Nitrate Poisoning of Livestock

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Nitrate poisoning can result from ingesting forage or water high in nitrate content, or by inhaling nitrogen gases. Both humans and livestock can be affected.

Nitrates are found in most plants and groundwater in varying amounts, but under certain conditions, nitrates can accumulate in plants and water to toxic levels. Forages with high nitrate content are sometimes used for ensilage. Under the acid conditions of the silo, denitrification of the nitrate produces nitrogen dioxide, a toxic, heavy, yellow-brown gas, which is highly toxic to humans. Such toxicity is sometimes referred to as "silo-filler's disease."

Range livestock are most commonly poisoned by nitrates in forage. Cattle are most susceptible while sheep are less affected, possibly because of their ability to break down nitrate more quickly than cattle. Goats, horses, dogs, birds, and swine are also susceptible. Swine, however, are not affected as often as cattle or sheep, because they consume smaller amounts of roughages and, consequently, are less likely to ingest toxic amounts of high-nitrate forages.

Mechanism of Poisoning

Although poisoning from the various forms of nitrate is referred to as "nitrate poisoning," the nitrate ion itself is relatively nontoxic. In the ruminant, ingested nitrate is broken down to nitrite then undergoes further degradation to ammonia, which is used to form microbial protein. The reduction of nitrate to nitrite occurs much more rapidly in the rumen than the reduction of nitrite to ammonia. Consequently, when ruminants consume plants high in nitrate, some nitrite formed in the rumen enters the bloodstream where it converts blood hemoglobin to methomoglobin. This greatly reduces the oxygen-carrying capacity of blood, and the animal suffers from oxygen starvation of the tissues. Prussic acid also produces death by tissue asphyxiation, but by an entirely different process.

The methemoglobin content of the blood of cattle succumbing to nitrate poisoning may be as high as 80 percent. Conversion of one-third of the hemoglobin to methemoglobin produces only slight symptoms; life is still possible when 60 percent of the hemoglobin has been converted; but death is a certainty when hemoglobin has fallen to one-third normal levels.

Conditions of Poisoning

Plants containing more than 1.5 percent nitrate ($KN0_3$) are dangerous and nitrate consumption in amounts of as little as 0.05 percent of the animal's weight may be lethal. Losses are most frequently associated with cool temperatures and cloudy days, drought, heavy applications of nitrate fertilizers, and soils characteristically high in nitrogen.

The rate of nitrate formation is very slow at soil temperatures below 50°F, but rates of conversion increase in direct proportion to increased soil temperatures up to 80-90°F.

Nitrate concentration in forages increases greatly during drought conditions.

Low light, such as a cloudy day, causes nitrate accumulation in plants, because nitrates accumulated during the night are not dispersed until sunlight hits the plants.

Some plants contain a substance that, under proper conditions, is capable of reducing nitrates to nitrites. This is thought to be the mechanism whereby nitrate poisoning has occurred on previously harmless pastures and hays. Controlled experiments, as well as carefully investigated field cases, have shown that oat hay moistened with

water and exposed to air may contain toxic amounts of nitrates in a relatively short time. The reduction of nitrates to nitrites reaches a peak in 18 to 22 hours after the hay or plant material has been moistened. During this time, about 40 percent of the nitrate is converted to nitrite; hence, toxic amounts of nitrites are present where harmless amounts of nitrates previously existed.

Symptoms of Poisoning

Nitrate poisoning acts very quickly, therefore symptoms may not be observed before animals are found dead. Animals being poisoned may stand apart from the herd, then collapse; or they may fall in their tracks if driven. Signs of poisoning, in the usual order of appearance, are weakness and unsteady gait, collapse, shallow and rapid breathing, rapid pulse, coma, and death—the latter accompanied by the usual terminal muscular reflex movements.

Respiratory distress is not as obvious as when associated with choking or pneumonia. The unpigmented parts of the body, such as the white of the eye, the tongue, and lips, have a blue-brown discoloration from the onset, as a result of methemoglobin circulating in the superficial vessels.

Blood in which at least 10 percent of the hemoglobin has been converted to methemoglobin is chocolate-brown in color. Fatal methemoglobin levels range above 70 percent of the total hemoglobin, so the color of the blood of a dead animal may indicate poisoning. However, even though plant nitrate poisoning is suspected as a cause of death, be cautious in accepting the color of the blood of the dead animal as confirmatory evidence, if some time has passed since death. A chemical analysis to determine the presence of methemoglobin, nitrate, or nitrite in a blood sample is the most reliable method of determining nitrate poisoning.

Few tissue changes are evident at autopsy after nitrate poisoning. Some inflammation of the respiratory and gastrointestinal tract may be noted, and there may be a few small hemorrhages, particularly on the heart.

Following an abnormal exposure to nitrates or nitrites, a cow may abort a fetus that died because of oxygen starvation. The grazing of plants containing “borderline” levels of nitrate has also been associated with abortion, reduced milk flow, lower weight gains, and signs of vitamin A deficiency. (Nitrate is thought to interfere with the conversion of plant carotene to vitamin A.)

Testing for Nitrates

The diphenylamine test for nitrates can be used in the field to detect dangerous nitrate levels in forages or rumen contents. The test reagent is made by dissolving 500 milligrams of diphenylamine in 20 milliliters of water and carefully adding enough sulfuric acid to make 100 milliliters. This stock solution should be stored in a brown bottle.

The steps in conducting a quick nitrate test are:

1. Learn the environmental conditions conducive to high nitrate content in forages.

2. Obtain a forage sample that is representative of that eaten by the animal, or a sample of the rumen contents.

3. Finely crush the sample in a glass container, such as an ash tray.

4. Add 10 to 20 drops of distilled water and mix well, with crushing action.

5. Add a few drops of the diphenylamine-sulfuric acid solution.

6. Formation of a deep blue precipitate within 30 minutes indicates a high concentration of nitrate in the forage and the need for a more quantitative test.

Treatment

Death usually occurs so suddenly that treatment is not possible, and few treated animals recover.

Handle poisoned animals quietly, and administer methylene blue intravenously. Use a 1- to 4-percent solution containing 5 percent dextrose at the rate of 1 gram of methylene blue for each 250 pounds of body weight. A typical commercial preparation contains 1 percent of methylene blue and is used in 125 to 250 milliliter doses per adult cow or horse. Doses are reduced proportionately for smaller animals. Due to the vasodilation eftect of nitrate, vasoconstrictor drugs such as adrenalin should be administered. In chronic poisoning, vitamin A should be given.

Nitrate-Accumulating Plants

Plant species that are most likely to accumulate toxic concentrations of nitrate are:

Field Crops

alfalfa	millet	sorghum
barley	oats	soy bean
corn	rape	sudan
fescue	rye	wheat

Weeds

bindweed	elderberry	Russian thistle
blue-green algae	fiddleneck	smartweed
bull thistle	goldenrod	stinging nettle
burdock	lambsquarter	sunflower
Canadian thistle	nighshades	velvetweed
carelessweed	ragweed	whitecockle

Vegetables

beets	lettuce	spinach
celery	mangles	squash
cucumbers	parsnips	swiss chard
kale	radishes	turnips

Other plants may accumulate toxic levels under conducive environmental conditions.

Management Practices

Feeding rations high in carbohydrates will reduce and some times prevent losses from nitrate poisoning.

- Control weeds that accumulate nitrates. Freshly sprayed plants may become more palatable, so defer grazing of sprayed areas.
- During periods of cool or cloudy weather. avoid grazing a suspect area if possible. During periods of sunlight allow' animals to eat large quantities of dry forage and then graze the area.
- Test the nitrate content of forage when in doubt.
- Distinguish nitrate poisoning from prussic acid poisoning or grass tetany, so the appropriate treatment may be administered.

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