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Nitrate Poisoning in Cattle

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Nitrate poisoning in cattle is caused by the consumption of an excessive amount of nitrate or nitrite from grazing crops, hay, silage, weeds, drinking water, lubricating oil, fertilizer, etc.

Nitrate Accumulation in Plants

All plants contain some nitrate, but excessive amounts are likely to occur in forages which have been grown under conditions of excessive fertilization and/or stress. The buildup of nitrates in soil brought on by excessive fertilization with poultry litter or animal manure is a common cause of nitrate accumulation in plants. Commercial fertilizers aren't likely to cause excessive nitrate accumulation in plants when recommended application rates and practices are followed. However, plant species and adverse environmental conditions before harvest affect the concentration of nitrates even more than available nitrogen in the soil. Direct ingestion of fertilizers that contain nitrates can be toxic to livestock.

Any stress condition which causes an abrupt decrease in plant growth may contribute to plant nitrate accumulation, even with a normal nitrogen supply. Some of these conditions are:

1. **Lack of Sunlight** – Shaded valleys, continued cloudy days and high plant populations may contribute to excess nitrates in plants.
2. **Detrimental Weather** – Drought and high temperatures or low humidity, cold temperatures, hail damage and frost may slow or stop plant growth and cause nitrates to accumulate.
3. **Herbicides** – Spraying with herbicides such as 2,4-D may result in temporary high nitrate levels in plants. Herbicides disrupt the normal enzyme systems of plants, and this action interferes with the reduction of nitrates and their conversion into protein. Judicious, timely spraying of pastures to control young weeds will actually reduce the nitrate hazard because those weed species which are normally high in nitrates are killed early in the year. This reduces the overall threat of nitrate toxicity through more of the season.
4. **Diseases** – Diseases may destroy photosynthetic and/or conductive tissue that could cause nitrates to accumulate in plants by interfering with nitrate reduction, protein synthesis or the manufacture and translocation of carbohydrates.
5. **Imbalance of Soil Nutrients** – A balance of soil nutrients is important in preventing nitrate accumulations. A lack of trace minerals, such as molybdenum, copper, iron, magnesium, sulfur or manganese that are involved in the enzyme system for using nitrates or potassium, may cause nitrates to accumulate in plants.

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Kinds of Plants

Nitrate toxicity in cattle is primarily a problem associated with some annuals, certain perennial weeds and some cool-season grasses (fescue, bromegrass, orchardgrass, small grains and ryegrass). Warm-season grasses generally cause fewer problems. Corn and sorghum have occasionally caused problems. Sorghum-sudan hybrids have probably caused more problems than any other summer annual forage.

Accumulators of nitrates, ranked from highest to lowest, are as follows:

- Weeds
- Corn
- Sorghums
- Sudangrass
- Cereal grains
- Tame forage grasses

While these plants are the most common cause of nitrate poisoning, any grass or weed beyond the seedling stage with a high stem-to-leaf ratio is more likely to be a problem than a less stemmy forage.

Stage of Growth and Plant Parts – The nitrate content is usually highest in young plants and decreases as the plant matures. However, at high levels of soil nitrate or under conditions of growth stress, the plant nitrate content may be high at maturity. The highest levels of nitrates occur just before flowering and decline rapidly after pollination and seed formation. The highest concentration of nitrate accumulates in the lower third of the plant stalk or stem. It is progressively diluted toward the top of the stem. Very little nitrate is found in the flowers or seed.

Nitrates in Water

The effects of nitrate levels of forage, feed and water are additive. So, both feed and water must be considered when evaluating a nitrate problem.

Nitrates may reach dangerous levels in ponds, shallow wells or streams that collect drainage from manure, highly fertilized fields or industrial waste. Deep wells are usually safe sources of water. No safety standards have been set for livestock water, but it has been suggested that up to 100 ppm of nitrate nitrogen in water should be safe if cattle are consuming an adequate ration that is free of nitrates. This is ten times the safe level set for humans.

Nitrate Detection

Forage analysis is necessary to determine if nitrates are present at toxic levels. A field test can indicate if nitrates are present, but suggestions for diluting feeds are based upon a more precise laboratory analysis of the forage. When submitting a forage sample for laboratory analysis, be sure your sample accurately represents your feed. A good sample can be collected by taking 12 or more samples at various levels or locations within your silo or pasture. A hay probe is desirable for taking hay samples.

Nitrate analysis of forage and water samples is available from the University of Arkansas Agricultural Diagnostic Service Laboratory. Information on sampling, shipping and costs can be obtained from county Extension offices. (Ask specifically for a nitrate analysis.)

Interpretation of Nitrate Analysis

Guidelines for uses of feeds with known nitrate contents are given in the table on page 3. Figure 1 shows the percentage of various hays tested at the UofA Diagnostic Lab that falls within different tolerance ranges. Less than 50 percent of the 708 sorghum-sudan samples fall below 700 ppm nitrate nitrogen. Accurately categorizing the toxic dosage of nitrate is difficult because it depends on the tolerance of the animal, type and quantity of diet and the rate at which nitrate is consumed.

For example, about twice as much nitrate is necessary to kill cattle when nitrate is eaten in forage as opposed to when it is consumed quickly as in a protein supplement or a drench. Therefore, the toxic levels shown in the table are generally regarded as conservative but are the best recommendations available for a variety of circumstances.

Causes and Symptoms of Nitrate Toxicity

Most forages contain some nitrate. Nitrate is not particularly toxic to cattle. When feeds containing nitrate are eaten by ruminants, the nitrate is normally broken down to ammonia and converted by bacteria into microbial protein. Nitrite, one of the intermediate products involved in this process, is the cause of “nitrate poisoning.” Some of the nitrite is absorbed into the animal’s bloodstream where the nitrite is capable of changing the normal oxygen-transporting substance, hemoglobin, into methemoglobin, a substance that cannot carry oxygen from the lungs to the tissues.

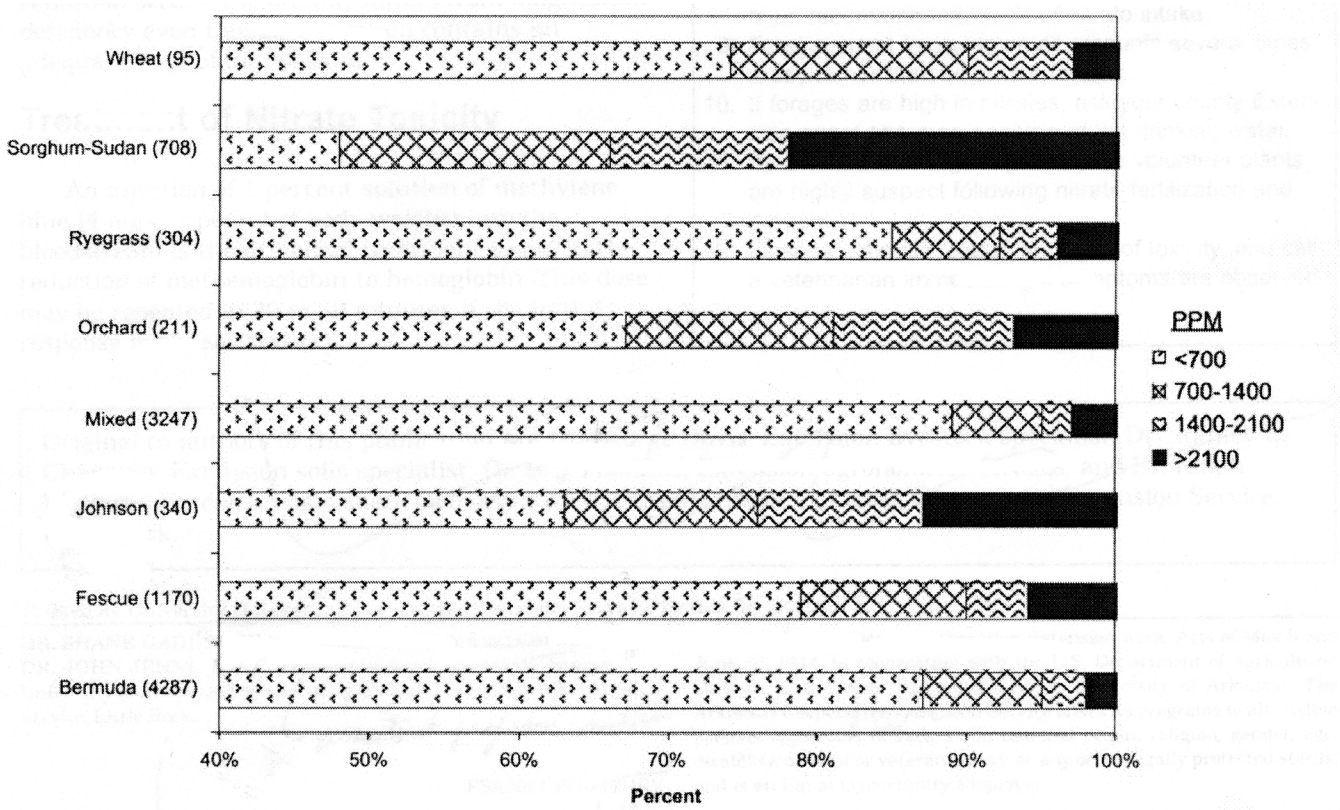
Guidelines for Use of Feeds With Known Nitrate Content[a]

Level (ppm, dm basis)[b]	Animal Response	Comments and Recommendations
Below 700 NO_3-N 3080 NO_3 5040 KNO_3	Normal if on an adequate ration.	Safe to feed.
700-1400 NO_3-N 3080-6160 NO_3 5040-10,080 KNO_3	May be hazardous to pregnant and very young animals.	Generally safe when fed balanced rations but best to limit the feed to half of the total dry ration for pregnant animals. Also be sure water is low in nitrate.
1400-2100 NO_3-N 6160-9240 NO_3 10,080-15,120 KNO_3	May result in poor appetite, slow growth, abortions, vitamin A deficiency symptoms in the sixth to eighth week and a decrease in milk production (slow at first, increasing after six to eight weeks).	Limit the feed to less than half of the total dry ration. Be sure water is safe. Be sure ration is well fortified with energy, minerals and vitamin A.
Above 2100 NO_3-N 9240 NO_3 15,120 KNO_3	Potentially lethal. Poor appetite, vitamin A deficiency, abortions, general production lowered.	Hazardous intake level for all animals.

[a]In most situations feed would refer to forages.
[b]Move decimal four places to left to convert ppm to percent (i.e., 700 ppm equals .07 percent).

NO_3 = nitrate
NO_3N = nitrate nitrogen (value reported by UofA Diagnostic Lab)
KNO_3= potassium nitrate

Figure 1. Percentage of hay samples for various species that fell within four different tolerance levels for nitrate-nitrogen in the diet of beef cattle



Nitrates also cause dilation of blood vessels, and further lack of oxygen is caused by peripheral circulatory failure. Lack of oxygen to the tissues may be the cause of abortions, which sometimes occur following nitrate poisoning. Abortions due to nitrate should be accompanied or preceded by some evidence of nitrate problems in the adult animal, including death or bluish discoloration of unpigmented areas of the skin or mucous membranes.

The most likely signs of nitrate poisoning are difficult and painful breathing, cyanotic membranes, rapid breathing, muscle tremors, weakness, low tolerance to exercise, incoordination, diarrhea, frequent urination, dark- to chocolate-colored blood and collapse. Milk production may also be reduced.

Nitrate poisoning may cause death within one-half hour to four hours after symptoms appear. Symptoms usually appear when methemoglobin reaches 30 to 40 percent, and death occurs when methemoglobin reaches 80 to 90 percent.

Another condition can occur that complicates the diagnosis of either nitrate or urea poisoning. Excess ammonia in the rumen, which occurs in urea toxicity and may occur in nitrate toxicity, may prevent the absorption of magnesium and cause grass tetany. A complex chemical salt is known to form at about pH 6.2 to 6.4 when magnesium is present with ammonia and phosphorus. This insoluble salt apparently cannot pass through the rumen and intestinal walls into the bloodstream. When this condition occurs, the animal suffers from magnesium deficiency even though the ration contains an adequate level of magnesium.

Treatment of Nitrate Toxicity

An injection of 1 percent solution of methylene blue (4 mg per pound of body weight) into the bloodstream is the preferred treatment to aid in the reduction of methemoglobin to hemoglobin. This dose may be repeated in 20 to 30 minutes if the initial response is not satisfactory.

Prevention of Nitrate Toxicity

Recommendations for preventing nitrate toxicity are as follows:

1. Follow recommendations for nitrogen fertilization, and be careful not to exceed 4 tons of poultry litter yearly per acre on cool-season grasses. The risk will be minimized by spreading litter uniformly and limiting application to 2 tons per acre per application.
2. When a crop is grown under conditions that cause nitrate accumulation, delay harvest of the crop until conditions improve to permit nitrate content to drop to a safe level.
3. Consider making silage of drought-damaged forage. The ensiling process reduces the nitrate level 40 to 60 percent.
4. If high levels of nitrate have accumulated in plants, raise the cutter bar and leave more stem, the portion of the plant with the highest concentration of nitrate, in the field.
5. Have suspected forage tested before feeding to cattle.
6. Dilute toxic forage by mixing it with nontoxic forages and/or energy feeds such as molasses or corn. Use forage nitrate analysis to determine dilution rates. Energy feeds, such as shelled corn, when fed daily at a minimum of 2 pounds per head, will offset production losses as long as the average forage NO_3-N concentration does not exceed 1,500 ppm.
7. Feed a nutritionally balanced ration. Iodized salt and vitamin A or green feed supplementation lessen the toxicity of nitrates.
8. Adapt cattle slowly to elevated levels of nitrate. Don't give hungry animals a full feed. Never exceed maximum recommended levels of nitrate intake.
9. Feed suspect forage in small amounts several times a day rather than all at one feeding.
10. If forages are high in nitrates, ask your county agent about an analysis of the drinking water.
11. Be aware that forage regrowth and volunteer plants are highly suspect following nitrate fertilization and drought.
12. Observe animals closely for signs of toxicity, and call a veterinarian immediately if symptoms are observed.

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