Iowa Beef Center
IOWA STATE UNIVERSITY

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. In the rumen of cattle and sheep, nitrates (NO_3) are reduced to highly toxic nitrites (NO_2) which in turn are reduced to ammonia and then incorporated into bacterial protein. When nitrate consumption is excessive, the reduction of nitrite to ammonia becomes overloaded, and toxic levels of nitrites accumulate in the rumen.

Excessive levels of nitrites oxidize iron in the hemoglobin molecule from the ferrous to the ferric form. This compound is called methemoglobin and lacks the capacity to 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. Cool season grasses such as fescue, orchard grass, and timothy are not incriminated in nitrate poisoning, and legumes are seldom a problem. Green chop made from drought stressed crops such as corn grown on highly fertile soils is the most dangerous.

Silage loses more than half, in many cases 80-90%, of the nitrate in the ensiling process. Toxic gases such as nitrogen dioxide (NO_2) 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 an extremely dry condition may lose only 20% of the nitrate. An addition of 10 to 20 lbs. of limestone per ton of silage delays the drop in 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.

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. Acid soils, low molybdenum, sulfur deficiency, phosphorus deficiency, low environmental temperature (55 degrees), and good soil aeration are conducive to nitrate accumulation. Herbicide damage to plants also can lead to significant nitrate uptake.

The following plants are known to accumulate nitrate, possibly other annual grasses will as well:

Plants that can accumulate nitrates

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

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. Drop in milk production, abortion due to lack of oxygen getting to the fetus, poor performance and feed conversion are seen in cases of nitrate toxicosis.

Of the crop plants, drought stressed green chop corn is the most likely to cause 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 caused a few cases of nitrate poisoning. Several weeds can accumulate nitrates but seldom cause toxicity because livestock usually will not eat them.

A useful rule of thumb is that cattle and sheep can tolerate up to 0.5% nitrate on a dry matter basis. Total nitrate intake, including from drinking water, must be considered. 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 ruminants less susceptible to nitrate toxicity.

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
Corn 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

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

Form of Nitrate Reported			Recommendations for Feeding
KNO_3	NO_3-N	NO3	
0 - 1% 0-10,000ppm	0 - 0.15% 0-1500ppm	0 - 0.65% 0-6500ppm	Generally considered safe for livestock.
1 - 1.6% 10,400-16000 ppm	0.15 - 0.23% 1495-2300 ppm	0.65 - 1% 6500-10,000 ppm	Caution: Potentially toxic at this level. Mix, dilute, limit feed forages at this level.
>1.6% >16,000 ppm	>0.23% >2300 ppm	>1% >10,000 ppm	DANGER, DO NOT FEED: Potential for toxicity high.

Summary Recommendations:

1. 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.
2. Cattle and sheep can tolerate up to 0.5% nitrate on a dry matter basis.
3. Cattle and sheep can tolerate more nitrates if feeding occurs over a period of several hours.
4. Nitrate tolerance is increased if grain is fed.
5. The nitrate levels in the feed and water sources are additive.
6. Drought stressed corn should be cut at 12 to 18 inches above the ground level, as the lower stock has the highest concentration of nitrate.
7. The ensiling process results in the loss of much of the nitrate and greatly reduces the risk of toxicity.
8. Gradually introduce cattle to suspect forages over a period of several days.

To give a perspective on similar recommendations information from surrounding states:

Minnesota (About the same levels as Iowa but 4 categories) NOTE the units are listed as ppm NO_3-N)

ppm NO_3-N in dry matter	Comment
0-1500	Safe level under all conditions
1500-3000	Feeds will generally be safe when introduced into the ration gradually. At upper end (2500-3000), limit nitrate feed to 50% of the total ration DM.
3000-4500	Feeds in this range should be restricted to 25% of the total ration DM.
Over 4500	Forages over 4500 are potentially toxic and should not be fed.

Kansas (More conservative on the upper end)

ppm NO_3	"Effect on Animals"
0-3000	Virtually Safe
3000-6000	Moderately safe for most situations, limit use for stressed animals to 50% of the total ration
6000-9000	Potentially toxic to cattle depending on the situation; should not be the only source of feed
9000 and above	Dangerous to cattle and often will cause death

Nebraska (Like Kansas, more conservative on the upper end)

Potentially Lethal Levels	%	ppm
NO_3 – N	>0.21	2100
NO_3	>0.9	9000
KNO_3	>1.5	15,000

Wisconsin and Kentucky

NO_3-N ppm	NO_3-N %	NO_3%	Comment
<1000	0.1	0.44	Safe. A 1000 lb cow consuming 20 pounds of dry matter would consume about 9g of NO_3-N or less than 1g per 100 lb of body weight.
1000-2000	0.1-.2	0.44-.88	Generally safe when fed balanced rations. Best to limit to half of the total dry ration for pregnant animals and also be sure water is low in nitrate.
2000-4000	0.2-0.4	0.88-1.5	Limit amount to less than half of total ration (KY to ¼). Be sure ration is well fortified with energy, minerals, and vitamin A.
Over 4000	>0.4	>1.5	Potentially toxic – do not feed.

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