

*This is an updated version of the Oct. 16, 2023 TAM-AAMM with additional information from Dr. Jason Banta, Extension Animal Sciences, Overton, TX, [jason.banta@ag.tamu.edu](mailto:jason.banta@ag.tamu.edu) & Dr. Sandy Johnson, Kansas State Research & Extension animal scientist, Colby, KS.*

## **TAM-AAMM**

*Texas A&M—AgriLife Agronomic Monday Memo*

### **Prussic Acid (Hydrogen Cyanide) in Sorghum Forages—New Understanding**

*Much of what many state Extension services have said for decades may be wrong.*

Prussic acid is another name for hydrogen cyanide (HCN). There is long-time concern about this animal health issue especially in sorghum family forages where prussic acid *potential* is much higher. [Forthcoming information is changing/correcting our understanding of prussic acid and its animal injury potential.](#) This may alter our advice on sorghums frosted and frozen in the fall.

### **Examples of Freezes on Texas High Plains Sorghums**



**Fig. 1.** Dallam Co., Texas, moderate frost damage on sorghum/sudan, Oct. 14, 2023. Exposed leaves at top of canopy are burned but leaves are green down in canopy which was a few degrees warmer. (Laura Taylor, Dallam-Hartley Co. AgriLife Extension).



**Fig. 2.** Dallam Co., Texas, moderate frost damage on grain sorghum, Oct. 14, 2023. Exposed leaves at top and side of canopy are burned. It appears most stalks are still green which means the plants are not dead and might still be able to fill the grain some as close observation suggests for some heads (later tillers?) grain is not mature which would lead to low test weight. (Laura Taylor, Dallam-Hartley Co. AgriLife Extension).

Figures 1 & 2 depict typical moderate frost damage in sorghums. We will see this expand further south across Texas, mostly on late sorghum/sudan as grain sorghum is already harvested in most areas except the northern Rolling Plains and High Plains. For suggestions on how to manage this forage see the “Bottom Line” comments below.

### **A Brief Explanation of Prussic Acid (HCN) in Sorghums**

Most sorghums and some other plants contain cyanogenic glycosides which contain a –CN functional group that can be released as free hydrogen cyanide (HCN). The cyanogenic glycoside in sorghum is called ‘**dhurrin**.’ Dhurrin is higher in younger sorghum plants, and you may see advice not to graze until sorghums are at least 18 or even 24” tall. Dhurrin is generally higher in leaves than in stalks. In the past the more common expressed reason not to graze before 18-24” height was due to enabling plants to be better established and reach a more rapid growth stage that could better keep pace with grazing demand.

The cyanide group in dhurrin and other cyanogenic glycosides is not free cyanide. It is best regarded as *potential cyanide, or HCN-p*. The release of the —CN group is a process fostered by specific enzyme(s) most commonly beta-glucosidase(s). When sorghum plant tissues are frozen cells are disrupted and the —CN group in dhurrin comes in contact with beta-glucosidase. **Free** prussic acid, or hydrogen cyanide (*HCN-f*), is produced.

However, the process of mastication by livestock can mimic the cell rupture of a freeze enabling contact of dhurrin compounds with the enzyme. Furthermore, for livestock, in the rumen there are also beta-glucosidases that contact dhurrin further releasing prussic acid to the free, toxic form. This could be an animal health concern—the risk which is difficult to estimate, especially for ruminants, if levels exceed the animal’s ability to detoxify HCN.

### **Historical Prussic Acid Advice vs. New Testing Observations**

For a long time—decades—the traditional advice for managing livestock on sorghum forages has been:

- Remove cattle from grazing frosted and frozen sorghums to allow the potential or likely increase in prussic acid to dissipate (gas off) from the forage before reintroducing animals to the forage.
- For sorghums that have been cut for forage, do not bale until the forage is fully “cured”, that is dried. This, too, was believed that it allowed any prussic acid to dissipate and thus animals can then be safely fed the forage now or in the future.

Former Texas A&M AgriLife beef cattle Extension specialist Dr. Ted McCollum, Amarillo, questioned this advice. The first few times he explained this to me (or tried to!), I was perplexed. What he said did not align with our Extension literature, which often lacked sufficient references to documented research. Texas A&M AgriLife Extension and many other states said the same things about the dangers of prussic acid in cattle centered around the two above points.

Subsequent study of this earlier advice and their sources of information are now questioned. It appears much of the original information was inaccurate if not wrong. I credit Texas A&M AgriLife Extension beef cattle specialist Dr. Jason Banta, Overton, for leading a re-examination of this question in Texas. AgriLife Extension agronomists Dr. Vanessa Corriher-Olson, Overton; Dr. Jourdan Bell, Amarillo; and Dr. Reagan Noland, San Angelo have assisted with this work.

Today there is a better understanding of prussic acid potential and the need to differentiate between the cyanide in dhurrin and free HCN to know the degree of potential threat to animal health. Researchers at Kansas State, Purdue Univ., and elsewhere are careful to ensure they are

properly documenting dhurrin and its timing and release of cyanide, its forms, timing of free HCN and why, etc. before revising new guidelines are revised.

### ***Today's Research Response to Above Bullet Points about Prussic Acid***

Those investigating prussic acid potential, particularly in sorghums, note several points:

- 1) Ruminants as well as other mammals can detoxify some level of HCN. The question we don't know is how much increase in free HCN there may be when a freeze occurs. Kansas State and Purdue have documented that dhurrin can increase in sorghums after a frost or freeze. How much is "safe" is unknown and probably risky to attempt to quantify at this point.
- 2) A combination of factors has sometimes misled forage and livestock growers about the potential risk of dhurrin/HCN in forage cut for hay. In sorghum hays that have not been frosted or frozen the dhurrin content appears to be stable for at least two months. This means prussic acid potential remains in the forage upon animal consumption and possible development of HCN in the rumen. On the other hand, long-time guidelines have stated that any HCN formed in a forage will dissipate or gas off, especially during the time needed for hay to cure (dry) for baling. HCN does dissipate on formation, but there are questions about this scenario that would benefit from further research. This would include how quickly gassing off may occur and whether some HCN may be retained in hay.

### **Correct Test for Prussic Acid in Sorghums and other Forages**

The correct test for prussic acid potential contains an essential step that adds the needed enzyme to convert potential HCN-p to the free form HCN. It appears most tests historically have been incorrect—and misleading. These tests did not add the above needed enzyme to release HCN-p. They only measured free prussic acid. Yes, this is the immediate threat to animal health. I have noticed a change in 20+ years where labs used to provide a specific number of prussic acid concentration in forages in parts per million (ppm) and a scale of what was safe to feed. And Extension guidelines stated varying levels HCN and relative "safety". This sometimes reflected whether animals were healthy or pregnant. These numbers did not agree among states.

Also, Dr. Banta notes recommended sampling procedures for prussic acid, [Testing-Forages-for-Hydrogen-Cyanide-Potential-7-12-22.pdf \(agrillife.org\)](#)

*Where to get a correct prussic acid test?*

Servi-Tech, Amarillo, TX (<https://servitech.com/locations>) is the only lab in Texas we currently know that includes a beta-glucosidase enzyme a part of the testing procedure. (Cost as of October 2024 is \$30 for prussic acid + \$10 for the moisture content test needed to correctly calculate HCN concentration. Nitrate is \$12 per sample.) The Texas Veterinary Medical Diagnostic Lab only conducts prussic acid tests on rumen samples. TVMDL refers all forage prussic sampling inquiries to Servi-Tech in Amarillo. The Texas A&M AgriLife Soil, Water, and Forage Testing Lab in College Station does not offer the test.

Dr. Banta notes prussic acid testing of grazing samples may or may not test the whole plant depending on the situation and what cattle are likely to consume. Remember younger growth is likely higher in prussic acid potential. Hay samples always test the whole plant for HCN. Whole-plant testing is the same for nitrates. Producers often want a nitrate test in forages at the same time as prussic acid. This is a routine analysis at any lab. (Typically, if nitrates are not an issue in the lower stalk where unassimilated nitrates tend to accumulate, especially in drought conditions, then they are not likely an issue anywhere else in the plant.)

### **Additional Fall Prussic Acid Sources of Concern**

Prussic acid can also be an issue in the new fresh growth at the base of the plant from a grain sorghum field near and after harvest (Figs. 3A-B). This can also occur from the base of sorghum/sudans for forage or hay. Also, a lesser-known potential issue with grazed sorghum/sudans, Johnsongrass, etc. is in the summer. Under drought conditions when the sorghum/sudan is struggling to grow, rains come, and the fresh growth, like early spring growth or Fig. 3, can have elevated potential for prussic acid.



**Figures 3A-B.** Basal tiller regrowth in grain sorghum near harvest (left)) and after harvest and mowing (right) of stalks. Young regrowth is susceptible to prussic acid development without a frost or freeze. Cattle released into a field to graze sorghum stubble with regrowth are drawn to this fresh tender regrowth thus at high risk from poisoning. (Calvin Trostle.)

## The **Bottom Line** with Prussic Acid Remains for Now—Play it Safe

Prussic acid, or potential HCN-p that is not yet released from the cyanogenic glycoside dhurrin—can be a threat to animal health. Cattle do detoxify lower levels of HCN in the diet, but when levels of HCN are greater than the ability detoxify that animal health risks increase. Frosts, freezes, drought (and immediate growth after a drought), and other consumed fresh new growth can load the animal with too much HCN at once. Due to the inaccurate nature of sampling, transporting, and testing prussic acid the results of a prussic acid test have some level of uncertainty. Until further research better quantifies the risk of prussic acid and its potential then possibly revises safer grazing and feeding guidelines, livestock producers should be cautious and limit exposure of cattle especially to sorghum forages when there is a question of animal safety. This would still involve removing cattle from sorghums with a freeze though this may ultimately not be necessary. Reintroducing cattle after a minimum of days (7? 10? 14?) appears to continue to offer protection for animal health. Proper testing—is encouraged.

What to do?—Here are final “**bottom line**” comments suggestions from KSU’s Dr. Johnson:

- 1) A heavy frost has occurred, but there is still much green in the forage (Fig. 1). The top of the canopy is singed. A) if I have cattle already grazing in this forage (a week or more?), what do I do? Do I need to remove them? B) I have cattle I had planned to put into this field. Now what? What do I do, and when?

*Kansas State recommendations state:* “For 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. After frost, 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. See further comments for frost and also for non-frost grazing from KSU’s/Purdue’s “Managing the Prussic Acid Hazard in Sorghum” (MF 3607, June 2022)

[https://bookstore.ksre.ksu.edu/pubs/managing-the-prussic-acid-hazard-in-sorghum\\_MF3607.pdf](https://bookstore.ksre.ksu.edu/pubs/managing-the-prussic-acid-hazard-in-sorghum_MF3607.pdf)

The challenge is determining if all growth has stopped or not. The most concern regarding prussic acid is still in the small tillers and regrowth.

- 2) Take the image above (Fig. 1). There has been a killing freeze. No green left. Repeat #1 A & B: A) if I have cattle already grazing, what do I do? B) I had planned to put cattle into this field. What do I do, and when?

If you expect a freeze, remove the cattle before the freeze and leave them out for a week or so. If you were going to turn out, then delay a week.

- 3) I have cattle that are grazing a field of sorghum/sudan or harvested grain sorghum where there is significant regrowth. (This could be at any time in the season for the S/S, but only later for harvested grain sorghum—this could be as soon as early July in South Texas to Nov. 1 in the High Plains.) What should I do if I have grazing cattle, or want to?

Wait until after a hard freeze to start grazing.

- 4) I have cut down sorghum/sudan. It is curing in the row. When it is cured (dried) sufficiently for baling, what precautions should I take in feeding (or selling) the hay? (Some of the confusion in this question is the issue, or not, of dissipation of HCN, but it may not have formed but could be released in the rumen when consumed. Relative risk?)

If the forage is very high in prussic acid prior to harvest it can remain high. One example—of 6-12" drought stressed regrowth of forage sorghum—a fresh sample by Kansas State averaged 2,600 ppm prussic acid. But when dried and sent to a lab one week later the average was 3,250 ppm. Servi-Tech dries samples prior to testing. The original harvest of this forage was in early August and height was 3-4 ft tall (why was it cut that soon?). Bales tested in early October contained 62 ppm prussic acid but nitrate-nitrogen, NO<sub>3</sub>-N was 1,000 to 1,620 ppm.

Of course, testing for prussic acid potential can provide guidance for any of these scenarios.

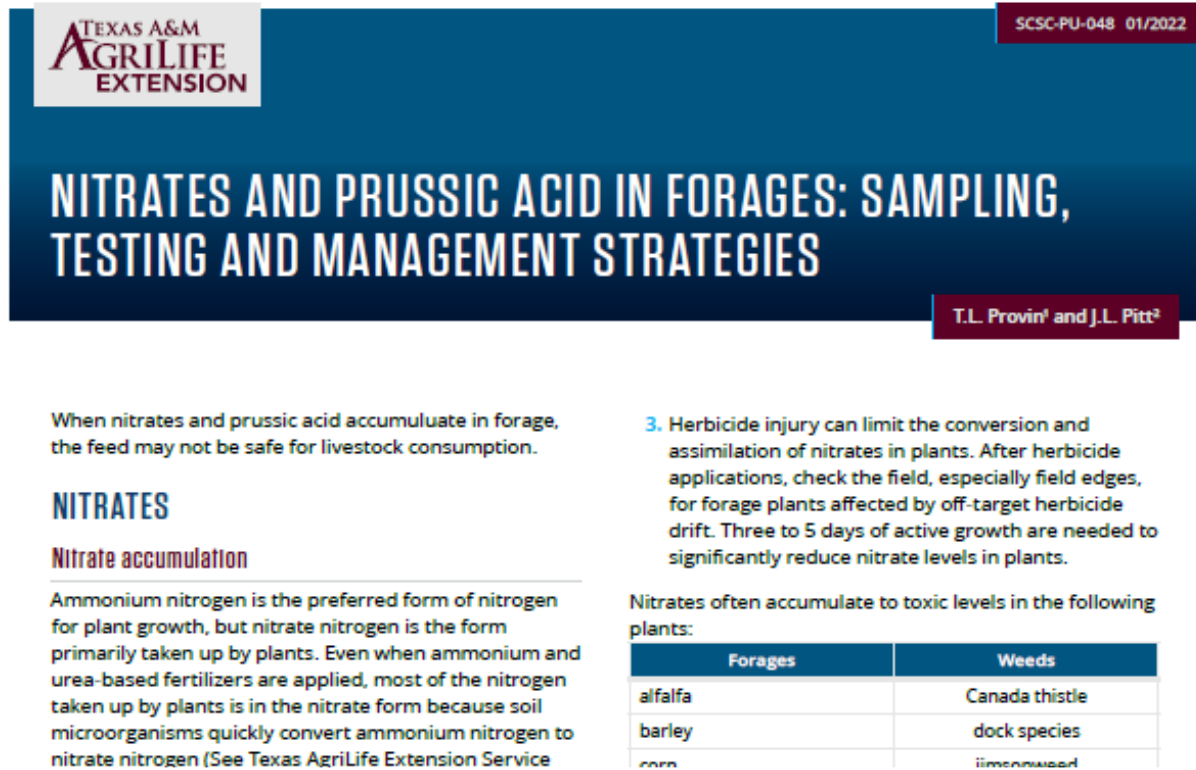
### **Nitrate in Sorghums and Other Forages**

Unlike prussic acid there are no changes in understanding of nitrate, where it can accumulate, and how to manage it. There are varied levels of what many consider "safe" levels of nitrate for animal consumption. The AgriLife Extension guide below has the proper information for understanding, testing, and managing possible nitrate issues in all forages.

**Nitrate** accumulates at the bottom of the plant when they are not growing. Plants are still accumulating—but not assimilating—the N into plant proteins or other components. This nitrate concentrates in the bottom (up to 12 inches or so) of the stalk. When you mow hay, the nitrate level is fixed. It does not dissipate. When nitrate is high in a forage (often noted as near 1.0% and higher) for healthy animals, it can be blended with low nitrate forage. Or at hay harvest one can raise the cutter bar (if a swather) a few inches. This reduces yields but leaves a significant amount of nitrate in the field.

Unlike the common issues of prussic acid toxicity primarily in sorghums, nitrate issues are not unique to sorghum family forages. Other crops like corn, several small grains, hybrid pearl millet and several weeds (including pigweed/carelessweed/Palmer amaranth) also have potential nitrate issues. Nitrate poisoning from irrigated sorghum forages is rare. These plants are actively growing and assimilating uptake nitrate into plant structures.

The primary AgriLife document for nitrates (and also prussic acid, but information is changing) at Texas A&M AgriLife is “Nitrate and Prussic Acid in Forages” is at <https://agrilifeextension.tamu.edu/library/ranching/nitrates-and-prussic-acid-in-forages/> (Fig. 4). This document discusses both prussic acid and nitrate, what field environmental and weather conditions can lead to a concern, and how to recognize them. All labs can conduct a nitrate test in forage samples.



**Fig. 4.** Texas A&M AgriLife’s primary document for nitrate and prussic acid concerns in forages. This document discusses in further detail the issues in these two potentially toxic accumulations in forages, the factors that cause them, and how to manage them.

**Reference** (these two documents are exactly the same)

The most comprehensive Extension guides for forage and animal growers that reflect the most recent published research are the following two identical documents:

Managing the Prussic Acid Hazard in Sorghum (2022)

Gruss, S.M., K.D. Johnson, S.K. Johnson, J.D. Holman, A. Obour, R.A. Aiken, and M.R. Tuinstra.

- Kansas State University, MF3607, [https://bookstore.ksre.ksu.edu/item/managing-the-prussic-acid-hazard-in-sorghum\\_MF3607](https://bookstore.ksre.ksu.edu/item/managing-the-prussic-acid-hazard-in-sorghum_MF3607)
- Purdue University, A-378-W, <http://www.extension.purdue.edu/extmedia/AY/AY-378-W.pdf>

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