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Managing the Prussic Acid Hazard in Sorghum

Forage sorghum, sorghum-sudangrass and sudangrass are important forage crops throughout the United States. Sorghum forage has many important traits, including high drought tolerance, less need for fertilizer, lower production cost as compared to corn, and a variety of usable forms (hay, silage, greenchop, and pasture).

While sorghum is a valuable forage crop, sorghum species can produce prussic acid, which can be toxic to livestock. Prussic acid, also known as hydrogen cyanide (HCN), can cause acute toxicity and death. Hydrogen cyanide interacts with cellular respiration and leads to the body's inability to utilize oxygen for respiration to do work. Symptoms include shortness of breath and convulsions. Death can occur within minutes after the onset of symptoms, if toxic sorghum is consumed in large enough quantities. Concentrations (on a dry matter basis) between 500-750 ppm HCN can be toxic and should be fed with another source of feed; concentrations above 750 ppm are very dangerous to

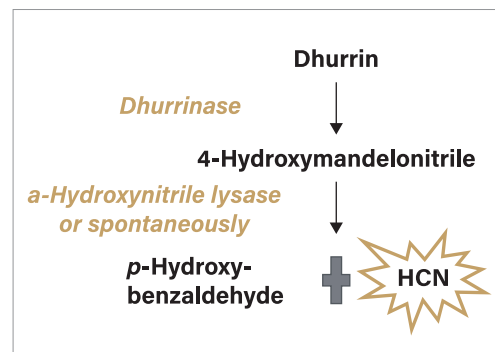


Figure 1. The pathway of dhurrin conversion to HCN. The enzymes that result in the breakdown of dhurrin are italicized.

livestock and should not be fed (Cope, 2021).

Potential of HCN toxicity (HCN potential) is directly related to dhurrin content, which is the precursor to HCN. Dhurrin likely serves as an insect deterrent by facilitating the release of HCN. Dhurrin is broken down through cell disruption, such as chewing or freezing, which causes rapid HCN release. Figure 1 illustrates the steps in the breakdown of dhurrin to HCN.

Characteristics Affecting Dhurrin Content and HCN Potential

Dhurrin content, and therefore HCN potential, can vary due to species, variety within a species, growth stage, plant tissue type, and different abiotic (non-biological) stresses.

Species/Varieties

Dhurrin content in sudangrass is about 40 percent less than in most other sorghums. As a group, the sorghum-sudangrass hybrids have more HCN potential than sudangrass, and forage sorghum has more HCN potential than sorghum-sudangrass and sudangrass. Sorghum-sudangrass hybrids have been developed to contain less dhurrin. As a precaution, select hybrids known to be lower in HCN potential by talking with a seed supplier.

Johnsongrass, shattercane, and sorghum alnum have high HCN potential and may be hazardous when found in pastures and fence rows.

Plant Age

Sorghum age has a significant effect on dhurrin content. Plants have larger amounts of dhurrin in the early growth stages or early regrowth.



Figure 2. Four tillers growing off the main shoot.

Seedlings generally have the highest HCN potential in the first two weeks of growth, which decreases as the plant ages to minimal or negligible amounts by maturity (Halkier and Moller, 1989; Nielsen et al., 2016). Older plants, however, can increase HCN potential as a result of environmental factors, as described below. Delay grazing until the plants have reached a height of 18 to 24 inches to avoid HCN toxicity under good growing conditions.

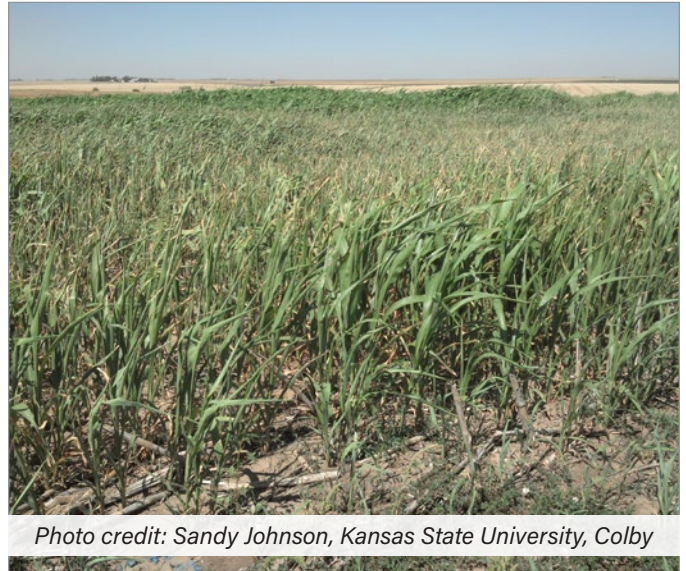


Figure 3. Sorghum undergoing drought stress.

Tissue Type

The vegetative portion of all sorghums can contain dhurrin. HCN potential varies within a single sorghum plant, depending on the plant tissue. Leaves generally contain larger amounts of dhurrin in comparison to stems and roots (Gleadow et al., 2016). Tillers, commonly called shoots, can contain a large amount of dhurrin, too. Examine fields for the presence of young tillers on more mature sorghum plants. Tillers growing off the main shoot of a young sorghum plant are shown in Figure 2.

Drought

Drought stress that restricts plant growth can cause an increase in dhurrin content (Gleadow et al., 2016; Rosati et al., 2019). In the western and southern US, ingestion of sorghum species during drought can be a cause of cyanide toxicity in livestock. Nitrate levels can also be high in drought-stressed plants. Droughty plants have evidence of rolled leaves and browning. Figure 3 shows sorghum plants under drought conditions.



Photo credit: Shelby Gruss, Purdue University

Figure 4. Mid-October morning freeze on sorghum-sudangrass.

Frost

Sorghum can become stressed in frost conditions, leading to an increase in dhurrin. It is important to remove livestock from sorghum when a frost is predicted to occur. After a frost occurs, keep livestock off frosted sorghum plants for at least one week. This recommendation is a rolling suggestion, meaning that every time another frost occurs, livestock should be removed from the frosted plants for another week, until the plants have been completely killed with a hard frost. After a non-killing frost, sorghum should be scouted for regrowth because it can contain a large amount of HCN. If regrowth is apparent, you should wait 10-14 days or until the regrowth has reached 24 inches tall before grazing or chopping. Figure 4 shows frosted sorghum-sudangrass.

Response of sorghum hybrids' dhurrin content following a frost at multiple locations is noted in Figure 5. Data collection occurred with collaboration between Purdue University and Kansas State University. The West Lafayette, Indiana, location received one

frost without a continuation of cold weather. At the two Kansas locations in Garden City and Colby, consecutive light frosts occurred before a hard freeze, which led to a continuous increase in dhurrin content. The Kansas data illustrates the importance of the rolling recommendation.

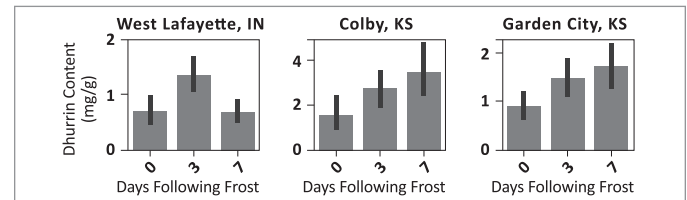


Figure 5. Sorghum hybrid dhurrin content (based on the fresh weight) response following frost events. Day zero represents dhurrin content before the frost occurred. The Garden City and Colby locations had another hard freeze between three and seven days. *Black bars in the graphs represent standard error. This gives a 95% confidence interval that the average dhurrin content would be between the black bars.*

Nitrogen Application

Over-fertilization with nitrogen can cause the crop to be toxic by two different mechanisms: HCN potential can be increased, and nitrate concentration may also become problematic (Holman et al., 2019).

Feeding Options

Pasture

Grazing sorghum is considered to be the most dangerous option when HCN potential is a concern. However, proper management can reduce risk. Figure 6 shows a calf grazing sorghum-sudangrass that is over 18 inches tall and shows no stress from frost or extreme drought – conditions that can increase HCN potential. Limit nitrogen fertilizer to 50 lbs per acre (soil nitrate residual plus fertilizer) per cutting to reduce risk of nitrate and HCN toxicity (Holman et al., 2019). Remember, fertilization recommendations vary based on soil tests and soil type. If new growth occurs after the frost, the recommendation is to wait until new growth reaches at least 18 to 24 inches tall or a killing freeze occurs.

Residues from grain sorghum, commonly called milo, can be safely grazed after grain harvest if the remaining plant is totally dead after a frost, or a week has passed since the frost occurred. Grain sorghum can have small tillers that can be high in HCN until after a killing frost.



Photo credit: Keith Johnson, Purdue University

Figure 6. Calf grazing on a sorghum-sudangrass pasture where HCN poisoning is not a concern.

Hay

Previously, dhurrin degradation was thought to occur when sorghum was used as hay. Recent research at Purdue University, in collaboration with Kansas State University, found that dhurrin remains stable in hay for at least two months after a harvest, although dhurrinase becomes inactive. Dhurrinase is the enzyme that facilitates the breakdown of dhurrin to HCN, as shown in Figure 1. This does not suggest, however, that hay is safe for consumption, because it was also confirmed that cattle have enzymes within their rumen that can lead to the breakdown of dhurrin and release of HCN without an active dhurrinase enzyme. Recommendations would be to utilize sorghum forage as hay when HCN potential is not a concern; plants are greater than 18-24 inches tall, and not drought- or cold-stressed. If in doubt about the degree of stress that might lead to elevated dhurrin in hay, collect a representative sample and test for HCN potential.

Silage

Silage is considered one of the safest options when feeding sorghum forage. The process of chopping and fermentation has been estimated to reduce dhurrin content by 50 percent or more, which reduces the risk of HCN toxicity (McCarty et al., 1971; Smith and Frederiksen, 2000).

Greenchop

Use of greenchop reduces HCN potential as compared to grazing but is not considered as safe as feeding silage. Chopping of sorghum material can help release some HCN through cell disruption, and greenchop includes stems and leaves (Smith and Frederiksen, 2000), whereas livestock can selectively graze leaves in a pasture, making pasture grazing more dangerous.

If HCN is a concern, several steps can be taken to reduce the potential of cyanide toxicity:

- Utilize the sorghum before a frost occurs.
- Submit sorghum sample(s) to a qualified lab, such as the Indiana Animal Disease Diagnostic Laboratory (ADDL).
- Wait to graze 7 to 10 days after a killing freeze.
- Do not apply more than 50 lbs of nitrogen (soil plus fertilizer) per cutting.
- Dilute the sorghum feed with another feed source.

Symptoms and Treatment for HCN Toxicity

The onset of cyanide toxicity in livestock occurs very quickly. Clinical signs of toxicity include labored breathing, staggering, and convulsions. Livestock can die soon after consumption of the toxic feedstuff. Many of the clinical signs are similar to nitrate poisoning, which also interferes with the body's ability to use oxygen. One key difference between cyanide and nitrate toxicity is that an animal's blood will be bright cherry red in cyanide intoxication, compared to dark-chocolate brown blood in nitrate poisoning. If you suspect HCN poisoning in even one animal, call your local veterinarian immediately and remove the rest of the livestock from the feed. Accurate diagnosis of clinical signs and removal from feed is very important in these cases. Your veterinarian may collect samples of forage, rumen contents, or blood to help confirm a diagnosis.

Overall, sorghum has many beneficial properties. If proper management occurs, sorghum can be a safe and beneficial forage crop. Soon, a new hybrid will be on the market that is dhurrin-free. This hybrid will not release HCN because there is no accumulation of dhurrin. This new hybrid will be a great option for removing the fear of cyanide toxicity.

Key Points to Remember

- Sorghum species can cause cyanide toxicity in livestock due to their ability to release HCN.
- HCN potential varies based on sorghum variety, plant age, tissue type, and environmental factors.
- Utilization method impacts risk of HCN toxicity. For a given forage, grazed forage should be considered the most dangerous feed, followed by hay, greenchop, with silage being the safest.
- Stop grazing sorghum forage before a frost occurs and resume only when the plants have been entirely dead for a week.
- Dhurrin-free sorghum removes the risk of cyanide toxicity, and new hybrids are being developed with this trait.

More Information

Indiana Animal Disease Diagnostic Laboratory (ADDL)

406 S University St.

West Lafayette, IN 47907

(765) 494-7440

<https://vet.purdue.edu/addl/tests/fees.php?id=231>

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