Nutrient Management for Increasing Wheat Grain Protein

C. Jones* and K. Olson-Rutz

Dept. of Land Resources and Environmental Sciences, Montana State University, Bozeman, MT

IMPACT STATEMENT

A pound of nitrogen (N) put into protein may be better for the bottom line than a pound of N put into yield when protein discounts are high. Mid- to late-season N may provide a necessary protein boost to prevent revenue lost to protein discounts.

SUMMARY

We provide guidelines for optimum N management for grain protein based on local and regional research, as presented in *Practices to Increase Wheat Grain Protein.* Management considerations include: basing N rates on realistic yield potential, knowing the soil residual N, using appropriate fertilizer N rates, timing, placement, and sources, and using tissue N concentrations to determine the likelihood of a protein increase. Combining a conservative early season N rate followed by fertilization near heading to enhance protein, is generally an economically and environmentally efficient N fertilization strategy.

INTRODUCTION

Low wheat grain protein can have a financial impact on Montana producers resulting in reduced economic returns equivalent to $25 to $60/acre. Statewide this is tens of millions of lost revenue dollars. Nitrogen is essential for protein production; thus its management is critical for maximizing returns. In addition to N, protein production requires sufficient amounts of several nutrients such as sulfur and potassium, however, here we focus on N management.

This report provides suggestions to guide management for improved wheat grain protein (additional resources listed at the end).

PRACTICES TO INCREASE PROTEIN

1. Variety Growing wheat with high grain protein begins with selecting the varieties with known high grain protein potential. High grain protein varieties sometimes produce slightly less than low protein varieties, but the economic return from high protein varieties can be greater. The MSU small grain variety selection tool is available to identify the best variety for a given goal and location.

2. Nitrogen management

2.a. Realistic Yield Goal to Determine N rate Past yields and protein are a good indication of future performance. Advances in equipment and technology for mid- to late-season N application allow a conservative yield goal to be used to determine pre-plant N rates.

2.b. Residual Soil N November to early spring soil samples better reflect available soil nitrate-N than late summer samples, which can result in under- or over fertilization depending on whether soils lose or gain N overwinter. In general, MT soils gain about 20 lb N/ac from late summer to early spring, though amounts depend on previous crop and soil depth. However, some soils can easily lose that amount (Fertilizer Facts No. 55). Tracking 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.

2.c. Rate Winter wheat requires about 2.6 lb N/bu, and spring wheat requires roughly 3.3 lb N/bu (with 14% protein; Fertilizer Facts No. 17). 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 *Fertilizer Rate Calculations*.

MSU's small grains economic N 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.

If available N is known to be high, yet protein is low, there may be a sulfur (S) deficiency. This shows up first as yellowing upper (younger) leaves, whereas N deficiency shows up as yellowing lower (older) leaves. A foliar application of 3-5 lb S/acre in a sulfate form should correct the problem if there is sufficient rain or irrigation water after application to wash the sulfate into the root zone.

2.d. Source Urea (46-0-0) is the preferred N source by MT producers because of cost, yet it is susceptible to volatilization (loss to air). Treating urea or UAN (28-0-0 or 32-0-0) with N-butyl-thiophosphoric triamide (NBPT, the active ingredient in Agrotain® and Arborite ® AG) can buy time for incorporation by precipitation, which may increase grain protein. Slow or controlled release N fertilizers can be too slow to benefit yield, but may increase protein.

2.e. Timing Nitrogen available to wheat plants after stem elongation has completed contributes directly to grain protein and has less chance of causing lodging. Urea or UAN to boost protein are ideally applied at flowering and must be followed by irrigation or rain to move the fertilizer into the root zone. If there is high risk of scab, avoid watering, and therefore applying N, within 5 days of flower. In dryland production, apply N between boot and the onset of flowering to increase the chance rainfall will move N into the soil. Control or slow release N fertilizers are best seed-placed to benefit grain protein. Under irrigation they can be spring broadcast to benefit spring wheat protein. To increase wheat protein by 1 point (percent) requires roughly an additional 0.75 lb N/bu of expected yield, applied before or during flowering in dryland production, and roughly an additional 0.45 lb N/bu yield, applied around flowering in irrigated production.

Irrigated spring wheat grain protein is likely to increase with late-season N if the flag-leaf N concentration is less than 4.2% (Fertilizer Facts No. 12). The critical flag-leaf N (CFLN) is the flag-leaf N below which a late-season top-dress should increase protein enough to maximize profit. It goes down as N cost goes up and protein discount goes down (CFLN = 4.2 – 0.18(N cost/protein discount), using N cost as $/lb N and protein discount as cents/bu per 1% protein). Chlorophyll readings are another tool for irrigated spring wheat. Readings at heading that are less than 93% of a well-fertilized reference plot indicate grain protein will likely respond to late-season N. Neither flag-leaf N concentration, nor chlorophyll readings are a reliable tool to predict protein response in dryland wheat in our region.

2.f. Placement Foliar applications should be limited to less than 30 lb N/acre of UAN and 45 lb N/acre of liquid urea to minimize leaf burn and yield loss, and far less should be applied if tank-mixed with surfactant, NBPT, herbicide or fungicide. Liquid, as well as broadcast N, needs about ½-inch of rain or irrigation to be washed into the soil to be very effective due to risk of volatilization and minimal uptake by leaf.

2.g. Crop rotation Legumes in rotation can help increase protein, especially at low N rates. Legumes grown as a green manure (nitrogen-rich cover crop) rather than for grain should be terminated by flowering to retain more soil moisture and allow time for the N to become available (Miller et al., 2006).

REFERENCES

Publications are available at http://landresources.montana.edu/soilfertility/

Fertilizer Rate Calculations under "Soil Scoop"

Practices to Increase Wheat Grain Protein under "Extension Publications"

Fertilizer Facts http://landresources.montana.edu/fertilizerfacts/index.html

No. 12. *Flag Leaf Diagnosis of Grain Protein Response to Late-Season N Application in Irrigated Spring Wheat.*

No. 17. *Predicting Spring Wheat Yield and Protein Response to Nitrogen*

No. 55. *Changes in Soil Nitrate-N Levels from Late Summer to Early Spring in Montana*

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

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

Miller, P.R., R.E. Engel, and J.A. Holmes. 2006. Cropping sequence effect of pea and pea management on spring wheat in the northern Great Plains. Agron. J. 98:1610–1619. doi:10.2134/agronj2005.0302

ACKNOWLEDGEMENTS

We appreciate Rick Engel's review of this paper.

*Corresponding author: clainj@montana.edu