

Nitrate Poisoning in Forages

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Forage crops can accumulate toxic amounts of nitrate (NO_3). High quantities of nitrates can accumulate in cereal grains (oats, rye, wheat, barley, triticale, etc.), sorghum, sudangrass, millet, corn and, on very rare occasions, alfalfa. Some weeds, like kochia and Russian thistle are sometimes used for forage and have high nitrate levels especially when growing under adverse conditions. Abnormal growing conditions such as drought, frost, unseasonable or prolonged cool temperatures, hail, shade, disease and herbicide damage can cause high nitrate accumulation in forage. The roots of growing plants will continue to take in nitrate nitrogen; however, normal plant metabolism which converts nitrate to protein is disrupted and high nitrate levels accumulate. All plants contain nitrate, but nitrate levels toxic to livestock are mostly associated with forages (hay, fodder, silage, pasture or weeds) grown on soils that have received high applications of manure or nitrogen fertilizer.

As early as 1895, nitrate poisoning of livestock was reported. Livestock losses occurred for many years before elevated nitrate levels in forage were determined to be the cause of death. The term "oat hay poisoning" was the common explanation for livestock losses in the 1930s because large acreages of oats were harvested for forage during the drought years.

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Nitrate Toxicity

Nitrate in itself is not toxic to animals, but at elevated levels it causes a noninfectious disease called nitrate poisoning. Nitrates normally found in forage consumed by ruminant animals are broken down to nitrite (NO_2) and then to ammonia (NH_3). The ammonia is then converted to protein by microbes in the rumen (first stomach of a ruminant). Ruminant animals with high nitrate levels in their diet accumulate nitrite. Nitrite is absorbed into the blood and combines with hemoglobin forming methemoglobin which causes a reduction in the ability of blood to carry oxygen from the lungs to the body tissue. When the blood can no longer supply oxygen to the body, the animal suffocates.

Symptoms of nitrate poisoning

Signs of early or chronic toxicity:

- Watery eyes
- Reduced appetite
- Reduced milk production
- Rough hair, unthrifty appearance
- Weight loss or no weight gain
- Signs of Vitamin A deficiency
- Abortion

Signs of acute toxicity:

- Accelerated pulse rate
- Labored breathing, shortness of breath
- Muscle tremors
- Weakness

- Staggering gait
- Cyanosis (some membranes, such as the tongue, mouth, vulva and the whites of eyes, turn blue)
- Death

Nitrogen from the soil is taken up by plant roots in the nitrate form. Plants convert nitrate to nitrite which in turn is converted to ammonia and then to amino acids, the building blocks that form protein. Higher nitrate levels are usually present in immature plants and decrease as plants mature. Nitrate concentration is highest in the stems, especially in the lower third of the stem, and at the nodes. An intermediate level usually exists in leaves and very little is found in grain.

The effect of sub-lethal nitrate levels on livestock health and performance is not well-defined; however, safe and unsafe levels of nitrate in livestock feed have been established. Despite the guidelines, the effects of nitrate vary with each animal, condition of livestock, other feeds in the diet and weather.

The following nitrate levels are used as a guideline for most Montana conditions:

Concentration of Nitrate (% on Dry Matter basis)	Comment
Less than 0.3	Generally safe to feed
0.3 to 0.4	Can be fed if limited to 75% DM in ration
0.4 to 0.6	Can be fed if limited to 50% DM in ration
0.6 to 1.2	Can be fed if limited to 25% DM in ration DO NOT USE FOR PREGNANT ANIMALS
More than 1.2	DO NOT FEED

Nitrate toxicity is most likely to occur when livestock are pastured or fed green-chop, followed by hay. The least hazardous feed is silage. Ensiling forage usually lowers the nitrate level 10 to 60 percent. The nitrate level in hay will usually remain constant or decline slightly in storage. Producers should never assume their forage levels are safe if they know a crop was exposed to any of the growing conditions mentioned earlier which can increase nitrate accumulation.

Sampling plants or feeds for nitrate

Precautionary measures should be taken if high nitrate concentrations are suspected prior to harvesting or feeding the forage. Even under ideal conditions, nitrate accumulation is unpredictable. Nitrate concentration can vary in areas of a single field, haystack or silo. Therefore, nitrate testing is advised in many situations. Most county MSU Extension Service Offices can provide a rapid qualitative test for green forages to determine the presence of nitrates.

Standing crops such as oats or barley should be sampled by collecting 20 stems randomly by traversing in a zigzag pattern across an entire field. The plants should be clipped at ground level, and tested by an Extension Agent trained in nitrate testing. If nitrate is detected using the qualitative test, and growing conditions are normal, a harvest delay of several days will usually reduce nitrate levels rapidly.

Periodic testing may be necessary to assure that the nitrate level has declined. The qualitative test should only be used as a preliminary screening measure, and forages suspected of having elevated levels of nitrates should be submitted for laboratory analysis. Nitrate levels can be quantitatively determined at the Chemistry Station Analytical Laboratory, McCall Hall, MSU, Bozeman, MT 59717, or at private commercial laboratories.

Sampling hay or haylage (low moisture silage) for nitrate requires that appropriate samples be collected and tested. An accurate measurement of forage nitrate is not possible unless the sample analyzed in the laboratory is representative of the forage lot in question. Poor sampling techniques and an inadequate number of subsamples are the main sources of error in analysis. For hay, at least 20 random bales from a lot should be sampled with a hollow core probe and composited. A hay lot is defined as the hay from a single field that is uniform in maturity and harvested within a 48-hour period. At least one pound of forage is needed for an adequate sample. Representative silage samples should be kept frozen until analysis to prevent nitrogen

losses from volatilization or chemical changes. Hay and silage samples should be sealed in plastic bags and shipped to the laboratory for testing.

Feeding forages with elevated levels of nitrate

Forages with sub-lethal nitrate levels can be fed to livestock with appropriate precautions. If there is a potential nitrate problem, growers should first have an accurate laboratory analysis of nitrate concentration. No single level of nitrate is toxic under all conditions. Cattle can safely convert nitrates present at up to two percent of the total dry matter of the ration, or about 20 grams of nitrate per 100 pounds of body weight. If forages constitute 40 to 60 percent of the total diet, then the nitrate concentration could be three to four percent of the ration dry weight to be considered hazardous under most conditions.

High-nitrate feeds can be diluted with low-nitrate feeds to reduce the nitrate hazard by using the following equation:

$$W_L = (W_H) (\%_H - \%_B) / (\%_B - \%_L), \text{ where}$$

W_L = weight of low-nitrate hay required,

W_H = weight of high-nitrate hay,

$\%_H$ = nitrate concentration of high-nitrate hay,

$\%_B$ = nitrate concentration desired in final blend,

$\%_L$ = nitrate concentration of low-nitrate hay to be used for blending.

For example, a producer with 10 tons of hay tested at 0.6% (6000 ppm) nitrate, could blend 15

tons of hay tested at 0.1% (1000 ppm) to produce 25 tons of feed with 0.3% (3000 ppm) nitrate. The two hay lots should be processed and mixed thoroughly in a tub grinder to provide the proper dilution. Levels of non-protein nitrogen (urea, etc.) and nitrates in drinking water should be considered in rations blended to reduce nitrate problem. Livestock should not be hungry when fed forages suspected of being high in nitrate. Rations should be rich in carbohydrates to encourage rapid conversion of nitrate to ammonia. Animals should be fed hay known to be safe prior to grazing a pasture of forage suspected of having high nitrate.

Please consult with your local county Extension agent and veterinarian for specific questions regarding nitrate poisoning or sampling of forage suspected of containing dangerous levels of nitrate.

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