



Forage Checks

Testing nitrate levels in forages before feeding cattle can prove beneficial.

by Heather Smith Thomas

Nitrates are compounds created by combinations of nitrogen and oxygen and are necessary for plant growth. Almost all plants contain detectable amounts of nitrates when plant samples are tested for nitrate levels, but some types of plants, especially annuals, can accumulate high levels. This accumulation can occur when the uptake of nitrogen from the soil is faster than the plant can utilize it for protein synthesis.



Nitrates in some forages can be a problem for cattle under certain conditions, especially when plants are stressed by drought, according to Ken Olson, South Dakota State University (NDSU) Extension beef specialist. Plants may be stressed by low soil moisture, high temperatures or low humidity. Some plants may accumulate too much nitrate to be safely fed to cattle unless those high-nitrate feeds can be diluted by mixing them with other forages.

It generally pays to check nitrate levels before feeding some of these crops. There are a number of species that tend to accumulate higher nitrate levels including: sorghum; Sudan grass; sorghum-Sudan hybrids; corn; soybeans; fescue; pearl millet; and Bermuda grass.

“Nitrate toxicity potential often occurs in two scenarios,” says Kevin Sedivec, NDSU. “When planting annual forage crops (such as oats, barley, etc.) to be harvested for hay, nitrate levels can be excessive if you use too much nitrogen fertilizer. If you fertilize the crop thinking in terms of what would be adequate for “X” amount of production and it’s a dry summer — and the crop has less biomass than expected — there will be elevated nitrogen levels in those plants.”

This elevation can also happen if the producer fertilizes a crop to promote grain production and the weather is too dry to make grain. “If you put it up as hay or straw, but it was fertilized heavy enough for grain production, it probably had too much nitrate available for what actually

grew,” Olson explains. Fertilizer management for forage crops must be different from that used for grain production.

Sedivec recommends testing soils for nitrogen levels and then adding fertilizer as needed to achieve the production potential. If there’s a shorter crop because of drought, test the crop for nitrates.

The second scenario is when dealing with certain crops that are known to be prone to nitrate toxicity. “The main one would be oats, however all cereal grain crops can become high in nitrates under stressful conditions,” says Sedivec. If you are buying oat hay or buying any kind of cereal straw to feed to cows through the winter — as is commonly done, supplementing the straw with a protein source like alfalfa hay or a commercial protein product — it is crucial to have it tested for nitrates.

The only way to safely feed high-nitrate forage is to blend it with other feeds to dilute the nitrates.

Nitrates and nitrites

“When ruminant animals consume feed that is high in nitrates, the nitrates are quickly

converted to nitrite by the rumen microbes,” Olson explains. “The original form (nitrate) in the plant is not poisonous. It’s the nitrites that are toxic,” he says. This conversion is the reason why consuming plants with high nitrate levels is a bigger problem in ruminants than in horses, pigs or other animals with a simple stomach.

“Once it’s converted to nitrite in the rumen, the nitrite accumulates in the animal’s system,” Olson says. “If you are feeding a high enough level, it eventually becomes toxic. The amount on any one day may not be toxic, but it eventually exceeds the threshold for safety. The first thing we notice in pregnant cattle or sheep is abortions. If the safety threshold is exceeded after lambing or calving it affects milk production.” If the animals keep eating the high-nitrate feed, the continuing toxicity and accumulation in the body leads to muscle tremors, weakness and eventual death.

Signs of nitrate poisoning include labored breathing, muscle tremors and staggering gait. These animals generally have blue mucous membranes (due to lack of oxygen in the tissue), fast breathing, a high pulse rate, weakness, uneasiness, excessive salivation, frequent urination, and dilated and bloodshot eyes.

These cattle often die fairly quickly unless treatment is given immediately. If your veterinarian can treat them soon enough, an injection of 1% solution of methylene blue (4 mg. per lb. of body weight) into the bloodstream is the preferred treatment. This treatment aids in the reduction of methemoglobin to hemoglobin. If the animal doesn’t respond within 20 to 30 minutes, this dose may be repeated.

As long as producers can stay below dangerous thresholds while feeding nitrate-containing forages, nitrates will be converted to nitrite in the rumen, and the microbes continue the process of conversion, changing the nitrites to ammonia.

“Rumen microbes can then use ammonia to form amino acids. This is how a ruminant synthesizes protein,” Olson says. “Cattle convert nitrates to nitrites quickly, but conversion of nitrites to ammonia is slower. This is why the excess nitrites accumulate in the body.”

The process in plant metabolism is similar to what occurs in the rumen. “The plant pulls nitrate from the soil,” Olson explains. “This is how it gets nitrogen. In the plant the nitrate is converted to nitrite, and then to ammonia and then to amino acids and that’s how we get protein in plants. The nitrate converts

quickly to nitrite and sometimes it gets stuck there and never gets converted to ammonia — as when the plant is drought-stressed. It can’t finish the process.”

Other things may affect plant metabolism. During a cloudy, wet summer, there can also be nitrate problems in forage because photosynthesis slows down without adequate sunlight. “Last summer, for instance, we had wet conditions and still saw a lot of nitrate problems here in South Dakota. There are many environmental stresses that can lead to high nitrates in the plants — because they don’t get converted properly to plant protein,” Olson says.

Problem plants

Some plants like small grains accumulate nitrates. “The worst is oats,” Olson says. “Next is barley and triticale, and then wheat. There are also differences within the varieties of each of those species. A producer can work with a forage agronomist to select varieties that are safer.”

Summer annuals like corn, Sudan grass, sorghum, millets, etc. can present a problem, as can brassicas. Even some perennial cool-season grasses like brome and orchard grass can accumulate nitrates under certain conditions. If there is a lot of nitrate in the soil, there are many plants that can bring excess nitrates into their systems and not be able to convert it all.

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Nitrate safety levels



1,000 ppm or less
Nitrate level is safe under all conditions.



1,000-1,500 ppm
Nitrate level is safe for non-pregnant animals. For pregnant animals, this feed should be limited to 50% of the total ration.



1,500-2,000 ppm
Feed is safe if limited to 50% of the total dry matter intake.



2,000-3,500 ppm
Feed should be limited to 35-40% of the total dry matter intake.



3,500-4,000 ppm
Limit to 25% of dry matter intake. Do not feed to pregnant animals.



Above 4,000 ppm
Do not feed.

Information from Rock River Laboratory Inc.

Factors that affect nitrate levels

Drought stress, soil fertility, plant maturity, etc. can make a difference when it comes to nitrate levels in forages. Ken Olson, South Dakota State University Extension beef specialist says, “Even the time of day matters — regarding the best time to cut hay.”

He notes it’s safest to wait until afternoon because plants accumulate nitrates from the soil all night long, but there is no photosynthesis until daylight.

“The plants store nitrates until they can be processed, so levels are highest in the early morning and lower in the afternoon,” he says.

A herbicide can also increase nitrate levels if the amount of herbicide is not enough to kill the plant but affects metabolism.

Maturity makes a difference, as well. Nitrate levels decline as the plant matures. The nitrates accumulated early in growth eventually get converted to protein.

“If we delay cutting a small grain crop for hay until the plants are more mature and starting to form seed heads the levels will be lower,” Olson says.

Ranchers who are putting up crops for cattle need to be aware of the things that can affect nitrate levels. **HW**



“Producers who plant brassicas like turnips and radishes for cover crops should be aware that in drought conditions these will accumulate nitrogen,” Sedivec says. “Many producers graze those crops because they are hard to put up for hay. I recommend testing brassica species for toxicity levels before you graze them. Toxic levels are usually associated with drought. Oats, barley, sorghum-sudan grass, millet, etc. should always be tested if you harvest these species for hay. This is where we generally see toxic levels, following a stress period like drought or an early freeze.”

Olson says other plants that can cause problems include weeds, especially certain annual weeds. “Wild oats are just like farmed oats,” Olson says. “Quack-grass, pig-weed, lambs-quarter, kochia, Russian thistle and many other weeds that we find in forage crops are nitrate accumulators.”

These weeds can be deadly in hay or when grazed. Barnyards and corrals may grow a lot of weeds, and if you put cattle in these areas when there are a lot of weeds, they may consume them.

Sampling and testing

“Because soils vary, and soil fertility can vary greatly across a field, it is important to sample forage at several locations,” Olson says.

Usually samples are sent to a lab, but the nitrate quick test is available through Extension services in some states. “A producer can bring a sample to an extension person who is trained to do it, and have immediate results,” he says. “We cut the stems open and apply a few drops of solution and look for a color change. If it turns blue, there are nitrates. We don’t know if it’s just a little or a lot, but if it doesn’t turn blue we can tell the producer it’s safe to cut it for hay.”

If it turns blue, either wait until the forage is more mature, or send samples to a lab for a more definitive quantitative test. The quick test is just a yes or no answer. It can be helpful, however, if a person needs to know if hay is safe to cut or is looking for hay to purchase and needs to decide quickly whether to buy a certain batch or not.

In some instances, actual nitrate numbers from a lab are needed. “If you are checking hay you want to cut, and it turns blue and you decide to wait a week, and it’s still turning blue, and you wait another week and it’s getting too mature to make good hay you cut it anyway,” Olson says. “Or, perhaps you buy some hay and you know it was turning color on the test but you needed to buy something. In these instances you’d send samples to a

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lab to find out what the actual level is and whether it’s safe to feed.”

Managing nitrates

The lab will provide what the levels are — whether safe, moderately safe or toxic. “If the hay is high in nitrates, the next question is what to do with it,” Sedivec says. “Even after it’s been stored a long time, it is still toxic; nitrates don’t volatilize out like prussic acid does in sorghum-sudan grasses.”

The only way to safely feed high-nitrate forage is to blend it with other feeds to dilute the nitrates. “Many producers will put that hay into a total mix ration, and if they know what the levels are, they can blend it off with a grass mix to bring those levels down,” he says. “It’s easier to deal with a moderately high level feed, such as 2,000 parts per million (ppm). You can blend those easier than the feeds that are really high. Two years ago I saw some turnips that were over 4000 ppm, and those levels are deadly.”

Test other feeds to accurately determine how to blend them and

adequately dilute the nitrates. “It costs a little to test, but it will be a lot cheaper than dead cattle,” Sedivec says.

Questionable forage should always be blended with safe forage. Feeding large round bales or any forage free-choice in feeders can increase the risk for nitrate poisoning since cattle have unlimited access and may overeat. Rate of ingestion can increase the nitrate levels in the rumen.

Olson points out different classes of livestock have different safety levels. “Non-pregnant animals can be safe with higher nitrate levels than pregnant animals,” he says. “If you are backgrounding calves or have a pen of young replacement heifers that are not bred yet and won’t be pregnant until after the winter feeding, you could feed them the higher levels, versus pregnant cows. There are more options for managing nitrate feeds for non-pregnant animals, with more latitude for safety.” **HW**