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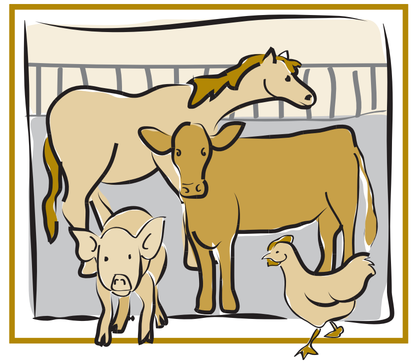

Nitrate Poisoning

Fact Sheet No. **1.610** Livestock Series | **Health**

by J.C. Whittier*

Quick Facts

- Death loss from nitrate is an occasional problem in cattle consuming certain annual forages, particularly sorghum hybrids.
- Cattle producers should be concerned if rations contain over 5,000 ppm nitrate on a dry matter basis.
- Avoid poisoning with good management practices.
- A qualitative check called the diphenylamine test can be used to screen forages for potential harm.
- High nitrate forages can be used if diluted with other feedstuffs and supplemented with energy.

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Nitrate toxicity is sometimes a lethal problem for livestock especially during the fall. The amount of nitrate accumulated within the plant depends on two factors: the rate of uptake by the plant from the soil, and the rate the plant reduces it. If uptake exceeds the rate of reduction, large amounts of nitrate can accumulate. If the rate of reduction equals the rate of uptake, there is no accumulation.

Nitrate accumulation usually results from plant stress, such as drought, and is accentuated by excessive soil nitrogen. Most nitrate accumulates in plant stems rather than leaves, and concentration tends to be highest in immature forage. A characteristic symptom of nitrate toxicity in the animal is a chocolate-brown color to the blood.

Use good management practices to avoid poisoning. Fertility programs consistent with plant needs and growing conditions minimize the problem. Test potentially dangerous forage before feeding. Often hay containing excessive nitrate can be fed safely when diluted with other feed, particularly concentrates.

Nitrate Accumulation

Nitrate is the primary nutrient form of nitrogen in most soils and is a normal constituent of plants. Normally nitrate is assimilated so rapidly following absorption from soil that its concentration in plant tissues is low. Occasionally, excessive levels in plants occur. In Colorado, the most notorious accumulators of nitrate are the sorghums. Other annuals that less frequently accumulate nitrate are small grains (wheat, oats, rye and barley) and millet.

Some perennial grasses (fescue and johnsongrass) and weeds (pigweed, mustard, kochia, nightshade and lamb's quarters) also can contain dangerous levels. The corn may be safe but weeds harvested with it may be poisonous. Stinging nettle, elderberry, burdock and Canadian thistle are a few of the known nitrate accumulators. In fact, some of these will accumulate nitrate to such a high concentration that they literally explode when burned – nitrate is explosive.

Accumulation usually is triggered by some environmental stress where plant growth is restricted but absorption of nitrate from soil continues. The most common stress of summer annuals is drought. Lack of moisture, together with excessive soil nitrogen for existing growing conditions, is a frequent cause of toxic levels of nitrate in sorghums. Other stress factors that favor buildup are reduced sunlight from cloudiness or shading, frost, certain herbicides including 2,4-D, acid soils, low growing temperatures, and deficiencies of essential nutrients like phosphorus, sulfur and molybdenum.

When more soil nitrogen is present than needed for maximum growth, some plants tend to accumulate nitrate even without environmental stress. This response is particularly true with hardy soil feeders like sorghum, noted for "luxury consumption" of certain nutrients.

When accumulation occurs, the concentration of nitrate is greater in stems than leaves. Seeds seldom contain significant amounts. Rate of uptake diminishes with maturity; mature plants usually contain less nitrate than immature ones. Differences in potential for accumulation exist among species and varieties.

Toxic Levels of Nitrate

The level of nitrate that causes toxicity in ruminants varies depending on rate of intake, diet, acclimation to nitrate and nutritional status. As a rule, forage containing less than 5,000 ppm NO_3 on a dry matter basis is safe. Forage containing 5,000 to 10,000 ppm NO_3 is considered potentially toxic when provided as the only feed. Forage containing over

*J.C. Whittier, Colorado State University professor, department of animal sciences. 6/2011

10,000 ppm NO_3 is considered dangerous but often can be fed safely after proper dilution with other feeds.

Various methods of reporting nitrates in feed are used by laboratories. Use the formulas in Table 1 to convert nitrate reporting to a common basis.

The effects of feed and water levels are additive. Consider both in avoiding or assessing nitrate problems. Common causes of high nitrate levels in water include shallow wells contaminated with surface water, water containing animal wastes, and surface runoff from heavy rain after fertilization with ammonium nitrate. Water containing more than 200 ppm NO_3 is potentially toxic, especially when feed also contains an excessive level.

Laboratories report nitrate content of feed and water in different forms. Consider the form for expressing nitrate levels to avoid errors in determining the potential for toxicity. Table 2 should aid in interpreting laboratory results.

Although the term "nitrate toxicity" is commonly used, the toxic principle is actually nitrite. Nitrate is converted to nitrite in the rumen. Nitrite is absorbed from the rumen and converts blood hemoglobin to methemoglobin. Methemoglobin cannot transport oxygen to body tissues, so animals die from oxygen insufficiency.

The first symptom to appear is a grayish to brownish discoloration of nonpigmented skin and mucous membranes of the mouth, nose, eyes and vulva. This discoloration results from the chocolate-brown color of the blood, a distinct characteristic of nitrate toxicity that persists several hours after death. As the syndrome progresses, a staggering gait, rapid pulse, labored breathing and frequent urination develop, followed by collapse, coma and death. Symptoms often occur rapidly, within one-half to four hours after ingestion of a toxic dose. Some animals exhibit symptoms but recover spontaneously and completely. Pregnant animals may abort a few days later.

Treatment of nitrate poisoning with 4 percent methylene blue at the rate of 100 cubic centimeters per 1,000 pounds live weight (intravenously) is effective if administered soon after symptoms appear.

Table 1. Formulas for converting methods of reporting nitrates.

Potassium nitrate: = Nitrate x 1.6 = Nitrate nitrogen x 7.0
Nitrate: = Potassium nitrate x 0.6 = Nitrate nitrogen x 4.4
Nitrate nitrogen: = Potassium nitrate x 0.14 = Nitrate x 0.23

Table 2. Equivalent levels of nitrate.

Nitrate		Nitrate-nitrogen (NO_3-N)		Potassium nitrate (KNO_3)	
ppm[1]	%	ppm	%	ppm	%
200	.02	46	.0046	326	.0326
5,000	0.5	1,150	.115	8,150	.815
10,000	1.0	2,300	.23	16,300	1.63

[1]parts per million

Preventing Nitrate Poisoning

Problems with nitrate toxicity can be avoided with proper management of forage and livestock. Nitrate accumulation can be minimized by analyzing soil and using a balanced fertility program consistent with plant needs and moisture conditions. For sorghum hays, split nitrogen into two or three applications, with a maximum of about 50 pounds of actual nitrogen applied per cutting. In situations where tests indicate soil is laden with nitrogen, reduce rates accordingly.

Use of true sudans or sudan-sudan hybrids instead of sorghum-sudan or sorgo-sudan hybrids may be warranted to reduce potential for accumulating nitrate. Usually the potential for problems is only reduced, not eliminated. Do not ignore differences in yield, quality, drought tolerance and insect and disease resistance.

Take extra care when moisture stress occurs in sorghums before harvest or grazing. Test samples of plants from different areas of the field, particularly those showing the most stress, for nitrate content. If the level is dangerous, delay harvest until rain comes and the plant increases in maturity. Occasionally forage that is questionable as hay can be grazed safely when forage is abundant, because animals tend to select leaves and refuse stalks. Silage also may be a good alternative since appreciable reduction in nitrate levels occurs during ensiling. Forages that are high in nitrate will normally lose 40 to 60 percent of their nitrate content during fermentation.

Testing for Nitrates

Avoid poisoning by routinely testing any forage – pasture, hay or silage – suspected of containing excessive nitrate. A qualitative check called the diphenylamine test can be used to screen forages for potential harm. Positive results indicate more than 5,000 ppm NO_3^- and possible danger.

If results of the diphenylamine test are positive, send forage samples to a laboratory for quantitative analysis.

When forage is collected for analysis, it is essential that representative samples be taken. Although samples often are pooled for other laboratory analyses like moisture and protein, nitrate tests often are required on individual bales or from specific areas of a field to accurately assess the potential for toxicity. To illustrate this point, an evaluation of 15 large round bales of sorghum hybrid hay from one cutting showed considerable variation from bale to bale, with nitrate levels ranging from 17,500 to 39,000 ppm.

Feeding High Nitrate Forages

In most instances, hay high in nitrate can be fed safely with adequate laboratory testing and good management. The best alternative is to dilute dangerous forage with feeds low in nitrate, preferably concentrates. Unfortunately for many producers, proper dilution makes it necessary to grind and mix. Gradual acclimation to questionable feed is a good practice to minimize risk. Animals should be healthy, on a good nutrition plane, and filled with low nitrate feed before they are allowed access to nitrate-containing forage. With respect to supplementary rations, those containing urea result in less toxicity than soybean meal, and the presence of readily available carbohydrate (corn, sugar, etc.) offers a considerable degree of protection. This may be due to lower pH in the rumen that facilitates reduction of nitrate.

Diphenylamine Test

This is a qualitative test to evaluate forages (hay, pasture, silage) for nitrate levels that are potentially dangerous to ruminants.

1. Prepare the test solution by mixing 0.5 grams diphenylamine with 20 milliliters of distilled water, then bringing the total to 100 milliliters with concentrated sulfuric acid. ***Caution: The solution contains a strong acid. Avoid contact with skin, eyes and clothing. Store in a cool dark place. Do not add water or any other material to the solution.***
2. Carefully place a drop of the solution at various locations on the inner tissue of the plant stem; repeat for several stems in each sample.
3. If an intense blue color appears in a few seconds, the forage contains potentially dangerous levels of nitrate.
4. If the results are positive (blue color), send the forage to a laboratory for quantitative analysis before feeding.
5. Occasionally, false positive reactions occur. However, any sample resulting in a positive reaction should be tested in the laboratory.
6. Avoid contaminating the solution in the bottle with plant tissue or other material. Discard any solution that is not clear.

Nitrates have been reported to increase the need for vitamin A in the ration. Recent information indicates that a relationship of this kind may not be of practical importance under most feeding conditions. Formulate rations to be adequate in vitamin A as well as other nutrients. Excessive vitamin A fortification does not appear to be needed.

Hay, straw or fodder suspected of being high in nitrate should not be fed when damp. Damp feed seems to be more toxic. The probable explanation is that some of the nitrate is converted to the more toxic nitrite before being consumed.

Summary

Nitrate poisoning can be a serious problem for livestock producers if not considered in their management plan. Drought, excessive soil nitrogen, shade, frost, certain herbicides, acid soils, low growing temperatures and nutrient deficiencies can contribute to high nitrate levels in plants. Stems usually have higher nitrate content than leaves. Do not overlook the nitrate content of water when a nitrate problem arises. Avoid poisoning by routinely testing any forage suspected of containing excessive nitrate. High nitrate forages can be used by diluting it with other feedstuffs and supplementing it with energy.

Chemical Formulas

NO_3^- = nitrate ion

NO_2^- = nitrite ion

NH_3 = ammonia

NH_4^+ = ammonium cation