



U.S. GRAINS
COUNCIL

2016/2017
SORGHUM HARVEST
QUALITY REPORT

Generous support from the United Sorghum Checkoff Program (USCP) allows for the scope and caliber of this *Sorghum Harvest Quality Report*. The U.S. Grains Council is grateful for their recognition of the value of these data and for their assistance in making the information accessible to all of those engaged in the sorghum marketplace worldwide.



Developing a report of this scope and breadth in a timely manner requires participation by a number of individuals and organizations. The U.S. Grains Council (Council) and the United Sorghum Checkoff Program (Sorghum Checkoff) are grateful to Dr. Sharon Bard and Mr. Chris Schroeder of Centrec Consulting Group, LLC (Centrec) for their oversight and coordination in developing this report. They were supported by internal staff along with a team of experts that helped in data gathering, analysis, and report writing. External team members include Drs. Curt Weller, Joseph Awika, Ignacio Ciampitti, Tom Whitaker, and Marvin R. Paulsen. In addition, the Council is indebted to the Cereal Quality Lab (CQL) at Texas A&M University and Amarillo Grain Exchange (AGE) for providing the sorghum quality testing services.

This report would not be possible without the thoughtful and timely participation by local grain elevators across the United States. We are grateful for their time and effort in collecting and providing the harvest samples during their very busy period.



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The U.S. Grains Council (USGC) has conducted its second annual sorghum quality survey and is pleased to present the results in this *2016/2017 Sorghum Harvest Quality Report*.

The Council is committed to providing accurate and timely information about the quality of the U.S. sorghum crop. Such information helps buyers make well-informed decisions and increases their confidence in the capacity and reliability of the U.S. sorghum market.

This year's sorghum crop condition showed higher national yields and a higher percentage of sorghum ranked good or excellent than in past reviews. In most areas, harvest progress outpaced its respective average for the 2011-2015 period. Overall, 2016 had a favorable weather pattern and an adequate pollination environment, which contributed to the record yield.

As in the past edition, the *2016/2017 Sorghum Harvest Quality Report* provides information about the quality of the current U.S. sorghum crop at harvest as it enters international merchandising channels, using consistent methodology to allow for comparison with the past year's quality. Sorghum quality observed by buyers will be further affected by subsequent handling, blending, and storage conditions.

The Council strives for global food security and mutual economic benefit through the expansion of trade and overseas market development. Our global staff serves as a bridge between international sorghum buyers and the world's largest and most sophisticated agricultural production and export system.

As part of this role, the Council is pleased to offer this report as a service to our partners in support of the Council's mission of developing markets, enabling trade, and improving lives. We hope you find the information in this report valuable.

Sincerely,



Phillip "Chip" Councell, Jr.
Chairman, U.S. Grains Council
December 2016



The 2016 sorghum growing season experienced generally favorable weather conditions during the growing season, resulting in slightly higher average yields than in 2015. However, fewer planted acres in 2016 produced a U.S. sorghum crop of 11.7 million metric tons (462 million bushels), an approximate 23% decrease in production from the 2015 crop. The

2016 harvest samples were, on average, good, with average moisture near-optimum for harvest moisture; no detectable levels of tannins; and averages for chemical and most physical traits within a recognized range in literature for U.S. sorghum. The 2016 U.S. sorghum crop entered the market channel with the following characteristics:

Grade Factors and Moisture

- Average test weight of 59.1 lb/bu (76.1 kg/hl), with 87.8% at or above the minimum limit for U.S. No. 1 grade sorghum, and 96.1% at or above the minimum limit for U.S. No. 2 grade sorghum.
- Relatively low levels of broken kernels and foreign material (BNFM) (1.8%), with 86.5% at or below the maximum limit for U.S. No. 1 grade, and 97.3% at or below the maximum limit for U.S. No. 2 grade.
- Average foreign material level of 0.6%, with 88.4% at or below the maximum limit for U.S. No. 1 grade, and 98.8% at or below the maximum limit for U.S. No. 2 grade.
- Low levels of total damage (average of 0.4%), with 96.4% at or below the maximum limit for U.S. No. 1 grade, and 97.6% at or below the maximum limit for U.S. No. 2 grade.
- No observed heat damage, which could be attributed to no or minimal on-farm drying.
- Average elevator moisture content of 13.7%, a near-optimum level for harvest moisture, with 62.7% of the samples having 14% or less moisture content.

Chemical Composition

- Average protein concentration of 8.5% (dry basis), below 2015, but still within a recognized range of protein concentration values in literature for U.S. sorghum hybrids.
- Average starch concentration of 72.6% (dry basis), a value within recognized levels as reported in literature for any sorghum sample.
- Average oil concentration of 4.4% (dry basis), within a recognized range of oil concentration values in literature for U.S. sorghum hybrids, and similar to 2015.
- All samples had no detectable levels of tannins (below 4.0 mg CE/g).





Physical Factors

- Average kernel diameter of 2.61 mm and average 1000-kernel weight (TKW) of 28.17 g, both higher than 2015, indicating slightly larger kernels in 2016.
- Average kernel volume of 20.57 mm³, a value within a normal range reported in literature. This value was also slightly higher than 2015, confirming larger kernels in 2016.
- Average kernel true density of 1.370 g/cm³, within a range of values suitable for size reduction in feed preparation and higher than 2015.
- Average kernel hardness index of 67.1, lower than 2015, possibly implying less energy needed for grinding this year's crop compared to the 2015 crop on an equivalent weight basis, to a similar particle size.

Mycotoxin

- 100% of the 2016 sorghum harvest samples tested below the FDA action level of 20 ppb total aflatoxins, the same as in 2015.
- 100% of the 2016 sorghum harvest samples tested below the 5 ppm FDA advisory level for DON (deoxynivalenol or vomitoxin), the same as in 2015.



The *U.S. Grains Council 2016/2017 Sorghum Harvest Quality Report* is designed to help international buyers of U.S. sorghum understand the quality of U.S. commodity sorghum as it enters the merchandising channel. This is the second annual measurement survey of the quality of the U.S. sorghum crop at harvest. Two years of results are currently laying the foundation for understanding how weather and growing conditions may impact the quality of U.S. sorghum as it comes out of the field.

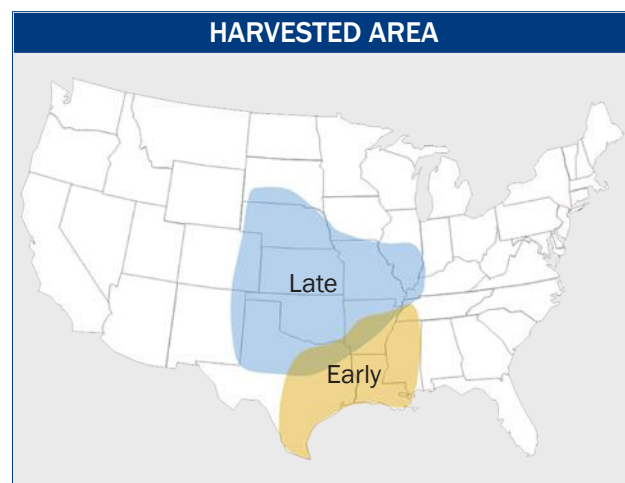
This *2016/2017 Harvest Report* is based on 254 commodity sorghum samples taken from defined areas within the nine top sorghum-producing states. Inbound, unblended samples were collected from local grain elevators to observe quality at the point of origin, and to provide representative information about the variability of the quality characteristics across the diverse geographic regions.

The sampling areas in the nine states are divided into two general groupings that are labeled Harvest Areas (HAs). These two HAs are identified by:

- The Early Harvest Area, which consists of areas that typically harvest sorghum from the beginning of July through the end of September; and
- The Late Harvest Area, which consists of areas that typically harvest sorghum from the beginning of September through the end of November or later.

The 2016 growing season in the Early Harvest Area was largely on or ahead of schedule, with abundant rains during the early-growth period (from planting until pollination). Excessive precipitation, particularly in the central part of Texas, affected yield and harvest. Pollination and reproductive periods had near-average temperatures, which promoted a normal crop development, and laid the foundation

for high yields in some areas. The Late Harvest Area had a near-average start to the growing season, but planting in May was slightly delayed due to wet conditions and above-average temperatures. Pollination was characterized by wet moisture conditions and near-average temperatures, which created favorable conditions for floret fertility and grain formation. October witnessed warmer than average temperatures, which accelerated maturity, natural drying, and harvest.



Overall, this *2016/2017 Harvest Report* indicates the 2016 sorghum crop entered the 2016/2017 market channel with average quality factor levels in good condition, and the majority met the standards for U.S. No. 1 grade sorghum. In addition, sorghum composition was in the recognized range of sorghum levels found in literature; no detectable levels of tannins were found; and typical values were found for kernel volume and true density. Kernel diameter and average 1000-kernel weight were both higher in 2016 than 2015, implying slightly larger kernels. The average kernel hardness index was slightly lower than 2015, implying potentially less energy needed for grinding this year's crop compared to the 2015 crop.

The sorghum harvest samples are proportionately stratified according to Agricultural Statistical Districts (ASDs) across the key 2016 sorghum-producing states. This is to ensure a sound statistical sampling of the U.S. sorghum crop at the first stage of the market channel. Sample test results are reported at the U.S. Aggregate level and for the two HAs, providing a general perspective on the geographic variability of U.S. sorghum quality at harvest.

This report provides detailed information on each of the quality factors tested for the harvest samples. This includes averages and standard deviations for the aggregate of all harvest samples, and for the two HAs. The “Quality Results” section summarizes the following quality factors:

- Grade Factors: test weight, broken kernels and foreign material (BNFM), foreign material, total damage, and heat damage
- Moisture
- Chemical Composition: protein, starch, oil, and tannins



- Physical Factors: kernel diameter, 1000-kernel weight (TKW), kernel volume, kernel true density, and kernel hardness index
- Mycotoxins: aflatoxins and DON (Deoxynivalenol or Vomitoxin)

In addition, this *Harvest Report* includes brief descriptions of the U.S. crop and weather conditions; U.S. sorghum production, usage, and outlook; and detailed descriptions of survey, statistical, and testing analysis methods.

This second year of sorghum harvest quality data will lay the foundation for evaluating trends and the factors that impact sorghum quality. In addition, the cumulative measurement surveys will increase in value by enabling export buyers and other stakeholders to begin making year-to-year comparisons and assessing patterns in sorghum quality, based on growing, drying, handling, storage, and transport conditions.

The quality characteristics of the sorghum identified at harvest establish the foundation for the quality of the grain ultimately arriving at the export customers' doors. However, as sorghum passes through the U.S. marketing system, it is mingled with sorghum from other locations; aggregated into trucks, barges, and railcars; and stored, loaded, and unloaded several times. Therefore, the quality and condition of the sorghum do change between the initial market entry and the export elevator. As always, the quality of an export cargo of sorghum is established by the contract between buyer and seller, and buyers are free to negotiate any quality factor that is particularly important to them.

A. GRADE FACTORS

The U.S. Department of Agriculture (USDA) Federal Grain Inspection Service (FGIS) has established numerical grades, definitions, and standards for grains. The attributes that determine the numerical grades for sorghum are test weight, broken kernels

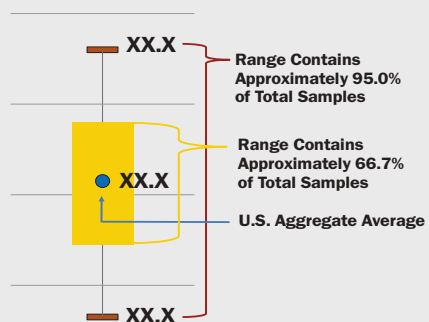
and foreign material (BNFM), foreign material, total damage, and heat damage. The table “U.S. Sorghum Grades and Grade Requirements” is provided on page 59 of this report.

SUMMARY: GRADE FACTORS AND MOISTURE

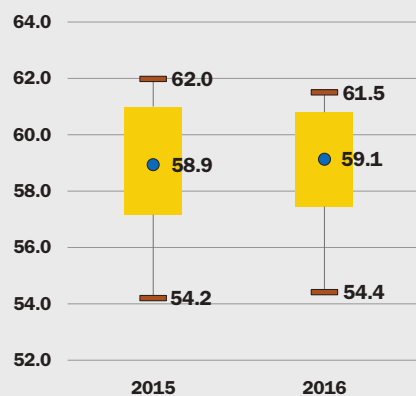
- Average U.S. Aggregate test weight (59.1 lb/bu or 76.1 kg/hl) was similar to 2015, with 87.8% of the samples at or above the factor limit for U.S. No. 1 grade sorghum (57.0 lb/bu or 73.4 kg/hl), and 96.1% of the samples at or above the limit for U.S. No. 2 grade (55.0 lb/bu or 70.8 kg/hl).
- Average U.S. Aggregate broken kernels and foreign material (BNFM) (1.8%) was well below the maximum for U.S. No. 1 grade (3.0%), with 86.5% of the samples also at or below the maximum for U.S. No. 1 grade, and 97.3% of the samples at or below the maximum for U.S. No. 2 grade (6.0%).
- Foreign material in the U.S. Aggregate samples averaged 0.6%, well below the maximum value of 1.0% for U.S. No. 1 grade. Over 88% of the samples were at or below the maximum for U.S. No. 1 grade, and almost 99% of the samples were at or below the maximum foreign material allowable for U.S. No. 2 grade (2.0%).
- Total damage in the 2016 samples was distributed with 96.4% of the samples having 2% or less total damage (the maximum allowable for U.S. No. 1 grade), and 97.6% having 5% or less total damage (the maximum allowable for U.S. No. 2 grade).
- There was no heat damage observed in any of the 2016 samples.
- The U.S. Aggregate moisture content levels recorded at the elevator in the 2016 samples averaged 13.7%, with a minimum value of 10.8% and a maximum value of 17.6%.
- The generally favorable weather conditions in 2016, especially those during harvest in the Late Harvest growing area, likely contributed to about 63% of the samples being delivered to elevators with 14% or less moisture, compared to 52% in 2015.



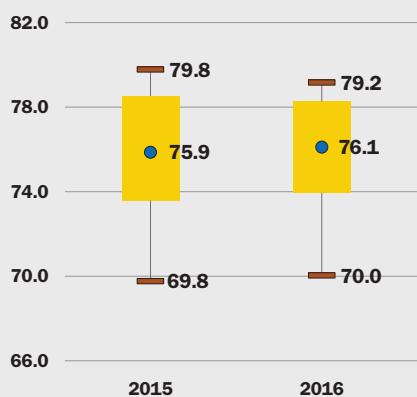
HOW TO READ THE CHARTS



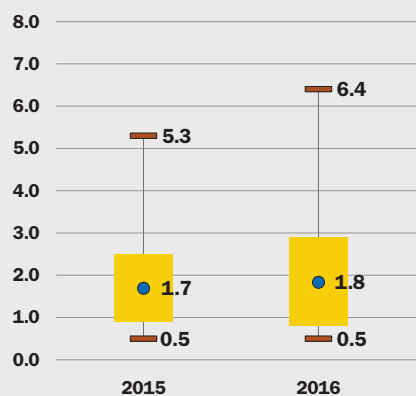
TEST WEIGHT (lb/bu)



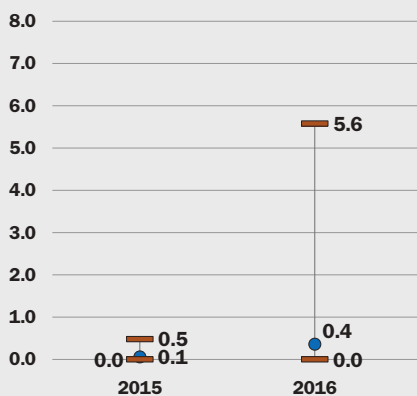
TEST WEIGHT (kg/hl)



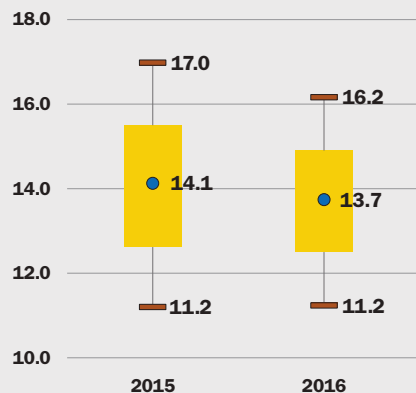
BNFM (%)



TOTAL DAMAGE (%)¹



MOISTURE (%)



¹No range containing 66.7% of samples was shown in the Total Damage chart because over 66.7% of samples in both 2015 and 2016 had 0.0% total damage.

Test Weight

Test weight (kernel weight per standard container volume) is a measure of bulk density. It is often used as a general indicator of overall quality and as a gauge of endosperm hardness for size reduction and value-added processing. High test weight sorghum takes up less storage space than the same weight of sorghum with a lower test weight. Test weight is initially impacted by genetic differences in the structure of the kernel. However, it is also affected by moisture content, method of drying, physical damage to the

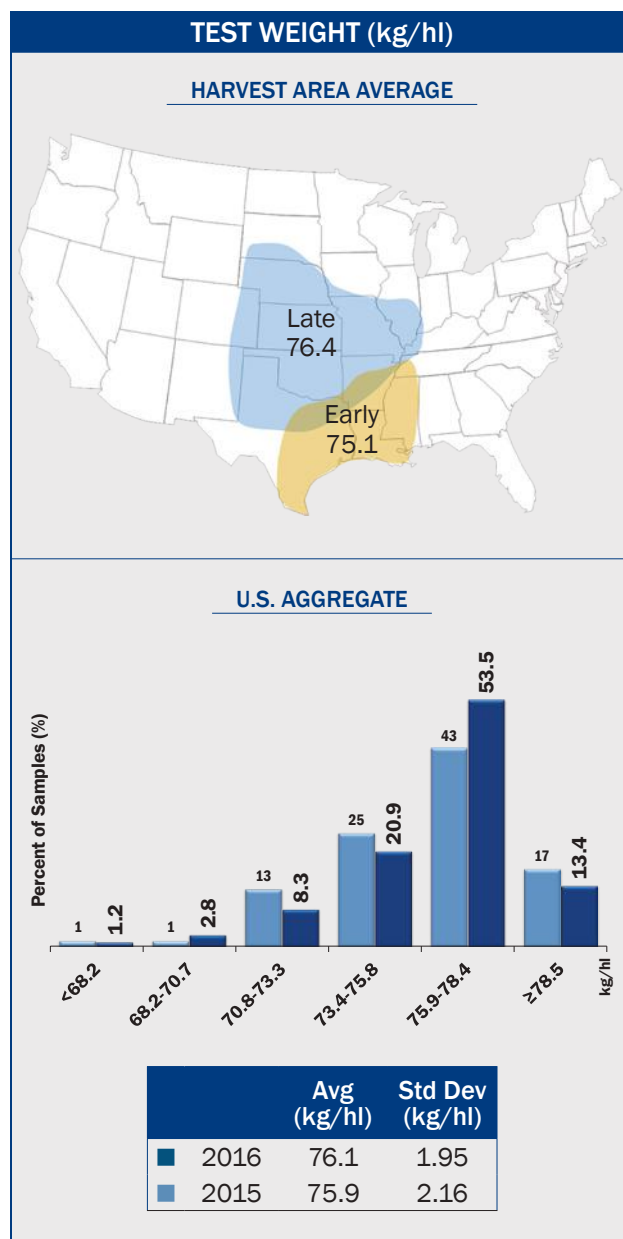
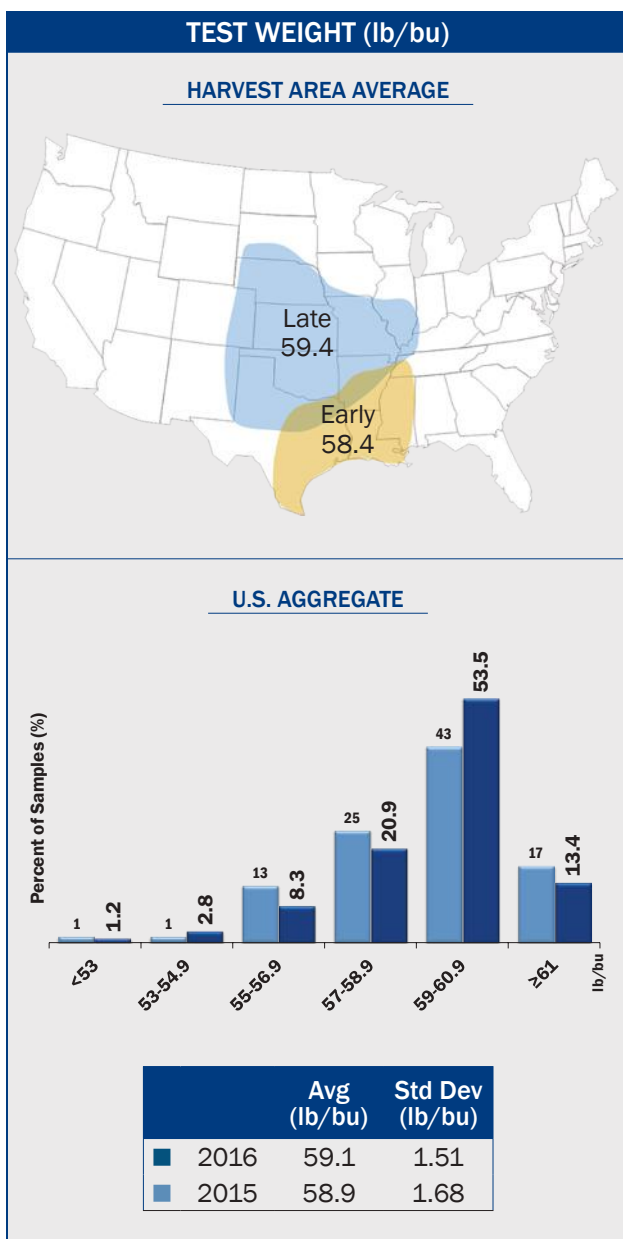
kernel (broken kernels and scuffed surfaces), foreign material in the sample, kernel size, stress during the growing season, and microbiological damage. When sampled and measured at the point of delivery from the farm at a given moisture content, high test weight generally indicates high quality, high percentage of hard (or vitreous) endosperm, and sound, clean sorghum. Test weight is usually correlated with kernel true density and reflects kernel hardness and kernel maturity².

Results

- Average U.S. Aggregate test weight in 2016 was 59.1 lb/bu (76.1 kg/hl), above the minimum for U.S. No. 1 grade (57.0 lb/bu or 73.4 kg/hl), and was about the same as 2015 (58.9 lb/bu or 75.9 kg/hl).
- U.S. Aggregate test weight standard deviation in 2016 (1.51 lb/bu or 1.95 kg/hl) was lower than in 2015 (1.68 lb/bu or 2.16 kg/hl).
- The 2016 test weight values were distributed with 87.8% of the samples at or above the factor limit for U.S. No. 1 grade, and 96.1% of the samples at or above the limit for U.S. No. 2 grade (55.0 lb/bu or 70.8 kg/hl).
- Average Late Harvest test weight (59.4 lb/bu or 76.4 kg/hl) was slightly higher than average Early Harvest test weight (58.4 lb/bu or 75.1 kg/hl) in 2016. This outcome may be attributable to the more favorable 2016 weather conditions for grain-fill in the Late Harvest Area compared to the Early Harvest Area. Average Late Harvest test weight was also higher than average Early Harvest test weight in 2015.

U.S. Grade Minimum Test Weight
No. 1: 57.0 lbs
No. 2: 55.0 lbs
No. 3: 53.0 lbs

²Buffo, R.A., C.L. Weller and A.M. Parkhurst. 1998. Relationship among grain sorghum quality factors. *Cereal Chemistry* 75(1):100-104.



Broken Kernels and Foreign Material (BNFM)

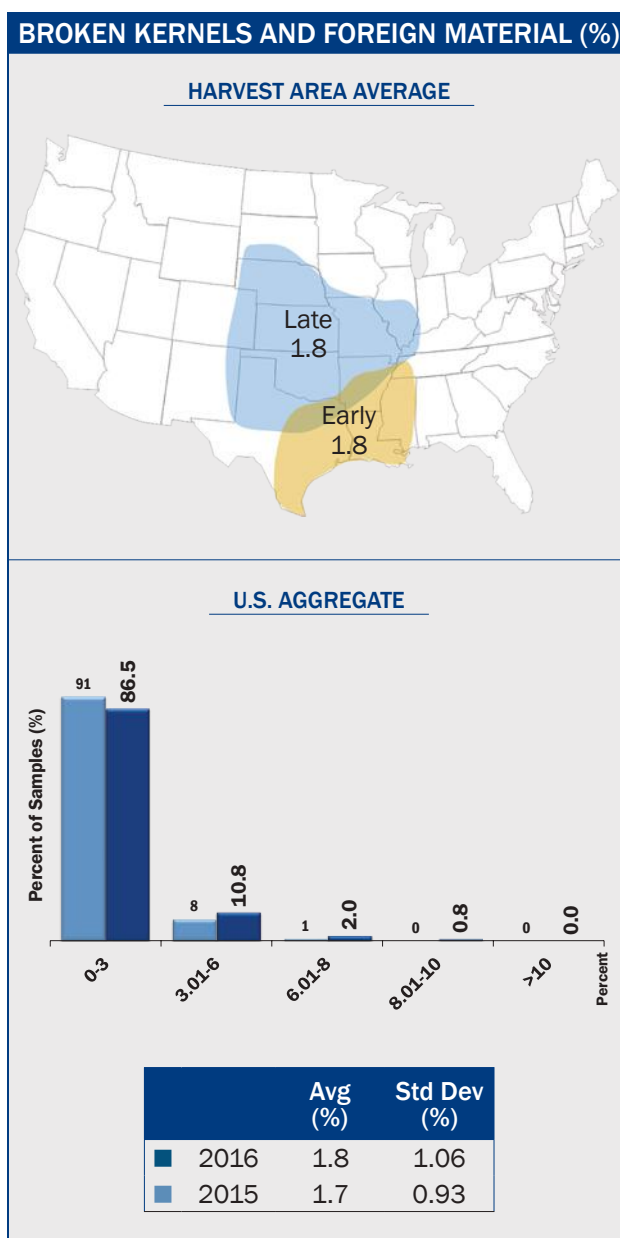
Broken kernels and foreign material (BNFM) is an indicator of the amount of clean, sound sorghum available for feed and processing. The lower the percentage of BNFM, the less foreign material and/or fewer broken kernels are in a sample. Higher levels of BNFM in farm-originated samples generally stem from combine settings and/or weed seeds in the

field. BNFM levels will normally increase during drying and handling, depending on the methods used and the soundness of the kernels. Stress crack formation during dry down or during mechanical drying after harvest will also result in an increase in broken kernels and BNFM during subsequent handling.

Results

- Average U.S. Aggregate BNFM in 2016 (1.8%) was well below the maximum for U.S. No. 1 grade (3.0%) and was about the same as 2015 (1.7%).
- The 2016 U.S. Aggregate BNFM standard deviation (1.06%) was slightly higher than 2015 (0.93%).
- Of the 2016 U.S. Aggregate samples, 86.5% of the samples were at or below the maximum BNFM allowable for U.S. No. 1 grade, and 97.3% were at or below the maximum for U.S. No. 2 grade (6.0%).
- No difference was observed between average Early Harvest and Late Harvest BNFM.

U.S. Grade BNFM Maximum Limits	
No. 1:	3.0%
No. 2:	6.0%
No. 3:	8.0%



Foreign Material

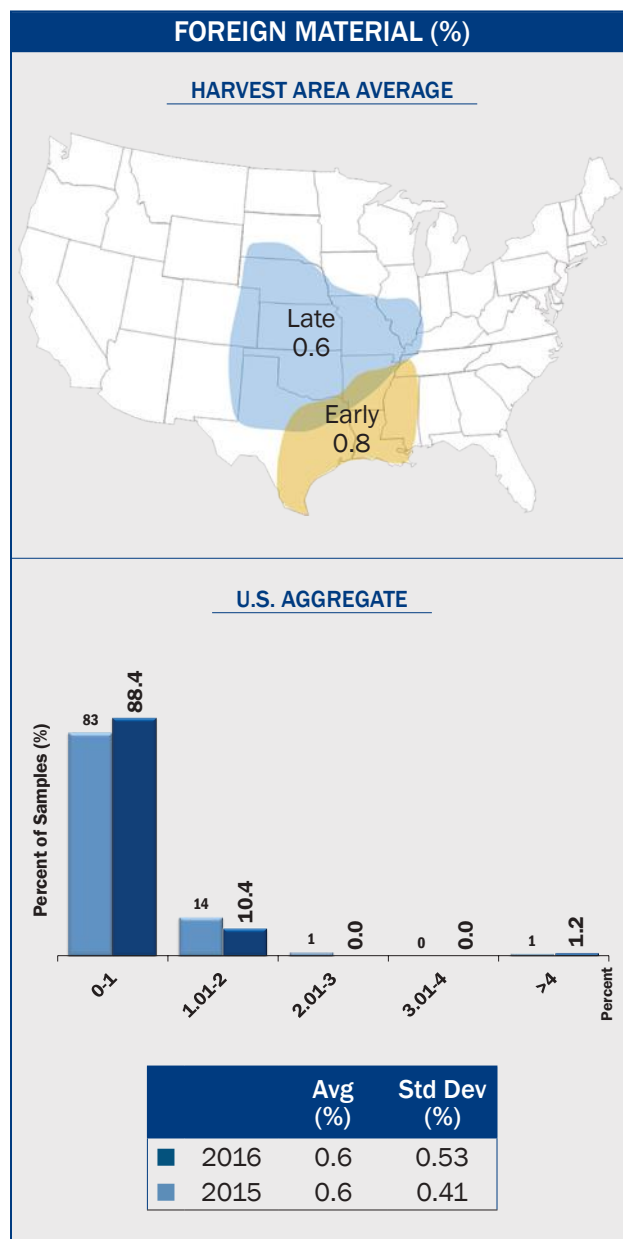
Foreign material, a subset of BNFM, is of importance because it has little feed or processing value. It is also generally higher in moisture content than the sorghum itself, and therefore creates a potential for deterioration of sorghum quality during storage.

Foreign material also contributes to the spout-line and has the possibility of creating more quality problems and damage because of its higher moisture level, as previously mentioned.

Results

- Average U.S. Aggregate foreign material in 2016 (0.6%) was almost half of the maximum value of 1.0% for U.S. No. 1 grade, and was the same as 2015 (0.6%).
- U.S. Aggregate foreign material standard deviation in 2016 (0.53%) was slightly higher than 2015 (0.41%).
- In 2016, 88.4% of the samples were at or below the maximum foreign material allowable for U.S. No. 1 grade, and 98.8% were at or below the maximum for U.S. No. 2 grade (2.0%).
- Average Late Harvest foreign material (0.6%) was slightly lower than average Early Harvest foreign material (0.8%) in 2016. This difference may be attributable to pest pressure and weather conditions at harvest and differences in the growing areas of the samples.

U.S. Grade FM Maximum Limits
No. 1: 1.0%
No. 2: 2.0%
No. 3: 3.0%



Total Damage

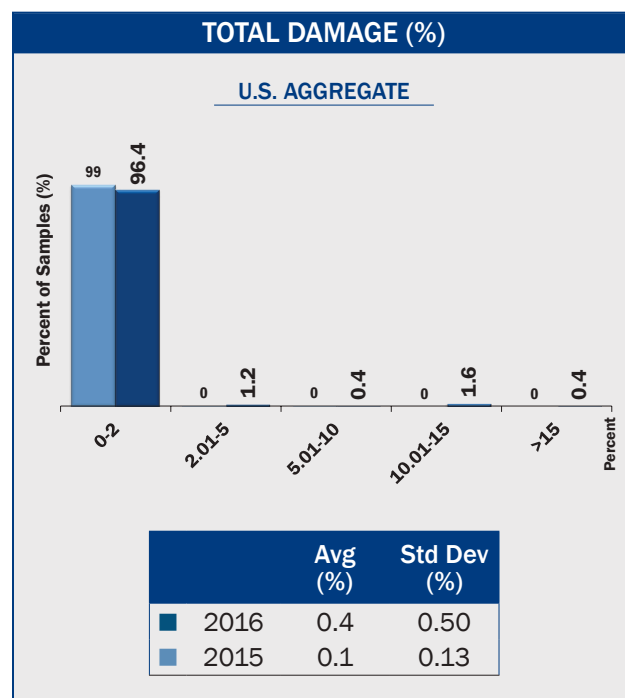
Total damage is the percentage of kernels and pieces of kernels that are visually damaged in some way, including badly ground-damaged, badly weather-damaged, diseased, frost-damaged, germ-damaged, heat-damaged, insect-bored, mold-damaged, sprout-damaged, or otherwise materially damaged kernels. Most of these types of damage result in some sort of discoloration or change in kernel texture. Damage does not include broken pieces

of grain that are otherwise normal in appearance. Mold damage is usually associated with higher than desired moisture content levels and temperatures during growth and/or in storage. Mold damage and the associated potential for development of mycotoxins are the damage factors of greatest concern. Mold damage can occur prior to harvest as well as during temporary storage at high moisture and high temperature levels prior to delivery.

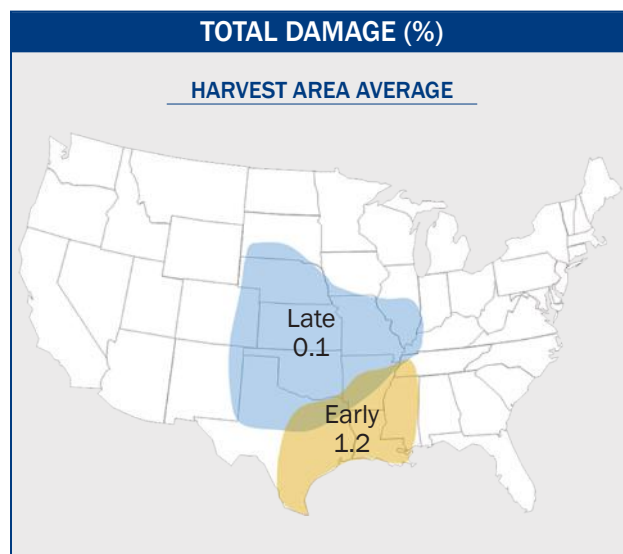
Results

- Average U.S. Aggregate total damage was 0.4% in 2016, well below the limit for U.S. No. 1 grade (2%).
- The 2016 U.S. Aggregate total damage standard deviation (0.50%) was higher than 2015 (0.13%).
- Total damage in the 2016 samples was distributed with 96.4% of the samples having 2% or less total damage (the maximum allowable for U.S. No. 1 grade), and 97.6% having 5% or less total damage (the maximum allowable for U.S. No. 2 grade).

U.S. Grade Total Damage Maximum Limits
No. 1: 2.0%
No. 2: 5.0%
No. 3: 10.0%



- Very little total damage (0.1%) was observed in Late Harvest samples, whereas the observed total damage levels for the U.S. Aggregate samples (0.4%) can be attributed to the total damage observed in Early Harvest samples (1.2%). The observed Early Harvest total damage may have been due to early season pest problems, harvest weather and sprouting issues encountered in that area.
- Average U.S. Aggregate total damage in 2016 (0.4%) was higher than 2015 (0.1%), largely due to the average total damage of 2016 Early Harvest samples.



Heat Damage

Heat damage is a subset of total damage and has separate allowances in the U.S. Grade Standards. Heat damage can be caused by microbiological

activity in warm, moist grain or by high heat applied during drying. Heat damage is seldom present in sorghum delivered at harvest directly from farms.

Results

- There was no heat damage observed in any of the 2016 samples.
- The absence of heat damage likely was due in part to recently-harvested samples coming directly from farm to elevator with minimal, if any, prior drying.

U.S. Grade Heat Damage Maximum Limits
No. 1: 0.2%
No. 2: 0.5%
No. 3: 1.0%

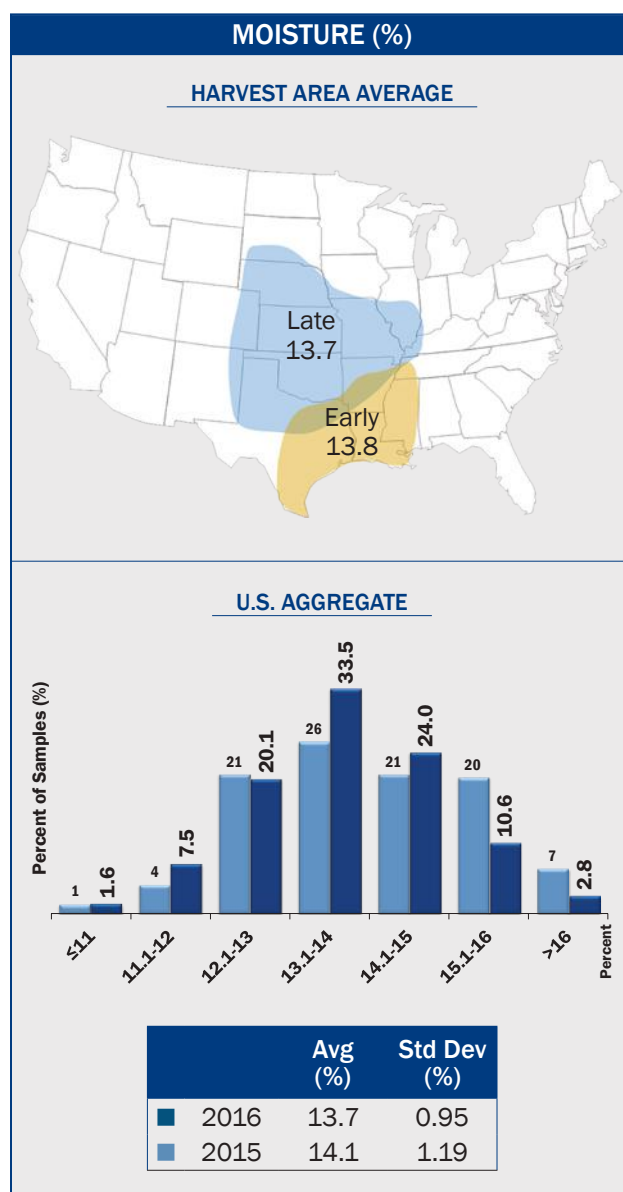
B. MOISTURE

Moisture content (water weight in kernels per total weight of kernels (i.e., water weight plus dry matter weight) also known as wet basis) is reported on official grade certificates, but does not determine which numerical grade will be assigned to the sample. Moisture content affects the amount of dry matter being sold and purchased. Also an indicator for potential drying, moisture has potential implications for storability, and affects test weight. Higher moisture content at harvest increases the chance of kernel

damage occurring during harvesting and drying. Moisture content and the amount of mechanical drying required will also affect stress-crack formation, breakage, and germination. Extremely wet kernels may be a precursor to high mold damage later in storage or transport. While the weather during the growing season affects yield and the development of the kernels, harvest moisture is influenced largely by the timing of harvest and harvest weather conditions.

Results

- The U.S. Aggregate moisture content recorded at the elevator in the 2016 samples averaged 13.7%, with a minimum value of 10.8% and a maximum value of 17.6%.
- U.S. Aggregate moisture content standard deviation in 2016 (0.95%) was lower than 2015 (1.19%).
- The 2016 moisture values were distributed with 62.7% containing 14% or less moisture; 14% is the moisture level used by most elevators as the basis for discounts and a level considered safe for storage for short periods during low winter-time temperatures.
- Late Harvest average moisture content was slightly lower than Early Harvest average moisture content in 2016 (13.7% and 13.8%, respectively) and 2015 (14.0% and 14.5%, respectively). This difference may have been due to longer in-field dry down in the Late Harvest Area than in the Early Harvest Area. A longer harvest window and more favorable harvest weather conditions likely contribute to longer in-field dry down.
- In 2016, the generally favorable weather conditions, especially during harvest in the Late Harvest Area, likely contributed to 62.7% of the samples being delivered to elevators at or below 14% moisture, compared to 52% in 2015.





SUMMARY: GRADE FACTORS AND MOISTURE

2016 Harvest						2015 Harvest		
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.
U.S. Aggregate						U.S. Aggregate		
Test Weight (lb/bu)	254	59.1	1.51	51.4	61.8	207	58.9	1.68
Test Weight (kg/hl)	254	76.1	1.95	66.2	79.5	207	75.9	2.16
BNFM (%)	251 ²	1.8	1.06	0.4	8.9	207	1.7	0.93
Foreign Material (%) ¹	251 ²	0.6	0.53	0.0	7.3	207	0.6	0.41
Total Damage (%) ¹	251 ²	0.4	0.50	0.0	32.5	207	0.1*	0.13
Heat Damage (%)	251 ²	0.0	0.00	0.0	0.0	207	0.0	0.00
Moisture (%)	254	13.7	0.95	10.8	17.6	207	14.1*	1.19
Early Harvest						Early Harvest		
Test Weight (lb/bu)	56	58.4	1.88	51.4	61.8	50	57.8	2.20
Test Weight (kg/hl)	56	75.1	2.41	66.2	79.5	50	74.4	2.83
BNFM (%) ¹	56	1.8	1.19	0.5	8.9	50	1.4*	0.62
Foreign Material (%) ¹	56	0.8	0.92	0.1	7.3	50	0.5*	0.27
Total Damage (%) ¹	56	1.2	1.61	0.0	32.5	50	0.2*	0.38
Heat Damage (%)	56	0.0	0.00	0.0	0.0	50	0.0	0.00
Moisture (%)	56	13.8	1.00	11.8	17.1	50	14.5*	0.86
Late Harvest						Late Harvest		
Test Weight (lb/bu)	198	59.4	1.38	54.7	61.7	157	59.5	1.42
Test Weight (kg/hl)	198	76.4	1.78	70.4	79.4	157	76.6	1.83
BNFM (%)	195 ²	1.8	1.02	0.4	6.5	157	1.8	1.08
Foreign Material (%)	195 ²	0.6	0.40	0.0	4.9	157	0.7*	0.47
Total Damage (%) ¹	195 ²	0.1	0.11	0.0	12.8	157	0.0*	0.00
Heat Damage (%)	195 ²	0.0	0.00	0.0	0.0	157	0.0	0.00
Moisture (%)	198	13.7	0.93	10.8	17.6	157	14.0*	1.36

¹Indicates averages in 2015 were significantly different from 2016, based on a 2-tailed t-test at a 95% level of significance.

¹The Relative ME for predicting the harvest population average exceeded $\pm 10\%$.

²Three samples were not tested for these grade factors due to insufficient sample size.

C. CHEMICAL COMPOSITION

Chemical composition of sorghum is important because the components of protein, starch, oil, and tannins are of significant interest to end users. The chemical composition attributes are not grade factors. However, they provide additional information

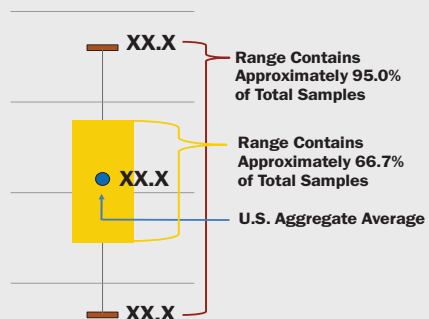
related to nutritional value for livestock and poultry feeding and other processing uses of sorghum. Unlike many physical attributes, chemical composition values are not expected to change significantly during storage or transport.

SUMMARY: CHEMICAL COMPOSITION

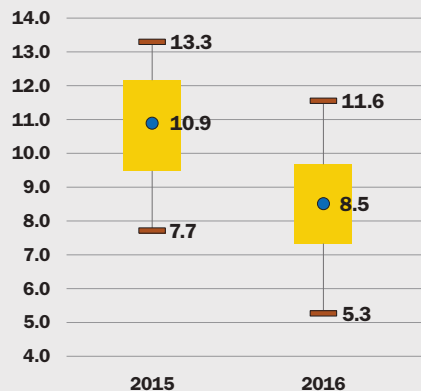
- In 2016, U.S. Aggregate protein concentration averaged 8.5% (dry basis), with a standard deviation of 1.10%.
- U.S. Aggregate starch concentration averaged 72.6% (dry basis) in 2016, with a standard deviation of 0.91%. Almost all the 2016 samples had at least 70% starch.
- U.S. Aggregate oil concentration averaged 4.4% (dry basis) in 2016. Over half (52.8%) of the 2016 samples had an oil concentration of 4.5% or higher.
- All samples had no detectable levels of tannins (below 4.0 mg CE/g), the same as in 2015.



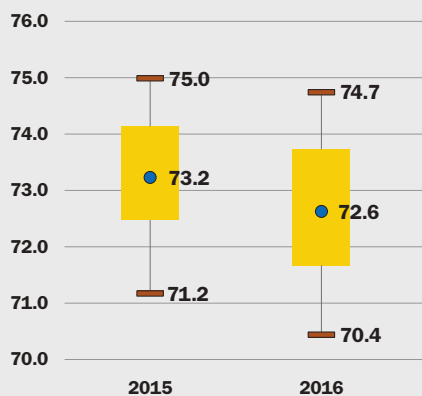
HOW TO READ THE CHARTS



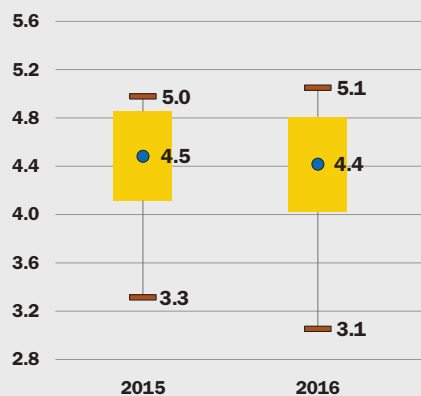
PROTEIN (Dry Basis %)



STARCH (Dry Basis %)



OIL (Dry Basis %)



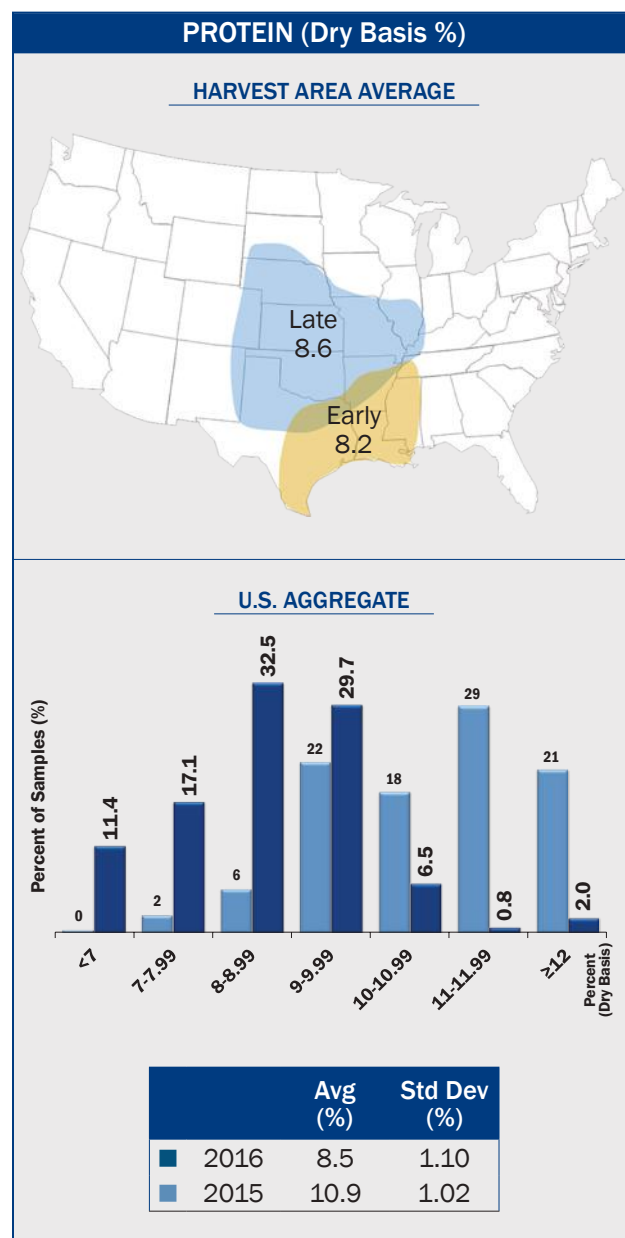
Protein

Protein is very important for poultry and livestock feeding, as it supplies essential sulfur-containing amino acids and helps to improve feed conversion efficiency. Variation in protein concentration from

year to year is usually inversely related to variation in starch concentration and yield³. Results are reported on a dry basis (protein weight in kernels per total dry matter weight of kernels).

Results

- In 2016, U.S. Aggregate protein concentration averaged 8.5%, which is within recognized levels found in literature for U.S. sorghum hybrids.
- The lower average U.S. Aggregate protein concentration in 2016 (8.5%) compared to 2015 (10.9%) was consistent with slightly higher average yield in 2016 (76.5 bu/ac or 4.80 mt/ha) versus 2015 (76.0 bu/ac or 4.77 mt/ha). The decline in average protein may also be attributed to differences in hybrid seeds planted between 2016 and 2015.
- The 2016 U.S. Aggregate protein standard deviation was 1.10% in 2016, compared to 1.02% in 2015.
- Protein concentration range in 2016 (4.2 to 14.5%) was greater than in 2015 (6.8 to 14.1%).
- Protein concentration in the 2016 samples was distributed with 61.0% below 9%, 36.2% between 9 and 10.99%, and 2.8% at or above 11%.
- Average Late Harvest protein concentration (8.6%) was higher than average Early Harvest protein concentration (8.2%) in 2016. Average Late Harvest protein concentration was also higher than Early Harvest protein concentration in 2015.



³Worker, Jr., G.F. and J. Ruckman. 1968. Variations in protein levels in grain sorghum grown in southwest desert. *Agronomy Journal* 60(5):485-488.

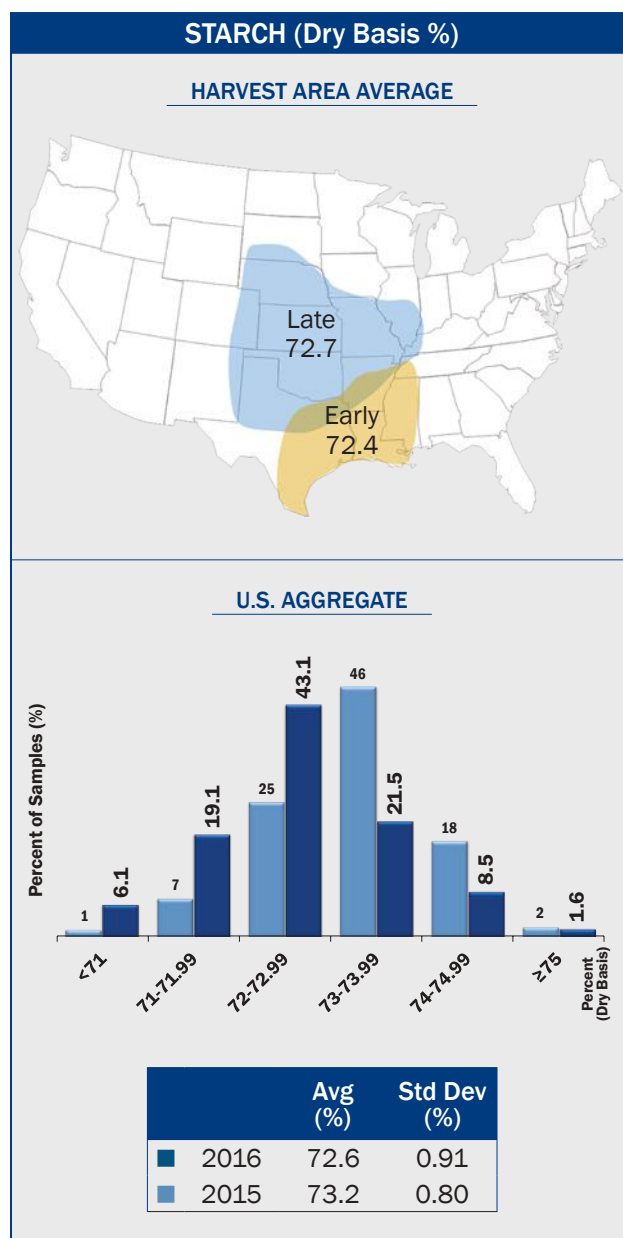
Starch

Starch is an important factor for sorghum and is related to metabolizable energy for livestock and poultry. Levels of starch in sorghum may also be of interest to processors, as starch provides the substrate for several value-added processes. High starch concentration is often indicative of good kernel mat-

uration/filling conditions and reasonably moderate kernel densities. Variation in starch concentration from year to year is usually inversely related to variation in protein concentration. Results are reported on a dry basis (starch weight in kernels per total dry matter weight of kernels).

Results

- U.S. Aggregate starch concentration averaged 72.6% in 2016, a level within recognized levels found as reported in literature for any commercial hybrid sorghum sample, compared to 73.2% in 2015.
- The 2016 U.S. Aggregate starch concentration standard deviation (0.91%) was slightly greater than 2015 (0.80%).
- Starch concentration range in 2016 (67.4 to 76.8%) was greater than in 2015 (68.7 to 75.6%).
- Starch concentration in the 2016 samples was distributed with 68.3% between 70 and 72.99%, 21.5% between 73 and 73.99%, and 10.1% equal to or greater than 74%.
- Average starch concentration for Late Harvest samples (72.7%) was essentially the same as that for Early Harvest samples (72.4%). The starch concentration averages for the 2015 Late Harvest and Early Harvest samples were also comparable.



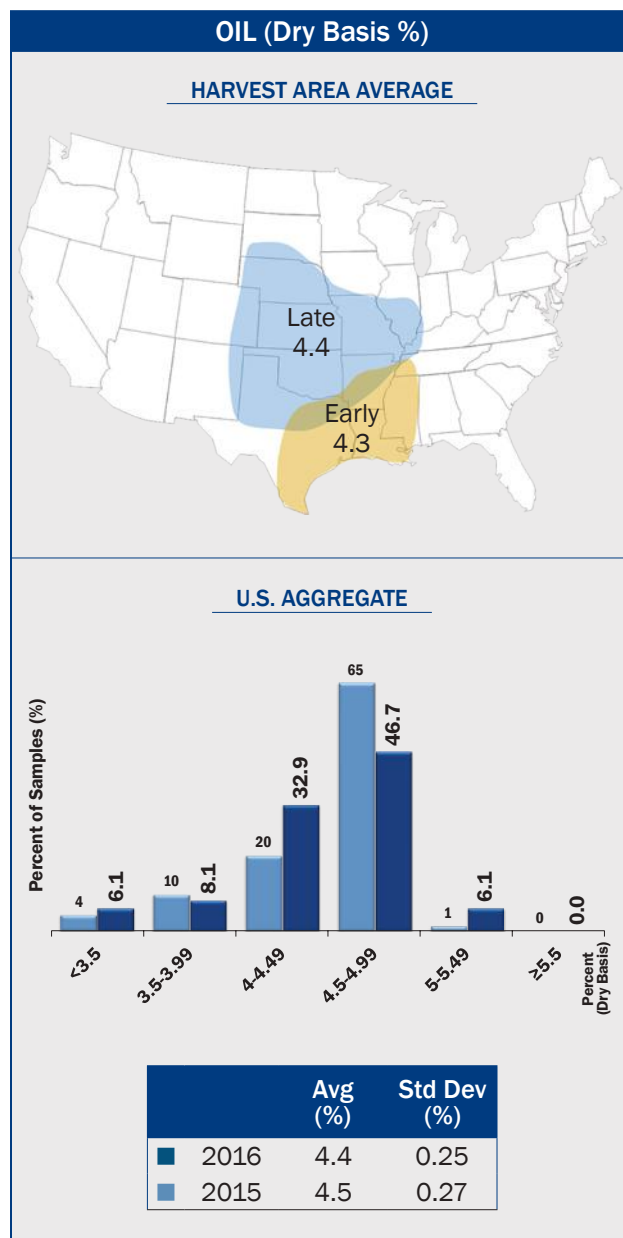
Oil

Oil is an essential component of poultry and live-stock rations. It serves as an energy source, enables fat-soluble vitamins to be utilized, and provides certain essential fatty acids. Oil may also be an import-

ant co-product of sorghum value-added processing. Results are reported on a dry basis (oil weight in kernels per total dry matter weight of kernels).

Results

- Average U.S. Aggregate oil concentration in 2016 (4.4%), within a recognized range of oil concentration values in literature for U.S. sorghum hybrids, was similar to 2015 (4.5%).
- The 2016 U.S. Aggregate oil concentration standard deviation (0.25%) was about the same as 2015 (0.27%).
- Oil concentration range in 2016 (2.7 to 5.2%) was slightly greater than in 2015 (3.0 to 5.1%).
- Over half of 2016 U.S. Aggregate samples (52.8%) had an oil concentration at 4.5% and higher, 32.9% between 4 to 4.49%, and 14.2% equal to or less than 3.99%.
- Late Harvest samples had an average oil concentration of 4.4%, whereas the Early Harvest samples had an average oil concentration of 4.3%.



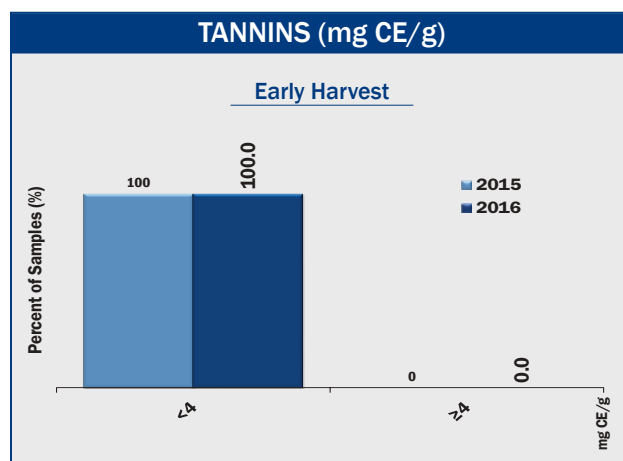
Tannins

Tannins are present in sorghum varieties that have a pigmented testa within their kernels. Chemically, tannins are compounds that are large molecules comprised of smaller phenolic molecules (catechins, epicatechins, etc.). These compounds, which have antioxidant and other possible health benefits, are widely distributed in nature. For example, they are found in grapes, bark, tea leaves, etc., influencing aroma, flavor, mouth-feel, and astringency. While present in sorghum varieties grown around the world, more than 99% of sorghum currently grown in the United States is tannin-free due to decades of breeding efforts to eliminate tannins from sorghum

hybrids. Tannins have effects on nutritional and functional properties as a result of interactions of the tannins with nutrients in the kernel. Livestock and poultry growth performance can be negatively affected by the presence of tannins in sorghum-containing rations. Current non-tannin sorghum varieties grown in the United States have virtually the same energy profile as corn in feed rations. Results are reported as being below 4.0 milligrams of catechin equivalents (CE) per gram sample (4.0 mg CE/g) or above. Values below 4.0 mg CE/g generally imply absence of condensed tannins^{4, 5}.

Results

- All observed tannin levels in the 2016 U.S. Aggregate samples (includes all Late and Early Harvest samples) were less than 4.0 mg CE/g, indicating there were no detectable levels of tannins. This is the same result as in 2015.



⁴Awika, J.M. and L.W. Rooney. 2004. Sorghum phytochemicals and their potential impact on human health. *Phytochemistry* 65(9):1199-1221.

⁵Price, M.L., S. Van Scoyoc and L.G. Butler. 1978. A critical evaluation of vanillin reaction as an assay for tannin sorghum. *Journal of Agricultural and Food Chemistry* 26(5):1214-1218.

SUMMARY: CHEMICAL COMPOSITION

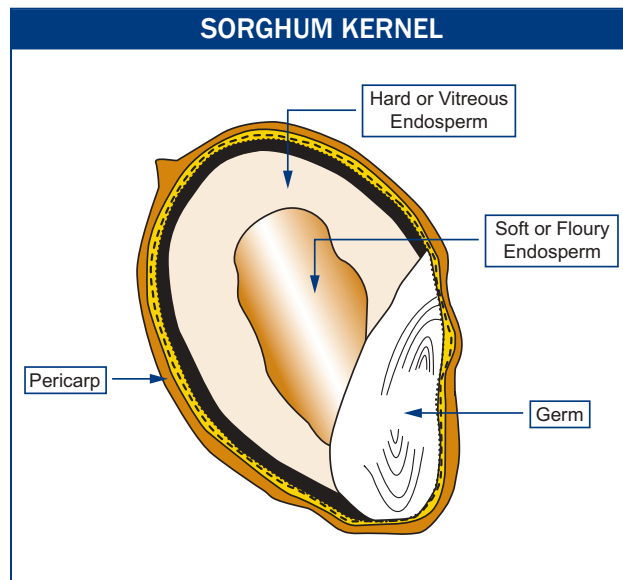
2016 Harvest						2015 Harvest		
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.
U.S. Aggregate						U.S. Aggregate		
Protein (Dry Basis %)	246 ¹	8.5	1.10	4.2	14.5	207	10.9*	1.02
Starch (Dry Basis %)	246 ¹	72.6	0.91	67.4	76.8	207	73.2*	0.80
Oil (Dry Basis %)	246 ¹	4.4	0.25	2.7	5.2	207	4.5*	0.27
Early Harvest						Early Harvest		
Protein (Dry Basis %)	51 ¹	8.2	0.84	6.1	9.8	50	10.4*	0.75
Starch (Dry Basis %)	51 ¹	72.4	0.78	70.2	74.1	50	73.3*	0.69
Oil (Dry Basis %)	51 ¹	4.3	0.19	3.0	4.9	50	4.3*	0.31
Late Harvest						Late Harvest		
Protein (Dry Basis %)	195 ¹	8.6	1.19	4.2	14.5	157	11.1*	1.15
Starch (Dry Basis %)	195 ¹	72.7	0.95	67.4	76.8	157	73.2*	0.86
Oil (Dry Basis %)	195 ¹	4.4	0.27	2.7	5.2	157	4.6*	0.25

*Indicates averages in 2015 were significantly different from 2016, based on a 2-tailed t-test at a 95% level of significance.

¹Results are not reported for eight samples because the NIR instrument could not generate valid results due to sample damage. Five samples were from the Early Harvest Area and three samples were from the Late Harvest Area.

D. PHYSICAL FACTORS

Physical factors include other quality attributes that are neither grading factors nor chemical composition. Tests for physical factors provide additional information about the processing characteristics of sorghum for various uses, as well as its storability and potential for breakage in handling. The storability, ability to withstand handling, and processing performance of sorghum are all influenced by sorghum's morphology. Sorghum kernels are morphologically made up of three parts: the germ or embryo, the pericarp or outer covering, and the endosperm. The endosperm represents about 82 to 86% of the kernel and consists of soft (also referred to as floury) endosperm and of hard (also called vitreous) endosperm, as shown at right. The endosperm contains primarily starch and protein, whereas the germ contains oil and some proteins. The pericarp is comprised mostly of fiber, with a small coating of waxy material. Softer and smaller kernels usually require less energy than harder and larger kernels to reduce to similar particle size⁶.

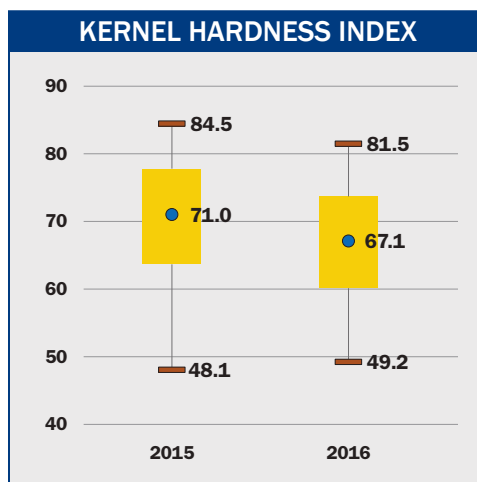
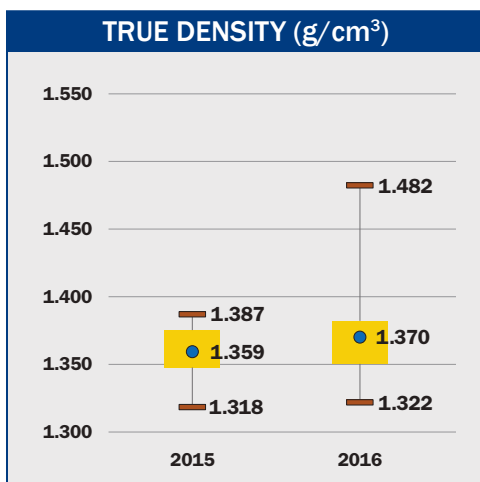
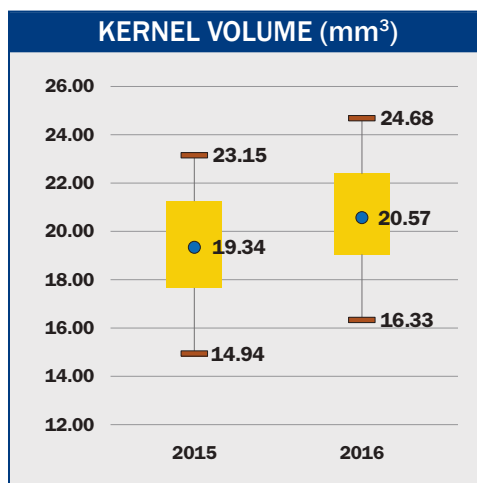
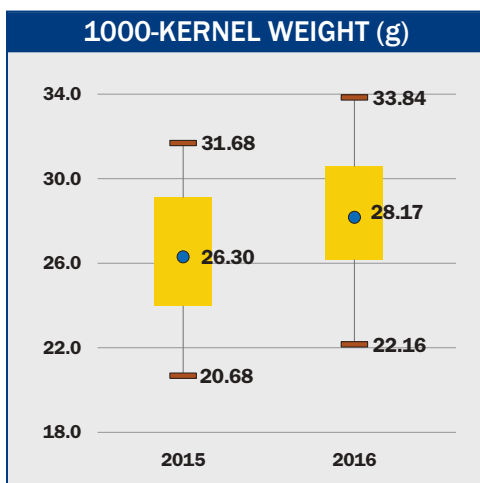
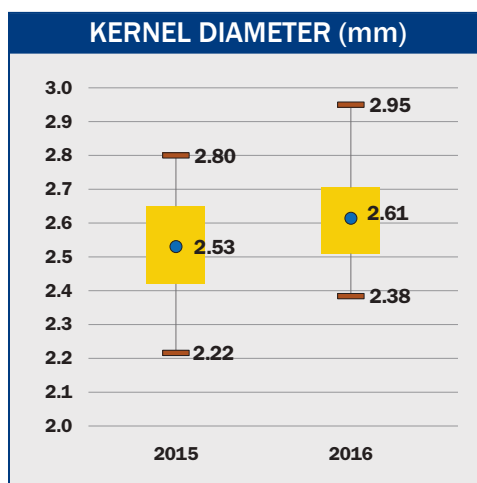
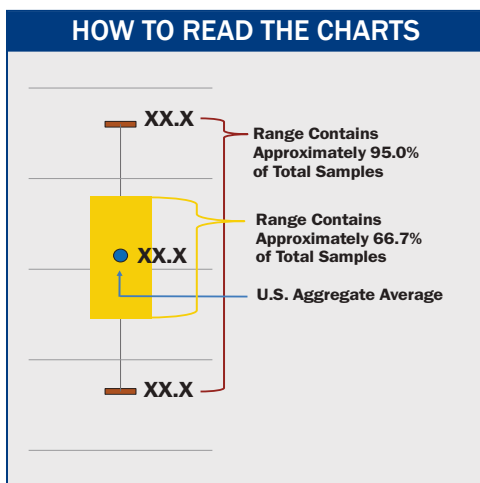


Adapted from Rooney, L.W. and F.R. Miller. 1982. Variation in the structure and kernel characteristics of sorghum. In L.W. Rooney, D.S. Murty and J.V. Mertin eds., *Proceedings of the International Symposium on Sorghum Grain Quality*, pp. 143-162. Patancheru, India: ICRISAT.

SUMMARY: PHYSICAL FACTORS

- Average U.S. Aggregate kernel diameter (2.61 mm) and 1000-kernel weight (TKW) (28.17 g) were both higher in 2016 than in 2015, indicating slightly larger kernels in 2016 than in 2015.
- Average U.S. Aggregate kernel volume (20.57 mm³) is within a normal range reported in literature and is slightly higher than 2015, confirming larger kernels in 2016 than in 2015.
- U.S. Aggregate kernel true density averaged 1.370 g/cm³, which is within the range of values suitable for size reduction in feed preparation. Three-quarters of the 2016 samples' true density was between 1.345 and 1.389 g/cm³.
- Average U.S. Aggregate kernel hardness index (67.1) was lower than 2015 (71.0). This may imply less energy needed for grinding the 2016 crop compared to the 2015 crop (on an equivalent weight basis) to a similar particle size.
- Late Harvest samples had higher average true density, TKW, hardness, test weight, and protein concentration than the Early Harvest samples in 2016 and 2015.

⁶Healy, B.J., J.D. Hancock, G.A. Kennedy, P.J. Bramel-Cox, K.C. Behnke and R.H. Hines. 1994. Optimum particle size of corn and hard and soft sorghum for nursery pigs. *Journal of Animal Science* 72(9):2227-2236.



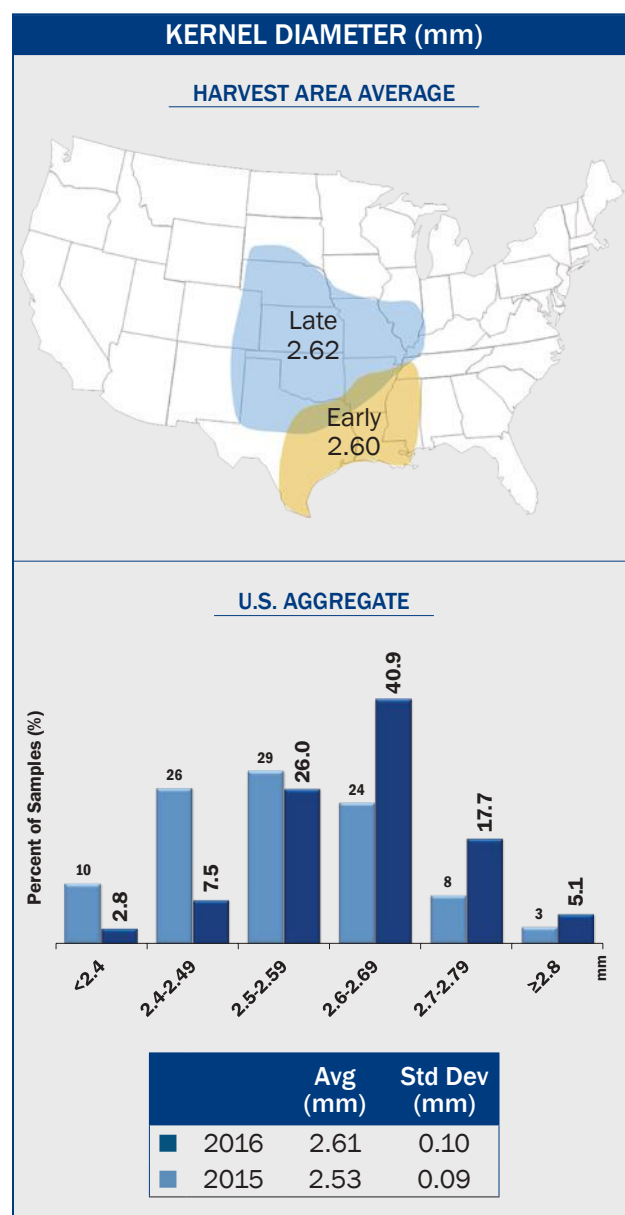
Kernel Diameter

Kernel diameter (reported in mm) directly correlates with kernel volume, affects size reduction behavior and material handling practices, and may indicate maturity of kernels. Size reduction refers to reducing kernels (large particles) to ground material (small particles), commonly through grinding/milling. Size reduction, energy consumption, decortication efficiency, and yield of kernel components depend

on diameter. Decortication refers to the removal of the pericarp and germ from a kernel by attrition or abrasion, with minimal removal of endosperm before subsequent grinding/milling. The smaller the kernels, the more care and concern required in handling. Incomplete kernel fill and unexpected weather conditions may contribute to small diameter values.

Results

- Average U.S. Aggregate kernel diameter in 2016 (2.61 mm) had a value within a recognized range reported in literature for any commercial sorghum hybrid sample, and was higher than 2015 (2.53 mm).
- The 2016 U.S. Aggregate kernel diameter standard deviation (0.10 mm) was about the same as 2015 (0.09 mm).
- Kernel diameter range in 2016 (2.20 to 3.01 mm) was greater than in 2015 (2.18 to 2.90 mm).
- In 2016, kernel diameters were distributed so that 22.8% of the samples had kernel diameters of 2.7 mm or greater, 66.9% between 2.5 and 2.69 mm, and 10.3% less than 2.5 mm.



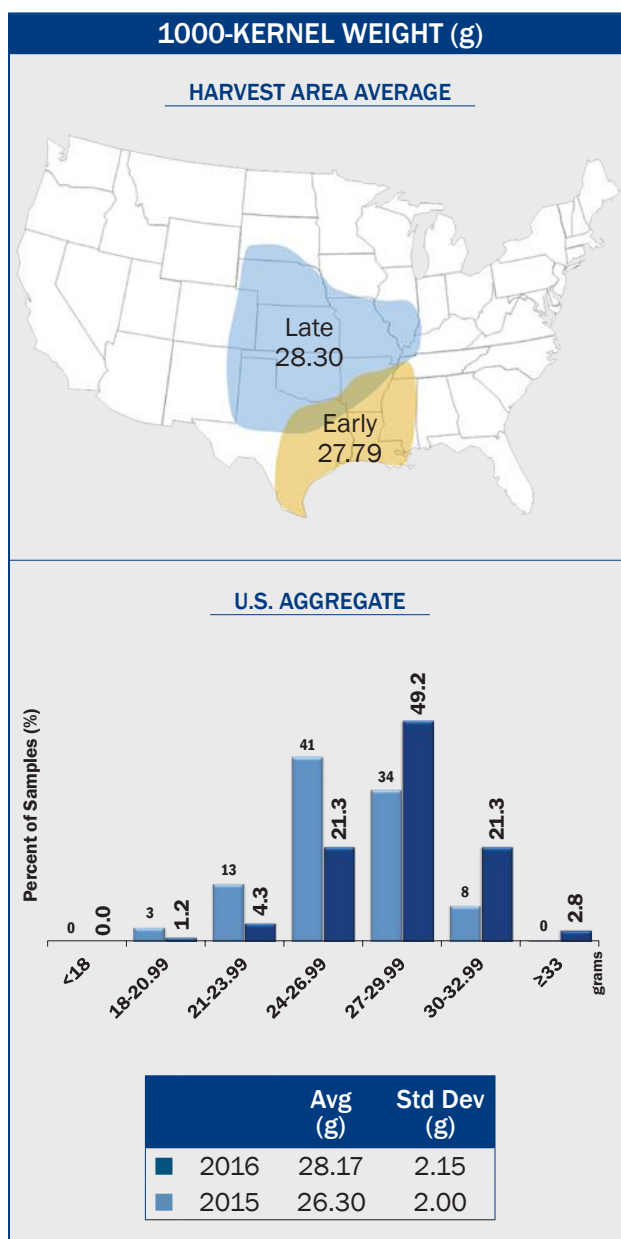
1000-Kernel Weight (TKW)

1000-kernel weight (commonly referred to as TKW) is the weight for a fixed number of kernels, and is reported in grams. Kernel volume (or size) can be inferred from TKW, since as TKW increases or decreases, kernel volume will proportionally increase or decrease. Kernel volume affects drying rates. As

kernel volume increases, the volume-to-surface-area ratio for the kernel becomes greater, and drying time to a desired moisture level takes longer. Kernel weights tend to be higher for specialty varieties of sorghum that have high amounts of hard (vitreous) endosperm.

Results

- TKW averaged 28.17 g for the U.S. Aggregate in 2016, a value within a recognized range of TKW values in literature for U.S. sorghum hybrids.
- Average U.S. Aggregate TKW in 2016 was higher than in 2015 (26.30 g).
- U.S. Aggregate TKW standard deviation in 2016 (2.15 g) was slightly greater than in 2015 (2.00).
- TKW range in 2016 (19.30 to 37.13 g) was greater than in 2015 (19.49 to 34.66 g).
- In the 2016 samples, TKWs were distributed with 24.1% at 30 g or greater, 70.5% between 24 and 29.99 g, and 5.5% less than 24 g.
- The slightly greater average TKW in 2016 for Late Harvest samples (28.30 g) than for Early Harvest samples (27.79 g) generally parallels the slightly higher test weight average in 2016 for Late Harvest samples than for Early Harvest samples.



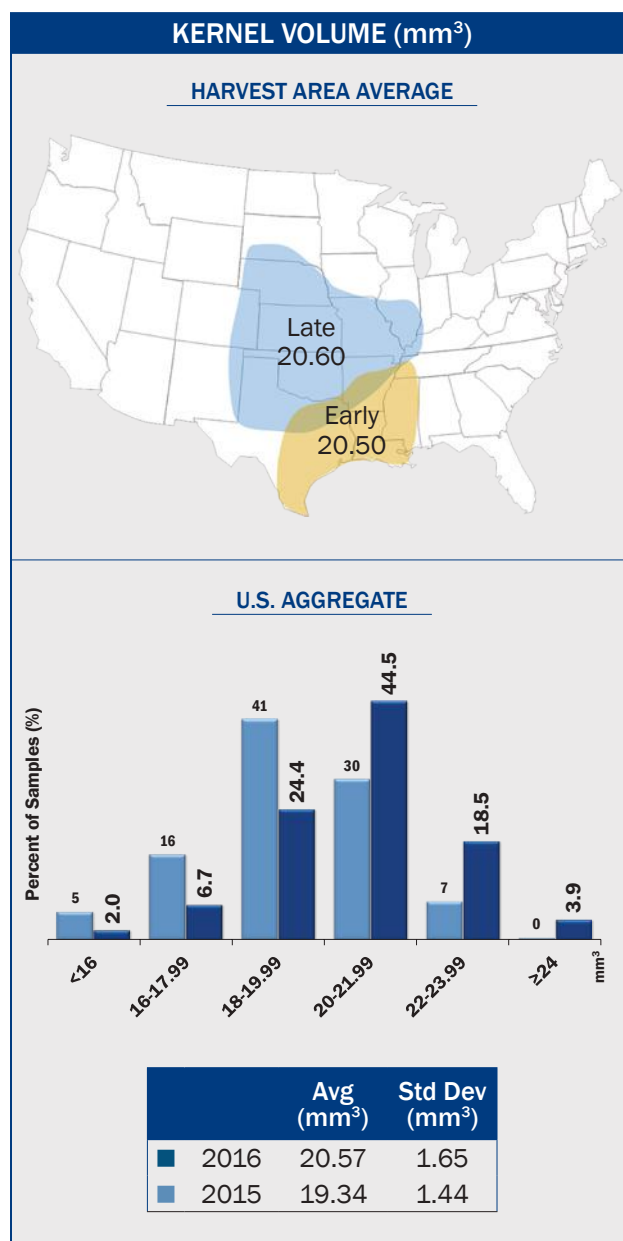
Kernel Volume

Kernel volume (or size), reported in mm^3 , is directly related to kernel diameter and is often indicative of growing conditions. If conditions are dry, kernels may be small due to stunted development. If drought hits later in the season, kernels may have lower fill.

Small kernels are more difficult to handle and, due to their having a greater surface-area-to-volume ratio than large kernels, greater amounts of endosperm are removed during decortication, reducing yield of endosperm-derived products.

Results

- Kernel volume averaged 20.57 mm^3 for U.S. Aggregate samples in 2016, a value within a recognized range of values reported in literature for any commercial sorghum hybrid sample.
- Average U.S. Aggregate average kernel volume in 2016 was greater than 2015 (19.34 mm^3), confirming larger-sized kernels in 2016 than in 2015.
- The 2016 U.S. Aggregate kernel volume standard deviation (1.65 mm^3) was greater than 2015 (1.44 mm^3).
- Kernel volume range in 2016 (13.51 to 26.97 mm^3) was greater than in 2015 (14.31 to 25.40 mm^3).
- In the 2016 samples, kernel volumes were distributed with 8.7% less than 18 mm^3 , 68.9% between 18 and 21.99 mm^3 , and 22.4% equal to or greater than 22 mm^3 .
- The average kernel volume for Late Harvest samples (20.60 mm^3) was slightly higher than the average for Early Harvest samples (20.50 mm^3) in 2016. Average kernel volume was also higher for Late Harvest samples than Early Harvest samples in 2015.



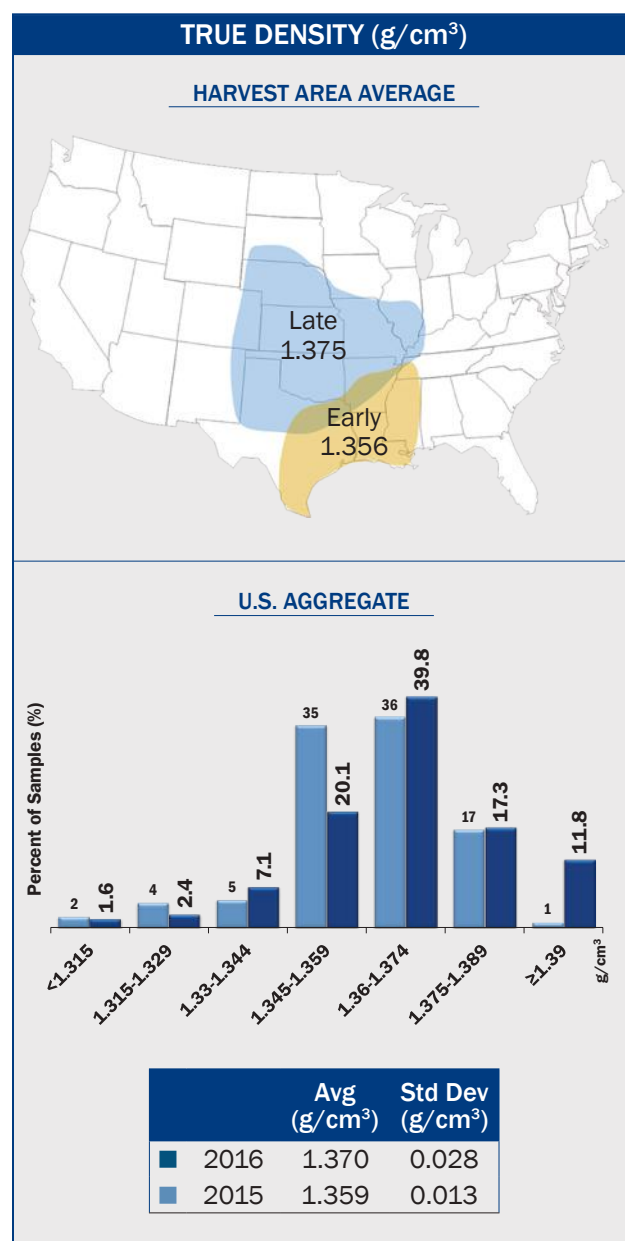
Kernel True Density

Kernel true density (kernel weight per kernel volume, reported as g/cm³) is a relative indicator of kernel hardness, which is useful during size reduction operations. Genetics of the sorghum hybrid and the growing environment affect kernel true density. Sorghum with higher density is typically less susceptible to breakage in handling than lower-density sorghum.

Most sorghum used for feed has true density values ranging from 1.330 to 1.400 g/cm³. Sorghum with density greater than 1.315 g/cm³ is judged suitable for processing to brewers' grits and stiff porridge, whereas sorghum with density less than 1.315 g/cm³ is suitable for processing into soft bread flour and starch.

Results

- U.S. Aggregate kernel true density averaged 1.370 g/cm³ in 2016, which falls within a recognized range of kernel true density values in literature for U.S. sorghum hybrids.
- Average U.S. Aggregate kernel true density in 2016 was higher than 2015 (1.359 g/cm³), indicating that, on average, kernels from the 2016 crop weighed more than similarly-sized kernels from the 2015 crop.
- The U.S. Aggregate true density standard deviation in 2016 (0.028 g/cm³) was greater than in 2015 (0.013 g/cm³).
- True density range in 2016 (1.208 to 1.522 g/cm³) was greater than in 2015 (1.295 to 1.402 g/cm³).
- In the 2016 samples, kernel true densities were distributed with 1.6% below 1.315 g/cm³, 2.4% between 1.315 and 1.329 g/cm³, 7.1% between 1.330 and 1.344 g/cm³, and 89.0% at 1.345 g/cm³ and above.
- The greater average true densities for Late Harvest samples (1.375 g/cm³) than for Early Harvest samples (1.356 g/cm³) in 2016 generally corresponds to the higher test weight and protein averages for Late Harvest samples than Early Harvest samples in 2016.



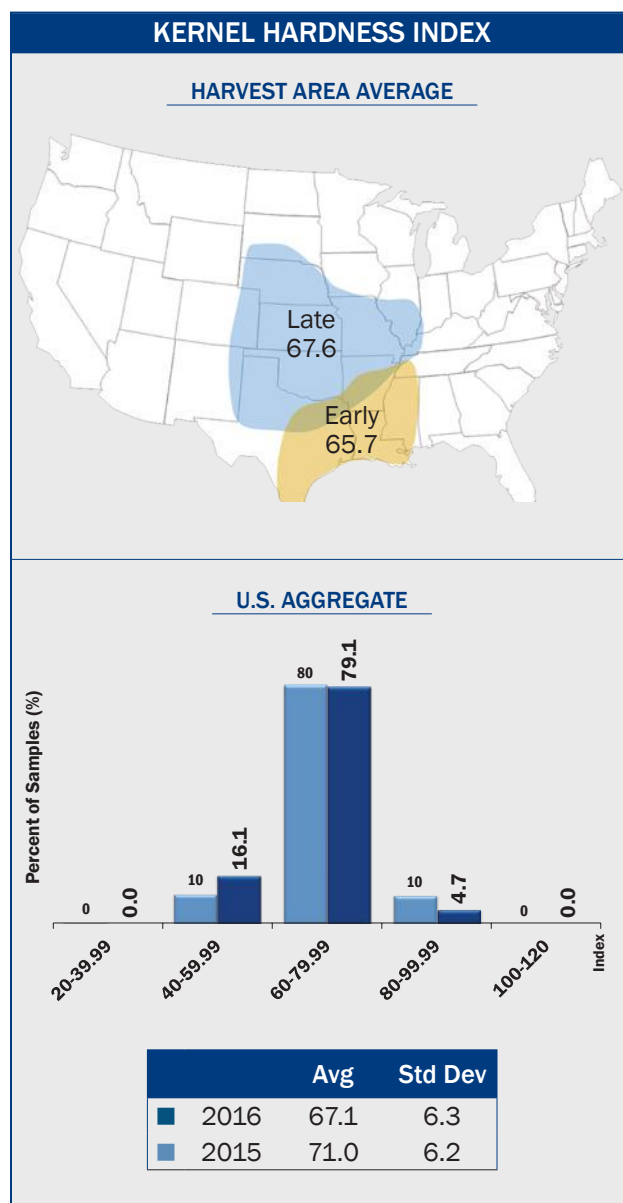
Kernel Hardness Index

Kernel hardness affects resistance to molds and insects, size reduction behavior, and the end use of sorghum. Sieving behavior, size reduction energy consumption, particle size distribution of ground material, and yield of kernel components depend on hardness. Harder sorghum not only produces coarser or larger particles than softer sorghum; it also requires more energy per mass of sorghum to

achieve similar particle size distribution during size reduction. As a result, grinding/milling for optimum particle size for livestock or poultry feed may be costlier for harder sorghum than for softer sorghum. Test weight and kernel density correlate with hardness. Kernel hardness index is a dimensionless number, with increasing value indicating kernels increasing in physical hardness.

Results

- Kernel hardness index averaged 67.1 for U.S. Aggregate samples in 2016, a value within a recognized range of kernel hardness index values in literature for U.S. commercial sorghum hybrids.
- Average U.S. Aggregate kernel hardness index in 2016 was less than 2015 (71.0), indicating slightly softer kernels in 2016 compared to 2015.
- The U.S. Aggregate kernel hardness index standard deviation in 2016 (6.3) was about the same as in 2015 (6.2).
- Kernel hardness index range in 2016 (41.7 to 88.2) was less than in 2015 (37.1 to 91.5).
- In the 2016 samples, kernel hardness indices were distributed so that 4.7% of the samples had kernel hardness indices of 80 or greater, 95.2% had 40 to 79.99, and none had less than 40.
- The slightly greater average kernel hardness index for Late Harvest samples (67.6) than for Early Harvest samples (65.7) in 2016 and 2015 generally parallels a higher test weight average for Late Harvest samples than Early Harvest samples in 2016 and 2015.



SUMMARY: PHYSICAL FACTORS

2016 Harvest						2015 Harvest		
	No. of Samples	Avg.	Std. Dev.	Min.	Max.	No. of Samples	Avg.	Std. Dev.
U.S. Aggregate						U.S. Aggregate		
Kernel Diameter (mm)	254	2.61	0.10	2.20	3.01	207	2.53*	0.09
TKW (g)	254	28.17	2.15	19.30	37.13	207	26.30*	2.00
Kernel Volume (mm ³)	254	20.57	1.65	13.51	26.97	207	19.34*	1.44
True Density (g/cm ³)	254	1.370	0.028	1.208	1.522	207	1.359*	0.013
Kernel Hardness Index	254	67.1	6.3	41.7	88.2	207	71.0*	6.2
Early Harvest						Early Harvest		
Kernel Diameter (mm)	56	2.60	0.06	2.38	2.76	50	2.54*	0.10
TKW (g)	56	27.79	1.71	20.28	32.02	50	25.97*	2.32
Kernel Volume (mm ³)	56	20.50	1.26	14.88	23.36	50	19.22*	1.61
True Density (g/cm ³)	56	1.356	0.019	1.312	1.487	50	1.350*	0.015
Kernel Hardness Index	56	65.7	5.5	41.7	79.0	50	68.5*	6.9
Late Harvest						Late Harvest		
Kernel Diameter (mm)	198	2.62	0.11	2.20	3.01	157	2.53*	0.09
TKW (g)	198	28.30	2.31	19.30	37.13	157	26.46*	1.84
Kernel Volume (mm ³)	198	20.60	1.79	13.51	26.97	157	19.40*	1.36
True Density (g/cm ³)	198	1.375	0.032	1.208	1.522	157	1.364*	0.012
Kernel Hardness Index	198	67.6	6.6	46.0	88.2	157	72.3*	5.9

*Indicates averages in 2015 were significantly different from 2016, based on a 2-tailed t-test at a 95% level of significance.



E. MYCOTOXINS

Mycotoxins are toxic compounds produced by fungi that occur naturally in grains. When consumed at elevated levels, mycotoxins may cause sickness in humans and animals. While several mycotoxins have been found in sorghum and other grains, aflatoxins and DON (deoxynivalenol or vomitoxin) are considered to be two of the important mycotoxins.

As in the previous *Sorghum Harvest and Export Cargo Quality Report*, the 2016 samples were tested for aflatoxins and DON for this year's report. Since the production of mycotoxins is heavily influenced by growing conditions, the objective of the *Sorghum Harvest Quality Report* is strictly to report on instances when aflatoxins or DON are detected in the sorghum crop at harvest. No specific levels of the mycotoxins are reported.

The *Harvest Report* review of mycotoxins is NOT intended to predict the presence or level at which mycotoxins might appear in U.S. sorghum exports. Due to the multiple stages of the U.S. grain merchandising channel and the laws and regulations guiding the industry, the levels at which mycotoxins appear in sorghum exports are less than what might first appear in the sorghum as it comes out of the field. In addition, this report is not meant to imply that this assessment will capture all the instances of mycotoxins across all of the top sorghum-producing states surveyed. The *Harvest Report's* results should be used only as one indicator of the potential for mycotoxin presence in the sorghum as the crop comes out of the field.



Assessing the Presence of Aflatoxins and DON

At least 25% of the minimum number of samples (250) across the sampling area was proportionately collected and tested to assess the impact of the 2016 growing conditions on total aflatoxins and DON development in the U.S. sorghum crop. The sampling criteria, described in the “Survey and Statistical Analysis Methods” section, resulted in a total number of 75 samples tested for mycotoxins.

A threshold established by the U.S. Department of Agriculture (USDA) Federal Grain Inspection Service (FGIS) as the “Lower Conformance Level” (LCL) was

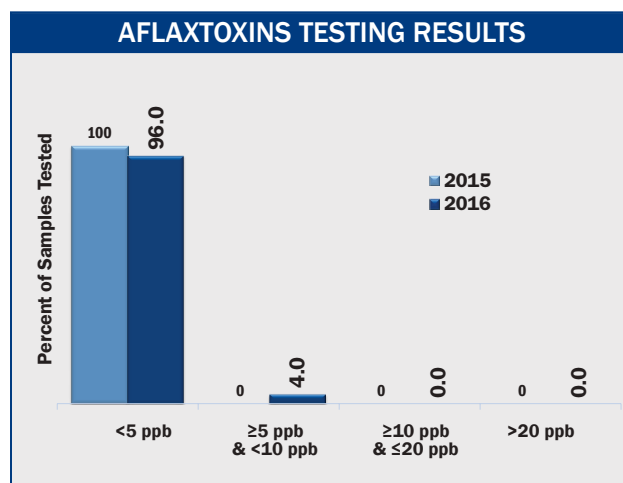
used to determine whether or not a detectable level of the mycotoxin appeared in the sample. The LCLs for the analytical kits approved by FGIS and used for this 2016/2017 report were 5.0 parts per billion (ppb) for aflatoxins and 0.5 parts per million (ppm) for DON. The FGIS LCL was higher than the Limit of Detection (LOD) specified by the kit manufacturer of 2.0 ppb and 0.1 ppm for aflatoxin and DON, respectively. Details on the testing methodology employed in this study for the mycotoxins are in the “Testing Analysis Methods” section.

Results: Aflatoxins

A total of 75 samples were analyzed for aflatoxins in 2016. Results of the *2016/2017 Harvest Report* are as follows:

- Seventy-two samples (72), or 96.0% of the 75 survey samples, had no detectable levels of aflatoxins (below the FGIS LCL of 5.0 ppb). This is below the percentage in 2015, where 100% of the samples tested had no detectable levels of aflatoxins.
- Three samples (3), or 4.0% of the 75 samples, showed aflatoxin levels greater than the LCL of 5.0 ppb, but less than or equal to 10 ppb.
- No samples (0), or 0.0% of the 75 samples, showed aflatoxin levels greater than 10 ppb, but less than or equal to the Food and Drug Administration (FDA) action level of 20 ppb.
- No samples (0), or 0.0% of the 75 samples, showed aflatoxin levels greater than the FDA action level of 20 ppb.

While the 2016 crop season had a slightly lower percentage of samples below the FGIS LCL of 5.0 than 2015, the high percentage of samples testing below the LCL indicated that the contamination level in the domestic crop was negligible. This may have been due, in part, to favorable weather conditions in 2016 (see the “Crop and Weather Conditions” section for more information on the 2016 growing conditions). Most of the growing area received ample moisture and experienced close-to-normal temperatures during pollination and grain-fill in 2016, and as a result, the plants were not under stress.

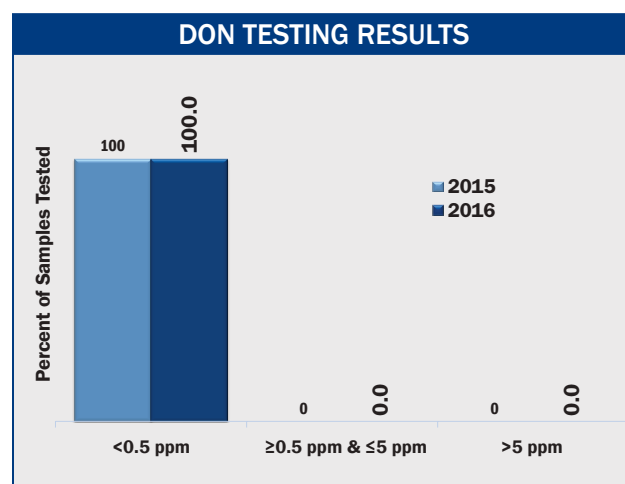


Results: DON (Deoxynivalenol or Vomitoxin)

A total of 75 samples were analyzed collectively for DON in 2016. Results of the 2016 survey are shown below:

- All seventy-five (75) samples, or 100.0% of the 75 survey samples, had no detectable levels of DON (all samples tested less than or equal to the FGIS LCL of 0.5 ppm). This is the same as the percentage in 2015, where 100% of the samples tested had no detectable levels of DON.
- No samples (0), or 0.0% of the 75 samples, tested greater than 0.5 ppm, but less than or equal to the FDA advisory level of 5 ppm.
- No samples (0), or 0.0% of the 75 samples, tested greater than the FDA advisory level of 5 ppm.

The fact that all survey samples tested below the FGIS LCL threshold of 0.5 ppm showed that the DON contamination level in the domestic crop was minimal. This may have been due, in part, to weather conditions that were not conducive to DON development in 2016 (see the “Crop and Weather Conditions” section for more information on the 2016 growing conditions).



Background: General

The levels at which the fungi produce the mycotoxins are impacted by the fungus type and the environmental conditions under which the sorghum is produced and stored. Because of these differences, mycotoxin production varies across the U.S. sorghum-producing areas and across years. In some years, the growing conditions across the sorghum-producing regions might not produce elevated levels of any mycotoxins. In other years, the environmental conditions in a particular area might be conducive to production of a particular mycotoxin to levels that impact the sorghum's use for human and livestock consumption. Humans and livestock are sensitive to mycotoxins at varying levels. As a result, the FDA has issued action levels for aflatoxins and advisory levels for DON by intended use.

Action levels specify precise limits of contamination above which the agency is prepared to take regulatory action. Action levels are a signal to the industry that the FDA believes it has scientific data to support regulatory and/or court action if a toxin or contami-

nant is present at levels exceeding the action level, if the agency chooses to do so. If import or domestic feed supplements are analyzed in accordance with valid methods and found to exceed applicable action levels, they are considered adulterated and may be seized and removed from interstate commerce by the FDA.

Advisory levels provide guidance to the industry concerning levels of a substance present in food or feed that are believed by the agency to provide an adequate margin of safety to protect human and animal health. While the FDA reserves the right to take regulatory enforcement action, enforcement is not the fundamental purpose of an advisory level.

A source of additional information is the National Grain and Feed Association (NGFA) guidance document titled "FDA Mycotoxin Regulatory Guidance", which can be found at <http://www.ngfa.org/wp-content/uploads/NGFAComplianceGuide-FDARegulatoryGuidanceforMycotoxins8-2011.pdf>.

Background: Aflatoxins

The most important type of mycotoxin associated with sorghum grain is aflatoxin. There are several types of aflatoxin produced by different species of *Aspergillus*, with the most prominent species being *A. flavus*. Growth of the fungus and aflatoxin contamination of grain can occur in the field prior to harvest or in storage. However, contamination prior to harvest is considered to cause most of the problems associated with aflatoxin. *A. flavus* grows well in hot, dry environmental conditions, or where drought occurs over an extended period of time. It can be a serious problem in the southern United States, where hot and dry conditions are more common. The fungus usually attacks only a few kernels on the plant and often penetrates kernels through wounds produced by insects.

There are four types of aflatoxin naturally found in foods – aflatoxins B1, B2, G1, and G2. These four aflatoxins are commonly referred to as "aflatoxins" or "total aflatoxins." Aflatoxin B1 is the most commonly found aflatoxin in food and feed and is also the most toxic. Research has shown that B1 is a potent, naturally-occurring carcinogen in animals, with a strong link to human cancer incidence. Additionally, dairy cattle metabolize aflatoxin B1 to a different form of aflatoxin called aflatoxin M1, which may accumulate in milk.

Aflatoxins express toxicity in humans and animals primarily by attacking the liver. The toxicity can occur from short-term consumption of very high doses of aflatoxin-contaminated grain or long-term ingestion of low levels of aflatoxins, possibly resulting in death in poultry and ducks, the most sensitive of the

animal species. Livestock may experience reduced feed efficiency or reproduction, and both human and animal immune systems may be suppressed as a result of ingesting aflatoxins.

The FDA has established action levels for aflatoxin M1 in milk intended for human consumption and aflatoxins in human food, grain, and livestock feed (see table below).

The FDA has established additional policies and legal provisions concerning the blending of sorghum with levels of aflatoxins exceeding these threshold

levels. In general, the FDA currently does not permit the blending of sorghum containing aflatoxin with uncontaminated sorghum to reduce the aflatoxin content of the resulting mixture to levels acceptable for use as human food or animal feed.

If required by the buyer, sorghum exported from the United States will be tested for aflatoxins by FGIS. Sorghum above the FDA action level of 20 ppb or the buyer's specification cannot be exported unless other strict conditions are met. These requirements result in relatively low levels of aflatoxins in exported grain.

Aflatoxins Action Level	Criteria
0.5 ppb (Aflatoxin M1)	Milk intended for human consumption
20 ppb	For corn and other grains intended for immature animals (including immature poultry) and for dairy animals, or when the animal's destination is not known
20 ppb	For animal feeds, other than corn or cottonseed meal
100 ppb	For corn and other grains intended for breeding beef cattle, breeding swine, or mature poultry
200 ppb	For corn and other grains intended for finishing swine of 100 pounds or greater
300 ppb	For corn and other grains intended for finishing (i.e., feedlot) beef cattle and for cottonseed meal intended for beef cattle, swine, or poultry

Source: FDA and USDA GIPSA, <http://www.gipsa.usda.gov/Publications/fgis/broch/b-aflatox.pdf>

Background: DON (Deoxynivalenol or Vomitoxin)

DON is another mycotoxin of concern to some importers of sorghum grain. It is produced by certain species of *Fusarium*, the most important of which is *Fusarium graminearum* (*Gibberellazeae*). *Gibberellazeae* can develop when cool or moderate and wet weather occurs at flowering. Mycotoxin contamination of sorghum caused by *Gibberellazeae* is often associated with excessive postponement of harvest and/or storage of high-moisture sorghum.

DON is mostly a concern with monogastric animals, where it may cause irritation of the mouth and throat. As a result, the animals may eventually refuse to eat the DON-contaminated sorghum and may have low weight gain, diarrhea, lethargy, and intestinal hemorrhaging. Additionally, DON may cause suppression of the immune system, resulting in susceptibility to a number of infectious diseases.

The FDA has issued advisory levels for DON. For grain products, the advisory levels are:

- 5 ppm in grains and grain co-products for swine, not to exceed 20% of their diet;
- 10 ppm in grains and grain co-products for chickens and cattle, not to exceed 50% of their diet; and
- 5 ppm in grains and grain co-products for all other animals, not to exceed 40% of their diet.

FGIS is not required to test for DON on sorghum bound for export markets, but will perform either a qualitative or quantitative test for DON at the buyer's request.

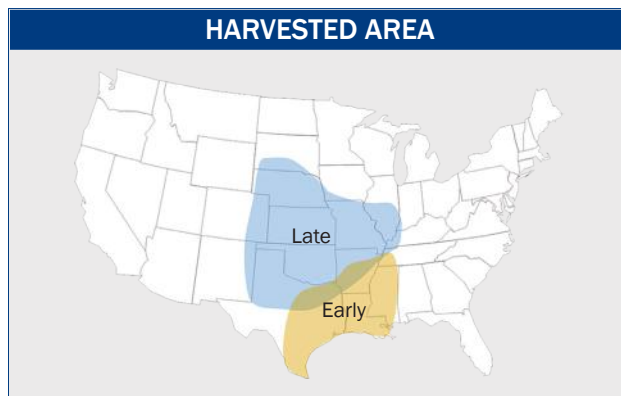
A. 2016 HARVEST HIGHLIGHTS

Weather conditions before and at planting, throughout the growing season, and even during harvest play a major role in the evolution of the sorghum plant and ultimately in the sorghum grain yield and quality. For U.S. sorghum production, two main harvest areas, Early Harvest Area (EHA) and Late Harvest Area (LHA), are highlighted.

For the Early Harvest Area (EHA), the 2016 growing season was on or ahead of schedule for most of the region. Precipitation from the February to April period was above- or much above-average, which imposed a wetter early-growth period (from planting until pollination) compared to the historical period of 1895 to 2016. Wet conditions lingered across the Texas coastal area and east-central portion of the EHA until harvest time, while drier conditions developed within the continental area (to the northwest) during the reproductive phase until harvest. The 2016 sorghum crop condition for the EHA improved until after pollination, but was slightly diminished as the crop approached harvest time.

The following list highlights the key events of the EHA for the 2016 growing season:

- Average temperatures during the early planting time frame (from February until April) were above the historical average (2 degrees Fahrenheit higher than the average for the 1981-2010 period), providing warm temperatures for rapid emergence conditions.
- Moving from the western to the eastern part of the EHA, above-average and much above-average moisture conditions increased during the early planting period (making the period the wettest on record in these areas) and continued until harvest in several areas.
- Excessive precipitation produced above-average moisture conditions, specifically for the central part of Texas, impacting yield and harvest.



- Pollination and reproductive periods experienced near-average temperatures, promoting a normal crop development and setting up the crop for high yield potential.

For the Late Harvest Area (LHA), the 2016 growing season started near-average, compared to the 2015 season. However, planting in May was slightly delayed due to wet conditions and temperatures above the historical temperature average (1985–2016). The 2016 sorghum crop condition for the LHA remained fairly constant from early emergence until harvest (June to October), with more than 70% of the crop having achieved a Good or Excellent condition rating¹.

The following list highlights the key events of the LHA for the 2016 growing season:

- Warm temperatures were recorded during planting (from May until June), 2 degrees Fahrenheit above the historical average for 1986 to 2016, speeding up the emergence of the crop.
- Heavy precipitation, specifically during the month of May, affected planting and delayed early-season crop growth progress.
- Pollination was characterized by wet moisture conditions and near-average temperatures, which created favorable conditions for floret fertility and grain formation.

¹A 'Good' rating means that yield prospects are normal, moisture levels are adequate, and disease, insect damage, and weed pressures are minor. An 'Excellent' rating means that yield prospects are above normal, and the crop is experiencing little or no stress. Disease, insect damage, and weed pressures are insignificant.



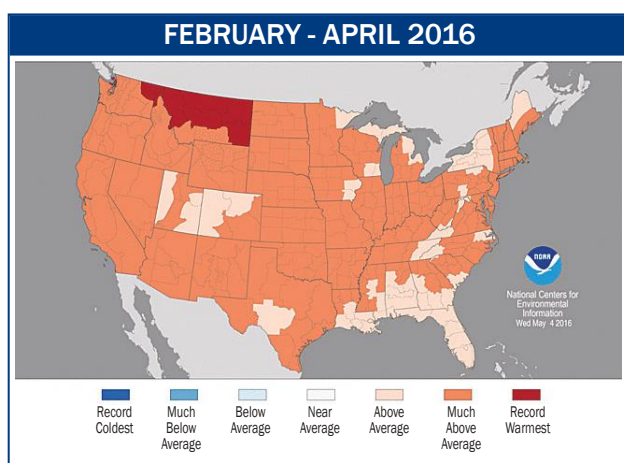
- Above-average temperatures in the Texas Panhandle (from July until August) potentially impacted maximum yield on irrigated areas. However, temperatures for pollination and grain-filling in areas further north during September were near- or slightly above-average, and had good conditions for the yield components of grain numbers and grain size.

- Warm temperatures during harvest time (4-6 degrees Fahrenheit higher than the average for the 1981-2010 period) accelerated maturity, natural drying, and harvest during October.

The following sections describe how the 2016 growing season weather impacted sorghum development and yield for both the EHA and LHA in the U.S. sorghum production regions.

DIVISIONAL AVERAGE TEMPERATURE RANKS

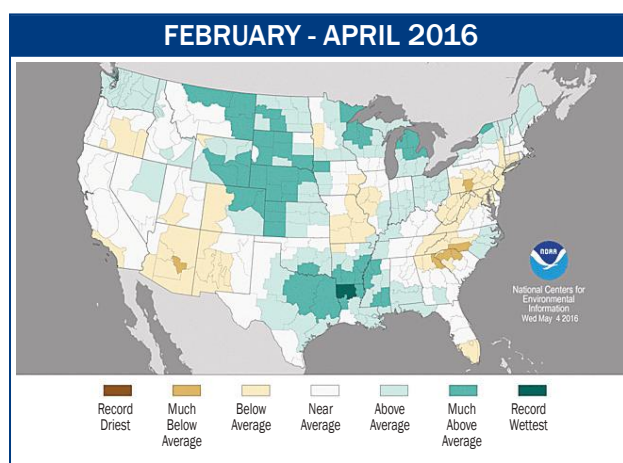
(Period: 1895-2016)



Source: Regional Climate Centers

DIVISIONAL PRECIPITATION RANKS

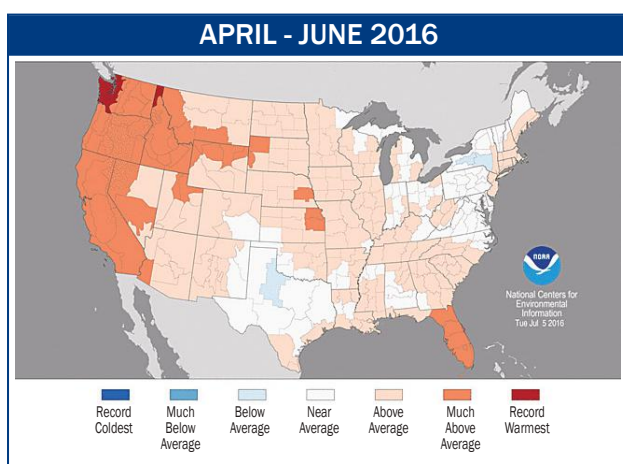
(Period: 1895-2016)



Source: Regional Climate Centers

DIVISIONAL AVERAGE TEMPERATURE RANKS

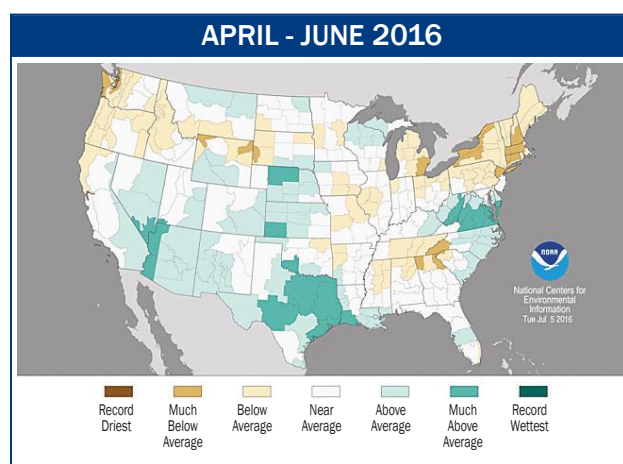
(Period: 1895-2016)



Source: Regional Climate Centers

DIVISIONAL PRECIPITATION RANKS

(Period: 1895-2016)



Source: Regional Climate Centers

B. PLANTING AND EARLY GROWTH CONDITIONS

Near- to above-average precipitation and temperature did not affect planting progress

Weather (i.e., temperature, solar radiation, precipitation) and environmental factors present a complex interaction with the genotype (sorghum hybrids) and management practices used in sorghum production (i.e., timing of planting, soil fertility, pesticide applications). These factors – weather and environment, genotype, and management practices – are referred to as the “G x E x M” interaction. Grain yield in sorghum is a function of the number of plants per acre, number of tillers² per plant, number of grains per head, and final seed weight per individual grain. Ultimately, potential sorghum yield depends on the influence of the G x E x M components on all the yield factors previously noted.

As general guidelines, wet and cool planting conditions can decrease uniformity, delay emergence, or hinder early plant growth, which may result in a lower number of plants and/or lower yields per area. Sorghum can compensate for small stand reductions via tillering capacity. The tillering capacity will also be affected by the G x E x M interaction. The genotype selected will set the genetic potential for that plant to produce tillers. The environment’s availability of resources (with/without stress conditions) will impact the plant’s growth. Lastly, management practices that can promote tillering, such as wide-row spacing, lower seeding rate, and better nutrition, will also impact the plant’s development. Optimal moisture and warmer conditions than normal early in the growing season are beneficial for proper root establishment and plant-to-plant uniformity. This is because these conditions promote the development of deeper root systems for adequate anchorage and sustain continuous access to water and nutrients during the growing season.

Early Harvest Area (EHA)

Overall, early planting conditions from February to April in the EHA were impacted by relatively above-normal temperatures and above-normal precipitation. Moving from west to east across the EHA, precipitation ranged from 5 to more than 20 inches in the spring. Planting was ahead of or near the average, with a slight delay in planting progress in April, when compared to the average for the 2011-2015 period.

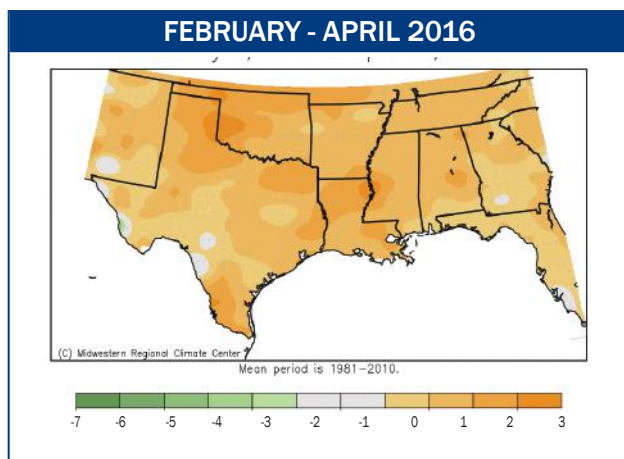
Late Harvest Area (LHA)

Planting progress started near-average, with a slight delay during the month of May, which was caused by excess precipitation experienced in many areas across the region. The 2016 LHA planting season spanned from April until July, with the largest planting progress made between late May to late June. Overall, the crop condition remained fairly constant from early planting until harvest time (more than 70% in Good or Excellent crop condition).

²Tillers are stems smaller than the main plant stalk that can also develop fertile heads.

AVERAGE TEMPERATURE (°F): DEPARTURE FROM MEAN

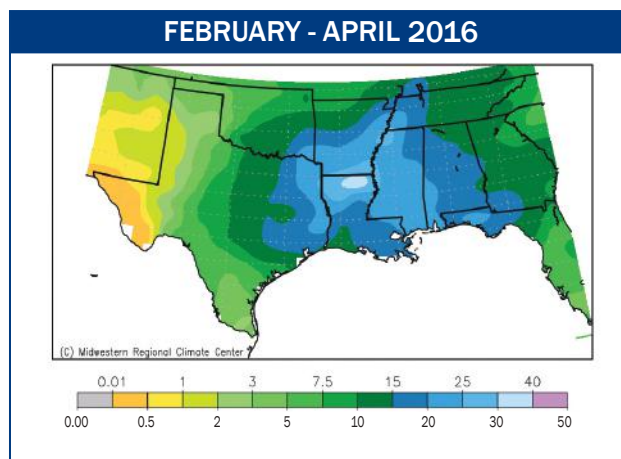
(Period: 1895-2016)



Source: Midwestern Regional Climate Centers

ACCUMULATED PRECIPITATION (in)

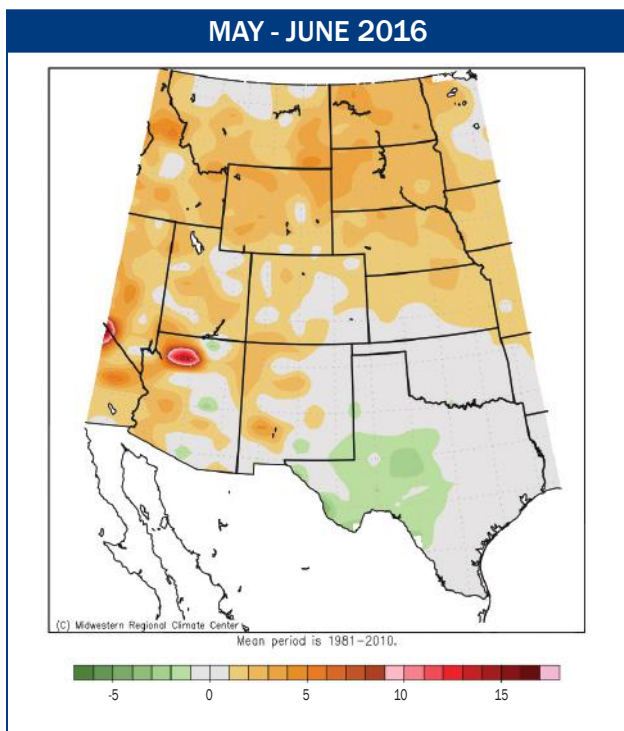
(Period: 1895-2016)



Source: Midwestern Regional Climate Centers

AVERAGE TEMPERATURE (°F): DEPARTURE FROM MEAN

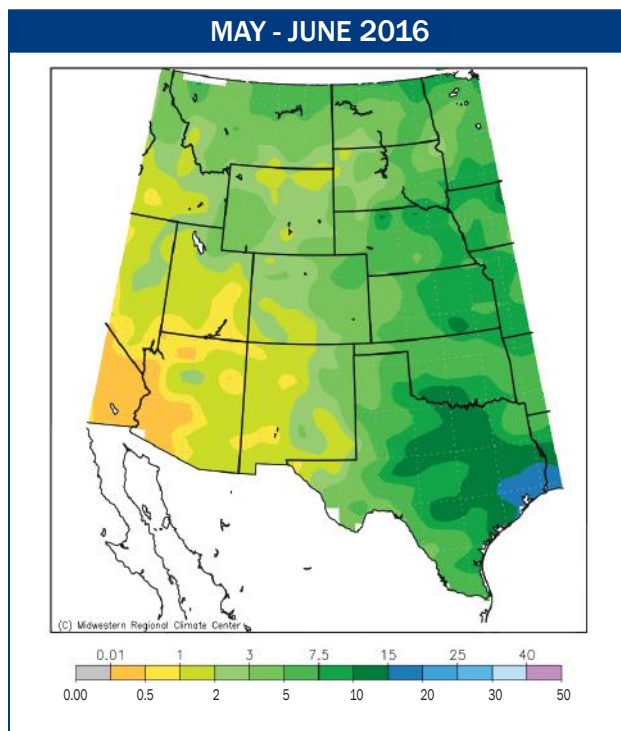
(Period: 1895-2016)



Source: Midwestern Regional Climate Centers

ACCUMULATED PRECIPITATION (in)

(Period: 1895-2016)



Source: Midwestern Regional Climate Centers

C. LATE VEGETATIVE AND POLLINATION CONDITIONS

Wet conditions and near- or slightly above-average temperatures favored pollination

Total time from emergence to pollination depends on the planting date, weather conditions for this period (temperature and precipitation), and the sorghum hybrid. High temperature stress after growing point differentiation (approximately 30 days after emergence) delays heading³ and decreases seed set (number and size of seeds), affecting final yields. Delayed planting may result in delayed pollination. If pollination occurs later than normal during the growing season, it increases the likelihood of the crop being exposed to excessive heat at blooming, which could jeopardize yields and final grain numbers. Temperatures below 40° F during grain-fill can negatively impact the ability of the plant to fill the grains, thus affecting final yields. Hybrid selection also affects the length of time from planting until mid-pollination; short-season hybrids have a shorter time from emergence to flowering than the full-season hybrids, and therefore have lower yield potential compared to the full-season hybrids.

Early Harvest Area (EHA)

Sorghum heading in the EHA was concentrated from late-June to early-August, the time during which the most heading progress was made. Wetter than normal conditions and near-average temperatures dominated the vegetative period until pollination time. Excess precipitation in some areas may have challenged tiller production and slowed plant growth, consequently reducing nutrient uptake and impacting potential yield. In addition, heading progress was

slightly delayed during July, compared to the average for the 2011-2015 period. However, the cool temperatures favored the blooming process, resulting in low probability of grain abortion. While normal or slightly above-average temperatures occurred during the grain-fill period, the main challenge for sorghum's production environment was related to the wet conditions at the end of the season.

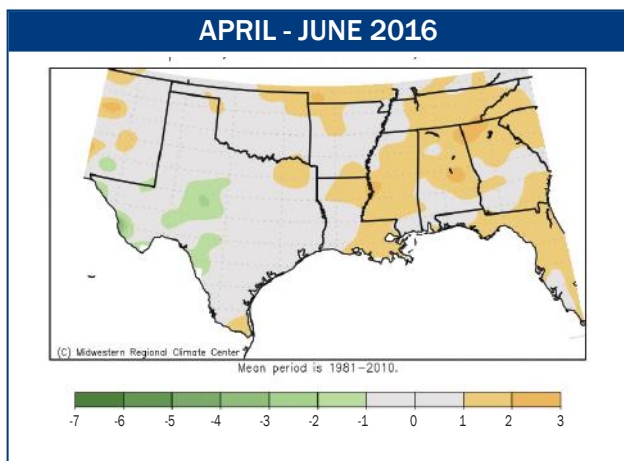
Late Harvest Area (LHA)

Sorghum heading for the LHA spanned from early-August to early-October, with more than 50% of the LHA crop heading during the month of September. For the northern section of this area, if flowering took place in early- to mid-September, the probability of reaching maturity before the first freeze was lowered because of the lack of accumulation of growing degree days⁴. Conditions for the late vegetative heading phase remained wet, but with average temperatures. These conditions favored the pollination time and the early phase of grain-filling, which in turn, positively impacted potential seed size. Across the LHA region, the grain-fill period went from a wet to dry moisture condition, and experienced normal to slightly above-average temperatures. The impact of the warmer temperatures on yields varied, depending on the timing of the crop development; late-planted crops had a shorter grain-fill period than the early-planted crops.

³Heading, the process in which sorghum heads are exerted and visible on the plant tops, occurs after boot stage and before flowering.

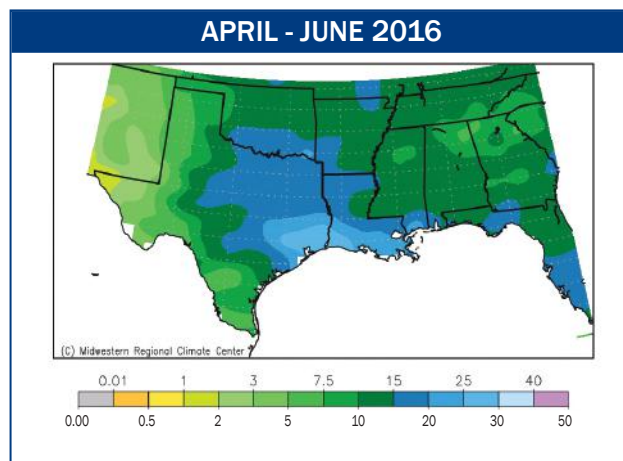
⁴Growing degree days is a parameter related to heat accumulation in order to predict plant development stages.

**AVERAGE TEMPERATURE (°F):
DEPARTURE FROM MEAN**
(Period: 1895-2016)



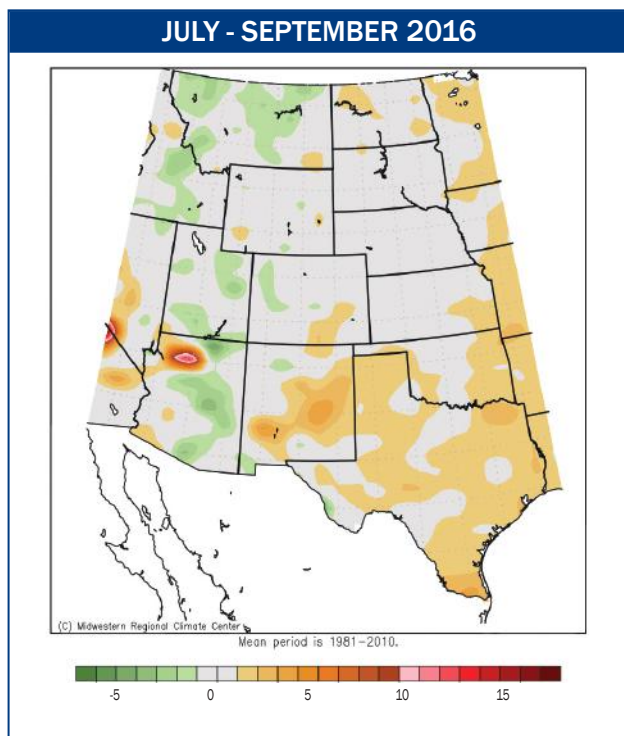
Source: Midwestern Regional Climate Centers

ACCUMULATED PRECIPITATION (in)
(Period: 1895-2016)



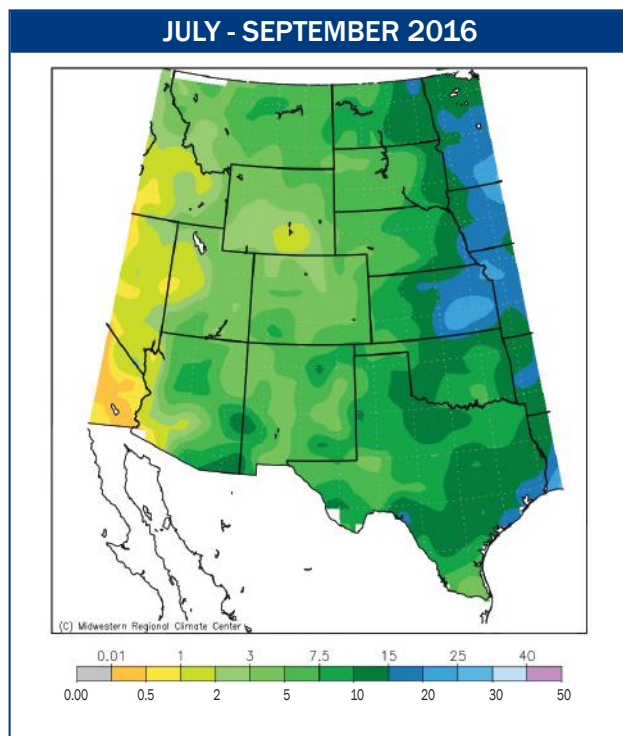
Source: Midwestern Regional Climate Centers

**AVERAGE TEMPERATURE (°F):
DEPARTURE FROM MEAN**
(Period: 1895-2016)



Source: Midwestern Regional Climate Centers

ACCUMULATED PRECIPITATION (in)
(Period: 1895-2016)



Source: Midwestern Regional Climate Centers

D. MATURITY AND HARVEST CONDITIONS

Wet conditions and near- or slightly above-average temperatures favored harvest

When the sorghum plant reaches physiological maturity (or black layer), the grain achieves its final maximum dry mass and nutrient content. Prior to reaching the black layer stage, freezing temperatures could lower test weight (through small seeds), impede final maturity, and consequently reduce yields. Once maturity has been reached and until harvest time, sorghum grain will dry down from about 35% to around 20% moisture. The dry down rate is influenced by hybrid maturity, grain moisture at the beginning of dry down, and temperature during the dry-down period. If sorghum does not dry down sufficiently, the higher-moisture grain remains soft and becomes more susceptible to pericarp breakage, as well as becomes more difficult to thresh.

Early Harvest Area (EHA)

The majority of EHA sorghum was harvested by the end of August. From late-June to early-August, harvest progress was 20% above average for the 2016 growing season compared to the average of the 2011-2015 period. Overall, the 2016 growing season was ahead of or near the average for the 2011-2015 period for planting, heading, and harvesting. The main weather factor for this season was the constant wet conditions extending from planting to harvest. The wet conditions were excessive in some specific areas, affecting growth and crop yield potential. For this area, freeze has not been an issue. The main production issue for the EHA in 2016 was the sugarcane aphid (*Melanaphis sacchari*), which infested and damaged some of the crop. The infestation of this pest can impact plant health, final grain number and seed weight, and consequently yield and grain quality. Data are still being collected to understand the main effects of this pest on sorghum yield and quality.

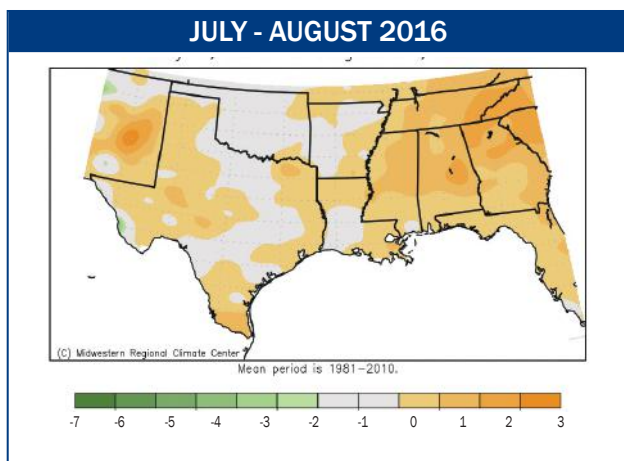
Late Harvest Area (LHA)

While the greatest LHA harvest progress was from late-September to early-November, close to 80% of the LHA sorghum crop was harvested by late-October. Harvest progress in 2016 was slightly ahead of the average for the 2011-2015 period. Similar to the EHA, LHA average planting progress for 2016 was close to the average planting progress for the 2011-2015 period. However, heading and harvesting progress in 2016 were ahead of the average for the 2011-2015 period. The main weather factor affecting the 2016 crop in the LHA was the moisture condition, remaining wet from the planting season until well after pollination. Similar to the 2015 season, there was also no widespread early freeze that may have slowed maturity and enabled pericarp-cracked grain or led to harvest and disease issues. In the northern section of the LHA, specific areas may have been affected by early freeze temperatures, and therefore possibly interrupting grain-filling and affecting grain size and quality.

In specific areas across the LHA, the early-season wet conditions created an environment that could have caused poor root establishment and compaction problems. Wet conditions prevailed until late pollination and early grain-filling. During the current growing season, the sugarcane aphid (*Melanaphis sacchari*) impacted sorghum production, primarily from the mid-vegetative to late-reproductive stages, in the Texas Panhandle region and areas in Oklahoma. It also was introduced to new areas by advancing to North Central Kansas. Depending on when this infestation took place, aphids could have impacted yield by affecting the leaf area. The aphids could have also affected yield later in the crop development when seed is set by impacting the number of grains set and their weight, and thus potentially also affecting grain quality. In addition, sooty mold fungal disease was encountered in some plants affected by the aphids, consequently reducing yield and quality.

AVERAGE TEMPERATURE (°F): DEPARTURE FROM MEAN

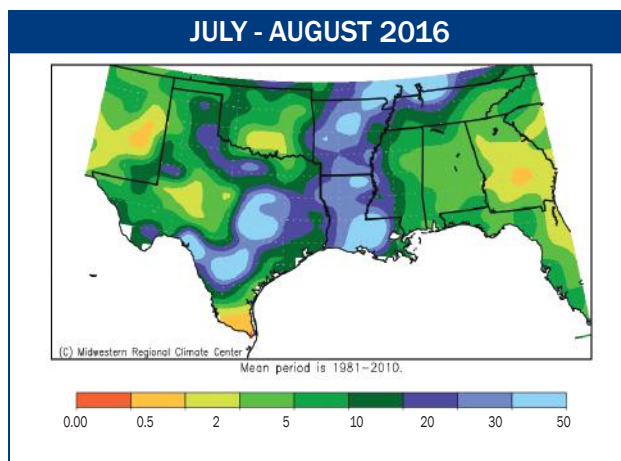
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Source: Midwestern Regional Climate Centers

ACCUMULATED PRECIPITATION: PERCENT OF MEAN

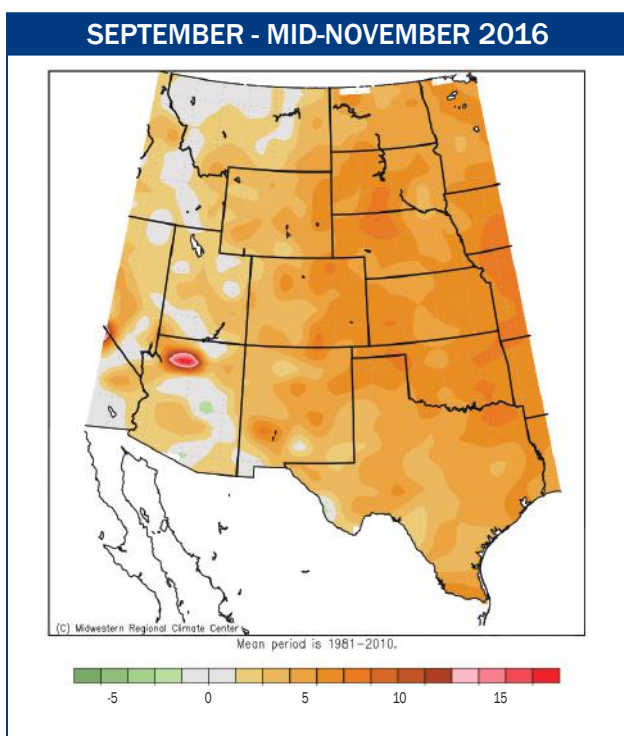
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Source: Midwestern Regional Climate Centers

AVERAGE TEMPERATURE (°F): DEPARTURE FROM MEAN

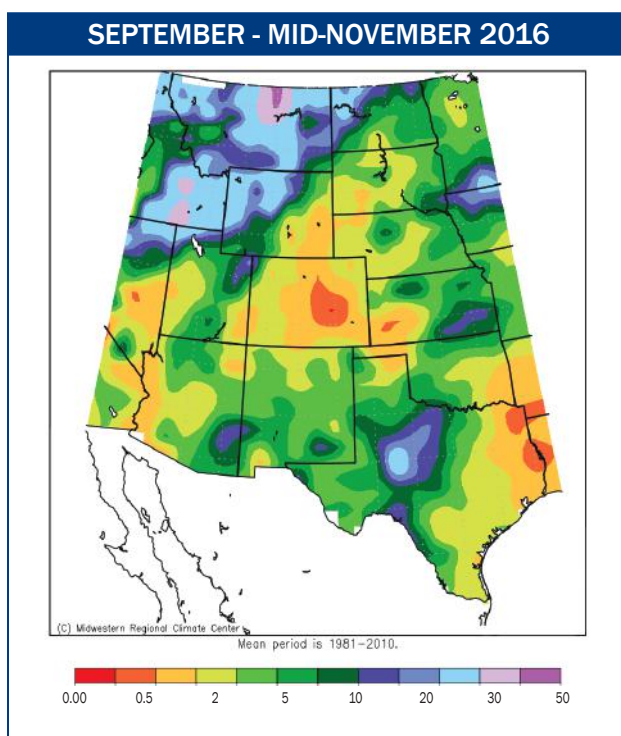
(Period: 1895-2016)



Source: Midwestern Regional Climate Centers

ACCUMULATED PRECIPITATION: PERCENT OF MEAN

(Period: 1895-2016)



Source: Midwestern Regional Climate Centers

E. COMPARISON OF 2016 TO 2015 AND 2011-2015

2016 was ahead on planting, heading, and harvesting

Early Harvest Area (EHA)

While the average 50% planting progress milestone was around early-April in the 2015 season, producers in the EHA reached 50% planting progress about one month earlier in 2016 (mid-March). The 2016 planting progress was similar to the average planting progress recorded for the 2011-2015 period. Planting progress by mid-April in 2016 (80%) was 30% ahead of the 2015 season (50%).

Despite the early-season precipitation slowing plant growth, the 50% heading progress threshold for the 2016 season (mid-July) was ahead by approximately three weeks compared to the 2015 season (early-August). Heading progress for the 2016 season was similar to the average for the 2011-2015 period.

From the late reproductive phase until harvest, wet and warmer grain-fill conditions improved the crop. Harvest progress for the 2016 EHA was two weeks ahead of the average of the 2011-2015 period, until 80% of the crop was harvested by the end of August. For the EHA, freeze events were not of concern for reducing yields and impacting grain quality.

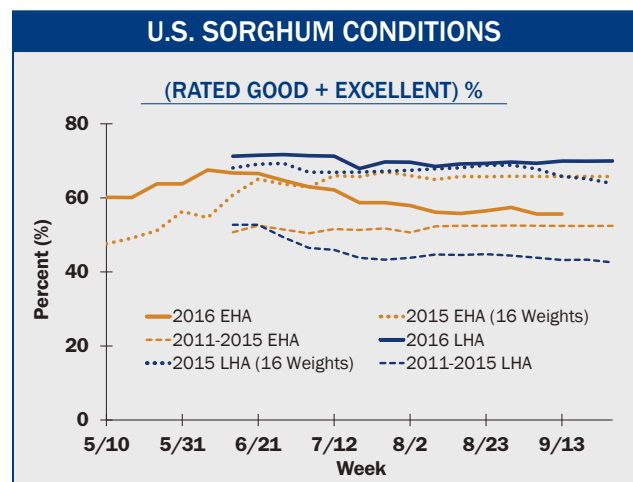
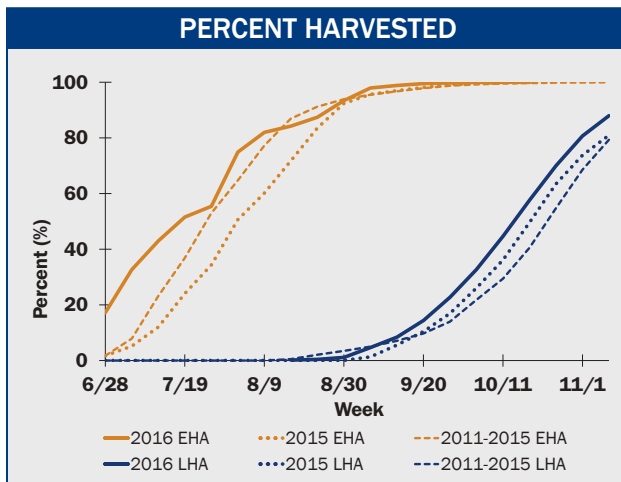
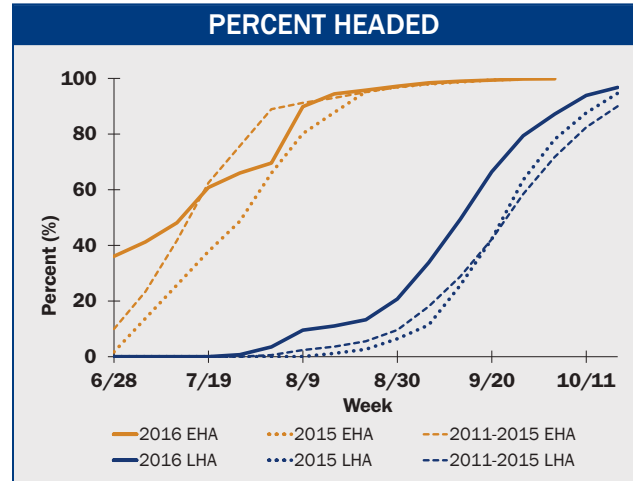
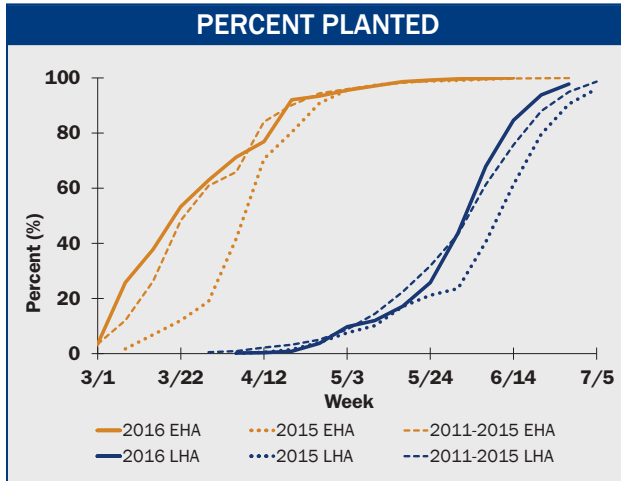
Throughout much of the 2016 season, the sorghum crop in the EHA had a steady Good or Excellent crop condition rating that varied around 60%. The average rating improved until the crop reached the heading phase and then declined below a 60% rating of Good or Excellent. This rating reflected the challenges in sorghum production experienced early in the 2016 growing season, including wet early-season conditions, which affected plant growth and yield potential. The lowered crop rating also reflected the wet conditions that extended late into the season and pest infestation, both of which affected yield.

Late Harvest Area (LHA)

In 2016, sorghum producers experienced similar conditions to the 2015 season up until late May. After this point, farmers made steady progress, moving from 20% to 80% planted progress in only three weeks (until mid-June). This progress quickly outpaced 2015 LHA planting progress. Overall, 2016 planting progress was similar to the average of the 2011-2015 period.

Weather conditions in 2016 favored crop progress from the vegetative stage until heading time. Fifty percent of the 2016 crop was heading in early September, and this progress was approximately two weeks earlier than in 2015 and the average of the 2011-2015 period. From the late reproductive stage until harvest, drier and warmer grain-fill conditions hastened maturity and harvest time, with crop progress for 2016 ahead of 2015 and the average of the 2011-2015 period. Freeze events were of concern for reducing yields in the LHA, but problems were isolated to the north-central and northwestern sections.

The 2016 LHA sorghum crop condition rating was near 70% from early planting until harvest. This crop condition rating implied good plant health, normal vegetative development, and good plant growth. The average crop condition for the 2011-2015 period was at or below 50%, portraying a better season for 2016 relative to the average for the 2011-2015 period. The more favorable sorghum conditions in 2016 than in 2015 were also reflected in the projected slightly higher yields in 2016 than in 2015.

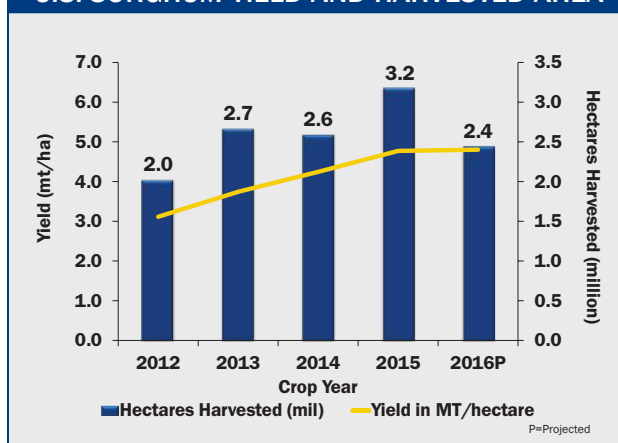


A. U.S. SORGHUM PRODUCTION¹

U.S. Average Production and Yields

- According to the November 2016 U.S. Department of Agriculture (USDA) World Agricultural Supply and Demand Estimates (WASDE) report, average U.S. sorghum yield for the 2016 crop is projected to be 4.80 mt/ha (76.5 bu/ac). This is 0.03 mt/ha (0.5 bu/ac) higher than the average yield of the 2015 sorghum crop, and is the highest average yield on record.
- The number of hectares harvested in 2016 is projected to be 2.4 million (6.0 mil ac). This is 0.8 mil ha (1.9 mil ac) less than in 2015. The projected 2.4 mil ha harvested in 2016 is about the same as the average annual harvested acres since 2003.
- While it is projected to have the highest average yield in history, declines in harvested acres lowers the expected size of the 2016 sorghum crop to 11.7 mmt (462.2 mil bu). This is about 3.5 mmt (134.6 mil bu) lower than 2015, but is the sixth highest since 2000.

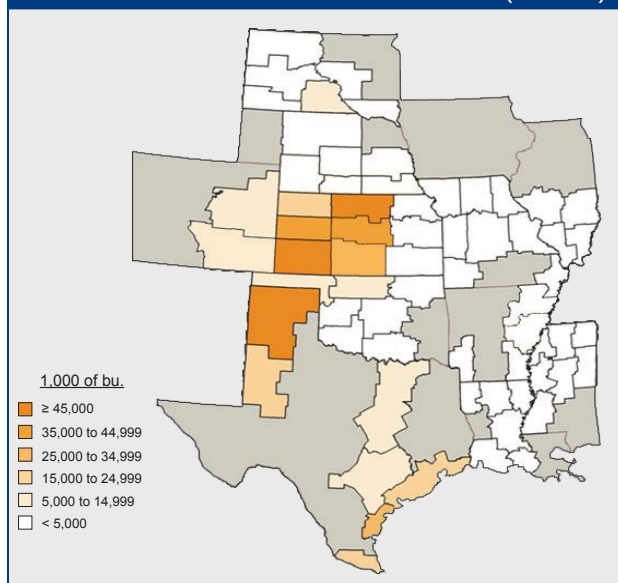
U.S. SORGHUM YIELD AND HARVESTED AREA



ASD and State-Level Production

The geographic areas included in the 2016/2017 *Sorghum Harvest Quality Report* encompass the highest sorghum-producing areas in the United States for the 2016 crop. This can be seen on the map showing projected 2016 sorghum production by USDA Agricultural Statistical District (ASD).

U.S. SORGHUM PRODUCTION BY ASD (2016P)

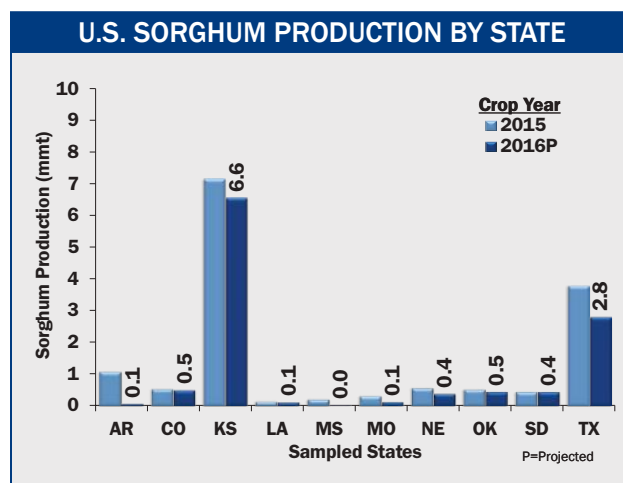


Source: USDA NASS and Centrec Estimates

¹mt - metric ton; mmt - million metric tons; ha - hectare; bu - bushel; mil bu - million bushels; ac - acre.



Relative to the sorghum crop produced in 2015, the decreased size of the 2016 crop was driven by lower production in all key sorghum-producing states.



Source: USDA NASS

The U.S. Sorghum Production table summarizes the differences in both quantity (mmt) and percentages between 2015 and projected 2016 sorghum production for each state. Also included is an indication of the relative changes in harvested acres and yield between 2015 and projected 2016. The green bar indicates a relative increase and the red bar indicates a relative decrease from 2015 to projected 2016. This illustrates that yields marginally increased and harvested acres were slightly lower to lower in ten states. In fact, large decreases in harvested acres (greater than 10%) were experienced in Arkansas, Louisiana, Mississippi, Missouri, Nebraska, Oklahoma, and Texas.

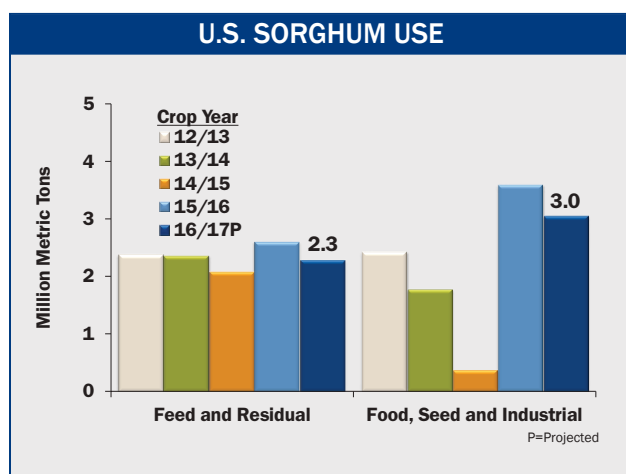
U.S. SORGHUM PRODUCTION						
State	2015	2016P	Difference		Relative % Change*	
			MMT	Percent	Acres	Yield
Arkansas	1.1	0.1	(1.0)	-93%		
Colorado	0.6	0.5	(0.1)	-10%		
Kansas	7.2	6.6	(0.6)	-8%		
Louisiana	0.2	0.1	(0.0)	-23%		
Mississippi	0.2	0.0	(0.2)	-89%		
Missouri	0.3	0.1	(0.2)	-60%		
Nebraska	0.6	0.4	(0.2)	-33%		
Oklahoma	0.5	0.5	(0.1)	-17%		
South Dakota	0.5	0.4	(0.0)	-3%		
Texas	3.8	2.8	(1.0)	-26%		
Total U.S.	15.2	11.7	(3.4)	-23%		

*Green indicates 2016 is higher than 2015 and red indicates 2016 is lower than 2015; bar height indicates the relative amount.

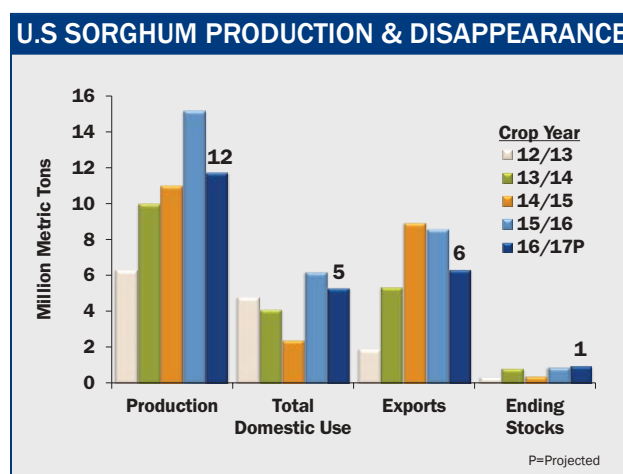
P=Projected, Source: USDA NASS

B. U.S. SORGHUM USE AND ENDING STOCKS

- As a result of Chinese demand, the U.S. exported approximately 8.9 mmt (351.7 mil bu) of sorghum in the 2014/2015 marketing year (MY14/15). This record amount represented more than 80% of the total U.S. sorghum crop. This demand created higher sorghum prices relative to corn prices in many parts of the United States, which in turn led to reduced domestic consumption of sorghum for feed and ethanol usage (reported under “food, seed and industrial use”). While China remained the dominant destination for U.S. sorghum exports worldwide, China’s demand for sorghum softened in MY15/16.
- The amount of sorghum used for food, seed and industrial uses dramatically increased from MY14/15 to MY15/16, because a large crop and reduced export demand in MY15/16 created a greater availability of sorghum for ethanol production.
- Despite the surge in export demand for U.S. sorghum in MY14/15, domestic consumption of sorghum for feed and residual uses remained fairly constant over the past four completed marketing years.
- Ending stocks of sorghum have been rebuilt after hitting their lowest level in 50 years in MY12/13. Tempered sorghum export demand and an ample supply of corn, the crop which is most often substituted with sorghum, have contributed to the rebuilding of sorghum stocks.



Source: USDA WASDE and ERS



Source: USDA WASDE and ERS



C. OUTLOOK

U.S. Outlook

- While the 2016 U.S. sorghum crop is projected to have the highest average yield on record, the forecasted 23.0% reduction in harvested hectares has led to an estimated 22.6% decrease in the size of the 2016 crop.
- Due to the reduced size of the 2016 sorghum crop, both domestic consumption and exports are forecasted to be lower relative to MY15/16. However, the reduction in exports is anticipated to be proportionally greater than the reduction in domestic consumption.
- Domestic use of sorghum is projected to be about 5.3 mmt (14.1%) lower in MY16/17 than in MY15/16. Use for food, seed, and industrial (FSI) uses are expected to be down 15.4% and feed and residual use down 12.5% in MY16/17 from MY15/16.
- U.S. sorghum exports during MY16/17 are projected to be 6.5 mmt (26.2%) lower than MY15/16.
- MY16/17 sorghum ending stocks are projected to be slightly higher than in MY15/16, primarily due to slightly less sorghum export demand and this year's large corn crop, which is often substituted for sorghum.

International Outlook

Global Supply

- Global sorghum production during MY16/17 is expected to be slightly higher than the production of MY 15/16. The largest increases in MY16/17 production from the previous year are expected in Ethiopia, India, Mexico, and Sudan. These four countries are estimated to represent 33.0% of world production in MY16/17.
- Total non-U.S. exports are expected be slightly higher in MY16/17 than in MY15/16, with the largest increase in exports expected from Argentina. This increased volume in non-U.S. exports only represents 1.2% of global sorghum exports. Even after a forecasted decrease in U.S. exports and higher non-U.S. exports, the United States is still the principal supplier of sorghum exports and is forecasted to supply 73.6% of global sorghum exports in MY16/17.

Global Demand

- Total global sorghum use is expected to increase slightly in MY16/17 from MY15/16.
- While China is expected to remain the world's largest sorghum consumer, it is projected to consume less sorghum in MY16/17 than in MY15/16.
- The largest increases in consumption are expected to occur in Ethiopia, India, Mexico, and Sudan, the same four countries projected to have the highest increases in production. Ethiopia, India, and Sudan, which are not major sorghum exporters, utilize the majority of their sorghum crop for human consumption. Mexico, which is expected be the third largest importer of sorghum in MY16/17, utilizes sorghum primarily for feed use.
- Year-over-year imports are expected to decrease globally in MY16/17 from MY15/16, with China responsible for the vast majority of the change.

U.S. SORGHUM SUPPLY AND USAGE SUMMARY BY MARKETING YEAR

Metric Units	12/13	13/14	14/15	15/16	16/17P
Acreage (million hectares)					
Planted	2.5	3.3	2.9	3.4	2.7
Harvested	2.0	2.7	2.6	3.2	2.4
Yield (mt/ha)	3.1	3.7	4.2	4.77	4.80
Supply (million metric tons)					
Beginning stocks	0.6	0.4	0.9	0.5	0.9
Production	6.3	10.0	11.0	15.2	11.7
Imports	0.2	0.0	0.0	0.1	0.0
Total Supply	7.1	10.4	11.9	15.7	12.7
Usage (million metric tons)					
Food, seed, and industrial use	2.4	1.8	0.4	3.6	3.0
Feed and residual	2.4	2.4	2.1	2.6	2.3
Exports	1.9	5.4	8.9	8.6	6.4
Total Use	6.7	9.5	11.4	14.8	11.7
Ending Stocks	0.4	0.9	0.5	0.9	1.0
Average Farm Price (\$/mt*)	249.12	168.43	158.73	130.31	110.23-133.85

English Units	12/13	13/14	14/15	15/16	16/17P
Acreage (million acres)					
Planted	6.3	8.1	7.1	8.5	6.8
Harvested	5.0	6.6	6.4	7.9	6.0
Yield (bu/ac)	49.6	59.6	67.6	76.0	76.5
Supply (million bushels)					
Beginning stocks	23	15	34	18	37
Production	248	392	433	597	462
Imports	10	0	0	5	1
Total Supply	280	408	467	620	500
Usage (million bushels)					
Food, seed, and industrial use	95	70	15	142	120
Feed and residual	93	93	82	103	90
Exports	76	211	352	339	250
Total Use	265	374	449	583	460
Ending Stocks	15	34	18	37	40
Average Farm Price (\$/bu*)	6.33	4.28	4.03	3.31	2.80-3.40

P-Projected

* Farm prices are weighted averages based on volume of farm shipment.

Average farm price for 16/17P based on WASDE November projected price.

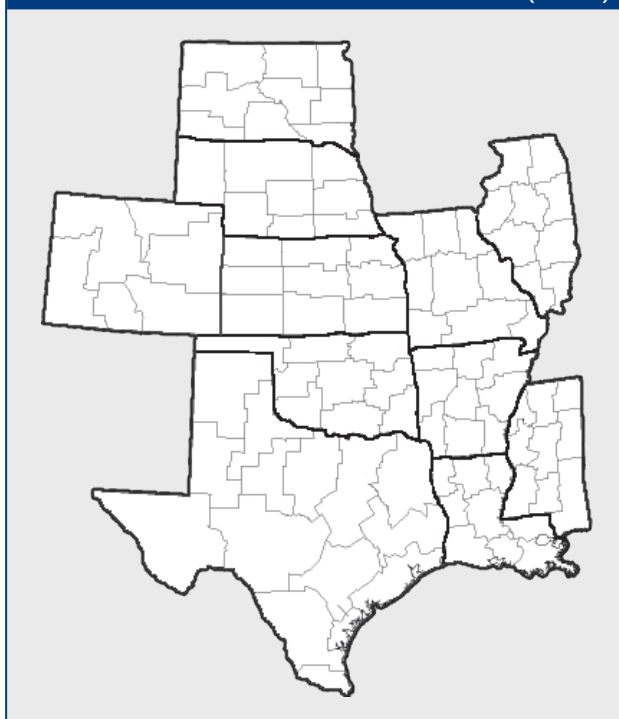
Source: USDA WASDE and ERS

A. OVERVIEW

The key points for the survey design and sampling and statistical analysis for this *2016/2017 Harvest Report* are as follows:

- Following the methodology developed for the *2015/2016 Harvest Survey*, the samples were proportionately stratified according to Agricultural Statistical Districts (ASDs) across nine key sorghum-producing states, which represented more than 99% of U.S. sorghum exports. Additionally, the samples were classified according to two Harvest Areas – Early Harvest and Late Harvest.
- A total of 250 samples collected from the nine states were targeted to achieve a maximum $\pm 10\%$ relative margin of error (Relative ME) at the 95% confidence level for the quality factors.
- There was a total of 254 unblended sorghum samples tested. These samples, pulled from inbound farm-originated trucks at local elevators, were received from July 18, 2016 through November 30, 2016.
- A proportionate stratified sampling technique was used for the mycotoxin testing across the ASDs in the nine states surveyed for the other quality factors. This sampling resulted in 75 samples being tested for aflatoxins and DON.
- Weighted averages and standard deviations following standard statistical techniques for proportionate stratified sampling were calculated for the U.S. Aggregate and each of the two Harvest Areas.
- To evaluate the statistical validity of the samples, the Relative ME was calculated for each of the quality attributes at the U.S. Aggregate and the Harvest Areas. The Relative ME for the quality factor results was less than $\pm 10\%$, except for foreign material and total damage for the U.S. Aggregate, BNFM, foreign material, and total damage for the Early Harvest Area, and total damage for the Late Harvest Area. While the lower level of precision for these quality factors is less than desired, these levels of Relative ME do not invalidate the estimates.
- Two-tailed t-tests at a 95% confidence level were calculated to measure statistical differences between the 2016 and 2015 quality factor averages.

AGRICULTURAL STATISTICAL DISTRICTS (ASDs)



B. SURVEY DESIGN AND SAMPLING

Survey Design

For this *2016/2017 Harvest Report*, the target population was commodity sorghum from the nine key U.S. sorghum-producing states representing more than 99% of U.S. sorghum exports. A **proportionate, stratified, random sampling** technique was applied to ensure a sound statistical sampling of the U.S. sorghum crop at the first stage of the market channel. Three key characteristics define the sampling technique: the **stratification** of the population to be sampled, the **sampling proportion** per stratum, and the **random sample** selection procedure.

Stratification involves dividing the survey population of interest into distinct, non-overlapping sub-populations called strata. For this study, the survey population was sorghum produced in areas likely to export sorghum to foreign markets. The U.S. Department of Agriculture (USDA) divides each state into several ASDs and estimates sorghum production for each ASD. The USDA sorghum production data, accompanied by USDA sorghum consumption data and foreign export estimates, were used to define the survey population in nine key sorghum-producing states representing more than 99% of U.S. sorghum exports. The ASDs were the subpopulations, or strata, used for this sorghum quality survey. From those data, the Council calculated each ASD's proportion of the total U.S. foreign exports to determine the **sampling proportion** (the percent of total samples per ASD) and ultimately, the number of sorghum samples to be collected from each ASD. The number of samples collected for the *2016/2017 Harvest Report* differed from ASD to ASD because of the different shares of estimated foreign export levels.

The **number of samples collected was established** so the Council could estimate the true averages of the various quality factors with a specific level of precision. The level of precision chosen for the *2016/2017 Harvest Report* was a Relative ME of no greater than $\pm 10\%$, estimated at a 95% level of confidence. A Relative ME of $\pm 10\%$ is a reasonable target for biological data such as these sorghum quality factors.

To determine the number of samples for the targeted Relative ME, ideally the population variance (i.e., the variability of the quality factor in the sorghum at harvest) for each of the quality factors should be used. The more variation among the levels or values of a quality factor, the more samples required to estimate the true mean within a given confidence level. In addition, the variances of the quality factors typically differ from one another. As a result, different sample sizes for each of the quality factors would be needed for the same level of precision.

Since the population variances for the quality factors evaluated for this year's sorghum crop were not known, the variance estimates from the *2015/2016 Harvest Report* were used as proxies. The variances and ultimately the estimated number of samples needed for the Relative ME of $\pm 10\%$ for quality factors were calculated using the 2015 results of 207 samples. Total damage, with a Relative ME of 29%, was the only quality factor for which the Relative ME exceeded $\pm 10\%$ for the U.S. Aggregate. Based on this outcome, the targeted sample size was increased from the 200 samples targeted in the *2015/2016 Harvest Survey* to 250. It was expected that this increased sample size would allow the Council to estimate the true averages of the quality characteristics with the desired level of precision for the U.S. Aggregate, with the exception of total damage.

The same approach of proportionate stratified sampling was used for the mycotoxin testing of the sorghum samples as for the testing of the grade, moisture, chemical, and physical characteristics. In addition to using the same sampling approach, the same level of precision of a Relative ME of $\pm 10\%$, estimated at a 95% level of confidence, was desired. Testing at least 63 samples (25% of the 250 targeted samples) would ensure with 95% confidence that the percent of tested samples with aflatoxin results below the U.S. Food and Drug Administration (FDA) action level of 20 parts per billion (ppb) would have a

Relative ME of $\pm 10\%$. It was also estimated that the percent of tested samples with DON results below the FDA advisory level of 5 parts per million (ppm) would have a Relative ME of $\pm 10\%$, estimated at a 95% level of confidence. The proportionate stratified sampling approach also required testing at least one sample from each ASD in the sampling area. To meet the sampling criteria of testing 25% of the minimum number of targeted samples (250) and at least one sample from each ASD, the targeted number of samples to test for mycotoxins was 75 samples.

Sampling

The **random selection** process was implemented by soliciting local grain elevators in the nine states by email and phone. Postage-paid sample kits were mailed to elevators agreeing to provide the 2500-gram sorghum samples requested. Samples were collected from the elevators when at least 30% of the sorghum in their area had been harvested. The 30% harvest threshold was established to avoid receiving old-crop sorghum samples (as farmers cleaned out their bins for the current crop) or new crop harvested earlier than normal (for reasons such as elevator premium incentives). The individual samples were pulled from inbound farm-originated trucks

when the trucks underwent the elevators' normal testing procedures. The number of samples each elevator provided for the survey depended on the targeted number of samples needed from the ASD along with the number of elevators willing to provide samples. A maximum of twelve samples from each physical location was collected, but nearly 90% of the participating elevators submitted four or fewer samples. A total of 254 unblended sorghum samples pulled from inbound farm-originated trucks were received from local elevators from July 18, 2016 through November 30, 2016, and tested.



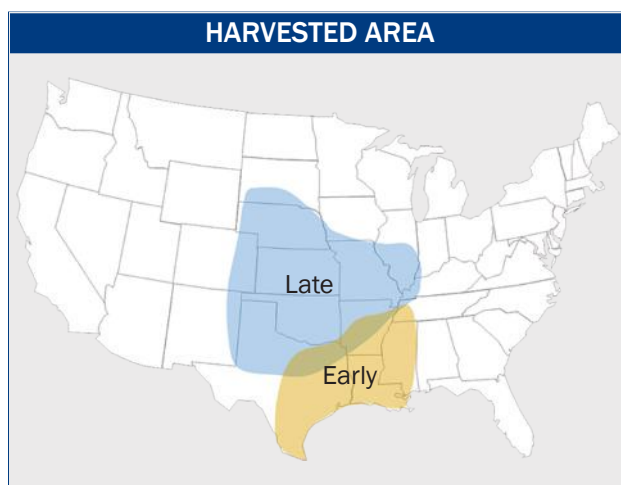
C. STATISTICAL ANALYSIS

The sample test results for the grade factors, moisture, chemical composition, and physical factors were summarized as the U.S. Aggregate and also by two groups. The groups, which harvest sorghum in differing time periods, were labeled as Harvest Areas:

- The Early Harvest Area, which consists of areas that typically harvest sorghum from the beginning of July through the end of September; and
- The Late Harvest Area, which consists of areas that typically harvest sorghum from the beginning of September through the end of November or later.

In analyzing the sample test results, the Council followed standard statistical techniques employed for proportionate stratified sampling, including **weighted averages** and **standard deviations**. In addition to the weighted averages and standard deviations for the U.S. Aggregate, weighted averages and standard deviations were calculated for the Harvest Areas. First, each sampled ASD was categorized by Harvest Area, based on historical USDA state-level harvest progress data, with each ASD exclusively belonging to a single Harvest Area. Second, each ASD was weighted by its estimated proportion of foreign exports. The Harvest Area and U.S. Aggregate statistics were calculated using these weights.

The Relative ME was calculated for each of the quality factors for the U.S. Aggregate and for each of the Harvest Areas. The Relative ME for the quality factor results was less than $\pm 10\%$, except for BNFM in the Early Harvest Area, foreign material for the U.S. Aggregate and Early Harvest Area, and total damage for the U.S. Aggregate and both harvest areas. The Relative ME for BNFM, foreign material, and total damage are shown in the table to the right.



While the level of precision for these quality factors is lower than desired, these levels of Relative ME do not invalidate the estimates. Footnotes in the summary tables for “Grade Factors and Moisture” indicate the attributes for which the Relative ME exceeds $\pm 10\%$.

References in the “Quality Test Results” section to statistical and/or significant differences between results in the *2015/2016 Harvest and Export Cargo Quality Report* and the *2016/2017 Harvest Quality Report* were validated by two-tailed t-tests at a 95% confidence level.

	Relative ME		
	BNFM	Foreign Material	Total Damage
U.S. Aggregate		10.2%	17.1%
Early Harvest Area	16.9%	28.8%	35.1%
Late Harvest Area			22.9%

The 2016/2017 Sorghum Harvest Quality Survey samples (each about 2500 grams) were sent directly from the local grain elevators to Amarillo Grain Exchange (AGE) in Amarillo, Texas. Upon arrival, the samples were dried, if needed, to a suitable moisture content to prevent any subsequent deterioration during the testing period. The samples were then split into two 1100- to 1250-gram subsamples using a Boerner divider. The divider splits the complete sample into two, while keeping the attributes of the grain sample evenly distributed between the two subsamples. One subsample was shipped to the Cereal Quality Lab (CQL) in the Department of Soil and

Crop Sciences at Texas A&M University in College Station, Texas, to be analyzed for chemical composition and other physical factors, following either industry norms or well-established procedures in practice for many years. AGE graded and performed the mycotoxin testing for the other subsamples. AGE is an official grain inspection service provider in Texas as designated by U.S. Department of Agriculture (USDA) Federal Grain Inspection Service (FGIS). The grade testing procedures were in accordance with FGIS's Grain Inspection Handbook, and the mycotoxin testing was performed using FGIS protocol and approved test kits.

A. SORGHUM GRADING FACTORS

Test Weight

Test weight is a measure of the quantity of grain required to fill a specific volume (Winchester bushel). Test weight is a part of the FGIS Official U.S. Standards for Sorghum grading criteria.

The test involves filling a test cup of known volume through a funnel held at a specific height above

the test cup to the point where grain begins to pour over the sides of the test cup. A strike-off stick is used to level the grain in the test cup, and the grain remaining in the cup is weighed. The weight is then converted to and reported in the traditional U.S. unit, pounds per bushel (lb/bu).

Broken Kernels and Foreign Material (BNFM)/Foreign Material

Broken kernels and foreign material (BNFM) and foreign material are part of the FGIS Official U.S. Standards for Sorghum.

This test determines the amount of broken kernels and foreign material contained in the sample. Broken kernels is defined as all material which passes through a 5/64th-inch triangular-hole sieve and over a 2.5/64th-inch round-hole sieve. Foreign material is defined as all material, except sorghum, that re-

mains on top of the 5/64th-inch triangular-hole sieve and all matter other than sorghum which passes over a No. 6 riddle. Foreign material is reported as a sum of the mechanically-separated foreign material as a percent of the dockage-free sample weight and the handpicked foreign material as a percent of the handpicked sample portion weight. BNFM is reported as the sum of broken kernels as a percent of the dockage-free sample weight and the foreign material.

Total Damage/Heat Damage

Total damage is part of the FGIS Official U.S. Standards for Sorghum grading criteria.

A representative working sample of 15 grams of BNFM-free sorghum is visually examined by a properly trained individual for content of damaged kernels. Types of damage include germ-damaged kernels, ground- and/or weather-damaged kernels, diseased kernels, frost-damaged kernels, heat-damaged kernels, insect-bored kernels, mold-damaged kernels (surface and/or internal), mold-like substance, purple-pigment-damaged kernels, and

sprout-damaged kernels. Total damage is reported as the weight percentage of the working sample that is total damaged grain.

Heat damage is a subset of total damage and consists of kernels and pieces of sorghum kernels that are materially discolored and damaged by heat. Heat-damaged kernels are determined by a properly trained individual visually inspecting a 15-gram sample of BNFM-free sorghum. Heat damage, if found, is reported separately from total damage.

B. MOISTURE

The moisture recorded by the elevators' electronic moisture meters at the time of delivery is reported. Electronic moisture meters sense an electrical property of grains called the dielectric constant that

varies with moisture. The dielectric constant rises as moisture content rises. Moisture is reported as a percent of total wet weight.

C. CHEMICAL COMPOSITION

NIR Proximate Analysis

Proximates are the major components of the grain. For sorghum, the proximate analysis measures oil, protein, and starch concentration (or total starch) using Near-infrared transmission spectroscopy (NIR). The NIR uses unique interactions of specific wavelengths of light with each sample. It is calibrated to traditional chemistry methods, to predict the concentrations of oil, protein, and starch in the sample. This procedure is nondestructive to the sorghum.

Chemical composition tests for protein, oil, and starch were conducted using an approximately 50-gram sample in a Perten DA 7250 Near-Infrared Reflectance (NIR) instrument. The NIR was calibrated to chemical tests, and the standard error of predictions for protein, oil, and starch was about 0.3%, 0.4%, and 0.5%, respectively. Results are reported on a dry basis (percent of non-water material).



Tannins

Leucoanthocyanidins (catechins) and proanthocyanidins (tannins) are a class of flavonoids known as flavanols that react with vanillin in the presence of mineral acids to produce a red color. Vanillin reacts with the flavanols, but other flavonoid compounds can give specific color development. Values near or below 4.0 mg catechin equivalents (CE) per gram (g) sample by this method generally imply absence of condensed tannins. Type III tannin sorghums usually have values greater than 8.0 mg CE/g. The

test involves grinding approximately 50 g of sound seed using a UDY grinder with 1-mm sieve, and accurately weighing 0.30 g of this sample for analysis. Extraction and analysis is performed using the vanillin-HCl test with blank subtraction to remove interference by sorghum pigments. Developed color is measured using a UV-Vis spectrophotometer at 500 nm. Standard curve is run using pure catechin. Tests are run in triplicates and the average value is reported as mg CE/g sample on a dry basis.

D. PHYSICAL FACTORS

1000-Kernel Weight (TKW), Kernel Volume, and Kernel True Density

The 1000-kernel weight (TKW) is determined from the average weight of 300 individual kernel replicates using the Perten Single Kernel Characterization System (SKCS 4100). The instrument weighs each seed to the nearest 0.01 mg and automatically calculates the TKW based on the average weight of the 300 individual seeds. The averaged TKW is reported in grams.

The kernel volume for an accurately weighed 80.00 ± 0.05 g kernel sample is calculated using a helium pycnometer and is expressed in $\text{mm}^3/\text{kernel}$. The individual kernel volume is obtained by dividing the TKW (g) by the total seed weight (g) used in the

pycnometer, and multiplying the recorded pycnometer volume (cm^3) by this factor. The value obtained, $\text{cm}^3/1000\text{-kernels}$, is equivalent to $\text{mm}^3/\text{kernel}$. Kernel volumes usually range from 12 to 28 mm^3 per kernel for small and large kernels, respectively.

True density of kernel samples is calculated by dividing the mass (or weight) of the 80.00 ± 0.05 g externally sound kernels by the pycnometer volume (displacement) of the same kernels, and is reported in grams per cubic centimeter (g/cm^3). True densities typically range from 1.24 to 1.39 g/cm^3 at “as is” moistures of about 12 to 15%.

Kernel Hardness Index

Grain hardness is measured using the SKCS 4100. The SKCS 4100 automatically selects individual kernels, weighs them, and then crushes them between a toothed rotor and a progressively narrowing crescent gap. As a kernel is crushed, the force between the rotor and crescent is measured. About 50 g of clean, externally intact seed is introduced into the instrument hopper. The instrument then

automatically characterizes 300 individual seeds. The data are reported as average kernel hardness index, based on the 300 individual seeds. Samples are also classified as hard, mixed, or soft, depending on average hardness index value and hardness distribution among the 300 seeds. Kernel hardness index values can range from 20 to 120.

Kernel Diameter

Kernel diameter is measured using the SKCS 4100. The instrument records the individual diameter

of 300 seeds, and calculates the average seed diameter in mm.

E. MYCOTOXIN TESTING

Detection of mycotoxins in sorghum is complex. The fungi producing the mycotoxins often do not grow uniformly in a field or across a geographic area. As a result, the detection of any mycotoxin in sorghum, if present, is highly dependent upon the concentration and distribution of the mycotoxin among kernels in a lot of sorghum, whether a truck load, a storage bin, or a railcar.

The objective of the testing for the *2016/2017 Sorghum Harvest Quality Survey* is only to report the frequency of occurrences of the mycotoxin in the current crop, and not to report specific levels of the mycotoxin in sorghum exports. To report the frequency of occurrences of aflatoxins and DON for the harvest samples, AGE performed the mycotoxin testing using FGIS protocol and approved test kits. FGIS's protocol requires a minimum of a 908-gram (2-pound) sample from trucks to grind for aflatoxin testing and approximately a 200-gram sample to grind for DON testing. For this study, a 1000-gram laboratory sample was subdivided from the 2.5-kg survey sample for the mycotoxin analysis. The 1-kg survey sample was ground in a GIPSA-FGIS-approved Romer Model 2A mill so that 60-75% would pass a 20-mesh screen. From this well-mixed ground sample, a 50-gram test portion was removed for each

mycotoxin tested. ROSA WET-S5 and ROSA DONQ2 quantitative test kits were used for the aflatoxin and DON analysis, respectively. The aflatoxins and DON were both extracted with water (5:1), with an added extraction powder used for aflatoxin. The extracts were tested using the ROSA lateral flow strips, and the mycotoxins were quantified by the Charm EZ-M system.

The ROSA WET-S5 quantitative test kits report specific concentration levels of the mycotoxin if the concentration level exceeds a specific level called a "Limit of Detection" (LOD). The LOD is defined as the lowest concentration level that can be measured with an analytical method that is statistically different from measuring an analytical blank (absence of a mycotoxin). The LOD will vary among different analytical methods developed for different types of mycotoxins and commodity combinations. The LODs for the ROSA WET-S5 and ROSA DONQ2 are 2.0 parts per billion (ppb) aflatoxins for diluted extract, and 0.1 parts per million (ppm) DON for diluted extract.

A letter of performance has been issued by FGIS for the quantification of aflatoxins and DON using the ROSA WET-S5 and ROSA DONQ2 kits, respectively.



U.S. SORGHUM GRADES AND GRADE REQUIREMENTS

Grade	Minimum Test Weight per Bushel (Pounds)	Maximum Limits of			
		Damaged Kernels		Broken Kernels and Foreign Material	
		Heat Damaged (Percent)	Total (Percent)	Foreign Material (part of total) (Percent)	Total (Percent)
U.S. No. 1	57.0	0.2	2.0	1.0	3.0
U.S. No. 2	55.0	0.5	5.0	2.0	6.0
U.S. No. 3 ¹	53.0	1.0	10.0	3.0	8.0
U.S. No. 4	51.0	3.0	15.0	4.0	10.0

U.S. Sample Grade is sorghum that: (a) Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, or 4; or (b) Contains 8 or more stones which have an aggregate weight in excess of 0.2 percent of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seeds (*Crotalaria spp.*), 2 or more castor beans (*Ricinus communis L.*), 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), 8 or more cockleburrs (*Xanthium spp.*) or similar seeds singly or in combination, 10 or more rodent pellets, bird droppings, or an equivalent quantity of other animal filth in 1,000 grams of sorghum, 11 or more pieces of other material from any combination of animal filth, castor beans, crotalaria seeds, glass, stones, unknown foreign substances, and cockleburrs; or (c) Has a musty, sour, or commercially objectionable foreign odor (except smut odor); or (d) Is badly weathered, heating or otherwise of distinctly low quality.

¹ Sorghum which is distinctly discolored shall not grade any higher than U.S. No. 3.

Source: Code of Federal Regulations, Title 7, Part 810, Subpart D, United States Standards for Sorghum

U.S. AND METRIC CONVERSIONS

Sorghum Equivalents	Metric Equivalents
1 bushel = 56 pounds (25.40 kilograms)	1 pound = 0.4536 kg
39.368 bushels = 1 metric ton	1 hundredweight = 100 pounds or 45.36 kg
15.93 bushels/acre = 1 metric ton/hectare	1 metric ton = 2204.6 lbs
1 bushel/acre = 62.77 kilograms/hectare	1 metric ton = 1000 kg
1 bushel/acre = 0.6277 quintals/hectare	1 metric ton = 10 quintals
56 lbs/bushel = 72.08 kg/hectoliter	1 quintal = 100 kg
	1 hectare = 2.47 acres



HEADQUARTERS:

20 F Street NW, Suite 600 • Washington, DC 20001
Phone: +1-202-789-0789 • Fax: +1-202-898-0522
Email: grains@grains.org • Website: grains.org

PEOPLE'S REPUBLIC OF CHINA: Beijing

Tel1: +86-10-6505-1314 • Tel2: +86-10-6505-2320
Fax: +86-10-6505-0236 • grainsbj@grains.org.cn

EGYPT: Cairo

Tel: +216-71-191-640 • Fax: +216-71-191-650
tunis@usgrains.net

JAPAN: Tokyo

Tel: +81-3-6206-1041 • Fax: +81-3-6205-4960
tokyo@grains.org

KOREA: Seoul

Tel: +82-2-720-1891 • Fax: +82-2-720-9008
seoul@grains.org

MEXICO: Mexico City

Tel: +52-55-5282-0244
usgcmexico@grains.org.mx

MIDDLE EAST AND AFRICA: Tunis

Tel: +216-71-191-640 • Fax: +216-71-191-650
tunis@usgrains.net

SOUTH AND SOUTHEAST ASIA: Kuala Lumpur

Tel: +603-2093-6826 • Fax: +603-2093-2052
grains@grainsea.org

TAIWAN: Taipei

Tel: +886-2-2523-8801 • Fax: +886-2-2523-0149
taipei@grains.org

TANZANIA: Dar es Salaam

Tel: +255-718-733-711
mary@usgrainstz.net

WESTERN HEMISPHERE: Panama City

Tel: +507-315-1008 • Fax: +507-315-0503
LTA@grains.org