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Nitrate Poisoning of Livestock


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Revised by
James Rogers
Forage Crops Production Specialist,
NDSU Extension – North Central Research Extension Center
Justin (Jake) Gilbreath
Assistant Professor/Extension Veterinarian – Livestock Stewardship
Department of Animal Science
Michelle Mostrum
Research E/C Specialist,
AES Veterinary Diagnostic Services

Nitrate poisoning can occur commonly in cattle raised in North Dakota and other areas of the western Great Plains.

Poisoning usually is associated with animals ingesting forage or feed with high nitrate content, causing nitrite to accumulate.

Sheep and cattle are more susceptible to poisoning than non-ruminant species because microbes in their digestive tract favor the conversion of nitrate to nitrite.

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Plant Factors Favoring Nitrate Poisoning

Plant Species and Agronomic Factors

High levels of nitrate accumulation in plant tissue occurs due to luxury uptake of nitrogen from the soil by the plant and the plant's inability to metabolize the luxury consumed nitrogen. This inability to metabolize nitrogen happens when the plant's growth has slowed or stopped, which can be caused by environmental conditions such as drought, overcast weather, frost, cool temperatures or other factors that can create plant stress and impede plant growth. The majority of nitrate poisoning cases in North Dakota occur with drought-stressed corn and small grains. However, a number of other plants also can accumulate nitrate, including sudangrass, sorghum-sudan hybrids and millet. Table 1 lists common plants known to accumulate nitrate if conditions are favorable.

Table 1. Common plants known to accumulate nitrate

Crops	Weeds
Barley	Canada thistle
Corn	Dock
Flax	Jimsonweed
Millet	Johnson grass
Oats	Kochia
Radishes	Lambsquarter
Rape	Nightshade
Rye	Pigweed
Soybeans	Russian thistle
Sorghum	Smartweed
Sudangrass	Wild sunflower
Sugar beets	
Sweetclover	
Turnips	
Wheat	

Plants that have been fertilized with nitrogen typically have higher nitrate levels than nonfertilized plants. Annual forage crops tend to be more susceptible to higher nitrate accumulation because they are often fertilized with nitrogen that can be taken up by the plant. Then, when plant stress occurs, which slows or stops growth, high levels of nitrate may accumulate. Perennial grasses, because they typically are not heavily nitrogen fertilized and also are more resistant to environmental stress factors, are at

much lower risk for nitrate accumulation. Legumes typically are not at risk of causing nitrate poisoning. An exception is alfalfa, which, under drought stress or high temperatures, can accumulate elevated levels of nitrate.

Additionally, factors such as acidic soils, sulfur or phosphorus deficiencies, low molybdenum and low temperatures are known to increase nitrate uptake by plants.

Plant Parts

Plant parts closest to the ground (stalks) contain the highest concentrations of nitrates. Leaves contain less than stalks or stems, and the seed (grain) and flower usually contain little or no nitrate. Most of the plant nitrate is in the bottom third of the stalk.

Research from Oklahoma has shown that the lower 6 inches of the stem in pearl millet contains three times more nitrate than the top part of the plant. Raising the cutter bar above 6 inches can reduce nitrate content of forages harvested as hay or silage, although this may be difficult to do with drought-stressed forages.

Stage of Plant Growth

Nitrate decreases as plants mature. Young plants have higher nitrate concentrations than mature plants. However, mature plants still can have excessive nitrate concentrations if environmental and soil conditions are favorable.

Nitrate levels in the plant can be higher in the morning than in the afternoon. Photosynthesis in the plant becomes more active from morning to afternoon. With increasing photosynthetic activity, the plant is using nitrate to produce amino acids that are used for plant growth. However, this only occurs in growing plants and not plants that have stopped growing due to environmental stresses.

Weather Conditions That Favor Nitrate Accumulation by Plants

Not all drought conditions cause high nitrate levels in plants. Some moisture must be present in the soil for the plant to absorb and accumulate nitrate. If the major supply of nitrates for the plant is in the dry surface soil, very little nitrate will be absorbed by the roots. In plants that survive drought conditions, nitrates are often high for several days following the first rain (as the plant regrows following drought).

Frost, hail and low temperatures all interfere with normal plant growth and can cause nitrates to accumulate in the plant. Frost and hail may damage, reduce or destroy the leaf area of the plant. A decrease in leaf area limits the photosynthetic activity of the plant, so nitrates absorbed by the roots are not converted to plant proteins but are accumulated in the stem or stalk instead.

Most plants require temperatures above 55 degrees Fahrenheit for active growth and photosynthesis. Nitrates can be absorbed quickly by plants when temperatures are low, but conversion to amino acids and protein occurs very slowly in plants during periods of cool weather. This allows nitrate to accumulate in the plant.

Water

Water may be a source of toxic levels of nitrate for livestock. Water may become contaminated by fertilizer, animal wastes or decaying organic matter. Remember that a large container used for fertilizer and the hoses cannot be effectively cleaned for use of hauling potable water to livestock. Numerous deaths have occurred in animals provided water from used fertilizer containers inadequately “cleaned.” Shallow wells with poor casings are susceptible to contamination. Marginally toxic levels of nitrate in water and feed together may cause nitrate toxicity in animals. Remember to consider both sources of nitrate.

Fertilizer

Acute nitrate poisoning may occur if livestock consume nitrate fertilizer. Avoid grazing immediately after spreading fertilizer. Areas where the fertilizer spreader turns or areas where filling (and consequently spilling) take place may have excessive quantities of nitrate freely available to animals.

Nitrate Toxicity

Nitrate in itself is not toxic to animals, but at elevated levels it causes a disease called nitrate poisoning. Nitrates normally found in forages are converted by the digestion process to nitrite (NO_2), and in turn the nitrite is converted to ammonia (NH_3). The ammonia is then converted to protein by bacteria in the rumen. If cattle ingest plants that contain high levels of nitrate, nitrite will accumulate in the rumen. Nitrite is 10 times as toxic to cattle as nitrate.

Nitrate toxicity may be chronic or acute. In chronic cases, a sublethal dose may result in abortion, weight loss, reduced milk production and increased susceptibility to infection. In acute cases, nitrite is absorbed into red blood cells and combines with hemoglobin (oxygen-carrying molecule) to form methemoglobin. Methemoglobin cannot transport oxygen in the body, leading to insufficient oxygenation of tissues, which can rapidly progress to death.

Clinical Signs

Clinical signs of nitrate poisoning are related to the lack of oxygen in the blood. Acute poisoning usually occurs within six to eight hours after consuming toxic levels of nitrate. The onset of symptoms is rapid and the symptoms include the following:

- bluish/chocolate brown mucous membranes
- rapid/difficult breathing
- noisy breathing
- rapid, weak pulse (150+/minute)
- salivation, bloat, tremors, staggering
- weakness, coma, death
- dark "chocolate-colored" blood
- frequent urination

Death can occur within 2-10 hours from the start of clinical symptoms. Pregnant females who survive nitrate poisoning may abort due to a lack of oxygen to the fetus. Abortions generally occur approximately 10 to 14 days following exposure to nitrates.

Diagnosis

Diagnosis of nitrate intoxication is based on observed clinical signs and the possibility of exposure to toxic plants or water. A veterinarian should be consulted for a definitive diagnosis. Laboratory analysis can be performed on suspected plants, water and forages. The NDSU Veterinary Diagnostic Lab offers blood serum testing from live cattle, but samples should be taken within 24 hours of exposure to high nitrate levels.

Ocular fluid (aqueous humor) from within the globe of the eye can potentially be easier to obtain postmortem than blood serum. This fluid should be placed in a small clean tube, kept cool, and shipped on ice to the lab. Fluid samples or the intact eye taken from animals over 36 hours after death have a greater risk of bacterial contamination and tissue breakdown that could cause a false positive result. Always confirm which sample type is needed as well as proper sampling, storage, and shipment requirements to ensure accurate results.

Postmortem specimens of rumen contents are of little value for nitrate determination because most nitrate in the rumen is reduced by anaerobic fermentation to ammonia.

Samples from fresh grass or dry forages need to be representative of the field or bales in question. These samples should be packaged in a clean plastic bag and shipped to the laboratory for analysis. Water samples must be collected in a sterile bottle. When collecting from a water system, let the water flow for a couple of minutes before collecting the sample.

Results of chemical analysis are interpreted according to guidelines in **Table 2**. **These guidelines apply to livestock only**.

Table 2. Interpretation of laboratory results

Form of Nitrate Measured						Recommendations for use in livestock
Potassium Nitrate (KNO_3)		Nitrate Nitrogen (NO_3-N)		Nitrate (NO_3)		
ppm	%	ppm	%	ppm	%	
Forage (DM basis)						
0-7,220	0-0.72	0-1,000	0-0.10	0-4,430	0-0.44	Generally considered safe for livestock
7,220-10,830	0.72-1.08	1,000-1,500	0.10-0.15	4,430-6,645	0.44-0.66	Safe for nonpregnant animals; limit to 50% of ration dry matter for pregnant animals
10,830-14,440	1.08-1.44	1,500-2,000	0.15-0.20	6,645-8,860	0.66-0.88	Limit to 50% of ration dry matter for all animals
14,440-25,270	1.44-2.52	2,000-3,500	0.20-0.35	8,860-15,505	0.88-1.55	Limit to 30% to 35% of ration dry matter; do not feed to pregnant animals
25,270-28,880	2.52-2.88	3,500-4,000	0.35-0.40	15,505-17,720	1.55-1.77	Limit to 25% of ration dry matter; do not feed to pregnant animals
>28,880	>2.88	>4,000	>0.40	>17,720	>1.77	Danger: do not feed
Water (as received basis)						
0-720	0-0.072	0-100	0-0.01	0-443	0-0.04	Generally considered safe for livestock
720-2,166	0.072-0.21	100-300	0.01-0.03	443-1,329	0.04-0.13	Caution: Possible problems; consider additive effect with nitrate in feed
>2,166	>0.21	>300	>0.03	>1,30	>0.13	Danger: Could cause typical signs of nitrate poisoning

If you have questions concerning submitting samples to a laboratory for analysis, contact the North Dakota State University Veterinary Diagnostic Laboratory at 701-231-8307.

Treatment

Suspect animals should be moved carefully, as their blood oxygen levels may be significantly reduced. Stressful handling can result in respiratory distress and sudden death.

If ingestion of nitrate fertilizer is observed, prompt administration of mineral oil orally can help reduce caustic effects on the GI tract and speed passage.

Animals can be treated by intravenous injections of methylene blue. Commercial preparations intended for treatment of prussic acid poisoning only should not be used to treat nitrate poisoning. **Methylene blue is not approved by the Food and Drug Administration for use in food-producing animals. You must consult your veterinarian before using this treatment**.

Prevention

Prevention of nitrate poisoning is best achieved by controlling the type and quantity of forage offered to livestock. Avoid forages with potentially toxic levels of nitrate or at least dilute them with feeds low in nitrate. **When in doubt, have feeds and forages analyzed for nitrate before grazing or feeding them**.

Forages with sublethal nitrate levels can be fed to livestock with appropriate precautions. No single level of nitrate is toxic under all conditions. When grazing, feed a dry roughage first to reduce the amount of affected plants ingested by hungry animals.

Harvested forages that are high in nitrate often can be fed safely by mixing them with other feeds to reduce the total dietary intake of nitrate. Contact your veterinarian or Extension personnel if you need assistance in determining the correct ratios of high- and low-nitrate forages to blend to develop a ration for a particular class of livestock.

Management Guidelines

- Drought-stressed small-grain forages and other forages suspected of being high in nitrates should be tested before feeding.
- Dilute high-nitrate forages with other forages or feedstuffs that are low in nitrates. In some cases, this can reduce nitrate levels in the diet enough to make the forages safe to feed.
- Allow for frequent intake of small amounts of high-nitrate feed because that helps adjust livestock to high-nitrate feeds and increases the total amount of nitrate that livestock can consume daily without adverse effects.
- Allow cattle time to adapt to increased nitrate in the diet. If nitrate levels are not excessively high (9,000 parts per million nitrate, or NO_3), the animals can adapt to increasing amounts in the feed.
- Give livestock access to fresh, nitrate-free water at all times.
- Be sure pastures are not overstocked when grazing high-nitrate forages. Overstocking increases the amount of high-nitrate plant parts (stems and stalks) that livestock consume.
- Do not strip-graze high-nitrate forages. Strip grazing also increases the amount of stem and stalk material that livestock consume.
- Do not allow hungry cattle access to high-nitrate forages or pastures. Feed cattle hay or forages low in nitrates before turning them onto high-nitrate pastures.
- Supplement cattle grazing high-nitrate forages with other low-nitrate feedstuffs, such as low-nitrate forages, feed grains or byproducts. The addition of high-energy feeds stimulates the conversion of nitrate to nontoxic compounds and helps reduce the potential for toxicity.
- Graze cattle on high-nitrate pastures during the day and remove them at night for the first week of grazing if possible. This reduces the amount of high-nitrate forage consumed and helps acclimate cattle to the high nitrate levels.
- Don't graze high-nitrate pastures until one week after a killing frost if possible.
- Observe cattle frequently when you turn them into a suspected field or pasture to detect any signs of toxicity.
- Be aware that cattle in poor health and condition, especially cattle suffering from respiratory disease, are more susceptible to nitrate poisoning.
- Consider harvesting and feeding high-nitrate forages as silages. The fermentation process that occurs when feeds are ensiled reduces nitrate levels; however, this does not guarantee that silage will contain "safe" levels of nitrate. Testing is still recommended.
- Do not allow cattle access to areas where fertilizers are stored.
- Do not feed green chop that has heated after cutting or has been held overnight. Heating favors the formation of nitrite, which is more toxic than nitrate.

This publication was authored by Charlie Stoltenow, assistant NDSU Extension agriculture and natural resources director and former Extension veterinarian; Greg Lardy, NDSU vice president for Agricultural Affairs and former Extension beef cattle specialist; and revised in 2020 by Janna Block, former Extension Livestock Systems Specialist.

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