Colorado State University
Extension

Fertilizing Spring-Seeded Small Grains

Fact Sheet No. 0.534 Crop Series|Soil

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Adequate soil fertility is one of the requirements for profitable small grain production. Nitrogen (N) is the most yield-limiting nutrient. Phosphorus (P) is the next most limiting nutrient. Levels of potassium (K) and micronutrients generally are sufficient for small grain production in Colorado soils.

Spring-seeded small grains include feed barley, malting barley, oats and wheat, grown mainly under irrigated conditions, and proso millet and pearl millet grown under dryland conditions.

Soil Sampling

The value of a soil test in predicting nutrient availability during the growing season depends on how well the sample collected represents the area sampled. Take surface samples from the 1-foot soil depth. Take subsoil samples to a depth of 2 feet for determination of available NO_3-N. If the field has been in no-till, reduce the sampling to the tillage layer.

A good sample is a composite of 15 to 20 soil cores taken from an area uniform in soil type. This number of soil cores is especially important in sampling fields where P fertilizers were band applied in previous years. Sample areas with major differences in soil properties or management practices separately.

Thoroughly air-dry all soil samples within 12 hours after sampling by spreading the soil on a clean surface where the soil will not be contaminated. **Do not oven dry the soil** because this can change the soil test results. Place the air-dried soil in a clean sample container for shipment to the soil test laboratory.

Submit a carefully completed information form with the soil sample. This form provides information so fertilizer suggestions can be tailored to your specific situation. Take soil samples for NO_3-N analysis every year for optimum N fertilization of crops. Soil analyses for availability of the other nutrients, pH and organic matter content may be sufficient every three to four years.

More detailed explanations of the importance of taking proper soil samples can be found at the Colorado State University Soil, Water and Plant Testing Laboratory, located in Room A319, Natural and Environmental Sciences Building, Colorado State University, Fort Collins, CO 80523; (970) 491-5061, or at www.extsoilcrop.colostate.edu/SoilLab/soillab.html.

Nitrogen Suggestions

Base N rates for small grains on expected yields for each field. Nearly all small grains will require some N fertilizer, unless there is a substantial release of available N in the soil prior to planting. This situation may occur where the previous crop was a legume, or where manure has been recently applied. High N rates in excess of crop needs can result in potential groundwater contamination by NO_3-N under irrigated conditions.

Give credit for the level of available residual NO_3-N in the soil, as determined by a soil test. Other credits for N include the amounts estimated to become available during the season from mineralization of soil organic matter, manure and previous legume crops. Subtract these credits from the total crop needs to determine the suggested N fertilizer rate for the expected yield.

Nitrogen requirements vary somewhat with small grain species. In this fact sheet, suggested N rates are divided into the following groups: (1) irrigated feed barley, oats and wheat; (2) irrigated malting barley; and (3) dryland proso and pearl millet.

Quick Facts

- Nitrogen is the most limiting nutrient for small grain production.
- Apply nitrogen fertilizers at rates based on expected crop yields minus credits for residual soil nitrates, manure applications, nitrogen mineralized from soil organic matter and previous legume crops, and nitrogen contained in irrigation water.
- Apply phosphate fertilizers at rates based on soil test results.
- Most Colorado soils contain sufficient available potassium, sulfur and micronutrients for small grain production.

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Suggested N rates for winter wheat are given in 0.544, *Fertilizing Winter Wheat*.

Soil Nitrate-N Credit

Residual NO_3-N in soil is immediately available to plants, so decrease the fertilizer N rate to give credit for the amount in the root zone. Sample soil to a depth of 2 feet in 1-foot increments and test for NO_3-N. The sum of the ppm values for the two samples is used to estimate the NO_3-N content in the soil. For example, if the NO_3-N contents of the 0-1 and 1-2 foot soil samples are 10 and 4 ppm, use the N rates in the 13 to 18 ppm row of Tables 2 and 3. When soil is sampled to a 1-foot depth, multiply the ppm NO_3-N value by 1.67 before using Tables 2 and 3. For Table 4, use the first column if soil was sampled to a 1-foot depth and the second column if samples were taken to a depth of 2 feet.

Table 1: Nitrogen credits for previous legume crops and manure applications.

Legume crop	lb N/A credit*
Alfalfa > 80% stand 60-80% stand 0 - 60% stand Dry beans	100 - 140 60 - 100 0 - 60 30
Manure lb	N/ton credit**
Beef Dairy Poultry litter	as is 5 (at 50% DM***) 3 (at 20% DM) 20 (at 75% DM)

*For the second year, use ½ of the first year N credit
**For the second and third years, use ½ and ¼ of the first year N credits, respectively.
***Dry matter.

Table 2: Suggested N rates for irrigated feed barley, oats and wheat, as related to NO_3-N and soil organic matter content (expected yield, 100 bu/A).

ppm NO_3-N in soil*	Soil organic matter content, %		
	0 - 1.0	1.1 - 2.0	> 2.0
	– Fertilizer rate, lb N/A –		
0 - 6	125	95	75
7 - 12	105	75	55
13 - 18	85	55	35
19 - 24	65	35	15
25 - 30	45	15	0
31 - 36	25	0	0
> 36	0	0	0

*Sum of ppm NO_3-N in 1-foot depth increments to 2 feet (for sample depths of 1 foot only, multiply the ppm value by 1.67 before using the table).
- To adjust the N rate for expected yields different from 100 bu/A, add or subtract 20 lb N/A for each 10 bu/A difference.

Soil Organic Matter Credit

Nitrogen in soil organic matter becomes available to plants through a mineralization process. About 30 pounds of N per acre will be available to the crop during each growing season for each 1.0 percent organic matter in the surface soil layer. Assume a level of 1.5 percent organic matter for eastern Colorado soils when a soil test result for organic matter is not available.

Other N Credits

When legumes are incorporated by tillage or killed by herbicides, they release N to the succeeding crop. Therefore, reduce fertilizer N rates by a legume credit (see Table 1).

The N content of manure varies considerably, depending on source of manure, feeding practices, handling techniques, and moisture content. Obtain a laboratory analysis of the manure for nutrient and moisture content and request the results in pounds of N per ton of manure to determine the N credit. In the absence of an analysis, the minimum N credit is 5 pounds per ton (as is) for beef feedlot manure, 3 pounds per ton (as is) for dairy manure, and 2 pounds per ton (as is) for poultry litter for the first year after application and less for the next two years (see Table 1). For more information on the nutrient value of manure, refer to *Bulletin 568A, Manure Utilization - Best Management Practices*, from the CSU Extension storefront at: www.csuextstore.com.

Irrigation water may contain NO_3-N which is available to plants. The amount supplied for each ppm of NO_3-N in irrigation water is equal to 2.7 lb N per acre-foot of water. The consumptive water use by irrigated small grains is about 1.0 to 1.2 acre feet per year. Calculate the N credit from irrigation water as follows: ppm NO_3-N x 2.7 x acre-feet of water use = lb N/A.

Irrigated Feed Barley, Oats and Wheat

Table 2 gives suggested N rates for irrigated feed barley, oats and spring wheat at an expected yield of 100 bu/A at various soil NO_3-N and organic matter contents. Suggested N rates in this table do not account for other N credits that have been discussed earlier. These credits (legume, manure and irrigation water) should be subtracted from the N rates in Table 2 to determine the fertilizer N rate for a given field.

Table 3: Suggested N rates for irrigated malting barley, as related to NO_3-N and soil organic matter content (expected yield, 100 bu/A).

ppm NO_3-N in soil*	Soil organic matter content, %		
	0 - 1.0	1.1 - 2.0	> 2.0
	– Fertilizer rate, lb N/A –		
0 - 6	115	85	65
7 - 12	95	65	45
13 - 18	75	45	25
19 - 24	55	25	0
25 - 30	35	0	0
> 30	0	0	0

*Sum of ppm NO_3-N in 1-foot depth increments to 2 feet (for sample depths of 1 foot only, multiply the ppm value by 1.67 before using the table).
- To adjust the N rate for expected yields above or below 100 bu/A, add or subtract 10 lb N/A for each 10 bu/A difference on sand, loamy sand, and sandy soils; and 15 lb N/A for each 10 bu/A on all other soils.
NOTE: Excess N may increase grain protein content to a level not acceptable for malting purposes.

Irrigated Malting Barley

Table 3 gives suggested N rates for irrigated malting barley at an expected yield of 100 bu/A, at various soil NO_3-N and organic matter contents. Suggested N rates in this table do not account for other N credits that have been discussed earlier. These credits (legume, manure, and irrigation water) should be subtracted from the N rates in Table 3 to determine the fertilizer N rate for a given field. Nitrogen nutrition is especially important for malting barley. Excess N supplies, especially late in the growing season, will increase grain protein to levels unacceptable for malting quality. Manure applications are not suggested for malting barley.

Dryland Proso and Pearl Millet

Millet is a short-season crop, and generally is planted in late spring. Most of its N supply will come from the residual NO_3-N in soil and fertilizer N. For more information on fertility requirements and cultural practices for pearl and proso millet, see *Producing and Marketing Proso*

Table 4: Suggested nitrogen rates for dryland proso and pearl millet, as related to NO_3-N in the soil (expected yield, 40 bu/A).

ppm NO_3-N in soil*		Relative level	Fertilizer rate, lb N/A
0 - 1 ft	0 - 2 ft		
0 - 3	0 - 6	very low	40
4 - 6	6 - 11	low	20
7 - 10	12 - 17	medium	10**
> 10	> 17	high	0

*Concentration of NO_3-N in the top foot of soil or the sum of NO_3-N concentrations in 1-foot sample depths to 2 feet.
**The 10 lb N/A rate is suggested only when phosphorus and/or potassium is being applied.
NOTE: Suggested N rates shown for proso or pearl millet may also be used for foxtail (hay) millet. However, nitrate accumulation in forage may occur during drought stress, so forage testing is recommended prior to feeding fertilized or unfertilized hay to livestock.

Millet in the High Plains, EC137, University of Nebraska.

Suggested N rates for dryland proso and pearl millet are given in Table 4 at an expected yield of 40 bu/A, depending on soil NO_3-N levels. Fertilizer N rates decrease with increasing levels of NO_3-N in the soil. Millet grown under very stressed dryland conditions may contain elevated NO_3-N concentrations in the forage, which may be toxic to livestock. Such harvested forage should be analyzed for NO_3-N prior to feeding to livestock.

Methods and Timing of N Applications

Nitrogen may be applied to soil by various methods. The most efficient method is to apply some of the N prior to or at planting and the remainder later in the growing season. Some growers prefer to apply anhydrous ammonia or urea-ammonium-nitrate solution in combination with P fertilizers in a tillage operation prior to planting. Some N may be band applied with or near the seed in combination with starter fertilizers, but the rate should be less than 20 lb of N/A because seedling damage may occur and emergence may be decreased in dry soil. All sources of N fertilizers are equally effective for small grains per unit of N if properly applied. Base your choice of N source on availability, equipment needs and cost per unit of N.

Topdressing N fertilizers later in the spring is an efficient way to supply a portion of the total N needs of small grains. Broadcase granular N fertilizers on small grains prior to jointing. Fluid N solutions also may be dribble-applied to the crop, although there is some potential for leaf burn.

Applying N fertilizers through sprinkler systems is an effective method for irrigated small grains. All closed-irrigation systems must be equipped with backflow prevention valves if N fertilizers are applied through the system.

Phosphorus Suggestions

Crop responses to applied P are most likely on soils with low or medium levels of extractable P. Suggested P fertilizer rates for irrigated small grains (Table 5) are for band (or row) and broadcast applications. The main soil tests for extractable P in Colorado soils are the AB-DTPA and sodium bicarbonate ($NaHCO_3$ also known as Olsen) tests. Values for both tests are given in Table 5. Suggested P fertilizer rates for proso and pearl millet (Table 6) are for band (or row) and broadcast application.

Placement of P fertilizers in the root zone is important because P is not mobile in soil. Band application of starter fertilizers with or near the seed is the most efficient placement method for P, and suggested rates for broadcast application are about double those for band application. If P fertilizers are applied broadcast, incorporate them into the soil prior to planting.

Dual application of ammonium-N fertilizers with P fertilizers in a band improves efficiency of P uptake by crops. Subsurface placement of P may be especially important for reduced tillage cropping systems. Monoammonium phosphate (MAP, 11-52-0), diammonium phosphate (DAP, 18-46-0), and ammonium polyphosphate (10-34-0) are equally effective per unit of P if properly applied. Base the choice of P source on availability, equipment needs and cost per unit of P.

Band application of P with hoe drills is an effective method for fertilizing dryland small grains. The P fertilizer can be banded on the soil surface directly above the seed row after row closure. Soil is moved into the deep furrow slot over the fertilizer by wind and rain action. Crown roots later develop in the fertilized soil and absorb the applied P.

Table 5: Suggested phosphorus rates for band (row) and broadcast applications to irrigated spring-seeded small grains.

ppm P in soil		Relative level	Fertilizer rate, lb P_2O_5/A	
AB-DTPA	$NaHCO_3$		Banded	Broadcast
0 - 3	0 - 6	low	60	120
4 - 7	7 - 14	medium	40	80
8 - 11	15 - 22	high	20	40
> 11	> 22	very high	0	0

Table 6: Suggested phosphorus rates for band (row) and broadcast applications to dryland proso and pearl millet.

ppm P in soil		Relative level	Fertilizer rate, lb P_2O_5/A	
AB-DTPA	$NaHCO_3$		Banded	Broadcast
0 - 2	0 - 4	very low	35	70
3 - 4	5 - 8	low	25	50
5 - 6	9 - 12	medium	15	30
> 6	> 12	high	0	0

Potassium (K) Suggestions

Most Colorado soils are relatively high in extractable K and few crop responses to K applications have been reported. Suggested K rates related to soil test values (AB-DTPA or NH_4OAc) are similar for dryland and irrigated small grains (Table 7). The main K fertilizer is KCl (potash), and broadcast application incorporated into the soil prior to planting is the usual method.

Table 7: Suggested potassium rates for irrigated and dryland spring-seeded small grains.

ppm K in soil AB-DTPA or NH_4OAc	Relative level	Fertilizer rate, lb K_2O/A
0 - 60	low	40
60 - 120	medium	20
> 120	high	0

Other Nutrients

Most Colorado soils contain adequate levels of available sulphur (S). Soil tests for available S are not routinely performed. Under rare situations some sandy soils may require S applications; however, research shows that even when yield responses occur, they may not be economical. Irrigation water from most surface waters and some wells often contains appreciable SO_4-S, so irrigated soils usually are adequately supplied with S.

There have been no confirmed deficiencies of boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), or zinc (Zn) in small grains in Colorado.