

Managing Nitrates and Prussic Acid in Forages

Chris Teutsch, cteutsch@vt.edu
Southern Piedmont AREC
Blackstone, VA

Nitrates can accumulate to toxic levels in commonly grown forages. This most often occurs when heavy nitrogen fertilization is followed by drought. Nitrates are taken up by the plant, but not utilized since plant growth is restricted by the drought. Any factor that slows plant growth in combination with heavy nitrogen fertilization can result in nitrate accumulation. Some plants tend to accumulate nitrates at greater rate; these include, but are not limited to commonly used summer annual grasses, corn, crabgrass, small grains, annual ryegrass, bermudagrass, Johnsongrass, tall fescue, and some annual and perennial weeds commonly found in pastures and hayfields.

In contrast to nitrates, prussic acid or hydrogen cyanide can be formed in commonly used sorghum species such as forage sorghum, sorghum-sudangrass hybrids, sudangrass, and Johnsongrass. Under normal conditions these forages contain little free cyanide. However, when freezing, drought stress, wilting, or mechanical injury damages plant tissue, an enzymatic reaction occurs and free cyanide is produced. Being aware of the factors that can result in accumulation of nitrates or the formation of prussic acid and using alternative forages during these periods will reduce chances of livestock losses.

Nitrates

In cattle, nitrate is converted to nitrite in the rumen, and the nitrite is absorbed into the blood stream. Nitrite interferes with the blood's ability to carry oxygen. Symptoms of nitrate poisoning include trembling, staggering, rapid and labored breathing, rapid pulse, frequent urination followed by collapse, coma, and death. The onset of symptoms and death is rapid and usually occurs within one to two hours. Most often, animals are simply found dead. In animals affected by nitrate poisoning, the blood will take on a brownish chocolate color, giving the non-pigmented skin and mucus membranes a muddy brown color.

The following practices can help to reduce nitrate accumulation in forages and manage the risk associated with feeding high nitrate forages:

Split nitrogen applications. Applying smaller applications of nitrogen throughout the growing season will reduce the risk of nitrate accumulation in forages.

Delay harvest or grazing after a drought ending rain. Nitrates are often the highest just after plant growth resumes. Grazing or harvesting should be delayed for 7 days after a drought ending rain.

Raise cutting or grazing height. Nitrates tend to accumulate at higher concentrations near the base of the plant. Raising your cutting or grazing height from 2-4 inches to 6-8 inches can significantly reduce nitrate concentrations in the forage tissue that is being conserved or ingested. For corn silage and forage sorghum, raising the cutting height even more (12-16 inches) can help avoid high levels of nitrates.

Test all suspect forages. All forages that may contain high levels of nitrates should be tested at a qualified lab. Several labs are listed at end of this article.

Segregate all forages high in nitrates. Once identified, forages high in nitrates should be clearly marked and separated from low nitrate forages if possible.

Harvest forage as silage if possible. Ensiling high nitrate forage can reduce nitrates by 40 to 60%. Silage should be tested before feeding to confirm nitrate levels.

Nitrates are stable in hay. Nitrates do NOT decrease over time in dry hay. This means that you can kill livestock months or even years later. If you suspect nitrates in your hay, make sure to test it.

Avoid feeding high nitrate forage to susceptible animals. Feeding high nitrate forage to animals that are in poor condition and under stress, or are pregnant, lactating, or sick is especially risky and should be avoided.

Limit the intake of high nitrate forages. Guidelines for feeding high nitrate forages can be found in Table 1. The best way to feed high nitrate forages is in a total mixed ration. This reduces the animal's ability to select individual components. If feeding a total mixed ration is not possible, then limit access to the high nitrate hay in a manner that allows livestock to consume 50% or less of their total daily dry matter requirement. A high energy supplement that is balanced for the ration should be fed PRIOR to hay feeding. Simply unrolling one bale of low nitrate hay and one bale of high nitrate hay is NOT an adequate way to feed high nitrate hay.

Supply free access to clean, nitrate-free water. In addition to clean water, make sure to provide access to high quality mineral and vitamin supplement.

Nitrates and horses. Horses, monogastrics with a functional cecum, tend to be more tolerant of nitrates in forage tissue. Although no threshold levels have been officially established, forages are generally considered safe for horses if the nitrate concentration in the plant material is below 1.5 to 2.0%. An accurate nitrate test is needed to make this assessment. Local veterinarians should be consulted before feeding high nitrate forage materials to horses.

Nitrate testing is available from the following laboratories:

Toxicology Laboratory

College of Veterinary Medicine

Duck Pond Drive

Virginia Tech

Blacksburg, VA 24061-0442

(540) 231-7666

<http://www.vth.vt.edu/>

Cumberland Valley Analytical Services

Mail: PO Box 669, Maugansville, MD 21767

UPS: 14515 Industry Drive, Hagerstown, MD 21742

Phone: 800-282-7522 (800-CVAS-LAB) Fax: 301-790-1981

<http://www.foragelab.com/>

A&L Eastern Laboratories, Inc.

7621 Whitepine Road

Richmond, Virginia 23237

Email: office@al-labs-eastern.com

Phone: (804) 743-9401

Fax: (804) 271-6446

<http://www.al-labs-eastern.com/>Table 1. Nitrate levels in forages^a.

Nitrate Concentration ^b		Forage Status	Comments
----%----	---ppm---		
0-0.25	0-2,500	SAFE	Generally considered safe.
0.25-0.5	2,500-5,000	CAUTION	Generally safe when fed with a balanced ration. Can be a problem for pregnant and young animals. Limit to ½ of ration. Do not feed with non-protein N. Check water for nitrates.
0.5-1.5	5,000-15,000	DANGER	Limit to ¼ of ration. Supplement with energy, minerals, and vitamin A.
Over 1.5	Over 15,000	TOXIC	Forage should not be fed. If forage must be fed, limit to less than 15% of ration.

^aAdapted from Southern forages, fourth edition, 2007.^bNitrate concentration is expressed as NO₃. To convert these values to NO₃-N multiply by 0.23.**Prussic Acid**

A potential problem with sorghum, sudangrass, sorghum-sudangrass hybrids, and naturally occurring Johnsongrass is prussic acid or cyanide poisoning. Under normal conditions these forages contain little free cyanide. However, when plant tissue is damaged by freezing, drought or mechanical injury, an enzymatic reaction occurs and free cyanide is produced. If forage is ingested during this period, cyanide is readily absorbed into the bloodstream where it interferes with normal cellular respiration. Symptoms of cyanide poisoning are similar to nitrate poisoning and include labored breathing, excitement, gasping, convulsions, weakness, prostration and death. The onset of symptoms and death is very rapid, occurring in minutes to several hours. In contrast to nitrate poisoning, the blood of animals affected by cyanide poisoning is fully oxygenated and bright cherry red in color.

Note: Pearl millet, corn, crabgrass and most other commonly used forages DO NOT form prussic acid.

In most situations, *Sorghum* species (including Johnsongrass) pose little danger to grazing animals when properly managed. The following guidelines will help to reduce the risk of prussic acid poisoning:

Avoid grazing young plants and new growth. Young plants or regrowth after grazing contain higher concentrations of prussic acid and should not be grazed until plants have reached a height of 20-30 inches.

Avoid grazing drought stressed plants. Drought stressed plants should not be grazed until growth has resumed after a drought breaking rainfall (usually 7 days).

Avoid grazing frosted plants. Plants that have been frosted should not be grazed for 7-14 days or until the leaves are dead and dried out. Early frost may only affect certain portions of field, so additional frosts may result in toxic forage in other areas of the field.

Make sure hay is properly cured before baling. Cyanide does escape from plant tissue; therefore hay that has been properly cured is safe to feed. Properly ensiled forage is also safe to feed.

Feed green chop in timely manner. If the green chop is allowed to wilt or heat, cyanide is released and the forage becomes toxic.

Feed good quality hay or silage BEFORE grazing questionable forages. Never turn hungry animals into questionable forage. Filling animals up with a good quality dry hay or silage before giving them free access to questionable forage can reduce rapid consumption of large quantities of potentially toxic forage.

Use tester animals to evaluate questionable forages. It may be advisable to allow several lower value animals to graze or consume questionable forage before allowing the entire herd to graze potentially toxic forage.

For more information on managing nitrates and prussic acid in forages contact your local extension office or veterinarian.

Additional information about nitrate and prussic acid poisoning can be found in the following references:

Ball, D.M., C.S. Hoveland, and G.D. Lacefield. 2007. Southern forages, fourth edition. Phosphate and Potash Institute and the Foundation for Agronomic Research, Norcross, GA.

Collins, M. and D.B. Hannaway. 2003. Forage-related animal disorders. p. 415-442. In (R.F. Barnes et al. (eds.) Forages: An Introduction to Grassland Agriculture, sixth edition. Blackwell Publishing, Ames, IA.

Cheeke, P.R. 1998. Natural toxicants in feeds, forages, and poisonous plants, second edition. Interstate Publishers, inc., Danville, IL.

Chris Teutsch conducts forage research at Virginia Tech's Southern Piedmont Agricultural Research and Extension Center located near Blackstone, Va. and resides on a small farm in Dinwiddie County with his wife and four children.