Nitrate and Prussic Acid Toxicity in Forages

NITRATE TOXICITY

The two most limiting factors for forage production in hay and pasture crops are moisture and nitrogen. Unless irrigated, moisture is not manageable but the addition of nitrogen fertilizer has been shown to increase both yield and quality of forages. Issues can arise when soil nitrate levels, either natural or from fertilizer, are high and plant growth is inadequate for utilization.

Nitrogen Assimilation in Plants

Nitrate toxicity occurs when plant growth slows from drought, cool weather, frost, or some other condition and nitrates accumulate to an unsafe level. Plants primarily take up nitrogen in the form of nitrates from the soil. This nitrate is converted to nitrite and then to ammonium. The ammonium is joined with organic acids to make amino acids and are assembled into proteins or other N-containing compounds like chlorophyll. If plant growth slows or stops, the plant continues to take up nitrate but with reduced photosynthesis, the nitrate is not converted to amino acid. This causes a buildup of nitrate in the plant. Elevated nitrate levels can persist indefinitely.

Nitrogen Assimilation in Ruminants

The assimilation process in ruminants is very similar to the plant process. Nitrate is relatively non-toxic to ruminants. Microbes in the rumen covert nitrate to nitrite and then to ammonia for protein production. Nitrate poisoning occurs when a high nitrate containing feed is consumed and the nitrate concentration in the rumen is higher than the capacity of the microbes to convert nitrite to ammonia. Nitrite escapes the rumen, enters the bloodstream and ties up hemoglobin to produce methemoglobin. This reduces the oxygen carrying capacity of the blood and causes the animal to suffer from oxygen deficiency. Sick, hungry, lactating, or pregnant animals are more susceptible to nitrate toxicity

Forages

All forages contain nitrates. Forage crops that receive nitrogen fertilization or manure applications relatively close to the time of a stress are more likely to contain high nitrate concentrations but plant species and environmental conditions prior to harvest are more important. It is common for summer annuals, warm-season perennials, small grains, and many common weed species to accumulate high levels of nitrate.

Selection of Common Plants Known to Accumulate Nitrate

Grasses		Forbs
Bermudagrass	Wheat	Dock (Curly, Broadleaved, etc)
Rye	Brown top millet	Horsenettle
Crabgrass	Ryegrass	Jimsonweed
Corn	Sorghum	Lambsquarter
Tall Fescue	Sudangrass	Nightshade
Johnson grass	Sorghum x Sudangrass	Pigweed
Oats	Pearl millet	

Management Strategies to Decrease Risk

Forages should not be harvested or fed during or immediately after a stressful period of reduced plant growth. Do not harvest or graze forages within seven days following a drought-ending rain. Nitrate tends to be highest in the lower stems and leaves. Thus, overgrazing or setting the mower lower than six inches should be avoided. Herbicides can be an effective practice to kill weeds that are known to be accumulators of nitrate, but care should be exercised after an herbicide application that can disrupt normal plant growth and possibly cause temporarily high nitrate concentration in plants. Splitting nitrogen applications and using rates that match realistic yield expectations are also recommended.

Symptoms of High Nitrates in The Animal Diet

Symptoms could manifest five to seven days after feeding high nitrate forages and are dependent on the amount of nitrates in the forage and the amount of forage consumed. Low nitrate intake often causes lower milk production, abortion, breeding problems or symptoms that mimic a nutritional deficiency. Signs of acute nitrate toxicity include bluish color of mucous membranes, rapid and difficult breathing, pulse of over 150 beats/minute, tremors, staggering, collapse and death. Another indication of acute nitrate toxicity is brown or "chocolate-colored" blood.

TESTING FOR NITRATE

A nitrate analysis can be added to any Waypoint Analytical feed or plant tissue sample.

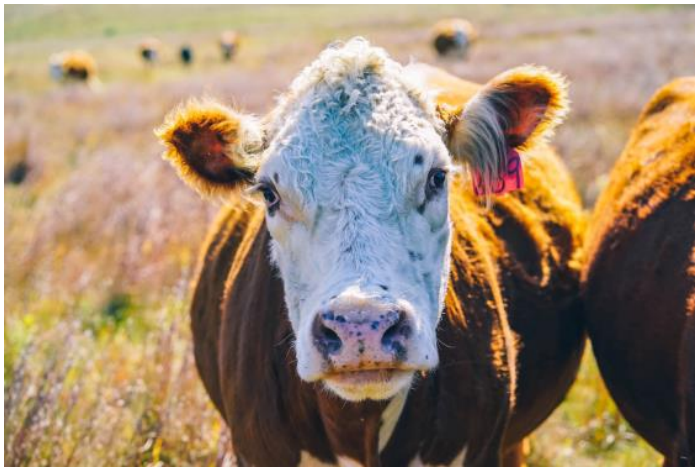
1) Fill a gallon freezer bag with the forage to be tested.
2) Indicate "Nitrate-N" analysis on the submittal form.

The results will be reported as parts per million (ppm) of nitrate-N (NO_3-N). NO_3-N refers only to the nitrogen portion of the nitrate molecule. The nitrate molecule contains 1 nitrogen atom and 3 oxygen atoms. Conversion between nitrate and nitrate-N can be accomplished by the following formulas:

(ppm NO_3) X (0.226) = ppm NO_3-N

or

(ppm NO_3-N) X (4.43) = ppm NO_3.



Feeding Guidelines of Feeds According to Nitrate Concentrations

Nitrate Ion (NO_3) ppm	Nitrate-N (NO_3-N) ppm	Recommendation for unadapted animals
<4400	<1000	Safe, non-toxic level
4400-9300	1000-2100	Safe for non-pregnant animals. Adapt pregnant animals slowly or mix with low nitrate feed
9300-15,000	2100-3390	Limit to less than 50% of ration dry matter. Do not feed to pregnant animals without mixing with low nitrate feed. Adapt animals to mixture
>15,000	>3390	Limit to less than 25% of ration dry matter. Do not feed without diluting with low nitrate feed. Adapt animals to feed mixture.

PRUSSIC ACID TOXICITY

Prussic acid toxicity is also known as hydrocyanic acid or hydrogen cyanide (HCN). Prussic acid poisoning is caused by cyanide production and is most commonly associated in sorghums and closely related species.

Potential Prussic Acid Toxicity of Different Forage Species

Forage sorghums	Intermediate to high
Foxtail millet	Very low
Grain sorghums	High to very high
Johnsongrass	High to very high
Pearl millet	Very low
Sorghum-sudan hybrids	Intermediate to high
Sudangrass common varieties	Low to intermediate
Sudangrass hybrids	Intermediate

Trees such as apricot, peach, cherry, chokecherry, elderberry, apple, and wild black cherry also accumulate prussic acid.

Sugar to Cyanide

The above plants produce sugars, cyanogenetic glycosides, in the leaves and stems that produce the cyanide ion. When the cyanogenetic plant is damaged or chewed these sugars combine with other enzymes in the plant to produce HCN. Normally, plant growth keeps the concentration of these sugars low enough that the animal can detoxify the HCN. Concentrations reach toxic levels in drought stressed, frost or storm damaged plants.

Symptoms of High Prussic Acid in The Animal Diet

Once eaten, cyanide is absorbed directly into the bloodstream and binds to enzymes in the cell. This cyanide complex prevents blood hemoglobin from transferring oxygen to individual body cells and the animal dies from asphyxiation. Animals with cyanide poisoning have bright red blood that clots slowly. Because the process occurs quickly, the symptoms are usually observed too late for effective treatment.

Management Strategies to Reduce Risk

Prussic acid concentrations are higher in fresh forage than in silage or hay because the HCN is volatile and dissipates as the forage dries or ensiles. The prussic acid content of sorghum hay decreases as much as 75 percent while curing and is rarely hazardous when fed to livestock. Dried cherry leaves also do not pose a danger. Producers should wait four days to a week or more before allowing forages that have experienced a drought ending rain or frost to be fed. Prussic acid concentrations are higher in younger plants than mature plants, so do not graze sorghums until plants are 18-24 inches high. A 2,4-D herbicide application may cause prussic acid content to increase and the effect may last several weeks. High nitrogen rates applied to forage crops whose soils are deficient in phosphorus and potassium usually have increased prussic acid levels. Phosphorus and potassium levels should be maintained to soil test report recommendations. Also consider split-applying high nitrogen rates into two to four applications.

SUMMARY

Nitrate and prussic acid toxicity are both caused by compounds that accumulate in a forage crop under stressed environments and deprive the animal of oxygen when ingested. Both can also occur simultaneously. As an example, late season warm season hay or pasture crops that have high nitrate levels because of drought can also have increased prussic acid concentrations after a light frost that does not kill the plant. Always have questionable forage tested for nitrate and allow enough time for the HCN to volatize.

REFERENCES

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