



## Drought and Risk of Nitrate Toxicity in Forages

All forages contain nitrates. They become a problem only when there is excessive accumulation. Nitrate can accumulate in any forage species given the combination of high available soil nitrate and cool temperatures, drought, or other stress that slows plant growth. In this factsheet, causes of nitrate buildup and best management practices to avoid nitrate poisoning of cattle are discussed.

### Drought Causes Nitrate Buildup

Drought slows or prevents nitrate from being converted to amino acids and proteins in the plant. In droughts, buildup of high levels of nitrate occurs and the nitrate levels can be maintained in the plant indefinitely. Nitrate toxicity is much more likely in grasses, as they are more likely to receive N fertilization. Nitrate toxicity is more likely in drought-stressed pasture, corn or sorghums that are grazed or harvested as hay or green chop (i.e. not fermented first). Weeds are much more likely to be higher in nitrates than crop species, so weedy fields are of more concern. The use of urea or ammonium-based forms of nitrogen (N) fertilizer will not solve the problem, as they are quickly converted to nitrate in the soil. With moderate to high levels of N fertilization, nitrate levels peak in grass forage about two to three weeks following N application (Fig. 1). Under normal weather conditions, nitrate levels decline rapidly after peaking, but plant stress conditions may prevent this decline.

### Signs of Nitrate Poisoning

Excess nitrate in the animal is absorbed into the bloodstream. Rapid or noisy breathing, salivation, muscle tremors, weakness, diarrhea, and frequent urination are all symptoms of nitrate toxicity. Severe nitrate poisoning may cause death within a few hours after symptoms appear. Pregnant animals are much more susceptible to nitrate poisoning than non-pregnant animals. Forage with a nitrate concentration exceeding 1.5% should not be fed, even as a smaller portion of the

diet. If nitrate poisoning is suspected, immediately switch animals to another forage source. Animals with moderate nitrate poisoning can be successfully treated with a methylene blue solution intravenously.

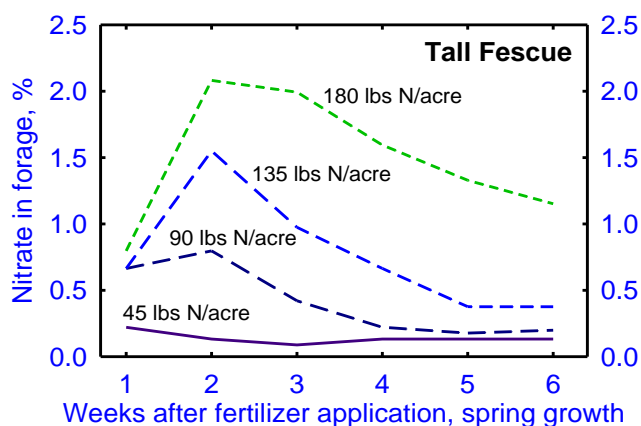


Fig. 1: Nitrate risk increases in intensity and duration with increased N fertilizer application (adapted from Hojjati et al. (1973), Agronomy Journal 65: 880).

### Nitrate Testing

There are tests available for nitrates in forages that can be used on-farm, including quick field tests for a qualitative analysis. One of the more recently developed quantitative tests was designed to eliminate use of hazardous chemicals present in older versions of these tests (Nitrate Elimination Company (NECi; <http://www.nitrate.com/>); Telephone: 1-888-NITRATE; Email: [sales@nitrate.com](mailto:sales@nitrate.com)). A 5-pack of nitrate tests costs about \$30, and can be performed by non-skilled users in about 30 minutes.

No single level of nitrate is toxic under all conditions but general guidelines are available. Analyses from commercial laboratories may be reported as nitrate, or as nitrate-N. A forage nitrate concentration up to 0.44% (4400 ppm nitrate or 1000 ppm nitrate-N) is safe to feed as the sole forage source in the diet. This is conservative; some guidelines list 0.66% nitrate as the cut-off. Non-pregnant cattle can tolerate up to 0.88% nitrate in forage, but concentrations exceeding 0.90% nitrate are

potentially lethal. Nitrate in forage is less toxic than nitrate directly consumed from other sources, such as direct ingestion of fertilizers.

### **Nitrate Toxicity in Manured Fields**

Manure can be a major source of N. If the ammonium-N content of the manure is high, peaks in nitrate levels can be expected two to four weeks after spreading. For manure sources that contain primarily organic N, it can take longer before a peak in nitrate levels is seen. Because it is difficult to determine when peaks in nitrate content occur following manure application, farmers using manure as N fertilizer for dry hay forages should test their forages prior to feeding. Similarly, pasturing of drought-stressed fields that received a supplemental manure application in the past month is not recommended.

### **Silage is Safer**

Green-chopped forage carries the highest risk of nitrate toxicity. Nitrate is stable in dried forage, so dry hay can remain high in nitrate. Proper silage fermentation reduces nitrates by one-half or more, and minimizes risk from nitrate toxicity. Poor fermentation, however, may not reduce nitrates. As with most all anti-quality compounds in forages, one potential solution to the problem is dilution of the toxic forage with other feeds in the diet. Most nitrate problems can be solved by replacing one half of the high nitrate forage in the diet with another, low nitrate, feed source.

### **Options if High Nitrate is Suspected:**

- Delay harvest until drought has been over for a week or two.
- Raise the cutter bar for harvest. Lower stem typically has the highest nitrate concentrations.
- If possible harvest for silage instead of hay or green chop.
- Have suspected forage tested to determine whether it is necessary to dilute the forage or completely avoid feeding it.
- Dilute high nitrate forages with a low nitrate feed source.
- Feed a balanced ration, cattle should have access to nitrate-free water at all times.
- Adapt cattle slowly to forage with elevated levels of nitrate. Feed forage several times a day if possible, rather than one feeding.
- Avoid feeding green chop, particularly green chop that has heated or was kept overnight.

Nitrites are formed with heating and nitrites are much more toxic than nitrates.

- Do not overstock pastures with high nitrate forages. Heavy grazing results in consumption of lower canopy and thus higher nitrate fractions.
- Feed cows before turning them out into a suspected high nitrate pasture. Cattle will adapt to higher levels of nitrate over time, if concentrations do not exceed 0.9% (9000 ppm) nitrate.
- Observe cattle frequently if the pasture they are in is suspected to be high in nitrates.
- Remove animals from their forage source if symptoms occur, and call a veterinarian.

### **Summary**

Nitrate accumulation in forage species can be a concern when high available soil nitrate levels are combined with cool temperatures, drought, or other stress that slows plant growth. Green-chopped forages and pastures have the highest risk of nitrate toxicity. When high nitrate levels are suspected, it is recommended to test the forage for nitrate prior to green-chop or grazing.

### **Additional Resources**

- Cornell University website for forage production: [www.forages.org](http://www.forages.org).
- Cornell University Grass Bioenergy website: [www.grassbioenergy.org](http://www.grassbioenergy.org).
- Cornell Guide for Integrated Field Crop Management: [www.fieldcrops.org](http://www.fieldcrops.org).

### **Disclaimer**

This fact sheet reflects the current (and past) authors' best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in this fact sheet does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of particular discharge levels from agricultural land.

For more information



**Cornell University  
Cooperative Extension**

Cornell Forage-Livestock Systems  
<http://www.forages.org>

Nutrient Management Spear Program  
<http://nmssp.cals.cornell.edu>

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