Nitrogen Management for Grain Yield

by Clain Jones, Montana State University Extension Soil Fertility Specialist, and Kathrin Olson-Rutz, Research Associate

Optimum nitrogen management for grain yield includes: basing nitrogen (N) rates on realistic yield potential, knowing the soil residual N, and using appropriate rates, timing, placement, and N sources. The steps are the same for all regions, but decisions should be based on guidelines specific to a grower's area.

REALISTIC YIELD GOAL Variety selection tools are available to pick the best variety for a given goal. Past yields and protein are a good indication of future performance. Advances in equipment and technology for mid-season N applications allow a conservative yield goal to be used to determine pre-plant N rates. A 2nd application can be omitted in dry years to save on N fertilizer.

RESIDUAL SOIL Late fall to early spring soil samples better reflect available soil nitrate-N than late summer to mid-fall samples. Late summer to mid-fall sampled soils can result in under- or over fertilization depending on whether they lose or gain N overwinter. Field specific patterns of overwinter loss or gain can guide adjustments to spring N rates based on fall samples or the decision to spring sample.

RATE Winter wheat requires about 2.6 lb N/bu, and spring wheat requires roughly 3.3 lb N/bu (with 14% protein). Further adjustments are made for soil organic matter, residual stubble, N 'credit' from legume rotations, and soil sampling timing and depth. These are described in the *Fertilizer Rate Calculations* Soil Scoop. Exact rates will vary with variety and growing conditions.

MSU's nitrogen rate calculation tool incorporates yield goal, residual soil N, soil organic matter, fertilizer costs, grain protein discounts, and grain prices to determine N rate for optimal net revenue.

The economic benefit of micro-managing fields for variable rate technology is inconsistent in our region. However, a simplified version of adjusting N rates in field zones with historically low, medium and high productivity may increase N use efficiency and net return. Traditional fertilizer spreaders can be used to variably apply N in these relatively large zones.

SOURCE Dry urea is still the best choice if it can be incorporated by tillage, or greater than ½-inch of water in a single event. Treating winter broadcast urea with N-butyl-thiophosphoric triamide (NBPT, e.g., Agrotain®) can buy time for incorporation by precipitation, which will reduce N loss to the air as ammonia gas. Slow or controlled release N fertilizers may benefit winter wheat yield in wet years or areas where regular urea can be lost to leaching. Their N release is generally too slow to benefit spring wheat yield in our region.

Legumes in rotation are an economical N source. The benefits of legumes depend on the species, when they are terminated, whether they are harvested for seed, forage or grown for green manure cover crops, and the number of times planted in rotation.

Perennial legumes contribute more N than annuals; green manure terminated early contributes more N than legume harvested or terminated late. Termination of cover crops by approximately first bloom is key to preventing yield loss in the subsequent wheat crop. Legumes should make up more than 50% of a mixed species cover crop biomass in order to contribute substantial available N to the following crop.

Legumes can provide a 10 lb/acre N credit (fertilizer N reduction) after just one year (See *Fertilizer Rate Calculations* Soil Scoop), but the wheat yield goal often needs to be adjusted lower than after fallow. Over the long term (at least 3 to 4 cycles), wheat grain yield and protein can be greater after cover crops than fallow with less or no fertilizer N. This provides higher economic returns with greater stability, by reducing the reliance on fertilizer N.

TIMING Nitrogen available to wheat plants up through stem elongation generally benefits yield, while N available after stem elongation contributes directly to grain protein (Figure 1).

Sources that slowly provide N, such as polymer coated urea (e.g., ESN®) or legume residue, are best incorporated in the fall to provide N for early growth. Fertilizers with readily available N [e.g., urea (46-0-0) and urea

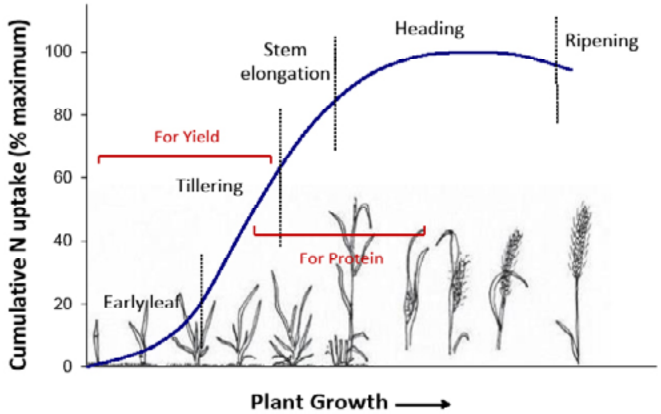

Figure 1. Cumulative N uptake by wheat over the growing season showing windows for readily available fertilizer application.

ammonium nitrate (28-0-0)] are best applied shortly before seeding up to mid-tillering to benefit yield.

Split applications allow for in-season N adjustment based on precipitation to date. Pre-plant and at seeding N should be high enough to meet the crop's early needs, and for longer if there is a risk that high rainfall amounts would interfere with in-season field access. Top-dressing can then boost yield and/or protein. Top dress application timing and rate depends on the amount of N available in the soil at seeding and whether the crop will reach its estimated yield potential. See the calculation box for an example calculation of in-season N rate and timing. Chlorophyll meters (e.g., SPAD, GreenSeeker®, Crop Circle™) and remote sensing technologies are increasingly available to guide in-season N adjustments.

PLACEMENT Ammonia and ammonium based fertilizers should be subsurface placed at least 2" deep or incorporated by tillage or a single rain/irrigation event greater than ½ inch. Safe rates of seed-placed fertilizer increase as soil texture goes from light (sandy loam) to heavy (clay), with wider openers, as row spacing decreases, and with the use of polymer coated or NBPT treated urea. Resources for determining safe rates are listed at the end of this document.

Foliar applications are discussed in the Soil Scoop *Nitrogen Management for Grain Protein*.

SUMMARY Combining optimal early N availability for a realistic yield, with additional fertilization as needed based on the growing season, is generally an economically and environmentally efficient N fertilization strategy. Close attention to N management is very important for optimal grain yields, protein, and economic returns, and protecting groundwater quality.

For more information and references: Publications are available under "Extension publications" at http://landresources.montana.edu/soilfertility/.

Fertilizer Rate Calculations Soil Scoop

Nitrogen Management for Grain Protein Soil Scoop

Nutrient Uptake Timing by Crops to Assist with Fertilizing Decisions EB0191

Practices to Increase Wheat Grain Protein EB0206

MSU Small Grain Variety Selection Tool http://www.sarc.montana.edu/php/varieties/

MSU Small Grains Nitrogen Economic Calculator http://landresources.montana.edu/soilfertility/small-grains-economic-calculator.html

Safe seed-placed rates:

- Saskatchewan Ministry of Ag http://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/soils-fertility-and-nutrients/guidelines-for-safe-rates-of-fertilizer-applied-with-the-seed
- IPNI Online Fertilizer Damage Tool http://anz.ipni.net/article/ANZ-3076

Calculation box: Example in-season top-dress rate and timing calculation for a semi-arid region. Total and fertilizer N need are calculated according to *Fertilizer Rate Calculations* Soil Scoop.

Step	N need (lb N/acre)	N credit (lb N/acre)
1. Example total available N (soil + fertilizer) need	156	
2. Example total fertilizer N need	70	
2. Reduce by amount in seeding blend, e.g., 10 lb N/acre		-10
3. The amount to top-dress = 70-10 = 60 lb N/acre	+60	
4. By when top-dress?		

(156-60)/156 = 61% of total need is used up by the end of tillering (see Figure 1), but since fertilizer takes time to become available and enter the plant, the 60 lb N/acre should be applied by mid-tillering to prevent N deficiency.

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