

Sap Analysis for Diagnosis of Nitrate Accumulation in Cereal Forages

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Introduction

Nitrate accumulation in forages can have serious deleterious effects on livestock performance, even leading to death, depending on the concentration of nitrate in the forage and the level of consumption. Recommendations for mixing forage with nitrate-free or low-nitrate feeds to attain safe rations for livestock feeding are based on ranges of nitrate levels in cured hay (Tables 1 and 2).

We sought to develop a new quickest for nitrate in cereal forages, one that could be used to predict from a standing crop what range of nitrate concentrations would be expected after harvest. Our objective was to determine if nitrate concentrations in sap expressed from the lower nodes of selected small grain forages at the time of harvest are correlated with nitrate levels in the dry hay. We also sought to determine if this sap nitrate analysis could be reliably performed with the Cardy portable nitrate meter (Spectrum Technologies).

Methods

Otana oats and Haybet barley were planted at four locations in Montana: the Northern, Northwestern, and Western Agricultural Research Centers and at the Post Farm in Bozeman. Six nitrogen (N) fertilizer rates ranging from 0 to 200 lb N/ac were applied to plots within each species. Each plot was sampled five times between crop heading and the soft dough stage of grain development. Part of each sample was dried and analyzed for dry matter nitrate concentration, while the remainder

was used for sap extraction.

Sap was extracted with a hand press from the lower stem portions of the plants and analyzed for nitrate concentration using a nitrate-specific electrode and the Cardy meter.

Dry matter nitrate concentration was linearly correlated with the nitrate-specific electrode sap nitrate readings for both oats and barley. For oats, the correlation equation was $Y = -0.0062 + 0.0012X$, $r = 0.89$; and for barley, $Y = 0.021 + 0.00084X$, $r = 0.87$, where Y = dry matter nitrate (%), and X = sap nitrate (ppm) for both equations. This indicates good reliability in predicting the nitrate concentration in cured hay from analysis of nitrate concentrations in sap taken at time of harvest.

Results

The Cardy meter readings were linearly correlated with the laboratory model nitrate-specific electrode readings, but were 25% greater. We therefore developed separate tables for relating sap nitrate readings to dry hay nitrate levels depending on the instrumentation used (Tables 1 and 2). Note that both nitrate and nitrate-N (nitrate as N) values are given because nitrate can be measured, and/or reported, using either name.

Fertilizer Facts:

- Sap nitrate concentration in cereal hays is well-correlated with dry matter nitrate concentrations.
- Sap nitrate analysis should be considered in management of nitrate levels in cereal hays.

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TABLE 1. Ranges of critical nitrate concentration in dry hay for livestock feeding and equivalent ranges in fresh plant internode sap as measured with a nitrate electrode. Sap values are to be used for pre-harvest diagnosis of potential nitrate toxicity in oats and barley grown for forage. Critical sap nitrate levels are reported as both nitrate-N and nitrate since standards used in nitrate quicktests vary. Critical ranges in dry hay and feeding guidelines are from Cash et al. (1993).

Dry hay nitrate (%)	Electrode Sap nitrate-N (ppm)		Electrode Sap nitrate (ppm)		Feeding guidelines
	Oat	Barley	Oat	Barley	
<0.3	<250	<320	<1130	<1400	Generally safe
0.3 to 0.4	250 to 340	320 to 430	1130 to 1500	1400 to 1900	<75% of ration
0.4 to 0.6	340 to 500	430 to 650	1500 to 2240	1900 to 2900	<50% of ration
0.6 to 1.2	500 to 1000	650 to 1330	2405 to 4450	2900 to 5910	<25% of ration
>1.2	>1000	>1330	>4450	>5910	Do not feed

TABLE 2. Ranges of critical nitrate concentration in dry hay for livestock feeding and equivalent ranges in fresh plant internode sap as measured with the Cardy portable nitrate meter. Sap values are to be used for pre-harvest diagnosis of potential nitrate toxicity in oat and barley grown for forage. Critical sap nitrate levels are reported as both nitrate-N and nitrate since standards used in nitrate quicktests vary.

Dry hay nitrate (%)	Cardy sap nitrate-N (ppm)		Cardy sap nitrate (ppm)		Feeding guidelines
	Oat	Barley	Oat	Barley	
<0.3	<350	<440	<1540	<1970	Generally safe
0.3 to 0.4	350 to 450	440 to 590	1540 to 2000	1970 to 2630	<75% of ration
0.4 to 0.6	450 to 660	590 to 890	2000 to 2930	2630 to 3950	<50% of ration
0.6 to 1.2	660 to 1290	890 to 1780	2930 to 5690	3950 to 8000	<25% of ration
>1.2	>1290	>1780	>5690	>8000	Do not feed

References:

Cash, S.D., H.F. Bowman, and R. Brownson. 1993. Nitrate poisoning in forages. Mont. St. Univ. Ext. Serv. MontGuide 9301.

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