Nitrate Toxicity

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Nitrogenous products accumulate in plants when soil nitrogen levels are high and readily available but the plant is unable to utilize it. This is why plants can accumulate toxic levels of nitrates during drought conditions. Nitrates (NO_3) are reduced to highly toxic nitrites (NO_2) in the rumen of cattle and sheep. Nitrites, in turn, are reduced to ammonia and then incorporated into bacterial protein. When nitrate consumption is excessive, the reduction of nitrite to ammonia overwhelms the system, and toxic levels of nitrites accumulate in the rumen and bloodstream. Excessive levels of nitrites oxidize iron in hemoglobin, producing a compound called methemoglobin. Methemoglobin cannot carry oxygen to the tissues. The result is a lack of oxygen throughout the body. High levels of methemoglobin give blood a chocolate color.

Nitrate levels can go up and down rapidly in plants. It accumulates only in the vegetative parts of plants, not in the grain or fruit. Highest levels are found in the lowest part of the stalk. In a test at the Veterinary Diagnostic Laboratory at Iowa State University, samples from a corn plant taken from 0 to 12" had 2.53% nitrate, from12 to 24" had 0.38% nitrate, and from 24 to 36" had 0.1%. Cool season grasses such as fescue, orchard grass, and timothy are not incriminated in nitrate poisoning, and legumes are seldom a problem.

Silage loses more than half, in many cases 80-90%, of the nitrate in the ensiling process. Toxic gases such as nitrogen dioxide and nitrogen tetroxide (N_2O_4) are produced in the ensiling process and may form a brown colored gas on top of the silo. Livestock and people have been killed when this gas, which is heavier than air, floats down a silo chute and into a barn or confined area. Crops that are put in a silo in a very dry condition may lose only 20% of the nitrate. Addition of 10 to 20 lbs of limestone per ton of silage delays the drop of silage pH and increases the amount of nitrate removed during the ensiling process.

Nitrate may be converted to the much more toxic nitrite by bacterial action in wet bales of hay. Excessive soaking with water may result in higher levels of nitrite near the bottom of large bales and stacks. Serious episodes of nitrate toxicity from oat hay have occurred in Iowa and other states.

Nitrate accumulation is usually not excessive unless adequate soil moisture is present. Drought stressed crops that receive rain a few days before harvest can accumulate significant levels of nitrate. Acidic soils, low molybdenum, sulfur, phosphorus, and low environmental temperature (<55 degrees), and good soil aeration are conducive to nitrate accumulation. Herbicide damage to plants can also lead to significant nitrate uptake.

Symptoms of acute nitrate poisoning in animals are related to the lack of oxygen in the tissues. These include muscular weakness, incoordination, accelerated heart rate, difficult or rapid breathing, cyanosis, coma, and death. Less severely affected animals may be listless and only show rapid respiration when exercised. A sudden decrease in milk production, abortion due to lack of oxygen supply to the fetus, poor performance and feed conversion are symptoms of chronic toxicity. Of the crop plants, drought stressed green chopped corn is the most likely cause of nitrate toxicity in Iowa. Sorghum/Sudan harvested or grazed under the same conditions may cause problems. Oat hay harvested from land that has had heavy applications of nitrate fertilizer and a rapid regrowth from rain just prior to harvest has resulted in nitrate poisoning.

Plants That Can Accumulate Nitrates

Crop Plants	Weeds
Oats	Pigweed
Beet	Lamb's quarter
Rape	Canada thistle
Soybean	Jimsonweed
Flax	Wild sunflower
Alfalfa	Fireweed
Rye	Cheeseweed
Sudan grass	Smartweed
Wheat	Dock
Corn	Russian thistle
Sweet clover	Nightshade
	Johnson grass

Cattle and sheep can usually tolerate up to 0.5% nitrate on a dry matter basis, although going from almost no nitrate intake to this level can cause problems. The rumen needs time to adapt. Total nitrate intake, including from drinking water, must be considered. Due to rapid growth of algae, farm ponds are rarely a significant source of nitrate unless direct runoff of nitrogen fertilizer has occurred. Feeding non-protein nitrogen such as urea does not affect susceptibility to nitrate toxicity. Intake of large amounts of nitrate at one feeding is more likely to produce toxicity than intake of the same levels spread out over several hours. Livestock can adapt to higher levels of nitrate intake over a period of several days. Inclusion of grain in the diet speeds up the conversion of ammonia to protein and makes ruminant animals much less susceptible to nitrate toxicity.

Acute nitrate toxicity is much less common than most people realize. Only a few episodes have occurred in Iowa. Those feeding green chopped drought-stressed corn on highly fertile land may want to consider testing.

Toxicity Potential of Green-chopped Corn

Condition of Corn	Toxicity Potential
Barren, stunted, N supply normal to high	High
Barren to poor grain yield, N supply normal to high	Medium
Poor to moderate grain yield, normal N supply	Low
Corn with moderate to high grain yield	Low

When sampling green chop, collect a total of two pounds from various areas of the field. Tightly pack and freeze the sample in a plastic bag pending delivery to the laboratory. Several private laboratories and the Veterinary Diagnostic Laboratory at Iowa State University can test for nitrates. Samples sent to the Veterinary Diagnostic Laboratory must be submitted by or in the name of a practicing veterinarian.

Representative Nitrate Sample Results
Veterinary Diagnostic Laboratory
Iowa State University in a "drought year"

Nitrate Levels	Number of Samples
0 to 0.2%	14
0.2 To 0.65%	8
0.65 to 1.0%	1
1.0 to 2.0%	1
>2.0%	1

Laboratory results may be reported in several ways such as nitrate, nitrate nitrogen (NO_3-N), or potassium nitrate (KNO_3). When interpreting laboratory values, make sure that interpretation is based on the correct reporting method.

Interpretation of Laboratory Results

KNO_3	NO_3-N	NO_3	Recommendations for feeding
0-1%	0-0.15%	0-0.65%	Generally considered safe
1-3%	0.15-0.45%	0.65-2%	Caution: Problems have occurred at this level. Mix, dilute, limit feed forages at this level
>3%	>0.45%	>2%	DANGER, DO NOT FEED: Potential for toxicity high.

Summary Recommendations:

1. Acute nitrate toxicity is much rarer than many realize.
2. Those who intend to feed drought stressed green-chopped corn from high fertility soils should consider testing, especially if a short period of rapid growth has occurred just prior to harvest.
3. Cattle and sheep can tolerate up to 0.5% nitrate on a dry matter basis. Give them time to adjust by diluting the suspect feed
4. Cattle and sheep can tolerate more nitrates if feeding occurs over a period of several hours.
5. Nitrate tolerance is increased if grain is fed.
6. The nitrate levels in the feed and water sources are additive.
7. Drought stressed corn should be cut at 12 to 18 inches above the ground level, as the lower stalk has the highest concentration of nitrate.
8. Fermentation during the ensiling process results in the loss of much of the nitrate and greatly reduces the risk of toxicity.
9. Corn plants with even a small ear ("nubbin") rarely accumulate significant levels of nitrogen, especially above the bottom 12" of stalk.
10. Gradually introduce cattle to suspect forages over a period of several days.

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