there was only limited evidence that grain sorghum residues following harvest would reach these levels (Figure 1 and 2). In most instances, nitrate levels rarely exceeded 2,000 ppm across varieties for the study conducted. Drier or more stress-prone regions, such as the southwest and the panhandle regions of Oklahoma, are the primary areas of greater concern and have showed elevated values. In 2018, the grain sorghum at Tipton trial failed. It was the were found to have consistently high nitrates (Figure 2). As a result, nitrate taken up throughout the season was not allowed to be incorporated into the grain, which resulted in higher levels remaining in the plant.

While both prussic acid and nitrate toxicity may be issues that are highly discussed when using sorghum as a forage, the risks associated with grain sorghum can be quite low. This is especially true if growers manage the residue with the knowledge of these risks. Growers are encouraged to sample forage and get it tested, either on site at the county Extension office or in an agricultural laboratory, prior to grazing as a sole means of knowing the value and quality. Understanding the risks of nitrate toxicity, proper sampling and evaluation will be critical. When sampling, growers need to understand their fields and make sure to sample in both potentially high-risk areas as well as low-risk areas.

Sorghum as an Alternative Forage

Grain sorghum residue following mechanical harvest can be a valuable alternative forage during a period where very little forage is available. It shows great potential in bridging the gap between high-quality summer pastures and winter wheat. As can be expected, the total amount and quality of the forage will vary greatly between production seasons, locations and management practices. However, grain sorghum can provide one to two months of grazeable pasture at approximately 0.8 to 1.2 animal unit per acre per month (using the conservative method), with quality parameters approximately 10% CP and 60% TDN. As with many sorghum forages, both prussic acid and nitrate toxicity can be potential problems, especially nitrate concentration in highly managed grain sorghum. Growers should take the time to sample residue, ensuring levels are below critical thresholds based on animal type and age.

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EXTENSION

The Potential of Grazing Grain Sorghum Residue Following Harvest

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Josh Lofton
Cropping System Specialist, Plant and Soil Sciences

Gary Strickland
SWREC Dryland Cropping System Specialist

Alex Rocateli
Forage System Extension Specialist, Plant and Soil Sciences

Anna Zander
Graduate Student, Plant and Soil Sciences

Chase Harris
Senior Agriculturist

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Grain sorghum is a summer crop grown throughout Oklahoma, mostly west of I-35. Sorghum fits into most Oklahoma crop rotations and provides growers with a rotational crop option considered to have a higher heat tolerance and a lower water demand than some other summer crops. For instance, grain sorghum requires a minimum of 18 inches of precipitation during the growing season, while high-yielding corn will need up to 30 inches (Assefa et al., 2010). Grain sorghum production has seen increased challenges through the latter half of the 2010s, associated with increased competition from other crops, increasing pressure from sugarcane aphids and lower commodity prices. These challenges have resulted in a decline in production acres throughout the state. However, most crops face similar production challenges and remain a viable option for growers, specifically for winter wheat growers. For sorghum to be a profitable option, growers have to look for ways to extend the value of the crop to increase the potential benefits.

Potential of Grazing Sorghum Residue

Grazing of crops and crop residue is not an uncommon practice. In Oklahoma, a large portion of winter wheat acres are traditionally grazed in both dual-purpose (forage and grain) and graze-out (forage only) systems. Information is currently available on utilizing corn and sorghum residue as a grazing forage and growers across the Midwest and northern Great Plains have been incorporating grazing these residues into their operations (Jenkin, 2015).

Early reports in Nebraska indicated that corn residue provided greater individual animal gains when compared to sorghum (1990 Nebraska Beef Cattle Report p. 55-58). The variation in individual gains observed between the two grazing systems was likely due to the difference in grain remaining in the field following harvest. Corn grain is more digestible and more easily accessed compared to grain sorghum, which will typically have to be processed prior to feeding. However, increased grain harvest efficiency over time has resulted in less grain left on the ground; consequently, the quality of the vegetative residue became more influential in animal gain during recent years. Due to a high ratio of leaves and palatable stems, grain sorghum vegetative residue might be comparable, if not a better forage alternative when compared to corn residues.

Grazeable Forage Availability

The amount of grazeable residue after grain harvest will vary greatly, depending on both the amount and palatability of sorghum residue (sorghum cultivar dependent), and grazing window length (forage availability, weather and operation management). For most grasses, the highest nutritive value comes from the leaves, upper stems and panicles still available following harvest. While the lower stalk region can still be grazed, the quality is lower and the risk of nitrate toxicity increases. To roughly estimate the total amount of sorghum residue produced for grazing, the direct rule of thumb applies: for every bushel of grain produced, 8 to 12 pounds of palatable residue was left in the field. For example, in an 80-bushels-per-acre yield, growers can expect between 640 to 960 pounds per acre of palatable forage. A different method used to estimate not only the palatable forage, but the total aboveground biomass utilizes 60 pounds per acre of dry matter per bushel of grain. Therefore, an 80-bushels-per-acre crop would result in 4,800 pounds per acre total biomass. While these values probably under- or over-estimate the total residue produced, they can provide fair forage amount estimations for stocking rate calculations (Table 1). Refer to the factsheet PSS-2871 Stocking Rate: The Key to Successful Livestock Production for proper stocking rate calculations. A more precise way to estimate total residue is accomplished by clipping small quadrants within the field at several points to determine a proper estimate. This can be done by measuring a set area within the field, then collecting, drying and weighing the dry samples. These sub-samples could then be easily used for determining forage quality and nitrate levels.

A study has been conducted evaluating the potential of grazing grain sorghum residue following harvest using the statewide Oklahoma Sorghum Performance Trials. In this, biomass estimates have been collected from various locations as well

Table 1. Grain sorghum residue estimations following harvest compared to actual measured values.

Year	*Location*	*Hybrid*	*Grain Yield bu/ac*	*Estimated forage (lbs/ac) times 8 to 12*	*Estimated forage (lbs/ac) times 60*	*Forage measured lbs/ac*
2016	Tipton	KS 585	106	846 to 1,269	6,347	3,821
		DKS 37-07	113	904 to 1,356	6,778	6,378
	Dacoma	KS 585	70	560 to 841	4,205	6,737
		DKS 37-07	79	636 to 954	4,769	6,104
2017	Tipton	KS 858	73	586 to 879	4,393	4,675
		DKS 3707	60	477 to 715	3,577	6,625
	Lahoma	KS 585	101	812 to 1,217	6,087	4,651
		DKS 37-07	97	778 to 1,167	5,836	5,404

as hybrids (Table 1). It can be seen that overall forage/crop residue production varied greatly by location and hybrid, ranging from 3,821 pounds per acre to 6,737 pounds per acre. When evaluating the methods for estimating total forage production, using the total biomass estimate (bushels multiplied by 60) provided reasonably similar biomass estimations. However, using the estimate for solely highly palatable forage (bushels multiplied by 8 to 12), forage estimates ranged from 476 to 1,356 pounds per acre. The under- or over-estimation of the proposed estimators could be due to several environmental or biotic stress factors. This further emphasizes the need to utilize smaller sub-sample plots to accurately estimate actual biomass available.

Determining the amount of dry matter forage that will be available is not the only important aspect in grazing residue, as the stocking rates associated also are highly variable and depend on type of animal, current weight and whether growth or maintenance is preferred. For most heifers and steers, a rule of thumb is 2% of their body weight should be consumed as dry weight within a single day. For a 1,200-pound heifer, this would result in 24 pounds of dry matter per day. Most of the grain sorghum residue tested within the study was between 4 to 6% moisture on the day of collection, resulting in 25 to 26 pounds of the residue needed to meet this daily dry matter requirement, or approximately 780 pounds per month (E-974, Nutrient Requirements of Beef Cattle). Therefore, by calculation and using the conservative approach, an 80-bushel crop would provided approximately 640 pounds of forage. This would make a stocking rate of 1.2 acres per head per month or 0.8 cattle per acre per month. Growers then could determine if they would like to stock at a higher rate for a shorter period or to stock at a lower rate for a prolonged period. However, it should be noted that the residue will degrade in both quality and quantity over time.

Sorghum Residue Quality

As with other aspects, the quality of the forage depends on the animal. For cattle, as a general rule, forages containing a minimum of 10% crude protein (CP) and more than 60% total digestible nutrients (TDN) are considered good to fair. Less than these values may require additional supplementation or mixing with additional forage. Based on initial evaluations, grain sorghum residue does fall within this range of a good to fair forage. However, depending on the year, these values could fall below these critical values (Table 2).

Table 2. Sorghum forage quality measure in Perkins and Tipton in 2018 from grain sorgum performance trials following harvest.

	Perkins			*Tipton*		
Entry	*Crude Protein %*	*ADF %*	*TDN %*	*Crude Protein %*	*ADF %*	*TDN %*
AG 1201	8.4	29.8	58.4	10.6	38.7	54.2
AG 1203	8.9	30.4	56.9	10.2	34.2	59.1
SP 73B12	9.3	33.7	60.1	9.9	40.1	58.7
KS 585	8.1	28.9	60.9	10.1	38.5	53.4
SP 68M57	9.0	29.1	55.6	10.7	38.7	57.0
DKS 28-05	8.7	30.3	58.1	10.4	41.7	54.1
DKS 37-07	8.3	31.7	59.0	9.7	40.8	61.2
P86G20	9.2	32.0	57.3	11.4	40.1	60.9
P84P68	9.0	28.6	56.8	10.8	37.2	62.3
Test mean	8.8	30.5	58.1	10.4	39.0	57.9
LSD (0.05)	NS	NS	NS	NS	NS	NS
CV (%)	4.8	5.5	2.9	5.0	5.7	5.8

Quality Influenced Environmental Conditions and Other Stressors

Several factors can alter grain sorghum residue quality. Typically, with high grain yields from the primary crop, the successive residue becomes lower quality. Lower grain yields, especially due to late-season stressors, can decrease grain development and fill and increase residue forage quality. If the crop is unable to produce grain and is solely used as a forage source, quality will typically be higher. This is due to less of the nutrients and sugars in the plants being utilized for grain fill, and those nutrients and sugars become available in the residue. The downside to the lack of grain fill can be nitrate accumulation within the plants. Therefore, caution should be used when grazing a traditionally managed grain sorghum crop not harvested. For more information on nitrate toxicity refer to the fact sheet PSS-2903, Nitrate Toxicity in Livestock.

Sugarcane aphids (SCA) have been a major pest in Oklahoma grain sorghum since 2015. The SCA does not directly feed on the plant but rather uses modified mouthparts to extract nutrients and sugars from within the plant. This type of feeding can potentially cause significant issues with residue quality due to these nutrients and sugars being the primary components of both CP and TDN. However, work out of Texas has found that excessively high populations of SCA are required to cause any significant changes to sorghum quality; therefore no significant changes in quality can be expected. More concerning with higher levels of SCA infestation would be lower grazeable biomass produced. While quality of the biomass may be similar, lower biomass could lower stocking rates potentially decreasing the agronomic and economic potential of using sorghum residue as a viable forage.

Cautions of Using Grain Sorghum Residue as an Alternative Forage

Two cautionary issues exist for growers interested in grazing grain sorghum stalks following harvest. Neither of these are factors that make grain sorghum residue a bad or sub-optimal forage source, but may require additional management of the forages or livestock. The first of these is prussic acid. Details for prussic acid poisoning are available in PSS-2904, Purssic Acid Poisoning. Fortunately, compared to other sorghum species, this is less of an issue when growers are choosing to graze grain sorghum stalks due to the plant already being dead in most cases. The issue exists if growers decide to allow cattle to graze grain sorghum prior to senescence, in the cases of a failed crop, living tillers or new growth following harvest. To ensure prussic acid is not a major issue, growers should allow the crop to fully terminate prior to allowing the cattle into the field. This can be done with a major freeze event or through desiccation. If growers allow grazing in fields prior to the first major freeze or without desiccation, they should remove livestock prior to the first killing freeze. Past this point, the residue will need to be "cured" for seven to 10 days prior to grazing to allow all the hydrocyanic acid to disperse.

The second, and more likely issue when grazing grain sorghum, is nitrate toxicity. This occurs when there is a buildup of nitrite in the animal as a result of consuming residues with high nitrate concentrations. Detailed information regarding nitrate poisoning can be found in PSS-2903, Nitrate Toxicity in Livestock. Unlike prussic acid, nitrates do not dissipate once accumulated following complete termination of the plant. Therefore, even following desiccation or a killing freeze, growers will still have to manage for high nitrates. Stressful growing conditions are a major factor in nitrate toxicity, and higher stress environments, such cloudy days and hot temperatures, can result in greater nitrate concentrations in the plant. In sorghum, nitrates tend to accumulate to higher levels in the stalks, with highest concentrations typically found immediately above the soil surface. The risk of nitrate accumulation is intensified because we typically manage grain sorghum with nitrogen fertilizer for grain yields. Higher rates of nitrogen fertilizer, especially if the sorghum does not yield adequately, could result in excessive nitrate accumulation in the plant.

Not all nitrate levels are considered dangerous, just levels where there will be an accumulation of nitrite in the animal. So how much nitrate is dangerous? This will depend on the type, age and intended use of the animal. For cattle, keeping the total nitrate concentrations below 3,000 ppm (dry weight basis) is considered safe, overall. Based on initial evaluations,

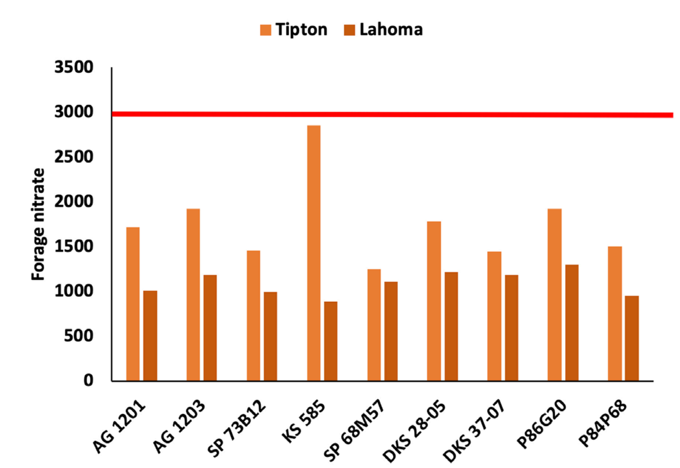

Figure 1. Forage nitrate levels of grain sorghum following harvest in the 2017 sorghum performance trials. Red line indicates the critical threshold for forage nitrate levels.

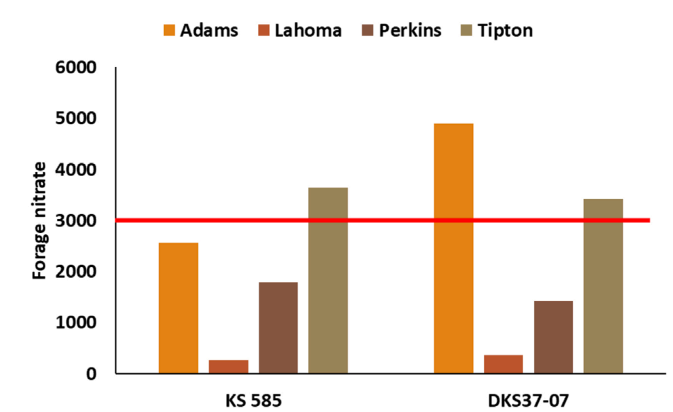

Figure 2. Forage nitrate levels of grain sorghum follow harvest in the 2018 sorghum performance trials. Red line indicates the critical threshold for forage nitrate levels.