergence). Seedling injury from salts increases when N and K fertilizers are placed with or near the seed. Drought stress substantially increases salt damage to wheat plants.

Salt-affected soil problems are not easily corrected. Information about management and reclamation of salt-affected soil is available in OSU Extension Service publication PNW 601-E, *Salt-affected Soils for Crop Production*.

# Preplant nutrient management

## Nitrogen (N)

Wheat requires only a small amount of N from planting through tillering (Feekes 5), as plants accumulate only 20 to 40 lb N/a during this period. However, insufficient N during early growth limits tiller development and ultimately reduces grain yield. See the sidebar "N application methods" for information about how to apply N.

### *Winter wheat*

For most crop rotations—especially if wheat follows potatoes, onions, or alfalfa—analysis of soil for N content is not necessary before planting. In most cases, residue from the previous crop will provide sufficient N for early wheat growth. Therefore, N application at planting is important only when wheat is planted following crops that leave little residual N (for example, corn, wheat, or oats), or when wheat is planted later than recommended.

When wheat is planted in situations where low residual N is possible, collect soil from the surface foot before planting to assess N need. When soil test results for nitrate-N in the top foot are below 20 lb nitrate-N/a following these crops, apply 20 to 30 lb N/a at planting.

Banding N with the seed is an efficient method of applying small amounts of N. If N is not banded, rates as high as 50 lb N/a may be warranted under high-residue situations (e.g., corn or wheat). Do not band more than 25 lb N/a with the seed. Higher amounts can be banded if placed at least 1.5 inches from the seed.

Most of the N needed for growth of winter wheat will be applied in the spring before jointing (Feekes 6). See "Spring nitrogen management," pages 8–9, for information about timing, rates, and application methods.

### *Spring wheat*

For spring wheat, see "Spring nitrogen management," pages 8–9, for information about N timing and rates.

## N application methods

Nitrogen fertilizer can be applied as a band at planting, preplant incorporated, or by fertigation. Banding fertilizer near or with the seed is an efficient method for delivering a small amount of fertilizer. The N may be applied in conjunction with other nutrients such as potassium, phosphorus, and sulfur as a "starter" fertilizer. Note, however, that placing fertilizer *with* the seed will delay emergence, sometimes by almost a week, and in dry years can reduce the stand. Do not apply more than 25 lb N/a with the seed.

## Phosphorus (P)

Phosphorus fertilizer recommendations in this publication are based on the sodium bicarbonate P test and do not apply to other test methods. This test is recommended throughout the western U.S. for alkaline soils and for soils that have recently become acidic. Test P only in the surface foot of soil. The test cannot be used to calculate the pounds of plant-available $P_2O_5$/a.

Use Table 2 to determine the recommended P fertilizer rate. A grain yield increase from P fertilizer application is likely when soil test P is below 10 ppm. In fields with soil test P values of 11 to 20 ppm, yield may or may not increase from P fertilizer application. In these instances, yield increases from P fertilization seem to be associated with late seeding dates or root diseases that limit plant growth and development. On-farm experiments are the best predictor of yield response to P fertilizer in this range of P soil test values. When soil test P values are greater than 20 ppm, P fertilizer application is not recommended.

When P is recommended, apply P in a band near or with the seed at planting. When a band application is not feasible, increase the P rate by at least 50 percent. High pH and fine-textured soils may require more P.

Table 2.—Fertilizer banded phosphorus (P) rate recommendations using the sodium bicarbonate soil test.

| Soil test P[a] (ppm) | Apply this amount of $P_2O_5$[b] (lb/a) |
|---|---|
| 0–5 | 60–100 |
| 6–10 | 40–60 |
| 11–15 | 20–40 |
| 16–20 | 0–20 |
| Over 20 | None |

[a]Sodium bicarbonate soil test method.

[b]If your farm or field has demonstrated need for higher P rates, use the P recommendations from the *Southern Idaho Fertilizer Guide for Irrigated Winter Wheat*.

## Fertilizer additives

Standard N and P fertilizer materials are marketed with coatings to reduce volatile loss of ammonia (urease inhibitors), to stop or slow conversion of ammonium-N to nitrate-N (nitrification inhibitors), to increase availability of P, and to protect fertilizer from leaching loss (polymer coatings). Fertilizer additives have been marketed for more than 100 years, and nitrification inhibitors have been common for 50 years. All of these materials add to fertilizer cost.

In most situations, management can accomplish the same result without purchasing the additive. The question you need to answer is, “Is management more difficult or costly than purchasing a fertilizer additive?” Another approach is to determine whether the reduction in nutrient loss achieved by an additive will allow you to reduce fertilizer application rates sufficiently to pay for the additive.

When considering whether to purchase a fertilizer additive, first identify the problem the additive might solve, and then consider whether you can meet the same goal with a slight management change. For example, when urea fertilizer is applied to the soil surface and not incorporated, N may be lost through volatilization. Additives such as Agrotain®, a urease enzyme inhibitor, can minimize ammonia loss. When urea remains on the soil surface for more than 24 to 48 hours, use of a urease inhibitor may pay for itself in reduced fertilizer cost (i.e., application rates can be reduced). On the other hand, incorporation of the fertilizer can eliminate the need for the additive.

Another type of additive, a nitrification inhibitor, slows the conversion of ammonium-N to nitrate-N and reduces the possibility of N loss by leaching. Research to assess the benefit of nitrification inhibitors was conducted in soft white winter wheat fields near Hermiston in 2008. Urea was applied at varying rates in a single application with and without a nitrification inhibitor, and as a split application without the nitrification inhibitor. Wheat yields ranged from 105 to 125 bu/a. Among the treatments producing wheat yields of 116 to 125 bu/a, no statistically significant difference was found for application timing or use of an inhibitor (Table 3). The most economical option that produced a yield within this range was a spring application of 200 lb urea/a in split applications (no inhibitor). This experiment shows that when the timing of urea application matches the timing of wheat N use, a nitrification inhibitor is not beneficial or needed.

Additional experiments with wheat and other crops have given similar results. Use of nitrification inhibitors or other fertilizer-enhancing material without consideration of your specific situation can result in additional expense without benefit.

Table 3.—Soft winter wheat yield, nitrogen (N) rate, application timing, and nitrification inhibitor (NI), Hermiston, 2008.[a]

| N rate (lb/a) | Single with NI[b] | Single w/o NI[b] | Split w/o NI[c] |
|---|---|---|---|
| | Wheat yield (bu/a) | | |
| 100 | 105 *e* | 107 *de* | — |
| 150 | 109 *cde* | 118 *abc* | — |
| 200 | 116 *abcd* | 115 *bcde* | 125 *ab* |
| 250 | 126 *a* | 116 *abcd* | 122 *ab* |
| 300 | — | 121 *ab* | — |

[a]Yields followed by the same letter are not statistically different.

[b]Single N application applied at Feekes 5.

[c]Split applications applied between Feekes 5 and 9.

## Potassium (K)

Soil test K results and the need for K fertilizer are often related to crop rotation. When wheat is planted following potatoes, onions, or many other vegetable crops, a sufficient supply of K is usually available for wheat growth, so no K application is expected to be necessary before or at planting. Low soil test K and the need for K fertilizer are most likely when wheat follows alfalfa or other forage crops.

Wheat uses about the same amount of K as N. However, unlike N, most of the K will be in the straw at harvest. This fact is important for crops following wheat. See the sidebar "Nutrient removal and recovery from straw" for more information.

A decision to fertilize with K should be based on a soil test. Soil test K is an index of plant K availability. K fertilizer recommendations in this publication are based on the sodium bicarbonate-extractable K soil test. Soil samples tested for K using this soil test should be obtained from the surface foot.

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Figure 2.—Wheat field near harvest. Most of the potassium (K) taken up by wheat plants will be in the straw at harvest. Baling straw removes this K, depleting soil K for the next crop.

## Nutrient removal and recovery from straw

The choice between baling or incorporating straw following harvest will affect nutrient availability for the following crop. Baling straw removes nutrients. The average amount of N, P, K, and S removed with grain and straw for a 150 bu/a yield is given in Table 4. For this yield, grain contains 135 lb N/a, and straw contains 25 lb N/a. Thus, 85 percent of the N is in the grain. In contrast, 75 percent of the K is in the straw. For this reason, baling straw removes a substantial amount of K and can quickly decrease soil test K.

K is easily removed from straw and chaff with rainfall or irrigation. Thus, if straw is incorporated, K is readily available to the next crop. Even when straw will be baled, however, the ease of K removal can be exploited to retain K in the field. A single postharvest irrigation of at least 0.25 inch of water will remove a substantial amount of K from straw that is on the ground prior to windrowing. Irrigation water does not remove K from standing stubble, however.

Table 4.—Nutrient content for a typical soft white winter wheat crop yielding 150 bu/a.[a]

| | N (lb/a) | $P_2O_5$ (lb/a) | $K_2O$ (lb/a) | S (lb/a) |
|---|---|---|---|---|
| Grain (150 bu) | 135 | 70 | 50 | 11 |
| Straw (4.5 ton) | 25 | 10 | 140 | — |
| Crop total | 160 | 80 | 190 | — |

[a]Nutrient content was calculated using average concentrations from Table 5 and a harvest index of 0.49.

Table 5 shows concentrations of N, P, K, and S in wheat grain and straw. These data are from field experiments performed in western and eastern Oregon. Grain P, K, and S values and straw P values are more consistent than are grain and straw N and straw K. The variability from field to field and year to year suggests that you should use these data only for information or as a comparison to values measured in your fields, rather than as a basis for fertilizer application rates.

In addition to nutrient removal, straw harvest gives rise to other concerns, such as soil health and soil organic matter content.

Table 5.—Grain protein concentration and nutrient concentrations in soft white winter wheat grain and straw from research in eastern and western Oregon.[a]

| | Protein (%) | N (%) | P (%) | K (%) | S (%) |
|---|---|---|---|---|---|
| **Grain** | | | | | |
| Range | 7–12 | 1.4–2.3 | 0.25–0.4 | 0.38–0.53 | 0.12 |
| Average | 9 | 1.5 | 0.33 | 0.46 | 0.12 |
| **Straw** | | | | | |
| Range | — | 0.20–0.50 | 0.02–0.24 | 0.75–5.0 | — |
| Average | — | 0.25 | 0.05 | 1.3 | — |

[a]From 1981 through 2008, more than 200 measurements were made for phosphorus, 100 for potassium, and as few as 15 for sulfur.

Apply K fertilizer using the recommended rates provided in Table 6. A yield increase from K application is likely when soil test K is below 75 ppm. In fields with soil test K values between 75 and 100 ppm, yield response from K application varies. On-farm experiments are the best predictor of yield response to K fertilizer in this range of soil test K values. K application is not recommended when soil test K is greater than 100 ppm.

Potassium can be broadcast applied and incorporated before planting, banded at planting, or applied through irrigation water. If 30 lb $K_2O$/a or less is to be applied, K can be banded at planting. Do not apply more than 25 lb N/a in the band with K. If 60 to 100 lb $K_2O$/a will be applied, broadcast and incorporate K fertilizer before planting. Alternatively, K may be applied through the irrigation water in the fall or in spring before jointing (Feekes 6, Figure 3).

Table 6.—Fertilizer potassium (K) rate recommendations using the sodium bicarbonate soil test.

| Soil test K[a] (ppm) | Apply this amount of $K_2O$ (lb/a) |
|---|---|
| Below 75 | 60–100 |
| 76–100 | 30–60 |
| Over 100 | None |

[a]Sodium bicarbonate soil test method.

## Sulfur (S)

Excluding N, sulfur is the nutrient most likely to limit wheat production. The S requirement of wheat is about 25 lb/a. Sulfate-sulfur ($SO_4$-S), the form of S available to plants, is common in irrigation water.

Unlike the macronutrients (N, P, and K), a soil test for S in wheat is not definitive. However, measuring S in irrigation water and soil will help determine the S fertilizer requirement. Low or moderate soil test values (below 10 ppm) are an indication that S application may be warranted. A yield increase from S application is likely if one or more of the following situations apply: (1) wheat is seeded late in the fall, (2) a greater-than-average quantity of straw is present in the field, and/or (3) the concentration of S in irrigation water is less than 5 ppm. Field experience, observation, and on-farm experimentation/experience are the best predictors of S fertilizer requirements.

If S fertilizer is required, apply 10 to 30 lb S/a. Sulfur can be applied as a band at planting and can be combined with other nutrients such as N in a "starter" fertilizer. Alternatively, S can be applied with irrigation water before jointing (Feekes 6).

## Micronutrients

Application of the micronutrients boron, copper, manganese, iron, molybdenum, or zinc does not routinely increase wheat yield in eastern Oregon. Most applications are the result of a low soil test or a previously observed deficiency symptom. Consider zinc (Zn) or boron (B) applications in the following situations.

- **Zinc**: Application of Zn may be beneficial when DTPA-extractable soil test values are less than 0.8 ppm. Apply Zn at a rate of 1 to 5 lb/a. If applying 1 to 2 lb Zn/a, apply in a band. Broadcast Zn if higher rates are used.
- **Boron**: When soil test B is less than 0.4 ppm, B need for wheat can be met with the application of 0.5 to 2 lb B/a.

## Physiologic leaf spot and chloride deficiency

Physiologic leaf spot is associated with chloride (Cl-) deficiency, but it is not as common in irrigated wheat as in dryland situations. In irrigated wheat production, chloride is supplied by irrigation water or by muriate of potash (KCl) applied to other crops in the rotation. A chloride application should be considered only if physiologic leaf spot has previously been found in the field. Apply 100 lb KCl/a prior to flag leaf emergence if physiologic leaf spot has been observed in the past.

## Feekes growth or development stages

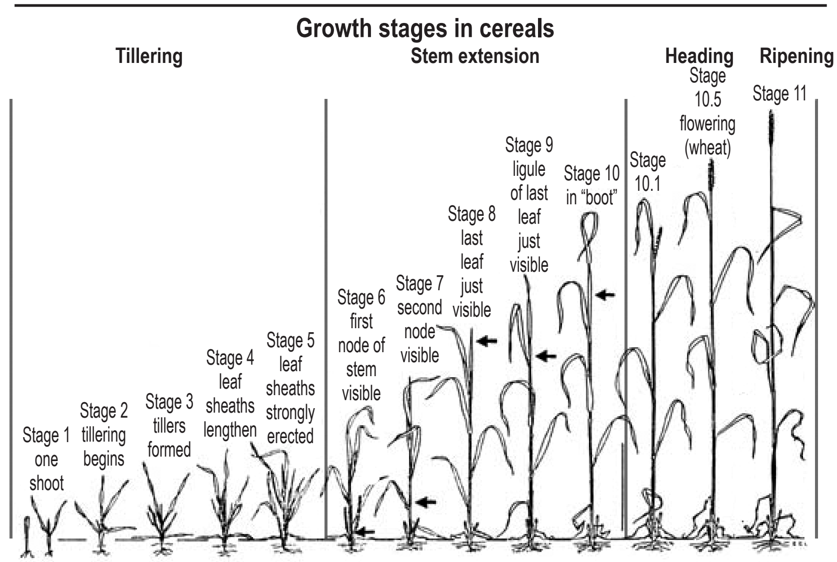


Figure 3.—Growth stages in cereals.

# Spring nitrogen management

Spring N applications are the most efficient way to fertilize irrigated wheat, regardless of whether wheat is planted in fall or spring. In this section, we will consider when to apply N and how much N to apply. See the sidebar “N application methods” (page 4) for information about how to apply N. For more information about the need for N for wheat growth, see the sidebar “Wheat grain yield and N supply.”

## N timing (when to apply)

Use plant growth and development—not the calendar—to determine N application timing in spring. Wheat growth and development stages are illustrated in Figure 3 (page 7).

Through tillering (Feekes 5), wheat accumulates only a small amount of N (20 to 40 lb/a). As jointing and stem elongation begin (Feekes 6), N is rapidly accumulated by the plant. In a 5- to 8-week period (Feekes 5–10), wheat takes up 100 to 150 lb N/a, with a peak N uptake rate of 2 to 3 lb N/a/day during stem elongation (Figure 4). By the boot stage (Feekes 10), the plant has accumulated the majority of its N for the season, but only about half its biomass (Figure 4). As wheat begins to mature and grain formation begins, N is translocated from the leaves and stems to the grain head.

Spring N may be applied incrementally with irrigation water. In general, application of N should be completed prior to jointing (Feekes 6), when rapid N uptake begins. Take care to ensure that adequate N is available during stem elongation (Feekes 6–9). Wheat yield is reduced when N is limited or unavailable during this period.

Wheat will not produce much additional yield when fertilized at or after the appearance of the flag leaf (Feekes 8). Late-season N fertilization will increase grain protein—an undesirable effect in soft white wheat. In addition, late-season N fertilization increases the risk of N loss to the environment.

### Wheat grain yield and N supply

Wheat yield is a combination of number of heads per unit area, kernels per head, and kernel weight. Both head number and kernels per head are set early in wheat development (Feekes growth stages 2 through 5, Figure 3, page 7). If wheat follows potatoes or other vegetable crops, N application is usually not needed at planting. If wheat follows a crop leaving little N in the soil, banding 20 to 30 lb N/a at planting supplies sufficient N for growth and development through these stages.

Nitrogen supply at jointing or stem elongation (Feekes growth stage 6 or first node) is critical for further plant development and optimum yield. Maximum N uptake occurs during this period of rapid growth and continues until head emergence (Feekes growth stage 10.1). Nitrogen stress during this period will reduce yield. Apply N fertilizer before jointing (Feekes growth stage 6) to optimize yield. Be careful not to overapply N at jointing, as lodging readily results.

Calendar date is not a reliable predictor of jointing, because temperature (accumulating heat units) controls wheat development. The date of jointing will vary by variety, planting date, spring temperatures, and growing conditions. In eastern Oregon, jointing typically occurs between March and April. Annual spring temperature variability can cause jointing to begin in early February or as late as early May. A degree-day calculator is available at http://pnwpest.org/wea/

Kernel weight is determined by the amount of N present in the plant and, to a lesser degree, the N present in the soil at head emergence (Feekes growth stages 10.1–10.5).

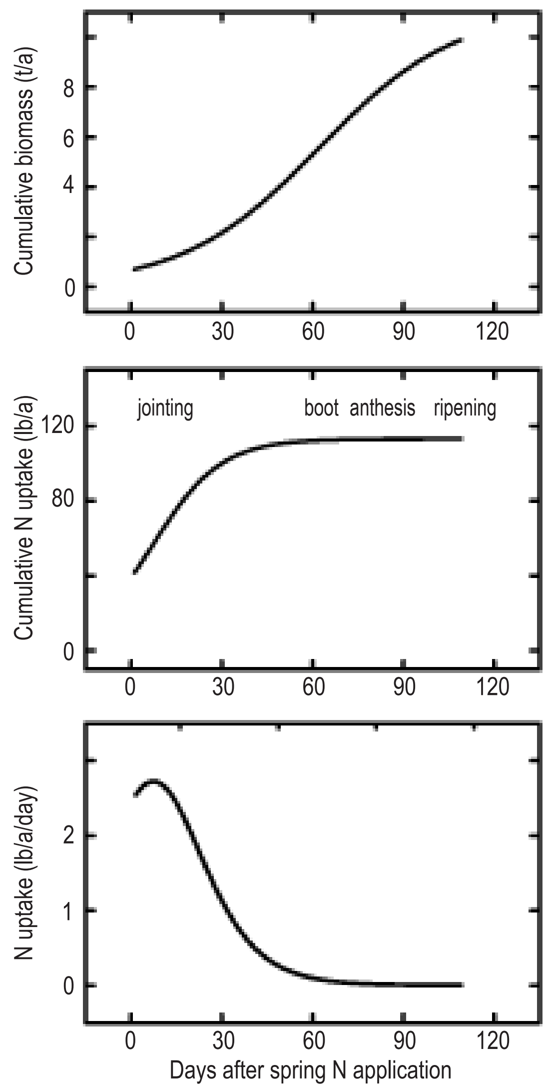


Figure 4.—Typical biomass accumulation and nitrogen (N) uptake for wheat. Data from one growing season.

## N rate (how much to apply)

Irrigated soft white winter and spring wheat requires 275 to 300 lb N/a to produce optimum yield when rooting depth is adequate and sufficient irrigation water is supplied. Grain yields approaching 200 bu/a have been produced with this amount of N. Nitrogen is supplied by the soil, decomposing crop residue, and fertilizer. Unless *no* available N is present in the soil (a highly unlikely situation!), application rates of N fertilizer do *not* need to be this high.

To determine the amount of fertilizer N to apply in the spring, you need to measure the amount of plant-available N in the root zone. To measure plant-available N, collect soil samples for laboratory analysis.

For spring wheat, soil samples can be collected before planting. For winter wheat, collect samples after winter dormancy, but early enough to allow for soil analysis and fertilizer application before jointing.

Collect samples from the effective root zone (usually 2 to 3 feet) in 1-foot increments and have them analyzed for nitrate-N ($NO_3$-N). Irrigation management influences rooting depth. Frequent, small water additions will result in wheat plants with shallow roots, typically around 2 feet deep. Dryland or deficit-irrigated systems, on the other hand, encourage deeper rooting, typically 4 to 5 feet. Thus, where wheat is deficit irrigated, sampling should extend to 4 or 5 feet.

Samples from the surface foot should also be analyzed for ammonium N ($NH_4$-N). Sum nitrate from all depths and ammonium N from the top foot to determine total plant-available N (see Table 7).

Decomposing residue from crops such as potatoes and alfalfa will contribute N to the wheat crop. In contrast, residue from grain crops, such as wheat or corn, requires N for decomposition. As soil microbes decompose these residues, they can take N from the current wheat crop.

Typical residue scenarios include the following:

- Nitrogen from potato residue becomes available rapidly in the fall and is almost completely available by January 1. This N can be measured in a spring soil test.
- Alfalfa killed in the fall will not decompose sufficiently by spring for the N to be measured in a spring soil test. Additional N will become available during the growing season as alfalfa residues decompose.
- Grass seed residue incorporated after harvest begins decomposing immediately after incorporation, providing plant-available N for the wheat crop. Most of the N from decomposing grass seed residue becomes available by late winter and can be measured in a spring soil test.

Use Table 9 (page 10) to determine the recommended spring N rate, based on results of the spring soil test (total plant-available N) and the previous crop. Table 9 takes into account the effect that decomposing crop residues have on plant-available N.

The effectiveness and adequacy of N application can be tested with a postharvest grain protein analysis. Use this analysis to adjust management in future wheat crops based on experience from previous crops. See "Postharvest nutrient considerations" for details (page 10).

## Foliar nutrient application

Foliar nutrient application is advocated for some crops in certain situations: when roots are damaged, yield potential is high, or high soil pH limits availability of micronutrients. However, foliar application of fertilizer to soft white wheat in Oregon is not supported by research in any of these situations. Foliar fertilizer use in wheat has not increased wheat yield and sometimes results in decreased yield (Table 8).

Nitrogen and zinc were applied to wheat foliage in three fields during April. Even where wheat yield was 120 bu/a (Field 3), the foliar nutrient application did not increase yield. Wheat yield also was not increased by foliar fertilizer application when yield was low due to infection by take-all root rot (Field 1).

Table 8.—Wheat grain yield with foliar application of nitrogen (N) and zinc (Zn) compared to grain yield without foliar nutrient application, 1981.

| | | | Field 1 | Field 2 | Field 3 |
|---|---|---|---|---|---|
| Material | Rate (lb/a) | Date | Grain yield (bu/a) | | |
| None | — | — | 65 | 102 | 122 |
| N+Zn | 1 pt/a | April | 61 | 78 | 117 |
| N+Zn | 2 pt/a | April | 66 | 87 | 110 |

Table 7.—Example of plant-available nitrogen (N) for samples collected in 1-foot increments when the rooting depth is 3 feet.

| Soil depth (inches) | Ammonium-N ($NH_4$-N) (lb/a) | Nitrate-N ($NO_3$-N) (lb/a) | Plant-available N ($NH_4$-N + $NO_3$-N) (lb/a) |
|---|---|---|---|
| 0–12 | 10 | 50 | 60 |
| 13–24 | — | 40 | 40 |
| 25–36 | — | 15 | 15 |
| Total plant-available N | 10 | 105 | 115 |

Table 9.—Recommended spring nitrogen (N) application rates for fall- or spring-seeded wheat based on previous crop and total plant-available N.

| | Total plant-available N (lb/a) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0–25 | 26–50 | 51–75 | 76–100 | 101–125 | 126–150 | 151–175 | 176–200 | 201–225 | 226–250 | 251–300 |
| **Previous crop** | **Recommended spring N rate (lb/a)[a,b]** | | | | | | | | | | |
| Potatoes, onions, and other vegetables[c] | 300 | 250 | 225 | 200 | 175 | 150 | 125 | 100 | 75 | 50 | 0–25 |
| Alfalfa[d] | 200 | 150 | 125 | 100 | 75 | 50 | 25 | 0 | 0 | 0 | 0 |
| Other legumes[e] | 250 | 200 | 175 | 150 | 125 | 100 | 75 | 50 | 25 | 0 | 0 |
| Grain[f] | 350 | 300 | 275 | 250 | 225 | 200 | 175 | 150 | 125 | 100 | 75 |

[a]N rates in this table are suitable for an expected yield of 140 bu/a or higher. Where yields typically are lower (e.g., Malheur County), where N is supplied through irrigation water, or where experience has shown that lower N rates are needed, use the N recommendations from the *Southern Idaho Fertilizer Guide for Irrigated Winter Wheat*.

[b]If N was applied in the fall, subtract the amount of applied N from the values below.

[c]Available N after a potato crop typically is 100 to 300 lb/a. If less than 100 lb N/a is measured in a spring soil sample after a potato crop, review your management practices and sampling procedure.

[d]Assumes a healthy stand and 6 inches of regrowth before incorporation or killing.

[e]Increase the spring N rate if pea vines (hay) are removed from the field.

[f]Wheat, barley, oats, or corn as a previous crop when stover or straw is incorporated.

# Postharvest nutrient considerations

## Evaluation of N

Nutrient management for wheat does not stop at harvest. Growers routinely receive grain protein data at the time of sale. This data can be used as a “report card” to check N fertilizer adequacy, as shown in Table 10.

Table 10.—Grain protein as a “report card” for nitrogen (N) management of soft white wheat.[a]

| Grain protein (%) | N supply for season was: |
|---|---|
| Below 8 | Inadequate |
| 8–10.5 | On target |
| Over 10.5 | Excess (or yield was limited by another factor) |

[a]Yield should be at least 80 bu/a to use this table.

Maximum economic yield of soft white wheat is associated with grain protein concentrations between 8.0 and 10.5 percent. Consider the following guidelines.

Grain protein levels less than 8.5 percent suggest that N was inadequate and that additional N fertilizer would have increased yield.

Grain protein levels greater than 10.5 percent suggest that N was excessive or that yield was limited by a factor other than N. Irrigated wheat yields can be limited by a variety of problems, such as disease, irrigation timing or amount, insect infestation, insufficient nutrients, poor nutrient timing, or weed competition.

If grain yield was near expectations and grain protein was above 10.5 percent, then excess N—rather than a yield limitation—was the cause of the high grain protein. Carefully evaluate N application rate, timing, and soil test values for future wheat crops.

# For more information

Ayers, R.S. and D.W. Westcot. 1985. *Water Quality for Agriculture*. Food and Agriculture Organization of the United Nations. Irrigation and Drainage Paper No. 29, Rev. 1, Rome.

*Monitoring Soil Nutrients Using a Management Unit Approach,* PNW 570. http://extension.oregonstate.edu/catalog/pdf/pnw/pnw570-e.pdf

*Salt-affected Soils for Crop Production,* PNW 601-E. http://extension.oregonstate.edu/catalog/html/pnw/pnw601-e

*Southern Idaho Fertilizer Guide for Irrigated Winter Wheat*. http://www.cals.uidaho.edu/edComm/pdf/CIS/CIS0373.pdf

Check with your local experiment station for pertinent wheat trials.



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