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Ohio State University Fact Sheet

Animal Sciences

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Nitrates in Dairy Rations

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Inadequate water, other plant stressors, and high application of nitrogen fertilizer can cause nitrates (NO_3) to accumulate in the vegetative portions of various plants. Plants require less soil moisture to absorb nitrates than is necessary to attain maximum plant growth. During a drought, plants can uptake nitrates but cannot convert them into plant proteins as rapidly as during normal growing conditions. This causes nitrates to accumulate in certain plants. After an extended dry period, rainfall may cause an immediate increase in nitrates for 2 to 3 days until the plant's growth begins to respond by convertiong nitrares to protein. The highest concentration of nitrates will be in the lower part of the plant. Therefore, a sample for nitrate analysis must be representative of the whole plant (Table 1). Various plants are prone to accumulation of nitrates, including corn, wheat, oats, barley, sorghum species, sweet clover, and most weeds. Some plant species, such as sorghum, planted for Fall forage may also accumulate nitrates late in the growing season. The cool nights and short days will reduce plant growth, but ample moisture may be present for rapid uptake of nitrates.

Table 1

Relative distribution of nitrate nitrogen in corn plants[1].

Plant Portion	NO_3-N(ppm)
Stalk, lower one-third	5524
Stalk, middle one-third	803
Stalk, upper one-third	153
Leaves	64
Ears	17
Whole plant	978

[1] Based on a study at University of Wisconsin.

Corn plants existing in drought conditions.

Animal Toxicity

Nitrate toxicity can be a problem for ruminants because of the extensive feeding of forages. Nitrates from feeds are converted very rapidly to nitrite (NO_2) by the rumen microorganisms, and then nitrite is converted to ammonia which can be used to synthesize bacterial protein. However, if the conversion of nitrates to nitrite is more rapid than conversion of nitrite to ammonia, absorption of nitrite will occur. Once in the bloodstream, nitrite will compete with oxygen for binding sites on hemoglobin. Hemoglobin with bound nitrite (called methemoglobin) loses its ability to carry oxygen to and carbon dioxide from tissues. Clinical signs of nitrate toxicity include pale mucous membranes, chocolate-brown-colored blood, and labored breathing. Sudden death may even occur. If toxicity is suspected, a veterinarian should be contacted immediately because an antidote is available.

Nitrate Tests

A qualitative test is available for nitrates:

a) Reagent A: Dissolve 500 mg of diphenylamine in 20 ml of water and bring to a final volume of 100 ml with concentrated sulfuric acid. (Use an amber bottle, and place the solution in a dark place for storage).

b) Reagent B: Cautiously add 80 ml of concentrated sulfuric acid to 20 ml of water.

c) Field test solution: Mix equal parts of Reagent A and Reagent B.

Remove a section of tissue from the lower section of the plant and apply a small amount of test material to the cut side of the tissue. A blue coloration using the reagent kit indicates presence of nitrates. If nitrates are found present with a qualitative test, a quantitative test is recommended.

Many laboratories will conduct quantitative analyses for nitrates. When analytical reports are returned, be sure to note units used to express nitrate level:

Nitrate nitrogen (NO_3-N)
= nitrate (NO_3) x 0.23,
= potassium nitrate (KNO_3) x 0.14,
= sodium nitrate ($NaNO_3$) x 0.16;

NO_3 = NO_3-N x 4.4,
= KNO_3 x 0.61,
= $NaNO_3$ x 0.73.

Samples for nitrate analysis should be representative of the feed, and wet samples should not be mailed in plastic bags because fermentation will reduce nitrate level.

Feeding Management

Forages high in nitrates generally should not be grazed or fed as green chop or hay. However, ensiling forages will reduce nitrate levels by 35 to 80 percent. Regardless of feeding method, a quantitative test for nitrates is advised if high levels are suspected. Silage and hay should not be sampled for analysis until two weeks after harvesting. Table 2 provides guidelines for using feeds with known nitrate levels. Since nitrate toxicity is dependent upon nitrate level in the total diet, water quality must also be considered (Table 3).

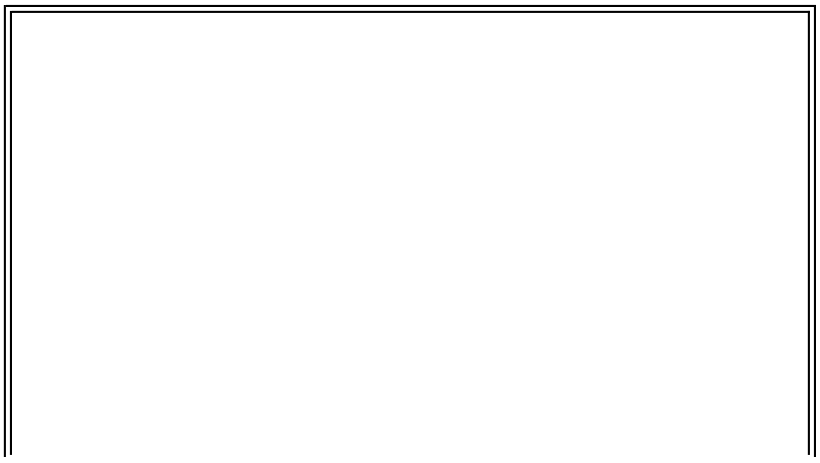

Table 2

Guidelines for using feeds with known nitrate level.*

Unit of Measurement (DM Basis)			
% NO_3-N	ppm NO_3-N	% NO_3	Comment
<0.1	<1000	<0.44	Safe
0.1–0.2	1000–2000	0.44–0.88	Generally safe. Limit to 50% of dietary dry matter for pregnant animals.
0.2–0.34	2000–3400	0.88–1.5	Limit to 50% of dietary dry matter for non-pregnant animals and do not feed to pregnant animals (<25% if necessary). Be sure water is low in nitrates and ration is well fortified with energy, minerals, and vitamin A.
0.34–0.4	3400–4000	1.5–1.8	Limit to 25% of dietary dry matter for non-pregnant animals. Be sure water is low in nitrates and ration is well fortified with energy, minerals, and vitamin A.
>0.4	>4000	>1.8	Potentially toxic - Do not feed.

Table 3

Guidelines for use of water with known nitrate content.*

ppm NO_3-N	Comment
< 10	Generally regarded as safe for all animals and humans.
10 to 20	Questionable or risky for humans, especially young children and pregnant women. Safe for livestock unless feed also has high levels.
20 to 40	Considered unsafe for humans. Might cause problems for livestock, especially swine and poultry.
40 to 101	Unsafe for humans and risky for livestock. Be sure feed is low in nitrates and be sure a well balanced ration is fed. Fortify ration with extra vitamin A.
101 to 202	Dangerous and should not be used. General or nonspecific symptoms such as poor appetite are likely to develop. Water apt to be contaminated with other foreign substances. When allowed free-choice to cows on a good ration, acute toxicity not likely.
> 202	Don't use. Acute toxicity and some death losses might occur in swine. Probably too much total intake for ruminants on usual feeds.

* Tables partially adopted from August 25, 1970 issue of Hoard's Dairyman.

Feeds marginal-to-high in nitrates should be slowly introduced to animals, and the allowable amount of such feed should be fed over the course of the day instead of feeding it all at once. Also, hungry animals should not be allowed access to feeds with moderate-to-high nitrate levels but should be fed low nitrate feeds first to curb their appetite. Adequate energy, particularly rapidly fermentable carbohydrates, must be in the diet to facilitate the utilization of nitrate nitrogen by rumen bacteria, and adequate minerals and vitamins, especially Vitamin A, must be supplied.

Feeding urea or other sources of non-protein nitrogen (NPN) with nitrate containing feeds can be practiced without harmful effects. These supplements should be fed within guidelines because excess NPN can result in ammonia (NH_3) toxicity. Ammonia toxicity is different than nitrate toxicity.

Gases produced from fermentation during the first few days after filling a silo can be harmful. Therefore, caution should always be practiced when working around freshly filled silos, especially when the silo is filled with forage containing high levels of nitrates. During fermentation, nitrates will be used to form yellowish-orange gases called nitric oxides that are lethal. If it is necessary to enter a silo shortly after filling, adequate ventilation must be provided.

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