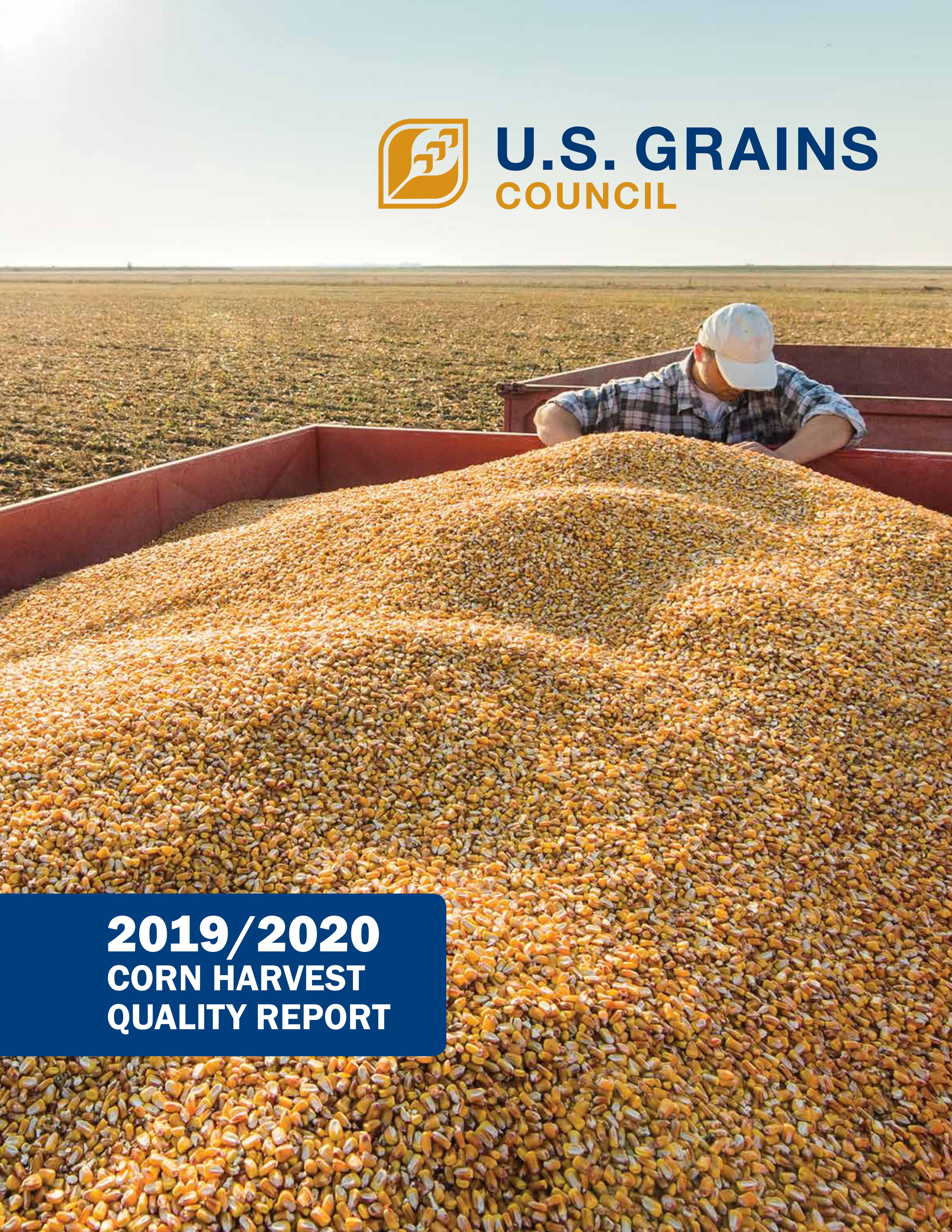

U.S. GRAINS COUNCIL

2019/2020 CORN HARVEST QUALITY REPORT

Developing a report of this scope and breadth in a timely manner requires participation by several individuals and organizations. The U.S. Grains Council (Council) is grateful to Steve Hofing, Lee Singleton, Lisa Eckel and Alex Harvey of Centrec Consulting Group, LLC (Centrec) for their oversight and coordination in developing this report. A team of experts provided analysis and writing support. External team members include Drs. Tom Whitaker, Lowell Hill, Marvin R. Paulsen and Fred Below. In addition, the Council is indebted to the Illinois Crop Improvement Association's Identity Preserved Grain Laboratory (IPG Lab) and Champaign-Danville Grain Inspection (CDGI) for providing the corn quality testing services.

Finally, 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 samples during their very busy harvest time.

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The U.S. Grains Council (USGC) is pleased to present findings from its ninth annual corn quality survey in this *2019/2020 Corn Harvest Quality Report*.

Through trade, the Council is committed to the furtherance of global food security and mutual economic benefit and, in doing so, offers this report to assist buyers in making well-informed decisions by providing reliable and timely information about the quality of the current U.S. crop to promote the continuous expansion of trade.

The 2019 growing season began with delayed planting due to wet weather conditions in April and May. Using the date when 50 percent of the corn crop is planted as a benchmark, this year's corn crop was the latest in the last 40 years. Despite generally favorable conditions during the remainder of the growing season, average yields are expected to be lower compared to each of the previous three crops. Late planting and wet weather conditions in October also delayed harvest. In recent memory, only the 1992 and 2009 crops reached the 50-percent-harvested benchmark later than the 2019 crop.

Despite these challenges, the Council projects this year's crop to be the sixth-largest U.S. corn crop on record at 347.0 million metric tons (13,661 million bushels). This year's crop is following the three largest and highest-yielding corn crops in U.S. history. The ample supply provided by these consecutive large crops allows the United States to remain the world's leading corn exporter and accounts for an estimated 28.1 percent of global corn exports during the marketing year.

The *2019/2020 Corn Harvest Quality Report* provides information about the quality of the current U.S. crop at harvest as it enters international merchandising channels.

Corn quality observed by buyers will be affected by subsequent handling, blending and storage conditions. A second Council report, the *2019/2020 Corn Export Cargo Quality Report*, will measure corn quality at export terminals at the point of loading for international shipment and will be available in early 2020.

The Council's series of quality reports use a consistent and transparent methodology to allow for insightful comparisons across time. This enables buyers to make well-informed decisions and have confidence in the capacity and reliability of the U.S. corn market.

Offering this report that provides accurate and timely insight into the quality of the U.S. corn crop is a service to our valued trading partners and serves as a means of fulfilling the Council's mission of developing markets, enabling trade and improving lives.

MAKE SOMETHING HAPPEN

Sincerely,

Darren Armstrong
Chairman, U.S. Grains Council
December 2019

The overall quality of the 2019 crop was impacted by late planting, delayed maturation and kernel filling and late harvest conditions as reflected in high corn moisture and low density. The high moisture led to the need for more heated-air drying, which increases the potential for stress cracking.

The average aggregate quality of the representative samples tested for the *U.S. Grains Council 2019/2020 Corn Harvest Quality Report* (*2019/2020 Harvest Report*) was better than the grade factor requirements for U.S. No. 1 grade corn, indicating an abundant amount of good quality corn is entering the marketing channel from the 2019 U.S. crop. The report also showed that 54.6% of the samples met the grade factor requirements for U.S. No. 1 grade, and 81.7% met the grade factor requirements for U.S. No. 2 corn.

Relative to each quality factor's average of the previous five crops (5YA[1]), the 2019 U.S. corn crop is entering the marketing channel with lower average test weight, whole kernels and protein concentration; and higher broken corn and foreign material (BCFM), moisture, total damage, stress cracks and oil concentration. The following points highlight the key harvest results from the 2019 crop.

Grade Factors and Moisture

- Lower **test weight** of 57.3 pounds per bushel (lb/bu) (73.8 kilograms per hectoliter (kg/hl)) than 2018 and the 5YA. While 89.9% of the samples were above the minimum requirement for U.S. No. 2 grade, this proportion is lower than in 2018 and 2017, when 98.2% and 99.9% of samples, respectively, were at or above the minimum requirement for U.S. No. 2 grade.

- Higher average **BCFM** (1.0%) than 2018 and the 5YA. While the average is higher than in previous crops, 96.8% of the samples were below the limit for U.S. No. 2 grade.

- Higher average **total damage** (2.7%) than 2018 and the 5YA. While the average is higher than in previous crops, 91.5% of the samples were below the limit for U.S. No. 2 grade. The variability in total damage (standard deviation = 2.43%) in 2019 was also much higher than in previous years.

- There was no observed **heat** damage in any samples received.

- Higher average **moisture** content (17.5%) and variability (standard deviation = 2.35%) than 2018 and the 5YA. This is the highest average moisture observed in the nine-year history of the report and may be the result of the historically late planting of the 2019 crop. The distribution shows that 45.7% of the samples were above 17% moisture content as compared to 24.7% and 36.2% in 2018 and 2017, respectively. This distribution indicates more samples required artificial drying in 2019 than in the two previous years.

U.S. Corn Grades and Grade Requirements

		Maximum Limits of		
		Damaged Kernels		
Grade	Minimum Test Weight per Bushel (Pounds)	Heat Damaged (Percent)	Total (Percent)	Broken Corn and Foreign Material (Percent)
U.S. No. 1	56.0	0.1	3.0	2.0
U.S. No. 2	54.0	0.2	5.0	3.0
U.S. No. 3	52.0	0.5	7.0	4.0
U.S. No. 4	49.0	1.0	10.0	5.0
U.S. No. 5	46.0	3.0	15.0	7.0

[1]*5YA represents the simple average of the quality factor's average or standard deviation from the 2014/2015, 2015/2016, 2016/2017, 2017/2018 and 2018/2019 Harvest Reports.*

Chemical Composition

- **Protein** concentration (8.3% dry basis) was lower than in 2018 and the 5YA.
- **Starch** concentration (72.3% dry basis) was slightly lower than in 2018 and the 5YA.
- The average **oil** concentration (4.1% dry basis) was higher than in 2018 and the 5YA.

Physical Factors

- The 2019 crop had a higher percentage of **stress cracks** (9%) than 2018 and the 5YA, with 10.8% of the samples having more than 20% stress cracks, indicating greater susceptibility to breakage than in 2018 and 2017. The higher percentage of stress cracks in 2019 is likely the result of the crop's delayed maturation, wet harvest conditions and additional artificial drying to reduce relatively high harvest moisture to safe levels for storage.
- **100-kernel weight** (34.60 grams) was lower than in 2018 and the 5YA, indicating smaller kernels than the previous two years.
- The average **kernel volume** (0.28 cubic centimeters (cm^3)) was smaller than 2017, but the same as 2018 and the 5YA.
- The average **true density** (1.247 grams per cubic centimeter (g/cm^3)) from the 2019 crop was lower than in 2018 and the 5YA. This is likely due to late planting, delayed maturation and kernel filling and late harvest conditions in 2019.
- The **whole kernel** average (90.8%) was lower than in 2018 and the 5YA.
- Average **horneous (hard) endosperm** of 81% was the same as in 2018 and 2017.

Mycotoxins

- All but one sample, or 99.4%, of the 2019 samples, tested below the U.S. Food and Drug Administration (FDA) action level for **aflatoxin** of 20.0 parts per billion (ppb); and 97.8% of the samples tested below 5.0 ppb.
- In 2019, 100% of the samples tested below the 5.0 parts per million (ppm) FDA advisory level for deoxynivalenol (**DON**), the same as in 2018 and 2017. Also, 59.9% of the samples tested below the U.S. Department of Agriculture (USDA) Federal Grain Inspection Service (FGIS) "Lower Conformance Limit," a higher proportion than in 2018 and 2017. This increase may be attributed to weather conditions that were more conducive to DON development in 2019 than in 2018 and 2017.
- One hundred fifty-six (156) of the 182 samples tested for fumonisin, or 85.7%, tested below the FDA's strictest guidance level for **fumonisin** of 5.0 ppm.

The *2019/2020 Harvest Report* has been designed to help international buyers of corn understand the initial quality of U.S. yellow corn as it enters the marketing channel. This is the ninth annual survey of the quality of the U.S. corn crop at harvest. Nine years of results are showing patterns in the impact of weather and growing conditions on the quality of U.S. corn as it comes out of the field.

Wet weather conditions in April and especially May in key regions of the United States brought an unprecedented beginning to the 2019 growing season. By any metric, this year's U.S. corn crop was planted extremely late. Using the date when 50% of the corn crop is planted as a benchmark, the 2019 crop was the latest in the past 40 years. While growing conditions were generally favorable across the remainder of the growing season, crop progress never returned to levels of the 5YA following the crop's late planting. With maturity already delayed, wet weather conditions in October further delayed harvest. In the past 40 years, only two crops reached a 50% harvested benchmark later than the 2019 crop.

Overall, the challenging growing conditions in 2019 produced a crop that had a combined good-to-excellent condition rating that remained at or above 55% all season, which was slightly lower than the average ratings from each of the previous five crops. In addition, the average yield is projected to be lower than each of the previous five crops.

In terms of the quality factor results, the 2019 crop's average moisture, damage, BCFM and stress cracks were all above the 5YA while test weight and whole kernels were slightly lower than the 5YA. Despite the results being slightly worse than the 5YA in these quality factors, the 2019 crop, on average, is entering the marketing channel with characteristics that met or exceeded each grade factor's numerical requirements for U.S. No. 1 grade corn. The report also showed that 54.6% of the samples met all grade factor requirements for U.S. No. 1 grade, and 81.7% met the grade factor requirements for U.S. No. 2 grade corn.

Nine years of data have laid the foundation for evaluating trends and the factors which impact corn quality. Also, the cumulative reports enable export buyers to make year-to-year comparisons and assess patterns of corn quality based on crop growing conditions across the years.

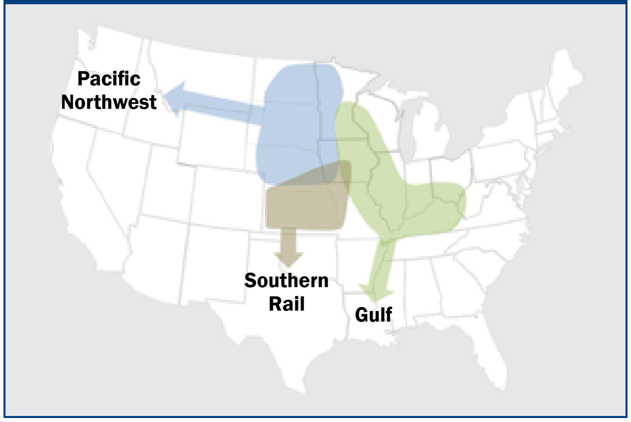
The *2019/2020 Harvest Report* is based on 623 yellow corn samples taken from defined areas within 12 of the top corn-producing and exporting states. Inbound samples were collected from local grain elevators to measure and analyze quality at the point of origin and to provide representative information about the variability of the quality characteristics across the diverse geographic regions.

U.S. GRAINS COUNCIL

The sampling areas in the 12 states are divided into three general groupings labeled Export Catchment Areas (ECAs). These three ECAs are identified by the three major pathways to export markets:

- The Gulf ECA consists of areas that typically export corn through U.S. Gulf ports;
- The Pacific Northwest ECA includes areas exporting corn through Washington, Oregon and California ports; and
- The Southern Rail ECA comprises areas generally exporting corn to Mexico by rail from inland port terminals.

EXPORT CATCHMENT AREAS



Test results from the sample analysis are reported at the U.S. Aggregate level and for each of the three ECAs, providing a general perspective on the geographic variability of U.S. corn quality.

The quality characteristics of the corn identified at harvest establish the foundation for the quality of the grain ultimately arriving at the export customers' doors. However, as corn passes through the U.S. marketing system, it is mingled with corn from other locations; aggregated into trucks, barges and railcars; and stored, loaded and unloaded several times. Therefore, the quality and condition of the corn change between the initial market entry and the export elevator. For this reason, the *2019/2020 Harvest Report* should be considered carefully in tandem with the Council's *2019/2020 Corn Export Cargo Quality Report,* which will follow early in 2020. As always, the quality of an export cargo of corn is established by the contract between buyer and seller, and buyers are free to negotiate any quality factor important to them.

This report provides detailed information on each of the quality factors tested, including averages and standard deviations for the aggregate of all samples, and the samples from each of the three ECAs. The "Quality Test Results" section summarizes the following quality factors:

- Grade Factors: test weight, BCFM, total damage and heat damage
- Moisture
- Chemical Composition: protein, starch and oil concentrations
- Physical Factors: stress cracks, 100-kernel weight, kernel volume, kernel true density, whole kernels and horneous (hard) endosperm
- Mycotoxins: aflatoxin, DON and fumonisin

In addition, the *2019/2020 Harvest Report* includes brief descriptions of the U.S. crop and weather conditions; U.S. corn production, usage and outlook; detailed descriptions of survey, statistical analysis and testing analysis methods; and a historical perspective section displaying the average of each quality factor from all nine reports.

A. GRADE FACTORS

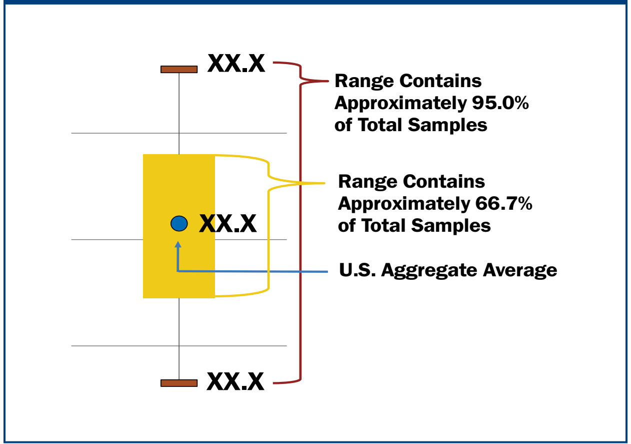
USDA FGIS has established numerical grades, definitions and standards for measurement of many quality attributes. The attributes that determine the numerical grades for corn are test weight, BCFM, total damage and heat damage. A table with the numerical requirements for these attributes is in the "U.S. Corn Grades and Conversions" section of this report.

SUMMARY: GRADE FACTORS AND MOISTURE

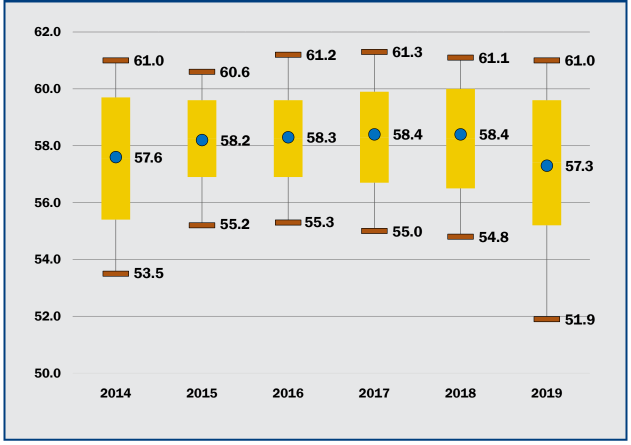
- Average U.S. Aggregate test weight (57.3 lb/bu or 73.8 kg/hl) was lower than 2018 and 2017 (both 58.4 lb/bu) and the 5YA (58.2 lb/bu). As a result of delayed planting and maturation, only 75.6% of the 2019 samples had test weights at or above 56.0 lb/bu.
- Average U.S. Aggregate BCFM (1.0%) was higher than 2018 (0.7%), 2017 and the 5YA (both 0.8%) and but still below the maximum for U.S. No. 1 grade (2.0%).
- BCFM levels in almost all (96.8%) of the corn samples were equal to or below the 3.0% maximum allowed for No. 2 grade.
- Average BCFM differed by no more than 0.4% among all three ECAs.
- Average U.S. Aggregate broken corn (0.7%) was higher than last year (0.5%), 2017 and the 5YA (both 0.6%).
- Average U.S. Aggregate foreign material (0.2%) was the same as last year, 2017 and the 5YA.
- Total damage in the U.S. Aggregate samples averaged 2.7% in 2019, higher than in 2018 and 2017 and the 5YA, but below the limit for U.S. No. 1 grade (3.0%). A total of 73.5% of samples contained 3.0% or less damaged kernels.
- The Gulf ECA had the highest or tied for the highest total damage for 2019, 2018, 2017 and the 5YA. The average total damage values in all ECAs were at or below the limit for U.S. No. 1 grade (3.0%).
- No heat damage was reported on any of the 2019 samples, nor in those of 2018, 2017 and the 5YA.
- Average U.S. Aggregate moisture content in 2019 (17.5%) was higher than 2018 (16.0%), 2017 (16.6%) and the 5YA (16.2%). Moisture variability was also higher than the 5YA and the two previous years.
- The 2019 average moisture contents for the Gulf, Pacific Northwest and Southern Rail ECAs were 17.6, 18.3 and 16.0%, respectively. Average moisture level for the Southern Rail ECA was lowest among all ECAs for 2019, 2018, 2017 and the 5YA. There were more high moisture samples in the 2019 crop than in 2018 and 2017, with 45.7% of the samples containing more than 17.0% moisture, compared to 24.7% in 2018 and 36.2% in 2017. This distribution indicates 2019 required more drying than in the previous years.
- With the average moisture content in 2019 higher at harvest than in 2018 and most previous years, extra care must be taken to monitor and maintain moisture levels sufficiently low to prevent possible mold growth during storage and transport.

GRADE FACTORS
AGGREGATE SIX-YEAR COMPARISON

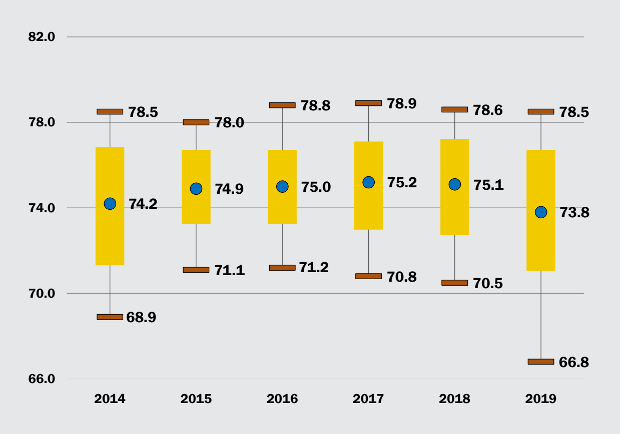
HOW TO READ THE CHARTS



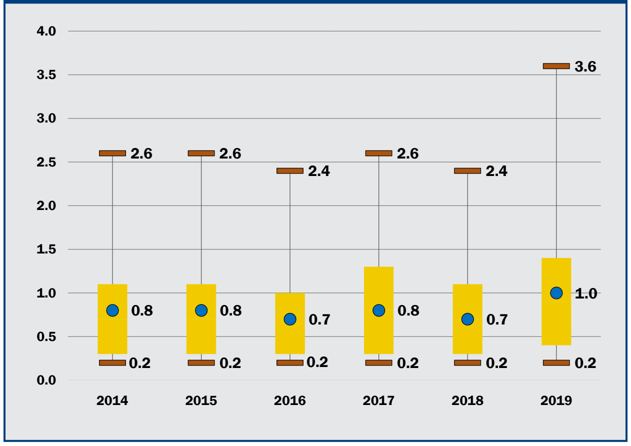
TEST WEIGHT (lb/bu)



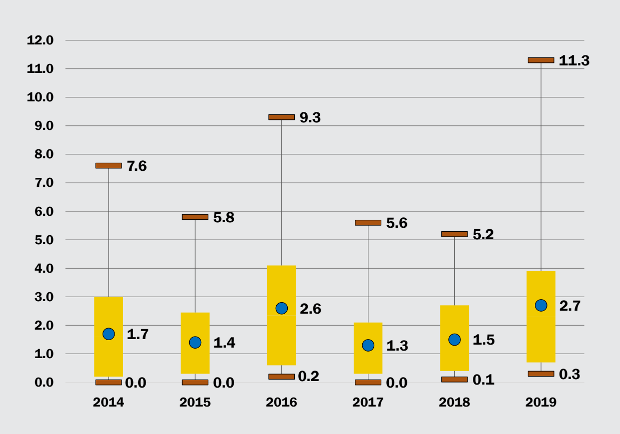
TEST WEIGHT (kg/hl)



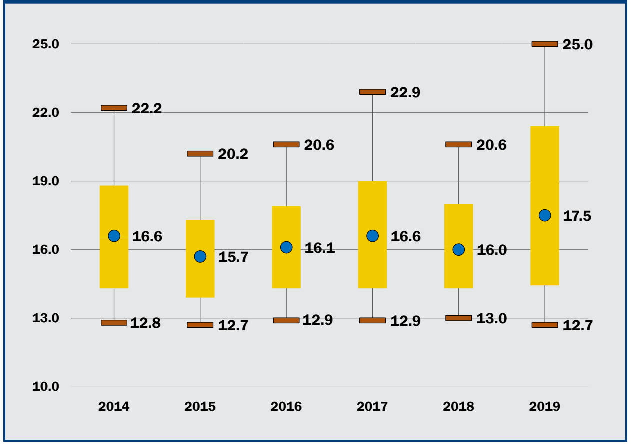
BCFM (%)



TOTAL DAMAGE (%)



MOISTURE (%)



Test Weight

Test weight (weight per volume) is a measure of bulk density and is often used as a general indicator of overall quality and as a gauge of endosperm hardness for alkaline cookers and dry millers. High test weight corn takes up less storage space than the same weight of corn with lower test weight. Genetic differences initially impact the structure of the kernel for test weight. 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, a high percent of horneous (or hard) endosperm and sound, clean corn. Test weight is positively correlated with true density and reflects kernel hardness and good maturation conditions.

Results

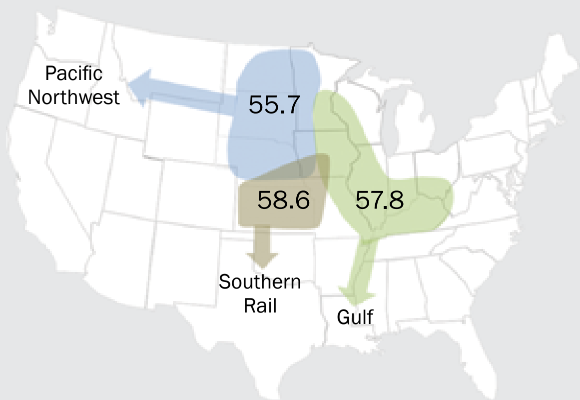
- Average U.S. Aggregate test weight in 2019 (57.3 lb/bu or 73.8 kg/hl) was lower than 2018 and 2017 (both 58.4 lb/bu or 75.2 kg/hl, and the 5YA (58.2 lb/bu or 74.9 kg/hl), but well above the minimum for U.S. No. 1 grade (56.0 lb/bu).
- U.S. Aggregate test weight standard deviation in 2019 (1.41 lb/bu) was higher than 2018 (1.20 lb/bu), 2017 (1.21 lb/bu) and the 5YA (1.21 lb/bu).

U.S. Grade Minimum Test Weight
No. 1: 56.0 lbs
No. 2: 54.0 lbs
No. 3: 52.0 lbs
No. 4: 49.0 lbs
No. 5: 46.0 lbs
Sample: <46.0 lbs

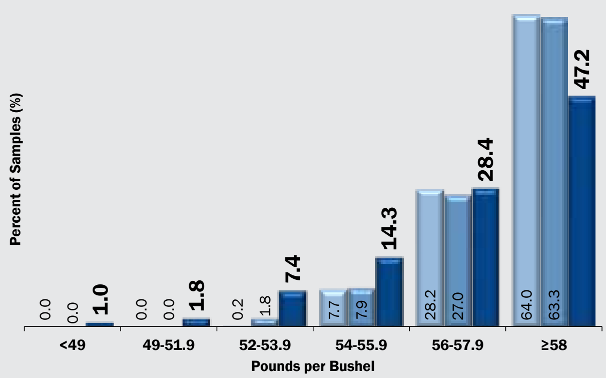
- The range in values among the 2019 harvest samples was 19.3 lb/bu (from 42.6 to 61.9 lb/bu), was greater than the 9.8 lb/bu range in the 2018 samples (from 52.3 to 62.1 lb/bu) and the 10.6 lb/bu range in 2017 (from 52.1 to 62.7 lb/bu).
- The 2019 test weight values were distributed with 75.6% of the samples at or above the factor limit for U.S. No. 1 grade (56.0 lb/bu) compared to 90.3% in 2018 and 92.2% in 2017. In 2019, 89.9% of the samples were above the limit for U.S. No. 2 grade (54.0 lb/bu), compared to 98.2% in 2018 and 99.9% in 2017.
- In 2019, the Gulf (57.8 lb/bu) and Southern Rail (58.6 lb/bu) ECAs had the highest average test weights. The Pacific Northwest ECA (55.7 lb/bu) had the lowest test weight in 2019, 2018, 2017 and the 5YA.
- In addition to having the lowest test weight in 2019, the Pacific Northwest ECA also had the highest variability, as indicated by its higher standard deviation (1.80 lb/bu), compared to the Gulf (1.27 lb/bu) and Southern Rail ECAs (1.18 lb/bu).

TEST WEIGHT (lb/bu)

EXPORT CATCHMENT AREA AVERAGE



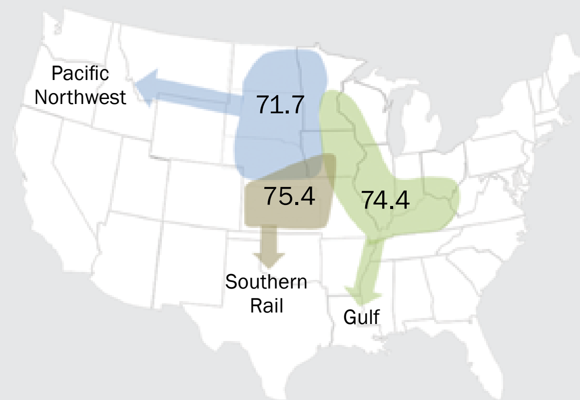
U.S. AGGREGATE



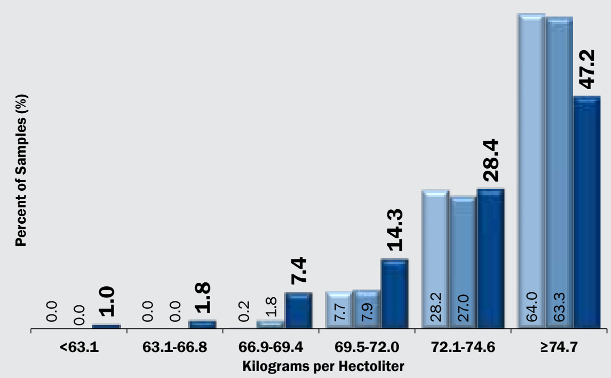
	Avg (lb/bu)	Std Dev (lb/bu)
2019	57.3	1.41
2018	58.4	1.20
2017	58.4	1.21

TEST WEIGHT (kg/hl)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg (kg/hl)	Std Dev (kg/hl)
2019	73.8	1.81
2018	75.1	1.54
2017	75.2	1.55

Broken Corn and Foreign Material

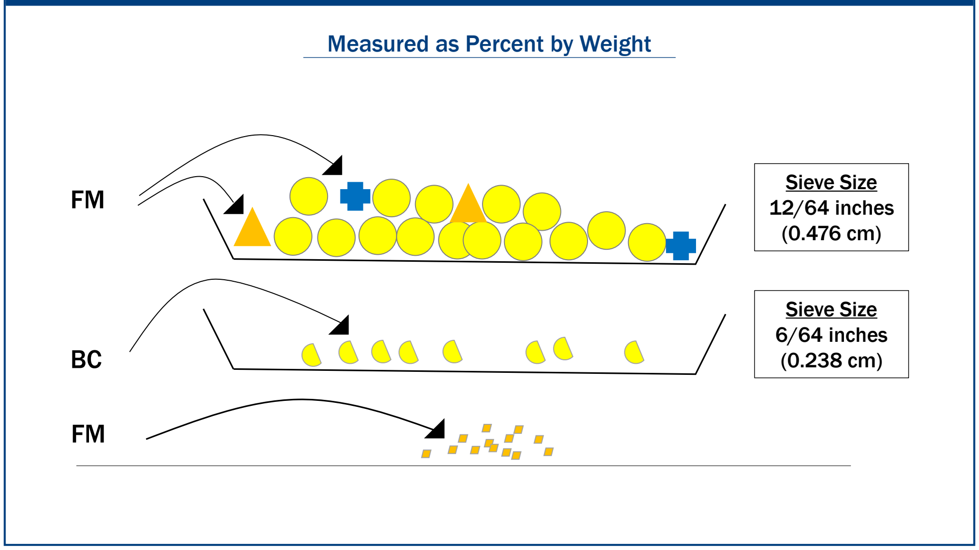
BCFM is an indicator of the amount of clean, sound corn available for feeding and processing. The lower the percentage of BCFM, the less foreign material or fewer broken kernels are in a sample. Higher levels of BCFM in farm-originated samples generally stem from harvesting practices or weed seeds in the field. BCFM levels will normally increase during drying and handling, depending on the methods used and the soundness of the kernels.

Broken corn (BC) is corn and any other material (such as weed seeds) small enough to pass through a 12/64th-inch round-hole sieve, and too large to pass through a 6/64th-inch round-hole sieve.

Foreign material (FM) is any non-corn material too large to pass through a 12/64th-inch round-hole sieve, as well as all fine material small enough to pass through a 6/64th-inch round-hole sieve.

The diagram shown below illustrates the measurement of broken corn and foreign material for the U.S. corn grades.

BROKEN CORN AND FOREIGN MATERIAL



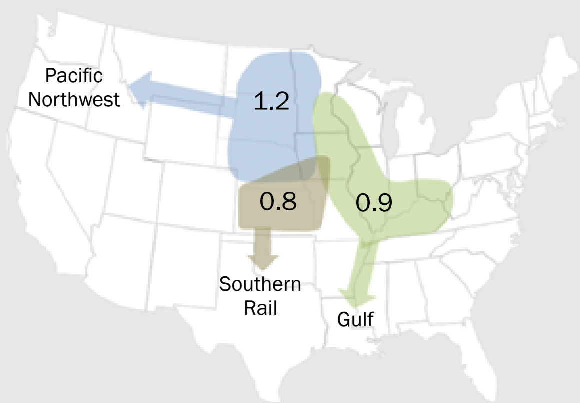
Results

- Average U.S. Aggregate BCFM in 2019 (1.0%) was higher than 2018 (0.7%), 2017 and the 5YA (both 0.8%) but well below the maximum for U.S. No. 1 grade (2.0%).
- The variability of BCFM in the 2019 crop, based on standard deviation (0.67%), was higher than 2018 (0.51%), 2017 (0.57%) and the 5YA (0.53%).
- The range between minimum and maximum BCFM values in 2019 of 0.0 to 8.2% (8.2%) was higher than in 2018 (7.5%) and 2017 (7.3%).
- The 2019 samples were distributed with 92.3% of the samples at or below the maximum BCFM level for U.S. No. 1 grade (2.0%), compared to 95.3% in 2018 and 94.7% in 2017. BCFM levels in nearly all samples (96.8%) were equal to or below the maximum 3.0% limit for No. 2 grade.
- Average BCFM for the Gulf, Pacific Northwest and Southern Rail ECAs (0.9, 1.2 and 0.8%, respectively) were all below the limit for No.1 grade. The difference in average BCFM among ECAs was 0.1 to 0.4% in 2019, compared to only 0.0 to 0.1% in 2018, 2017 and the 5YA.

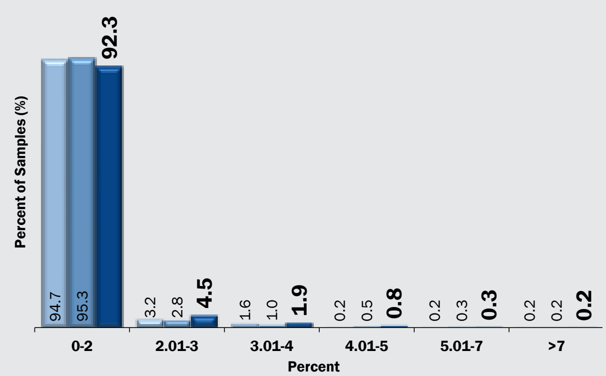
U.S. Grade BCFM Maximum Limits
No. 1: 2.0%
No. 2: 3.0%
No. 3: 4.0%
No. 4: 5.0%
No. 5: 7.0%
Sample: >7%

BROKEN CORN AND FOREIGN MATERIAL (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg (%)	Std Dev (%)
2019	1.0	0.67
2018	0.7	0.51
2017	0.8	0.57

Broken Corn

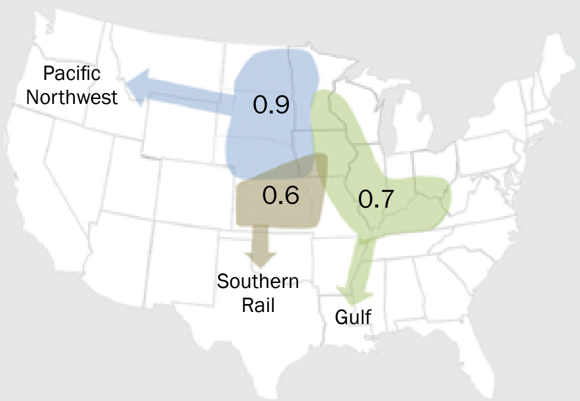
Broken corn in U.S. grades is based on particle size and usually includes a small percent of the non-corn material. Broken corn is more subject to mold and insect damage than whole kernels, and it can cause problems in handling and processing. When not spread or stirred in a storage bin, broken corn tends to stay in the center of the bin, while whole kernels are likely to gravitate outward to the edges. The center area in which broken corn tends to accumulate is known as a "spout-line." If desired, the spout-line can be reduced by drawing this grain out of the center of the bin.

Results

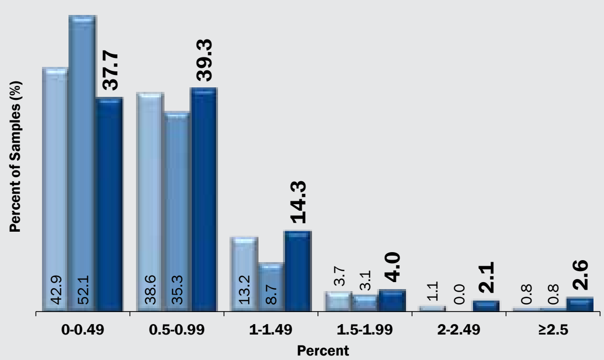
- Broken corn in the U.S. Aggregate samples averaged 0.7% in 2019, higher than in 2018 (0.5%), 2017 and the 5YA (both 0.6%).
- The variability among samples of broken corn for the 2019 crop was slightly higher than previous years and the 5YA, as measured by standard deviations. Standard deviations for 2019, 2018, 2017, and the 5YA were 0.47, 0.33, 0.39 and 0.37%, respectively.
- The range in broken corn values in 2019 was 5.3% (0.0 to 5.3%), higher than 2018 (3.6%) and 2017 (3.5%).
- The 2019 samples were distributed with 23.0% having 1.0% or more broken corn, compared to 12.6% in 2018 and 18.8% in 2017.
- The percentage of broken corn was fairly consistent across the Gulf, Pacific Northwest and Southern Rail ECAs, with averages of 0.7, 0.9 and 0.6%, respectively.
- The distribution chart on the next page, displaying broken corn as a percentage of BCFM, shows that in 60.7% of the samples, BCFM consisted of at least 80.0% broken corn.

BROKEN CORN (%)

EXPORT CATCHMENT AREA AVERAGE



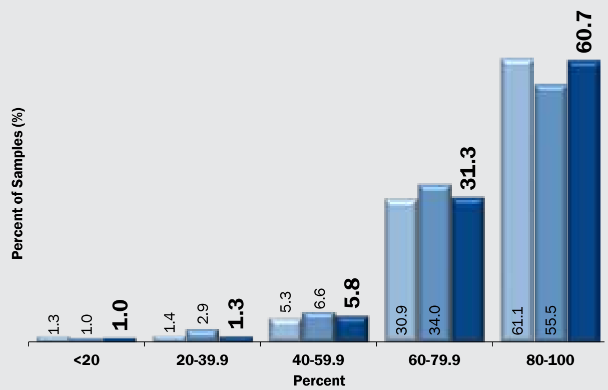
U.S. AGGREGATE



	Avg (%)	Std Dev (%)
2019	0.7	0.47
2018	0.5	0.33
2017	0.6	0.39

BROKEN CORN (%)

BROKEN CORN AS A PERCENT OF BCFM



Foreign Material

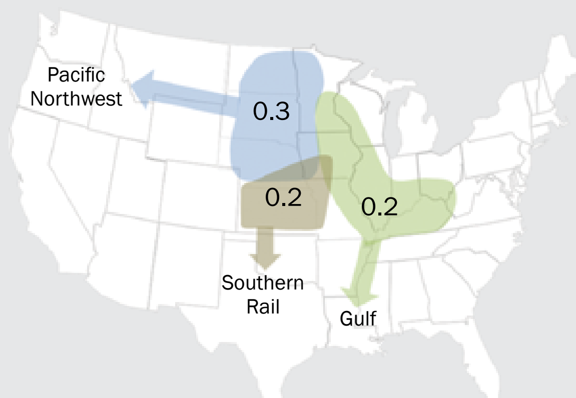
Foreign material is important because it has reduced feeding or processing value. It is also generally higher in moisture content than corn and therefore creates a potential for deterioration of corn quality during storage. Additionally, foreign material contributes to the spout-line (as mentioned in Broken Corn). It also has the potential to create more quality problems than broken corn, due to its higher moisture level.

Results

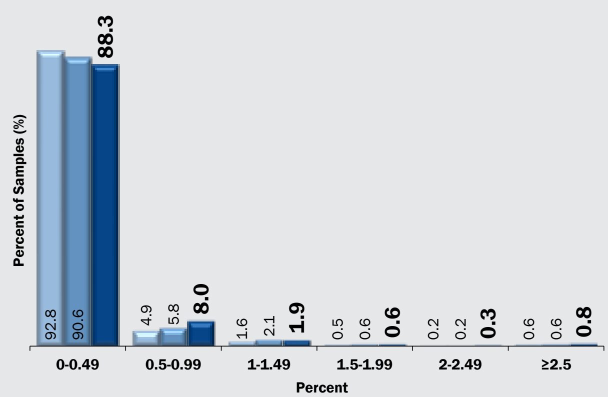
- Foreign material in the U.S. Aggregate samples averaged 0.2% in 2019, the same as in 2018, 2017 and the 5YA (all 0.2%). Combines, which are designed to remove most fine material, appear to be functioning well, given the consistently low level of foreign material found across the years.
- Variability, measured by standard deviation, among the U.S. Aggregate samples in 2019 (0.28%) was similar to 2018 (0.26%), 2017 (0.25%) and the 5YA (0.23%).
- Foreign material in the 2019 samples ranged from 0.0 to 3.3%: a narrower range than 2018 samples with a range of 0.0 to 7.3% and 2017 samples with a range of 0.0 to 6.3%.
- In the 2019 crop, 88.3% of the samples contained less than 0.5% foreign material, slightly lower than 2018 (90.6%) and 2017 (92.8%).
- The percentages of foreign material for the Gulf, Pacific Northwest and Southern Rail ECAs were 0.2, 0.3 and 0.2%, respectively. All ECAs had average foreign material values of 0.2% in 2018, 2017 and the 5YA.

FOREIGN MATERIAL (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg (%)	Std Dev (%)
2019	0.2	0.28
2018	0.2	0.26
2017	0.2	0.25

U.S. GRAINS COUNCIL

Total Damage

Total damage is the percent of kernels and pieces of kernels that are visually damaged in some way, including damage from heat, frost, insects, sprouting, disease, weather, ground, germ and mold. Most of these types of damage result in some discoloration or change in kernel texture. Damage does not include broken pieces of grain that are otherwise normal in appearance.

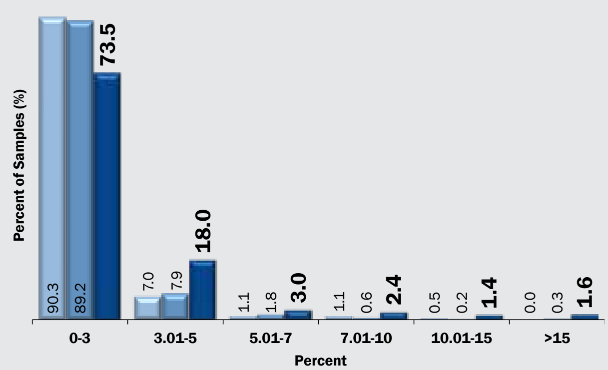
Mold damage is usually associated with higher moisture content and warm temperatures during the growing season or storage. There are several field molds, such as *Diplodia*, *Aspergillus*, *Fusarium* and *Gibberella*, that can lead to mold-damaged kernels during the growing season if the weather conditions are conducive to their development. While some fungi that produce mold damage can also produce mycotoxins, not all fungi produce mycotoxins. The chance of mold decreases as corn is dried and cooled to lower temperatures.

Results

- Average U.S. Aggregate total damage in 2019 (2.7%) was higher than in 2018 (1.5%), 2017 (1.3%) and the 5YA (1.7%). The 2019 total damage average was below the limit for U.S. No. 1 grade (3.0%).
- Total damage variability in the 2019 crop, as measured by the standard deviation (2.43%), was much higher than 2018 (1.25%), 2017 (1.09%) and the 5YA (1.26%).
- The range for total damage in 2019 (0.0 to 50.5%) was much greater than 2018 (0.0 to 19.3%) and 2017 (0.0 to 13.6%). The exceptionally wide range and high variability in total damage was likely due to late maturation, slow drying and prolonged harvest conditions for the 2019 crop.
- Total damage in the 2019 samples was higher than in previous years, with 73.5% of the samples having 3.0% or less and 91.5% having 5.0% or less damaged kernels, compared to 2018 with 89.2% and 97.1%, and 2017 with 90.3% and 97.3%, respectively.

TOTAL DAMAGE (%)

U.S. AGGREGATE



	Avg (%)	Std Dev (%)
2019	2.7	2.43
2018	1.5	1.25
2017	1.3	1.09

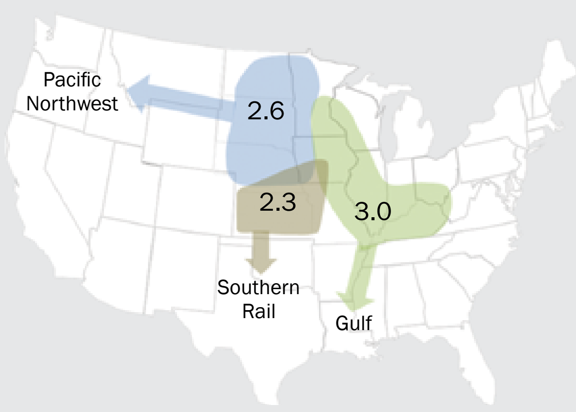
- The average total damage by ECA was 3.0% for Gulf, 2.6% for Pacific Northwest and 2.3% for Southern Rail. The Gulf ECA had the highest or tied for the highest total damage for 2019, 2018, 2017 and the 5YA.

- The average total damage values in all ECAs were at or below the limit for U.S. No. 1 grade (3.0%).

U.S. Grade Total Damage Maximum Limits
No. 1: 3.0%
No. 2: 5.0%
No. 3: 7.0%
No. 4: 10.0%
No. 5: 15.0%
Sample: >15%

TOTAL DAMAGE (%)

EXPORT CATCHMENT AREA AVERAGE



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 corn delivered directly from farms at harvest.

Results

- No heat damage was reported in any of the 2019 samples, the same results as 2018, 2017 and the 5YA.

- The absence of heat damage likely was due, in part, to fresh samples coming directly from farm to elevator with minimal artificial drying.

U.S. Grade Heat Damage Maximum Limits
No. 1: 0.1%
No. 2: 0.2%
No. 3: 0.5%
No. 4: 1.0%
No. 5: 3.0%
Sample: >3%

B. MOISTURE

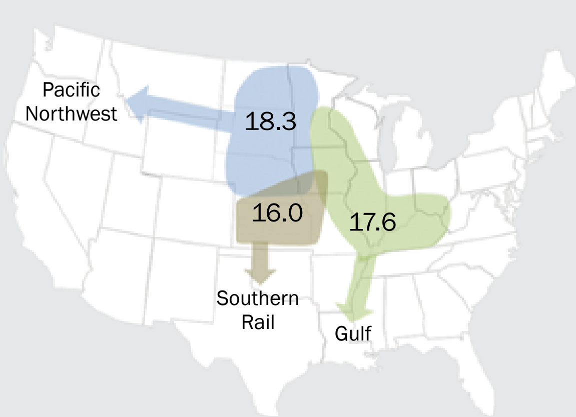
Moisture content is reported on official grade certificates, and maximum moisture content is usually specified in the contract. However, moisture is not a grade factor; therefore, it does not determine which numerical grade will be assigned to the sample. Moisture content is important because it affects the amount of dry matter being sold, is an indicator of the need for drying and has implications for storability. It also affects test weight. In general, if corn is dried gently, test weight may increase 0.25 to 0.33 lb/bu for a one percentage point reduction in moisture. Although other factors such as kernel size, shape, fine material, damage and rapidity of drying may act to reduce the potential increase in test weight[1]. The higher moisture content at harvest increases the chance of kernel damage during harvesting and drying. Moisture content and the amount of drying required will also affect stress cracks and breakage. Extremely wet grain may be a precursor to high mold damage later in storage or transport. While the weather during the growing season affects yield, grain composition and kernel development, grain harvest moisture is influenced largely by crop maturation, the timing of harvest and harvest weather conditions. General moisture storage guidelines suggest that 14.0% is the maximum moisture content for storage up to six to twelve months for quality, clean corn in aerated storage under typical U.S. Corn Belt conditions, and 13.0% or lower moisture content for storage of more than one year.[2]

Results[3]

- The average U.S. Aggregate moisture content recorded at the elevator in 2019 was 17.5%, which was higher than in 2018 (16.0%), 2017 (16.6%) and the 5YA (16.2%). Over the last nine years, average U.S. Aggregate moisture ranged from a low of 15.3% in the 2012 drought year to a high of 17.5% in 2019.

MOISTURE (%)

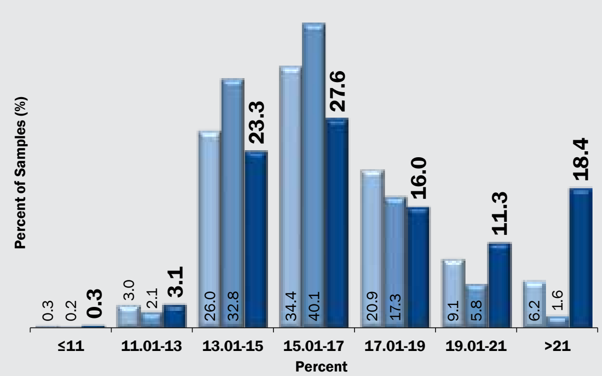
EXPORT CATCHMENT AREA AVERAGE



- U.S. Aggregate moisture standard deviation in 2019 (2.35%) was much higher than in 2018 (1.58%), 2017 (1.90%) and the 5YA (1.66%).

MOISTURE (%)

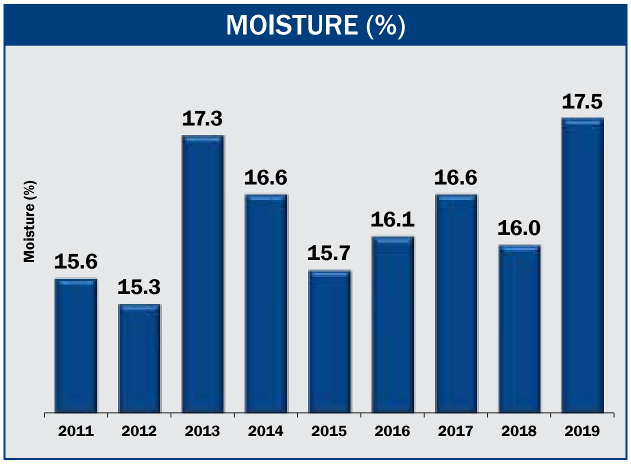
U.S. AGGREGATE

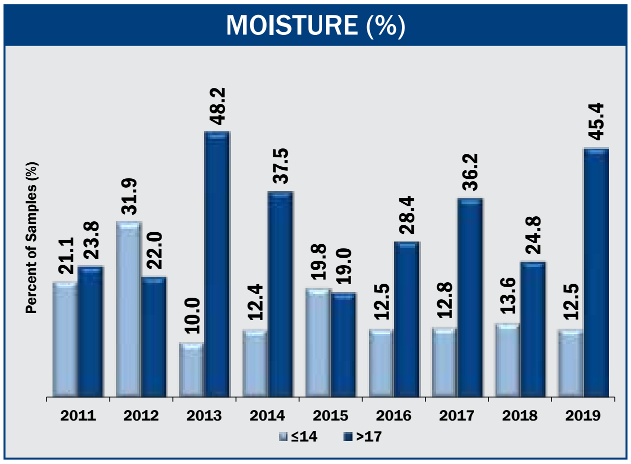


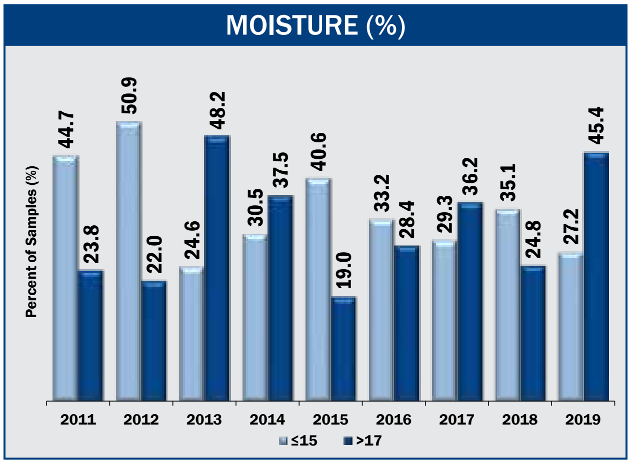
	Avg (%)	Std Dev (%)
2016	17.5	2.35
2018	16.0	1.58
2017	16.6	1.90

[1]*Hellevang, K. (2019) Many Factors Influence Corn Test Weight. NDSU Agricultural Communication Nov 27, 2019, NDSU Extension Service. North Dakota Experiment Station.*
[2]*WPS-13. 2017. Grain drying, handling and storage handbook. Midwest Plan Service No. 13 third edition, Iowa State University, Ames, IA 50011.*
[3]*Differences between the histograms in this section are solely due to rounding.*

- The range in moisture content values in 2019 (11.0 to 30.0%) was higher than 2018 (10.1 to 25.0%) and 2017 (9.0 to 24.4%).
- There were more high-moisture samples in the 2019 samples than in 2018 and 2017, with 45.7% of the samples containing more than 17.0% moisture, compared to 24.7% in 2018 and 36.2% in 2017. There were more samples in the 2019 crop with moisture levels above 21% (18.4%) than in 2018 (1.6%) and 2017 (6.2%). This distribution indicates that the 2019 crop required much more drying than in 2018 or 2017. In the 2019 crop, 12.5% of the samples contained 14.0% or less moisture, compared to 13.6% in 2018 and 12.8% in the 2017 samples. Moisture content values of 14.0% and below are generally considered a safe level for longer-term storage and transport.
- The 2019 moisture values were distributed with 27.2% of the samples containing 15.0% or less moisture. The base moisture used by elevators for discounts is generally 15.0%. This moisture content is considered safe for storage for only a short period during low wintertime temperatures.
- The average moisture contents for corn from the Gulf, Pacific Northwest and Southern Rail ECAs were 17.6, 18.3 and 16.0%, respectively.
- Average moisture levels for the Southern Rail ECA were lowest among all ECAs for 2019, 2018, 2017 and the 5YA. Samples from the Southern Rail ECA usually contain lower moisture content due to generally favorable weather conditions for grain drying in the field.
- Moisture contents in the 2019 samples were higher than in 2018 and the 5YA; thus, care should be taken to monitor and maintain moisture levels sufficiently low to prevent possible mold growth, which can reduce storage life.







SUMMARY: GRADE FACTORS AND MOISTURE

	2019 Harvest					2018 Harvest			2017 Harvest			Five-Year Average (2014-2018)	
	No. of Samples[1]	Avg.	Std. Dev.	Min.	Max.	No. of Samples[1]	Avg.	Std. Dev.	No. of Samples[1]	Avg.	Std. Dev.	Avg.	Std. Dev.
U.S. Aggregate						**U.S. Aggregate**			**U.S. Aggregate**			**U.S. Aggregate**	
Test Weight (lb/bu)	623	57.3	1.41	42.6	61.9	618	58.4*	1.20	627	58.4*	1.21	58.2	1.21
Test Weight (kg/hl)	623	73.8	1.81	54.8	79.7	618	75.1*	1.54	627	75.2*	1.55	74.9	1.55
BCFM (%)	623	1.0	0.67	0.0	8.2	618	0.7*	0.51	627	0.8*	0.57	0.8	0.53
Broken Corn (%)	623	0.7	0.47	0.0	5.3	618	0.5*	0.33	627	0.6*	0.39	0.6	0.37
Foreign Material (%)	623	0.2	0.28	0.0	3.3	618	0.2	0.26	627	0.2	0.25	0.2	0.23
Total Damage (%)	623	2.7	2.43	0.0	50.5	618	1.5*	1.25	627	1.3*	1.09	1.7	1.26
Heat Damage (%)	623	0.0	0.00	0.0	0.0	618	0.0	0.00	627	0.0	0.00	0.0	0.00
Moisture (%)	613	17.5	2.35	11.0	30.0	618	16.0*	1.58	627	16.6*	1.90	16.2	1.66
Gulf						**Gulf**			**Gulf**			**Gulf**	
Test Weight (lb/bu)	594	57.8	1.27	48.0	61.9	587	58.6*	1.13	612	58.6*	1.18	58.3	1.20
Test Weight (kg/hl)	594	74.4	1.64	61.8	79.7	587	75.4*	1.46	612	75.4*	1.52	75.1	1.54
BCFM (%)	594	0.9	0.61	0.0	5.1	587	0.7*	0.50	612	0.8*	0.58	0.7	0.53
Broken Corn (%)	594	0.7	0.43	0.0	3.9	587	0.5*	0.32	612	0.6*	0.39	0.6	0.37
Foreign Material (%)	594	0.2	0.26	0.0	3.2	587	0.2	0.26	612	0.2	0.27	0.2	0.23
Total Damage (%)	594	3.0	2.50	0.0	50.5	587	1.8*	1.41	612	1.6*	1.33	2.1	1.50
Heat Damage (%)	594	0.0	0.00	0.0	0.0	587	0.0	0.00	612	0.0	0.00	0.0	0.00
Moisture (%)	594	17.6	2.32	11.0	30.0	587	16.1*	1.58	612	17.0*	2.06	16.4	1.71
Pacific Northwest						**Pacific Northwest**			**Pacific Northwest**			**Pacific Northwest**	
Test Weight (lb/bu)	318	55.7	1.80	42.6	61.9	288	57.5*	1.37	291	57.7*	1.28	57.5	1.24
Test Weight (kg/hl)	318	71.7	2.31	54.8	79.7	288	74.0*	1.77	291	74.2*	1.65	74.0	1.60
BCFM (%)	318	1.2	0.88	0.0	8.2	288	0.8*	0.58	291	0.9*	0.55	0.8	0.57
Broken Corn (%)	318	0.9	0.60	0.0	5.3	288	0.6*	0.39	291	0.7*	0.40	0.6	0.40
Foreign Material (%)	318	0.3	0.37	0.0	3.3	288	0.2*	0.24	291	0.2*	0.23	0.2	0.23
Total Damage (%)[2]	318	2.6	3.02	0.0	50.5	288	0.9*	0.83	291	0.6*	0.49	0.7	0.60
Heat Damage (%)	318	0.0	0.00	0.0	0.0	288	0.0	0.00	291	0.0	0.00	0.0	0.00
Moisture (%)	318	18.3	2.96	11.5	29.6	288	16.1*	1.75	291	16.1*	1.78	16.0	1.66
Southern Rail						**Southern Rail**			**Southern Rail**			**Southern Rail**	
Test Weight (lb/bu)	324	58.6	1.18	51.9	61.9	355	58.9*	1.19	393	58.8*	1.21	58.5	1.20
Test Weight (kg/hl)	324	75.4	1.52	66.8	79.7	355	75.8*	1.53	393	75.6*	1.56	75.3	1.54
BCFM (%)	324	0.8	0.47	0.0	3.8	355	0.7	0.44	393	0.8*	0.52	0.7	0.46
Broken Corn (%)	324	0.6	0.35	0.0	3.6	355	0.5	0.28	393	0.7*	0.39	0.6	0.32
Foreign Material (%)	324	0.2	0.18	0.0	2.8	355	0.2	0.25	393	0.2	0.19	0.2	0.20
Total Damage (%)	324	2.3	1.27	0.0	27.9	355	1.8*	1.23	393	1.3*	0.97	1.6	1.20
Heat Damage (%)	324	0.0	0.00	0.0	0.0	355	0.0	0.00	393	0.0	0.00	0.0	0.00
Moisture (%)	324	16.0	1.42	11.0	27.2	355	15.5*	1.35	393	15.8*	1.48	15.7	1.45

**Indicates average was significantly different from 2019, based on a 2-tailed t-test at the 95.0% level of significance.*

[1]Due to the ECA results being composite statistics, the sum of the sample numbers from the three ECAs is greater than the U.S. Aggregate.

[2]The Relative ME for predicting the harvest population average exceeded ±10.0%.

C. CHEMICAL COMPOSITION

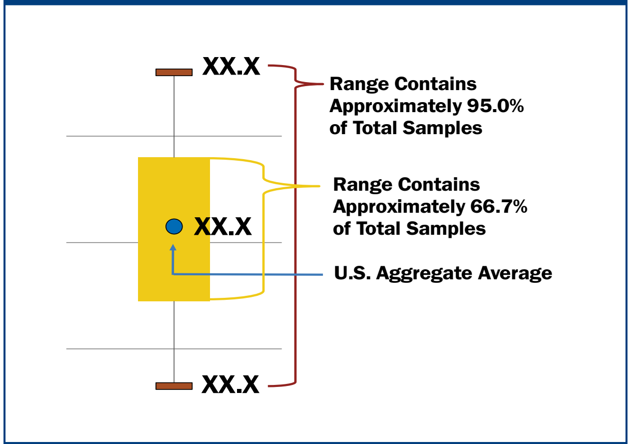
The chemical composition of corn consists primarily of protein, starch and oil. While these attributes are not graded factors, they are of significant interest to end-users. Chemical composition values provide additional information related to nutritional value for livestock and poultry feeding, for wet milling uses and other processing uses of corn. Unlike many physical attributes, chemical composition values are not expected to change significantly during storage or transit.

SUMMARY: CHEMICAL COMPOSITION

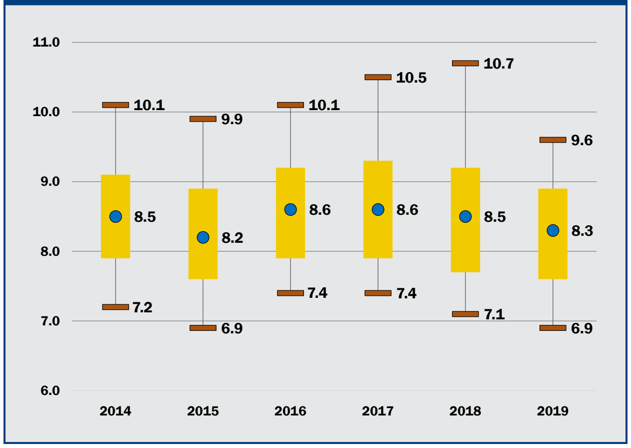
- Average U.S. Aggregate protein concentration in 2019 (8.3% dry basis) was lower than in 2018 (8.5%), 2017 (8.6%) and 5YA (8.5%).
- The Gulf ECA had the lowest or tied for lowest protein concentrations among the other ECAs in 2019, 2018, 2017 and the 5YA.
- Average U.S. Aggregate starch concentration in 2019 (72.3% dry basis) was below 2018 and the same as 2017 and lower than the 5YA (72.9%).
- The Gulf ECA had the highest starch concentration averages in 2019, 2018, 2017 and the 5YA among all ECAs.
- Average U.S. Aggregate oil concentration in 2019 (4.1% dry basis) was higher than in 2018 (4.0%), the same as in 2017 and higher than the 5YA (3.9%).
- The variability in chemical concentrations was similar for 2019, 2018 and 2017 based on similar standard deviations for protein, starch and oil.
- Oil concentration averages for Gulf, Pacific Northwest and Southern Rail ECAs were 4.0, 4.1 and 4.0%, respectively. Oil concentration averages have varied by 0.1% or less among the ECAs for 2019, 2018, 2017 and the 5YA.

CHEMICAL COMPOSITION
AGGREGATE SIX-YEAR COMPARISON

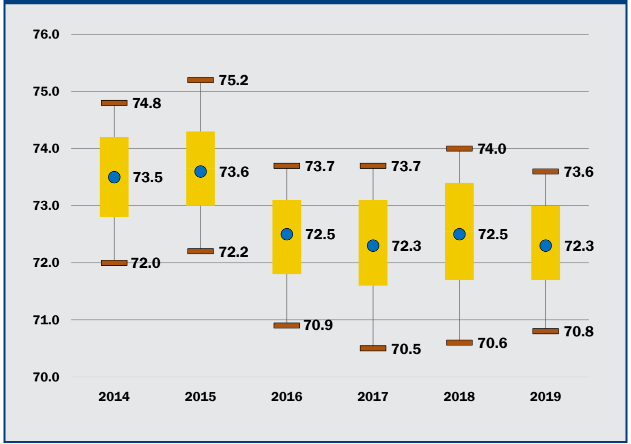
HOW TO READ THE CHARTS



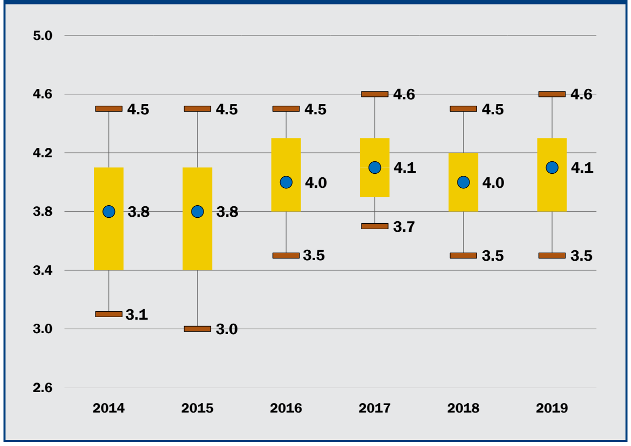
PROTEIN (Dry Basis %)



STARCH (Dry Basis %)



OIL (Dry Basis %)



Protein

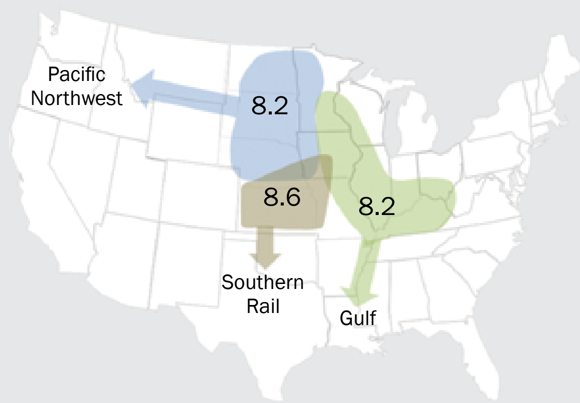
Protein is very important for poultry and livestock feeding because it supplies essential sulfur-containing amino acids and helps to improve feed conversion efficiency. Protein concentration tends to decrease with decreased available soil nitrogen and in years with high yields. Protein is usually inversely related to starch concentration. Results are reported on a dry basis.

Results

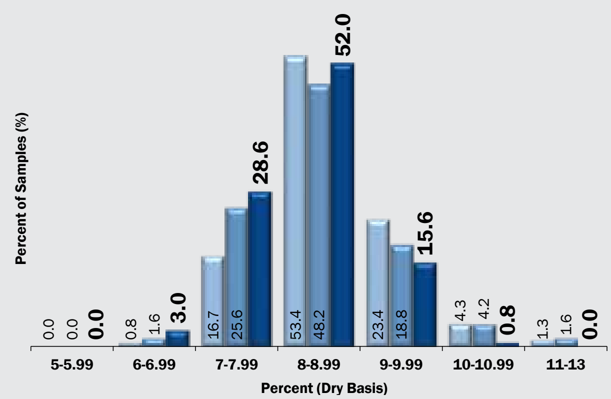
- Average U.S. Aggregate protein concentration in 2019 was 8.3%, lower than in 2018 (8.5%), 2017 (8.6%) and the 5YA (8.5%).
- Average U.S. Aggregate protein standard deviation in 2019 (0.54%) was similar to 2018 (0.53%), 2017 (0.55%) and the 5YA (0.53%).
- The range in protein concentration in 2019 (6.2 to 10.4%) was similar to ranges in 2018 (6.6 to 11.9%) and 2017 (6.4 to 12.2%).
- Protein concentrations in 2019 were distributed with 31.6% below 8.0%, 52.0% between 8.0% and 8.99% and 16.4% above 9.0%. The protein distribution in 2019 shows a lower number of high protein samples than in 2018 and 2017.
- Protein concentration averages for Gulf, Pacific Northwest and Southern Rail ECAs were 8.2, 8.2 and 8.6%, respectively. The Gulf ECA had the lowest or tied for the lowest protein in 2019, 2018, 2017 and the 5YA.

PROTEIN (%)

EXPORT CATCHMENT AREA AVERAGE



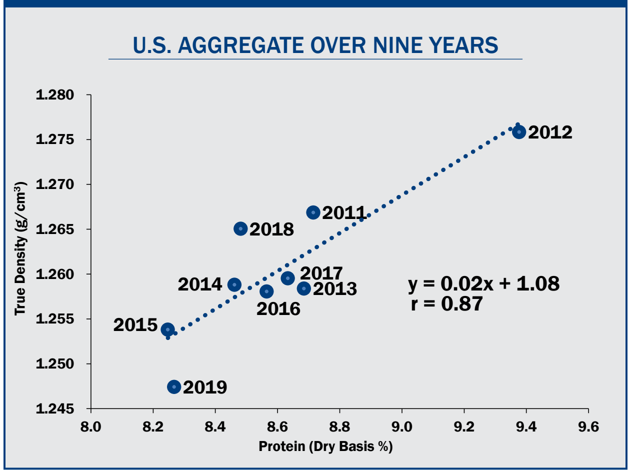
U.S. AGGREGATE



	Avg (%)	Std Dev (%)
2019	8.3	0.54
2018	8.5	0.53
2017	8.6	0.55

- Based on U.S. Aggregate averages over the past nine years, as protein concentration increases, true density also increases (resulting in a correlation coefficient of 0.87), as shown in the figure to the right. In general, protein concentration appears to be lower in years with lower true density and higher in years with higher true density.

TRUE DENSITY vs PROTEIN



Starch

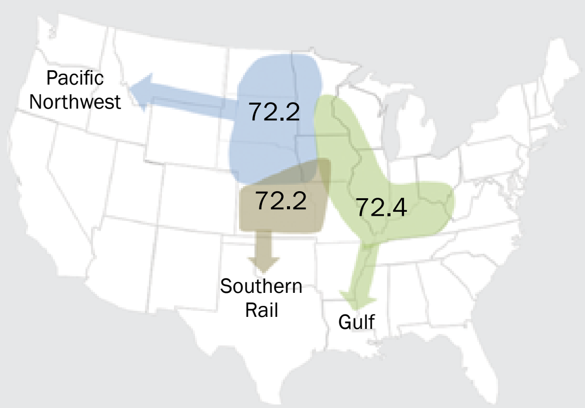
Starch is an important factor for corn used by wet millers and dry-grind ethanol manufacturers. High starch concentration is often indicative of good kernel growing/filling conditions and reasonably moderate kernel densities. Starch is usually inversely related to protein concentration. Results reported on a dry basis.

Results

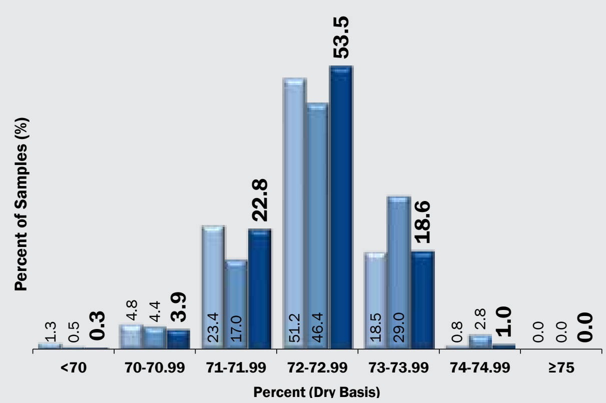
- Average U.S. Aggregate starch concentration in 2019 (72.3%) was similar to 2018 (72.5%) and 2017 (72.3%), but lower than the 5YA (72.9%).
- U.S. Aggregate starch standard deviation in 2019 (0.58%) was similar to 2018 (0.62%), 2017 (0.65%) and the 5YA (0.62%).
- Starch concentration range in 2019 (69.8 to 74.4%) was similar to 2018 (68.9 to 74.6%) and 2017 (69.0 to 74.2%).
- Starch concentrations in 2019 were distributed with 27.0% of the samples below 72.0%, 53.5% between 72.0% and 72.99% and 19.6% at 73.0% and higher. This distribution shows a lower number of samples at high starch levels than 2018, but levels were similar to 2017.

STARCH (%)

EXPORT CATCHMENT AREA AVERAGE



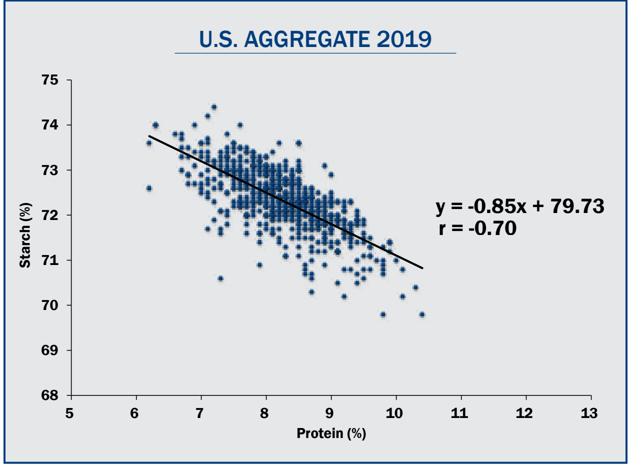
U.S. AGGREGATE



	Avg (%)	Std Dev (%)
2019	72.3	0.58
2018	72.5	0.62
2017	72.3	0.65

- Starch concentration averages for the Gulf, Pacific Northwest and Southern Rail ECAs were 72.4, 72.2 and 72.2%, respectively. Starch concentration averages were highest in the Gulf ECA in 2019, 2018, 2017 and the 5YA. The Gulf ECA had the highest starch and lowest or tied for lowest protein in 2019, 2018, 2017 and the 5YA.
- Since starch and protein are the two largest components in corn, when the percentage of one goes up, the other usually goes down. This relationship is illustrated in the adjacent figure showing a negative correlation (- 0.70) between starch and protein.

STARCH vs PROTEIN



Oil

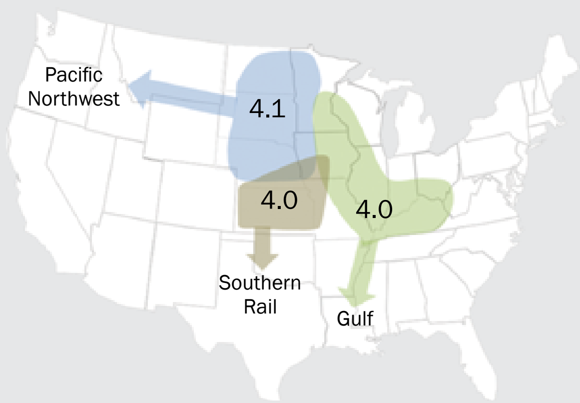
Oil is an essential component of poultry and livestock rations. It serves as an energy source, enables fat-soluble vitamins to be utilized, and provides certain essential fatty acids. Oil is also an important co-product of corn wet and dry milling. Results reported on a dry basis.

Results

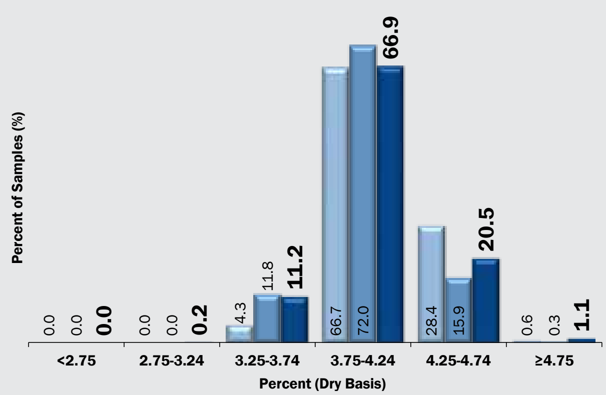
- Average U.S. Aggregate oil concentration in 2019 (4.1%) was higher than in 2018 (4.0%), the same as in 2017 and higher than the 5YA (3.9%).
- U.S. Aggregate oil standard deviation in 2019 (0.23%) was similar to 2018 and 2017 (both 0.22%), and the 5YA (0.26%).
- Oil concentration range in 2019 (3.2 to 5.0%) was similar to 2018 (3.3 to 5.2%) and 2017 (3.3 to 5.5%).
- Oil concentrations in 2019 were distributed with 11.4% of the samples at 3.74% or lower, 66.9% of samples at 3.75 to 4.24% and 21.6% at 4.25% and higher. The distributions in 2019 and 2017 showed a higher number of samples with oil concentrations at 4.25% or higher than in 2018.
- Oil concentration averages for Gulf, Pacific Northwest and Southern Rail ECAs were 4.0, 4.1 and 4.0%. Oil concentration averages have varied by 0.1% or less among the ECAs for 2019, 2018, 2017 and the 5YA.

OIL (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg (%)	Std Dev (%)
2019	4.1	0.23
2018	4.0	0.22
2017	4.1	0.22

SUMMARY: CHEMICAL FACTORS

	2019 Harvest					2018 Harvest			2017 Harvest			Five-Year Average (2014-2018)	
	No. of Samples[1]	Avg.	Std. Dev.	Min.	Max.	No. of Samples[1]	Avg.	Std. Dev.	No. of Samples[1]	Avg.	Std. Dev.	Avg.	Std. Dev.
U.S. Aggregate													
Protein (Dry Basis %)	623	8.3	0.54	6.2	10.4	618	8.5*	0.53	627	8.6*	0.55	8.5	0.53
Starch (Dry Basis %)	623	72.3	0.58	69.8	74.4	618	72.5*	0.62	627	72.3	0.65	72.9	0.62
Oil (Dry Basis %)	623	4.1	0.23	3.2	5.0	618	4.0*	0.22	627	4.1*	0.22	3.9	0.26
Gulf													
Protein (Dry Basis %)	594	8.2	0.54	6.2	10.4	587	8.3*	0.50	612	8.5*	0.54	8.4	0.52
Starch (Dry Basis %)	594	72.4	0.58	69.8	74.4	587	72.7*	0.61	612	72.4	0.64	73.0	0.62
Oil (Dry Basis %)	594	4.0	0.24	3.2	5.0	587	4.0	0.23	612	4.1*	0.22	4.0	0.27
Pacific Northwest													
Protein (Dry Basis %)	318	8.2	0.54	6.6	10.1	288	8.6*	0.60	291	8.9*	0.58	8.7	0.57
Starch (Dry Basis %)	318	72.2	0.58	69.8	73.8	288	72.4*	0.64	291	71.9*	0.68	72.7	0.62
Oil (Dry Basis %)	318	4.1	0.25	3.5	5.0	288	4.0*	0.21	291	4.1	0.21	3.9	0.24
Southern Rail													
Protein (Dry Basis %)	324	8.6	0.54	6.2	10.4	355	8.8*	0.55	393	8.8*	0.54	8.6	0.53
Starch (Dry Basis %)	324	72.2	0.56	69.8	74.2	355	72.3	0.63	393	72.3	0.62	72.8	0.61
Oil (Dry Basis %)	324	4.0	0.21	3.3	4.8	355	4.0*	0.21	393	4.1*	0.21	3.9	0.24

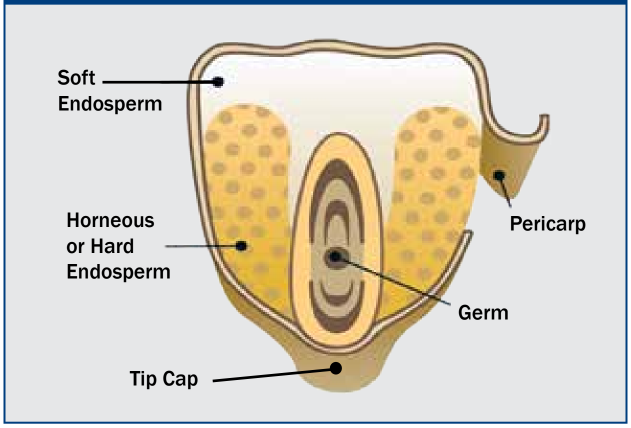
**Indicates average was significantly different from 2019, based on a 2-tailed t-test at the 95.0% level of significance.*

[1]Due to the ECA results being composite statistics, the sum of the sample numbers from the three ECAs is greater than the U.S. Aggregate.

D. PHYSICAL FACTORS

Physical factors are other quality attributes that are neither grade factors nor chemical composition. Physical factors include stress cracks, kernel weight, kernel volume, true density, percent whole kernels and percent horneous (hard) endosperm. Tests for these physical factors provide additional information about the processing characteristics of corn for various uses, as well as corn's storability and potential for breakage in handling. The physical composition of the corn kernel influences the quality attributes; which is, in turn, affected by genetics and growing and handling conditions.

CORN KERNEL



Source: Adapted from Corn Refiners Association, 2011

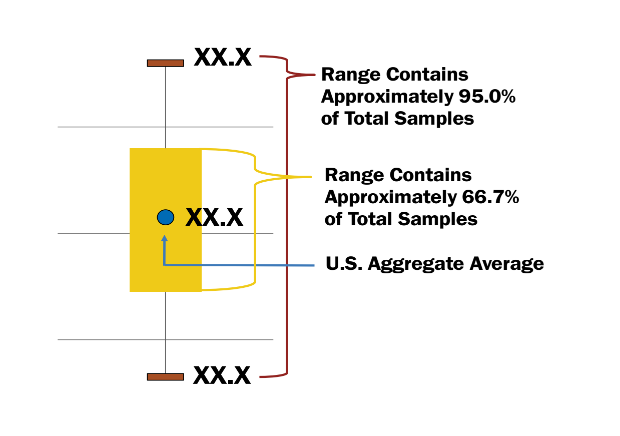
Corn kernels are made up of four parts: the germ or embryo, the tip cap, the pericarp or outer covering and the endosperm. The endosperm represents about 82% of the kernel and consists of soft (also referred to as floury or opaque) endosperm and of horneous (also called hard or vitreous) endosperm, as shown above. The endosperm contains primarily starch and protein, the germ contains oil and some protein, and the pericarp and tip cap are mostly fiber.

SUMMARY: PHYSICAL FACTORS

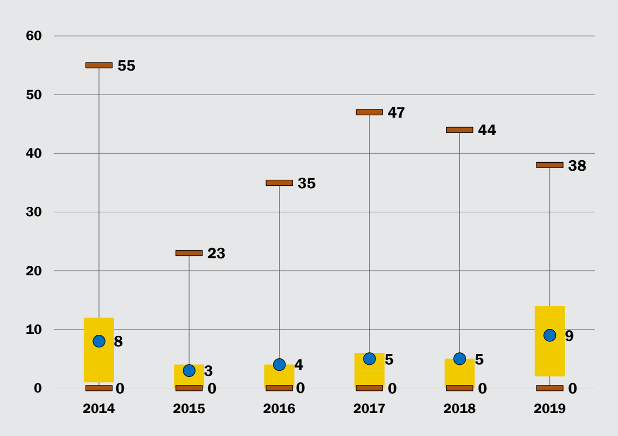
- Average U.S. Aggregate stress cracks (9%) was higher than 2018, 2017 and 5YA (all 5%), indicating susceptibility to breakage in 2019 may be higher than 2018, 2017 and the 5YA.
- Among the ECAs, the Gulf, Pacific Northwest and Southern Rail ECA had stress crack averages of 10, 9 and 6%, respectively. The Southern Rail has had the lowest stress crack averages in 2019, 2018, 2017 and 5YA among all ECAs.
- Average U.S. Aggregate 100-k weight in 2019 (34.60 g) was lower than 2018 (35.07 g), 2017 (36.07 g) and the 5YA (34.94 g).
- Average U.S. Aggregate kernel volume in 2019 (0.28 cm^3) was the same as 2018 and 5YA (both 0.28 cm^3) and lower than 2017 (0.29 cm^3).
- The Pacific Northwest ECA had the lowest average 100-k weight and the lowest kernel volume of the ECAs in 2019, 2018, 2017 and the 5YA.
- U.S. Aggregate kernel true density averaged 1.247 g/cm^3 in 2019, which was lower than 2018, 2017 and the 5YA. True density kernel distributions above 1.275 g/cm^3 in 2019 indicate softer corn than 2018 and 2017. Of the ECAs, the Pacific Northwest had the lowest true density and lowest test weights in 2019, 2018, 2017 and the 5YA.
- U.S. Aggregate whole kernels averaged 90.8% in 2019, lower than 2018 (93.0%) and the 5YA (93.3%), but higher than in 2017 (89.9%).
- Average U.S. Aggregate horneous (hard) endosperm in 2019 (81%) was the same as 2018 and 2017, but higher than the 5YA (80%). The Southern Rail ECA has had the highest or tied for the highest average horneous endosperm in 2019, 2018, 2017 and 5YA among all ECAs. Average horneous endosperm tends to increase in years with higher true density.

PHYSICAL FACTORS
AGGREGATE SIX-YEAR COMPARISON

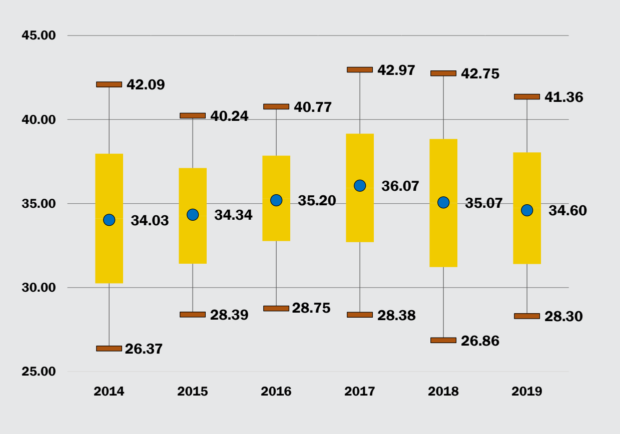
HOW TO READ THE CHARTS



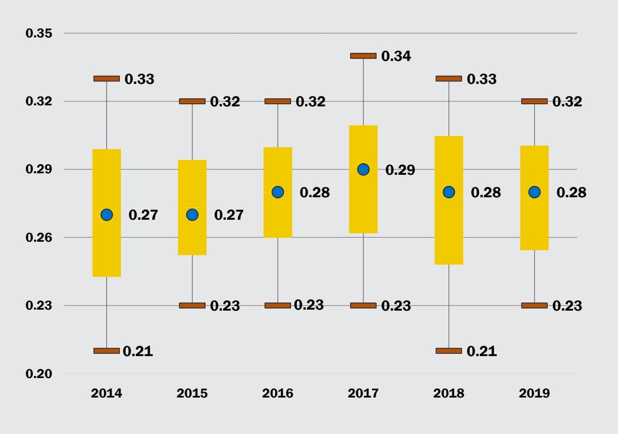
STRESS CRACKS (%)



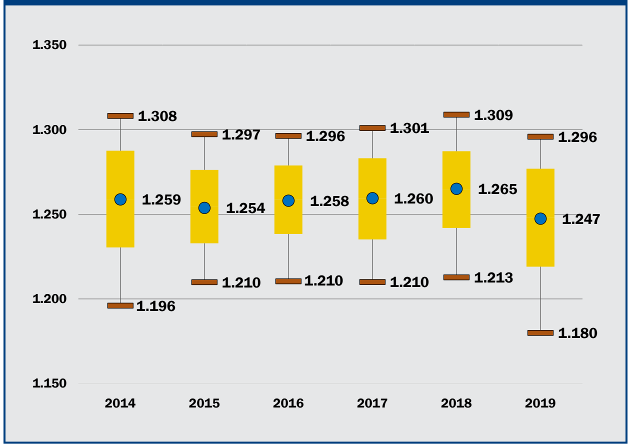
100-KERNEL WEIGHT (g)



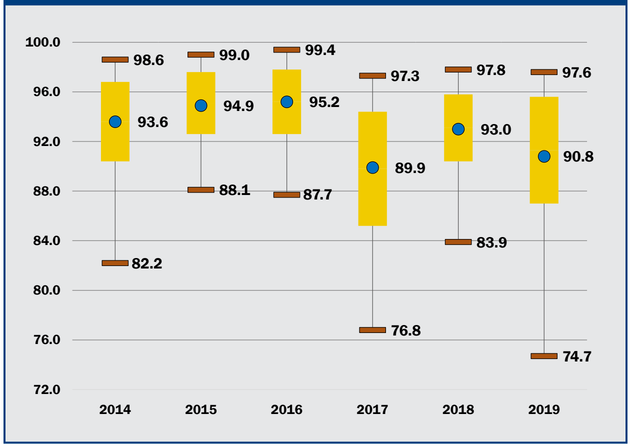
KERNEL VOLUME (cm^3)



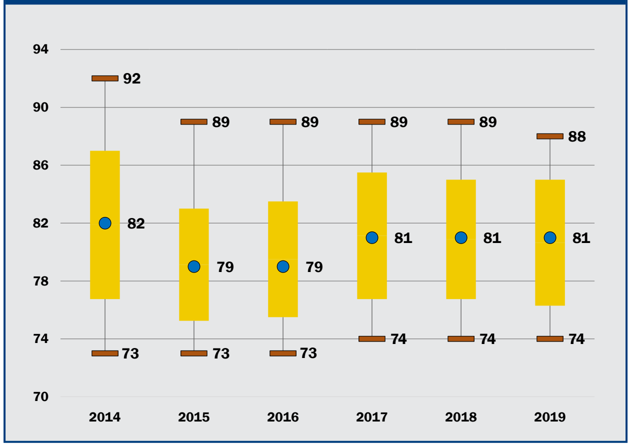
TRUE DENSITY (g/cm³)



WHOLE KERNELS (%)



HORNEOUS ENDOSPERM (%)



Stress Cracks

Stress cracks are internal fissures in the horneous (hard) endosperm of a corn kernel. The pericarp (or outer covering) of a stress-cracked kernel is typically not damaged, so the kernel may appear unaffected at first glance, even if stress cracks are present.

Stress crack measurements include 'stress cracks' (the percentage of kernels with at least one crack) and stress crack index, which is the weighted average of single, double and multiple stress cracks. Both measurements use the same sample of 100 intact kernels with no external damage. 'Stress cracks' measures only the number of kernels with stress cracks; whereas, the stress crack index shows the severity of stress cracking. For example, if half of the kernels have only a single stress crack, 'stress cracks' is 50%, and the stress crack index is 50 (50 x 1). However, if half of the kernels have multiple stress cracks (more than two cracks), indicating a higher potential for handling breakage, 'stress cracks' remains at 50%, but the stress crack index becomes 250 (50 x 5). Lower values for 'stress cracks' and the stress crack index are always preferable. Over the past eight years, both stress cracks and stress crack index were performed. However, there was a very high correlation between the two factors (r = 0.99). Therefore, only the stress crack measurements were performed and reported beginning with the *2019/2020 Harvest Report*.

The cause of stress cracks is pressure buildup due to moisture and temperature gradients within the kernel's horneous endosperm. This can equate to the internal cracks that appear when dropping an ice cube into a lukewarm beverage. The internal stresses do not build up as much in the soft, floury endosperm as in the hard, horneous endosperm; therefore, corn with a higher percentage of horneous endosperm is more susceptible to stress cracking than softer grain. A kernel may vary in severity of stress cracking and can have one, two or multiple stress cracks. The most common cause of stress cracks is high-temperature drying that rapidly removes moisture. The impact of high levels of stress cracks on various uses includes:

- General: Increased susceptibility to breakage during handling. This may lead to processors needing to remove more broken corn during cleaning operations and a possible reduction in grade or value.
- Wet Milling: Lower starch yields due to the increased difficulty in separating starch and protein. Stress cracks may also alter steeping requirements.
- Dry Milling: The lower yield of large flaking grits (the prime product of many dry milling operations).
- Alkaline Cooking: A method of non-uniform water absorption leading to overcooking or undercooking, which affects the process balance.

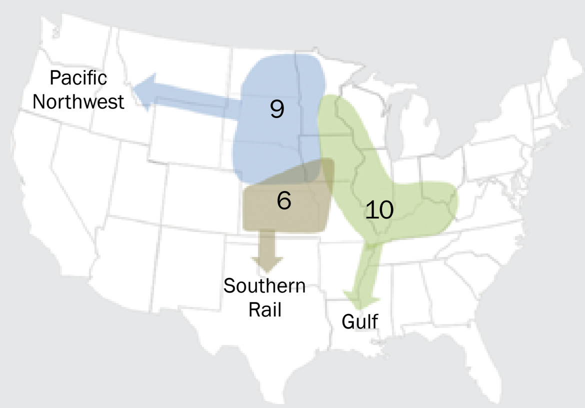
Growing conditions will affect crop maturity, timeliness of harvest and the need for artificial drying, which will influence the degree of stress cracking found from region to region. For example, late maturity or late harvest caused by weather-related factors, such as rain-delayed planting or cool temperatures, may increase the need for artificial drying, thus potentially increasing the occurrence of stress cracks.

Results

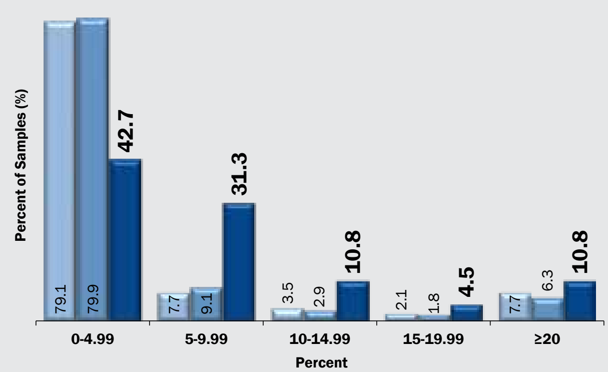
- U.S. Aggregate stress cracks in 2019 averaged 9%, which was higher than in 2018, 2017 and the 5YA (all 5%).
- U.S. Aggregate stress cracks standard deviation in 2019 (7%) was similar to 2018 (6%), 2017 (8%) and the 5YA (7%).
- Stress cracks in 2019 ranged from 0 to 95%, compared to 0 to 88% in 2018 and 0 to 90% in 2017.
- The percentage of samples with less than 10.0% stress cracks in 2019 (74.0%) was lower than in 2018 (89.0%) and 2017 (86.8%). Also, in 2019, 10.8% of the samples had stress cracks above 20.0%, which is higher than in 2018 (6.3%) and 2017 (7.7%). Stress crack distributions indicate that 2019 corn should be higher in breakage susceptibility than 2018 and 2017.
- Stress crack averages in 2019 for Gulf, Pacific Northwest and Southern Rail ECAs were 10, 9 and 6%, respectively. Among all ECAs, the Southern Rail had the lowest stress cracks in 2019, 2018, 2017 and the 5YA.
- Much of the 2019 crop was planted up to a month later than normal, resulting in a later harvest with slow late-season dry-down conditions. This led to higher moistures at harvest and increased need for artificial drying, resulting in the potential for higher stress cracks than in previous years. Average moistures (17.5%) were above those of 2018, 2017 and the 5YA.

STRESS CRACKS (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg (%)	Std Dev (%)
2019	9	7
2018	5	6
2017	5	8

100-Kernel Weight

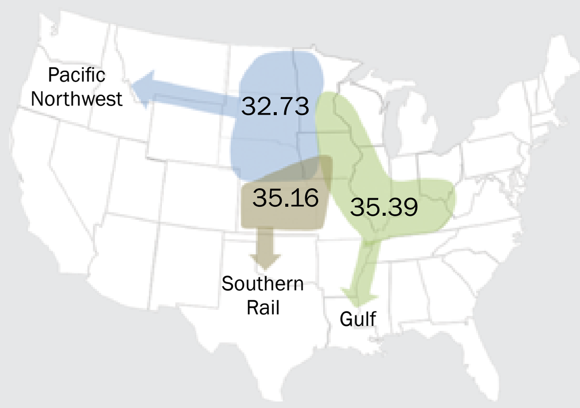
100-kernel (100-k) weight, reported in grams (g), indicates a larger kernel size as 100-k weight increases. Kernel size affects drying rates. As the kernel size increases, the volume-to-surface-area ratio becomes higher, and as the ratio gets higher; drying becomes slower. In addition, large, uniform-sized kernels often enable higher flaking grit yields in dry milling. Kernel weights tend to be higher for specialty varieties of corn that have high amounts of horneous (hard) endosperm.

Results

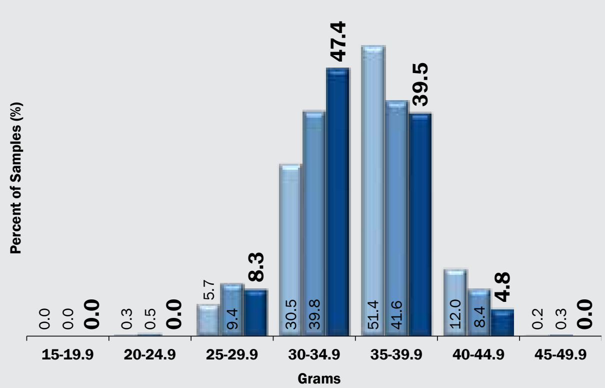
- U.S. Aggregate 100-k weight in 2019 averaged 34.60 g, lower than 2018 (35.07 g), 2017 (36.07 g) and the 5YA (34.94 g).
- Variability in the 2019 U.S. Aggregate 100-k weight (standard deviation of 2.48 g) was lower than 2018 (2.84 g), 2017 (2.53 g) and the 5YA (2.61 g).
- Range in 100-k weight in 2019 (25.11 to 43.93 g) was less than 2018 (23.86 to 45.88 g) and 2017 (23.06 to 46.44 g).
- The 100-k weights in 2019 were distributed with 44.3% of the samples having a 100-k weight of 35.0 g or greater, compared to 50.3% in 2018 and 63.6% in 2017. This distribution indicates a lower percentage of large kernels was found in 2019 as compared to 2018 and 2017.
- The average 100-k weight was lowest for the Pacific Northwest ECA (32.73 g), compared to the Gulf (35.39 g) and Southern Rail (35.16 g) ECAs. The Pacific Northwest ECA had the lowest 100-k weight in 2019, 2018, 2017 and the 5YA.

100-K WEIGHT (g)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg (g)	Std Dev (g)
2019	34.60	2.48
2018	35.07	2.84
2017	36.07	2.53

Kernel Volume

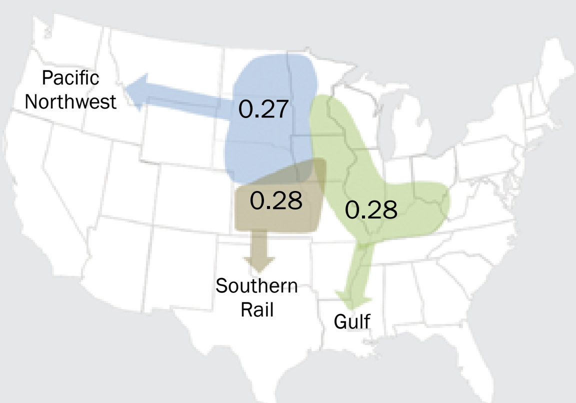
Kernel volume, measured in cubic centimeters (cm^3), is often indicative of growing conditions. If conditions are dry, kernels may be smaller than average. If a drought hits later in the season, kernels may have lower fill. Small or round kernels are more difficult to degerm. Additionally, small kernels may lead to increased cleanout losses for processors and higher yields of fiber.

Results

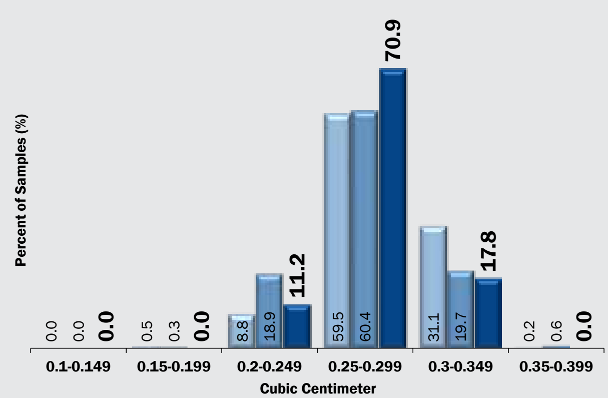
- U.S. Aggregate kernel volume averaged 0.28 cm^3 in 2019, same as 2018 and 5YA, but lower than 2017 (0.29 cm^3).
- Kernel volume variability was constant across the years. The standard deviation for U.S. Aggregate kernel volume was 0.02 cm^3 for 2019, 2018, 2017 and the 5YA.
- Kernel volume range in 2019 (0.22 to 0.34 cm^3) was similar to 2018 (0.19 to 0.36 cm^3) and 2017 (0.18 to 0.36 cm^3).
- The kernel volumes in 2019 were distributed, with 17.8% of the samples having kernel volumes of 0.30 cm^3 or greater, compared to 2018 (20.3%) and 2017 (31.3%). This distribution indicates there was a lower percentage of large kernels in 2019 compared to 2018 and 2017.
- Kernel volume for the Gulf, Pacific Northwest and Southern Rail ECAs averaged 0.28, 0.27 and 0.28 cm^3, respectively. Among the ECAs, the Pacific Northwest ECA had the lowest average kernel volume in 2019, 2018, 2017 and the 5YA.

KERNEL VOLUME (cm^3)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg (cm^3)	Std Dev (cm^3)
2019	0.28	0.02
2018	0.28	0.02
2017	0.29	0.02

Kernel True Density

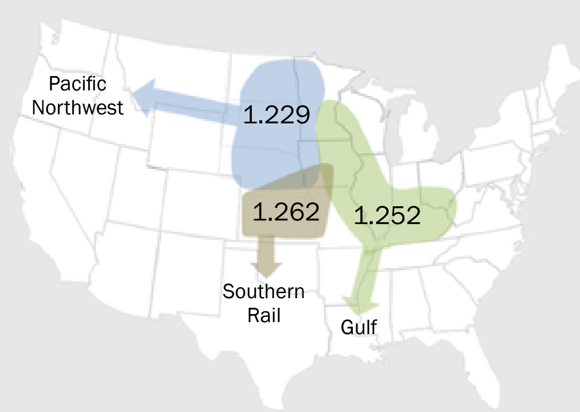
Kernel true density is calculated as the weight of a 100-k sample divided by the volume, or displacement, of those 100 kernels and reported as grams per cubic centimeter (g/cm³). True density is a relative indicator of kernel hardness, which is useful for alkaline processors and dry millers. True density may be affected by the genetics of the corn hybrid and the growing environment. Corn with a higher density is typically less susceptible to breakage in handling than lower density corn but is also more at risk for the development of stress cracks if high-temperature drying is employed. True densities above 1.30 g/cm³ indicate very hard corn, which is typically desirable for dry milling and alkaline processing. True densities near the 1.275 g/cm³ level and below tend to be softer and process well for wet milling and feed use.

Results

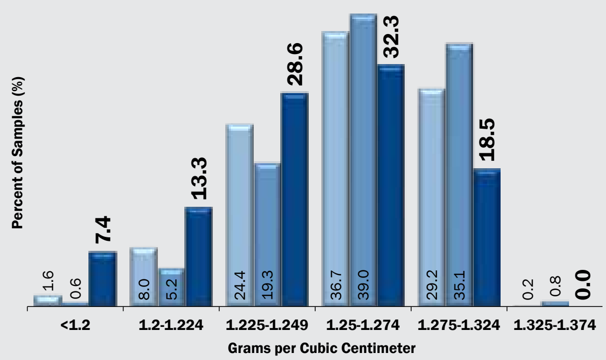
- Average U.S. Aggregate kernel true density in 2019 (1.247 g/cm³) was lower than 2018 (1.265 g/cm³), 2017 (1.260 g/cm³) and the 5YA (1.259 g/cm³). Over the past nine years, true densities have tended to be higher in years with higher protein.
- Variability, based on the standard deviation, in 2019 (0.021 g/cm³) was higher than 2018, 2017 and the 5YA (all 0.018 g/cm³).
- True densities in 2019 ranged from 1.116 to 1.322 g/cm³ compared to 2018 (1.167 to 1.374 g/cm³) and 2017 (1.135 to 1.332 g/cm³).
- About 18.5% of the 2019 samples had true densities at or above 1.275 g/cm³ compared to 35.9% in 2018 and 29.4% in 2017. Since corn with values above 1.275 g/cm³ is often considered to represent hard corn and values below 1.275 g/cm³ are often considered to represent soft corn, this kernel distribution indicates softer corn in 2019 than in 2018 and 2017.
- Kernel true densities for the Gulf, Pacific Northwest and Southern Rail ECAs averaged 1.252, 1.229 and 1.262 g/cm³, respectively. The Pacific Northwest ECA's average true density and test weight were lower than the other ECAs' values in 2019, 2018, 2017 and the 5YA.

KERNEL TRUE DENSITY (g/cm³)

EXPORT CATCHMENT AREA AVERAGE

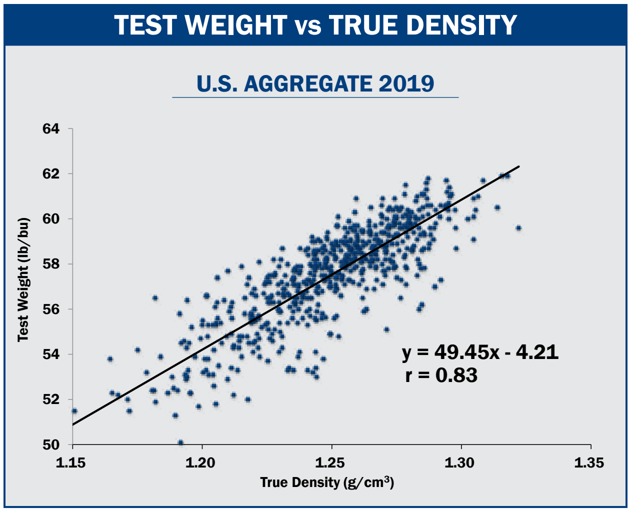


U.S. AGGREGATE



	Avg (g/cm³)	Std Dev (g/cm³)
2019	1.247	0.021
2018	1.265	0.018
2017	1.260	0.018

- Test weight, also known as bulk density, is based on the amount of mass contained in a quart cup. While test weight is influenced by true density, as shown in the adjacent figure (resulting in a correlation coefficient of 0.83), it is also affected by moisture content, pericarp damage (whole kernels), breakage and other factors. In 2019, test weight was 57.3 lb/bu, which was lower than 2018 and 2017 (both 58.4 lb/bu). Thus, both true density and bulk density averages were lower in 2019 than in the two previous years and 5YA.



Whole Kernels

Though the name suggests some inverse relationship between whole kernels and BCFM, the whole kernels test conveys different information than the broken corn portion of the BCFM test. Broken corn is defined solely by the size of the material. Whole kernels, as the name implies, is the percent of fully intact kernels in the sample with no pericarp damage or kernel pieces chipped away.

The exterior integrity of the corn kernel is very important for two key reasons. First, it affects water absorption for alkaline cooking and steeping operations. Kernel nicks or pericarp cracks allow water to enter the kernel faster than intact or whole kernels. Too much water uptake during cooking can result in loss of soluble, non-uniform cooking, expensive shutdown time, or products that do not meet specifications. Some companies pay contracted premiums for corn delivered above a specified level of whole kernels.

Second, intact whole kernels are less susceptible to storage molds and breakage in handling. While hard endosperm lends itself to the preservation of more whole kernels than soft corn, the primary factor in delivering whole kernels is harvesting and handling. This begins with proper combine adjustment followed by the severity of kernel impacts due to conveyors and the number of handlings required from the farm field to the end-user. Each subsequent handling will generate additional breakage. Actual amounts of breakage increase exponentially as moisture decreases, drop heights increase, or a kernel's velocity at impact increases.[4] In addition, harvesting at the higher moisture content (e.g., greater than 25%) will usually lead to soft pericarps and more pericarp damage to corn than when harvesting at lower moisture levels.

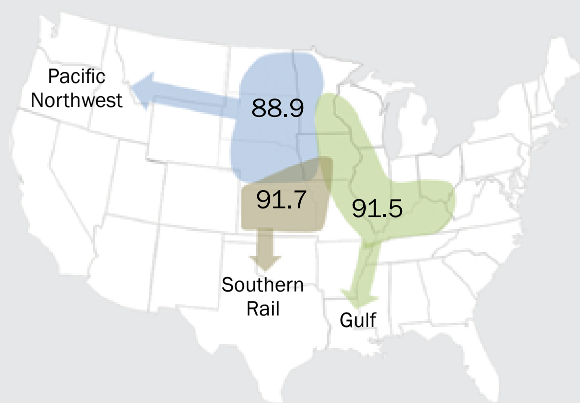
[4] *Foster, G. H. and L. E. Holman. 1973. Grain Breakage Caused by Commercial Handling Methods. USDA. ARS Marketing Research Report Number 968.*

Results

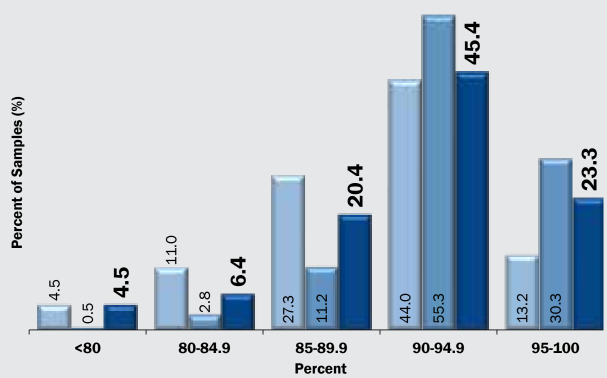
- U.S. Aggregate whole kernels averaged 90.8% in 2019, lower than 2018 (93.0%) and the 5YA (93.3%), but higher than 2017 (89.9%),
- The 2019 whole kernel standard deviation (4.2%) was higher than in 2018 (3.0%) and the 5YA (3.3%), but lower than in 2017 (4.6%).
- Whole kernel range in 2019 (25.4 to 99.6%) was much greater than 2018 (66.0 to 98.6%) and 2017 (67.0 to 99.2%).
- Of the 2019 samples, 68.7% had 90.0% or higher whole kernels, compared to 2018 (85.6%) and 2017 (57.2%). This distribution indicates that 2019 had a lower percentage of whole kernels than the samples in 2018.
- Whole kernel averages for Gulf, Pacific Northwest and Southern Rail ECAs were 91.5, 88.9 and 91.7%, respectively.

WHOLE KERNELS (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE



	Avg (%)	Std Dev (%)
2019	90.8	4.2
2018	93.0	3.0
2017	89.9	4.6

Horneous (Hard) Endosperm

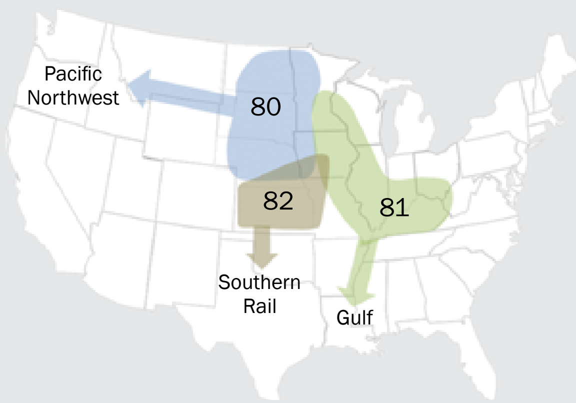
The horneous (hard) endosperm test measures the percent of horneous or hard endosperm out of the total endosperm in a kernel, with a potential value from 70 to 100%. The greater the amount of horneous endosperm relative to soft endosperm, the harder the corn kernel is said to be. The degree of hardness is important, depending on the type of processing. A hard kernel is needed to produce high yields of large flaking grits in dry milling. Desired hardness is hard to medium for alkaline cooking, and desired hardness is medium to soft for wet milling and livestock feeding. Hardness correlated to breakage susceptibility, feed utilization/efficiency and starch digestibility.

As a test of overall hardness, there is no good or bad value for horneous endosperm. There is only a preference by different end-users for particular ranges. Many dry millers and alkaline cookers would like greater than 85% horneous endosperm, while wet millers and feeders would typically like values from 70 to 85%. However, there are certainly exceptions in user preference.

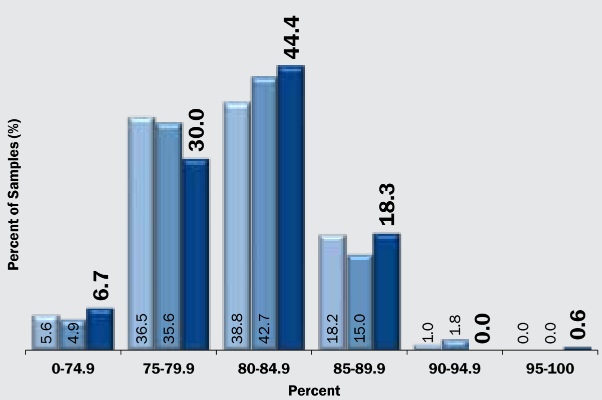
Beginning with the *2019/2020 Harvest Report*, only the samples tested for the mycotoxin would be tested for horneous endosperm. This quality factor's relative margin of error had never exceeded 0.4% in the samples tested from the eight previous reports when all samples were tested for this quality factor. Thus, reducing the number of samples tested for horneous endosperm would likely keep the precision of this quality factor's estimates well below the targeted level of ±10.0%. See the "Survey and Statistical Analysis Methods" section for more information regarding the relative margin of error calculations for the quality factors.

HORNEOUS ENDOSPERM (%)

EXPORT CATCHMENT AREA AVERAGE



U.S. AGGREGATE

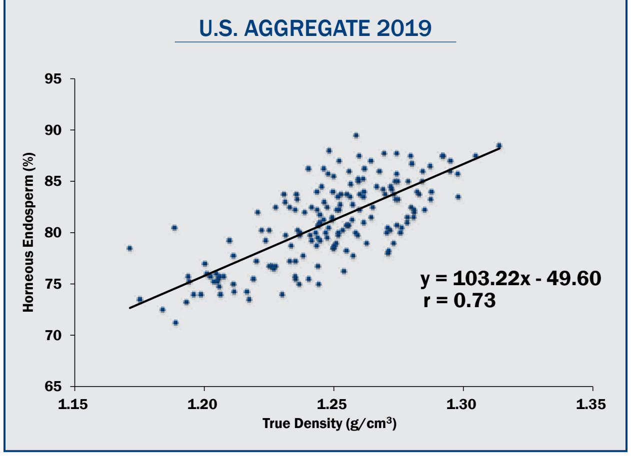


	Avg (%)	Std Dev (%)
2019	81	3
2018	81	3
2017	81	4

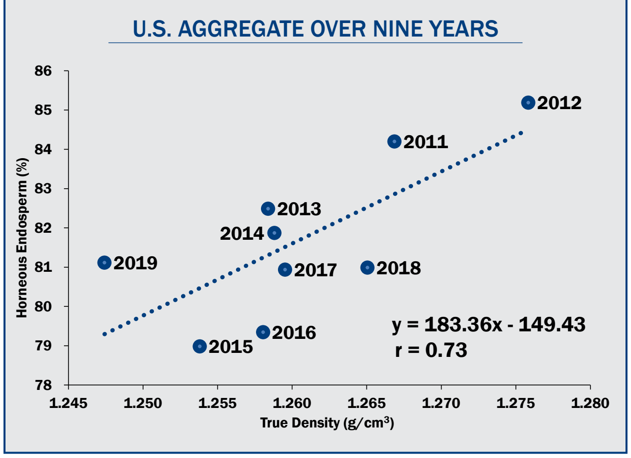
Results

- Average U.S. Aggregate horneous endosperm in 2019 (81%) was the same as 2018 and 2017 (both 81%) and higher than the 5YA (80%).
- U.S. Aggregate standard deviation for horneous endosperm was 3% in 2019 and 2018, but lower than in 2017 and the 5YA (both 4%).
- The 2019 horneous endosperm range (71 to 96%) was similar to 2018 (72 to 92%) and 2017 (71 to 92%).
- Of the 2019 samples, 63.3% contained more than 80% horneous endosperm, which was a higher percentage than in 2018 (59.5%) and 2017 (58.0%). This indicates 2019 had more kernels with hard endosperm than the two previous years.
- Average horneous endosperm for the Gulf, Pacific Northwest and Southern Rail ECAs was 81, 80 and 82%, respectively. The Southern Rail ECA has had the highest or tied for the highest average horneous endosperm in 2019, 2018, 2017 and 5YA among all ECAs.
- The first figure shows a weak but positive relationship (r = 0.73) between horneous endosperm and true density for the 2019 samples.
- The next figure shows the average U.S. Aggregate horneous endosperm and true density values over the past nine years. This illustrates that the average U.S. Aggregate horneous endosperm increases with true density (with a correlation coefficient of r = 0.73). Thus, horneous endosperm tends to be higher in years when average true density is higher.

HORNEOUS ENDOSPERM vs TRUE DENSITY



HORNEOUS ENDOSPERM vs TRUE DENSITY



SUMMARY: PHYSICAL FACTORS

	2019 Harvest					2018 Harvest			2017 Harvest			Five-Year Average (2014-2018)	
	No. of Samples[1]	Avg.	Std. Dev.	Min.	Max.	No. of Samples[1]	Avg.	Std. Dev.	No. of Samples[1]	Avg.	Std. Dev.	Avg.	Std. Dev.
U.S. Aggregate						**U.S. Aggregate**			**U.S. Aggregate**			**U.S. Aggregate**	
Stress Cracks (%)	623	9	7	0	95	618	5*	6	627	5*	8	5	7
100-Kernel Weight (g)	623	34.60	2.48	25.11	43.93	618	35.07*	2.84	627	36.07*	2.53	34.94	2.61
Kernel Volume (cm^3)	623	0.28	0.02	0.22	0.34	618	0.28	0.02	627	0.29*	0.02	0.28	0.02
True Density (g/cm^3)	623	1.247	0.021	1.116	1.322	618	1.265*	0.018	627	1.260*	0.018	1.259	0.018
Whole Kernels (%)	623	90.8	4.2	25.4	99.6	618	93.0*	3.0	627	89.9*	4.6	93.3	3.3
Horneous Endosperm (%)	180	81	3	71	96	618	81	3	627	81	4	80	4
Gulf						**Gulf**			**Gulf**			**Gulf**	
Stress Cracks (%)	594	10	9	0	95	587	4*	5	612	6*	8	5	7
100-Kernel Weight (g)	594	35.39	2.60	26.61	43.93	587	35.74*	2.86	612	36.94*	2.45	35.55	2.63
Kernel Volume (cm^3)	594	0.28	0.02	0.22	0.34	587	0.28	0.02	612	0.29*	0.02	0.28	0.02
True Density (g/cm^3)	594	1.252	0.019	1.116	1.322	587	1.266*	0.017	612	1.262*	0.018	1.261	0.018
Whole Kernels (%)	594	91.5	3.8	58.0	99.6	587	93.1*	3.0	612	90.0*	4.7	93.4	3.3
Horneous Endosperm (%)	170	81	3	71	96	587	81	3	612	81	4	80	4
Pacific Northwest						**Pacific Northwest**			**Pacific Northwest**			**Pacific Northwest**	
Stress Cracks (%)[2]	318	9	7	0	58	288	7*	8	291	5*	7	5	6
100-Kernel Weight (g)	318	32.73	2.19	25.11	42.33	288	32.97	2.67	291	33.39*	2.68	32.86	2.48
Kernel Volume (cm^3)	318	0.27	0.02	0.22	0.34	288	0.26*	0.02	291	0.27	0.02	0.26	0.02
True Density (g/cm^3)	318	1.229	0.025	1.116	1.316	288	1.257*	0.018	291	1.249*	0.018	1.251	0.018
Whole Kernels (%)	318	88.9	5.2	25.4	99.0	288	92.9*	3.1	291	89.4	4.8	93.1	3.5
Horneous Endosperm (%)	95	80	3	73	90	288	81*	3	291	81*	4	80	3
Southern Rail						**Southern Rail**			**Southern Rail**			**Southern Rail**	
Stress Cracks (%)	324	6	5	0	95	355	3*	4	393	4*	6	4	5
100-Kernel Weight (g)	324	35.16	2.54	27.21	42.74	355	35.59*	2.98	393	36.26*	2.65	35.42	2.69
Kernel Volume (cm^3)	324	0.28	0.02	0.22	0.34	355	0.28	0.02	393	0.29*	0.02	0.28	0.02
True Density (g/cm^3)	324	1.262	0.018	1.182	1.322	355	1.274*	0.019	393	1.265*	0.018	1.264	0.018
Whole Kernels (%)	324	91.7	3.8	58.0	99.6	355	92.8*	2.7	393	90.0*	4.3	93.3	3.1
Horneous Endosperm (%)	91	82	3	73	96	355	82	3	393	81*	3	81	4

**Indicates average was significantly different from 2019, based on a 2-tailed t-test at the 95.0% level of significance.*

[1]Due to the ECA results being composite statistics, the sum of the sample numbers from the three ECAs is greater than the U.S. Aggregate.

[2]The Relative ME for predicting the harvest population average exceeded ±10.0%.

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. Aflatoxin, DON and fumonisin are considered to be three of the most common mycotoxins found in corn.

As in the previous *Harvest Reports*, a subset of the 2019 harvest samples was tested for aflatoxin and DON. In the *2019/2020 Harvest Report*, fumonisins were added to the list of mycotoxins tested. The *2019/2020 Harvest Report* now includes three mycotoxins: aflatoxin, DON and fumonisin. Since the production of mycotoxins is heavily influenced by growing conditions, the objective of the *Harvest Report* is strictly to report on instances when aflatoxin, DON or fumonisin are detected in the corn crop at harvest.

The *Harvest Report* review of mycotoxins is not intended to predict the presence or level at which mycotoxins might appear in U.S. corn 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 corn exports are less than what might first appear in the corn 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 the 12 states or three ECAs surveyed. The *Harvest Report's* results should be used only as one indicator of the potential for mycotoxin presence in the corn as the crop comes out of the field. As the Council accumulates several years of *Harvest Reports*, patterns of mycotoxin presence in corn at harvest will be seen year-to-year. The *2019/2020 Corn Export Cargo Quality Report* will report corn quality at export points and will be a more accurate indication of mycotoxin presence in the 2019/2020 U.S. corn export shipments.

Background: Mycotoxins General

The fungus type and the environmental conditions under which the corn is produced and stored impact the levels at which fungi produce mycotoxins. Because of these differences, mycotoxin production varies across the U.S. corn-producing areas and years. In some years, the growing conditions across the corn-producing regions might not produce elevated levels of any mycotoxins. In other years, the environmental conditions in a particular area might be conducive to the production of a particular mycotoxin to levels that impact the corn'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 aflatoxin, advisory levels for DON and fumonisin 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 or court action if a toxin or contaminant is present at levels exceeding the action level if the agency chooses to do so. If imports 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 guide 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" found at https://drive.google.com/file/d/1tqeS5_eOtsRmxZ5RrTnYu7NCIr896KGX/view.

Background: Aflatoxin

The most important type of mycotoxin associated with corn is aflatoxin. There are several types of aflatoxin produced by different species of *Aspergillus*, with the most prominent species being *A. flavus*. The growth of the fungus and aflatoxin contamination of grain can occur in the field before harvest or in storage. However, contamination before 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. It can be a serious problem in the southern United States, where hot and dry conditions are common. The fungus usually attacks only a few kernels on the ear and often penetrates kernels through wounds produced by insects. Under drought conditions, it also grows down silks into individual kernels.

There are four types of aflatoxin naturally found in foods – aflatoxins B1, B2, G1 and G2, commonly referred to as “aflatoxin” or “total aflatoxin.” 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 will metabolize B1 to a different form of aflatoxin called aflatoxin M1, which may accumulate in milk.

Aflatoxin expresses 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 aflatoxin, possibly resulting in death for poultry, 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 aflatoxin.

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

The FDA has established additional policies and legal provisions concerning the blending of corn with levels of aflatoxin exceeding these threshold levels. In general, the FDA currently does not permit corn blended to reduce the aflatoxin content to be sold in general commerce.

Unless the contract exempts it, corn exported from the United States must be tested by FGIS for aflatoxin according to federal law. Corn above the FDA action level of 20.0 ppb cannot be exported unless other strict conditions are met. This results in relatively low levels of aflatoxin in exported grain.

Aflatoxin Action Level	Criteria
20.0 parts per billion	Dairy animals, pets of all ages, immature animals (including immature poultry) and when the animal’s destination is not known
100.0 parts per billion	Breeding beef cattle, breeding swine and mature poultry
200.0 parts per billion	Finishing swine of 100 pounds or greater
300.0 parts per billion	Finishing (i.e., feedlot) beef cattle

Source: www.ngfa.org

Background: Deoxynivalenol (DON or Vomitoxin)

DON is another mycotoxin of concern to some importers of corn. It is produced by certain species of *Fusarium*, the most important of which is *Fusarium graminearum* (*Gibberellazeae*), which also causes Gibberella ear rot (or red ear rot). *Gibberellazeae* can develop when cool or moderate temperatures and wet weather occur at flowering. The fungus grows down the silks into the ear. In addition to producing DON, it produces conspicuous red discoloration of kernels on the ear. The fungus can also continue to grow and rot ears when corn is left standing in the field. Mycotoxin contamination of corn caused by *Gibberellazeae* is often associated with excessive postponement of harvest or storage of high-moisture corn.

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

The FDA has issued advisory levels for DON. For products containing corn, the advisory levels are shown below.

DON Advisory Level	Criteria
5.0 parts per million	Swine, not to exceed 20% of their diet
5.0 parts per million	All other animals not otherwise listed, not to exceed 40% of their diet
10.0 parts per million	Chickens, not to exceed 50% of their diet
10.0 parts per million	Ruminating beef and dairy cattle older than four months

Source: www.ngfa.org

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

Background: Fumonisin

Fumonisins are naturally occurring mycotoxins found mostly in cereal grains, mainly corn. Fumonisins are a more recent discovery compared to aflatoxin and DON. Fumonisins are produced by several fungi of the *Fusarium* genus. The fumonisin family consists of fumonisin B1, fumonisin B2 and fumonisin B3. Fumonisin B1 is the most abundant, accounting for about 70 to 80% of total fumonisins. The main concern with fumonisins are feed contamination that can have detrimental effects, particularly to horses and pigs. Fungal and fumonisin formation occurs mainly before harvest. Insects play an important role in fumonisin contamination since they act as a wounding agent. Temperature and rainfall conditions are related to fungal growth and fumonisin contamination. In general, fumonisin contamination is related to plant stress, insect damage, drought and soil moisture. In 2001 FDA issued guidance levels for fumonisins in corn-based foods and feed to reduce human and animal exposure. FDA advisory levels are shown below.

Fumonisin Advisory Level	Criteria
5.0 parts per million	Equids (i.e., horses) and rabbits, not to exceed 20% of diet
20.0 parts per million	Swine and catfish, not to exceed 50% of diet
30.0 parts per million	Breeding ruminants, breeding poultry and breeding mink, not to exceed 50% of diet
60.0 parts per million	Ruminants older than three months raised for slaughter and mink raised for pelt production, not to exceed 50% of diet
100.0 parts per million	Poultry raised for slaughter, not to exceed 50% of diet
10.0 parts per million	All other animals not otherwise listed, not to exceed 50% of their diet

Source: www.ngfa.org

Assessing the Presence of Aflatoxin, Deoxynivalenol (DON or Vomitoxin) and Fumonisin

At least 25% of the minimum number of targeted samples (600) were tested to assess the impact of this year's growing conditions on total aflatoxin, DON and fumonisin development in the U.S. corn crop. The sampling criteria, described in the "Survey and Statistical Analysis Methods" section, resulted in a total number of 182 samples tested for mycotoxins. Details on the testing methodology employed in this study for the mycotoxins are in the "Testing Analysis Methods" section.

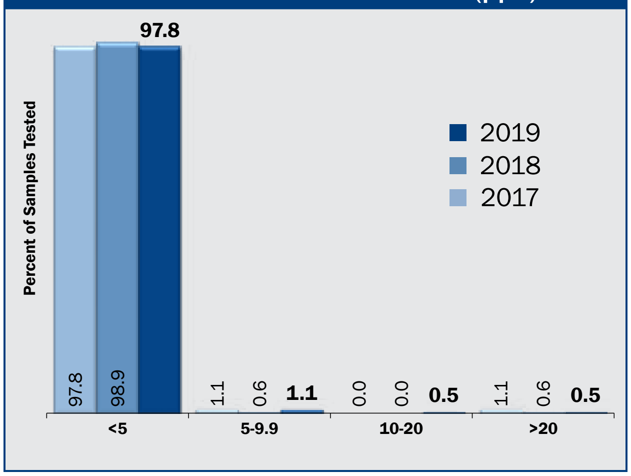
Results: Aflatoxin

A total of 182 samples were analyzed for aflatoxin in 2019, compared to 181 and 180 samples tested for aflatoxin in 2018 and 2017, respectively. Results of the 2019 survey are as follows:

- One hundred seventy-eight (178) samples, or 97.8% of the 182 samples, had no detectable levels of aflatoxin (below the FGIS lower conformance limit of 5.0 ppb). This is close to the percentage of the samples tested with no detectable levels of aflatoxin in 2018 (98.9%) and 2017 (97.8%).
- Two samples (2) or 1.1% of the 182 samples showed aflatoxin levels greater than or equal to 5.0 ppb, but less than 10.0 ppb. This percentage is almost identical to 2018 (0.6%) and 2017 (1.1%).
- One sample (1) or 0.5% of the 182 samples showed an aflatoxin level greater than or equal to 10.0 ppb, but less than or equal to the FDA action level of 20.0 ppb. This percentage is similar to both 2018 (0.0%) and 2017 (0.0%).
- One sample (1), or 0.5% of the 182 samples, showed an aflatoxin level greater than the FDA action level of 20.0 ppb. This percentage is almost identical to 2018 (0.6%) and 2017 (1.1%).
- These results denote that 181 samples, or 99.4% of the 182 sample test results in 2019, were below or equal to the FDA action level of 20.0 ppb, compared to 99.5% of the samples tested in both 2018 and 98.9% in 2017.

The relatively high percentage of this year's samples below the FGIS lower conformance limit of 5.0 ppb (97.8%) may be due, in part, to weather conditions not conducive to aflatoxin development in 2019 (see the "Crop and Weather Conditions" section for more information on 2019 growing conditions).

AFLATOXIN TESTING RESULTS (ppb)

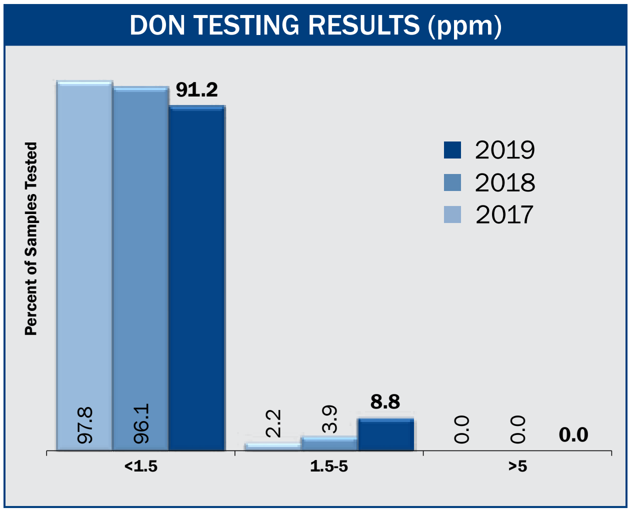


Results: Deoxynivalenol (DON or Vomitoxin)

A total of 182 samples were analyzed collectively for DON in 2019, compared to 181 and 180 samples tested for DON in 2018 and 2017, respectively. Results of the 2019 survey are as follows:

- One hundred sixty-six (166) samples, or 91.2% of the 182 samples, tested less than 1.5 ppm. This percentage for 2019 is lower than in 2018 (96.1%) and 2017 when 97.8% of the samples tested below 1.5 ppm.
- Sixteen (16) samples, or 8.8% of the 182 samples, tested greater than or equal to 1.5 ppm, but less than or equal to the FDA advisory level of 5.0 ppm. This percentage for 2019 is higher than in 2018 (3.9%) and 2017 (2.2%).
- Zero (0) samples or 0.0% of the 182 samples tested above the FDA advisory level of 5.0 ppm, which was the same as in 2018 and 2017.

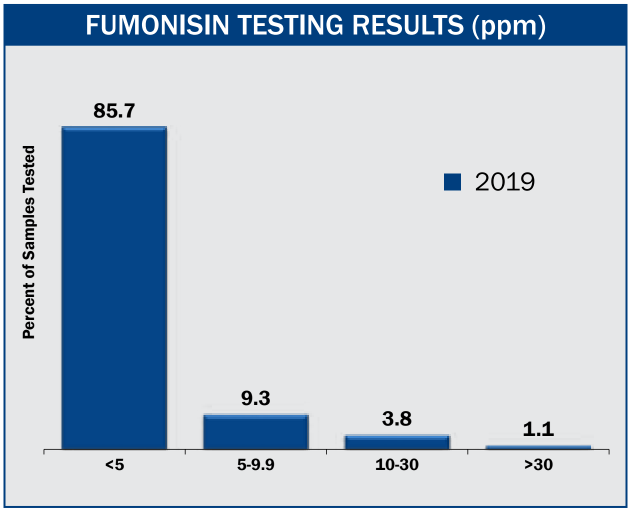
Having a lower percentage of samples in 2019 testing below 1.5 ppm than in the two previous crops may be attributed to wetter than usual weather conditions that were more conducive to DON development in 2019.



Results: Fumonisin

A total of 182 samples were analyzed collectively for fumonisin in 2019. This is the first year that survey samples have been tested for fumonisin. As a result, there are no comparisons to fumonisin results from previous years. Results of the 2019 survey are as follows:

- One hundred fifty-five (155) or 85.6% of the 182 samples tested below 5.0 ppm, the lowest advisory level for animals (equids and rabbits)
- Seventeen (17) or 9.4% of the 182 samples test greater than or equal to 5.0 ppm, but less than 10.0 ppm.
- Seven (7) or 3.9% of the 182 samples tested greater than or equal to 10.0 ppm, but not greater than 30.0 ppm.
- Two (2) or 1.1% of the 182 samples tested greater than 30.0 ppm, which is the advisory level for breeding ruminants, poultry and mink.



A. 2019 HARVEST HIGHLIGHTS

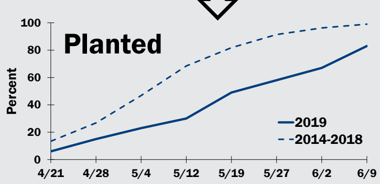
Weather plays a large role in the corn planting process, growing conditions and grain development in the field. These, in turn, impact final grain yield and quality. Overall, 2019 was characterized by a late, slow vegetative period (the period of growth between germination and pollination), an extended warm pollination time, a grain-filling period with diverse weather and a slow, intermittent harvest. This crop was planted record-late on average and experienced a rough growing season, with a 'Good-to-Excellent' crop condition rating[1] well below the 5YA. While a modest corn yield is predicted for 2019, the crop's average test weight, 100-k weight, true density and protein concentration were lower than the 5YA; while average stress cracks, broken corn and total damage were greater than the 5YA. The following highlights the key events of the 2019 growing season:

- Cold temperatures and excessive rain delayed and prolonged the planting season, up to six weeks behind the 5YA in Illinois of the Gulf ECA. But the late planting favored quick plant emergence.
- Pollination (silking stage) occurred one to two weeks later than the 5YA. July weather ranged from wet and warm in the Pacific Northwest ECA to cool and dry in the Southern Rail ECA, with the Gulf ECA being hot and dry.
- Early grain development in August was mostly cool and wet throughout the U.S. Corn Belt, promoting oil accumulation, but the eastern portion of the Gulf ECA was warm and dry.
- The second half of grain-fill in September was relatively hot for the whole region but wet in the northern Gulf and Pacific Northwest ECAs, while dry in the Southern Rail ECA, favoring horneous endosperm level.
- This year's corn crop had record slowest maturation, which delayed the start of harvest. These delays, coupled with rain and snow in October and November, forced producers to harvest corn at greater than ideal moisture levels, increasing broken corn while decreasing test weight.

The following sections describe how the 2019 growing season weather impacted corn yield and grain quality in the U.S. Corn Belt.

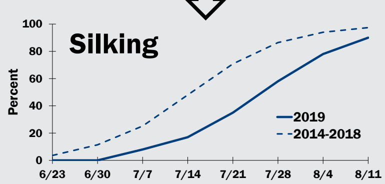
GROWING CONDITIONS AND IMPACT ON CROP DEVELOPMENT

Wet April and May led to crop's historically late planting



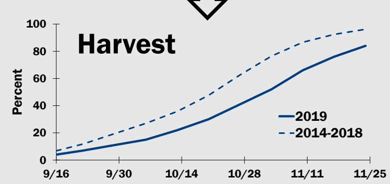
Crop compressed vegetative phase, smaller plants

Wide-range temperatures and precipitation



Favorable pollination, but cool, wet early grain-fill slowed development again

Late grain-fill was hot, but slow harvest progress with October rains



Crop harvested with higher moisture content

[1] *The USDA rates the U.S. corn crop weekly during the production cycle. The rating is based on yield potential and plant stress due to a number of factors, including extreme temperatures, excessive or insufficient moisture, disease, insect damage and/or weed pressure.*

B. PLANTING AND EARLY GROWTH CONDITIONS

Cold, wet May led to record late, prolonged planting time

Weather factors impacting corn yield and quality include the amount of precipitation and the temperature just prior to and during the corn-growing season. These weather factors interact with the corn variety planted and soil fertility. Grain yield is a function of the number of plants per acre, the number of kernels per plant, and the weight of each kernel. Cold or wet weather at planting could reduce plant numbers or hinder plant growth, which may result in lower yields per area. Some dryness at planting and early growth time are beneficial, as it promotes a deeper root system to access water better later in the season and keeps nitrogen fertilizer available for later plant growth.

Overall in 2019, planting happened in multiple phases in the U.S. Corn Belt, with many areas replanted or left unplanted due to wet conditions. There was no early planting. Plants were mostly wet and cold during vegetative growth, resulting in smaller and shorter-than-average plant size.

In the Pacific Northwest ECA, young plants experienced excessive rainfall, flooding and cold temperatures, leading to plant stress. June continued cool but drier.

The Gulf ECA was very wet in April, continuing into May, with delays in planting from a few days in the far south to over a month in the central region (Illinois). June continued wet and cold, preventing optimal growth.

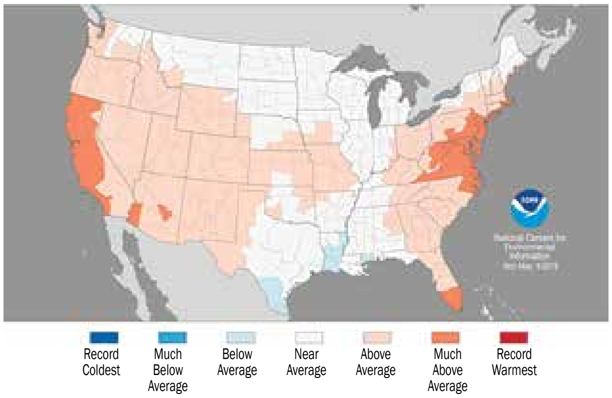
The Southern Rail ECA was also cold and wet during planting, with about a week delay on average. It was a bit drier with average temperatures during early vegetative growth, minimizing plant stress.

U.S. GRAINS COUNCIL

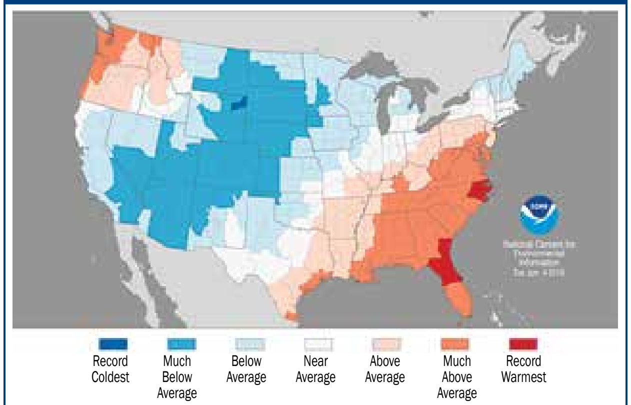
DIVISIONAL AVERAGE TEMPERATURE RANKS

(Period: 1895-2019)

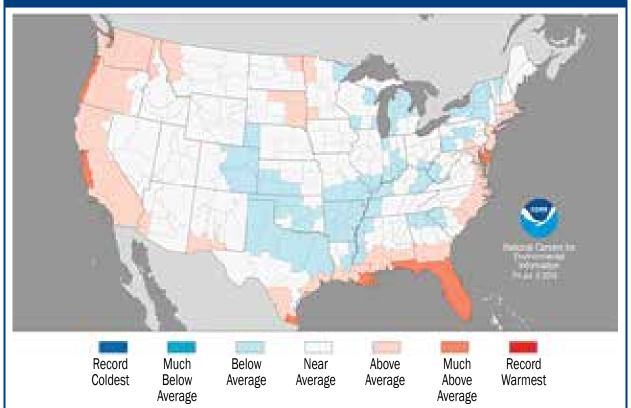
APRIL 2019



MAY 2019



JUNE 2019

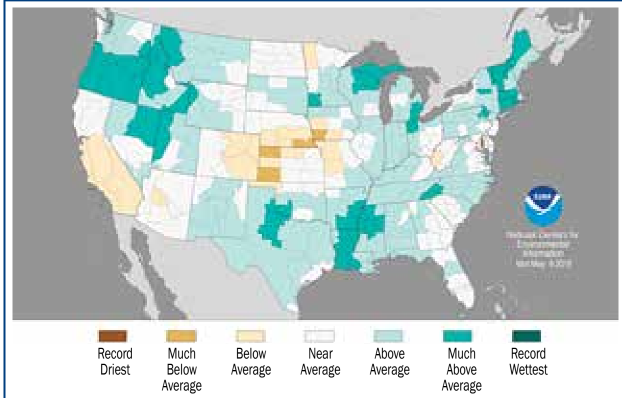


Source: NOAA/Regional Climate Centers

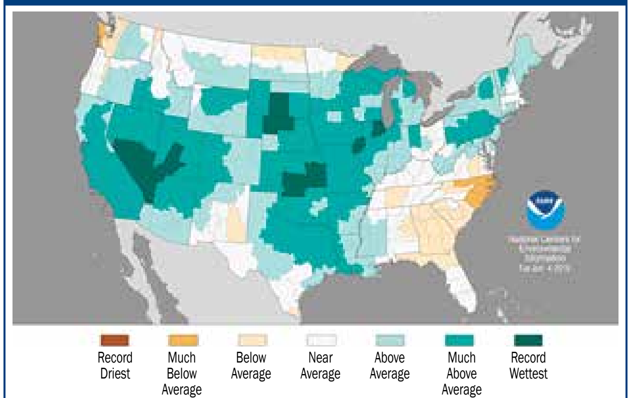
DIVISIONAL PRECIPITATION RANKS

(Period: 1895-2019)

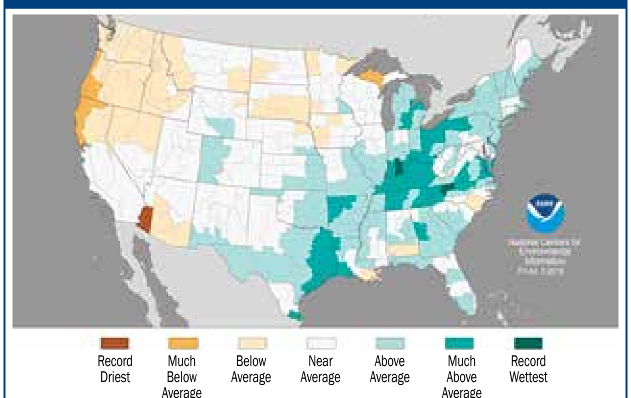
APRIL 2019



MAY 2019



JUNE 2019



Source: NOAA/Regional Climate Centers

C. POLLINATION AND GRAIN-FILL CONDITIONS

Grain-fill favored high oil and horneous endosperm

Corn pollination typically occurs in July, and at pollination time, greater-than-average temperatures or lack of rain typically reduce the number of kernels. The weather conditions during the early grain-filling period in July and August are critical to determining final grain composition. At pollination, moderate rainfall and cooler-than-average temperatures, especially overnight temperatures, lead to higher starch and oil levels and increased yields. Less rainfall and high temperatures, especially in the second half of grain-fill (August to September), lead to more protein. Nitrogen also remobilizes from the leaves to the grain during late grain-filling, leading to increases in grain protein and hard endosperm.

In 2019, the plants shortened their vegetative period, hastening pollination to occur closer to the 5YA. The weather during pollination and grain-fill cycled between heat stress and cool, with regions experiencing a range of precipitation, from drought in the southeastern Corn Belt to flooding in the northern Gulf and Pacific Northwest ECAs. The cool temperatures in August again slowed grain development maturation, but September changed to record heat for late grain-fill, promoting greater horneous endosperm levels.

In the Pacific Northwest ECA, July and August provided wet to cool temperatures during pollination and early grain-fill, favoring grain oil accumulation. However, the abundant rainfall led to lower protein concentrations than the 5YA.

In contrast, the Gulf ECA was relatively hot and dry during pollination in July, with early grain-filling in August turning cooler with more rain in the southern regions. In September, the heat stress was accompanied by a drought in the southern portion of the ECA, while the northern areas received excessive rain.

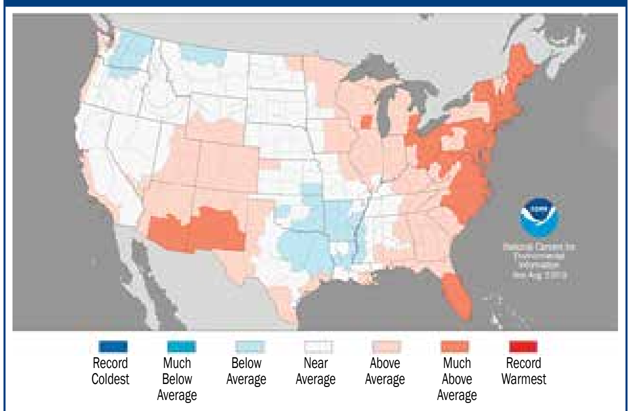
Overall, the Southern Rail ECA was dry and cool for pollination. The ECA received abundant rains in August before the record heat in September. Growing conditions in the Southern Rail ECA were conducive to test weight and oil concentration.

U.S. GRAINS COUNCIL

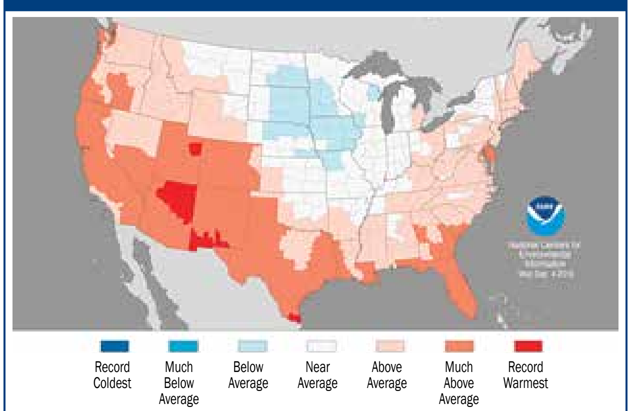
DIVISIONAL AVERAGE TEMPERATURE RANKS

(Period: 1895-2019)

JULY 2019



AUGUST 2019

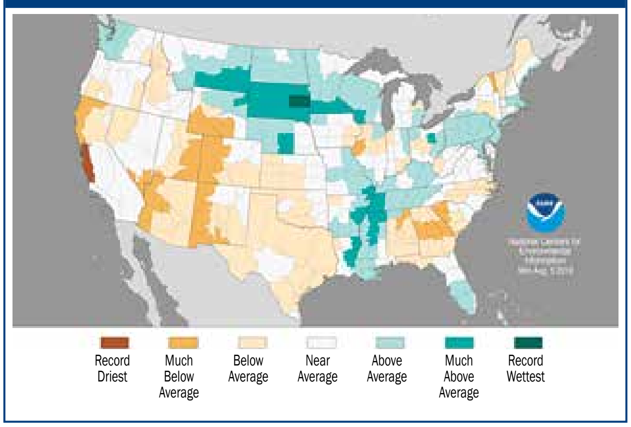


Source: NOAA/Regional Climate Centers

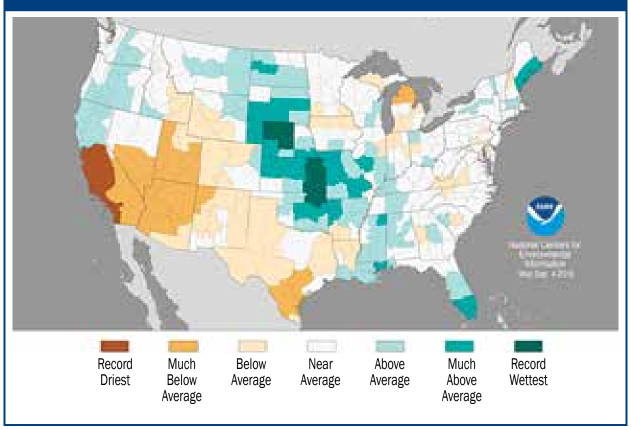
DIVISIONAL PRECIPITATION RANKS

(Period: 1895-2019)

JULY 2019



AUGUST 2019



Source: NOAA/Regional Climate Centers

D. HARVEST CONDITIONS

Slow, wet harvest

Corn grain at maturity ranges from 25 to 40% moisture. At the end of the growing season, the rate of dry-down of the grain to the ideal level of 15 to 20% moisture depends on sunshine, temperature, humidity and soil moisture. Corn can most effectively dry down with the least adverse impact on quality amid sunny, warm and dry days. One weather concern at the end of the growing season is freezing temperatures. Early freezing before the grain can sufficiently dry down may lead to lower yield, true density and test weight. Also, if harvested prematurely, higher moisture grain may be susceptible to more stress cracks and greater breakage than drier grain.

Typically, 20% of the U.S. corn crop is harvested by the start of October. However, in 2019 less than half of the crop was even mature at this time and only approximately 10% was harvested. Therefore, a greater-than-average percentage of the crop was still in the fields when rains returned in October, especially in the Gulf and Pacific Northwest ECAs, slowing harvest. While the majority of the crop was mature before typical freezing weather and snows, the cold, wet weather did not aid natural grain dry-down. Therefore, corn was harvested in the Gulf and Pacific Northwest ECAs at higher than average moisture levels, affecting both initial test weights and causing greater than average broken corn.

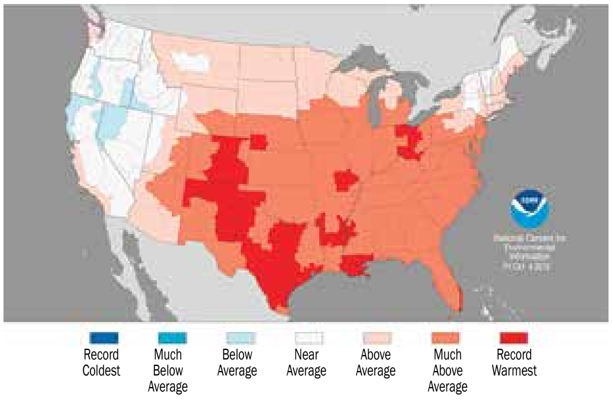
Fusarium-based ear mold (Gibberella ear rot) is promoted by cool and/or wet conditions soon after pollination. July 2019 was warm during pollination but was cool and wet in much of the Corn Belt at early grain development, potentially increasing *Fusarium* infection. The mycotoxin fumonisin that is produced by *Fusarium* is associated with prolonged periods of heavy rains and high relative humidity during grain-fill, along with temperatures between 10 to 30 degrees Celsius, with temperature fluctuations fostering fumonisin production. The 2019 crop did not have the necessary intra-day temperature fluctuations during grain-fill. The days and nights were both cool for early grain-fill changing to warm-hot for later stages. The mycotoxin deoxynivalenol (DON) vomitoxin that is also produced by *Fusarium* is often associated with harvest delay or storage of high-moisture corn. The 2019 crop had a greatly delayed harvest of relatively high-moisture corn, but the artificial drying will minimize DON accumulation.

Additionally, aflatoxin production by the *Aspergillus* family of molds is favored by hot temperatures, low precipitation and drought conditions followed by periods of high humidity. While it was hot throughout the corn-growing region during late grain-fill, most of the 2019 crop had ample water supply. Therefore, based on weather, aflatoxin should not be a problem this year.

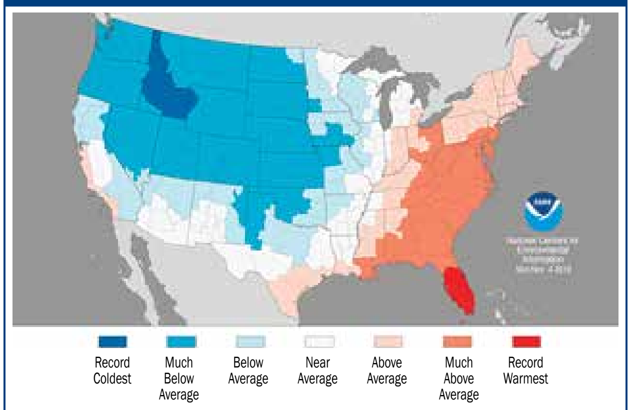
DIVISIONAL AVERAGE TEMPERATURE RANKS

(Period: 1895-2019)

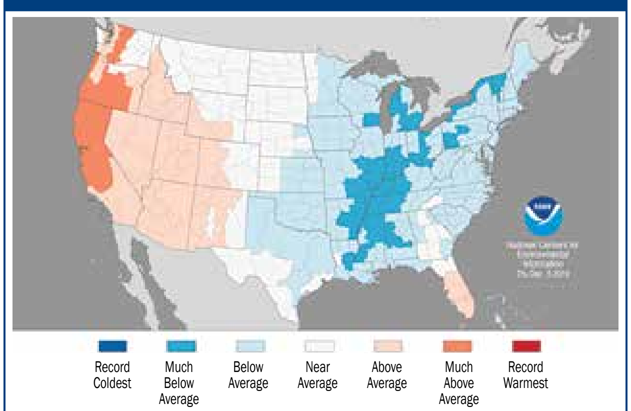
SEPTEMBER 2019



OCTOBER 2019



NOVEMBER 2019

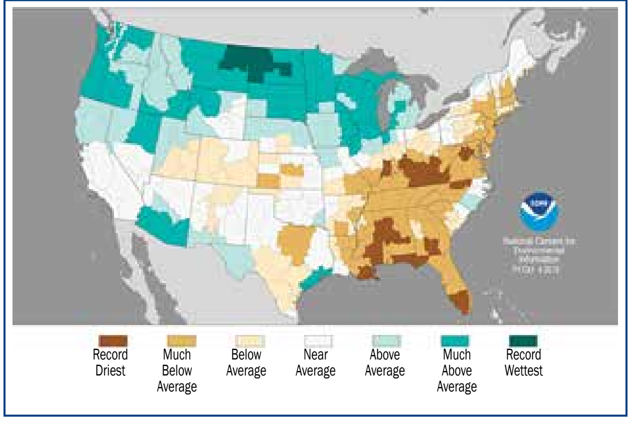


Source: NOAA/Regional Climate Centers

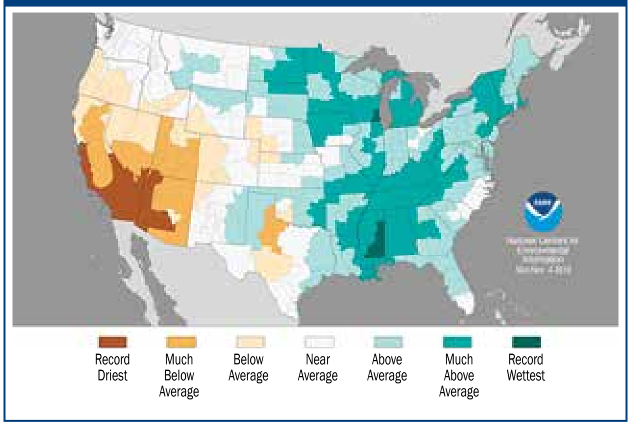
DIVISIONAL PRECIPITATION RANKS

(Period: 1895-2019)

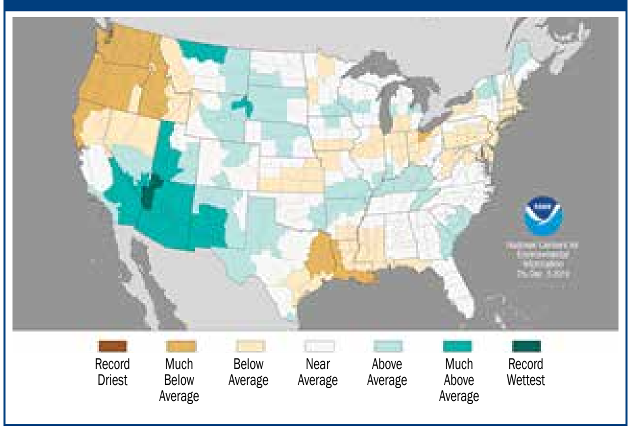
SEPTEMBER 2019



OCTOBER 2019



NOVEMBER 2019

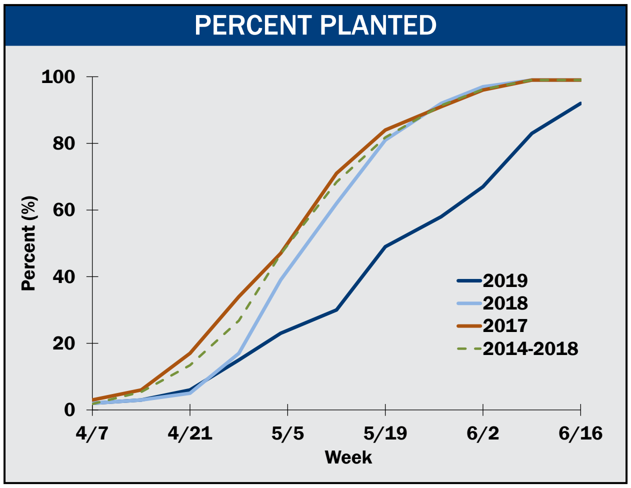


Source: NOAA/Regional Climate Centers

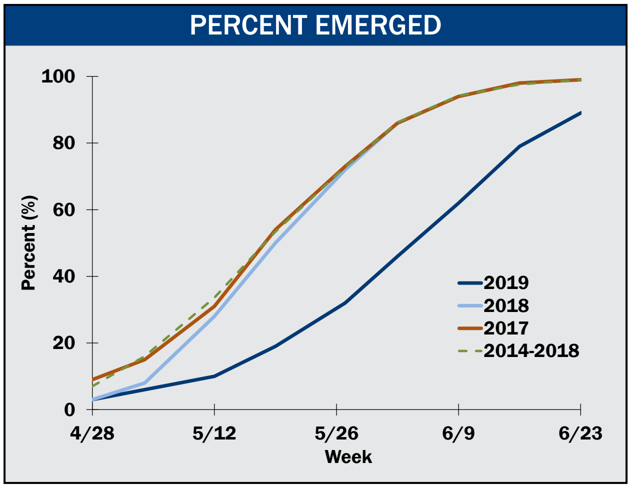
E. COMPARISON OF 2019 TO 2018, 2017 AND THE 5YA

2019 crop developed slowly under stress

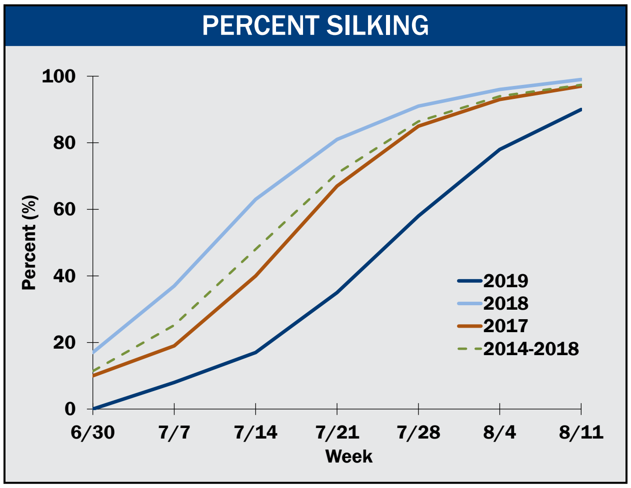
The crop in 2017 required a large proportion of replanting due to a wet spring. Cold weather in 2018 delayed planting slightly from the 5YA pace. In contrast, planting of the 2019 crop was greatly delayed throughout May into June, with a large area prevented from planting due to wet conditions.



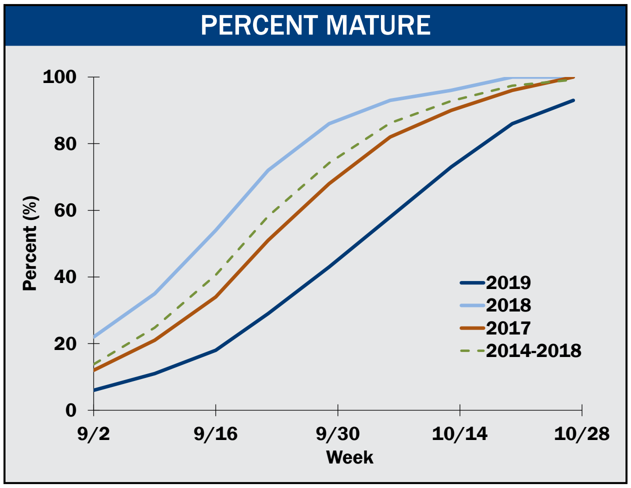
Warm weather in 2017 and 2018 led to near-5YA emergence, while 2019 lagged by two to three weeks. Vegetative growth in 2017 and 2018 was faster than the 5YA, prompted by warm weather.



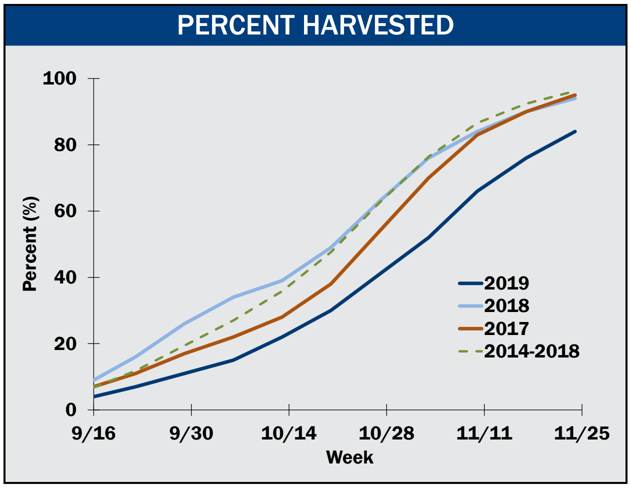
Rains mostly tapered off in the Pacific Northwest and Southern Rail ECAs in July 2017, and the Gulf ECA in 2018, which helped to maximize pollination; while the Gulf ECA in July 2017 had plentiful rains during early grain-fill. In 2019, plant development caught up for pollination to occur only about two weeks behind the 5YA.



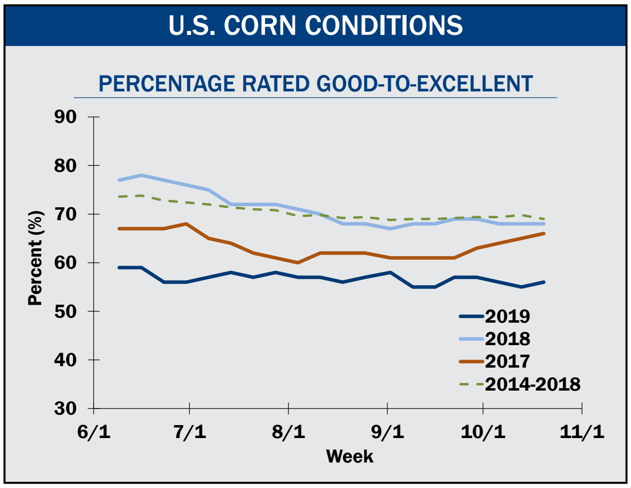
August 2017 provided cool weather throughout the Corn Belt, allowing good grain-fill. In 2017, the moderate temperatures and delayed maturity prolonged grain-fill through September, slightly behind the 5YA. The grain-fill period in 2018 was faster than the 5YA in the Gulf ECA that had continued warm weather, while the Pacific Northwest and the Southern Rail ECAs had cooler weather, conducive to producing larger kernels. In 2019, grain-fill slowed in August with cool temperatures; while record heat in September was unable to help speed development.



Harvest in 2019 was similar to 2017. Both were greatly delayed compared to the 5YA by late maturation of the plants and wet fields. The quick start of harvest 2018 was attributed to the warm weather earlier in the season, advancing the crop maturation approximately two weeks ahead of the 5YA.



The corn crop in 2019 had a modest combined good-to-excellent condition rating[2] compared to the 5YA, indicating the rough and highly variable growing season. The 2018 rating started above the 5YA, with excellent early growth. However, heat and leaf diseases moderated the condition rating by season's end; yet still signifying good plant health, photosynthesis, kernel size and yield. For 2017, 60 to 68% of the crop rated good or excellent throughout the growing season; yet still had record yields.

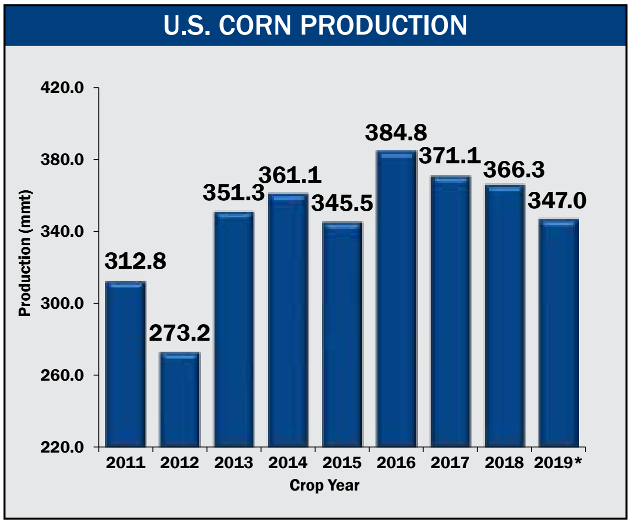


[2]*A 'Good' rating means that yield prospects are normal. Moisture levels are adequate and disease, insect damage and weed pressures are minor. An 'Excellent' rating means that yield prospects are above normal, and the crop is experiencing little or no stress. Disease, insect damage and weed pressures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

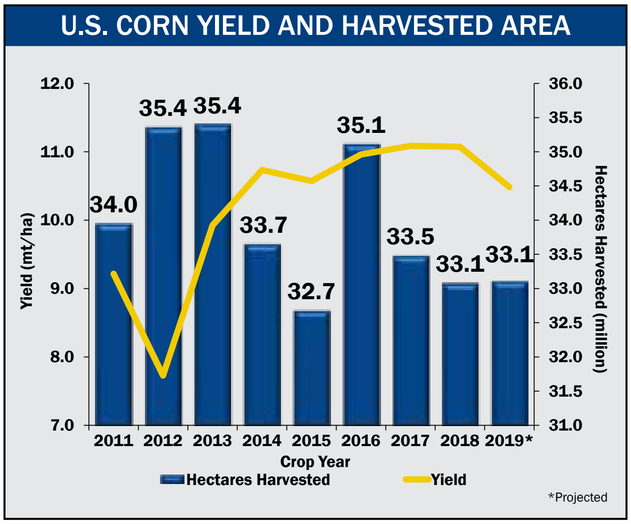
A. U.S. CORN PRODUCTION

U.S. Average Production and Yields

According to the December 2019 USDA World Agricultural Supply and Demand Estimates (WASDE) report, U.S. corn production in 2019 is projected to be 347.01 million metric tons (13,661 million bushels). If realized, this year's crop would be the smallest since the 2015 crop produced 345.51 million metric tons (13,602 million bushels). While the projected size of the 2019 crop is smaller compared to recent years, it is important to note that the previous three U.S. corn crops were the three largest and highest yielding in U.S. history. From a historical perspective, the 2019 crop is still projected to be the sixth-largest U.S. crop on record despite the challenges associated with its historically late planting.



Average U.S. corn yield and harvested hectares are both projected to be lower than the average of the previous five crops. Average projected corn yield in 2019 is projected to be 10.48 metric tons per hectare (167.0 bushels per acre) compared to the 5YA of 10.89 metric tons per hectare (173.4 bushels per acre). In terms of harvested hectares, the projected 33.12 million (81.8 million acres) harvested is also slightly less than the 5YA of 33.61 million hectares (83.0 million acres).



ASD and State-Level Production

The geographic areas included in the *2019/2020 Corn Harvest Quality Report* encompass the highest corn-producing regions of the United States. The map shows the projected 2019 corn production by USDA Agricultural Statistical District (ASD). These states represent over 90.0% of U.S. corn exports.[1]

The U.S. Corn Production by State chart and table summarize the changes in production between each state's 2018 and projected 2019 corn crops. The table also includes an indication of the relative changes in harvested acres and yield. A green bar indicates a relative increase, and a red bar indicates a relative decrease from 2018 to projected 2019. Eight of the 12 key corn-producing states expect large changes (greater than 10.0%) in production relative to their 2018 crops.

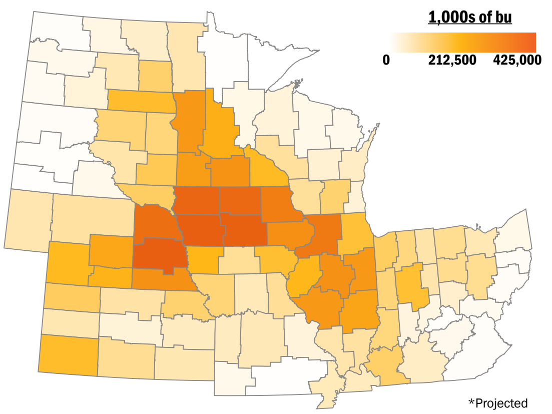
While not the only factor influencing production, the delayed planting of the 2019 crop contributed to year-over-year production declines projected to be more than 15.0% in five of the 12 key corn-producing states; including Illinois, Indiana, Ohio, South Dakota, and Wisconsin. Minnesota, the fourth largest corn-producing state, is also projected to have an 8.8% decrease in production relative to its 2018 crop. On the other hand, Kansas and Kentucky are projected to have increases in production of 23.7% and 19.2%, respectively, compared to their 2018 crops, largely due to increases in harvested acres. North Dakota, Missouri, Nebraska, and Iowa are the only four states projected to have production changes of less than 5.0% compared to their 2018 crops.

U.S. CORN PRODUCTION

State	2018	2019*	Difference MMT	Difference Percent	Relative % Change† Acres	Relative % Change† Yield
Illinois	57.9	46.6	(11.3)	-19.5%	red	red
Indiana	25.0	20.5	(4.4)	-17.7%	red	red
Iowa	63.7	63.9	0.2	0.3%	green	red
Kansas	16.4	20.3	3.9	23.7%	green	green
Kentucky	5.5	6.5	1.1	19.2%	green	green
Minnesota	34.6	31.6	(3.1)	-8.8%	red	red
Missouri	11.8	12.0	0.2	1.4%	red	green
Nebraska	45.4	45.1	(0.3)	-0.7%	green	red
North Dakota	11.4	11.9	0.6	4.8%	green	red
Ohio	15.7	10.7	(5.0)	-31.6%	red	red
South Dakota	19.8	15.0	(4.7)	-23.9%	red	red
Wisconsin	13.8	11.8	(2.1)	-15.1%	red	red
Total U.S.	366.3	347.0	(19.3)	-5.3%		

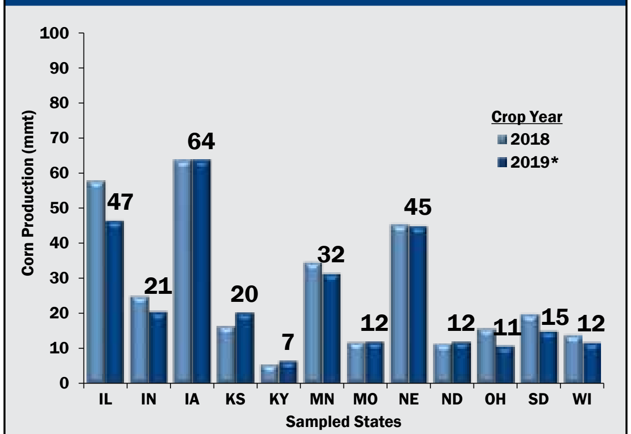
†Green indicates higher than in previous year and red indicates lower than in previous year; bar height indicates the relative amount.
**Projected*
Source: USDA NASS

U.S. CORN PRODUCTION BY ASD (2019*)



Source: USDA NASS and Centrec Estimates

U.S. CORN PRODUCTION BY STATE



Source: USDA NASS

[1]*Source: USDA NASS, USDA GIPSA and Centrec estimates.*

B. U.S. CORN USE AND ENDING STOCKS

U.S. corn use for food, seed and other non-ethanol industrial purposes has remained consistent over the past four completed marketing years.

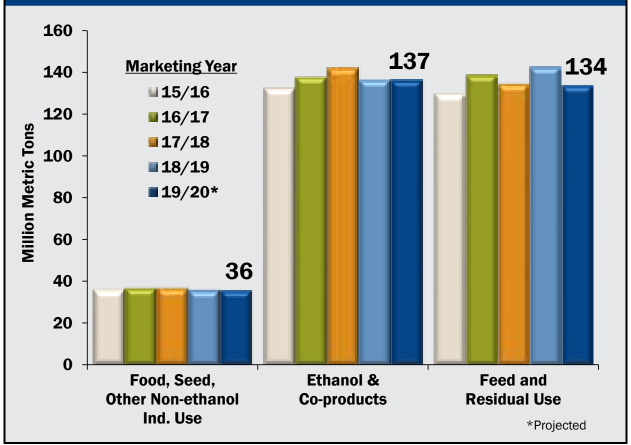
The amount of corn used for domestic ethanol production is largely dependent on U.S. consumption of finished gasoline. With domestic gasoline consumption stagnating from marketing year 15/16 through marketing year 17/18, annual increases in ethanol exports contributed to increases in corn consumption for ethanol production. However, the effects of a slight decrease in U.S. gasoline consumption and an increase in the proportion of sorghum used for ethanol production outweighed increasing ethanol exports in marketing year 18/19, leading to a 4.1% decline in the amount of corn used for ethanol in marketing year 18/19 compared to marketing year 17/18.

With ample corn supplies and competitive corn prices relative to other feed ingredients, direct consumption of corn as a feed ingredient in domestic livestock and poultry rations has remained strong.

U.S. corn exports peaked in marketing year 17/18, following the largest two U.S. crops in history in 2016 and 2017. A small increase in domestic consumption and lower production in 2018 left less corn available for export in marketing year 18/19.

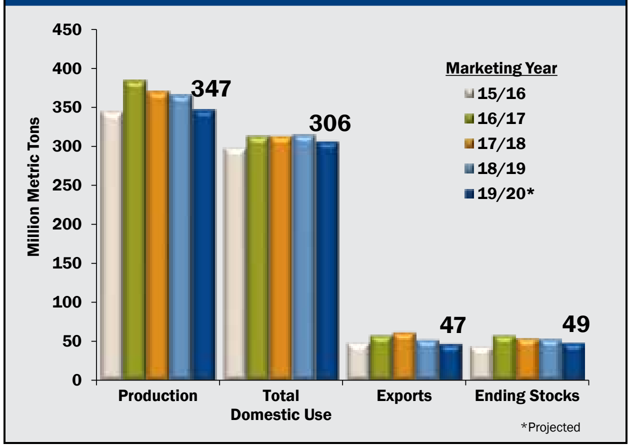
Ending stocks have decreased each year slightly since the record 2016 U.S. corn crop.

U.S. CORN USE



Source: USDA WASDE and ERS

U.S. CORN PRODUCTION & DISAPPEARANCE



Source: USDA WASDE and ERS

C. OUTLOOK

U.S. Outlook

The 2019 U.S. corn crop is projected to be smaller than each of the previous three crops, leaving a lower supply of corn available for export. However, it is important to note that the previous three crops were the largest and highest-yielding corn crops in U.S. history. Despite the challenges posed by inclement weather during the planting season, the 2019 U.S. crop is still projected to be the sixth-largest U.S. corn crop on record. The size of this crop will still leave an ample supply of corn available for domestic consumption and exports in marketing year 19/20 and will keep downward pressure on corn prices.

Additionally, the 2019 U.S. crop is still projected to be the sixth-largest U.S. corn crop on record despite the challenges posed by inclement weather during the planting season. This will leave an ample supply of corn available for domestic consumption and exports in marketing year 19/20 and will keep downward pressure on corn prices.

Corn use for food, seed and non-ethanol industrial purposes is expected to remain largely unchanged in marketing year 19/20 compared to marketing year 18/19, continuing the pattern of the previous four marketing years.

Projected marketing year 19/20 corn use for ethanol is the same as marketing year 18/19. Corn use for ethanol is influenced, in part, by domestic gasoline demand and ethanol exports. Increasing ethanol exports have been responsible for corn use for ethanol remaining steady in recent years as gasoline consumption has stalled. However, ethanol exports in marketing year 19/20 are anticipated to be slightly lower than in marketing year 18/19, counteracting a projected rebound in domestic gasoline consumption.

Domestic corn use for feed and residual use is expected to be 8.71 million metric tons lower (6.1% decrease) in marketing year 19/20 compared to marketing year 18/19.

Lower U.S. corn exports are also projected for marketing year 19/20 as a result of the smaller corn crop anticipated. U.S. corn exports are projected to be 46.99 million metric tons in marketing year 19/20, which is a decrease of 5.46 million metric tons (10.4% decrease) from marketing year 18/19.

In addition to lower U.S. exports and feed and residual use, U.S. ending stocks are also projected to be lower in marketing year 19/20 to offset the reduced production, as a reduction of 5.19 million metric tons (9.7%) is anticipated compared to the previous marketing year.

In terms of the stocks-to-use ratio, marketing year 19/20 is projected to have a ratio of 13.7%. This is slightly lower than the record 2016 crop's stocks-to-use ratio of 15.7%, which was the highest since marketing year 05/06 (17.5%). However, the projected stocks-to-use ratio in marketing year 19/20 is still slightly above the average from the past ten completed marketing years (11.6%).

International Outlook[2]

Global Supply

Global corn production during marketing year 19/20 is expected to be 1,108.62 million metric tons. This 15.87 million metric ton (1.4%) reduction from marketing year 18/19 production is mainly due to lower U.S. production.

In addition to lower projected U.S. exports, total non-U.S. exports are also expected to be lower in marketing year 19/20 than in marketing year 18/19 by 8.29 million metric tons (6.5%).

Global Demand

Global corn use is expected to decrease from 1,146.67 million metric tons in marketing year 18/19 to 1,127.23 million metric tons in marketing year 19/20, a 1.7% annual decrease.

Of the major corn-consuming countries and areas, Argentina, China, and Southeast Asia are each anticipated to consume at least 1.0 million metric tons more corn in marketing year 19/20 than in marketing year 18/19; while the European Union and Canada are each anticipated to consume at least 1.0 million metric tons less corn in marketing year 19/20 than in the previous year. However, the largest change in domestic corn consumption compared to marketing year 18/19 is projected to occur in the U.S., with an anticipated decrease of 8.73 million metric tons (2.7%).

A slight increase in year-over-year imports is expected globally in marketing year 19/20.

[2] *USDA/Foreign Agricultural Service–Production, Supply and Distribution Database*

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

Metric Units	15/16	16/17	17/18	18/19	19/20*
Acreage (million hectares)					
Planted	35.64	38.06	36.50	36.08	36.41
Harvested	32.69	35.12	33.50	33.09	33.12
Yield (mt/ha)	10.57	10.96	11.09	11.07	10.48
Supply (million metric tons)					
Beginning stocks	43.97	44.12	58.25	54.37	53.71
Production	345.51	384.78	371.10	366.29	347.01
Imports	1.72	1.45	0.91	0.71	1.27
Total Supply	**391.20**	**430.35**	**430.27**	**421.36**	**401.98**
Usage (million metric tons)					
Food, seed, other non-ethanol industry use	36.16	36.92	36.89	35.94	35.94
Ethanol and co-products	132.69	137.98	142.37	136.56	136.53
Feed and residual	130.00	138.94	134.73	142.70	133.99
Exports	48.23	58.27	61.92	52.46	46.99
Total Use	**347.07**	**372.10**	**375.89**	**367.66**	**353.46**
Ending Stocks	44.12	58.25	54.37	53.71	48.52
Average Farm Price ($/mt**)	142.12	132.28	132.28	142.12	151.57

English Units	15/16	16/17	17/18	18/19	19/20*
Acreage (million acres)					
Planted	88.0	94.0	90.2	89.1	89.9
Harvested	80.8	86.7	82.7	81.7	81.8
Yield (bu/ac)	168.4	174.6	176.6	176.4	167.0
Supply (million bushels)					
Beginning stocks	1,731	1,737	2,293	2,140	2,114
Production	13,602	15,148	14,609	14,420	13,661
Imports	68	57	36	28	50
Total Supply	**15,401**	**16,942**	**16,939**	**16,588**	**15,825**
Usage (million bushels)					
Food, seed, other non-ethanol industry use	1,424	1,453	1,452	1,415	1,415
Ethanol and co-products	5,224	5,432	5,605	5,376	5,375
Feed and residual	5,118	5,470	5,304	5,618	5,275
Exports	1,899	2,294	2,438	2,065	1,850
Total Use	**13,664**	**14,649**	**14,798**	**14,474**	**13,915**
Ending Stocks	1,737	2,293	2,140	2,114	1,910
Average Farm Price ($/bu**)	3.61	3.36	3.36	3.61	3.85

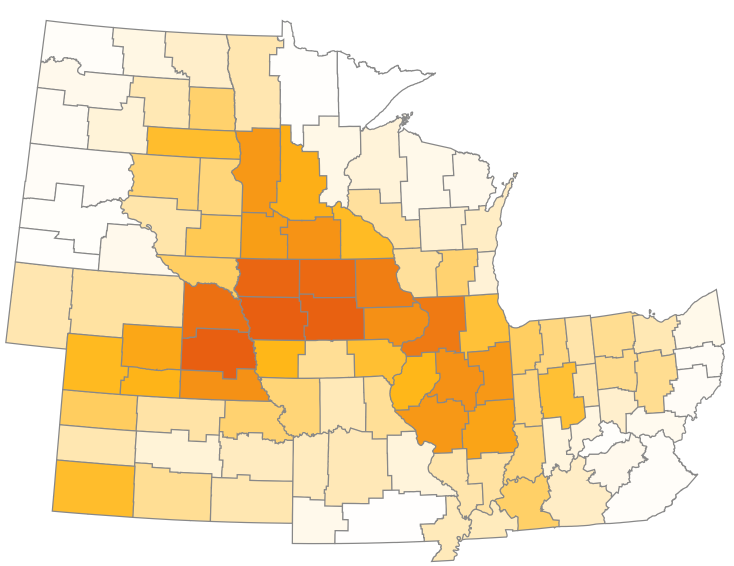
**Projected*
***Farm prices are weighted averages based on the volume of farm shipment.*
The average farm price for 19/20 based on WASDE December projected price.*
Source: USDA WASDE and ERS

A. OVERVIEW

The key points for the survey design, sampling methodology and statistical analysis for this *2019/2020 Harvest Report* are as follows:

- Following the methodology developed for the previous eight *Harvest Reports*, the samples were proportionately stratified according to ASDs across 12 key corn-producing states representing over 90% of U.S. corn exports.
- A total of 605 samples collected from the 12 states was targeted to achieve a maximum ±10.0% relative margin of error (Relative ME) at the 95.0% confidence level.
- A total of 623 unblended corn samples pulled from inbound farm-originated trucks were received and tested from local elevators from August 30 through December 3, 2019.
- The mycotoxin testing across the ASDs in the 12 states surveyed for the other quality factors used a proportionate stratified sampling technique. This sampling resulted in testing 180 samples for aflatoxin, DON and fumonisin.
- Weighted averages and standard deviations following standard statistical techniques for proportionate stratified sampling were calculated for the U.S. Aggregate and the three ECAs.
- Each quality factor's relative margin of error was calculated for the U.S. Aggregate and each of the three ECAs to evaluate the statistical validity of the samples. No quality factors had a relative margin of error above ±10.0% for the U.S. Aggregate. However, the relative margin of error for total damage was 12.6% for the Pacific Northwest ECA. While this level of precision is less than desired, this relative margin of error does not invalidate the estimate.
- Two-tailed t-tests at the 95.0% confidence level were calculated to measure statistical differences between 2019 and 2018 and the 2019 and 2017 quality factor averages.

AGRICULTURAL STATISTICAL DISTRICTS (ASDs)



B. SURVEY DESIGN AND SAMPLING

Survey Design

For this *2019/2020 Harvest Report*, the target population was yellow corn from the 12 key U.S. corn-producing states representing over 90% of U.S. corn exports.[1] A ***proportionate stratified, random sampling*** technique was applied to ensure a sound statistical sampling of the U.S. corn crop at the first stage of the marketing 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 subpopulations called strata. For this study, the survey population was corn produced in areas likely to export corn to foreign markets. The USDA divides each state into several ASDs and estimates corn production for each ASD. The USDA corn production data, accompanied by foreign export estimates, were used to define the survey population in the 12 key corn-producing states. The ASDs were the subpopulations or strata used for this corn quality survey. From those data, the Council calculated each ASD's proportion of the total production and foreign exports to determine the ***sampling proportion*** (the percent of total samples per ASD) and, ultimately, the number of corn samples to be collected from each ASD. The number of samples collected for the *2019/2020 Harvest Report* differed among the ASDs, due to their different shares of estimated production and foreign export levels.

Establishing the ***number of samples collected*** allowed the Council to estimate the true averages of the various quality factors with a certain level of precision. The level of precision chosen for the *2019/2020 Harvest Report* was a relative margin of error no greater than ±10.0%, estimated at a 95.0% level of confidence. A relative margin of error of ±10.0% is a reasonable target for biological data such as these corn quality factors.

To determine the number of samples for the relative margin of error target, ideally, the population variance (i.e., the variability of the quality factor in the corn 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 needed to estimate the true mean with a given confidence limit. In addition, the variances of the quality factors typically differ from one another. Therefore, different sample sizes would be needed for each of the quality factors for the same level of precision.

Since the population variances for the 17 quality factors evaluated for this year's corn crop were not known, the variance estimates from the *2018/2019 Harvest Report* were used as proxies. The variances and ultimately, the estimated number of samples needed for the relative margin of error of ±10.0% for 14 quality factors were calculated using the 2018 results of 618 samples. Broken corn, foreign material and heat damage were not examined. Based on these data, a minimum sample size of 600 would allow the Council to estimate the true averages of the quality characteristics with the desired level of precision for the U.S. Aggregate. Due to the rounding of the targeted number of samples per ASD and the criterion of a minimum of two samples per ASD, the targeted number of samples for the 2019 report became 605.

While the relative margin of error for stress cracks was not higher than ±10.0% in the 2018 results for the U.S. Aggregate, this quality factor has had a relative margin of error slightly higher than ±10.0%

[1] *Source: USDA NASS, USDA GIPSA and Centrec estimates.*

in three of the eight previous reports. Given the 2019 report's sample size and the unpredictability of this quality factor's variance, there was the potential that stress cracks may not meet the targeted level of precision for the U.S. Aggregate. However, the relative margin of error for stress cracks has never been above 12% in the past reports.

The testing of the grade, moisture, chemical and physical characteristics used the same approach of proportionate stratified sampling for the mycotoxin testing of the corn samples. In addition to using the same sampling approach, the same level of precision of a relative margin of error of ±10.0%, estimated at a 95.0% level of confidence, was desired.

Testing at least 25.0% of the minimum number of samples (600) was estimated to provide that level of precision. In other words, testing at least 150 samples would provide a 95.0% confidence level that the percent of tested samples with aflatoxin results below the FDA action level of 20.0 ppb and the percent of tested samples with DON results below the FDA advisory level of 5.0 ppm would have a relative margin of error of ±10.0%. There was no targeted level of precision for fumonisin for this year's report, as past data on the mycotoxin's variance were not available. 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 samples (600) and at least one sample from each ASD, the targeted number of samples to test for mycotoxins was 180 samples.

Beginning with the *2019/2020 Harvest Report*, only the samples tested for the mycotoxin would be tested for horneous endosperm. This quality factor's relative margin of error has never exceeded 0.4%, well below the targeted level of precision of ±10.0%, in the samples tested from the eight previous reports. Thus, reducing the number of samples tested for horneous endosperm would likely keep the precision of this quality factor's estimates well below the targeted level of ±10.0%.

Sampling

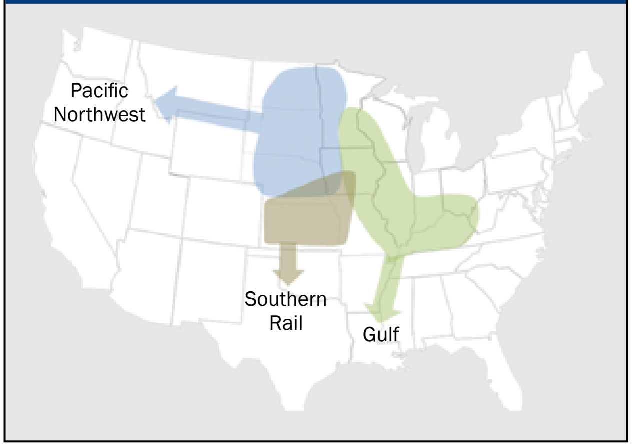
Soliciting local grain elevators in the 12 states by email and phone provided the ***random selection*** process. Postage-paid sample kits were mailed to elevators agreeing to provide the 2,050-gram to 2,250-gram corn samples requested. Elevators were told to avoid sampling loads of old crop corn from farmers cleaning out their bins for the current crop. 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. However, each sampling kit mailed to the participating locations contained bags to collect a maximum of four samples to ensure geographic variation in the samples collected. A total of 623 unblended corn samples pulled from inbound farm-originated trucks were received and tested from local elevators. The participating elevators indicated that these samples were pulled from inbound farm-originated trucks from August 30 through December 3, 2019, by writing the collection date on each sample bag.

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 three composite groups that supply corn to each of three major ECAs, as follows:

- The Gulf ECA consists of areas that typically export corn through the U.S. Gulf ports;
- The Pacific Northwest ECA includes areas that export corn through Washington, Oregon and California ports; and
- The Southern Rail ECA comprises areas generally exporting corn to Mexico by rail from inland subterminals.

EXPORT CATCHMENT AREAS



In analyzing the sample test results, the Council followed the 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 estimated for the composite ECAs. The geographic areas from which exports flow to each of these ECAs overlap due to available transportation modes. Therefore, composite statistics for each ECA were calculated based on estimated proportions of grain flowing to each ECA. As a result, corn samples could be reported in more than one ECA. These estimations were based on industry input, export data and evaluation of studies of grain flow in the United States.

The *2019/2020 Harvest Report* contains a simple average of the quality factors' averages and standard deviations of the previous five *Harvest Reports (2014/2015, 2015/2016, 2016/2017, 2017/2018 and 2018/2019)*. These simple averages are calculated for the U.S. Aggregate and each of the three ECAs and are referred to as the "5YA" in the text and summary tables of the report.

The relative margin of error was calculated for each of the quality factors for the U.S. Aggregate and each of the ECAs. None of the quality factor estimates had relative margin of errors above ±10.0% for the U.S. Aggregate. However, the relative margin of error for total damage was above ±10.0% for the Pacific Northwest ECA (12.6%). While this level of precision is less than desired, this relative margin of error does not invalidate the estimate. A footnote in the summary table indicates that the relative margin of error exceeded ±10.0% for this quality factor.

References in the "Quality Test Results" section to statistical or significant differences between results in the *2018/2019 Harvest Report* and the *2019/2020 Harvest Report* and in the *2017/2018 Harvest Report* and the *2019/2020 Harvest Report* were validated by two-tailed t-tests at the 95.0% confidence level.

The *2019/2020 Harvest Report* samples (each about 2,200 grams) were sent directly from the local grain elevators to the Illinois Crop Improvement Association's Identity Preserved Grain Laboratory (IPG Lab) in Champaign, Illinois. Upon arrival, samples above 16.0% moisture were ambient air-dried, if needed, to a suitable moisture content to prevent any subsequent deterioration during the testing period. Selected samples were dried using an ambient-air drying technique to prevent stress cracking and heat damage. Next, the samples were split into two subsamples of about 1,100 grams each using a Boerner divider, while keeping the attributes of the grain sample distributed evenly between the two subsamples. One subsample was delivered to the Champaign-Danville Grain Inspection (CDGI), in Urbana, Illinois, for grading. CDGI is the official grain inspection service provider for east-central Illinois as designated by the USDA FGIS. The grade testing procedures were in accordance with FGIS's *Grain Inspection Handbook* and are described in the following section. The other subsample was analyzed at IPG Lab for the chemical composition and other physical factors, following either industry norms or well-established procedures in practice for many years. IPG Lab has received accreditation under the ISO/IEC 17025:2005 International Standard for many of the tests. The full scope of accreditation is available at http://www.ilcrop.com/labservices.

A. GRADE FACTORS

Test Weight

Test weight is a measure of the volume of grain that is required to fill a Winchester bushel (2,150.42 cubic inches). Test weight is a part of the FGIS Official U.S. Standards for Corn 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 Corn and Foreign Material

BCFM is part of the FGIS Official U.S. Standards for Grain and grading criteria.

The BCFM test determines the amount of all matter that passes through a 12/64th-inch round-hole sieve and all matter other than corn that remains on the top of the sieve. BCFM measurement can be separated into broken corn and foreign material. Broken corn is defined as all material passing through a 12/64th-inch round-hole sieve and retained on a 6/64th-inch round-hole sieve. The definition of foreign material is all material passing through the 6/64th-inch round-hole sieve and the coarse non-corn material retained on top of the 12/64th-inch round-hole sieve. BCFM is reported as a percentage of the initial sample by weight.

Total Damage and Heat Damage

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

A trained and licensed inspector visually examines a representative working sample of 250 grams of BCFM-free corn for damaged kernels. Types of damage include blue-eye mold, cob rot, dryer-damaged kernels (different from heat-damaged kernels), germ-damaged kernels, heat-damaged kernels, insect-bored kernels, mold-damaged kernels, mold-like substance, silk-cut kernels, surface mold (blight), mold (pink *Epicoccum*) 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 corn kernels that are materially discolored and damaged by heat. Heat-damaged kernels are determined by a trained and licensed inspector visually inspecting a 250-gram sample of BCFM-free corn. 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 increases. Moisture is reported as a percent of total wet weight.

C. CHEMICAL COMPOSITION

Near-Infrared Transmission Spectroscopy (NIR) Proximate Analysis

The chemical composition (protein, oil and starch concentrations) of corn is measured using NIR. The technology uses unique interactions of specific wavelengths of light with each sample. It is calibrated to traditional chemistry methods to predict the concentrations of protein, oil and starch in the sample. This procedure is nondestructive to the corn.

Chemical composition tests for protein, oil and starch were conducted using a 550-gram to 600-gram sample in a whole-kernel Foss Infratec 1241 NIR instrument. The NIR was calibrated to chemical tests, and the standard errors of predictions for protein, oil and starch were about 0.22%, 0.26% and 0.65%, respectively. Comparisons of the Foss Infratec 1229 used in *Harvest Reports* prior to 2016 to the Foss Infratec 1241 on 21 laboratory check samples showed the instruments averaged within 0.25%, 0.26% and 0.25% points of each other for protein, oil and starch, respectively. Results are reported on a dry basis percentage (percent of non-water material).

D. PHYSICAL FACTORS

100-Kernel Weight, Kernel Volume and Kernel True Density

The 100-kernel weight is determined from the average weight of two 100-kernel replicates using an analytical balance that measures to the nearest 0.1 milligrams. The averaged 100-kernel weight is reported in grams.

The kernel volume for each 100-kernel replicate is calculated using a helium pycnometer and is expressed in cubic centimeters (cm^3) per kernel. Kernel volumes usually range from 0.14 cubic centimeters to 0.36 cubic centimeters per kernel for small and large kernels, respectively.

True density of each 100-kernel sample is calculated by dividing the mass (or weight) of the 100 externally sound kernels by the volume (displacement) of the same 100 kernels. The two replicate results are averaged. True density is reported in grams per cubic centimeter (g/cm^3). True densities typically range from 1.20 grams per cubic centimeter to 1.30 grams per cubic centimeter at “as is” moisture contents of about 12% to 15%.

Stress Crack Analysis

Stress cracks are evaluated by using a backlit viewing board to accentuate the cracks. A sample of 100 intact kernels with no external damage is examined kernel by kernel. The light passes through the horneous or hard endosperm, so the stress crack damage in each kernel can be evaluated. Kernels are sorted into two categories: (1) no cracks; (2) one or more cracks. Stress cracks, expressed as a percent, are all kernels containing one or more cracks divided by 100 kernels. Lower levels of stress cracks are always better since higher levels of stress cracks lead to more breakage in handling. Some end-users will specify by contract the acceptable level of cracks based on the intended use.

In previous *Harvest Reports*, the stress crack index was reported in addition to the percent stress cracks to provide an indication of the severity of stress cracking. The stress crack index is determined using the following calculation:

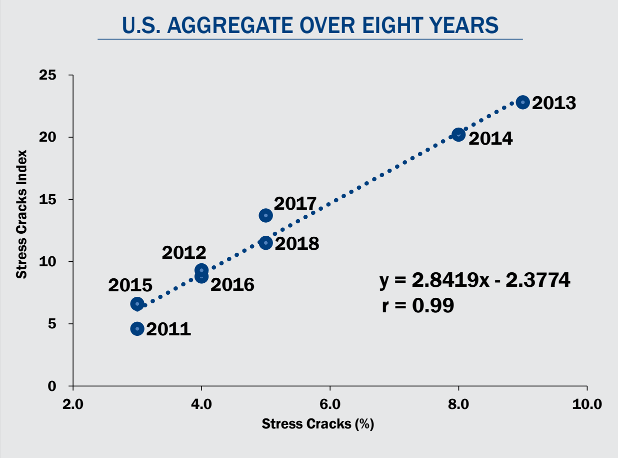
$$[SSC \times 1] + [DSC \times 3] + [MSC \times 5]$$

Where

- SSC is the percentage of kernels with only one crack;
- DSC is the percentage of kernels with exactly two cracks; and
- MSC is the percentage of kernels with more than two cracks.

The U.S. Aggregate percent stress cracks and stress crack index from the first eight harvest reports is displayed in the scatter chart below. Given its strong correlation (r = 0.99) to percent stress cracks, it was determined that the stress crack index provided limited additional value and was discontinued following the *2018/2019 Harvest Report*.

STRESS CRACKS INDEX VS STRESS CRACK (%)



Whole Kernels

In the whole kernels test, 50 grams of cleaned (BCFM-free) corn are inspected kernel by kernel. Cracked, broken or chipped grain, along with any kernels showing significant pericarp damage, are removed. The whole kernels are then weighed, and the result is reported as a percentage of the original 50-gram sample. Some companies perform the same test but report the "cracked & broken" percentage. A whole kernel score of 97.0% equates to a cracked & broken rating of 3.0%.

Horneous (Hard) Endosperm

The horneous (or hard) endosperm test is performed by visually rating 20 externally sound kernels, placed germ facing up, on a backlit viewing board. Each kernel is rated for the estimated portion of the kernel's total endosperm that is horneous endosperm. The soft endosperm is opaque and will block light, while horneous endosperm is translucent. The rating is made from standard guidelines based on the degree to which the soft endosperm at the crown of the kernel extends down toward the germ. The average of horneous endosperm ratings for the 20 externally sound kernels is reported. Ratings of horneous endosperm are made on a scale of 70% to 100%, though most individual kernels fall in the 70% to 90% range.

E. MYCOTOXINS

Detection of mycotoxins in corn 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 corn, if present, is highly dependent upon the concentration and distribution of the mycotoxin among kernels in a lot of corn, whether a truckload, a storage bin or a railcar.

The objective of the FGIS sampling process is to minimize underestimating or overestimating the true mycotoxin concentration since accurate results are imperative for corn exports. However, the objective of the *2019/2020 Harvest Report* assessment of mycotoxins is only to report the frequency of occurrences of mycotoxins in the current crop, and not to report specific levels of mycotoxins in corn exports.

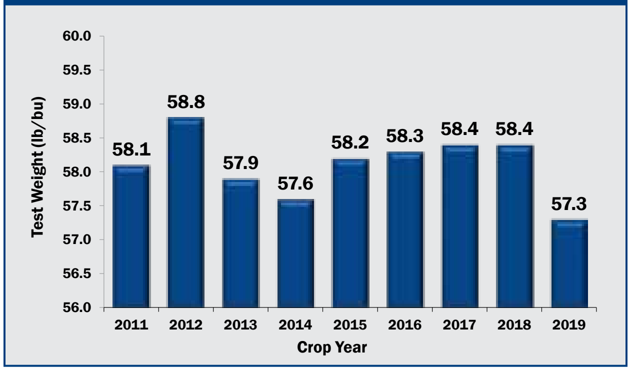
To report the frequency of occurrences of aflatoxin, DON and fumonisin for the *2019/2020 Harvest Report*, IPG Lab performed the mycotoxin testing using FGIS protocol and approved test kits. FGIS's protocol requires a minimum of a 908-gram (2-pound) sample from trucks to grind for aflatoxin testing, approximately a 200-gram sample to grind for DON testing and a 908-gram (2-pound) sample for fumonisin testing. For this study, a 1,000-gram laboratory sample was subdivided from the 2-kilogram survey sample of shelled kernels for the aflatoxin analysis. The 1-kilogram survey sample was ground in a Romer Model 2A mill so that 60% to 75% would pass a 20-mesh screen. From this well-mixed ground material, a 50-gram test portion was removed for each mycotoxin tested. EnviroLogix AQ 309 BG, AQ 304 BG and AQ 311 BG quantitative test kits were used for the aflatoxin, DON and fumonisin analysis, respectively. DON and fumonisin were extracted with water (5:1), while the aflatoxin was extracted with buffered water (3:1). The extracts were tested using the Envirologix QuickTox lateral flow strips, and the mycotoxins were quantified by the QuickScan system.

The EnviroLogix quantitative test kits report specific concentration levels of the mycotoxin if the concentration level exceeds a specific level called a "Limit of Detection." The limit of detection 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 limit of detection will vary among different types of mycotoxins, test kits and commodity combinations. The limit of detection for the EnviroLogix AQ 309 BG is 2.7 parts per billion for aflatoxin. The limit of detection for DON using the EnviroLogix AQ 304 BG is 0.1 parts per million. For the fumonisin tests, the EnviroLogix AQ 311 BG has a limit of detection of 1.5 parts per million. A letter of performance has been issued by FGIS for the quantification of aflatoxin, DON and fumonisin using the Envirologix AQ 309 BG, AQ 304 BG and AQ 311 BG kits, respectively.

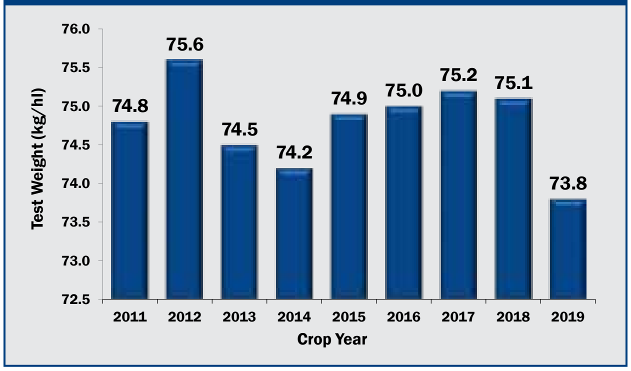
A. GRADE FACTORS AND MOISTURE

Since 2011, the U.S. Grains Council's Corn Harvest Quality Reports have provided clear, concise and consistent information about the quality of each U.S. crop entering international merchandising channels. This series of quality reports have used a consistent and transparent methodology to allow for insightful comparisons across time. The following charts display the average U.S. Aggregate from all reports for each quality factor tested to provide historical context to this year's results.

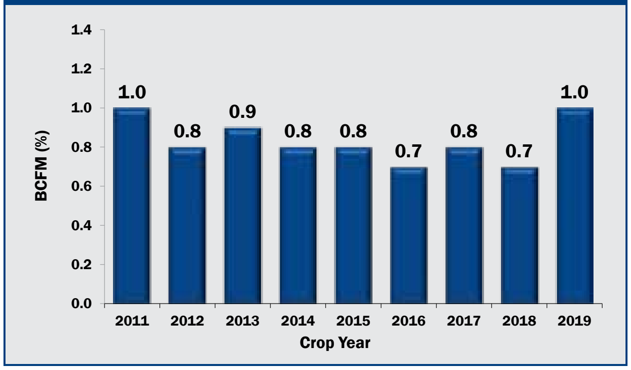
TEST WEIGHT (lb/bu)



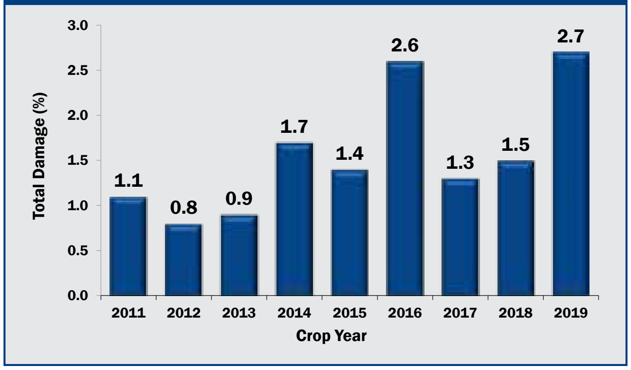
TEST WEIGHT (kg/hl)



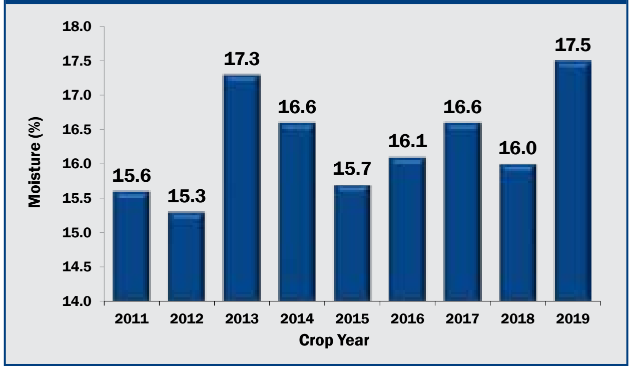
BCFM (%)



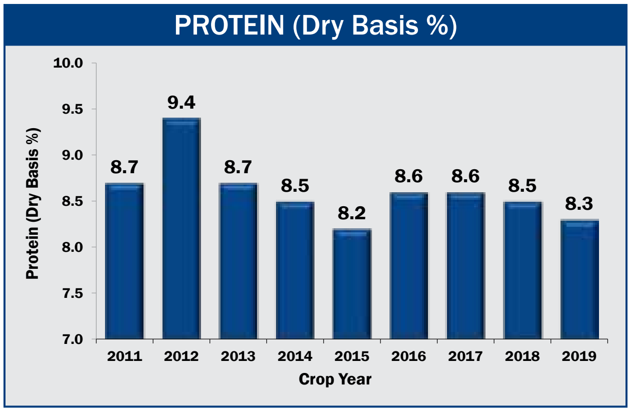
TOTAL DAMAGE (%)

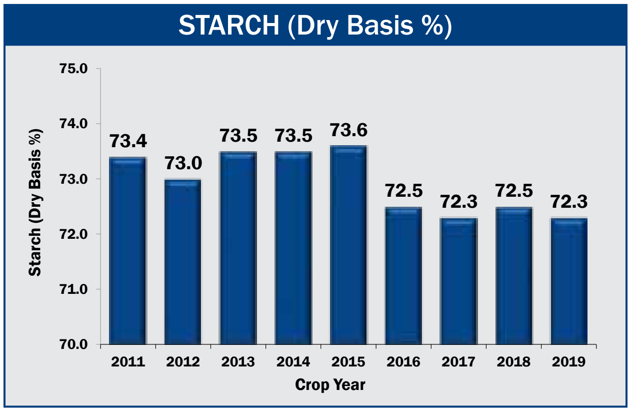


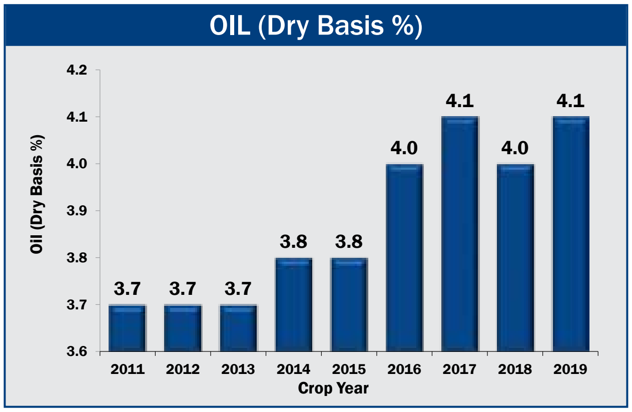
MOISTURE (%)



B. CHEMICAL COMPOSITION

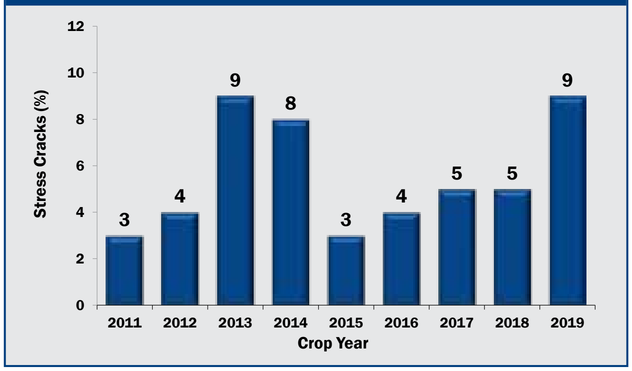




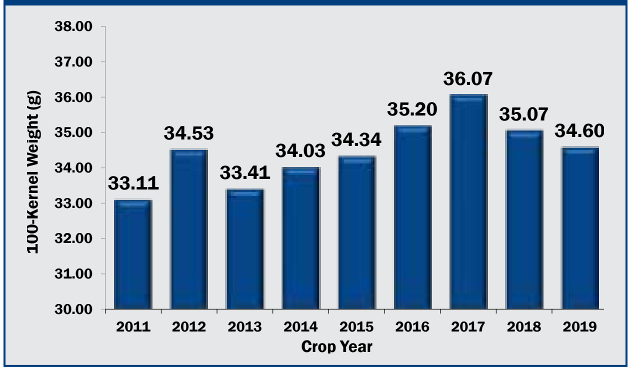


C. PHYSICAL FACTORS

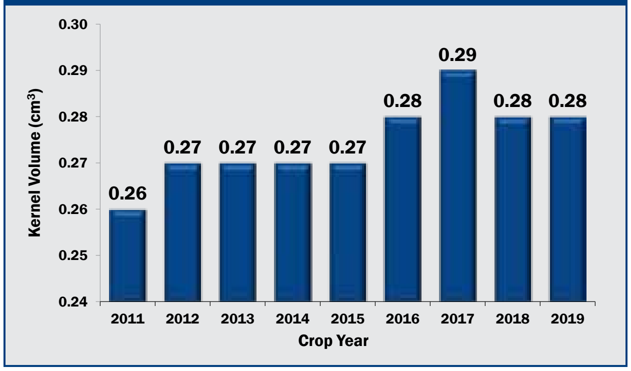
STRESS CRACKS (%)



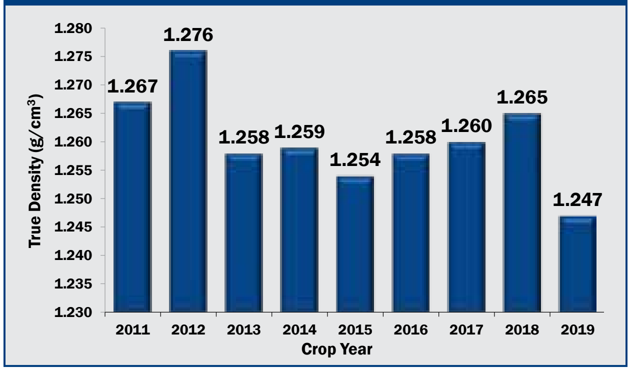
100-KERNEL WEIGHT (g)



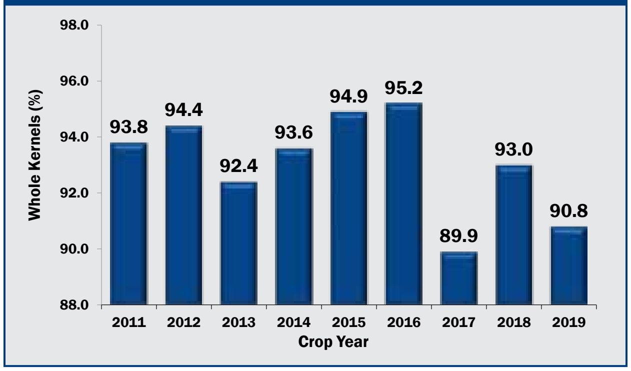
KERNEL VOLUME (cm^3)



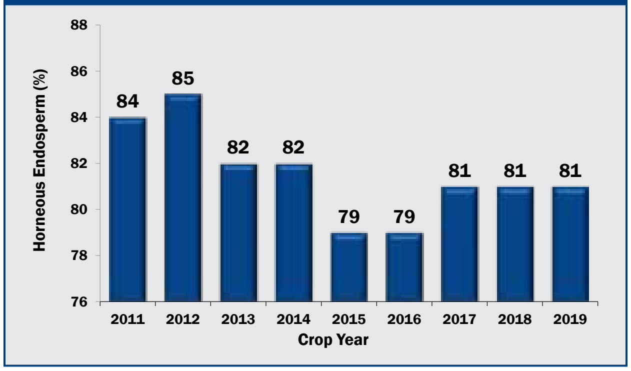
TRUE DENSITY (g/cm^3)



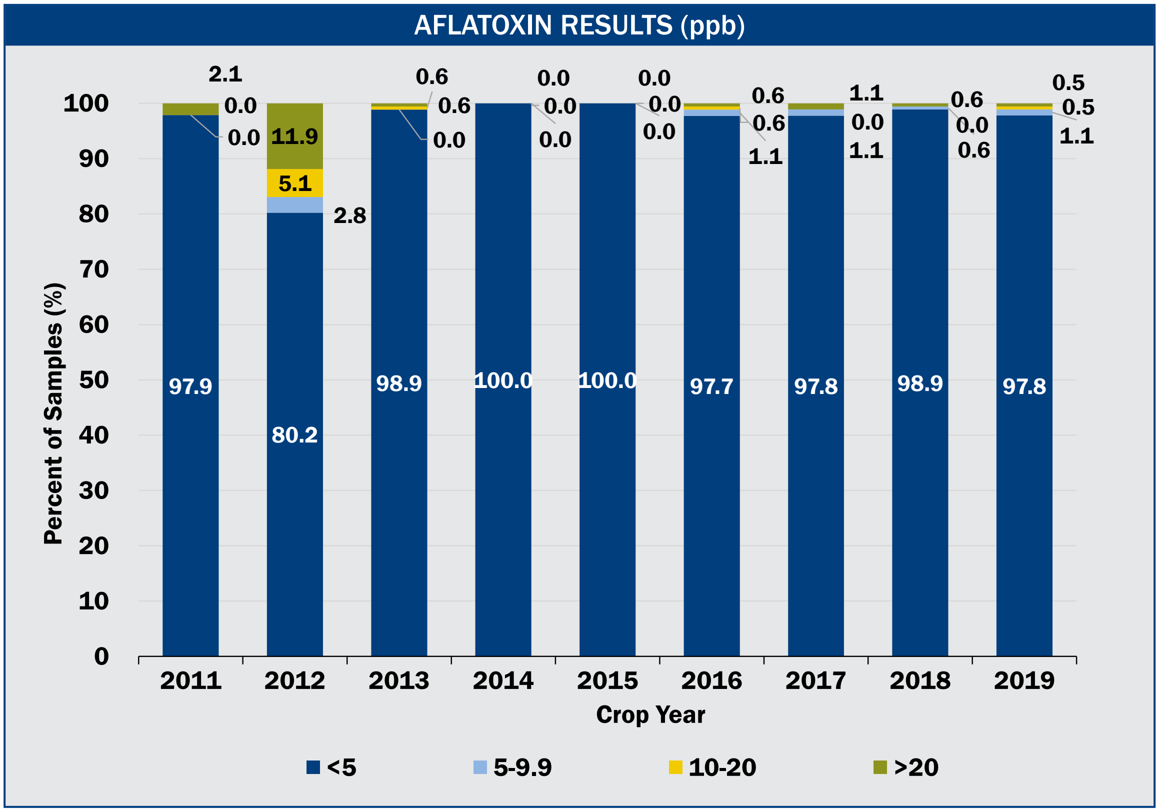
WHOLE KERNELS (%)

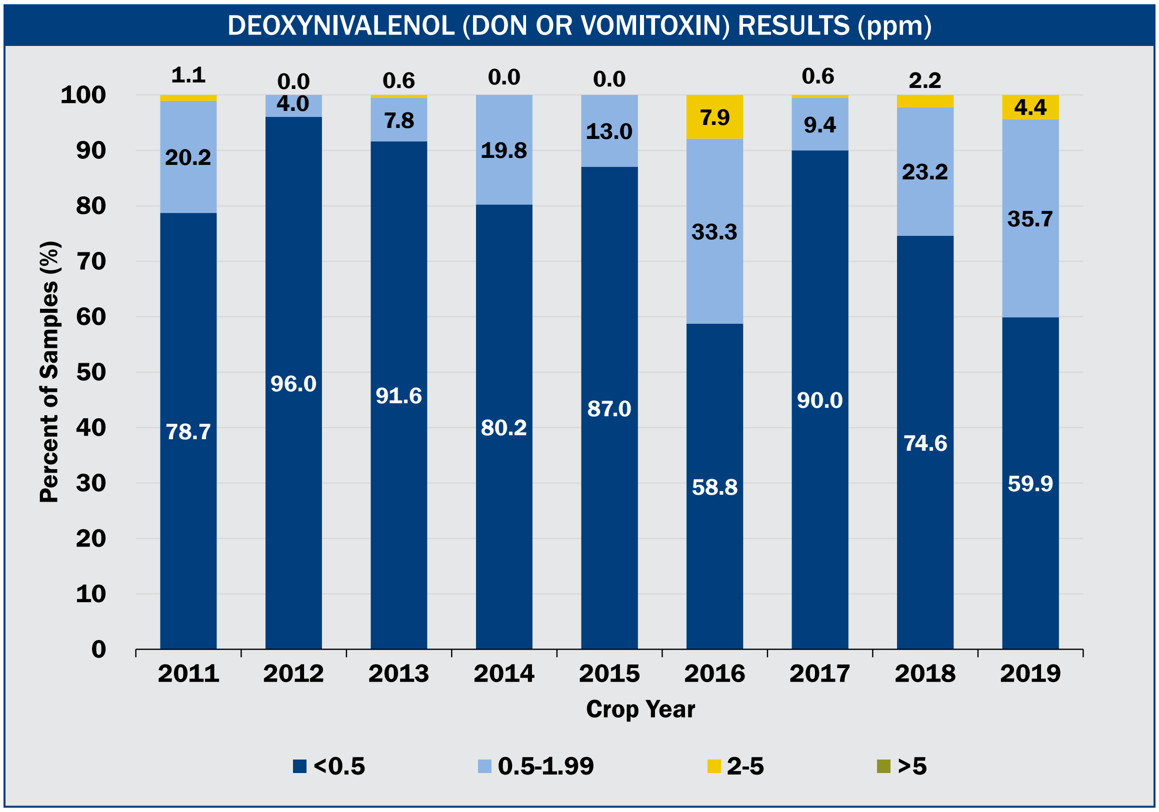


HORNEOUS ENDOSPERM (%)



D. MYCOTOXINS





U.S. CORN GRADES AND GRADE REQUIREMENTS

		Maximum Limits of		
		Damaged Kernels		
Grade	Minimum Test Weight per Bushel (Pounds)	Heat Damaged (Percent)	Total (Percent)	Broken Corn and Foreign Material (Percent)
U.S. No. 1	56.0	0.1	3.0	2.0
U.S. No. 2	54.0	0.2	5.0	3.0
U.S. No. 3	52.0	0.5	7.0	4.0
U.S. No. 4	49.0	1.0	10.0	5.0
U.S. No. 5	46.0	3.0	15.0	7.0

U.S. Sample Grade is corn that: (a) Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, 4, or 5; or (b) Contains stones with an aggregate weight in excess of 0.1% 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 cocklebrus (*Xanthium spp.*), or similar seeds singly or in combination, or animal filth in excess of 0.2% in 1,000 grams; or (c) Has a musty, sour, or commercially objectionable foreign odor; or (d) Is heating or otherwise of distinctly low quality.

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

U.S. AND METRIC CONVERSIONS

Corn 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

ABBREVIATIONS

cm^3 =	cubic centimeters
g =	grams
g/cm^3 =	grams per cubic centimeter
kg/hl =	kilograms per hectoliter
lb/bu =	pounds per bushel
ppb =	parts per billion
ppm =	parts per million

U.S. GRAINS COUNCIL

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