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Nitrate Toxicity In Horses

Nitrate poisoning (methaemoglobinaemia) is always a concern for producers growing summer annuals for forage and for pastures receiving applications of swine or poultry waste. It is not uncommon, as many annual plants, including wheat, may accumulate nitrates under moisture stress. Symptoms are seldom obvious in livestock. Often, the first signs noticed by producers are coma or death.

Some farmers test a field for nitrates by turning in a "sacrifice animal" to see if it shows any abnormal behavior or dies. A word of warning is in order here. When one animal is turned into a field, it will lightly graze the new leaves, which contain the lowest concentration of nitrates in the plant. Thus a sacrifice animal may not detect a high nitrate problem that will show up latter when the herd is turned in and heavier grazing occurs.

What Causes High Levels of Nitrates in Forages?

Most plants take up nitrogen from the soil primarily in the form of nitrate. Under normal conditions, this poses no animal health problem because nitrate is rapidly converted into nitrite (NO2), then to ammonia (NH3), then into plant proteins and other nitrogenous compounds. When plant growth is slowed or stopped because of moisture stress or other stress, nitrate continues to be taken up by the plant but it cannot be changed into other forms fast enough, and therefore, nitrate accumulates. This is when nitrate poisoning can occur. The stresses that slow plant growth and cause nitrate to accumulate to toxic levels are normally drought or frost. However, small grains actively growing in the fall or spring have been shown to accumulate nitrates at toxic levels during several cloudy or overcast days. Additionally, spraying 2,4-D or 2,4-DB may cause increased nitrate accumulations in some plants.

Certain plants are more likely to accumulate toxic levels of nitrate than others. Pearl millet, Johnsongrass, sorghum, sudangrass, pigweed, lambsquarter, and oats are known to be accumulators. These plants may contain toxic levels of nitrate when other plants growing beside them will not. For instance, a fertilized and drought-stressed bermudagrass pasture may not result in any animal heath problems, but the same pasture containing pigweed would cause animal deaths if the pigweed were eaten. In a Missouri study, sudangrass, orchardgrass, and tall fescue accumulated nitrate at high levels; smooth bromegrass and ladino clover were intermediate; and alfalfa and wheat had only low levels.

Nitrate levels will be highest in the stalks or stem bases and lowest in the new leaf growth. Nitrate content can change dramatically (either higher or lower) from day to day. Once cut for hay, nitrate levels do not change appreciably. However, ensiling high nitrate material will cause a portion of the nitrates to be converted to a brown gas (Nitrous Oxide) and given off. Thus silage becomes safer to feed, but it can remain toxic. The brown-colored gas (Nitrous Oxide) given off by fermenting high nitrate silage is poisonous, and care must be taken when near the silo while forage is fermenting. This is especially true when venting the top of and upright, airtight silo.

Why Test Forages for Nitrates?

Nitrates themselves are relatively nontoxic. Their importance as a cause of poisoning is due to their conversion, either in the feedstuff or in the animal's digestive tract, to nitrite. The nitrite ion (NO2) oxidizes ferrous iron in blood hemoglobin to the ferric state, for methemoglobin, which is unable to act as an oxygen carrier. If enough of the hemoglobin is changed to methemoglobin, the lack of oxygen causes the animal to suffocate (tissue anoxia).

Sub-lethal symptoms of nitrate poisoning are seldom very apparent. Signs of abdominal pain and diarrhea are seen due to the irritant action of nitrate ions. Muscular weakness and incoordination, convulsions, and accelerated heart rate accompany this. Abortion may occur in pregnant animals. In severe cases, progressive cyanosis occurs, which is first visible as a bluish discoloration of the mucous membranes and unpigmented areas of the body and leads to torpor, coma, and death. Dead animals will have discolored, dark, tar-like blood (chocolate color blood).

Nitrate in the diet (feed or water) at moderate levels will cause reduced milk production, lowered rates of gain, and reproductive difficulties. At higher levels, death will result. The exact level at which a given response occurs depends on the condition of the animal and the energy level of the ration. Cattle in good condition can tolerate 50 percent of the hemoglobin being changed to methemoglobin with ill effects, while this could be lethal to cattle in poor condition. High levels of energy in the ration speed up the reduction of nitrate in the rumen to ammonia and detoxifies it.

Fasting increases the susceptibility to nitrate poisoning. Cattle feeders do not "fast" their cattle on purpose of course, but drought frequently leaves the cattle with little to eat. This commonly results in cattle that are in poor condition, that have low-energy diets, and that will gorge themselves if given the

opportunity. All these factors will increase the severity of a given level of nitrate ingestion.

There appears to be some degree of adaptation to high nitrate levels. Animals that have gradually increased levels of nitrate in their diet tend to be able to tolerate higher levels of nitrate than animals first exposed to the higher levels.

The variable effects of nitrate make it difficult to make an absolute statement as to the actual toxic dose of nitrate.

Nitrate Sampling Procedures

The potential for nitrate poisoning can be assessed by being aware of the growing conditions prior to harvest. Plant stress indicates the potential for nitrate toxicity, especially when it is coupled with high nitrogen application rates, either inorganic (fertilizer), or organic (animal waste).

Before feeding forages that may be high in nitrate, first take a sample and send it in for laboratory nitrate analysis. The most critical factor in obtaining accurate and reliable information regarding nitrate levels in the forage is proper and careful sampling of the forage. For hay or silages, take several representative samples, mix them together thoroughly, and send a sample of the mixture to the laboratory. Sample silage after fermentation is completed because nitrate levels may be slightly lowered from that of the freshly chopped sample. In pastures, it is important to sample the entire portion of the plant that the animal will be eating. Remember that young leaves on top of the plant will tend to have a lower nitrate level than other parts of the plant.

Nitrate Poisoning in Horses

Fortunately, nitrate /nitrite poisoning is not a common problem in horses. However, due to serious and potentially fatal consequences of nitrate/nitrite poisoning, horse owners should be aware of the condition and understand the risk factors.

Nitrate/nitrite poisoning in animals is caused by ingestion of excessive amounts of nitrate or nitrite from forages or weeds, nitrate containing fertilizers, or contaminated water. Ingestion of large amounts of nitrate can cause gastrointestinal irritation, colic, and diarrhea, but the most important consequence is the conversion of nitrate to the more toxic nitrite anion by gastrointestinal microorganisms. Nitrite is absorbed from the gastrointestinal tract into the blood, causing injury to red blood cells and resulting in inability of red cells to carry oxygen. Clinical signs may include difficulty breathing, weakness, tremors, ataxia, rapid heartbeat, grey/blue or brown discoloration of blood and tissues, seizures, and rapid death. Abortion can occur in animals that survive the initial clinical signs.

While nitrate/nitrite poisoning can occur in any species, ruminants are most susceptible, due to efficient conversion of nitrate to nitrite in the rumen. Non-ruminant species such as horses are much less commonly affected because they do not readily convert nitrate to the more toxic nitrite. Conversion of nitrate to nitrite occurs primarily in the large bowel in horses and is roughly one-fourth as efficient as ruminal conversion in cattle. Hence, compared to ruminants, a much larger dosage of nitrate is required to cause clinical signs in horses. However, horses are very sensitive to nitrite. Ingestion of nitrite can occur when nitrates in forages or water have been converted to nitrite by environmental microbes prior to ingestion. Documented cases of nitrate poisoning in horses are rare. Most cases involve ingestion of nitrate/nitrite-contaminated water, nitrate fertilizer directly, or forage or hay grown in the area of a previous fertilizer spill. A few cases in horses have occurred from ingestion of high nitrate hay that was baled wet or became wet after baling. Nitrate was converted to nitrite by microorganisms in the hay, resulting in direct nitrite ingestion. Only a few experimental studies have been published documenting effects of administration of high concentrations of nitrate to horses. No studies have been published that determine the amount of nitrate that horses can safely tolerate. However, studies suggest that horses, including pregnant mares, can tolerate considerably more dietary nitrate than can cattle.

Chronic exposure to lower levels of nitrate has not been well researched in horses. Associations between chronic nitrate exposure and infertility, poor growth, hypothyroidism, and other disorders have been claimed, but none have been experimentally reproduced in horses, and much work remains to be done.

A small amount of nitrate is normally found in all animals, including horses, as nitrate is a normal component of the plants they eat. Many factors can increase the risk of excessive nitrate accumulation in plants, including species of plant, stage of growth, fertilization practices, plant stress (drought, frost, hail, herbicide use), and many other factors. Nitrate accumulates primarily in plant stalks, less in leaves, and not in grains or fruits. Many important crop plants can accumulate nitrates, including oat plants, sorghum/sudan, and alfalfa. Nitrate-accumulating weeds include ragweeds, pigweed, and Johnson grass, to name just a few. Although high-nitrate forages and weeds pose significant risks to ruminants, horses are rarely poisoned by these plants unless they have been grown on sites of previous fertilizer spills or nitrates have been converted to nitrite by environmental microbes. Treatment of affected animals is possible, but timing is critical, as animals can die very quickly. Prevention is key, and for horses includes the following: ensure that fertilizers are used as directed and stored safely away from animals; thoroughly clean up any spills; do not apply excessive fertilizer to pasture or hay fields; never use tanks that previously contained fertilizer to haul water, even if tanks have been washed; do not bale hay when it is too wet or allow hay to become wet during storage; and do not feed moldy or wet hay. It's important to have suspect forages or water tested for nitrate and nitrite concentrations before animals are exposed. Contact an appropriate laboratory, such as the Livestock Disease Diagnostic Center, for sampling protocols and testing services.

References: Dr. Cynthia Gaskill, University of Kentucky

"Nitrate Toxicity," Bruce Pinkerton, Clemson University CES; Don Ball, Auburn University CES; Jim Green, North Carolina State University CES, 1998.