Evaluation of Nitrate Potential in Hay from Five Cereal Forage Species

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Fertilizer Facts

Fertilizer Check-Off

Jan 2012
Number 56

Introduction

In some environments, most species and varieties of cereal can be grown for hay without toxic levels of nitrate appearing in the crop, while other environments are highly conducive to nitrate accumulation. For producers of cereal forages, it is desirable to identify species and varieties of cereals that are relatively stable in nitrate accumulation across a range of environments, and to avoid those that are unstable, that tend most to accumulate high nitrate levels in high nitrate environments. Our objective was to test ten varieties/species of cereals across a range of environments in order to identify those most at risk for high nitrate levels in high nitrate environments.

Methods

Nitrate stability in selected cereal forage varieties/species was determined by creating a range of nitrate environments. Two varieties each of barley (*Hordeum vulgare*, 'Haybet' and 'Westford'), oats (*Avena sativa*, 'Celsia' and 'Otana'), spring wheat (*Triticum aestivum*, 'McNeal' and 'Fortuna'), triticale (X *Triticosecale* Wittmack, 'Pronghorn' and 'Sunland') and spelt (*Triticum spelta*, 'Bavaria' and 'SK3PSelect') were planted in replicated trials at the Central and Western Agricultural Research Centers in Montana and the Sheridan Research and Extension Center in Wyoming. The experimental design was a factorial with each variety/species selection being grown under three nitrogen fertilizer treatments (60, 120, or 180 lb N/acre pre-plant). To determine how each crop's nitrate accumulation changed with maturity, whole plant nitrate concentrations were measured at heading, anthesis, and soft dough. This created 27 different nitrogen fertility level x crop maturity x location environments. Each selection's whole plant nitrate level at a given nitrogen fertility level, crop maturity and location was plotted against the mean of all 10 selections at that nitrogen fertility level, crop maturity and location. This generated 27 total points for regression analysis per selection. Selections with a slope greater than 1.0 have relatively unstable nitrate accumulation, and are simply more risky than those with lower slopes.

Results

All variety/species selections had highly significant correlations between their nitrate concentrations and the average nitrate concentrations across all nitrate environments (Table 1). The selections with the greatest slopes are those that responded to high nitrate environments by accumulating greater nitrate levels than the other selections. The most obvious of these are the two oat selections, Celsia and Otana with slope values over 1.4. These selections are undesirable for producers who are concerned about the risk of high nitrate accumulation in cereal forages. There were relatively large differences in how

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varieties responded to nitrate environment with both barley and spelt. For example, Haybet barley, with a slope of 0.90, accumulated relatively less nitrate than the average of the 10 selections (slope = 1.0), whereas Westford barley (slope = 1.14) accumulated more than the average. McNeal spring wheat had the lowest slope of all selections, and both triticale varieties had low slopes as well.

The greatest effect of crop maturity occurred between anthesis and soft dough (Table 2). During this period, nitrate levels dropped about 35%. This illustrates that, if faced with high nitrate levels at heading or anthesis, delaying harvest until soft dough is likely to result in significantly lower nitrate levels. This has to be weighed against the decline in feed value of the forage which can lose 1/3 of crude protein from heading to soft dough stage and may decrease in digestibility (Helsel and Thomas 1987; Khorsani et al. 1997).

Fertilizer Facts

- The oat varieties tested had a greater potential for nitrate accumulation in high nitrate environments than barley, spring wheat, triticale and spelt selections.
- Haybet barley has a lower potential for nitrate accumulation than Westford barley.
- McNeal spring wheat had the lowest potential for nitrate accumulation compared to the other selections.
- The two triticale selections also had low nitrate accumulation potential.
- Nitrate levels dropped 35% from anthesis to soft dough suggesting delayed harvest may be worthwhile in high N environments or with nitrate accumulating varieties.

References:

Helsel, Z.R. and J.W. Thomas. 1987. Small Grains for Forage. Journal of Dairy Science. 70:2330-2338.

Khorasani, G.R., P.E. Jedel, J.H. Helm and J.J. Kennelly. 1997. Influence of stage of maturity on yield components and chemical composition of cereal grain silages. Canadian Journal of Animal Science. 77:259-267. http://pubs.aic.ca/doi/abs/10.4141/A96-034

Table 1.For each selection, the regression of its whole plant nitrate levels against the mean of the 10 selections' whole plant nitrate levels at 27 nitrogen fertility level x crop maturity x location environments. Nitrate levels were measured as nitrate-N in ppm. All regressions are significant with 99.9% probability. Slopes below 1 indicate more stable nitrate accumulation (less risky).

Species	Variety	R^2	Slope
Barley	Haybet	0.89	0.90
	Westford	0.76	1.14
Oats	Celsia	0.82	1.49
	Otana	0.85	1.43
Spelt	SK3PSelect	0.90	0.81
	Bavaria	0.72	1.09
Spring Wheat	McNeal	0.54	0.70
	Fortuna	0.84	0.95
Triticale	Pronghorn	0.81	0.86
	Sunland	0.87	0.80

Table 2. Effect of growth stage on whole plant nitrate levels. Values are means across all selections, nitrogen fertility levels, and locations. Different letters indicate significant differences with 95% probability.

Growth stage	Nitrate-N (ppm)
Heading	1147 a
Anthesis	1074 a
Soft dough	688 b
$LSD_{0.05}$	193

Edited by Clain Jones, Extension Soil Fertility Specialist, and Kathrin Olson-Rutz, Research Associate