

Nitrate toxicity in forage crops:

Causes and remedial measures

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Dairy cattle work with the principle of converting forage crops which are useless for man into a useful product such as milk, curd, ghee and other milk products. Forage crops especially cereal forage have problem of nitrate toxicity when excess amount of fertilizer is applied to the crop. Forage crops can accumulate higher amounts of nitrate (NO_3). High amount of nitrates can accumulate in cereal grains (oats, rye, wheat, barley, triticale, etc.), sorghum, sudan grass, millet, corn and on very rare occasions, alfalfa. There are several reasons behind the accumulation of higher amounts of nitrates in the crops, especially under the adverse environmental conditions. Abnormal growing conditions such as drought, frost, unseasonable or prolonged cool temperatures, hail, shade, disease and herbicide damage can cause high nitrate accumulation in forage.

Key words: Forage crops, Nitrate toxicity

THE uptake of nitrate by the plant for metabolism is a common process, but when the uptake of nitrate nitrogen exceeds the limit it leads to accumulation of nitrate at toxic concentration. Agronomic practices also influence the rate of uptake of nitrate nitrogen in forage crops. The agronomic practices that mainly influence are: plant density (seed rate), nutrient management, especially nitrogen management, crop genotypes (variety) etc.

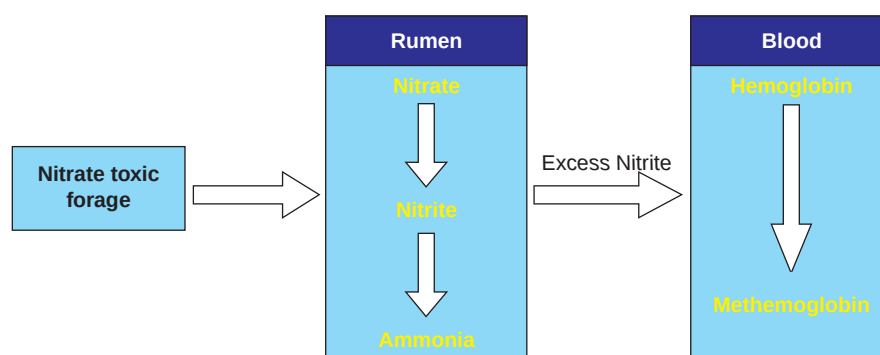
Nitrogen management decides the concentration level of nitrate in the crop. Crops usually uptake the nitrogen in NO_3 form. NO_2 is more toxic to the dairy cattle than NO_3 . When improper management of nitrogen or excess amount of nitrogen is applied to the forage crops in the form of organic manure, inorganic nitrogen fertilizer, the NO_3 is taken by the plants in excess amount that is toxic level and it is accumulated in the plant and is harmful to the cattle when it is fed to them.

Seed rate is also one of the important factors that decide the concentration of nitrogen (NO_3 ,

NO_2) in crop plants. In Indian conditions, the farmers usually prefer broadcasting method of sowing and when the high seed rate is used by the farmers, the plant population per m^2 will be higher. When plant density is higher, the lower leaves of the plants will experience lower photosynthetic light that leads to less photosynthetic energy. Absorption of photosynthetic energy which is necessary for conversion of NO_3 to protein and amino acids is once lowered, then low conversion occurs that results in higher accumulation of NO_3 and NO_2 in various parts of the crop plants.

Metabolism in nitrate toxicity

Around 1895, nitrate poisoning of livestock was reported. Livestock losses occurred for many years before elevated nitrate levels in forage were determined to be the cause of death. Nitrate nitrogen is less toxic to crop plant than nitrite nitrogen. Cattle, sheep, goats are ruminants and in ruminants, nitrate is converted to nitrite by the bacterial population present in the rumen of the cattle. This converted nitrite is then converted to ammonia. This ammonia is utilized for the growth and development of the cattle. Excess ammonia produced is absorbed by the



Nitrate metabolism in cattle.

blood and then it is passed out of the body through urine in the form of urea. Normal process of conversion occurs when the nitrate concentration in the body is optimum and no excess nitrate and nitrite accumulation will occur whereas when the excess nitrate concentration is there in the crop plant, accumulation of unconverted nitrate and nitrite occurs which is ultimately unhealthy to the cattle resulting into nitrate toxicity that may even result into death of the cattle.

Mechanism of nitrate toxicity in cattle

Due to higher plant density, the photosynthetic energy in plants especially in lower parts of the plants will be lower. Therefore, deficiency of photosynthetic energy that is responsible for conversion of nitrate to nitrite and then to ammonia will occur. When excess nitrate toxic forage is fed to the cattle, nitrate and nitrite accumulates in the rumen and this nitrate and nitrite go through the bloodstream and when nitrites combine with hemoglobin, it forms methemoglobin. Methemoglobin is incapable of transporting oxygen in the bloodstream. Oxygen deficiency occurs in the blood that results in higher heart rate, and respiration rate. Tissue of the animal turns blue to chocolate brown colour. Ultimately the animal suffers with suffocation.

Plant factors influence nitrate poisoning

- *Plant species*: Majority of nitrate poisoning occurs usually in oats, barley, sorghum and corn especially under drought stressed conditions. Usually, cereal forage crops suffer with nitrate toxicity since they consume or absorb higher amount of nutrient, in other sense, they have high affinity towards nutrients especially nitrogen. Higher uptake and accumulation of nitrate may also



Feeding of forage having nitrate at toxic level is unhealthy for cattle

- be due to several other factors such as moisture conditions, biotic and abiotic stress, soil factor, soil acidity, P, Mo and S deficient soil, frost and low temperature that leads to higher uptake of nitrogen by the plants.
- *Plant parts*: Lower part of plant accumulates more amount of nitrate especially stalk or stem portion. As we go towards upper side of the crop such as leaves and reproductive parts the nitrate accumulation rate decreases. Seeds will have lower or no nitrate accumulation since photosynthesis occurs more in upper parts of the plant that converts nitrate into ammonia.
- *Growth stage of plant*: Nitrate accumulation rate decreases as the plants get mature. Early growth stage of the plants has higher accumulation of nitrate in its parts and when plants get mature the nitrate accumulation rate decreases. Under adverse environmental conditions, even mature plants will have higher accumulation of nitrate into the plant parts.

Symptoms of nitrate poisoning in cattle

- Noisy breathing of cattle
- Weakness in cattle
- High pulse rate
- High respiration rate
- Blue to brown mucous membranes
- Bloating in cattle
- Death of cattle

Management of nitrate poisoning in cattle

- Drought stressed forage crops and its seed are tested before feeding it to the cattle.
- Provide nitrate free water and feed to the cattle.
- Do not allow cattle to graze grasses with high nitrate accumulation.
- Dilute the high nitrate accumulated feed with low nitrate feed.
- Do not allow hungry cattle to eat high nitrate feed.
- Do not feed the chaffed forage crop kept overnight since it accumulates heat in it.
- Do not feed the cattle with young forage crop especially the crop younger than 45 days.
- Dry the crop if it is high nitrate forage, after cut.
- Do not feed high nitrate feed to the unhealthy, weak cattle.

Recommendations for use of forage for feeding

Nitrate nitrogen (NO ₃ -N)		Nitrate (NO ₃)		Recommendations
ppm	%	ppm	%	
0-1,500	0-0.15	0-6,500	0-0.65	Safe
1,500-4,500	0.15-0.45	6,500-20,000	0.65-2.00	Can be fed with caution by diluting the concentration of feed
>4,500	>0.45	>20,000	>2.00	Not to feed

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