# Tennessee Cattle Producers Should Be Aware of the Possibility of Nitrate Toxicity

James B. Neel
Professor and Extension Beef Cattle Specialist
Department of Animal Science, University of Tennessee

Nitrate toxicity or nitrate poisoning could occur in Tennessee during the fall and early winter when feeding hays that were harvested during and/or following a drought. Nitrate toxicity is caused by cattle consuming forages that contain higher than normal levels of nitrates or nitrites. Problems with nitrate toxicity usually occur as results of consuming hay. Most of the problems are with beef cattle instead of dairy cattle. The greatest percentages of dairy rations are based on silage and nitrate levels are reduced by the ensiling process.

Some signs of nitrate toxicity include labored breathing, frequent urination, "frothing" at the mouth and staggering. Cattle will usually die within 30-45 minutes after exhibiting the symptoms. In fact, the first indication of nitrate toxicity is death of cattle that appeared to be healthy 6-8 hours before they were found dead. Hungry cattle that are allowed unlimited access to hay or pasture that contain high level of nitrates and consume a large amount of forage are usually the first ones that die.

## Causes of High Nitrate in Forage

Nitrates in the soil serve as the major source of nitrogen for the plants to produce high yields of dry matter. Nitrates are normally taken up by the plant roots and are made into proteins and other nitrogen containing compounds. The green leaves, which are actively involved in photosynthesis, are the major sites of the conversion of nitrates to proteins, therefore, the greatest concentrations are found in the lower stalk or stem with the lowest concentration in the leaves.

Nitrates accumulate during drought and high temperature or low humidity. Heavy nitrogen fertilization, especially if followed by a drought, can also contribute to higher nitrate levels. All plants contain some nitrates, but the factors which promote excessively high nitrate concentrations include: species of plants, weather (drought), high level of nitrogen application, shading (cloudy

weather) herbicides and stage of growth.

Hay produced under normal conditions would most likely not to be high in nitrates. However, feeding hay produced under drought should always be considered a potential cause of nitrate toxicity. Nitrate levels are not reduced during hay production or storage and may cause toxicity when fed several months following harvest.

**Plants That Could Be Higher in Nitrates**

The plants that are more likely to have high levels of nitrate are those that are "summer annuals." These include sorghum, sudan grass, hybrids of the two and millet. These plants normally receive high levels of nitrogen fertilization that contribute to nitrate accumulation.

Some other plants that are not normally considered to be potential nitrate accumulators are Bermuda grass, fescue, corn, and soybeans.

Young plants are generally higher in nitrates than older plants. Plants used for grazing (young) will have higher nitrate content than when used for hay.

Weeds can also accumulate higher levels of nitrates. Some of these weeds include pigweeds, smartweeds, ragweeds, Canadian thistle and golden rod. Controlling weeds in hay fields would aid in reducing potential nitrate toxicity. Nitrate toxicity occurs more frequently in pig weeds than any other.

**Dry Weather**

During dry weather, plants do not have enough moisture to convert the nitrates to plant tissue. The nitrate that has not been utilized by the plant can be at levels that can be toxic to cattle. If it is suspected that higher nitrate levels are present in the plants, wait until a rain occurs and the plants have had time to utilize the nitrates before grazing or cutting for hay.

**High Levels of Application of Nitrogen Fertilizer and Litter**

Heavy applications of nitrogen fertilizers and poultry litter have increased the nitrate content in plants and have been responsible for excessively high nitrate in many cases. Producers should follow soil test recommendations. Even with following recommended amounts of nitrogen fertilization, under drought conditions, some plants can still contain high nitrate levels. Remember to consider the nitrogen

contained in manure and reduce the nitrogen to be applied.

It takes about several weeks following nitrogen fertilization, with adequate rain, before the nitrates can be reduced to “low levels”. A nitrate test of the forage is recommended.

**Shading**

Lower leaves, which are shaded, do not convert nitrates to amino acids and proteins as fast as leaves in the sun. Cloudy days lower the light intensity and slow nitrate conversion. Under good growing conditions, there is a lower nitrate content in afternoon than in early morning due to the complete shade during night time.

**Frost**

Frost can damage plant leaf area and reduce photosynthesis. This causes nitrates to accumulate in the plant.

**Herbicides**

Some herbicides when applied to weeds tend to increase the nitrate content of the weeds. They also make some of the weeds more palatable and cattle readily graze them.

**Stage of Growth and Part of Plant**

Young plants usually have higher nitrate contents than old plants, but old plants can have high nitrate contents under high soil nitrate and stress conditions. The base of the stem has higher nitrate content than the top. The top leaves have the lowest nitrate level. Corn grain has a very low level of nitrate, but corn stalks could be high. Corn crop residue should be analyzed for nitrate level prior to grazing or feeding.

**Toxicity**

Nitrate itself is not particularly toxic to animals. Most forages normally contain some nitrate. When nitrates are consumed by ruminants, they are normally broken down to nitrites and then converted to ammonia, amino acids and into protein.

Nitrite, one of the intermediate products in the conversion process, is the cause of “nitrate toxicity”.

The rates of these conversion steps are where the problem arises. Conversion of nitrates to nitrites is much faster than nitrite to ammonia, so nitrites accumulate in the rumen. When nitrites are absorbed into the blood stream, they change hemoglobin to methemoglobin. Metemoglobin cannot carry oxygen, so the animal's tissue essentially smoothers to death due to lack of oxygen, and the animal dies. A dramatic but often unnoticed seen sign is the color change of the blood from red to chocolate brown.

Symptoms of nitrate toxicity can be both chronic and acute. Symptoms of chronic nitrate poisoning are somewhat non-specific. This occurs with prolonged exposure to low levels of nitrate. They include lowered milk production and lower weight gains.

The symptoms of acute nitrate poisoning are much more dramatic. They are: staggering, muscle tremors, rapid pulse, dark mucous membranes, and abortion. Often the first sign is finding dead animals. All of the acute signs of nitrate poisoning are due to lack of oxygen delivered to the tissues.

At the first sign, the veterinarian must be called because death will be quick if enough nitrates were eaten and the animals are not treated.

**Determining the Threat of Nitrate Toxicity**

Most of the toxicity problems that occur in Tennessee have been the result of hungry cattle being allowed free access to hay produced during a drought and/or excess application fertilizer with nitrogen. Hays produced under these conditions should be suspected. Refer to the prior sections "Plants that could be Higher in Nitrates" in this fact sheet.

Before starting to feed the hay, it would be a good practice to a have it analyzed for nitrate content. It would be an even better practice to have a complete forage test done to determine protein and TDN values.

A nitrate test can be done by the UT Soil, Plant and Pest Center Laboratory. Following is information about how to go about collecting a forage sample and submitting it for analysis (Joines, 2009. Personal Communication).

When collecting forage samples for nitrate levels, collect samples as you would for a routine forage analysis. It is important to submit a comprehensive sample (one collected from 6-8 areas in the pasture or at least 10 bales of hay) to provide good results. Place grab sample (if fresh forage) in a pa-

per sack of at least ½ gallon in quantity. Hay samples should be preferably cored and if dry (recommended collection procedure), can be placed in a ziplock sandwich bag. If a sample is "hand grabbed" from several bales, quantity should be at least ½ gallon in size. Cored samples are preferred and many Extension agents have the equipment available to assist in collection.

The Soil, Plant and Pest Center offers a nitrate screen free of charge however the quantitative Nitrate analysis is $6.00 each. A discount is available if the Basic Forage Test (Moisture, Protein, ADF, NDF, Ca, Mg, K, P, Energies, TDN, and RFV) is chosen in addition to Nitrates for a combined cost of $14.00. For more details and information sheets, please visit the Soil, Plant and Pest Center at the following web site address: soilplantandpest.utk.edu.

For information on securing a nitrate as well as a forage test, contact the local UT Extension office.

Lab testing, when there is any doubt, is a must. The health of the cattle is at stake.

## Recommendations

Understanding the situation should help in reducing or preventing a problem. Nitrate is broken down in the rumen from nitrate to nitrite to ammonia. Nitrite is the form which is most readily absorbed into the circulatory system. The quicker ammonia is formed, the smaller the amount of nitrite absorbed. Energy is necessary for formation of ammonia. Feeding corn is a good way to supply the energy necessary for a more rapid breakdown and conversion to protein. Corn would also dilute the breakdown and conversion to protein and dilute the amount of nitrate in the total ration.

Following are some suggestions that might help in reducing the problems that could occur with nitrate toxicity.

1. **If nitrate toxicity is suspected, the forage should be sent to a laboratory equipped to do quantitative nitrate analysis.** See the comments on nitrate testing.
2. **Dilute the nitrate concentration by mixing feeds low in nitrate with those suspected of having dangerous levels.** Feed those that would be high in carbohydrates such as corn.
3. **Do not aggravate the situation by feeding cattle a Non Protein Nitrogen (NPN) pro-**

**tein source such as urea.** Protein supplementation would probably not be needed. Unlimited access to a NPN source would be especially hazardous.

4. **Do not allow "hungry" cattle free access to suspected forage due to over consumption.**

5. **Feed the suspect forage in smaller amounts several times daily.** For example, if the cattle need to be fed 30 lb. of hay per day, feed them the total amount twice daily. For example, feed 15 lb. in the morning and 15 lb. in the evening. By frequent feeding of limited amounts of high nitrate feed, the concentration of nitrate in the rumen does not become extremely high at any one time. A greater incidence of problems is apt to occur if cattle are allowed unlimited access to large bales and fed every other day. Most of the incidents reported with beef cattle have been when being fed large bales of sorghum-sudan hybrid and Bermuda grass hay.

6. **Make ration changes slowly.**

7. **Provide cattle access to clean water at all times.** Water from ponds could also be a source of nitrates.

8. **Control both external and internal parasites.** Parasitism or other conditions contributing to anemia can increase susceptibility to nitrate toxicity.

9. **If a summer annual forage or bermuda grass is harvested for hay following a drought, the hay should be analyzed for nitrates.**

10. **Following all sound management practices that are conducive to successful cattle feeding and management program would also aid in reducing problems.**

**These recommendations are not intended as a "guarantee" that no problems will occur.** A nitrate toxicity problem will be accompanied by reduced performance, even death, and the occurrence is difficult to predict because it is influenced by many factors.

For additional information about nitrate toxicity and beef cattle management, contact the UT Extension office in your county

In Table 1, there are listed recommendations for producers to consider following results of a nitrate test.

**Table 1. Guide for Nitrate Levels in Forages for Mature Cattle[1]**

| Content of Nitrate Nitrogen (dry matter basis) | | |
|---|---|---|
| **Percentage** | **ppm[2]** | **Comments[3]** |
| 0.0-0.10 | **0-1,000** | **Safe to feed if adequate feed and water are available** |
| 0.1-0.15 | **1,000-1,500** | **Safe for non pregnant animals. Limits to 50 percent of total ration dry matter for pregnant animals; animals may go off feed, have a slow drop in production, some abortions possible** |
| | | |
| 0.15-0.20 | **1,500-2,000** | **Limit to 50 percent of total ration dry matter for all animals; may experience some symptoms, possibly death** |
| | | |
| 0.20-0.35 | **2,000-3,500** | **Limit to 34 to 40 percent total ration dry matter. Do not feed to pregnant animals.** |
| 0.35-0.40 | **3,500-4,000** | **Limit to 25 percent total ration dry matter. Do not feed to pregnant animals.** |
| greater than 0.40 | **greater than 4,000** | **Toxic-do not feed** |

[1]Vough, L.R., E. Kim Cassel and Scott M. Baro. "Causes and Prevention Nitrate Poisoning of Livestock". Fact Sheet 426. Maryland Cooperative Extension, University of Maryland.

[2]ppm = parts per million

[3]Total ration dry matter refers to total dry matter being consumed are forages and concentrates.

## References


Joines, Debbie. 2009. Personal Communication.

Soilplantandpest.utk.edu.

UT Extension Soil, Plant and Pest Center.

Vough, L.R. E. Kim Cassel and Scott M. Baro. "Cause and Prevention Nitrate Poisoning of Livestock". Fact Sheet 426. Maryland Cooperative Extension. University of Maryland.