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Managing Nitrogen for Yield and Protein in Hard Wheat

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The successful production of hard wheat with acceptable protein is based, in part, on an effective nitrogen (N) management plan. This fact sheet discusses the principles of managing N for hard wheat production and explains how to calculate an N application rate. The information contained in this fact sheet is applicable to both irrigated and dryland production systems in eastern Oregon.

Principles of nitrogen management for hard wheat production

- Grain protein goals differ among hard wheat classes (Table 1).

Table 1.—Wheat class and corresponding protein goals.

Wheat class	Protein goal (%)
Hard red winter (HRW)	12.5
Hard white winter (HWW)	12.5
Hard red spring (HRS)	14
Hard white spring (HWS)	12.5

- Maximum N uptake in wheat occurs after tillering and before flowering (Figure 1). Nitrogen accumulated during these growth stages is used primarily to establish yield potential. Nitrogen accumulated after flowering has little effect on yield but can increase grain protein content under favorable conditions.
- 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 N exceeds that required for yield (Figure 2). Nitrogen requirements for desired grain protein goals are listed in Table 2.
- Moisture availability throughout the growing season influences both grain yield and protein content. Under favorable moisture conditions, yield potential increases and "dilutes" the amount of protein in the developing wheat kernels. Supplying additional N to compensate for the higher yield potential may be necessary to attain targeted protein contents. Conversely, under limited moisture conditions, yield potential decreases and grain protein may increase because N is concentrated in fewer wheat kernels.

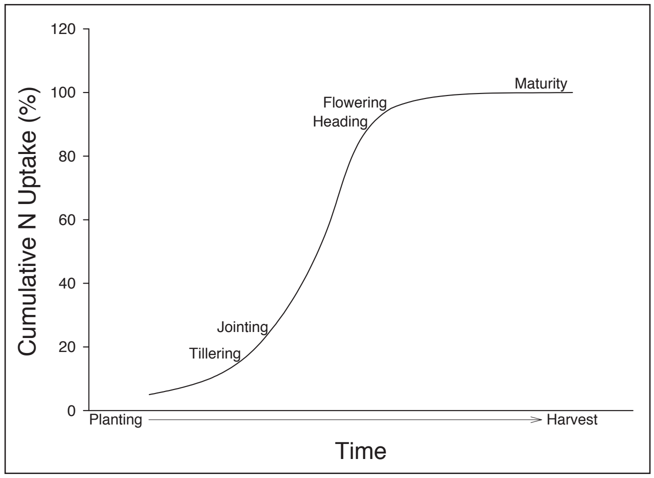

Figure 1.—Wheat nitrogen (N) uptake during the growing season.

Table 2.—Nitrogen (N) required (per bushel of wheat) to reach a specific grain protein goal.

Grain protein goal %	N requirement Average (lb N/bu)	Range (lb N/bu)
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
14	3.5	3.0–3.7
15	3.7	3.3–4.0

- Nitrogen fertilizer may be applied in split applications, depending on the production system and moisture conditions during the growing season. In irrigated cropping systems, N may be applied as required by the crop. Dryland growers should apply most of the N fertilizer prior to or during seeding. Early-spring (prior to jointing) applications may be necessary if fall, winter, or spring moisture is greater than expected and yield potential has increased beyond the N supply.
- Account for residual soil N when determining the amount of N required to achieve grain yield and protein goals.
- The results from a flag leaf tissue test can be a useful indicator of grain protein content in some hard wheat classes. Take flag leaf samples at 50 percent heading (Feekes 10.3). Grain protein is unlikely to increase in hard spring wheat if the flag leaf N concentration exceeds 4.2 percent. If the flag leaf N concentration is below 4.2 percent, a late-season N application may increase grain protein. Late-season N applications are untested under dryland conditions, and their effectiveness for raising grain protein is unknown.
- Sulfur is an important component of grain protein and often is a limiting nutrient in hard wheat production. The sulfur requirement is approximately one-tenth of the nitrogen requirement. Applications of up to 25 lb S/acre are common in hard wheat production.

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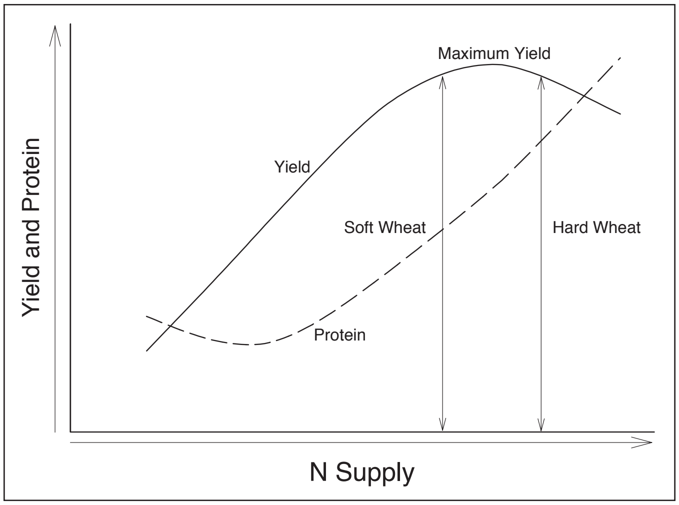

Figure 2.—Generalized relationship between grain yield, grain protein, and nitrogen (N) supply.

Calculating a nitrogen application rate

Step 1. Determine the total amount of N required to reach the desired yield and protein goal.

Use past production history to set realistic yield goals for each field. Generally, hard winter wheat yields are equal to or slightly (10 percent) lower than those for soft white winter wheat. Using the appropriate protein target from Table 1, determine the amount of N required per bushel of wheat using Table 2. Keep in mind the following when determining the amount of N required per bushel of wheat.

- Highly productive systems require less N per bushel than low-productivity systems. For example, irrigated systems require less N per bushel than less productive dryland systems.
- In general, hard wheat requires an additional 0.4 lb N/bushel compared to that required for maximizing yield.

Calculate the total amount of N required by the crop by multiplying the yield goal (bushels of wheat per acre) by the pounds of N required per bushel. This is the total amount of N required per acre.

Step 2. Determine the amount of residual soil N.

Collect a representative soil sample from the effective crop root zone in 1-foot increments and send to a laboratory for analysis of plant-available nitrogen. The surface sample (0–1 foot) should be analyzed for nitrate N (NO_3^-) and ammonium N (NH_4-N). The remaining samples should be analyzed for NO_3^- only. Add reported values for all depths to determine the amount of residual soil N.

Step 3. Determine the amount of N fertilizer required.

Subtract the residual soil N (Step 2) from the total N requirement (Step 1) to obtain the amount of N fertilizer required.

Example: Nitrogen (N) application rate calculation for hard red winter wheat.

Step 1. Determine the total amount of N required (per acre).

Yield goal = 60 bu/acre

HRW protein goal (Table 1) = 12.5%

Nitrogen required per bushel of wheat to reach protein goal (Table 2) = 2.6–3.5 lb N/acre; average = 3.1 lb N/acre

Total N required per acre = yield goal x N required per bushel

Total N required: 60 bu/a x 3.1 lb N/a = 186 lb N/a

Step 2. Determine residual soil N.

Depth (feet)	Soil NO_3^-N (lb/acre)	Soil NH_4^+N (lb/acre)	Total N (lb/acre)
0–1	15	10	25
1-2	15	—	15
2–3	10	—	10
Total	40	10	50

Soil residual N: 50 lb N/a

Step 3: Determine N fertilizer rate.

N fertilizer rate = Step 1 - Step 2

N fertilizer rate: 186 lb N/a - 50 lb N/a = 136 lb N/a

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Nitrogen Management for Hard Wheat Protein Enhancement, PNW 578 (2005).

Winter Wheat in Summer-Fallow Systems (Low Precipitation Zone), FG 80 (revised 2006).

Winter Wheat and Spring Grains in Continuous Cropping Systems (Low Precipitation Zone), FG 81 (revised 2006).

Winter Wheat in Summer-Fallow Systems (Intermediate Precipitation Zone), FG 82 (revised 2006).

Winter Wheat in Continuous Cropping Systems (Intermediate Precipitation Zone), FG 83 (revised 2006).

Winter Wheat in Continuous Cropping Systems (High Precipitation Zone), FG 84 (revised 2006).

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