Section 5

Fertilizer Management

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The most important first step in your fertilizer management program is to take a soil sample. Except for nitrogen (N), your fertilizer and lime decisions will be based on the soil test results. It is advantageous to take the sample as soon as possible after harvest of the previous crop to supply the necessary phosphorus (P) and potassium (K) for the seedling wheat plant. However, in drought years, soil testing at this time can result in soil pH and K test values that are artificially low due to extremely dry soil conditions during August and September. Extension publication AGR-189 gives recommendations on taking soil samples under such conditions. Refer to Extension publication AGR-1, *Lime and Fertilizer Recommendations,* for specific recommendations based on soil tests.

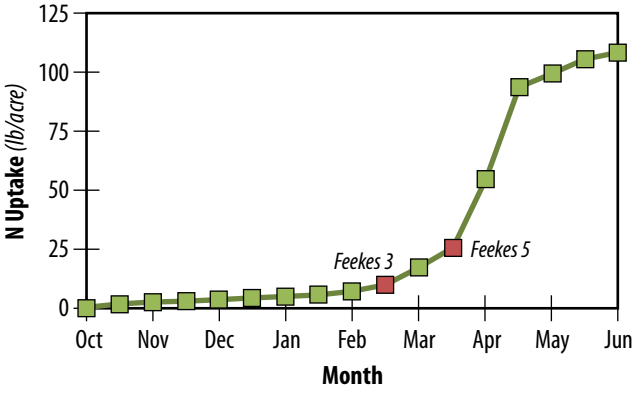
Nitrogen

Nitrogen is the nutrient requiring the most management. Proper N rate and timing are important for high tiller numbers and yield (Figure 5-1). Nitrogen deficiency symptoms consist of pale green (chlorotic) plants that are poorly tillered (Photos 5-2 and 5-3). Excessive N can cause lodging, increased disease incidence and severity, and lower yield. Additionally, excessive N may result in increased levels of N in ground and surface waters, with negative environmental (and economic) consequences.

Rates and Timing. Wheat requires a small, but important, amount of N in the fall. This requirement can almost always be met by soil N remaining after the preceding corn or soybean crop. Producers needing additional P may select P fertilizer sources containing N (for example, diammonium phosphate, DAP, 18-46-0). In the unusual event where and when corn yields greatly exceed (by at least 30 bu/acre) the expectations built in to the corn crop's nutrient management plan, residual N for the succeeding wheat crop will likely be low. If the corn yield exceeds expectations, then 20 to 40 lb N/acre should be added at or near planting. Fall N fertilization becomes more important with late planting (after the first week of November) in a wet fall season

Photo 5-1. The wheat is at about Feekes 2 (Zadoks 21). Stand counts at this stage can help determine how much N to apply for the first application.

Figure 5-1. Nitrogen uptake during the growth of winter wheat.

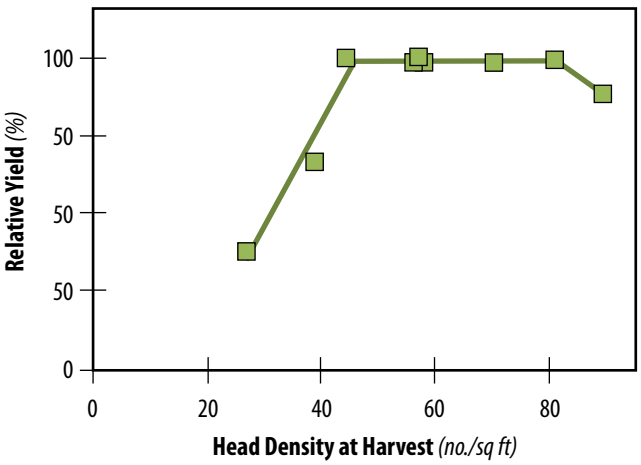


and poor initial emergence (less than 25 plants per square foot). Sufficient fall N stimulates early tillering, which is important for high yields. The fall N rate should not exceed 40 lb N/acre.

Nitrogen applied in late winter-early spring is most effective for yield. There are two approaches that can be used for spring N applications: a single application or a split spring application. Research indicates that a split spring application of N can increase yield by 3 bu/acre (although this varies from year to year), and split N applications reduce lodging potential. Split spring N applications are recommended when possible, but equipment and logistic problems cause some growers to make a single application.

When using the split N strategy, the first application should be made in late winter (mid-February to early March, Feekes 2-3, Zadoks 20-29) at a rate between 30 and 50 lb N/acre. Nitrogen applied at this time encourages further tillering and maintains current tillers. Fields with thin stands or little fall tillering should receive higher early N rates, while those with high tiller counts (above 70 tillers per square foot) should receive lower early N rates (Figure 5-2). Excessive N applied in late winter can increase the potential for lodging, disease, and late spring freeze damage. The second N application should be made to no-till fields in mid to late March (Feekes 5.6, Zadoks 30-31) at a rate sufficient to bring the total amount of spring N to 80 to 110 lb N/acre. In no-till fields with yield potential greater than 70 bu/acre, spring N should total 100 to 120 lb N/acre. If there is some freeze damage or excessively high rainfall in February and March, then the higher N rates should be targeted. For tilled plantings the total should be decreased by 20 lb N/acre because N fertilizers are more efficient with tillage and N loss potential is slightly lower. Higher rates of N application than those recommended here increase lodging potential and do not increase yield potential, unless specific conditions that require more N nutrition are identified.

Figure 5-2. Tillering influences on relative yield of wheat (average of three varieties in two tillage systems over three years).



When making a single N fertilizer application, the best time is when the crop growth stage is Feekes 4-5 (Zadoks 30, usually mid-March), just before the first joint appears on the main stem and, when wheat starts growing rapidly. Rapid growth causes a large demand for N. The rate of N fertilizer for a single application should be between 60 and 90 lb N/acre for fields with a yield potential less than 70 bu/acre and 90 to 100 lb N/acre for fields with greater yield potential. An early (late February) single N application is recommended only when the field's stand or tiller density is low. Earlier N applications are at increased risk of denitrification loss (N loss during extended wet periods). Early single applications increase the risk of spring freeze damage because they encourage earlier heading. Single applications made too early generally result in lower yields and encourage the growth of succulent plants with lush canopies susceptible to diseases like powdery mildew.

Single applications made too late are equally problematic. Nitrogen must be applied in a timely manner to maximize yield potential. Delaying N application after Feekes 6 (Zadoks 31, appearance of the first joint on the main stem) to an N-deficient crop will result in decreased yield potential most years. As plant development advances, yield response to added N progressively declines. After Feekes 9 (Zadoks 39, flag leaf fully developed), there is usually little yield return to added N. However, N applied after Feekes 9 will increase the grain protein concentration.

Fertilizer N Sources. Fertilizer N sources for wheat include ammonium nitrate (33-34% N), urea (45-46% N), and urea-ammonium nitrate solutions (28-32% N). All are equally good sources of wheat N nutrition, when properly managed, in all tillage systems and regardless of previous crop residue. Slow release N is now available for use on wheat. It is a polyurethane (plastic polymer) coated urea prill. The

Photo 5-2. Streaks in this field were caused from anyhdrous ammonia applications made before corn where some knife slits were closed and others were not. Where the knife slits were closed, more N was in the soil (for the corn and then for the wheat), resulting in greener wheat.

Photo 5-3. Streaks in a field are common at field entrances where sprayers overlaps and skips in N application are more likely to occur.

trade name is ESN®. This product should be used at the same rate of N as recommended for other N sources. Since ESN releases N slowly, there is no advantage to split N applications with this source. Research results show that ESN applications between January 15 and February 15 produce wheat yields equal to those observed with uncoated urea applied at Feekes 5 (Zadoks 30). Applying ESN after March 1 increases the risk that too little N will be made available for plant uptake during the critical early growth period.

Distribution of Fertilizer N and Leaf Burn. Since the difference between enough and too much N is small, distribution in the field is important. The best distribution will be achieved using liquid N sources or, for solid N sources, an airflow delivery truck. Spinner systems delivering solid materials are less accurate. Distribution of a solid N material that contains a lot of fine material can be improved by double spreading (reducing the distance between passes by half and spreading half the desired rate on each pass). If evenly distributed, N from liquid and solid sources perform equally well in February and March.

Leaf burn can be a concern with liquid N sources, but you can eliminate this concern by using streamjet or flood nozzle application, mixing the liquid N with additional water, applying less than 60 lb N/acre per application, and avoiding applications on cold, windy days. Although wheat fertilizer burn is visually disturbing, research indicates no yield reduction occurs when N is applied late winter-early spring (February and March). Leaf burn after flag leaf emergence (Feekes 9) can cause yield reductions.

Methods to Fine-Tune Wheat Fertilizer N Application Rates. When the amount of fertilizer N to apply in March is in question, a plant sample collected at Feekes 5 (Zadoks 30) might be helpful. Cut a handful of wheat about ½ inch above the ground at 20 to 30 places in the field, and place a subsample of the total plant material collected in a paper bag. Send the sample to a laboratory with a quick turnaround time so fertilizer N application will not be delayed. Table 5-1 shows guidelines for fertilizer N rates recommended at various tissue N concentrations.

Table 5-1. Guidelines for fertilizer N application using wheat tissue N concentrations at Feekes 5.

Plant N Concentration *(%)*	**Recommended Fertilizer N Rate** *(lb N/acre)*
2.3	100
2.7	80
3.2	60
3.6	40
4.0	20

Murdock (unpublished data)

A chlorophyll meter is a hand-held, non-destructive, field diagnostic tool that actually measures plant leaf greenness. Chlorophyll measurements can provide additional information to help predict the amount of N fertilizer that needs to be added at Feekes 5 or 6 (Zadoks 30 or 31, usually in March). To help calibrate the chlorophyll meter, large amounts of fertilizer N (150 pounds per acre) are added to two or three small areas or strips in the field, in early to mid February. At Feekes 5, chlorophyll readings are taken on 10 to 20 plants in the high N areas and then on 20 to 30 plants in the rest of the field. The measurements are made on the first fully expanded leaf (leaf with a leaf collar) from the top of the plant. Measurements are made about halfway between the tip and

Photo 5-4. Wheat varieties at Feekes 5 (Zadoks 30) ready for a second application of fertilizer N.

Photo 5-5. Variations in green color within a field can be due to application methods as well as weather and soil conditions.

base of the leaf. The following formula is used to make the March fertilizer N rate recommendation:

N = 6 + (7 x D)

N = N (lb N/acre) needed for optimum growth at Feekes 5 (March).
D = difference between chlorophyll reading in the bulk of the field and that found in the small areas/strips with high N rates added in February.

Example: Small areas or strips with high N (150 lbs/ac) added at Feekes 3 (Zadoks 26) read an average of 52 at Feekes 5 (Zadoks 30).

Bulk of field reads an average of 45.

52 – 45 = 7.

6 + (7 x 7) = 55 lb N/acre recommended fertilizer N rate.

A soil nitrate (NO_3) test usually is not helpful unless there are unusual conditions that might cause high N levels in the soil, such as high N carryover due to a very poor corn crop or heavy manure applications. Take soil samples to a depth of 3 feet in February, and place them on brown paper for drying. The NO_3-N measured in the samples will be reported in parts per million (ppm), which should be multiplied by 12 to get pounds per acre. If 120 pounds per acre of NO_3-N are found, no fertilizer N needs to be added. If the soil test indicates less than 120 pounds per acre of NO_3-N, then fertilizer N should be applied.

Phosphorus and Potassium

Phosphorus is essential for root development, tillering, early heading, grain fill, timely maturity, and winterkill resistance. Wheat takes up about 0.67 pounds of P_2O_5 for each bushel produced, and 80 percent of this ends up in the grain. A soil test is necessary in order to determine the proper rate of P fertilizer. Apply P fertilizer in the fall, prior to seeding, for best results. See Table 5-2 for the P_2O_5 concentrations of wheat in grain and straw.

Potassium helps to lower the incidence of some diseases and increases straw strength, which helps reduce lodging. Wheat takes up about 2 pounds of K_2O for each bushel produced, but only about 20 percent of this is removed with the grain. A soil test is required in order to determine the proper rate of K fertilizer. Potassium fertilizer should be applied in the fall, but can be applied in the spring if necessary. See Table 5-2 for the K_2O concentrations of wheat in grain and straw.

Other Nutrients

Calcium (Ca), magnesium (Mg), and sulfur (S) deficiencies have not been observed on wheat in Kentucky. Calcium and Mg will generally be adequate if the proper soil pH is maintained using agricultural lime. Additional Mg should

Table 5-2. Nutrients in wheat grain and straw.

Crop Part	Yield Unit	Nutrient Concentration (lb)		
		N	P_2O_5	K_2O
Grain	Bu	1.2	0.5	0.3
Straw	Ton	12	4	20

Photo 5-6. Scientists are constantly working with equipment to improve N application, N timing and N use by the wheat crop.

be added only if soil test Mg is below 60 pounds per acre. Sulfur deficiencies are best determined by analysis of plant tissue sampled at Feekes 5 (Zadoks 30). If the N:S ratio is greater than 15:1, S should be added at a rate of 20 to 40 lb S/acre. Only water-soluble sources that contain sulfate-S (-SO_4), such as spray grade ammonium sulfate, should be used at this stage of growth.

Micronutrient deficiencies have not been found on wheat grown in Kentucky. The best way to determine micronutrient needs is through plant tissue analysis. See AGR-92 *(Sampling Plant Tissue for Nutrient Analysis)* for additional sampling instructions and interpretation. Micronutrient deficiencies generally occur when the soil pH is too high or too low. A soil pH between 6.0 and 7.0, with a target pH of 6.4, should provide excellent conditions for micronutrient availability and wheat growth. Lime should be applied prior to planting, in the fall.

Burning of Wheat Straw

Burning wheat straw in the field will cause loss of some of the nutrients with the vapor and smoke. Research indicates that losses of carbon (C), N, P and K are as follows:
C - 90 to 100%
N - 90 to 100%
P - 20 to 40%
K - 20 to 40%

Photo 5-7. Most nitrogen fertilizer is applied as a liquid urea ammonium nitrate (UAN) and 28 or 32% N. By using stream bars or stream jet style nozzles, leaf burn from the UAN is minimized. Granular nitrogen (usually urea) can also be applied.

Photo 5-8. Nitrogen test strips in a field with tram lines.