K-STATE
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Research and Extension

FORAGE FACTS
Publication Series

NITRATE TOXICITY

INTRODUCTION

The potential for high nitrate concentrations occurs when crops such as corn, sorghum, cereal grains and some grasses are exposed to drought, hail, frost, cloudy weather, or soil fertility imbalance. Nitrates accumulate in the lower portion of the plant when stresses reduce the crop yield to less than that expected based on the supplied nitrogen fertility level. When fed to livestock, nitrates interfere with the ability of the blood to carry oxygen.

WHY NITRATES ARE TOXIC

Nitrate toxicity is a misnomer because nitrite (NO_2), not nitrate (NO_3), is poisonous to animals. After a plant is eaten, rumen bacteria rapidly reduce nitrates in the forage to nitrites. Normally, the nitrites are converted to ammonia and used by rumen microorganisms as a nitrogen source. However, if nitrite intake is faster than its breakdown to ammonia, nitrites will begin to accumulate in the rumen. Nitrite is rapidly absorbed into the blood system where it converts hemoglobin to methemoglobin. Red blood cells containing methemoglobin cannot transport oxygen and the animal dies from asphyxiation.

Animals under physiological stress (sick, hungry, lactating, or pregnant) are more susceptible to nitrate toxicity than healthy animals. Toxicity is related to the total amount of forage consumed and how quickly it is eaten, but, generally, if forages contain more than 6,000 ppm nitrate, they should be considered potentially toxic (Table 1).

Symptoms of nitrate toxicity may appear within a few hours after eating or not for several days. Signs of toxicity include reduced appetite, weight loss, diarrhea and runny eyes. However, these are nonspecific symptoms of numerous disorders and are not a reliable diagnosis of nitrate poisoning. Lower nitrate levels can cause abortion without any other noticeable symptoms.

Acute toxicity usually is not apparent until methemoglobin approaches lethal concentrations. Symptoms include cyanosis (bluish color of mucus membranes), labored breathing, muscular tremors and eventual collapse. Coma and death usually follow within two to three hours. Postmortem confirmation of nitrate toxicity is chocolate-colored blood; however, the color will change to dark red within a few hours after death.

Diagnosis and treatment of nitrate toxicity should be performed by a veterinarian. However, in acute cases where time is limited, an antidote of meth-

Table 1. Level of forage nitrate (dry matter basis) and potential effect on animals.

ppm Nitrate (NO_3)	Effect on Animals
0–3,000	Virtually safe
3,000–6,000	Moderately safe in most situations; limit use for stressed animals to 50% of the total ration.
6,000–9,000	Potentially toxic to cattle depending on the situation; should not be the only source of feed.
9,000 and above	Dangerous to cattle and often will cause death.

ylene blue can be injected to convert the methemoglobin back to hemoglobin.

Forage suspected to contain high nitrate levels should be tested by a laboratory before feeding. Unfortunately, different laboratories may report nitrate level as either nitrate (NO_3), nitrate-nitrogen (NO_3-N), or potassium nitrate (KNO_3). Potassium nitrate, nitrate nitrogen, or percent nitrate can be converted to ppm nitrate using the conversion factors in Table 2.

Table 2. Conversion factors for expressing nitrate content of forages.

Potassium Nitrate x 0.61	= Nitrate (ppm NO_3)
Nitrate-Nitrogen x 4.42	= Nitrate (ppm NO_3)
% Nitrate x 10,000	= Nitrate (ppm NO_3)

PLANT FACTORS

Plant Species. Nearly all plants contain nitrate, but some species are more prone to accumulate nitrate than others. Crops such as forage and grain sorghums, sudangrass, sudan-sorghum hybrids and pearl millet are notorious nitrate accumulators. Weed species such as kochia, lambsquarters, sunflower, pigweed and Johnsongrass also are often high in nitrate. Under certain environmental and managerial conditions, corn and cereal grains like wheat and oats, and other plants can accumulate potentially toxic levels of nitrate. Under extreme stress, legumes like alfalfa and soybean also can accumulate nitrate.

Stage of Growth. Nitrate content generally is highest in young plant growth and decreases with maturity. Sorghums and sudangrasses, however, are exceptions because concentrations can remain high in mature plants. If plants are stressed at any stage of growth, they can accumulate nitrate.

Plant Parts. Highest nitrate levels occur in the lower one-third of the plant stalk and concentrations tend to be low in leaves because nitrate reductase enzyme levels are high there. Grain does not contain appreciable amounts of nitrate.

ENVIRONMENTAL FACTORS

Drought. Nitrates accumulate in plants during periods of moderate drought because the roots continually absorb nitrate, but very high daytime temperatures inhibit its conversion to amino acids. During a severe drought, lack of moisture prevents nitrate absorption by plant roots. Following a rain, however, the roots rapidly absorb nitrate and accumulate high levels. After a drought-ending rain, it requires at least two weeks before the nitrates will be metabolized to low levels, provided environmental conditions are optimum.

Sunlight. Shaded plants lack sufficient photosynthetic energy to convert nitrate to amino acids. Extended periods of cloudy weather increase nitrate content and dangerously high levels can occur when wet, overcast days follow a severe drought.

Frost, Hail, or Disease. Conditions such as hail, light frost, herbicide drift or plant disease can damage plant leaf area and reduce photosynthetic activity. With less available energy, nitrate reduction is inhibited and nitrates accumulate in the plant.

Temperature. Low temperatures (less than 55°F) in the spring or fall retard photosynthesis of warm-season plants and favor nitrate accumulation. Extremely high temperatures also increase concentrations by reducing nitrate reductase activity.

MANAGEMENT FACTORS

Fertilization. Applying high amounts of manure or other fertilizer, particularly in late season, increases concentrations. Split nitrogen applications provide better nutrient distribution and reduce the potential for toxicity.

Harvest Technique. Silages made from stressed forages should be analyzed after ensiling because the fermentation process usually converts about 50 percent of the nitrates to a nontoxic form. If forages are harvested as hay, nitrate concentrations remain virtually unchanged over time.

High nitrate forages may be grazed, but a dry roughage should be fed first to limit intake. Light to moderate stocking rates should be used because overgrazing forces cattle to eat the stems which contain the highest nitrate levels. Cattle should be removed from potentially susceptible forage for at least seven to 14 days after a drought-ending rain. Lush regrowth of heavily fertilized grasses can contain high nitrate levels and should not be grazed. If plants are fed as green chop, the harvested forage should be fed immediately after cutting and not allowed to heat.

FEEDING HIGH NITRATE FORAGES

Before feeding potentially troublesome plants such as sorghum and sudangrass, analyze the forage for nitrates. Environmental conditions in Kansas create high nitrate concentrations in some forages virtually every year. Consequently, nitrate analysis is necessary to determine if the feed is potentially toxic. High nitrate forages can be fed to animals if proper precautions are taken.

Gradually Adapt Cattle to High Nitrate Feeds. Nitrate toxicity frequently occurs in animals without prior exposure to nitrates. If nitrate levels in the forage are not excessively high (e.g., over 9,000 p.m.) the animal will usually be able to adapt somewhat to increasing amounts in the feed. Frequent feeding in limited amounts throughout the day rather than large amounts once daily will increase the total amount that can be safely fed.

Dilute With Other Feeds. Based on nitrate analysis, blend high nitrate forage so that the overall diet contains less than 5000 ppm nitrate on a dry basis. After three to four weeks of feeding, the animals normally become adjusted to nitrates and the proportion of high nitrate forage can be increased somewhat.

Supplement Grain. Feeding 2 to 5 pounds of grain or byproduct dilutes the amount of nitrate in the total ration and provides the energy necessary for bacteria to quickly convert nitrite to ammonia. Molasses also can provide needed energy for nitrite reduction but may be cost prohibitive.

Feed a Balanced Ration. Formulate rations to ensure adequate protein, energy, vitamin A and other nutrients. Nitrates may increase the requirement for vitamin A, but excessive supplementation is unjustified. Non-protein nitrogen (urea) may not be well utilized and should not be fed with high nitrate forages.

Do not Feed to Stressed Livestock. Animals that are sick, hungry, pregnant, or lactating have a lower tolerance for nitrates than healthy animals.

Provide Clean Drinking Water. Frequent intake of high quality water is important for optimal rumen fermentation. Analyze the livestock water supply to determine whether it is contributing to the nitrate burden of cattle. Ponds or ditches that collect runoff from feedlots, heavily fertilized fields, septic tanks, or manure piles are likely polluted with nitrates.

SUMMARY GUIDELINES TO REDUCE NITRATE TOXICITY

- Pay close attention to potentially troublesome plants, such as sorghum, sudangrass and other summer annuals, which often have high nitrate levels.
- Avoid excessive application of manure or nitrogen fertilizer.
- Raise cutter bar 6 to 12 inches to exclude basal stalks. This will also minimize harvesting many weed species that have accumulated nitrate from shading.
- Delay harvesting any stressed forages. Two weeks of favorable weather generally are required for plants to reduce accumulated nitrate.
- Never feed green chop that has been heated after cutting or held over night.
- Harvest plants containing high levels of nitrate as silage rather than hay.
- Have representative samples of suspect forage analyzed before feeding.

OTHER PUBLICATONS

Nitrate and Prussic Acid Toxicity in Forage (MF-1018).

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