Nitrate Concentrations of Annual Forages Grown for Grazing in Nebraska

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Summary with Implications

Annual forage samples sent by producers to Ward Laboratories Inc. for nitrate analysis were evaluated to determine which cover crop species in Nebraska are most likely to accumulate nitrates, and how often the accumulated nitrates are considered toxic by traditional recommendations. Additionally, nitrate levels of cover crop mixes grown in research trials were analyzed to ensure species differences were repeated when grown together in the same fields. Brassicas accumulate more nitrate than small grains, millet, sorghum/sudan grasses, or cover crop mixes. Brassicas accumulated levels of nitrate considered moderately to highly toxic in 48% of the samples. The other cover crop species accumulated potentially toxic nitrate levels in 20–28% of the samples. However, when cattle graze these forages, there are multiple factors that may mitigate toxicity. Cattle have grazed annual forages containing nitrate concentrations considered toxic, and no adverse health consequences were observed. More research is needed to reevaluate the risk of nitrate toxicity when grazing cover crops.

Introduction

Nitrate toxicity has long been recognized in ruminant animals and general guidelines indicating threshold nitrate concentrations were developed in the 1940s and 1960s to advise producers on what levels of nitrate could be fed before becoming detrimental. Cover crops are frequently grazed by producers, but these forages often test high in nitrate, and a producer must then decide what course of action will be taken. The goal of this study was to determine which cover crop species grown in Nebraska are most prone to accumulating high nitrate concentrations, as well as how often these species would be considered toxic when using traditional guidelines.

Procedure

This experiment included a collaboration with Ward Laboratories Inc. (Kearney, NE). Fresh annual forage samples (n=443), that were sent by producers to Ward Laboratories for nitrate analysis and contained less than 26% DM (mean=18.2% SD ± 4.6%) during 2016–2017 were summarized to determine which forages accumulated the most nitrate-nitrogen (NO_3-N), and how often these forages accumulated nitrate considered toxic by traditional recommendations. The samples were classified into five species groups 1) brassica (turnip, radish, collard; n=63), 2) mix (cover crop mix or multiple annual forage species; n=34), 3) small grain (oat, rye, triticale, wheat, barley; n=70), 4) millet (pearl, foxtail, German; n=40), or 5) sorghum/sudan (cane, sorghum, sudangrass; n=236). These samples were analyzed to evaluate species differences in average nitrate accumulation. Each species category was also sorted to determine what proportion of the samples in each species category would fall into the traditional nitrate toxicity recommendations 1) Safe (<1400 ppm NO_3-N DM), 2) Marginal (1400–2100 ppm NO_3-N DM), 3) Caution (2100–5000 ppm NO_3-N DM), 4) Toxic (>5000 ppm NO_3-N DM).

Additionally, six fields planted to a small grain brassica mix in late summer were sampled in late fall to evaluate how species accumulation differs when grown under identical conditions. These mixtures included oats or rye planted with turnips and/or radishes. Samples were obtained by randomly selecting individual species throughout the field, clipping small grains at ground level, and pulling the whole brassica plant up and separating the top from the roots. All samples were dried in a 140 °F forced air oven and ground to a 1 mm particle size in a Wiley mill. Lab analysis was done to determine ppm nitrate-nitrogen on a dry matter basis (ppm NO_3-N DM) using a nitrate ion selective electrode. One gram of dried, ground sample was continuously mixed in 40 ml of pH 7 water at room temperature with a rocker for 30 minutes before measuring. A standard line with known nitrate standards was used to calibrate the electrode prior to sample analysis.

Results

From the commercial lab dataset, there was a significant effect of species on nitrate accumulation ($P < 0.01$). Brassicas contained the most ($P < 0.01$) nitrate with an average of 4060 ppm NO_3-N. The cover crop mix (1806 ppm NO_3-N), sorghum/sudan (1564 ppm NO_3-N), millet (1391 ppm NO_3-N), and small grains (1008 ppm NO_3-N) did not differ ($P > 0.05$) although there was a slight tendency for the cover crop mixes to contain more nitrates than small grains ($P = 0.10$).

The six field collections with small grain and brassica mixes grown agreed with the dataset from the commercial laboratory. Small grains (161 ppm NO_3-N) contained less nitrate than brassicas ($P < 0.01$). Radish tops (9248 ppm NO_3-N), radish roots (9073 ppm NO_3-N), turnip roots (6354 ppm NO_3-N), and turnip tops (5932 ppm NO_3-N) did not differ in nitrate content. However, there was a tendency for radish tops to contain more nitrate than turnip tops ($P = 0.06$) and turnip roots ($P = 0.10$), as well as a tendency for radish roots to contain more nitrate than turnip tops ($P = 0.07$).

Figure 1 illustrates how often each species category from the commercial lab dataset would be considered safe, marginally safe, fed with caution, and toxic. Brassicas exceeded the caution threshold in 48% of samples and were 5 times more likely ($P < 0.01$) to be above this threshold than any of the other species categories. The other species did not differ in the frequency they

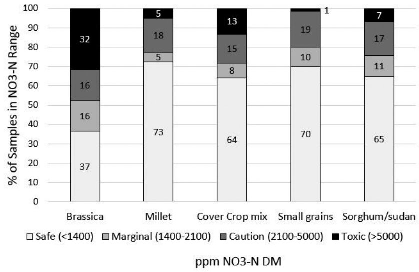

Figure 1. Species distribution of samples in NO_3-N risk of toxicity categories.

Table 1. Example annual forage trials with average nitrate-nitrogen concentrations

Forage Type	NO_3-N, ppm	Sex	Year	ADG (lb./d)
Oat, Turnip, Radish mix	6146	Steers	2014	2.2
Oat, Turnip, Radish mix	4655	Steers	2015	1.3
Oat, Turnip, Radish mix	2158	Heifers	2015	1.6
Oats (Hill)	912	Steers	2015	1.1
Oats (Valley)	4414	Steers	2015	1.5
Oats (Hill)	3921	Steers	2016	2.3
Oats (Valley)	8026	Steers	2016	2.5

[1]Oats sampled to ground level

[2]Brassicas sampled by harvesting the entire plant and separating the top from the root

[3]Traditional guidelines would consider NO_3-N concentrations >2100 as moderately toxic and >5000 as toxic

would fall into the caution and toxic categories ($P > 0.05$). The other species ranged from 20–28% of the samples falling into the caution or toxic categories, indicating that there is still a high likelihood that these annual forage samples could be considered toxic using traditional guidelines.

Although the nitrate concentrations in these forages frequently exceed what traditionally would be considered toxic, the signs of nitrate toxicity are not always present when grazed. The traditional guidelines were developed in trials feeding high nitrate hay, or supplemental nitrate salts given through a stomach tube or top dressed onto feed, resulting in guidelines that are not reflective of cattle grazing annual forages. Table 1 provides examples of seven different grazed cover crop paddocks with varying levels of nitrate in the forage. In these examples, weaned calves grazing these forages had no observable signs of nitrate toxicity even though the nitrate concentrations often exceeded traditional guidelines. When grazing, multiple factors may provide some mitigation that allow the cattle to graze high nitrate forages without adverse health consequences. If cattle are not forced, they tend to graze the leaf and top parts of the plant first which are lower in nitrate than the stem, with the lower part of the stem having the most nitrate. Thus, grazing at stocking rates that allow for selectivity and self-adaptation (grazing lower nitrate plant parts and working down the plant) can reduce toxicity potential. Some other mitigation factors include a high-quality diet (more energy for bacteria in the rumen to use the nitrite), fresh forages releasing nitrate in the rumen at a slower rate than dry forages, and a slower rate of intake when grazing rather than consuming hay.

Conclusion

When utilizing annual forages as a feed resource, it is important to be aware of the risk of nitrate accumulation. If utilizing brassicas as a forage, understand that these species frequently accumulate high levels of nitrate and utilizing a grass in the mix may be recommended as the grass will keep brassicas from being 100% of the diet. However, forages that exceed traditional "toxic" recommendations have been grazed without consequence. Future research is needed to reevaluate the toxic level of nitrate in grazed annual forages before better recommendations can be made.

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