U.S. GRAINS COUNCIL

2020/2021 CORN HARVEST QUALITY REPORT

ACKNOWLEDGMENTS

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 of local grain elevators across the United States. We are grateful for their time and effort to collect and provide samples during their very busy harvest time.

U.S. GRAINS COUNCIL

The U.S. Grains Council is pleased to present findings from its tenth annual corn quality survey in this *2020/2021 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.

The 2020 growing season was markedly better than that experienced by the 2019 U.S. corn crop. While wet weather conditions in April and May contributed to historic delays in planting and crop maturity in 2019, the 2020 crop was planted slightly ahead of the average pace of the previous five crops and experienced generally favorable conditions during the remainder of the growing season. Consequently, a corn crop with both high grain quality and yield was produced in 2020. If realized, the expected average yield from this year's crop (11.04 metric tons per hectare or 175.8 bushels per acre) will be the third highest average U.S. corn yield on record.

Given the high yields anticipated, the Council projects the 2020 crop to be the third largest U.S. corn crop on record at 368.49 million metric tons (14,507 million bushels). This ample supply allows the United States to remain the world's leading corn exporter and accounts for an estimated 36.4 percent of global corn exports during the marketing year.

The *2020/2021 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 *2020/2021 Corn Export Cargo Quality Report*, will measure corn quality at export terminals at the point of loading and will be available in early 2021.

The Council offers this report as 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.

BUILDING RELATIONSHIPS BUILDING TRADE

Sincerely,

Jim Raben
Chairman, U.S. Grains Council
November 2020

The favorable growing season conditions impacted the overall quality of the 2020 crop throughout the growing season. The average aggregate quality of the representative samples tested for the *U.S. Grains Council 2020/2021 Corn Harvest Quality Report* (*2020/2021 Harvest Report*) was better than the grade factor requirements for U.S. No. 1 grade, indicating an abundant amount of good quality corn is entering the market channel from the 2020 U.S. crop. The report also showed that 84.7% of the samples met the grade factor requirements for U.S. No. 1 grade, and 94.5% met the grade factor requirements for U.S. No. 2.

Relative to each quality factor's average of the previous five crops (5YA[1]), the 2020 U.S. corn crop is entering the market channel with a higher average test weight and lower moisture and total damage. The following points highlight the key harvest results from the 2020 crop.

GRADE FACTORS AND MOISTURE

Higher **test weight** of 58.7 pounds per bushel (lb/bu) (75.5 kilograms per hectoliter (kg/hl)) than 2019 and the 5YA. The proportion of samples above the minimum requirement for U.S. No. 2 grade this year (99.3%) was higher than in 2019 and 2018, when 89.9% and 98.2% of samples were at or above this minimum requirement, respectively.

- Lower average **BCFM** (0.8%) than 2019 but same as the 5YA. While the average is the same as the 5YA, 98.5% of the samples were below the limit for U.S. No. 2 grade.
- Lower average **total damage** (1.1%) than 2019 and the 5YA. The proportion of samples below the maximum limit for U.S. No. 1 grade this year (91.5%) was lower than in 2019 and 2018, when 73.5% and 88.5% of samples were at or below this maximum limit, respectively.
- Average **heat** damage of 0.0% was the same as 2019, 2018 and the 5YA. Only one sample in the survey tested above 0.0%. That sample had 0.1% heat damage.
- Lower average **moisture** content (15.8%) than 2019 and the 5YA. The distribution shows that 42.2% of the samples were at or below 15% moisture content as compared to 26.7% and 35.1% in 2019 and 2018, respectively. This distribution indicates fewer samples required artificial drying in 2020 than in the two previous years.

[1] The 5YA represents the simple average of the quality factors' average or standard deviation from the *2015/2016*, *2016/2017, 2017/2018, 2018/2019 and 2019/2020 Harvest Reports*.

CHEMICAL COMPOSITION

- **Protein** concentration (8.5% dry basis) was higher than in 2019 and similar to the 5YA.
- **Starch** concentration (72.2% dry basis) was slightly lower than in 2019 and the 5YA.
- The average **oil** concentration (3.9% dry basis) was lower than in 2019 and the 5YA.

PHYSICAL FACTORS

- The 2020 crop had a lower percentage of **stress cracks** (6%) than in 2019 but slightly higher than the 5YA.
- **100-kernel weight** (34.53 grams) was lower than in 2019 and the 5YA, indicating smaller kernels than the previous two years.
- The average **kernel volume** (0.27 cubic centimeters (cm^3)) was smaller than in 2019 and the 5YA.
- The average **true density** (1.255 grams per cubic centimeter (g/cm^3)) from the 2020 crop was higher than in 2019 and similar to the 5YA.
- The **whole kernel** average (92.5%) was higher than in 2019 and similar to the 5YA.
- Average **horneous (hard) endosperm** of 81% was the same as in 2019 and 2018.

MYCOTOXINS

- All 2020 samples but one, or 99.4%, tested at or below the U.S. Food and Drug Administration (FDA) action level for **aflatoxin** of 20.0 parts per billion (ppb); and 99.4% of the samples tested below 5.0 ppb.
- In 2020, 100% of the samples tested at or below the 5.0 parts per million (ppm) FDA advisory level for deoxynivalenol (**DON**), the same as in 2019 and 2018. Also, 98.3% of the samples tested below 1.5 ppm, a higher proportion than in 2019 and 2018.
- In 2020, 98.9% of the samples tested below the FDA's strictest guidance level for **fumonisin** of 5.0 ppm, a higher proportion than in 2019.
- This year, **ochratoxin A**, trichothecenes (**T-2**) and **zearalenone** were added to the list of mycotoxins tested for the *Harvest Report* on a provisional basis. Results of the 180 samples tested for each additional mycotoxin can be found in the "Quality Test Results" section.

The *2020/2021 Harvest Report* has been designed to help international buyers of corn understand U.S. yellow corn's initial quality as it enters the market channel. This is the tenth annual survey of the quality of the U.S. corn crop at harvest. Ten years of results show patterns in the impact of weather and growing conditions on the quality of U.S. corn as it comes out of the field.

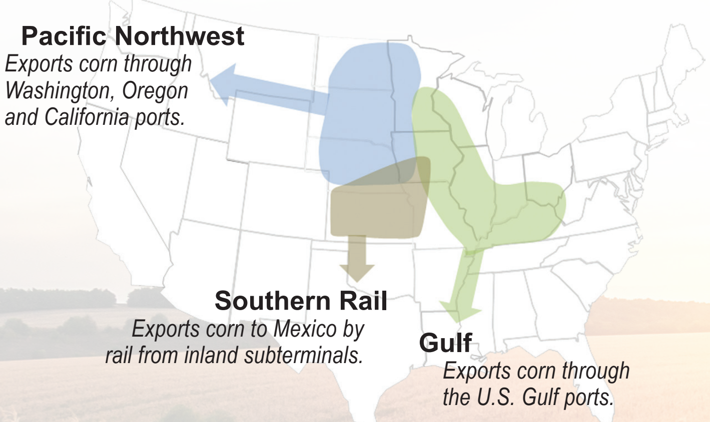
The 2020 U.S. corn crop is projected to be the third largest U.S. corn crop (368.49 million metric tons or 14,507 million bushels) and has the third highest average yield (11.04 mt/ha or 175.8 bu/acre) on record. The generally favorable growing season conditions contributing to this large crop also helped produce a crop with high grain quality. Regarding the quality factor results, the 2020 crop's average moisture and damage were lower than their respective 5YAs. Stress cracks and BCFM were below 2019 levels, and test weight was higher than 2019 as well as the 5YA. Protein was higher than 2019 but close to long-term averages; starch and oil were lower than last year and the 5YA. With these quality factors, the 2020 crop, on average, is entering the market 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 84.7% of the samples met all grade factor requirements for U.S. No. 1 grade, and 94.5% met the grade factor requirements for U.S. No. 2 grade corn.

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

The *2020/2021 Harvest Report* is based on 601 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 provide representative information about the variability of the quality characteristics across the diverse geographic regions.

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 shown on the map.

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 U.S. corn quality's geographic variability.

The corn's quality characteristics identified at harvest establish the foundation for the grain's quality 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 corn's quality and condition may change between the initial market entry and the export elevator. For this reason, the *2020/2021 Harvest Report* should be considered carefully in tandem with the Council's *2020/2021 Corn Export Cargo Quality Report*, published in early 2021. 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 as well as 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, fumonisin, ochratoxin A[1], T-2[1] and zearalenone[1]

In addition, the *2020/2021 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 ten reports.

[1] *Testing added to the 2020/2021 Harvest Report on a provisional basis.*

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 and on the following page.

SUMMARY: GRADE FACTORS AND MOISTURE

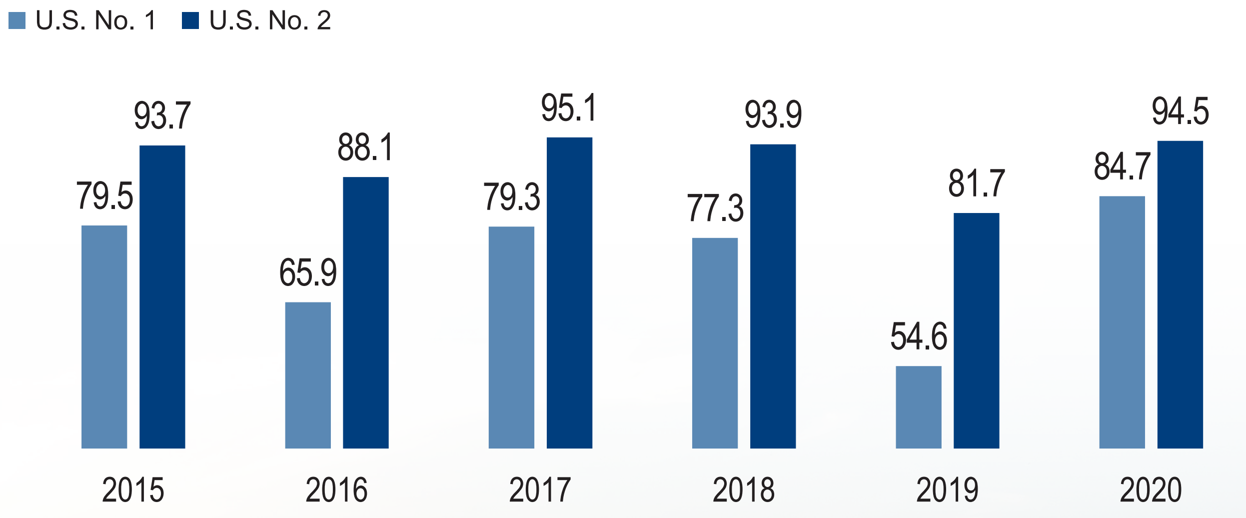
- The figure shown on the following page describes the percent of samples meeting grade factor limits for U.S. No. 1 and No. 2 grade by year. On average, 84.7% of the samples met all grade factor requirements for U.S. No. 1 grade, and 94.5% met the grade factor requirements of U.S. No. 2 grade.
- Average U.S. Aggregate test weight (58.7 lb/bu or 75.5 kg/hl) was higher than 2019 (57.3 lb/bu), 2018 (58.4 lb/bu), the 5YA (58.1 lb/bu) and the 10YA[1] (58.2 lb/bu). Of the 2020 samples, 94.8% had test weights at or above 56.0 lb/bu.
- Average U.S. Aggregate BCFM (0.8%) was lower than 2019 (1.0%), similar to 2018 (0.7%), same as the 5YA and the 10YA (both 0.8%) and well below the maximum for the U.S. No. 1 grade (2.0%).
- BCFM levels in 98.5% of the corn samples were equal to or below the 3.0% maximum allowed for No. 2 grade.
- Average BCFM was the same (0.8%) among all three ECAs.
- Average U.S. Aggregate broken corn (0.6%) was lower than 2019 (0.7%), higher than 2018 (0.5%) and the same as the 5YA and 10YA (both 0.6%).
- Average U.S. Aggregate foreign material (0.2%) was the same as last year, 2018, the 5YA and the 10YA.
- Total damage in the U.S. Aggregate samples averaged 1.1% in 2020, lower than 2019 (2.7%), 2018 (1.5%), the 5YA (1.9%) and the 10YA (1.5%), and well below the limit for U.S. No. 1 grade (3.0%). A total of 91.5% of samples contained 3.0% or less damaged kernels.
- The Gulf ECA had the highest or tied for the highest total damage for 2020, 2019, 2018 and the 5YA. The average total damage values in all ECAs were at or below the limit for the U.S. No. 1 grade (3.0%).

[1] *The 10YA represents the simple average of the quality factors' averages or standard deviations from the 2011/2012 Harvest Report through this 2020/2021 Harvest Report.*

SUMMARY: GRADE FACTORS AND MOISTURE

- Average U.S. Aggregate heat damage was 0.0% for the 2020 samples, as well as those in 2019, 2018, the 5YA and the 10YA.
- Average U.S. Aggregate moisture content in 2020 (15.8%) was lower than 2019 (17.5%), 2018 (16.0%), the 5YA (16.4%) and the 10YA (16.2%).
- The 2020 average moisture contents for the Gulf, Pacific Northwest and Southern Rail ECAs were 16.6, 14.9 and 14.8%, respectively. The Southern Rail ECAs average moisture level was lowest among all ECAs for 2020, 2019, 2018, the 5YA and the 10YA. There were fewer samples containing more than 17.0% moisture in the 2020 (26.3%) crop than in 2019 (45.7%).

Samples Meeting All Requirements by Grade (%)



U.S. Corn Grades and Grade Requirements

Grade	Minimum Test Weight per Bushel (Pounds)	Maximum Limits of Damaged Kernels: Heat Damaged (Percent)	Maximum Limits of Damaged Kernels: Total (Per-cent)	Maximum Limits of 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

TEST WEIGHT

Test weight (weight per volume) is a measure of bulk density. It is often used as a general indicator of overall quality and as a gauge of endosperm hardness for alkaline cooking processors 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 the 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, microbiological damage and moisture content. 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. However, other factors such as kernel size, shape, fine material, damage and rapidity of drying may influence the potential change in test weight.[2]

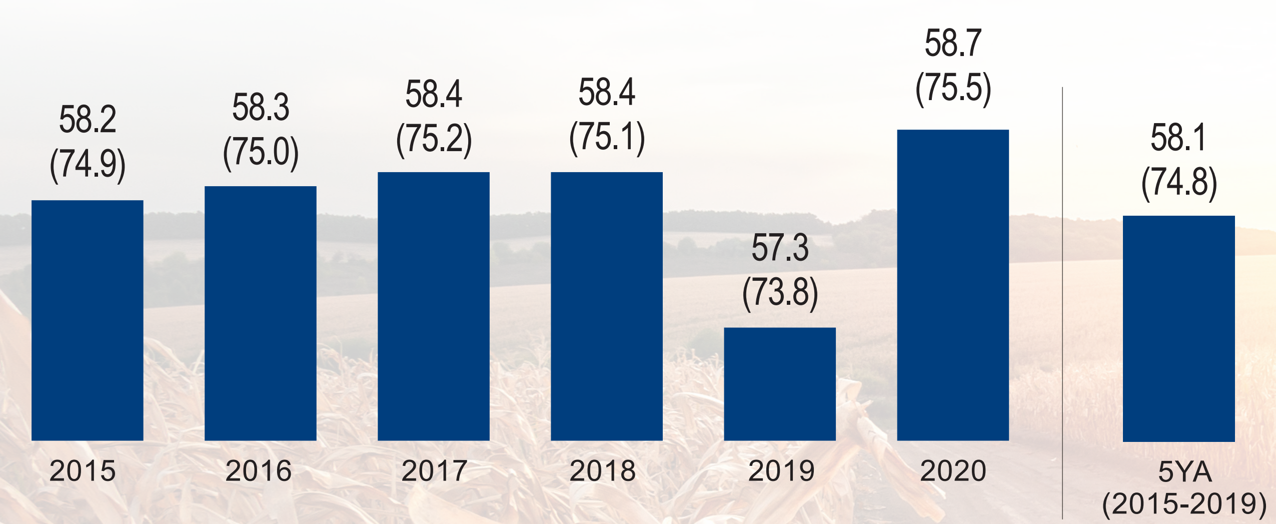
When sampled and measured at the point of delivery from the farm at a given moisture content, high test weight generally indicates high quality, a high percent of horneous (or hard) endosperm and sound, clean corn. Test weight is positively correlated with true density and reflects kernel hardness and good maturation conditions.

RESULTS

- Average U.S. Aggregate test weight in 2020 (58.7 lb/bu or 75.5 kg/hl) was higher than 2019 (57.3 lb/bu or 73.8 kg/hl), 2018 (58.4 lb/bu or 75.1 kg/hl and the 5YA (58.1 lb/bu or 74.8 kg/hl) and well above the minimum for the U.S. No. 1 grade (56.0 lb/bu).

TEST WEIGHT (lb/bu & kg/hl)

U.S. Aggregate Results Summary

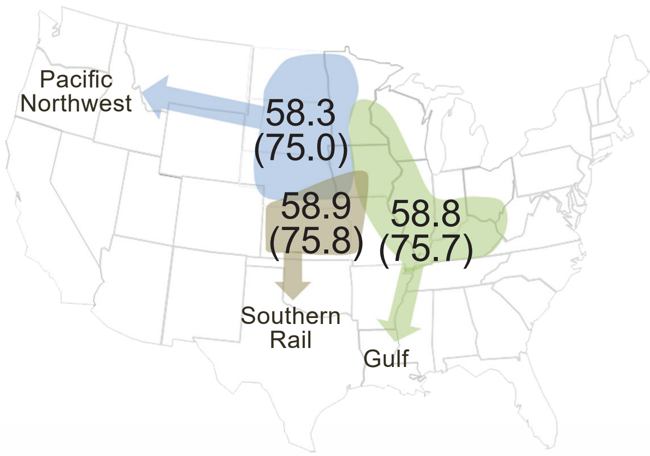


[2] *Hellevang, K. (2019) Many Factors Influence Corn Test Weight. NDSU Agricultural Communication November 27, 2019, NDSU Extension Service.*

- U.S. Aggregate test weight standard deviation in 2020 (1.22 lb/bu) was lower than 2019 (1.41 lb/bu), but similar to 2018 (1.20 lb/bu) and the 5YA (1.22 lb/bu).
- The range in values among the 2020 harvest samples was 9.9 lb/bu (from 52.6 to 62.5 lb/bu). It was lower than the 19.3 lb/bu range in 2019 (42.6 to 61.9 lb/bu), but similar to the 9.8 lb/bu range in the 2018 samples (from 52.3 to 62.1 lb/bu).
- The 2020 test weight values were distributed with 94.8% of the samples at or above the factor limit for the U.S. No. 1 grade (56.0 lb/bu) compared to 75.6% in 2019 and 90.3% in 2018. In 2020, 99.3% of the samples were above the limit for the U.S. No. 2 grade (54.0 lb/bu), compared to 89.9% in 2019 and 98.2% in 2018.
- In 2020, the Gulf (58.8 lb/bu) and Southern Rail (58.9 lb/bu) ECAs had the highest average test weights. The Pacific Northwest ECA (58.3 lb/bu) had the lowest test weight in 2020, 2019, 2018 and the 5YA.

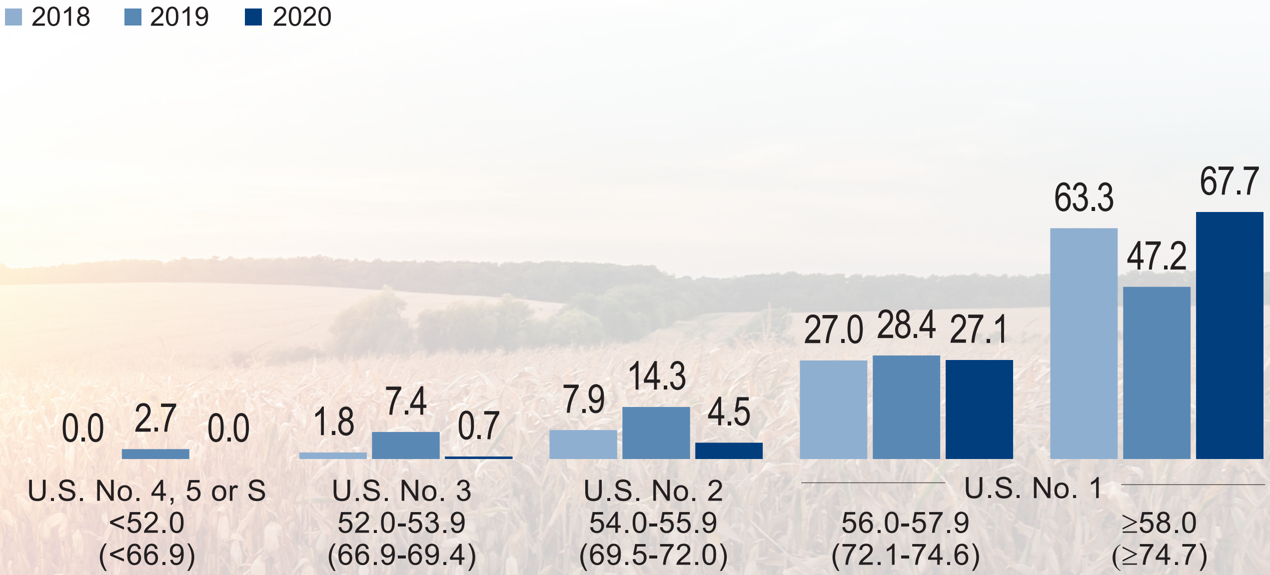
TEST WEIGHT (lb/bu & kg/hl)

2020 Average by Export Catchment Area



TEST WEIGHT (lb/bu & kg/hl)

Percent of Samples by Crop Year



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 as a result of more broken kernels, 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.

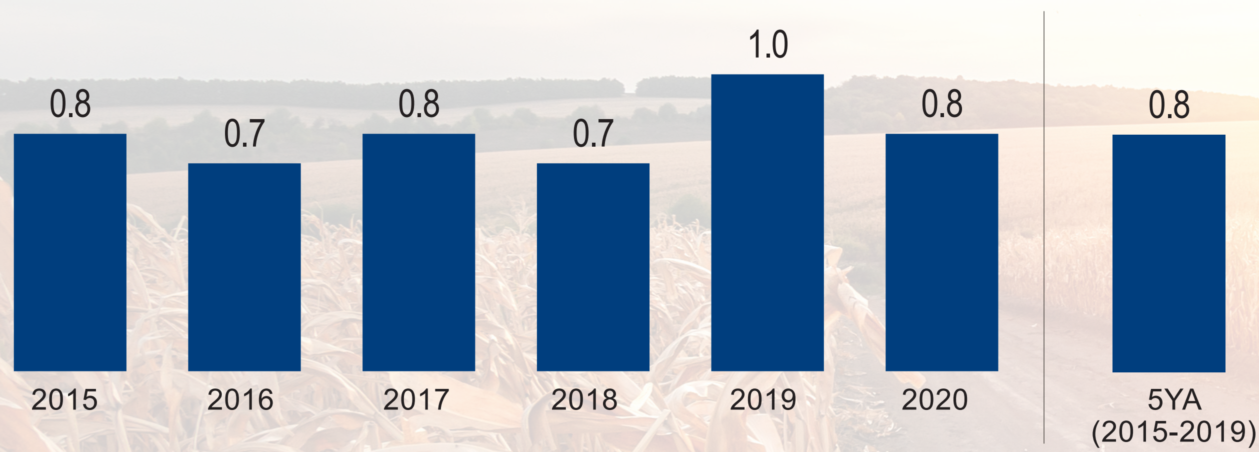
The diagram shown on the following page illustrates the measurement of broken corn and foreign material for the U.S. corn grades.

RESULTS

- Average U.S. Aggregate BCFM in 2020 (0.8%) was lower than in 2019 (1.0%), higher than in 2018 (0.7%) and same as the 5YA (0.8%), but well below the maximum for the U.S. No. 1 grade (2.0%).
- The variability of BCFM in the 2020 crop, based on standard deviation (0.49%), was more than 2019 (0.67%), 2018 (0.51%) and the 5YA (0.56%).

BCFM (%)

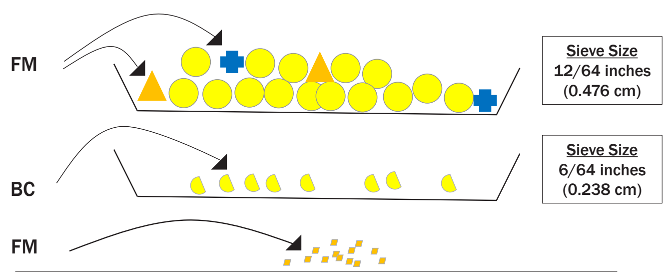
U.S. Aggregate Results Summary



- The range between minimum and maximum BCFM values in the 2020 harvest samples was 8.7% (from 0.1 to 8.8%). This was higher than 2019 (8.2%) and 2018 (7.5%).
- The 2020 samples were distributed with 95.8% of the samples at or below the maximum BCFM level for the U.S. No. 1 grade (2.0%), compared to 92.3% in 2019 and 95.3% in 2018. BCFM levels in nearly all samples (98.5%) were equal to or below the maximum 3.0% limit for No. 2 grade.
- Average BCFM levels for the Gulf, Pacific Northwest and Southern Rail ECAs were all 0.8%, all below the limit for No.1 grade.

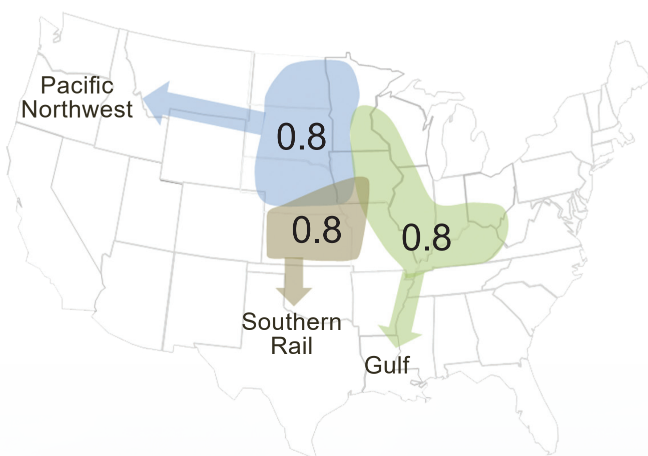
BCFM (%)

Broken Corn and Foreign Material Measured as Percent by Weight



BCFM (%)

2020 Average by Export Catchment Area



BCFM (%)

Percent of Samples by Crop Year

BROKEN CORN

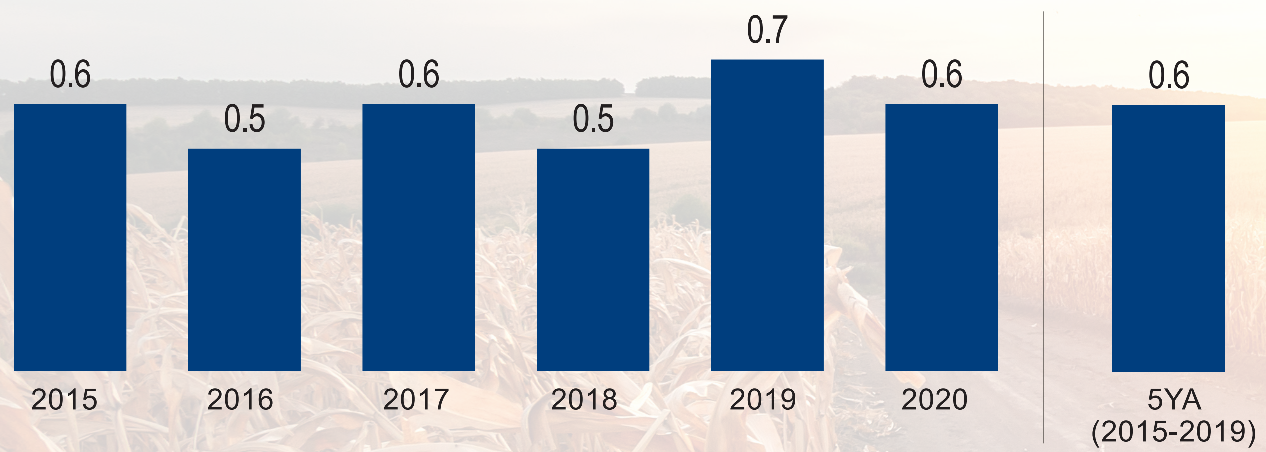
Broken corn in U.S. grades is based on particle size and usually includes a small percent of non-corn material. Broken corn is more subject to mold and insect damage than whole kernels, and it can cause problems in handling and processing. When not spread or stirred in a storage bin, broken corn tends 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 0.6% in 2020, lower than in 2019 (0.7%), higher than in 2018 (0.5%) and same as the 5YA and the 10YA (both 0.6%).
- The variability among samples of broken corn for the 2020 crop was slightly less than previous years and the 5YA, as measured by standard deviations. Standard deviations for 2020, 2019, 2018 and the 5YA were 0.34, 0.47, 0.33 and 0.39%, respectively.
- The range in broken corn values in 2020 was 2.8% (from 0.0 to 2.8%), lower than 2019 (5.3%) and 2018 (3.6%).

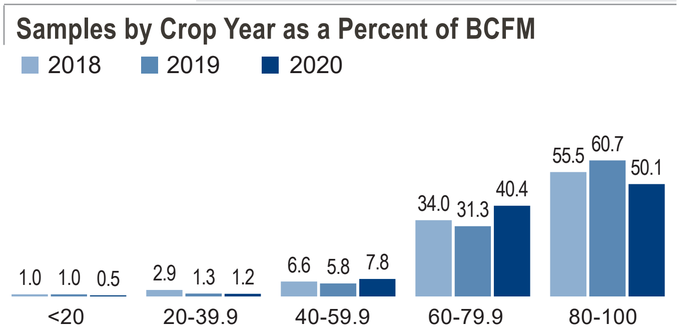
BROKEN CORN (%)

U.S. Aggregate Results Summary

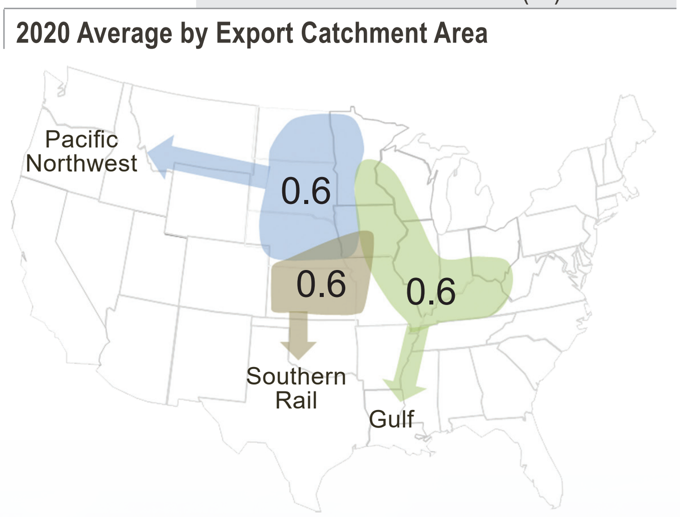


- The 2020 samples were distributed with 15.4% having 1.0% or more broken corn, compared to 23.0% in 2019 and 12.6% in 2018.
- The distribution chart to the right, displaying broken corn as a percentage of BCFM, shows that in 50.1% of the samples, BCFM consisted of at least 80.0% broken corn.
- The percentage of broken corn was consistent across the Gulf, Pacific Northwest and Southern Rail ECAs, with averages of 0.6, 0.6 and 0.6%, respectively.

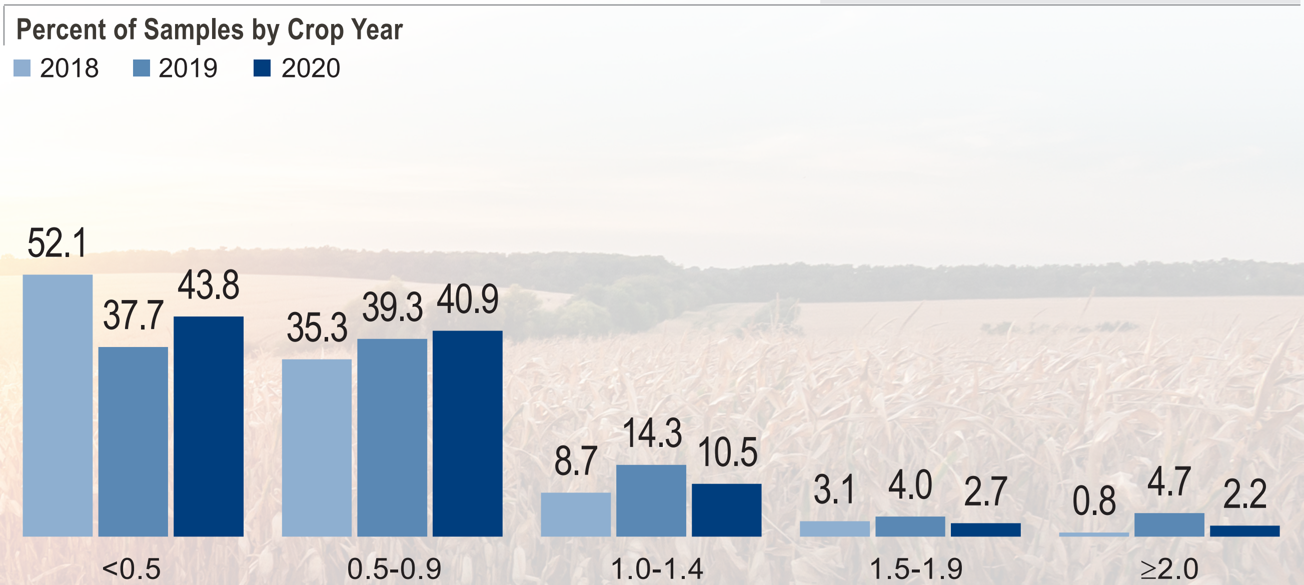
BROKEN CORN (% OF BCFM)



BROKEN CORN (%)



BROKEN CORN (%)



FOREIGN MATERIAL

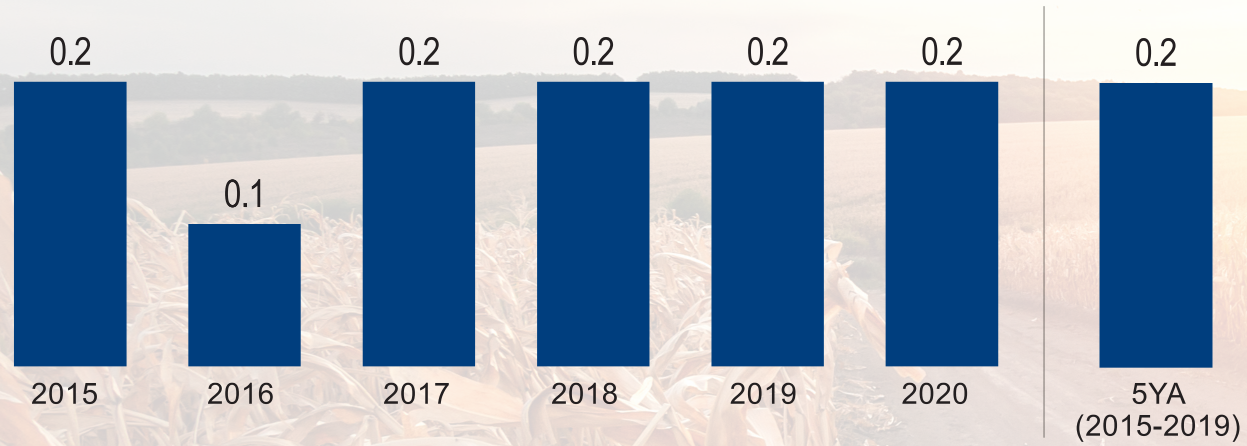
Foreign material is important because it has reduced feeding or processing value. It is also generally higher in moisture content than corn and, therefore, creates a potential for deterioration of corn quality during storage. Additionally, foreign material contributes to the spout-line (as mentioned 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 2020, the same as in 2019, 2018 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 2020 (0.22%) was similar to 2019 (0.28%), 2018 (0.26%) and the 5YA (0.24%).
- Foreign material in the 2020 samples ranged from 0.0 to 8.3%, higher than 2019 (0.0 to 3.3%), but similar to 2018 samples (0.0 to 7.3%).
- In the 2020 crop, 92.3% of the samples contained less than 0.5% foreign material, slightly higher than 2019 (88.3%) but similar to 2018 (90.6%).

FOREIGN MATERIAL (%)

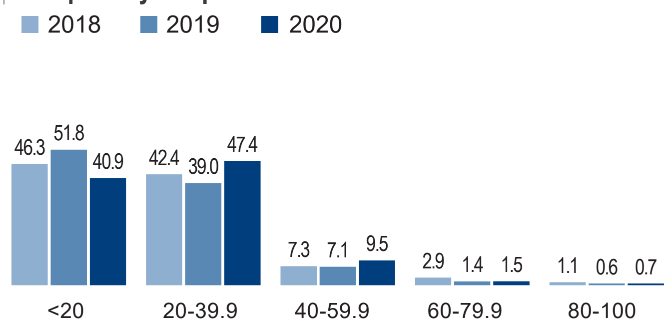
U.S. Aggregate Results Summary



- The distribution chart to the right, displaying foreign material as a percentage of BCFM, shows that in 40.9% of the samples, BCFM consisted of less than 20.0% foreign material.
- The percentages of foreign material for the Gulf, Pacific Northwest and Southern Rail ECAs were 0.2, 0.2 and 0.2%, respectively. All ECAs had average foreign material values of 0.2% in 2018 and the 5YA.

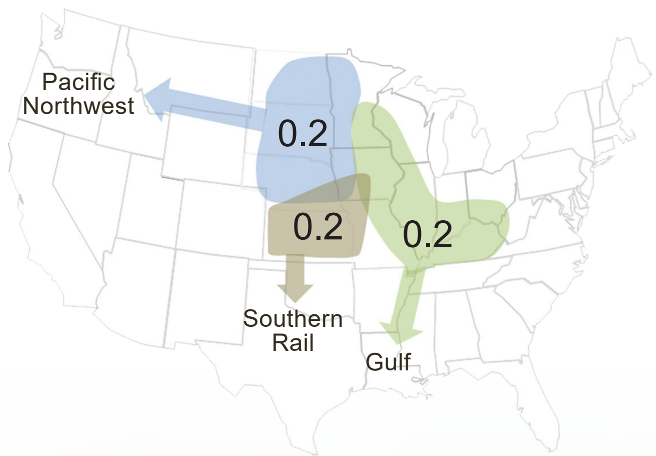
FOREIGN MATERIAL (% OF BCFM)

Samples by Crop Year as a Percent of BCFM



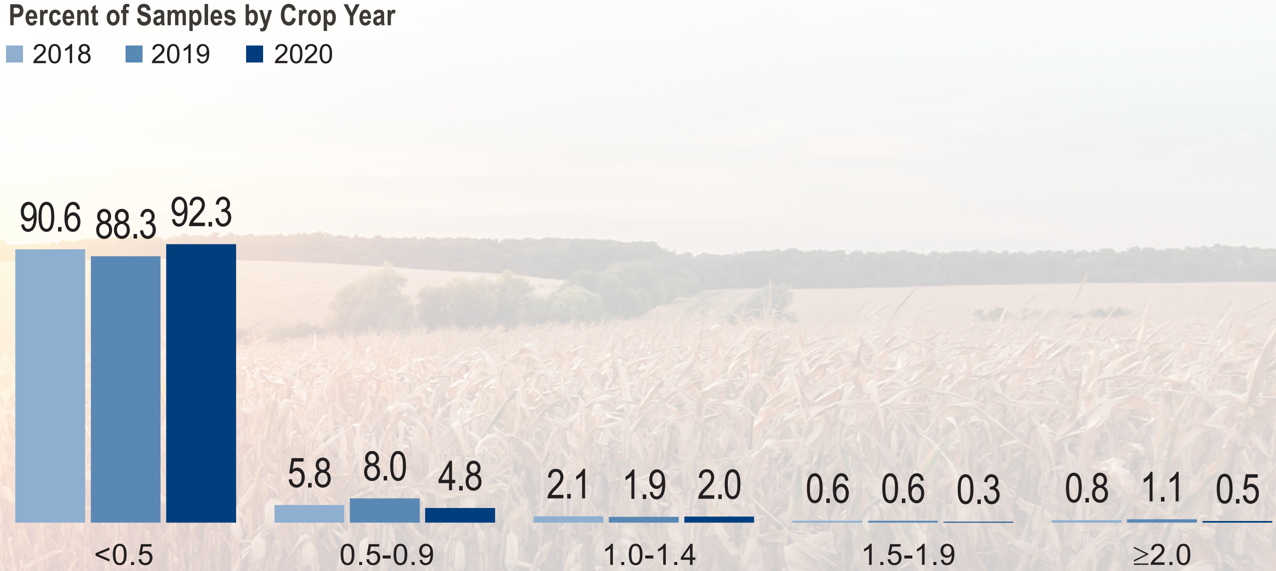
FOREIGN MATERIAL (%)

2020 Average by Export Catchment Area



FOREIGN MATERIAL (%)

Percent of Samples by Crop Year



TOTAL DAMAGE

Total damage is the percent of kernels and pieces of kernels that are visually damaged in some way, including damage from mold, frost, insects, sprouting, disease, weather, ground, germ and heat. Heat damage is a subset of total damage and has separate allowances in the U.S. Grade standards. 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. Several field molds, such as Diplodia, Aspergillus, Fusarium and Gibberella, 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.

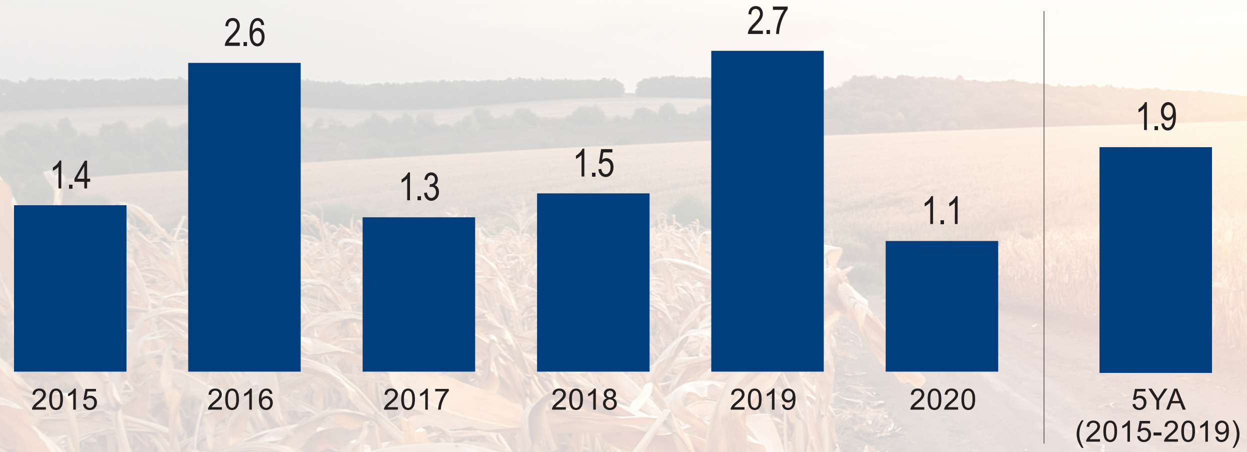
Heat damage can be caused by microbiological activity in warm, moist grain or high heat applied during drying. Heat damage is seldom present in corn delivered directly from farms at harvest.

RESULTS

- Average U.S. Aggregate total damage in 2020 (1.1%) was lower than 2019 (2.7%), 2018 (1.5%), the 5YA (1.9%) and the 10YA (1.5%). The 2020 total damage average was well below the limit for the U.S. No. 1 grade (3.0%).
- Total damage variability in the 2020 crop, as measured by the standard deviation (1.06%), was much less than 2019 (2.43%), 2018 (1.25%) and the 5YA (1.47%).

TOTAL DAMAGE (%)

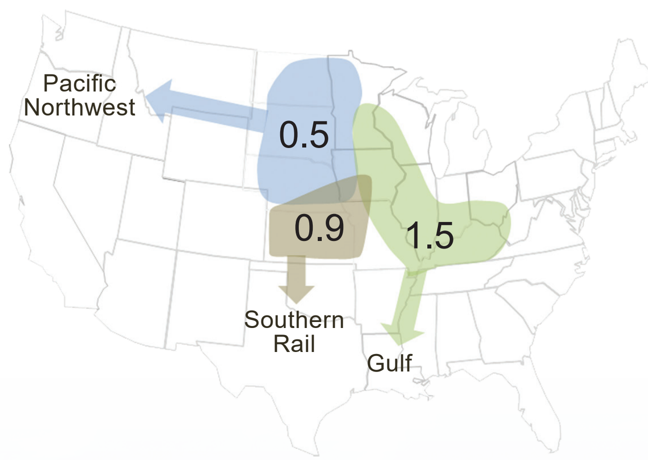
U.S. Aggregate Results Summary



- The range for total damage in 2020 (0.0 to 18.3%) was lower than 2019 (0.0 to 50.5%) but similar to 2018 (0.0 to 19.3%).
- Total damage in the 2020 samples was lower than 2019, with 91.5% of the samples having 3.0% or less compared to only 73.5 in 2019 having 3.0% or less damage.
- Average total damage was 1.5, 0.5 and 0.9% for the Gulf, Pacific Northwest and Southern Rail ECAs, respectively. The Gulf ECA had the highest or tied for the highest total damage for 2020, 2019, 2018, the 5YA and the 10YA.
- The average total damage values in all ECAs were at or below the limit for the U.S. No. 1 grade (3.0%).
- Aggregate heat damage averaged 0.0% for the 2020 samples, the same result as 2019, 2018 and the 5YA. Only one sample in the survey tested above 0.0%. That sample had 0.1% heat damage.
- The lack of heat damage likely was due, in part, to fresh samples coming directly from farm to elevator with minimal artificial drying.

TOTAL DAMAGE (%)

2020 Average by Export Catchment Area



TOTAL DAMAGE (%)

Percent of Samples by Crop Year

2018 2019 2020

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. Higher moisture content at harvest increases the chance of kernel damage during harvesting and drying, with the amount of drying required also affecting stress cracks and breakage.

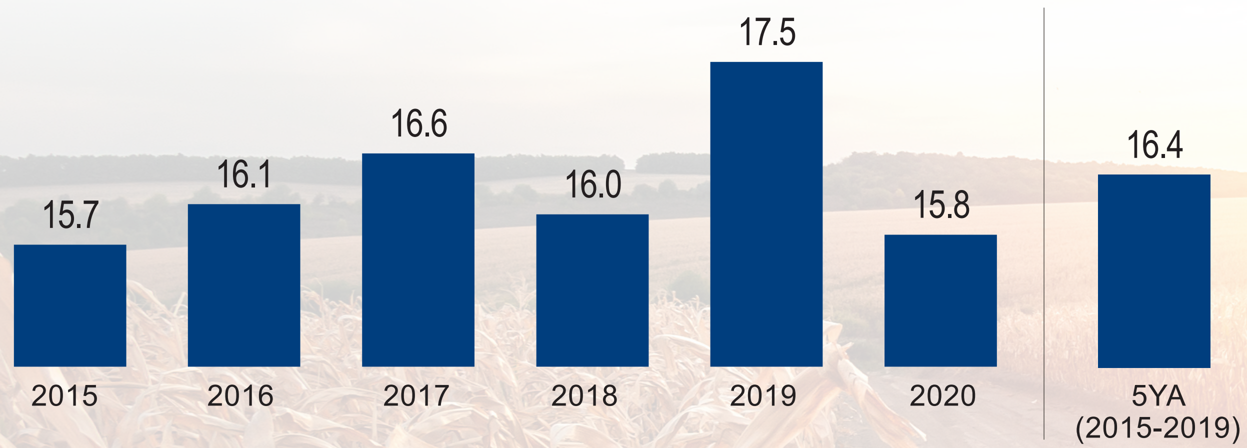
Extremely wet grain may be a precursor to high mold damage later in storage or transport. While the weather during the growing season affects yield, grain composition and kernel development, grain harvest moisture is influenced largely by crop maturation, the timing of harvest and harvest weather conditions. 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.[3]

RESULTS[4]

- The average U.S. Aggregate moisture content recorded at elevators in 2020 was 15.8%, which was lower than in 2019 (17.5%), 2018 (16.0%) and the 5YA (16.4%). Over the past ten 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 (%)

U.S. Aggregate Results Summary

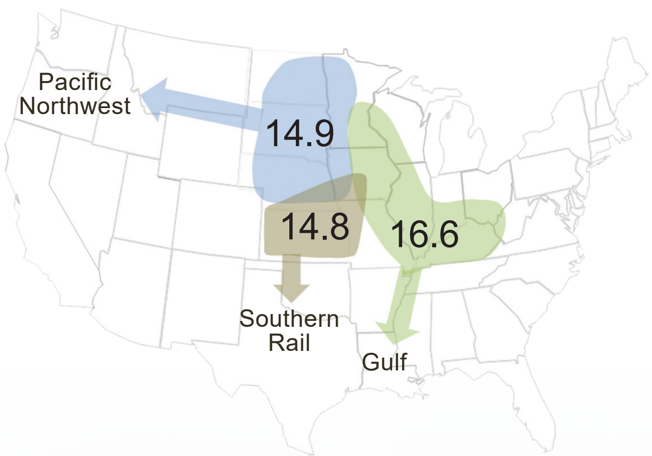


[3]*MWPS-13. 2017. Grain Drying, Handling and Storage Handbook. Midwest Plan Service No. 13. Iowa State University, Ames, IA 50011.*
[4]*Differences between the histograms in this section are solely due to rounding.*

- U.S. Aggregate moisture standard deviation in 2020 (1.97%) was lower than 2019 (2.35%) but higher than 2018 (1.58%) and the 5YA (1.77%).
- There were fewer high-moisture samples in the 2020 samples than in 2019, with 26.3% of the samples containing more than 17.0% moisture, compared to 45.7% in 2019. Care should still be made to monitor and maintain moisture levels sufficiently low to prevent possible mold growth, reducing storage life.
- The 2020 moisture values were distributed with 42.2% 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.
- In the 2020 crop, 9.7% of the samples contained 13.0% or less moisture, compared to only 3.4% in 2019. Moisture content values of 13.0% and below are generally considered safe for longer-term storage and transport.
- Average moisture levels for the Southern Rail ECA were lowest among all ECAs for 2020, 2019, 2018, 5YA and the 10YA.

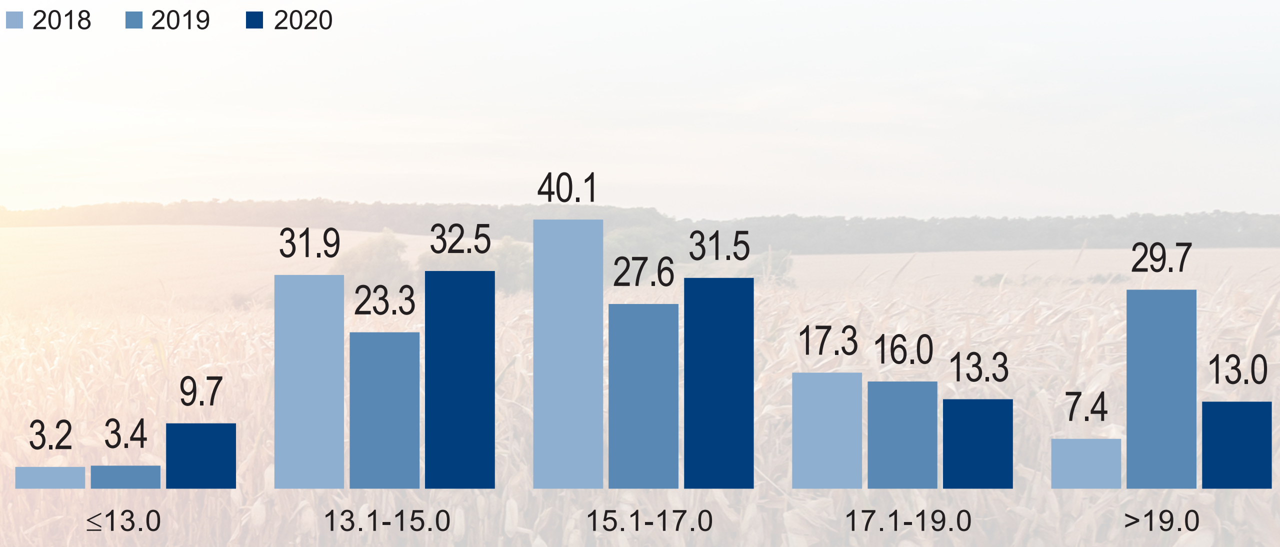
MOISTURE (%)

2020 Average by Export Catchment Area



MOISTURE (%)

Percent of Samples by Crop Year



SUMMARY: GRADE FACTORS AND MOISTURE

	2020 Harvest					2019 Harvest		2018 Harvest		Five-Year Average (2015-2019)		Ten-Year Average (2011-2020)	
	No. of Samples[1]	Avg.	Std. Dev.	Min.	Max.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.
U.S. Aggregate						**U.S. Aggregate**		**U.S. Aggregate**		**U.S. Aggregate**		**U.S. Aggregate**	
Test Weight (lb/bu)	601	58.7	1.22	52.6	62.5	57.3*	1.41	58.4*	1.20	58.1	1.22	58.2	1.29
Test Weight (kg/hl)	601	75.5	1.57	67.7	80.4	73.8*	1.81	75.1*	1.54	74.8	1.57	74.9	1.66
BCFM (%)	601	0.8	0.49	0.1	8.8	1.0*	0.67	0.7*	0.51	0.8	0.56	0.8	0.56
Broken Corn (%)	601	0.6	0.34	0.0	2.8	0.7*	0.47	0.5*	0.33	0.6	0.39	0.6	0.40
Foreign Material (%)	601	0.2	0.22	0.0	8.3	0.2	0.28	0.2	0.26	0.2	0.24	0.2	0.22
Total Damage (%)	601	1.1	1.06	0.0	18.3	2.7*	2.43	1.5*	1.25	1.9	1.47	1.5	1.23
Heat Damage (%)	601	0.0	0.00	0.0	0.1	0.0*	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Moisture (%)	585	15.8	1.97	9.2	29.0	17.5*	2.35	16.0*	1.58	16.4	1.77	16.2	1.82
Gulf						**Gulf**		**Gulf**		**Gulf**		**Gulf**	
Test Weight (lb/bu)	549	58.8	1.25	53.4	62.5	57.8*	1.27	58.6*	1.13	58.3	1.18	58.3	1.27
Test Weight (kg/hl)	549	75.7	1.61	68.7	80.4	74.4*	1.64	75.4*	1.46	75.1	1.52	75.1	1.64
BCFM (%)	549	0.8	0.53	0.1	8.8	0.9*	0.61	0.7*	0.50	0.8	0.56	0.8	0.55
Broken Corn (%)	549	0.6	0.36	0.0	2.8	0.7*	0.43	0.5*	0.32	0.6	0.38	0.6	0.40
Foreign Material (%)	549	0.2	0.25	0.0	8.3	0.2	0.26	0.2	0.26	0.2	0.25	0.2	0.23
Total Damage (%)	549	1.5	1.42	0.0	18.3	3.0*	2.50	1.8*	1.41	2.2	1.66	1.8	1.43
Heat Damage (%)	549	0.0	0.00	0.0	0.1	0.0*	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Moisture (%)	549	16.6	2.16	9.2	29.0	17.6*	2.32	16.1*	1.58	16.5	1.79	16.6	1.89
Pacific Northwest						**Pacific Northwest**		**Pacific Northwest**		**Pacific Northwest**		**Pacific Northwest**	
Test Weight (lb/bu)	293	58.3	1.19	52.6	61.9	55.7*	1.80	57.5*	1.37	57.3	1.33	57.4	1.35
Test Weight (kg/hl)	293	75.0	1.53	67.7	79.7	71.7*	2.31	74.0*	1.77	73.8	1.71	73.9	1.74
BCFM (%)	293	0.8	0.44	0.1	4.1	1.2*	0.88	0.8	0.58	0.9	0.62	0.9	0.62
Broken Corn (%)	293	0.6	0.32	0.0	2.8	0.9*	0.60	0.6	0.39	0.7	0.44	0.7	0.45
Foreign Material (%)	293	0.2	0.19	0.0	2.0	0.3*	0.37	0.2	0.24	0.2	0.24	0.2	0.24
Total Damage (%)[2]	293	0.5	0.64	0.0	8.4	2.6*	3.02	0.9*	0.83	1.1	1.12	0.8	0.81
Heat Damage (%)	293	0.0	0.00	0.0	0.1	0.0*	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Moisture (%)	293	14.9	1.74	9.2	22.7	18.3*	2.96	16.1*	1.75	16.4	1.91	15.8	1.78
Southern Rail						**Southern Rail**		**Southern Rail**		**Southern Rail**		**Southern Rail**	
Test Weight (lb/bu)	319	58.9	1.18	53.4	62.5	58.6*	1.18	58.9	1.19	58.6	1.17	58.5	1.25
Test Weight (kg/hl)	319	75.8	1.51	68.7	80.4	75.4*	1.52	75.8	1.53	75.5	1.51	75.4	1.61
BCFM (%)	319	0.8	0.44	0.1	8.8	0.8	0.47	0.7*	0.44	0.7	0.46	0.8	0.50
Broken Corn (%)	319	0.6	0.32	0.0	2.8	0.6	0.35	0.5*	0.28	0.6	0.33	0.6	0.37
Foreign Material (%)	319	0.2	0.20	0.0	8.3	0.2	0.18	0.2	0.25	0.2	0.19	0.2	0.20
Total Damage (%)	319	0.9	0.68	0.0	14.1	2.3*	1.27	1.8*	1.23	1.8	1.25	1.4	1.02
Heat Damage (%)	319	0.0	0.00	0.0	0.1	0.0*	0.00	0.0	0.00	0.0	0.00	0.0	0.00
Moisture (%)	319	14.8	1.77	9.2	29.0	16.0*	1.42	15.5*	1.35	15.7	1.43	15.6	1.54

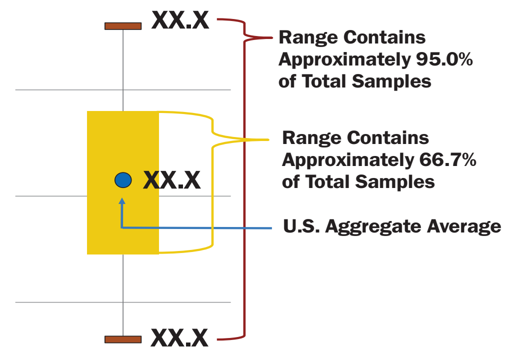
**Indicates average was significantly different from 2020, based on a 2-tailed t-test at the 95.0% level of significance.*

[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.

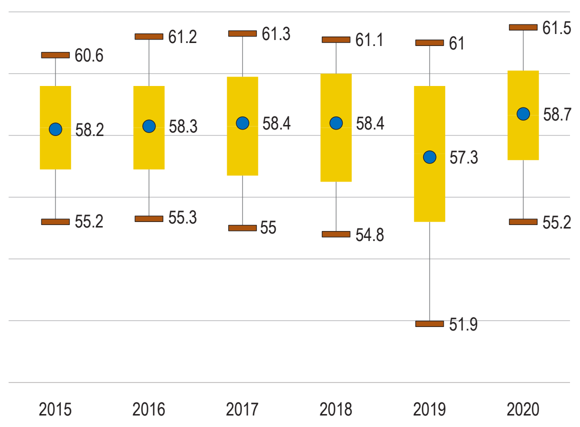
[2]The Relative ME for predicting the harvest population average exceeded ±10.0%.

GRADE FACTORS
AGGREGATE SIX-YEAR COMPARISON

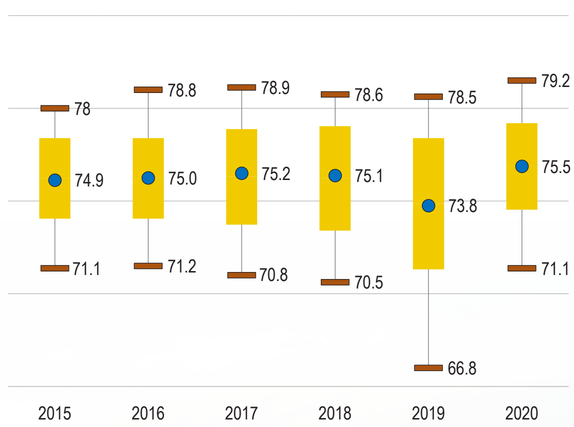
HOW TO READ THE CHARTS



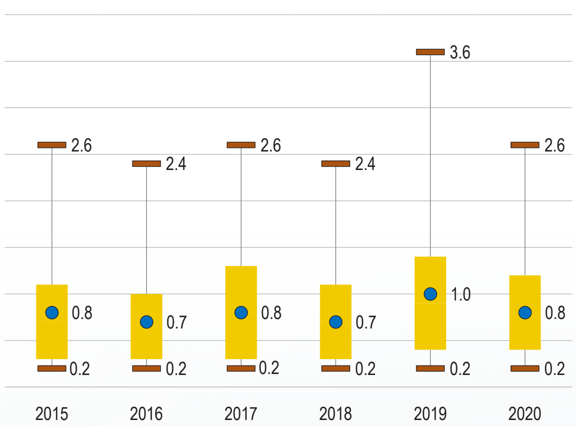
Test Weight (lb/bu)



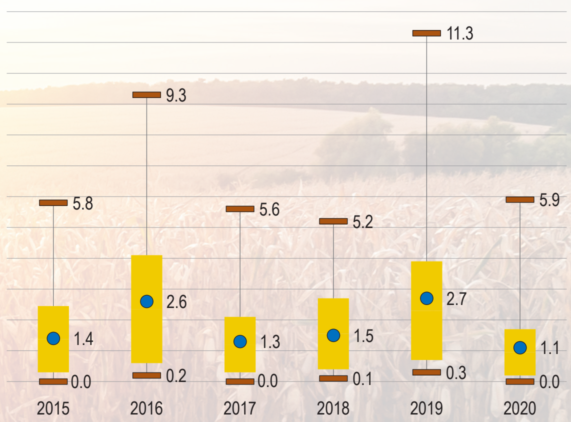
Test Weight (kg/hl)



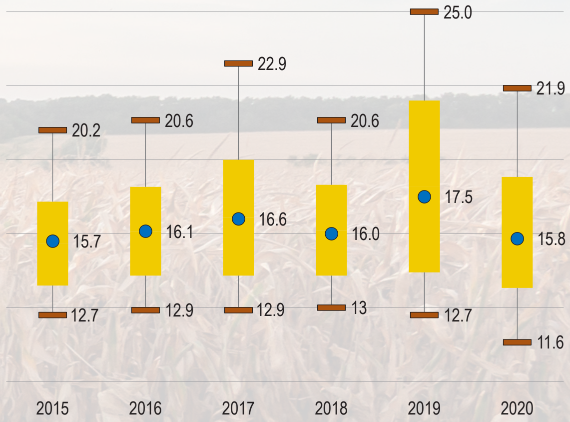
BCFM (%)



Total Damage (%)



Moisture (%)



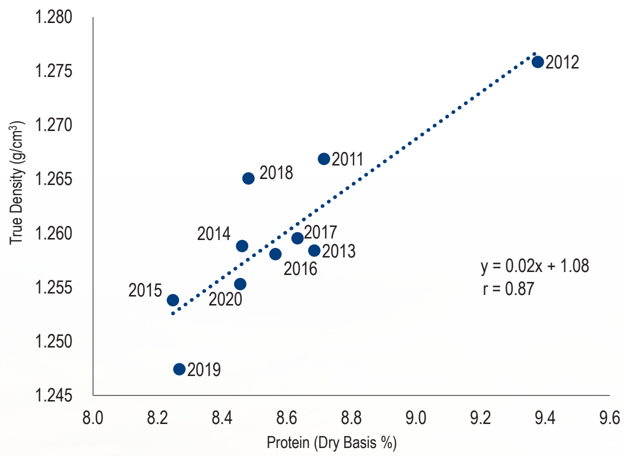
C.CHEMICAL COMPOSITION

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 about 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 2020 (8.5% dry basis) was higher than 2019 (8.3%), the same as 2018 and higher than the 5YA (8.4%).
- The Gulf ECA had the lowest or tied for lowest protein concentrations among the other ECAs in 2020, 2019, 2018 and the 5YA.
- Based on U.S. Aggregate averages over the past ten 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.
- Average U.S. Aggregate starch concentration in 2020 (72.2% dry basis) was below 2019 (72.3%), 2018 (72.5%) and the 5YA (72.6%).

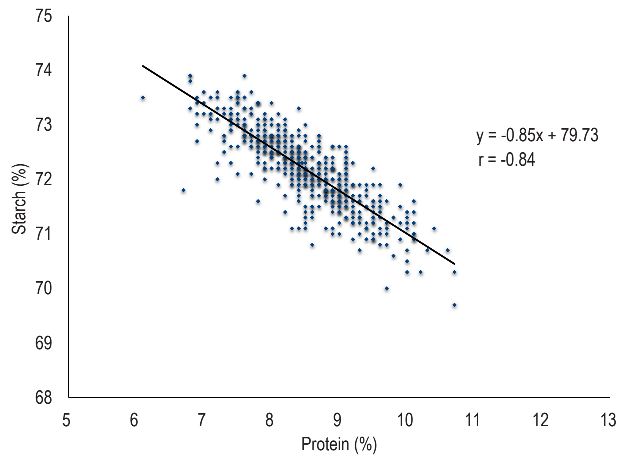
True Density vs Protein
U.S. Aggregate over Ten Years



SUMMARY: CHEMICAL COMPOSITION

- The Gulf ECA had the highest starch concentration averages in 2020, 2019, 2018 and the 5YA among all ECAs.
- Since starch and protein are the two largest corn components, when the percentage of one goes up, the other usually goes down. This relationship is illustrated in the adjacent figure showing a negative correlation (r = -0.84) between starch and protein.
- Average U.S. Aggregate oil concentration in 2020 (3.9% dry basis) was lower than 2019 (4.1%), 2018 (4.0%) and the 5YA (4.0%).

Starch vs Protein, U.S. Aggregate 2020



- The variability in chemical concentrations was similar for 2020, 2019 and 2018 based on similar standard deviations for protein, starch and oil.
- Oil concentration averages for Gulf, Pacific Northwest and Southern Rail ECAs were all 3.9%. Oil concentration averages have varied by 0.1% or less among the ECAs for 2020, 2019, 2018 and the 5YA.

PROTEIN

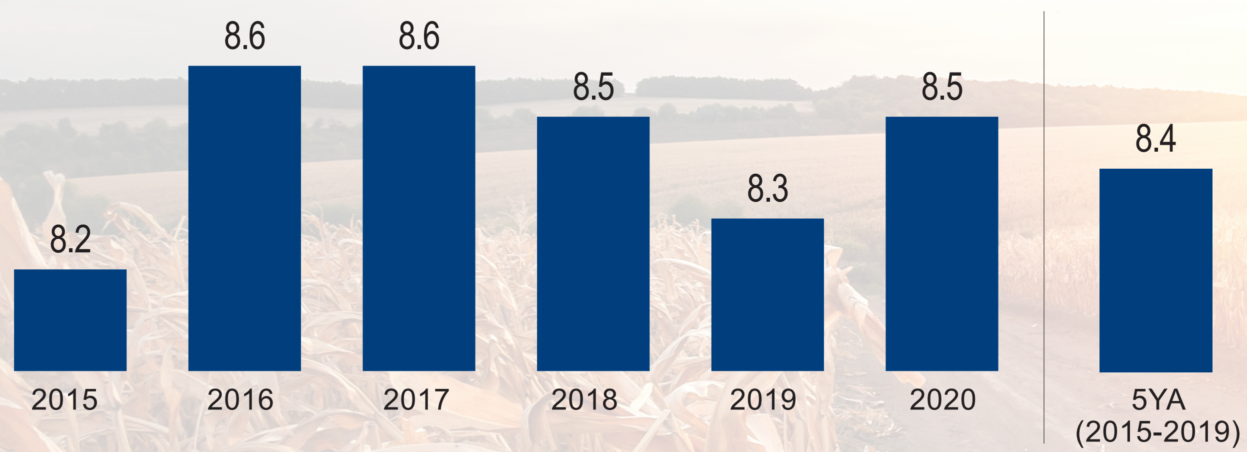
Protein is very important for poultry and livestock feeding because it supplies essential sulfur-containing amino acids and improves the feed conversion efficiency. Protein concentration tends to decrease with decreased available soil nitrogen and in years with high yields. Protein is usually inversely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

RESULTS

- Average U.S. Aggregate protein concentration in 2020 was 8.5%. This was higher than 2019 (8.3%) and the 5YA (8.4%), same as 2018 (8.5%), and lower than the 10YA (8.6%).
- Average U.S. Aggregate protein standard deviation in 2020 (0.58%) was similar to 2019 (0.54%), 2018 (0.53%) and the 5YA (0.53%).
- The range in protein concentration in 2020 (6.1 to 10.7%) was similar to ranges in 2019 (6.2 to 10.4%) and 2018 (6.6 to 11.9%).
- Protein concentrations in 2020 were distributed with 25.5% below 8.0%, 48.4% from 8.0 to 8.9% and 26.1% at or above 9.0%. The protein distribution in 2020 shows a higher number of high protein samples than in 2019.

PROTEIN (DRY BASIS %)

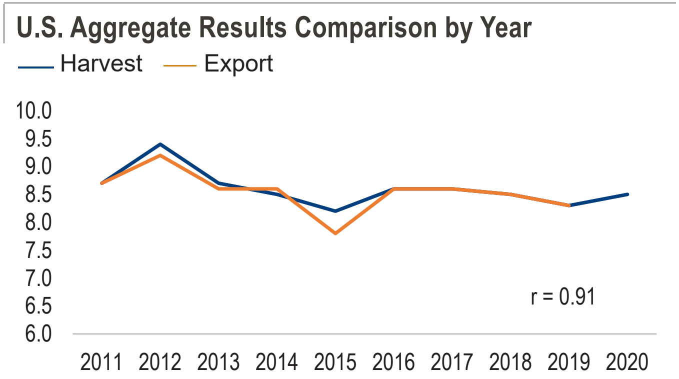
U.S. Aggregate Results Summary



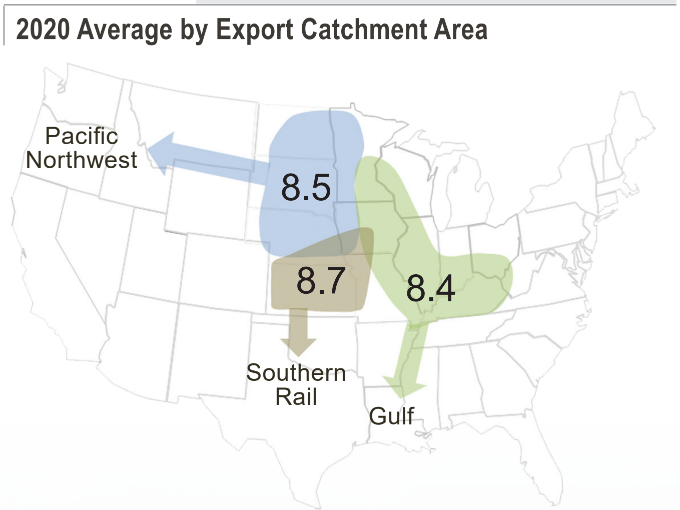
- Additional handling, blending and storage from harvest to export has little impact on average chemical composition. Similar chemical composition has been observed between each individual year's *Harvest Report and Export Cargo Report*. The line chart at the right displays the U.S. Aggregate protein concentrations observed in each of these reports. The high correlation coefficient (r = 0.91) illustrates this consistency.

- Protein concentration averages for Gulf, Pacific Northwest and Southern Rail ECAs were 8.4, 8.5 and 8.7%, respectively. The Gulf ECA had the lowest or tied for the lowest protein in 2020, 2019, 2018, the 5YA and the 10YA.

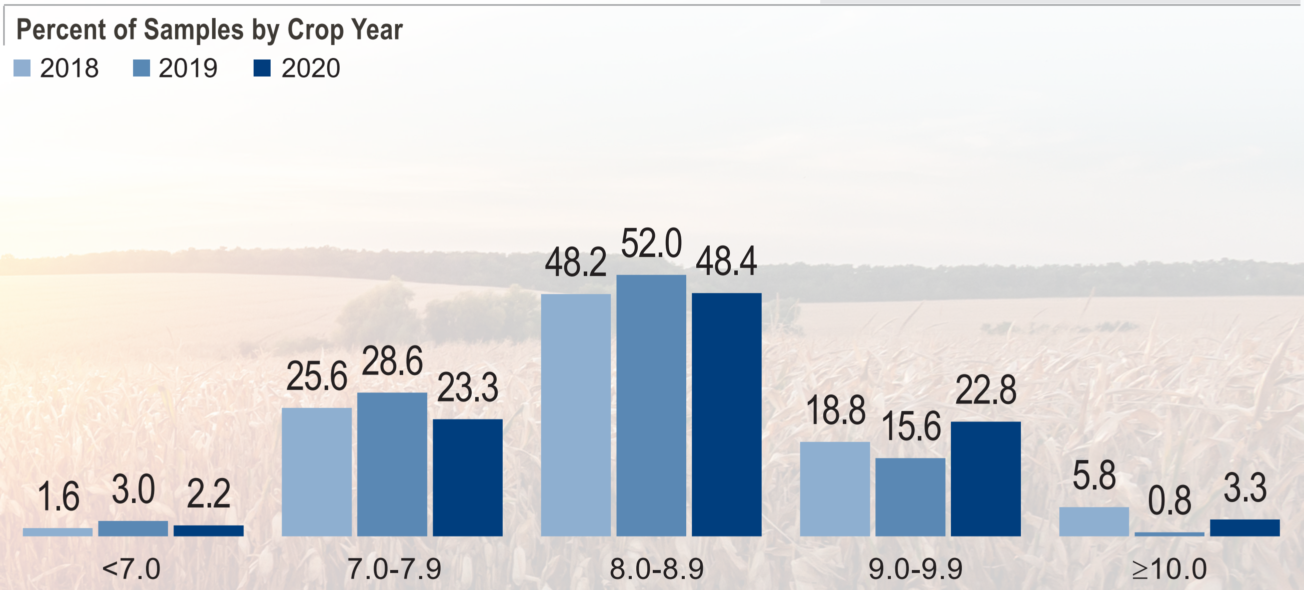
PROTEIN (DRY BASIS %)



PROTEIN (DRY BASIS %)



PROTEIN (DRY BASIS %)



STARCH

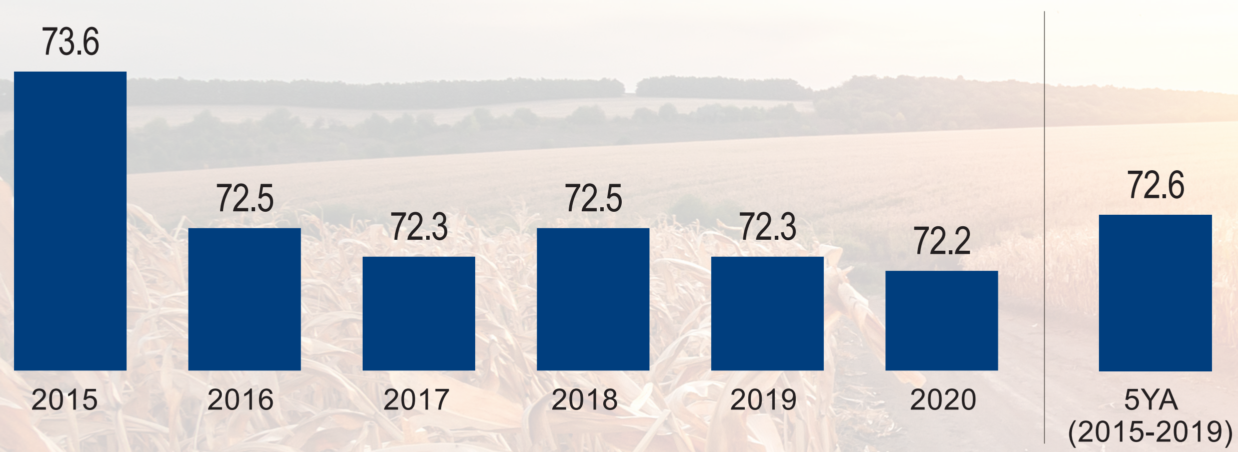
Starch is an important factor for corn used by wet millers and dry-grind ethanol manufacturers. High starch concentration is often indicative of good kernel growing/filling conditions and reasonably moderate kernel densities. Starch is usually inversely related to protein concentration. Results are reported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

RESULTS

- Average U.S. Aggregate starch concentration in 2020 (72.2% dry basis) was below 2019 (72.3%), 2018 (72.5%) and the 5YA (72.6%).
- U.S. Aggregate starch standard deviation in 2020 (0.61%) was similar to 2019 (0.58%) and 2018 (0.62%) and the 5YA (0.61%).
- Starch concentration range in 2020 (69.7 to 74.5%) was similar to 2019 (69.8 to 74.4%) and 2018 (68.9 to 74.6%).
- Starch concentrations in 2020 were distributed with 34.6% of the samples below 72.0%, 49.8% from 72.0 to 72.9% and 15.6% at 73.0% and higher. This distribution shows a lower number of samples at high starch levels than 2019 and 2018.

STARCH (DRY BASIS %)

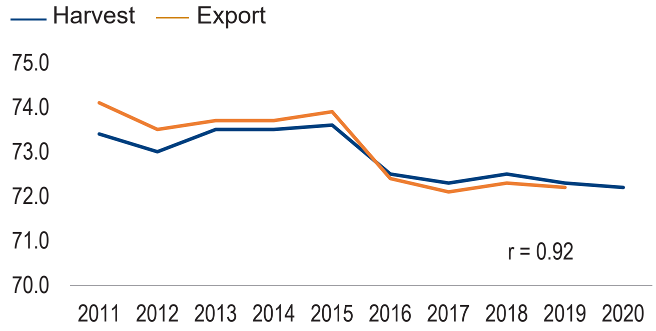
U.S. Aggregate Results Summary



- Additional handling, blending and storage from harvest to export has little impact on average chemical composition. Similar chemical composition has been observed between each individual year's *Harvest Report and Export Cargo Report*. The line chart at the right displays the U.S. Aggregate starch concentrations observed in each of these reports. The high correlation coefficient (r = 0.92) illustrates this consistency.
- Starch concentration averages for the Gulf, Pacific Northwest and Southern Rail ECAs were 72.3, 72.2 and 72.1%, respectively. Starch concentration averages were highest in the Gulf ECA in 2020, 2019, 2018, the 5YA and the 10YA. The Gulf ECA had the highest starch and lowest or tied for lowest protein in 2020, 2019, 2018, the 5YA and the 10YA.

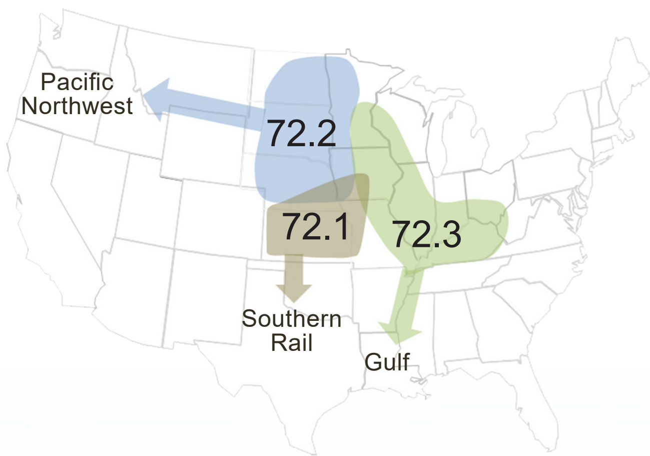
STARCH (DRY BASIS %)

U.S. Aggregate Results Comparison by Year



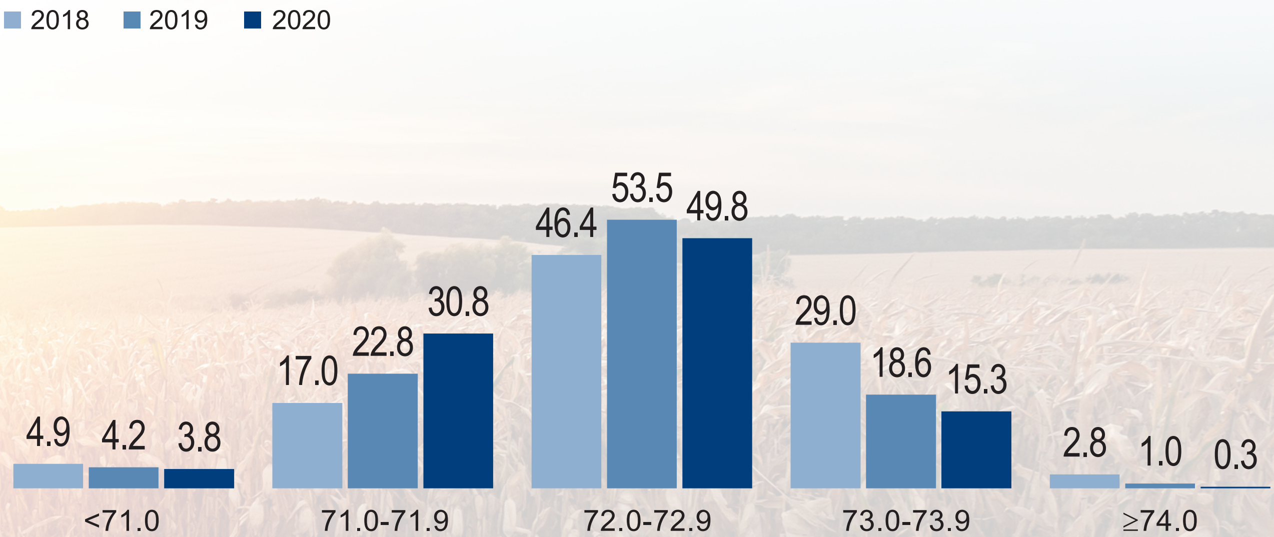
STARCH (DRY BASIS %)

2020 Average by Export Catchment Area



STARCH (DRY BASIS %)

Percent of Samples by Crop Year



OIL

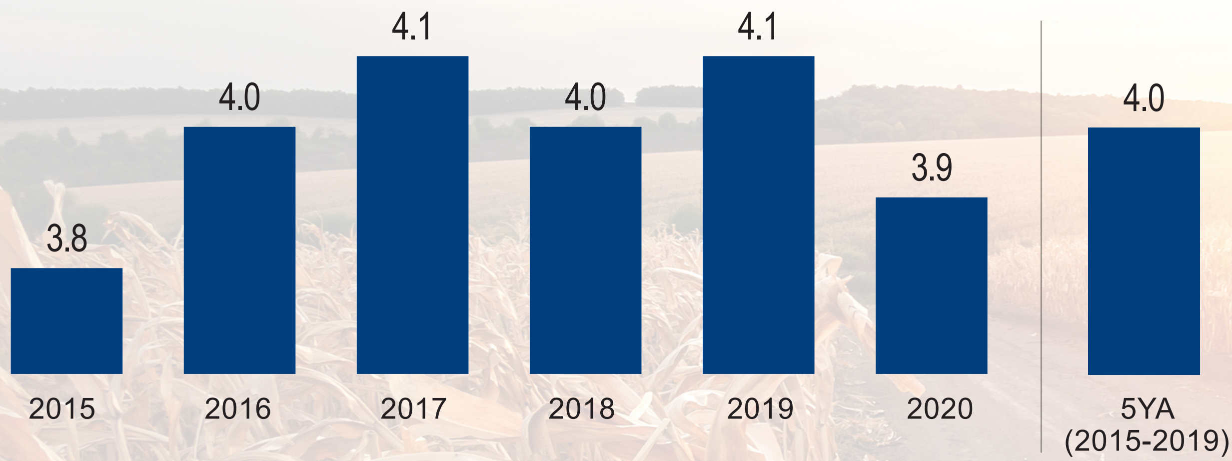
Oil is an essential component of poultry and livestock rations. It serves as an energy source, enables fat-soluble vitamins to be utilized, and provides certain essential fatty acids. Oil is also an important co-product of corn wet and dry milling. Results are reported on a dry basis.

RESULTS

- Average U.S. Aggregate oil concentration in 2020 (3.9%) was lower than 2019 (4.1%), 2018 (4.0%) and the 5YA (4.0%), but same as the 10YA (3.9%).
- U.S. Aggregate oil standard deviation in 2020 (0.22%) was similar to 2019 (0.23%), 2018 (0.22%) and the 5YA (0.24%).
- Oil concentration range in 2020 (3.2 to 4.8%) was similar to 2019 (3.2 to 5.0%) and 2018 (3.3 to 5.2%).
- Oil concentrations in 2020 were distributed with 15.5% of the samples less than 3.7%, 77.5% of samples at 3.7 to 4.2% and 7.0% at 4.3% and higher. The distribution in 2020 shows a lower number of samples with oil concentrations at 4.0% or higher than in the previous two years.

OIL (DRY BASIS %)

U.S. Aggregate Results Summary

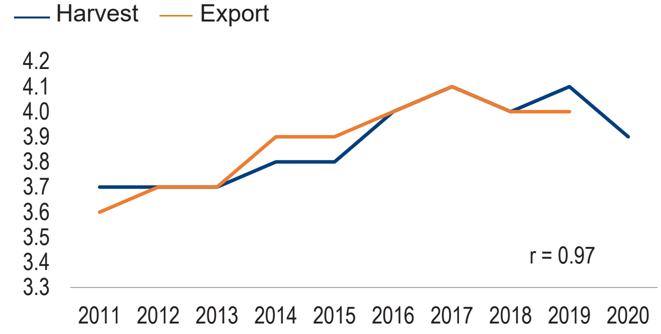


- Additional handling, blending and storage from harvest to export has little impact on average chemical composition. Similar chemical composition has been observed between each individual year's *Harvest Report and Export Cargo Report*. The line chart at the right displays the U.S. Aggregate oil concentrations observed in each of these reports. The high correlation coefficient (r = 0.97) illustrates this consistency.

- Oil concentration averages for Gulf, Pacific Northwest and Southern Rail ECAs were all 3.9%. Oil concentration averages have varied by 0.1% or less among the ECAs for 2020, 2019, 2018, the 5YA and the 10YA.

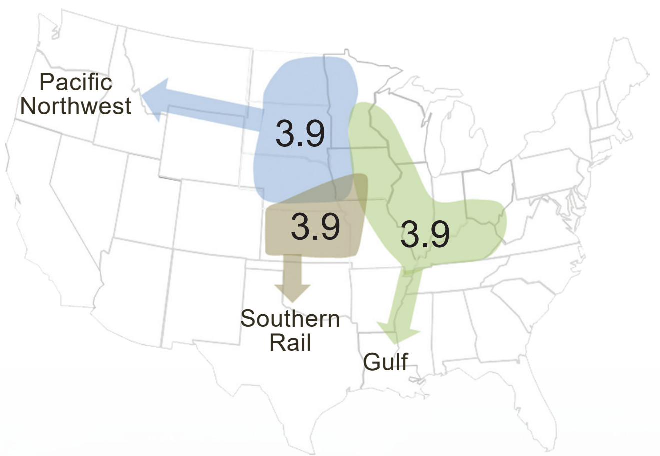
OIL (DRY BASIS %)

U.S. Aggregate Results Comparison by Year



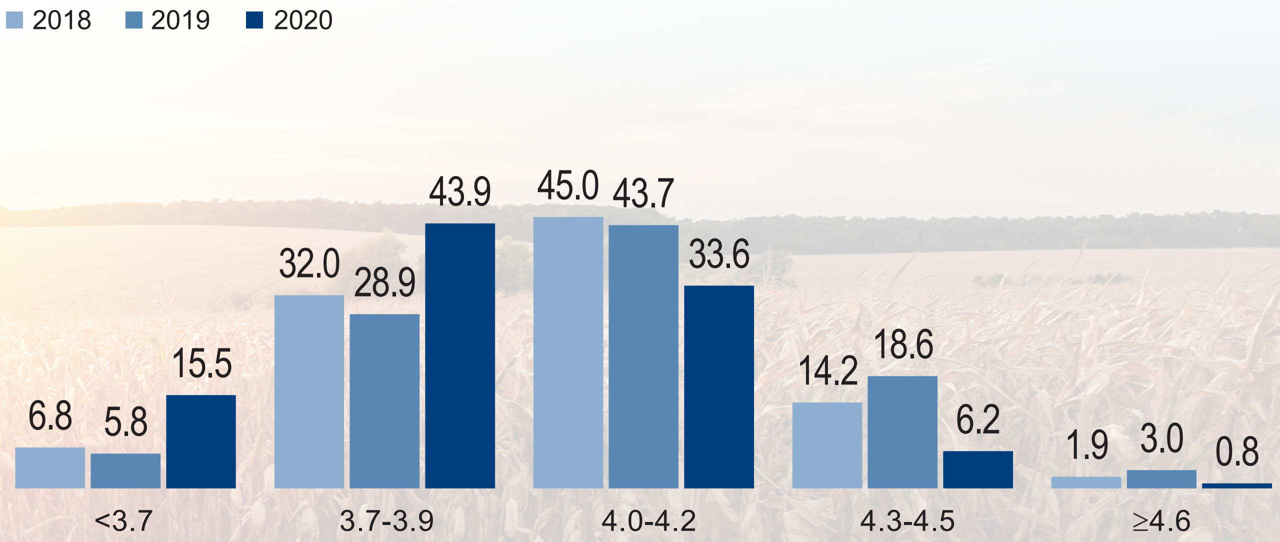
OIL (DRY BASIS %)

2020 Average by Export Catchment Area



OIL (DRY BASIS %)

Percent of Samples by Crop Year



SUMMARY: CHEMICAL FACTORS

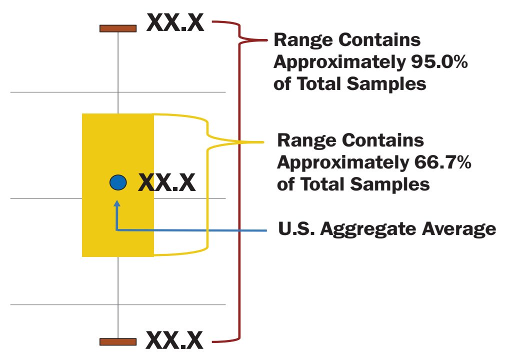
	2020 Harvest					2019 Harvest		2018 Harvest		Five-Year Average (2015-2019)		Ten-Year Average (2011-2020)	
	No. of Samples[1]	Avg.	Std. Dev.	Min.	Max.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.
U.S. Aggregate						**U.S. Aggregate**		**U.S. Aggregate**		**U.S. Aggregate**		**U.S. Aggregate**	
Protein (Dry Basis %)	601	8.5	0.58	6.1	10.7	8.3*	0.54	8.5	0.53	8.4	0.53	8.6	0.57
Starch (Dry Basis %)	601	72.2	0.61	69.7	74.5	72.3*	0.58	72.5*	0.62	72.6	0.61	72.9	0.62
Oil (Dry Basis %)	601	3.9	0.22	3.2	4.8	4.1*	0.23	4.0*	0.22	4.0	0.24	3.9	0.27
Gulf						**Gulf**		**Gulf**		**Gulf**		**Gulf**	
Protein (Dry Basis %)	549	8.4	0.56	6.1	10.7	8.2*	0.54	8.3	0.50	8.3	0.52	8.5	0.56
Starch (Dry Basis %)	549	72.3	0.60	70.0	74.5	72.4*	0.58	72.7*	0.61	72.8	0.61	73.0	0.62
Oil (Dry Basis %)	549	3.9	0.23	3.2	4.8	4.0*	0.24	4.0*	0.23	4.0	0.25	3.9	0.28
Pacific Northwest						**Pacific Northwest**		**Pacific Northwest**		**Pacific Northwest**		**Pacific Northwest**	
Protein (Dry Basis %)	293	8.5	0.63	6.1	10.7	8.2*	0.54	8.6*	0.60	8.6	0.57	8.7	0.59
Starch (Dry Basis %)	293	72.2	0.65	69.7	74.5	72.2	0.58	72.4*	0.64	72.4	0.62	72.8	0.62
Oil (Dry Basis %)	293	3.9	0.21	3.2	4.8	4.1*	0.25	4.0*	0.21	4.0	0.23	3.8	0.25
Southern Rail						**Southern Rail**		**Southern Rail**		**Southern Rail**		**Southern Rail**	
Protein (Dry Basis %)	319	8.7	0.54	6.8	10.7	8.6*	0.54	8.8*	0.55	8.6	0.53	8.8	0.58
Starch (Dry Basis %)	319	72.1	0.58	70.0	73.9	72.2*	0.56	72.3*	0.63	72.5	0.60	72.7	0.62
Oil (Dry Basis %)	319	3.9	0.21	3.3	4.7	4.0*	0.21	4.0*	0.21	4.0	0.23	3.9	0.26

**Indicates average was significantly different from 2020, based on a 2-tailed t-test at the 95.0% level of significance.*

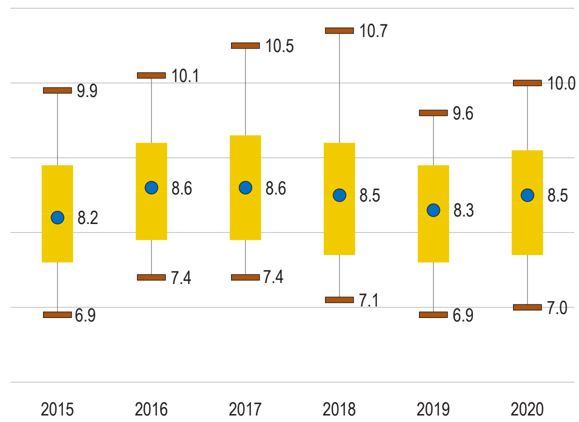
[1]Due to the ECA results being composite statistics, the sum of the sample numbers from the three ECAs is greater than the U.S. Aggregate.

CHEMICAL COMPOSITION
AGGREGATE SIX-YEAR COMPARISON

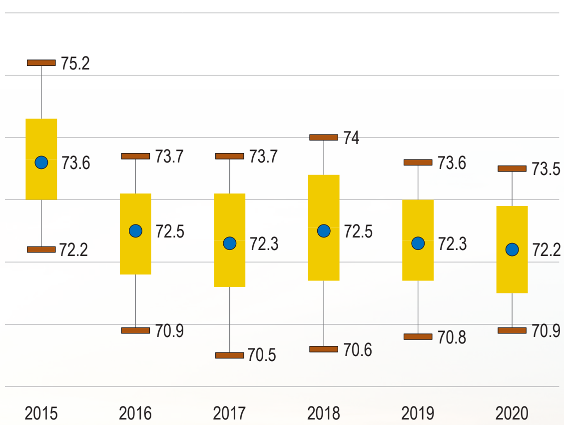
HOW TO READ THE CHARTS



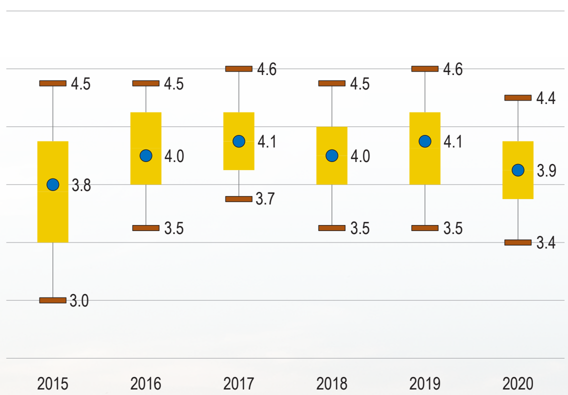
Protein (Dry Basis %)



Starch (Dry Basis %)



Oil (Dry Basis %)

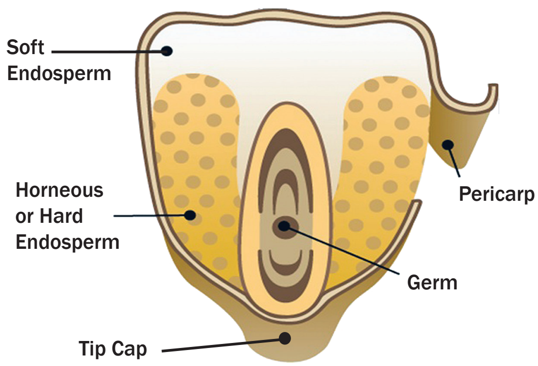


D.PHYSICAL FACTORS

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 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. It consists of soft (also referred to as floury or opaque) endosperm and of horneous (also called hard or vitreous) endosperm, as shown to the right. The endosperm contains primarily starch and protein, the germ contains oil and some protein, and the pericarp and tip cap are mostly fiber.

Corn Kernel



Source: Adapted from Corn Refiners Association, 2011

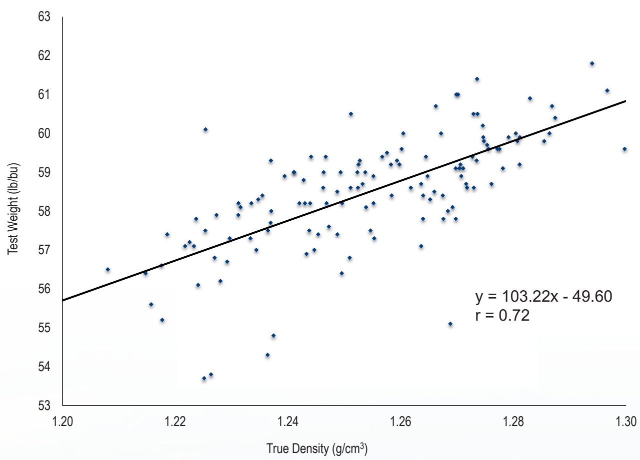
SUMMARY: PHYSICAL FACTORS

- Average U.S. Aggregate stress cracks in 2020 (6%) was lower than 2019 (9%) but higher than 2018 and the 5YA (both 5%). This indicates that susceptibility to breakage in 2020 may be lower than 2019, but similar to 2018 and the 5YA.
- Among the ECAs, the Gulf, Pacific Northwest and Southern Rail ECA had stress crack averages of 7, 5 and 5%, respectively. The Southern Rail has had or tied for the lowest stress crack averages in 2020, 2019, 2018 and the 5YA among all ECAs.
- Average U.S. Aggregate 100-k weight in 2020 (34.53 g) was similar to 2019 (34.60 g), but lower than 2018 (35.07 g) and the 5YA (35.06 g).
- Average U.S. Aggregate kernel volume in 2020 (0.27 cm^3) was lower than 2019, 2018 and the 5YA (all 0.28 cm^3).
- The Pacific Northwest ECA had the lowest average 100-k weight and the lowest kernel volume of the ECAs in 2020, 2019, 2018, the 5YA and the 10YA.

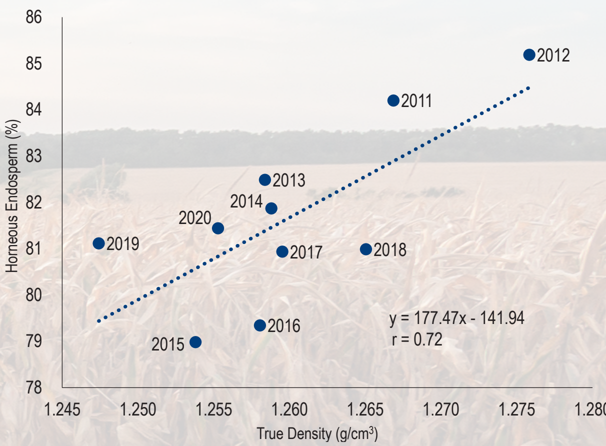
SUMMARY: PHYSICAL FACTORS

- U.S. Aggregate kernel true density averaged 1.255 g/cm³ in 2020, higher than 2019, but lower than 2018. Of the ECAs, the Pacific Northwest had the lowest true density and lowest test weights in 2020, 2019, 2018, the 5YA and the 10YA.
- Test weight, also known as bulk density, is based on the amount of mass contained in a quart cup. Test weight is influenced by true density, as shown in the figure below (r = 0.72). Test weight is also affected by moisture content, pericarp damage (whole kernels), breakage and other factors. In 2020 and 2018, test weight was 58.7 and 58.4 lb/bu, respectively, which was higher than 2019 (57.3 lb/bu). Both true density and test weight averages were higher in 2020 and 2018 than in 2019.
- U.S. Aggregate whole kernels averaged 92.5% in 2020, higher than 2019 (90.8%), but slightly lower than 2018 (93.0%) and the 5YA (92.8%).
- Average U.S. Aggregate horneous (hard) endosperm in 2020 (81%) was the same as 2019 and 2018, but higher than the 5YA (80%). Average horneous endosperm tends to increase in years with higher true density.
- The figure to the right shows the average U.S. Aggregate horneous endosperm and true density values over the past ten years. This indicates that the average U.S. Aggregate horneous endosperm increases with true density (r = 0.72). Thus, horneous endosperm tends to be higher in years when average true density is higher.

Test Weight vs True Density
U.S. Aggregate 2020



Horneous Endosperm vs True Density
U.S. Aggregate over Ten Years



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.

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. A kernel may vary in severity of stress cracking and can have one 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, requiring more removal of broken corn during cleaning operations.

Wet Milling: Lower starch yields due to the increased difficulty in separating starch and protein. Stress cracks may also alter steeping requirements.

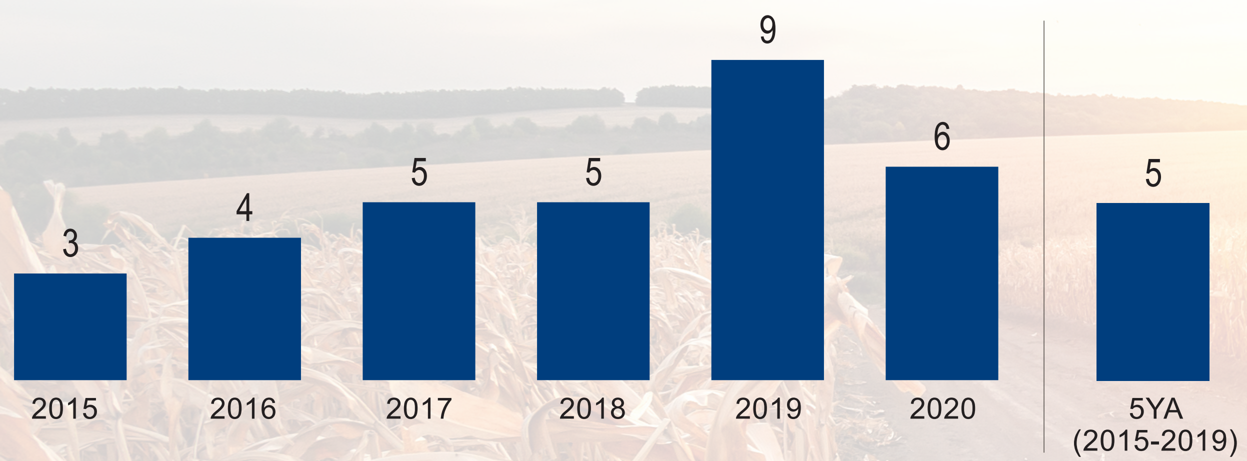
Dry Milling: The lower yield of large flaking grits.

Alkaline Cooking: Non-uniform water absorption leading to over or undercooking, which affects the process balance.

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

STRESS CRACKS (%)

U.S. Aggregate Results Summary

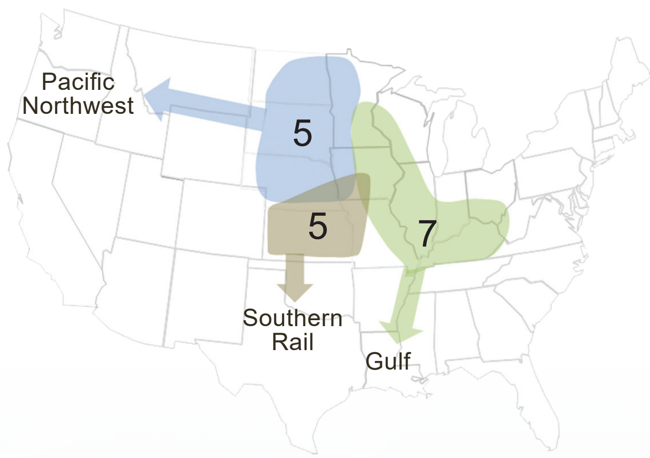


RESULTS

- U.S. Aggregate stress cracks in 2020 averaged 6% which was lower than 2019 (9%), but higher than 2018 and the 5YA (both 5%).
- U.S. Aggregate stress cracks standard deviation in 2020 (5%) was lower than 2019 (7%), 2018 (6%) and the 5YA (6%).
- The percentage of samples with less than 10.0% stress cracks in 2020 (87.2%) was higher than 2019 (74.0%), but lower than in 2018 (89.0%). In 2020 4.3% of the samples had stress cracks above 20.0%, which is lower than in 2019 (10.8%) and 2018 (6.3%). Stress crack distributions indicate that 2020 corn should be lower in breakage susceptibility than 2019 but similar to 2018.
- Among all ECAs, the Southern Rail either had or tied for the lowest stress cracks in 2020, 2019, 2018 and the 5YA.
- Much of the 2020 crop was planted in a timely manner, resulting in an on-time harvest with good dry-down conditions. This led to lower moisture at harvest and reduced need for artificial drying, resulting in a lower potential for stress cracks. Average moistures (15.8%) were below those of 2019, 2018 and the 5YA.

STRESS CRACKS (%)

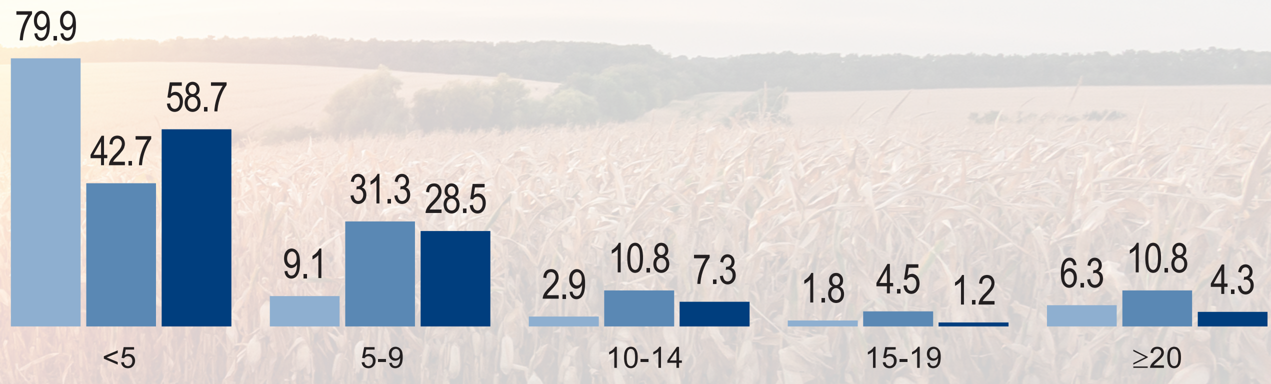
2020 Average by Export Catchment Area



STRESS CRACKS (%)

Percent of Samples by Crop Year

2018 2019 2020



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 with high amounts of horneous (hard) endosperm.

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

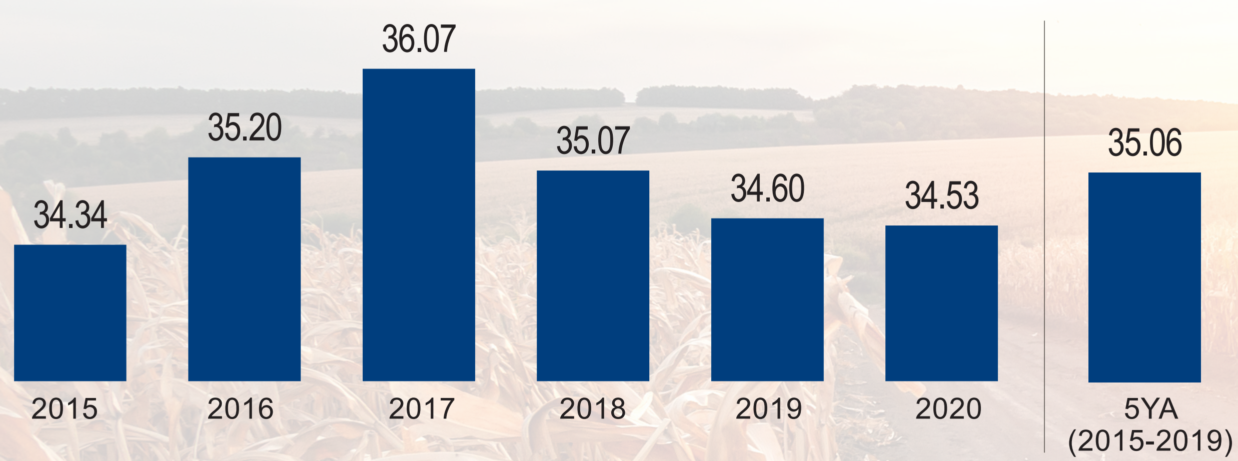
Beginning with the *2020/2021 Harvest Report*, only the samples tested for mycotoxins were tested for 100-k weight. While this protocol reduced the number of samples tested for 100-k weight to 180 in the *2020/2021 Harvest Report*, this quality factor's relative margin was expected to remain well below the targeted level of precision of ±10.0%. Further details on the sampling criteria employed by this study are described in the "Survey and Statistical Analysis Methods" section.

RESULTS

- U.S. Aggregate 100-k weight in 2020 averaged 34.53 g, lower than 2019 (34.60 g), 2018 (35.07 g) and the 5YA (35.06 g), but close to the 10YA (34.49).
- Variability in the 2020 U.S. Aggregate 100-k weight (standard deviation of 3.64 g) was more than 2019 (2.48 g), 2018 (2.84 g) and the 5YA (2.54 g).

100-KERNEL WEIGHT (g)

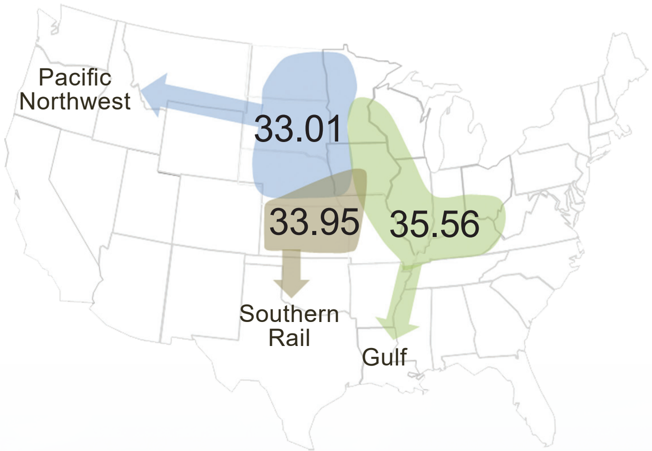
U.S. Aggregate Results Summary



- The range in 100-k weight in 2020 (22.32 to 43.18 g) was similar to 2019 (25.11 to 43.93 g) and 2018 (23.86 to 45.88 g).
- The 100-k weights in 2020 were distributed, with 59.5% of the samples having a 100-k weight of 34.0 g or greater, compared to 56.0% in 2019 and 61.3% in 2018. This distribution indicates a similar percentage of large kernels was found in 2020 as in 2019 and 2018.
- The average 100-k weight was lowest for the Pacific Northwest ECA (33.01 g), compared to the Gulf (35.56 g) and Southern Rail (33.95 g) ECAs. The Pacific Northwest ECA had the lowest 100-k weight in 2020, 2019, 2018 and the 5YA.

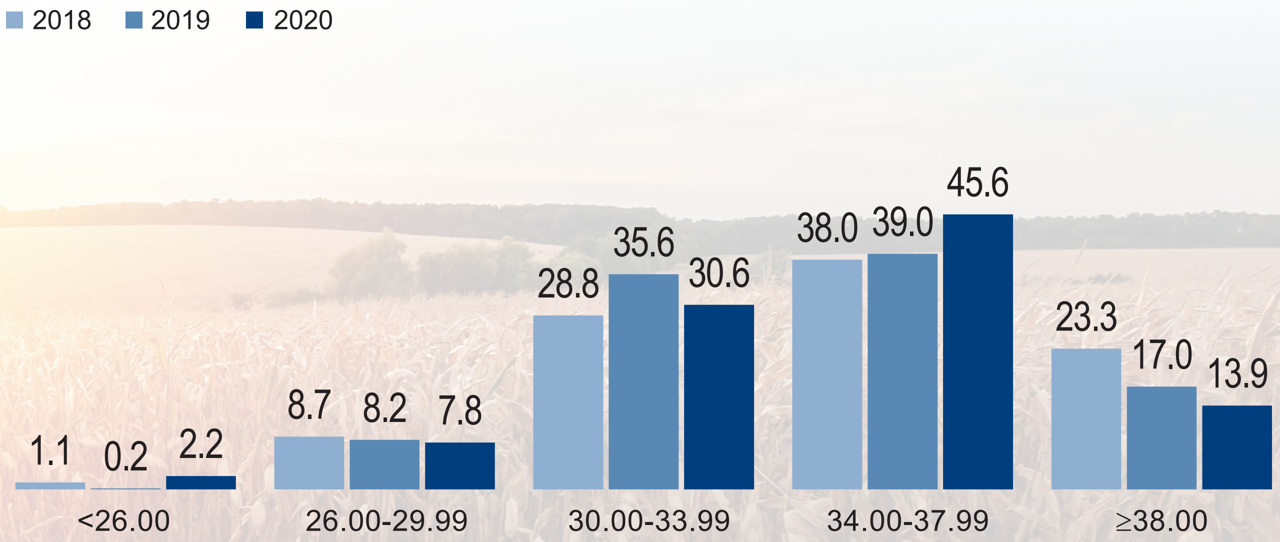
100-KERNEL WEIGHT (g)

2020 Average by Export Catchment Area



100-KERNEL WEIGHT (g)

Percent of Samples by Crop Year



KERNEL VOLUME

Kernel volume is calculated using a helium pycnometer and expressed in cubic centimeters (cm^3). Kernel volume 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.

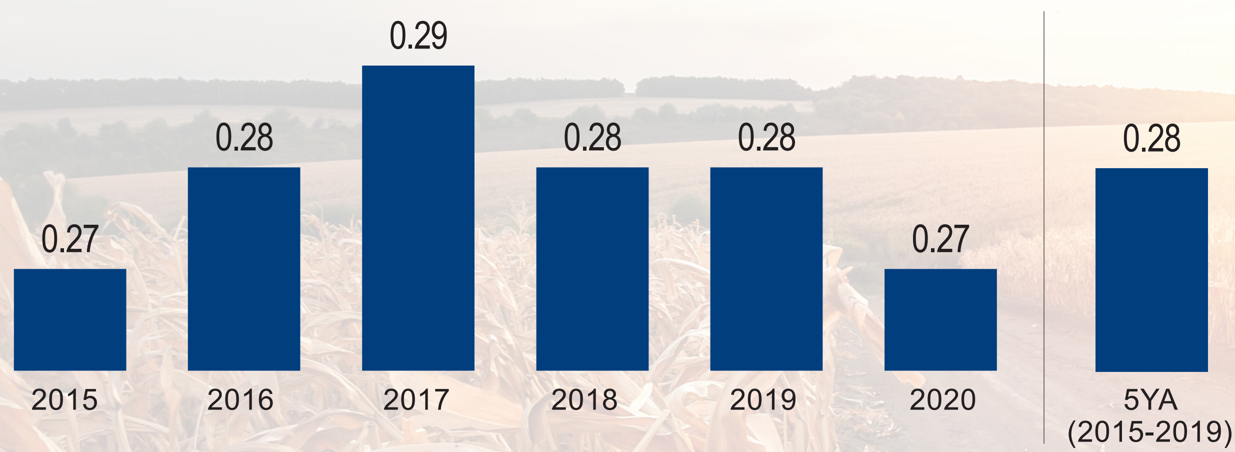
Beginning with the *2020/2021 Harvest Report*, only the samples tested for mycotoxins were tested for kernel volume. While this protocol reduced the number of samples tested for kernel volume to 180 in the *2020/2021 Harvest Report*, this quality factor's relative margin was expected to remain well below the targeted level of precision of ±10.0%. Further details on the sampling criteria employed by this study are described in the "Survey and Statistical Analysis Methods" section.

RESULTS

- U.S. Aggregate kernel volume averaged 0.27 cm^3 in 2020, lower than 2019, 2018 and the 5YA (all 0.28 cm^3).
- The standard deviation for U.S. Aggregate kernel volume was 0.03 cm^3 for 2020, slightly higher than in 2019, 2018 and the 5YA (all 0.02 cm^3).

KERNEL VOLUME (cm^3)

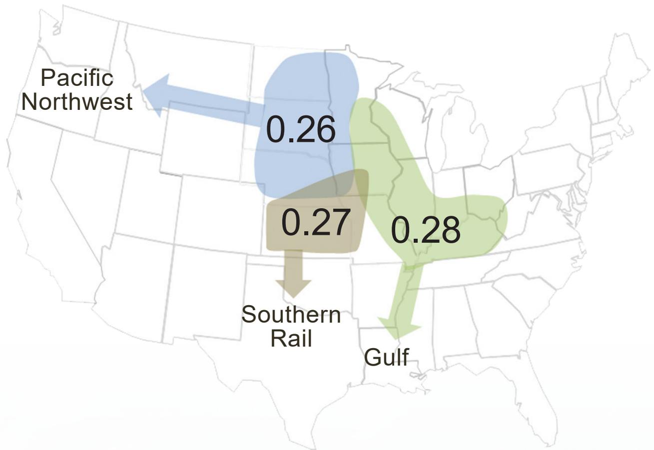
U.S. Aggregate Results Summary



- Kernel volume range in 2020 (0.19 to 0.33 cm^3) was similar to 2019 (0.22 to 0.34 cm^3) and 2018 (0.19 to 0.36 cm^3).
- The kernel volumes in 2020 were distributed, with 32.8% of the samples having kernel volumes of 0.29 cm^3 or greater, compared to 2019 (36.3%) and 2018 (38.5%). This distribution indicates a slightly lower percentage of large kernels in 2020 than 2019 and 2018.
- Kernel volume for the Gulf, Pacific Northwest and Southern Rail ECAs averaged 0.28, 0.26 and 0.27 cm^3, respectively. Among the ECAs, the Pacific Northwest ECA had the lowest average kernel volume in 2020, 2019, 2018, the 5YA and the 10YA.

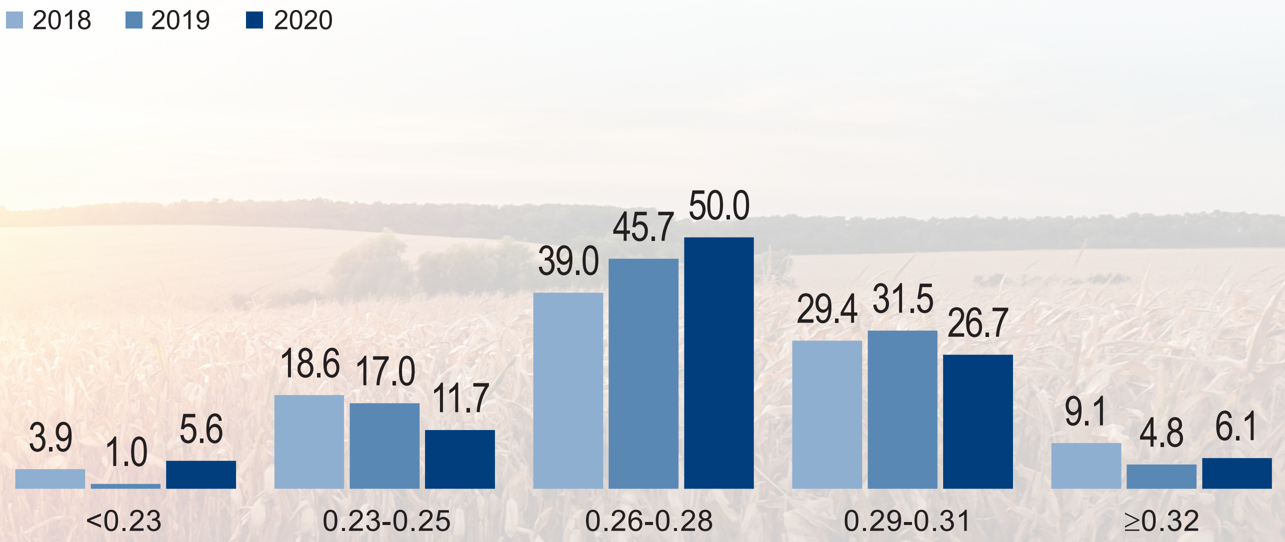
KERNEL VOLUME (cm^3)

2020 Average by Export Catchment Area



KERNEL VOLUME (cm^3)

Percent of Samples by Crop Year



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, useful for alkaline cooking processes 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 of developing stress cracks if high-temperature drying is employed. True densities above 1.30 g/cm³ indicate very hard corn, typically desirable for dry milling and alkaline cooking processes. True densities near the 1.275 g/cm³ level and below tend to be softer and process well for wet milling and feed use.

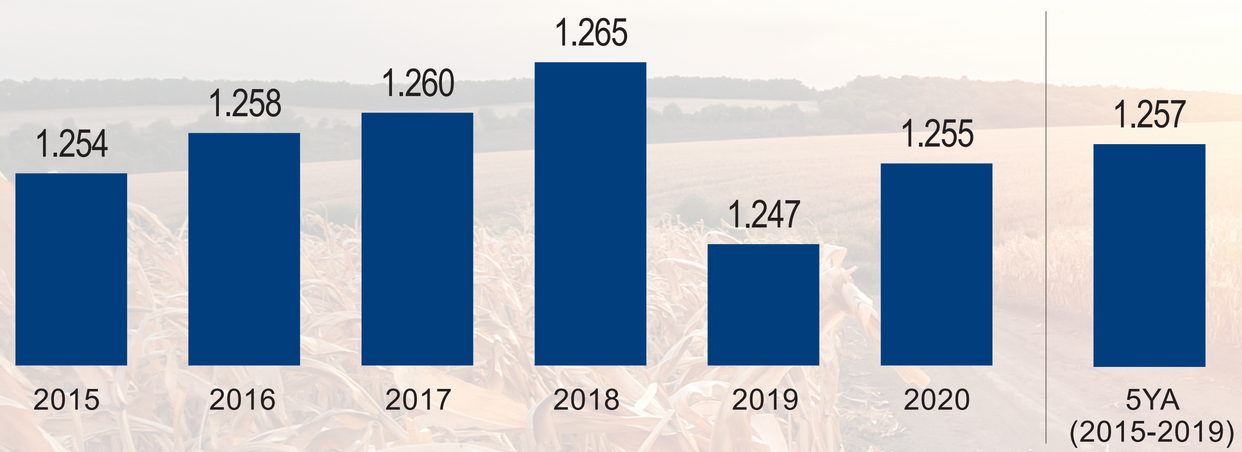
Beginning with the *2020/2021 Harvest Report*, only the samples tested for mycotoxins were tested for 100-k weight and kernel volume, which are the two analytical tests needed for the calculation of true density. While this protocol reduced the number of samples with true density results to 180 in the *2020/2021 Harvest Report*, this quality factor's relative margin was expected to remain well below the targeted level of precision of ±10.0%. Further details on the sampling criteria employed by this study are described in the "Survey and Statistical Analysis Methods" section.

RESULTS

- Average U.S. Aggregate kernel true density in 2020 (1.255 g/cm³) was higher than 2019 (1.247 g/cm³), but lower than 2018 (1.265 g/cm³), the 5YA (1.257 g/cm³) and the 10YA (1.260 g/cm³). Over the past ten years, true densities have tended to be higher in years with higher protein with a correlation coefficient of 0.87.

TRUE DENSITY (g/cm³)

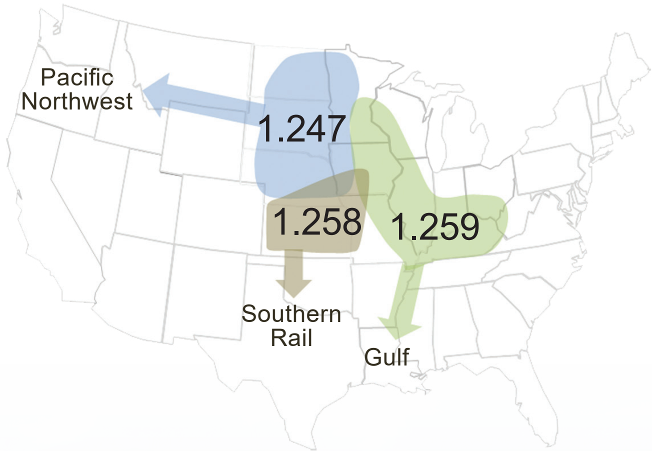
U.S. Aggregate Results Summary



- Variability, based on the standard deviation, in 2020 (0.023 g/cm^3) was slightly more than 2019 (0.021 g/cm^3), 2018 and the 5YA (both 0.018 g/cm^3).
- True densities in 2020 ranged from 1.171 to 1.312 g/cm^3 compared to 2019 (1.116 to 1.322 g/cm^3) and 2018 (1.167 to 1.374 g/cm^3).
- About 16.1% of the 2020 samples had true densities at or above 1.275 g/cm^3 compared to 18.5% in 2019 and 36.0% in 2018. Since corn with values above 1.275 g/cm^3 is often considered to represent hard corn and values below 1.275 g/cm^3 are often considered to represent soft corn, this kernel distribution indicates softer corn in 2020 than in 2018 but similar to 2019.
- Kernel true densities for the Gulf, Pacific Northwest and Southern Rail ECAs averaged 1.259, 1.247 and 1.258 g/cm^3, respectively. The Pacific Northwest ECAs average true density and test weight were lower than the other ECAs' values in 2020, 2019, 2018 and the 5YA.

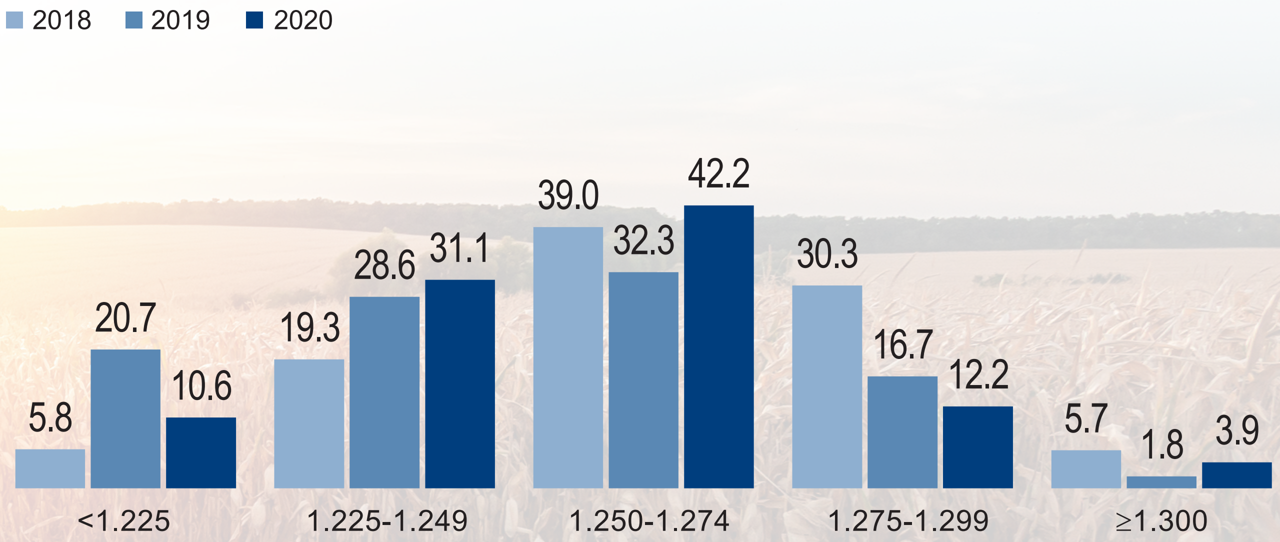
TRUE DENSITY (g/cm^3)

2020 Average by Export Catchment Area



TRUE DENSITY (g/cm^3)

Percent of Samples by Crop Year



WHOLE KERNELS

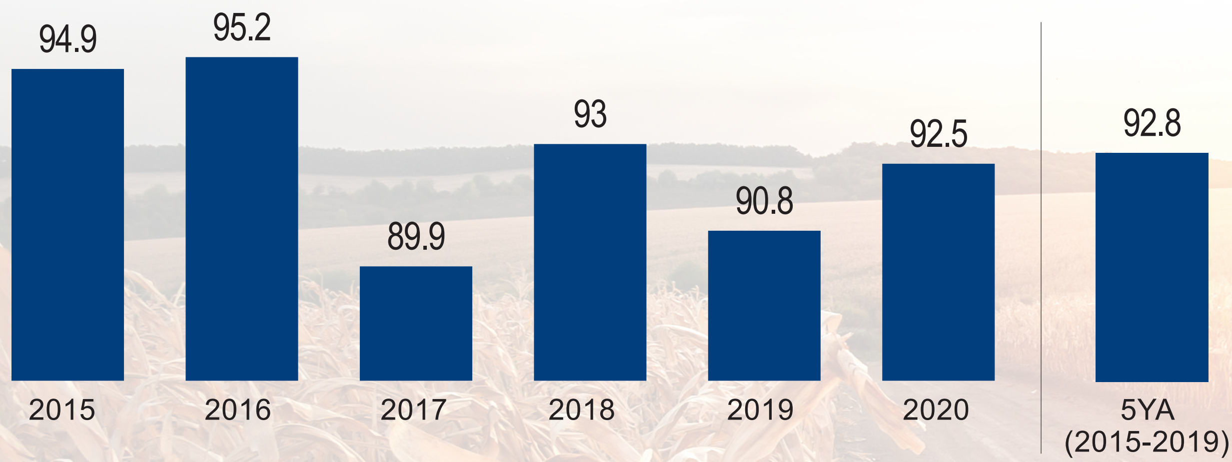
Though the name suggests some inverse relationship between whole kernels and BCFM, the whole kernels test conveys different information than the broken corn portion of the BCFM test. Broken corn is defined solely by the size of the material. As the name implies, whole kernels are the percent of fully 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 processes 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 preserving 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.[5] In addition, harvesting at 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.

WHOLE KERNELS (%)

U.S. Aggregate Results Summary



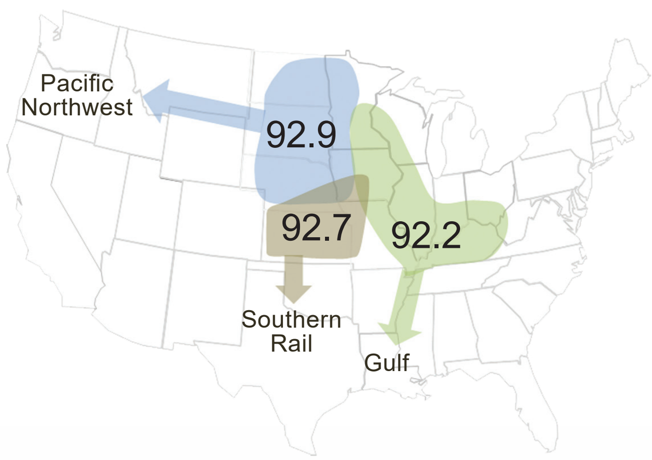
[5] *Foster, G. H. and L. E. Holman. 1973. Grain Breakage Caused by Commercial Handling Methods. USDA. ARS Marketing Research Report Number 968.*

RESULTS

- U.S. Aggregate whole kernels averaged 92.5% in 2020, higher than 2019 (90.8%), but lower than 2018 (93.0%), the 5YA (92.8%) and the 10YA (93.0).
- The 2020 whole kernel standard deviation (3.9%) was lower than 2019 (4.2%) but higher than 2018 (3.0%) and the 5YA (3.4%).
- Whole kernel range in 2020 (35.8 to 99.6%) was between 2019 (25.4 to 99.6%) and 2018 (66.0 to 98.6%).
- Of the 2020 samples, 79.9% had 90.0% or higher whole kernels, compared to 2019 (68.7%) and 2018 (85.6%). This distribution indicates that 2020 and 2018 had a higher percentage of whole kernels than the samples in 2019.
- Whole kernel averages for Gulf, Pacific Northwest and Southern Rail ECAs were 92.2, 92.9 and 92.7%, respectively.

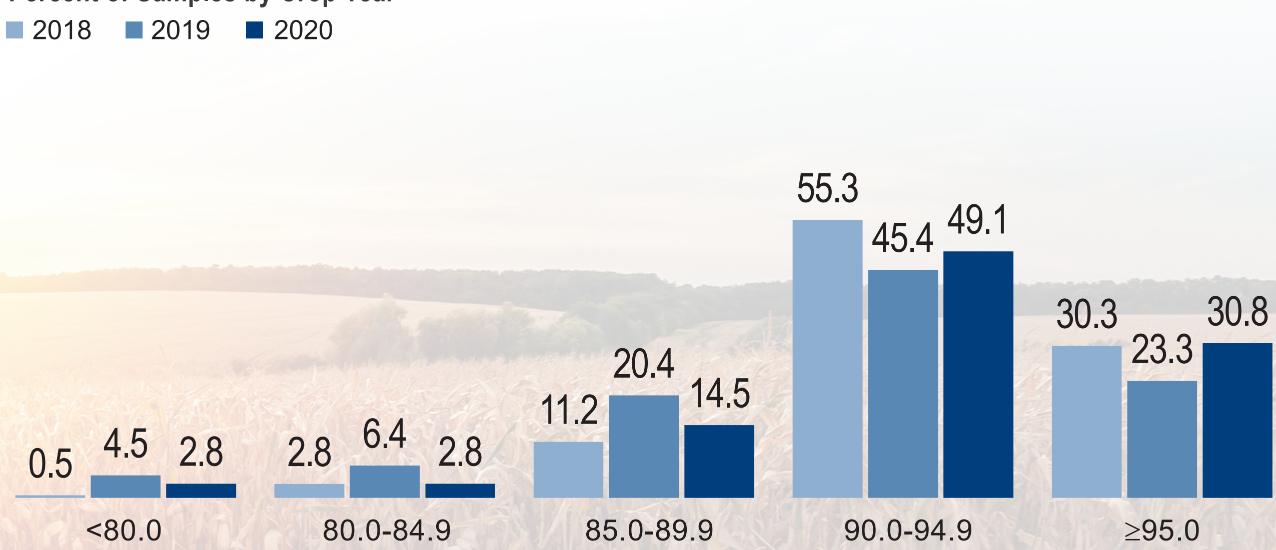
WHOLE KERNELS (%)

2020 Average by Export Catchment Area



WHOLE KERNELS (%)

Percent of Samples by Crop Year



HORNEOUS (HARD) ENDOSPERM

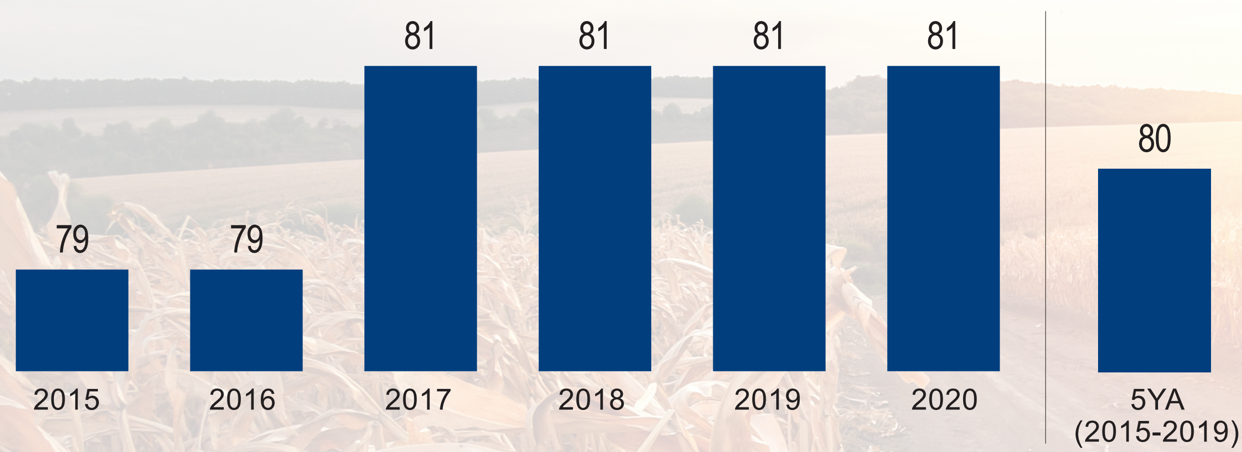
The horneous (hard) endosperm test measures the percent of horneous or hard endosperm out of the total endosperm in a kernel, with a potential value from 70 to 100%. The greater the amount of horneous endosperm relative to soft endosperm, the harder the corn kernel is said to be. The degree of hardness 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 processes, and desired hardness is medium to soft for wet milling and livestock feeding. Hardness is correlated to breakage susceptibility, feed utilization/efficiency and starch digestibility. The internal stresses causing stress cracks 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.

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 cooking processors 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 protocol resulted in a total of 180 samples tested for horneous endosperm in the *2020/2021 Harvest Report*. This quality factor's relative margin of error did not exceed 0.4% in the *2011/2012 Harvest Report* through the *2018/2019 Harvest Report* when all samples were tested for this quality factor. Further details on the sampling criteria employed by this study are described in the "Survey and Statistical Analysis Methods" section.

HORNEOUS ENDOSPERM (%)

U.S. Aggregate Results Summary



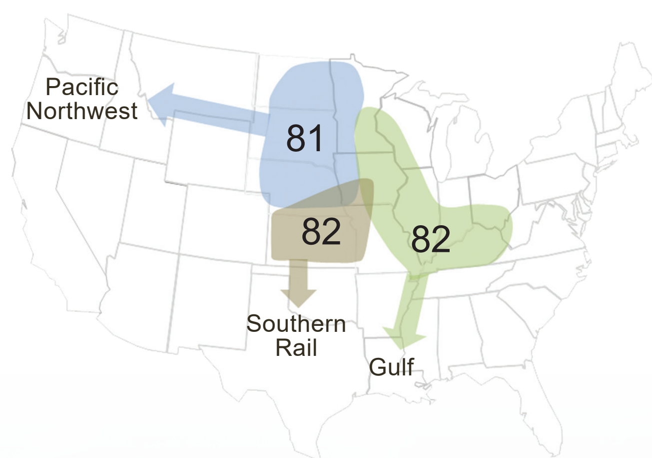
U.S. GRAINS COUNCIL

RESULTS

- Average U.S. Aggregate horneous endosperm in 2020 (81%) was the same as 2019 and 2018, but between the 5YA (80%) and the 10YA (82%).
- U.S. Aggregate standard deviation for horneous endosperm was 4% in 2020, slightly higher than 2019, 2018 and the 5YA (all 3%).
- The 2020 horneous endosperm range (72 to 92%) was similar to 2019 (71 to 96%) and 2018 (72 to 92%).
- Of the 2020 samples, 65.0% contained more than 80% horneous endosperm, which was higher than 2019 (63.3%) and 2018 (59.5%)
- Average horneous endosperm for the Gulf, Pacific Northwest and Southern Rail ECAs was 82, 81 and 82%, respectively. The Southern Rail ECA has had the highest or tied for the highest average horneous endosperm in 2020, 2019, 2018, 2017 and the 5YA among all ECAs.

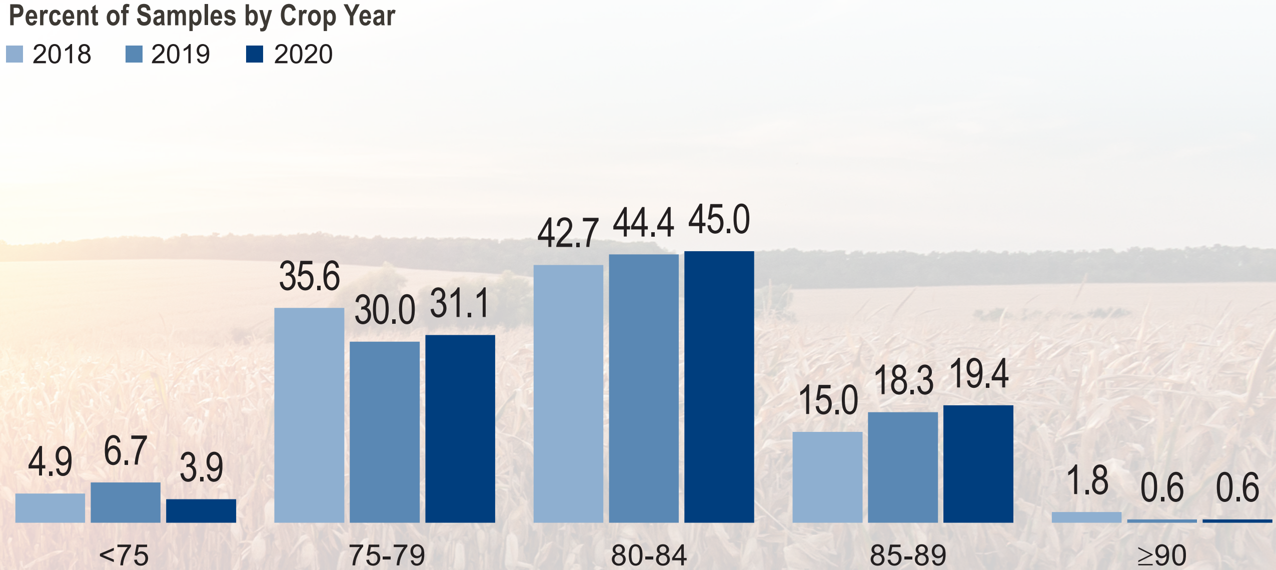
HORNEOUS ENDOSPERM (%)

2020 Average by Export Catchment Area



HORNEOUS ENDOSPERM (%)

Percent of Samples by Crop Year



SUMMARY: PHYSICAL FACTORS

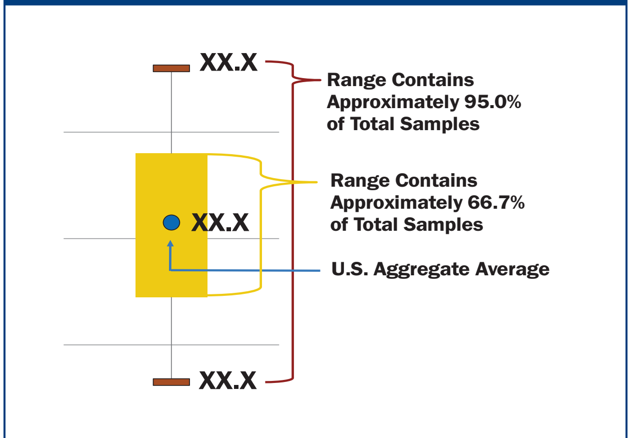
	2020 Harvest					2019 Harvest		2018 Harvest		Five-Year Average (2015-2019)		Ten-Year Average (2011-2020)	
	No. of Samples[1]	Avg.	Std. Dev.	Min.	Max.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.	Avg.	Std. Dev.
U.S. Aggregate						**U.S. Aggregate**		**U.S. Aggregate**		**U.S. Aggregate**		**U.S. Aggregate**	
Stress Cracks (%)	601	6	5	0	80	9*	7	5*	6	5	6	6	6
100-Kernel Weight (g)	180	34.53	3.64	22.32	43.18	34.60	2.48	35.07	2.84	35.06	2.54	34.49	2.75
Kernel Volume (cm^3)	180	0.27	0.03	0.19	0.33	0.28	0.02	0.28	0.02	0.28	0.02	0.27	0.02
True Density (g/cm^3)	180	1.255	0.023	1.171	1.312	1.247*	0.021	1.265*	0.018	1.257	0.018	1.260	0.019
Whole Kernels (%)	601	92.5	3.9	35.8	99.6	90.8*	4.2	93.0*	3.0	92.8	3.4	93.0	3.6
Horneous Endosperm (%)	180	81	4	72	92	81	3	81	3	80	3	82	4
Gulf						**Gulf**		**Gulf**		**Gulf**		**Gulf**	
Stress Cracks (%)	549	7	6	0	80	10*	9	4*	5	5	7	6	7
100-Kernel Weight (g)	160	35.56	3.31	23.47	43.18	35.39	2.60	35.74	2.86	35.65	2.58	35.12	2.74
Kernel Volume (cm^3)	160	0.28	0.02	0.19	0.33	0.28	0.02	0.28	0.02	0.28	0.02	0.28	0.02
True Density (g/cm^3)	160	1.259	0.024	1.171	1.312	1.252*	0.019	1.266*	0.017	1.259	0.018	1.262	0.019
Whole Kernels (%)	549	92.2	4.2	35.8	99.6	91.5*	3.8	93.1*	3.0	92.9	3.4	93.1	3.6
Horneous Endosperm (%)	160	82	4	72	92	81	3	81*	3	80	4	82	4
Pacific Northwest						**Pacific Northwest**		**Pacific Northwest**		**Pacific Northwest**		**Pacific Northwest**	
Stress Cracks (%)	293	5	4	0	52	9*	7	7*	8	6	7	6	6
100-Kernel Weight (g)	89	33.01	3.37	22.32	39.71	32.73	2.19	32.97	2.67	33.23	2.41	32.57	2.58
Kernel Volume (cm^3)	89	0.26	0.03	0.19	0.32	0.27	0.02	0.26	0.02	0.27	0.02	0.26	0.02
True Density (g/cm^3)	89	1.247	0.022	1.171	1.285	1.229*	0.025	1.257*	0.018	1.247	0.019	1.250	0.020
Whole Kernels (%)	293	92.9	3.9	59.0	99.6	88.9*	5.2	92.9	3.1	92.3	3.7	92.7	3.7
Horneous Endosperm (%)	89	81	4	72	89	80*	3	81	3	80	3	81	4
Southern Rail						**Southern Rail**		**Southern Rail**		**Southern Rail**		**Southern Rail**	
Stress Cracks (%)	319	5	4	0	69	6*	5	3*	4	4	4	4	4
100-Kernel Weight (g)	92	33.95	3.32	23.47	41.09	35.16*	2.54	35.59*	2.98	35.55	2.63	34.77	2.80
Kernel Volume (cm^3)	92	0.27	0.02	0.19	0.33	0.28*	0.02	0.28*	0.02	0.28	0.02	0.27	0.02
True Density (g/cm^3)	92	1.258	0.021	1.171	1.305	1.262	0.018	1.274*	0.019	1.263	0.018	1.265	0.018
Whole Kernels (%)	319	92.7	3.5	35.8	98.8	91.7*	3.8	92.8	2.7	92.9	3.2	93.2	3.3
Horneous Endosperm (%)	92	82	4	72	88	82	3	82	3	81	3	82	4

**Indicates average was significantly different from 2020, based on a 2-tailed t-test at the 95.0% level of significance.*

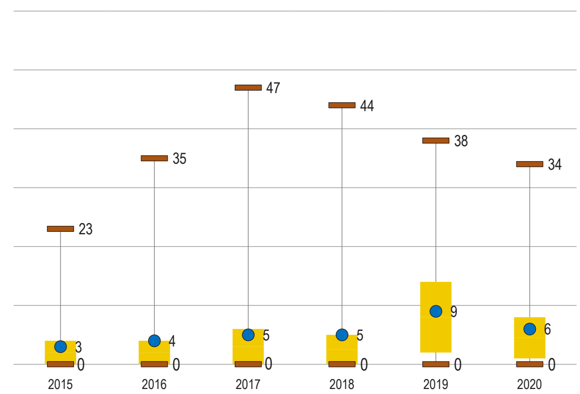
[1]Due to the ECA results being composite statistics, the sum of the sample numbers from the three ECAs is greater than the U.S. Aggregate.

PHYSICAL FACTORS
AGGREGATE SIX-YEAR COMPARISON

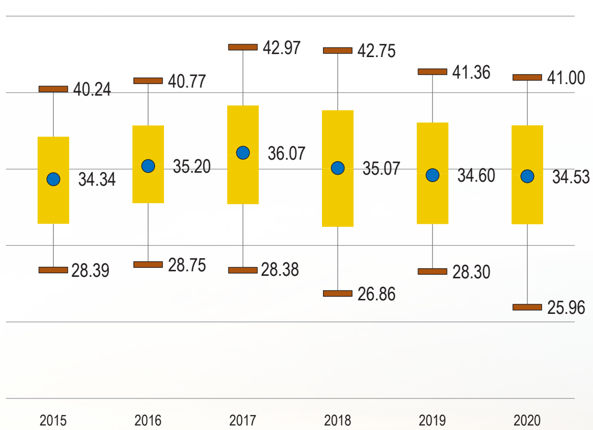
HOW TO READ THE CHARTS



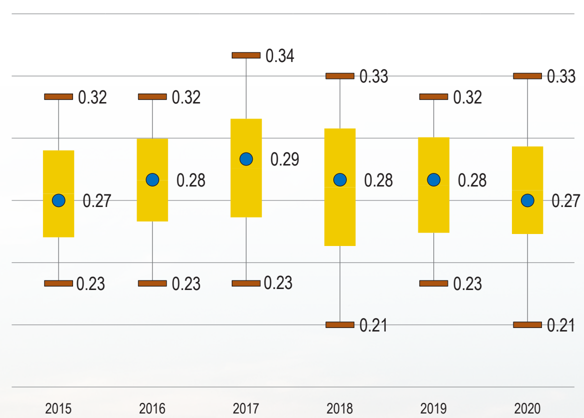
Stress Cracks (%)



100-Kernel Weight (g)

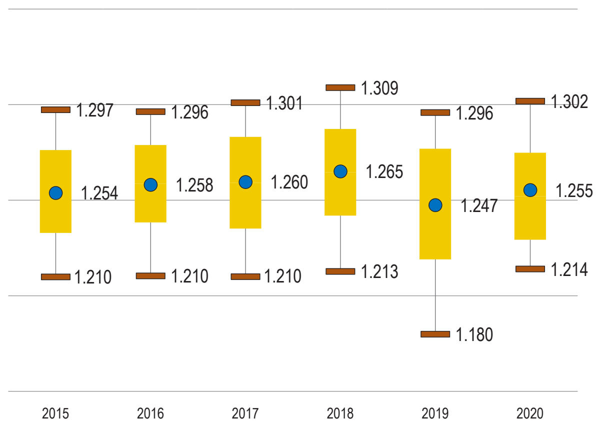


Kernel Volume (cm³)

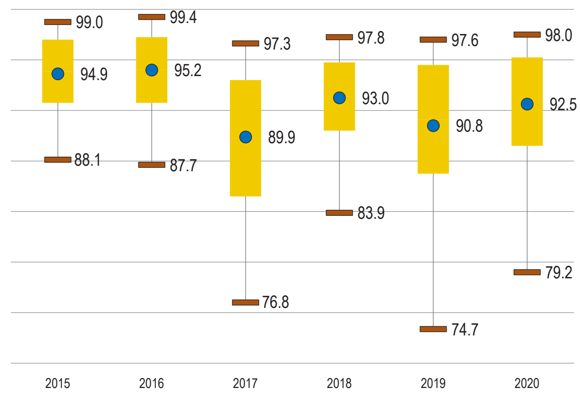


PHYSICAL FACTORS
AGGREGATE SIX-YEAR COMPARISON

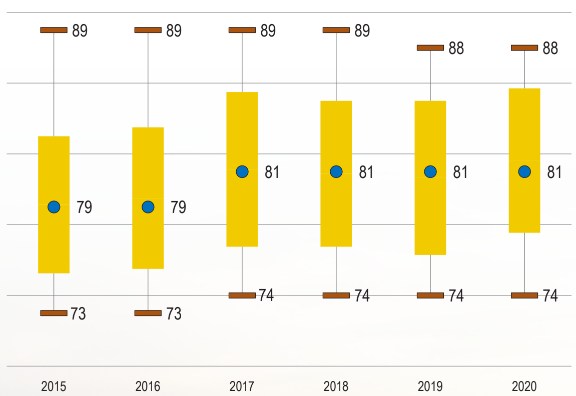
True Density (g/cm³)



Whole Kernels (%)



Horneous Endosperm (%)



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.

A subset of the harvest samples have been tested for aflatoxin and DON in all ten years of *Harvest Reports*. Beginning with the *2019/2020 Harvest Report*, fumonisins were added to the list of mycotoxins tested. In addition to testing survey samples for aflatoxin, DON and fumonisin, the *2020/2021 Harvest Report* also tested harvest samples for ochratoxin A, T-2 and zearalenone. The testing for these three additional mycotoxins is provisional and is intended to complement the information provided by the test results from the three mycotoxins tested on an annual basis (aflatoxin, DON and fumonisin).

Depending on the year, environmental conditions under which the corn is produced and stored may or may not be conducive to developing 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 limits of contamination above which the agency is prepared to take regulatory action. Action levels signal that the FDA believes it has 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 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 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.

Since growing conditions heavily influence the production of mycotoxins, the *Harvest Report's* objective is strictly to report on instances when mycotoxins are detected in the corn crop at harvest and not to predict the 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, mycotoxin levels that appear in corn exports may be less than what initially appear at harvest. The *Harvest Report's* results should be used only as one indicator of the potential for mycotoxin presence in the corn at harvest. The *2020/2021 Corn Export Cargo Quality Report* will report corn quality at export points and be a more accurate indication of mycotoxin presence in U.S. corn export shipments.

The sampling criteria, described in the "Survey and Statistical Analysis Methods" section, resulted in a total number of 180 samples tested for mycotoxins. Details on the testing methodology employed in this study for the mycotoxins are in the "Testing Analysis Methods" section.

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 due to 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 (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.

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

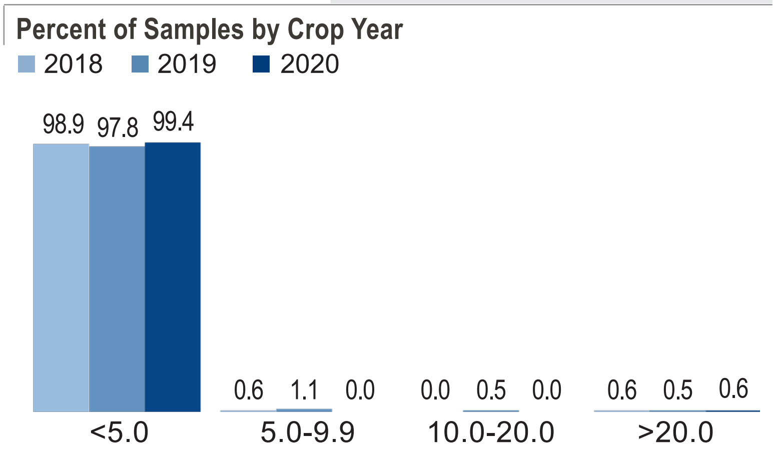
Source: www.ngfa.org
For additional information, see the National Grain and Feed Association's guidance document titled "FDA Mycotoxin Regulatory Guidance" found at https://drive.google.com/file/d/1tqeS5_eOtsRmxZ5RrTnYu7NCIr896KGX/view.

According to federal law, unless the contract exempts it, corn exported from the United States must be tested by FGIS for aflatoxin. 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.

RESULTS

A total of 180 samples were analyzed for aflatoxin in 2020, compared to 182 and 181 samples tested for aflatoxin in 2019 and 2018, respectively. Results of the 2020 survey are as follows:

AFLATOXIN (ppb)



- One hundred seventy-nine (179) samples, or 99.4% of the 180 samples, had no detectable levels of aflatoxin (below the FGIS lower conformance limit of 5.0 ppb). This is slightly higher than the percentage of the samples tested with no detectable levels of aflatoxin in 2019 (97.8%) and 2018 (98.9%).
- Zero (0) samples or 0.0% of the 180 samples showed aflatoxin levels greater than or equal to 5.0 ppb but less than 10.0 ppb. This percentage is almost identical to 2019 (1.1%) and 2018 (0.6%).
- Zero (0) sample or 0.0% of the 180 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 2019 (0.5%) and 2018 (0.0%).
- One (1) sample, or 0.6% of the 180 samples, showed an aflatoxin level greater than the FDA action level of 20.0 ppb. This percentage is almost identical to 2019 (0.5%) and 2018 (0.6%).
- These results denote that 179 samples, or 99.4% of the 180 sample test results in 2020, were below or equal to the FDA action level of 20.0 ppb, compared to 99.4% and 99.5% of the samples tested in 2019 and 2018, respectively.

The relatively high percentage of this year's samples below the FGIS lower conformance limit of 5.0 ppb (99.4%) may be due, in part, to weather conditions not conducive to aflatoxin development in 2020 (see the "Crop and Weather Conditions" section for more information on 2020 growing conditions).

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.

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.

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

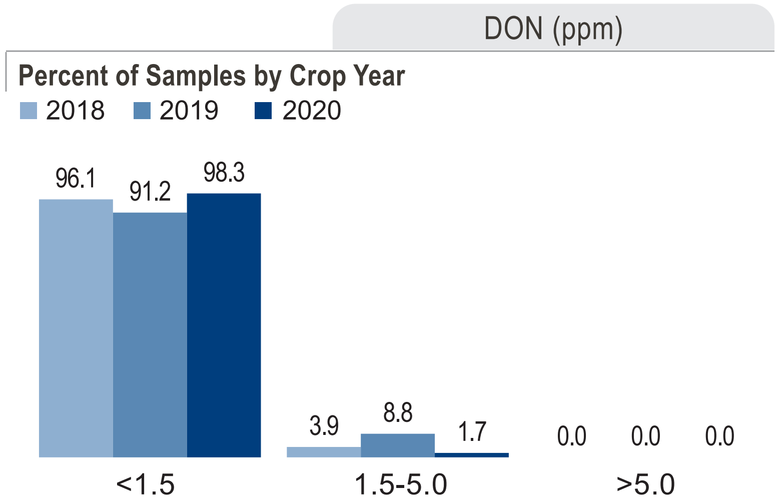
DON Advisory Level	Criteria
5.0 parts per million	Swine, not to exceed 20% of their diet
5.0 parts per million	All other animals not otherwise listed, not to exceed 40% of their diet
10.0 parts per million	Chickens, not to exceed 50% of their diet
10.0 parts per million	Ruminating beef and dairy cattle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

Source: www.ngfa.org
For additional information, see the National Grain and Feed Association's guidance document titled "FDA Mycotoxin Regulatory Guidance" found at https://drive.google.com/file/d/1tqeS5_eOtsRmxZ5RrTnYu7NCIr896KGX/view.

RESULTS

A total of 180 samples were analyzed collectively for DON in 2020, compared to 182 and 181 samples tested for DON in 2019 and 2018, respectively. Results of the 2020 survey are as follows:

- One hundred seventy-seven (177) samples, or 98.3% of the 180 samples, tested less than 1.5 ppm. This percentage for 2020 is higher than in 2019 (91.2%) and 2018 when 96.1% of the samples tested below 1.5 ppm.



- Three (3) samples, or 1.7% of the 180 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 2020 is lower than in 2019 (8.8%) and 2018 (3.9%).
- Zero (0) samples or 0.0% of the 180 samples tested above the FDA advisory level of 5.0 ppm, which was the same as in 2019 and 2018.

Having a higher percentage of samples in 2020 testing below 1.5 ppm than in the two previous crops may be attributed to drier than usual weather conditions that were less conducive to DON development in 2020.

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 is 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, the FDA issued guidance levels for fumonisins in corn-based foods and feed to reduce human and animal exposure. FDA advisory levels are shown below.

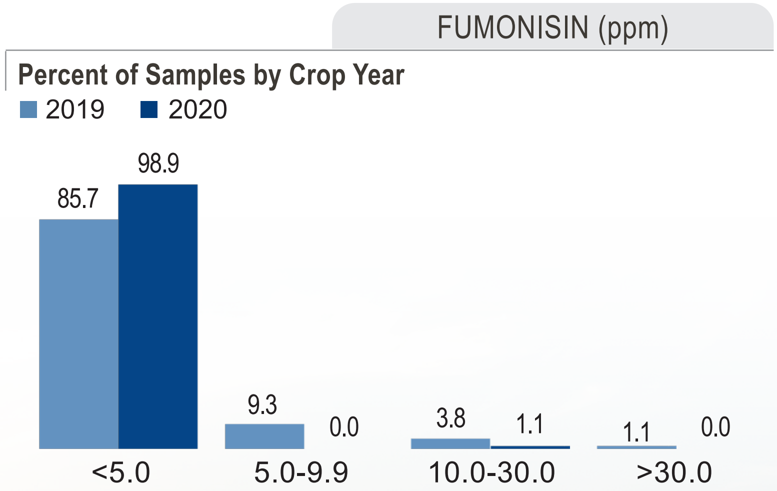
Fumonisin Advisory Level	Criteria
5.0 parts per million	Equids (i.e., horses) and rabbits, not to exceed 20% of diet
20.0 parts per million	Swine and catfish, not to exceed 50% of diet
30.0 parts per million	Breeding ruminants, breeding poultry and breeding mink, not to exceed 50% of diet
60.0 parts 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
For additional information, see the National Grain and Feed Association's guidance document titled "FDA Mycotoxin Regulatory Guidance" found at https://drive.google.com/file/d/1tqeS5_eOtsRmxZ5RrTnYu7NCIr896KGX/view.

RESULTS

A total of 180 samples were analyzed collectively for fumonisin in 2020. This is the second year that survey samples have been tested for fumonisin. Results of the 2020 survey are as follows:

- One hundred seventy-eight (178) or 98.9% of the 180 samples tested below 5.0 ppm, the lowest advisory level for animals (equids and rabbits). This percentage for 2020 is higher than in 2019 (85.7%).
- Zero (0) or 0.0% of the 180 samples test greater than or equal to 5.0 ppm, but less than 10.0 ppm. This percentage for 2020 is lower than in 2019 (9.3%).
- Two (2) or 1.1% of the 180 samples tested greater than or equal to 10.0 ppm, but not greater than 30.0 ppm. This percentage for 2020 is lower than in 2019 (3.8%).
- Zero (0) or 0.0% of the 180 samples tested greater than 30.0 ppm, which is the advisory level for breeding ruminants, poultry and mink. This percentage for 2020 is lower than in 2019 (1.1%).



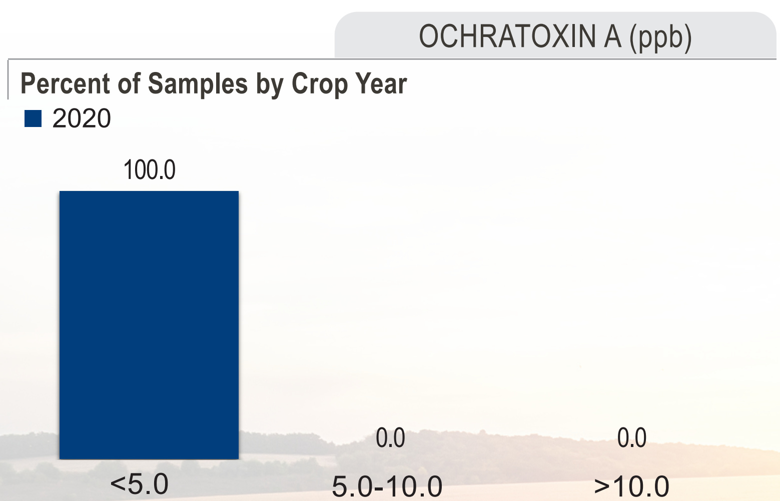
Ochratoxin A

Ochratoxins are considered a hazardous mycotoxin produced by a number of fungal species such as *Penicillium verrucosum* and *Aspergillus ochraceus* that can colonize grains, cereals and a range of other food products. Of these products, grains and cereals are considered to represent 50–80% of the intake of ochratoxins. The fungi can produce ochratoxins A, B and C, but ochratoxin A is produced in the greatest quantity. While ochratoxin A can occur all along the production chain from the field to storage, it is primarily considered a storage problem. Grains stored under high moisture/humidity (>14%) at warm temperatures (>20°C) and/or inadequately dried have the potential to become contaminated with the fungi and produce ochratoxins. Also, damage to the grain by mechanical means, physical means or insects can provide a portal of entry for the fungus. Initial growth of fungi in grains can form sufficient moisture from metabolism to allow for further growth and mycotoxin formation. Because grains and cereal products represent a large portion of the human diet, several countries have established maximum levels for ochratoxin A in unprocessed cereals. The European Commission established a maximum level for ochratoxin A in raw cereals at 5.0 parts per billion. The FDA has issued no advisory levels for ochratoxin A.

RESULTS

This is the first year that survey samples have been tested for ochratoxin A. Results of the 180 samples analyzed for ochratoxin A in 2020 are as follows:

- One hundred eighty (180) or 100.0% of the samples tested below 5.0 ppb, the European Commission's established a maximum level for ochratoxin A.
- Zero (0) or 0.0% of the samples tested greater than or equal to 5.0 ppb, but not greater than 10.0 ppb.
- Zero (0) or 0.0% of the samples test greater than 10.0 ppb.



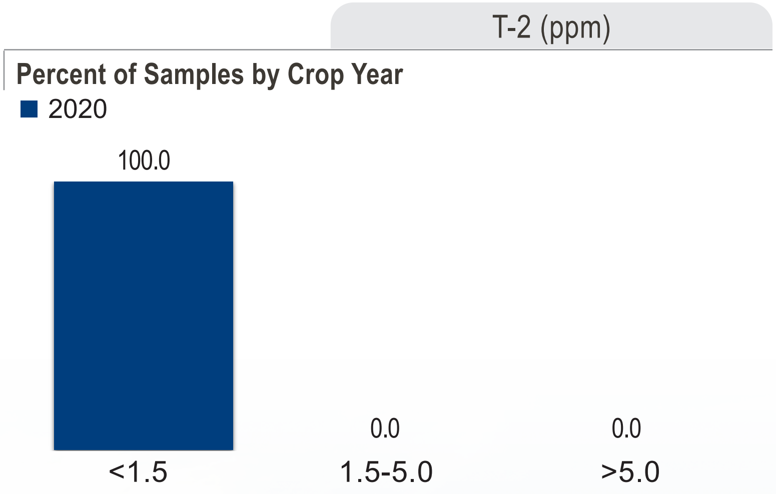
T-2

T-2 is one of several mycotoxins (including Deoxynivalenol or DON) belonging to a group of mycotoxins called trichothecenes. T-2 toxin is produced in growing cereal grain crops by various *Fusarium* species of fungi. The fungi can grow over a wide range of temperatures (-2 to 35°C) and only at a water activity above 0.88. As a result, T-2 is not normally found in grain at harvest but in grain that has suffered water damage when left in the field after harvest (especially over winter). However, T-2 can occur in storage if the grain has suffered water damage in storage. The FDA has issued no advisory levels for T-2 toxin.

RESULTS

This is the first year that survey samples have been tested for T-2. Results of the 180 samples analyzed for T-2 in 2020 are as follows:

- One hundred eighty (180) or 100.0% of the samples tested below 1.5 ppm.
- Zero (0) or 0.0% of the samples tested greater than or equal to 1.5 ppm, but not greater than 5.0 ppm.
- Zero (0) or 0.0% of the samples test greater than 5.0 ppm.



Zearalenone

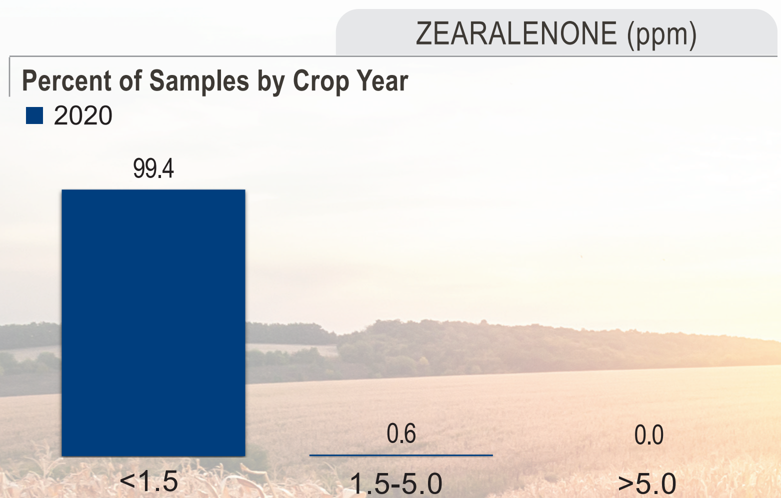
Zearalenone is a mycotoxin that is very similar to deoxynivalenol (DON) in most aspects, with a few exceptions. Both are produced by *Fusarium* species of fungi. As a result, it would not be uncommon to find both mycotoxins in grain and grain products at the same time. The growing conditions for zearalenone production are very comparable to DON, with the optimal temperatures ranging from 65 to 85°F. A drop in temperature during growth also stimulates the production of toxins by the fungi. A moisture content of 20% or greater is required by the fungi to produce zearalenone, which is also similar to that needed to produce DON. But if the moisture content during growth drops below 15%, the production of toxins is halted. This is one of the reasons that it is recommended that corn for storage should be dried to moisture levels less than 15%. Levels of as little as 0.1 ppm to 5.0 ppm have been shown to cause reproductive problems in swine, so great care should be used when feeding possibly contaminated grain to pigs. The FDA has issued no advisory levels for zearalenone but recommends only that the levels of concern for DON be observed.

As with the other mycotoxins, at least 25% of the minimum number of targeted samples (600) were tested to assess the impact of this year's growing conditions on ochratoxin A, T-2 and zearalenone. The sampling criteria and the testing methodology employed are described in the "Survey and Statistical Analysis Methods" and "Testing Analysis Methods" sections, respectively.

RESULTS

This is the first year that survey samples have been tested for T-2. Results of the 180 samples analyzed for T-2 in 2020 are as follows:

- One hundred seventy-nine (179) or 99.4% of the samples tested for below 1.5 ppm.
- One (1) or 0.6% of the samples tested greater than or equal to 1.5 ppm, but not greater than 5.0 ppm.
- Zero (0) or 0.0% of the 180 samples test greater than 5.0 ppm.

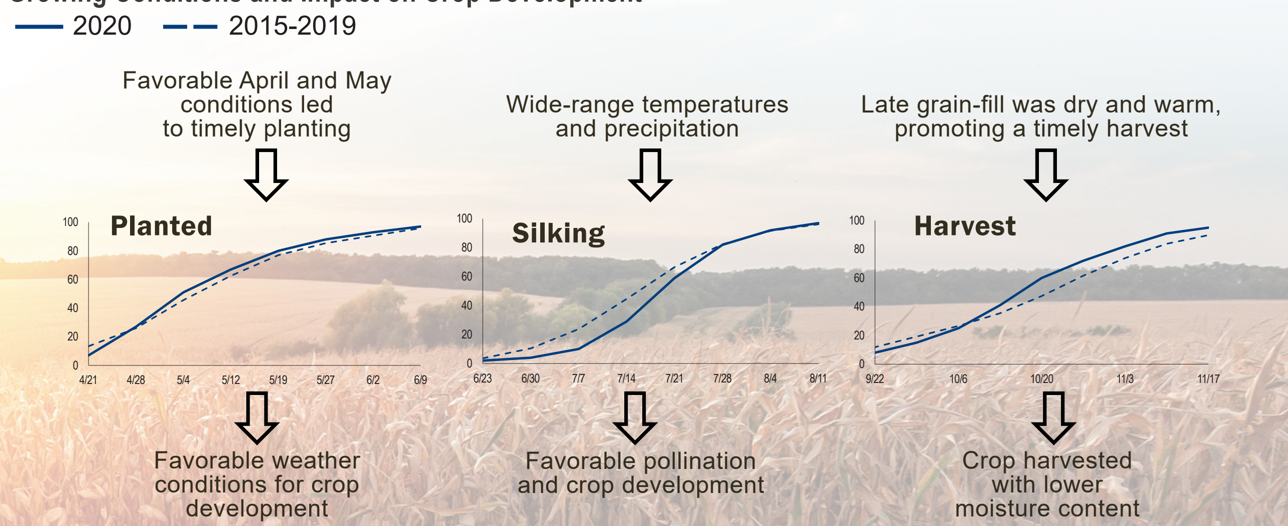


A. 2020 HARVEST HIGHLIGHTS

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, 2020 was characterized by an average vegetative period duration (the period of growth between germination and pollination), with scant nitrogen fertilizer loss, helpful rains at pollination time, a cool grain-filling period and quick dry-down and harvest. This crop was planted slightly early on average and experienced a dry growing season, with the good-to-excellent crop condition rating[1] remaining near the 5YA throughout the season. The weather conditions increased the crop's average test weight, hard endosperm, and protein concentration over the 5YA, while decreasing moisture compared to the 5YA. The following highlights the key events of the 2020 growing season:

- Cold but dry conditions hastened the planting season, up to a week ahead of the 5YA, followed by a very warm and continued dry vegetative stage.
- Pollination (silking stage) occurred at a similar time as the 5YA, with beneficial rains in July to help silks emerge and to accumulate nitrogen fertilizer for future protein accumulation.
- Early grain development in August was mostly cool and dry in the middle to southern U.S. Corn Belt, promoting protein accumulation, but the northern Gulf and Pacific Northwest ECAs were warm and wet.
- The second half of grain-fill had average to cool temperatures for the whole region. Wet conditions in the central Gulf ECA, while dry elsewhere, favored increased test weight.
- The crop's quick maturation allowed for more field drying and encouraged the harvest of dry grain, favorable for reducing stress cracks.

Growing Conditions and Impact on Crop Development



[1] *The U.S. Department of Agriculture 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

Cool, dry April, followed by a wetter May and hot June

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. 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 2020, corn planting happened about a week ahead of the 5YA, but cooler weather delayed the emergence of early-planted fields to near the 5YA. Cool conditions continued in May, slowing development slightly, but decreasing plant stress until the timely rains came for much of the Corn Belt in May, fostering good early vegetative growth. June brought some warm temperatures.

In the Pacific Northwest ECA, planting was ahead of the 5YA, except for the far north (North Dakota), which had wet soils and still had some unharvested crop from last year. Vegetative growth continued with hot and dry conditions to the north, but above average rainfall in May in the region's southern portions helped relieve heat stress.

The Gulf ECA was cool in April and May with above-average rain fostering excellent vegetative growth. June was warmer than average, with abundant rains, except for a dry belt across the mid-latitudes.

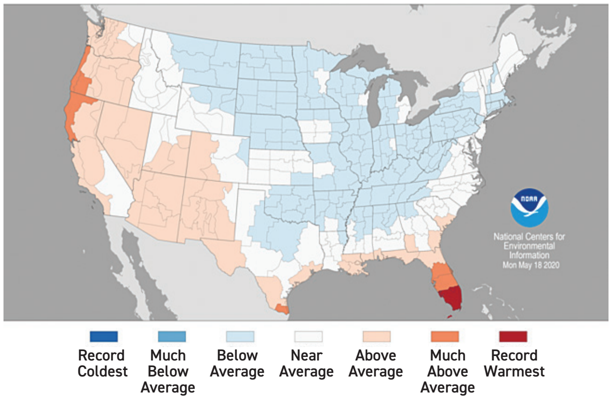
The Southern Rail ECA had good planting, with above-average rain. When the heat came in June during vegetative growth, the extra soil water supply minimized plant stress.

U.S. GRAINS COUNCIL

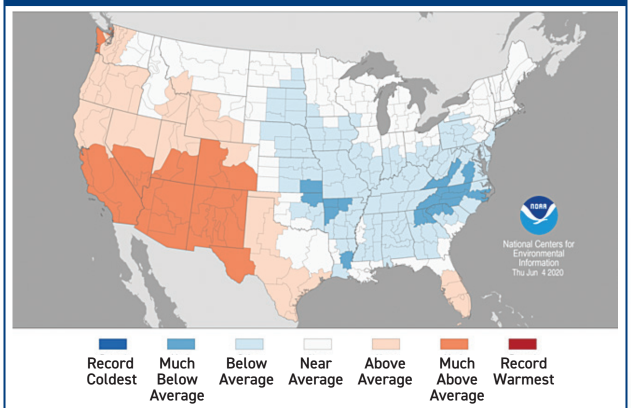
DIVISIONAL AVERAGE TEMPERATURE RANKS

(Period: 1895-2020)

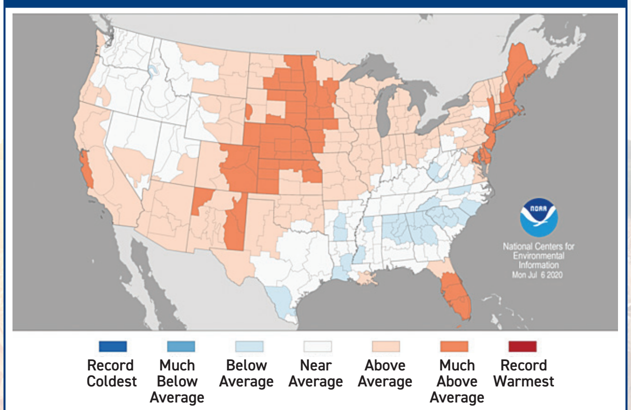
APRIL 2020



MAY 2020



JUNE 2020

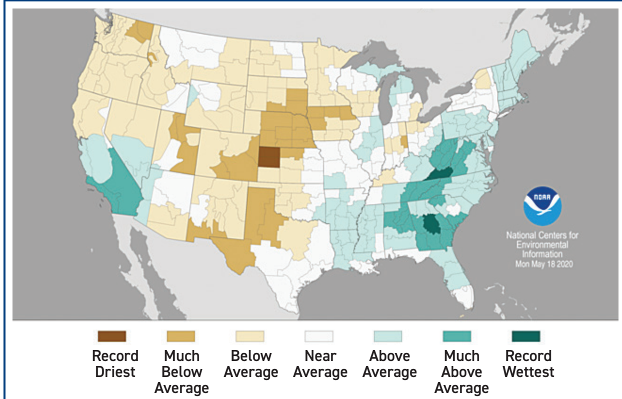


Source: NOAA/Regional Climate Centers

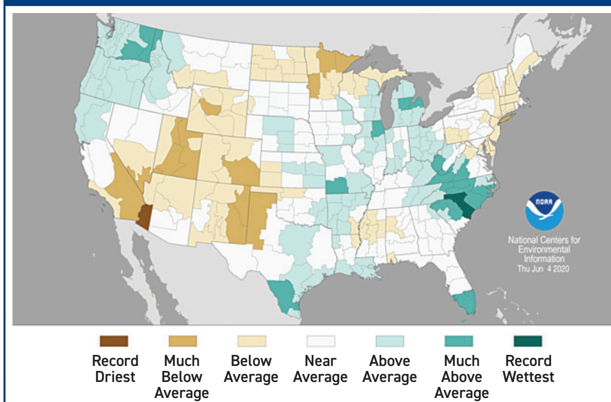
DIVISIONAL PRECIPITATION RANKS

(Period: 1895-2020)

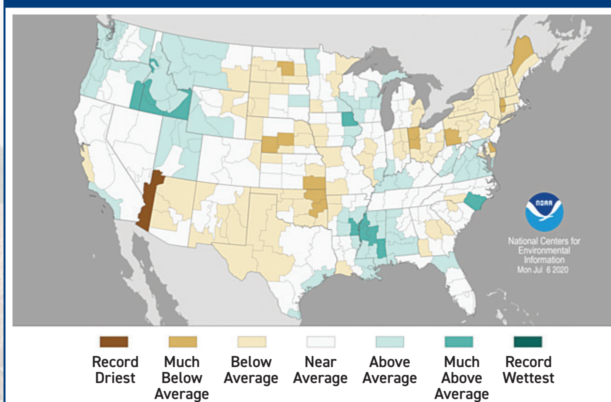
APRIL 2020



MAY 2020



JUNE 2020



Source: NOAA/Regional Climate Centers

C.POLLINATION AND GRAIN-FILL CONDITIONS

Grain-fill favored high test weight and horneous endosperm

Corn pollination typically occurs in July. At pollination time, greater-than-average temperatures or lack of rain typically reduce the number of kernels. During the early grain-filling period in July and August, the weather conditions are critical to determining final grain composition. At pollination, moderate rainfall and cooler-than-average temperatures, especially overnight temperatures, lead 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 terms of mycotoxin development, aflatoxin production is induced by heat stress, low precipitation and drought conditions during flowering followed by periods of high humidity with warmth. While the production of DON is associated with harvest delay or storage of high-moisture corn, the fungal infections responsible for DON's production are promoted by cool (26 to 28°C) or wet conditions within three weeks after pollination by infecting through the silks of the corn ear.

Overall in 2020, it was hot and mostly dry throughout the corn-growing region before pollination. Warm, wet weather helped pollination, but cool, dry conditions were predominant during grain-fill. These weather conditions were not conducive for aflatoxin or DON development. While the crop had ample moisture during pollination, the warm temperature and short duration of rainfall events likely prevented infections responsible for DON development.

In the Pacific Northwest ECA, pollination commenced with above-average rains and warmth in July before the temperature moderated for the remainder of grain-fill. Warm and dry grain-fill conditions favored test weight and grain protein.

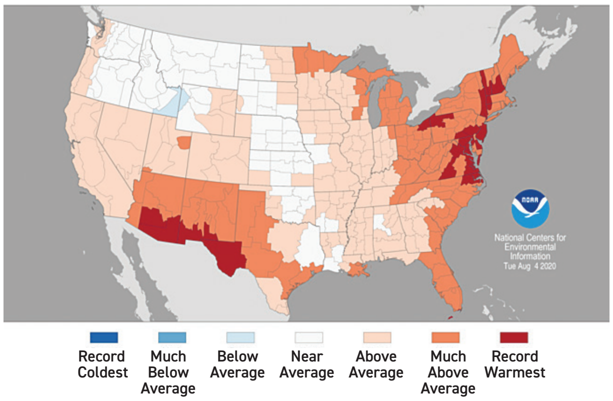
The Gulf ECA was relatively hot and wet during pollination in July, with early grain-filling in August turning cooler and drier in the central region. In September, average to cool temperatures were accompanied by a drought on the periphery and excessive rain in the center of the ECA

The Southern Rail ECA had abundant rains and moderate temperatures for pollination, then had ideal grain-fill conditions of cool and dry in August and September. Growing conditions in the Southern Rail ECA were conducive to excellent test weight and protein concentration.

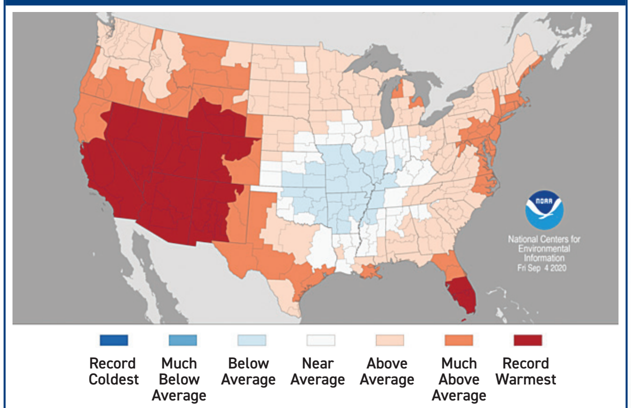
DIVISIONAL AVERAGE TEMPERATURE RANKS

(Period: 1895-2020)

JULY 2020



AUGUST 2020

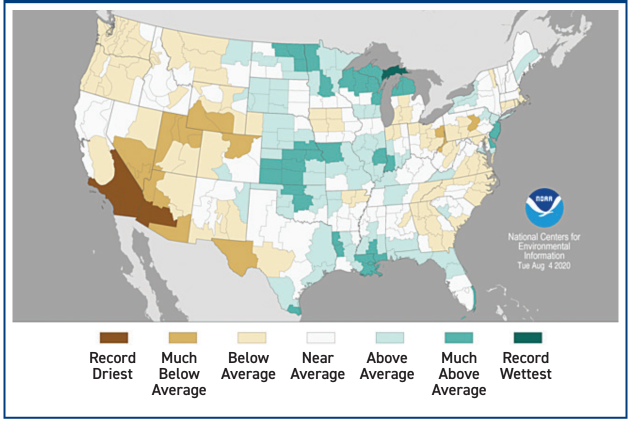


Source: NOAA/Regional Climate Centers

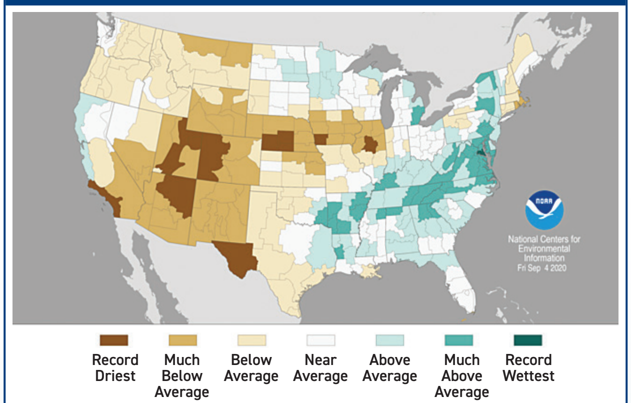
DIVISIONAL PRECIPITATION RANKS

(Period: 1895-2020)

JULY 2020



AUGUST 2020



Source: NOAA/Regional Climate Centers

D.HARVEST CONDITIONS

Early, dry harvest

Corn grain at maturity ranges from 25 to 40% moisture. At the end of the growing season, the dry-down rate 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. If harvested prematurely, higher moisture grain may be susceptible to more stress cracks and greater breakage than drier grain.

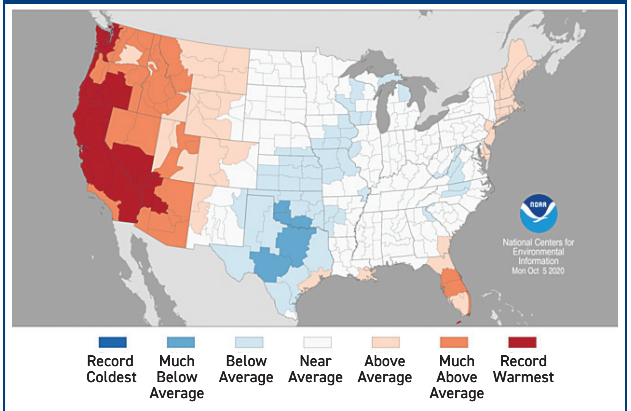
The fairly dry but abnormally cold conditions in September, primarily in the Pacific Northwest and Southern Rail ECAs, led to early maturity and harvest, with greater than the 5YA protein accumulation and test weight. While rainy weather during October delayed harvest in the eastern half of the Gulf ECA, the overall crop was harvested at a pace faster than the 5YA. This year's average moisture content was also lower than the 5YA, reflecting the conditions responsible for the crop's timely harvest.

The cool, dry conditions experienced by the crop at the end of the growing season were not conducive for the development of mycotoxins such as DON, fumonisin, ochratoxin A, T-2 and zearalenone. These same conditions also hastened the maturity of the crop and contributed to an early harvest, further preventing the development of these mycotoxins.

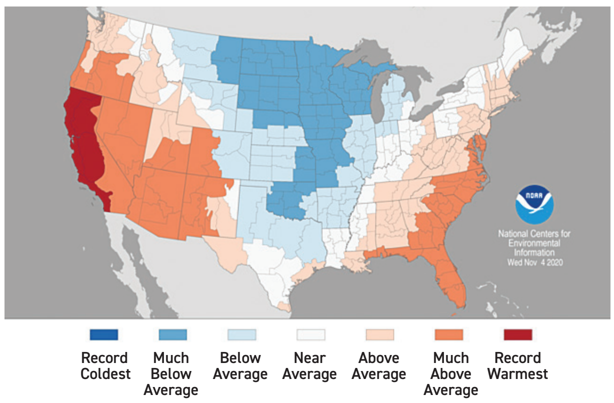
DIVISIONAL AVERAGE TEMPERATURE RANKS

(Period: 1895-2020)

SEPTEMBER 2020



OCTOBER 2020

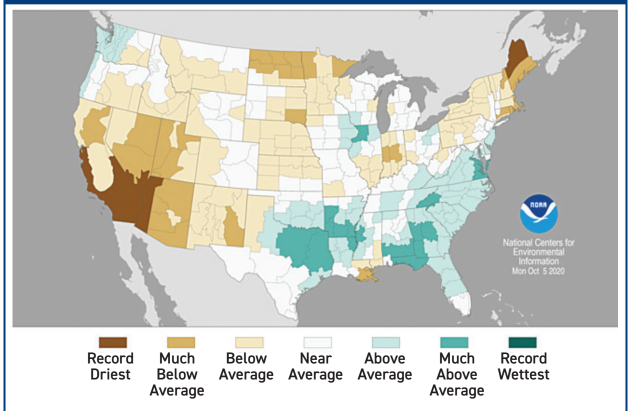


Source: NOAA/Regional Climate Centers

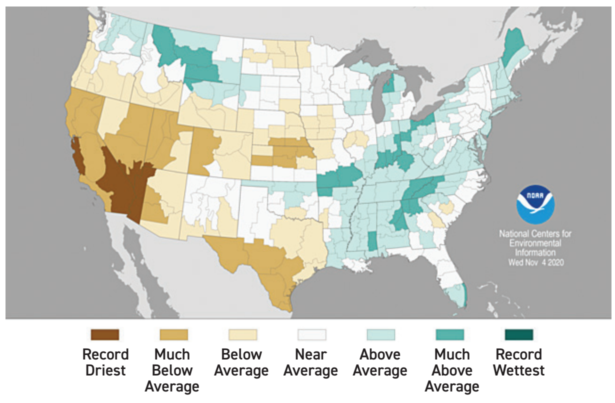
DIVISIONAL PRECIPITATION RANKS

(Period: 1895-2020)

SEPTEMBER 2020



OCTOBER 2020



Source: NOAA/Regional Climate Centers

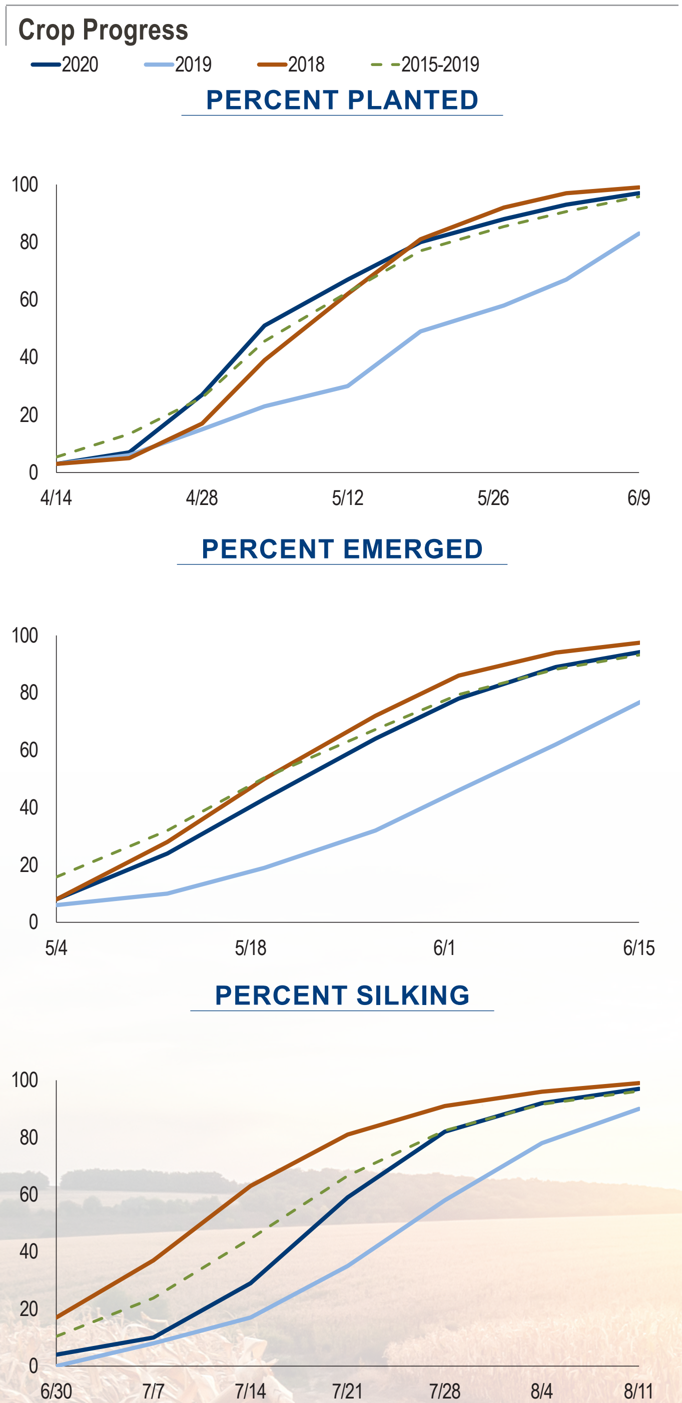
E. COMPARISON OF 2020 TO 2019, 2018 AND THE 5YA

2020 crop developed quickly, with moderate stress

Cool, dry weather in spring led to planting in 2020 ahead of the 5YA. 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.

Crop emergence in 2020 and 2018 was near the 5YA, while there was a two to three-week delay from the 5YA in 2019. Continued cool conditions in 2020 slowed vegetative growth compared to the 5YA, while warm weather in 2018 compressed this period.

At pollination in 2020, there was rain to counteract the earlier dryness. In 2019, plants developed quickly for pollination to occur only about two weeks behind the 5YA. Rains mostly tapered off in the Gulf ECA in 2018, which helped to maximize pollination.

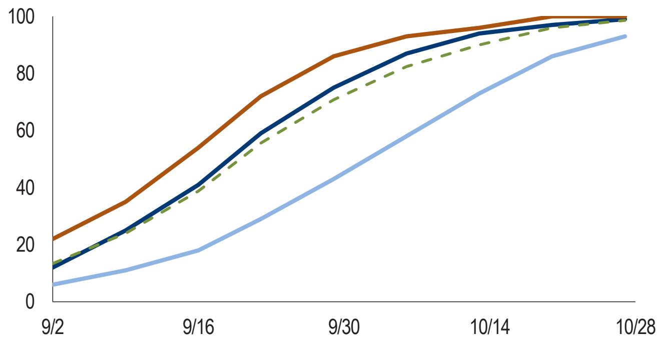


Source: USDA NASS

Crop Progress

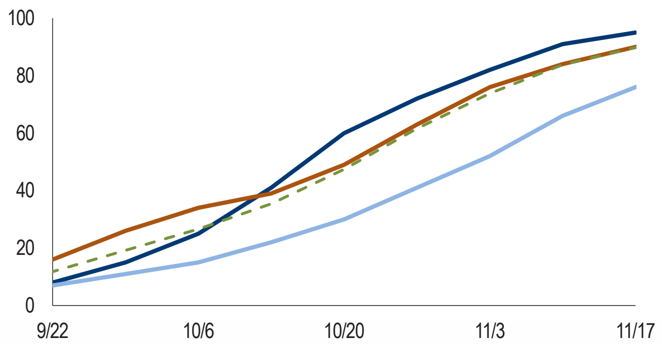
—2020 —2019 —2018 - -2015-2019

PERCENT MATURE



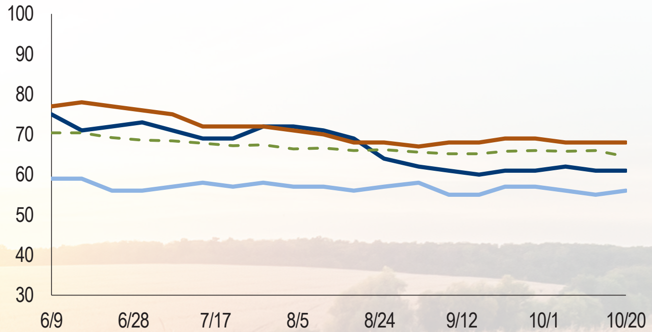
In 2019, grain-fill slowed in August with cool temperatures, while record heat in September was unable to help speed development. The grain-fill period in 2018 was faster than the 5YA in the Gulf ECA that had continued warm weather, while the Pacific Northwest and the Southern Rail ECAs had cooler weather, conducive to producing larger kernels.

PERCENT HARVESTED



Harvest in 2020 was faster than the 5YA due to dry conditions. The 2019 harvest was significantly delayed compared to the 5YA by the late plant maturation and wet fields. In 2018, early harvest was attributed to warm weather advancing the crop maturation approximately two weeks ahead of the 5YA.

U.S. Corn Conditions
Percentage Rated Good-to-Excellent



Source: USDA NASS

In 2020, the season started with a high good-to-excellent condition rating[2]; however, persistent dryness and heat during pollination led to a steady decreasing trend in the rating. The corn crop in 2019 had a modest rating 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.

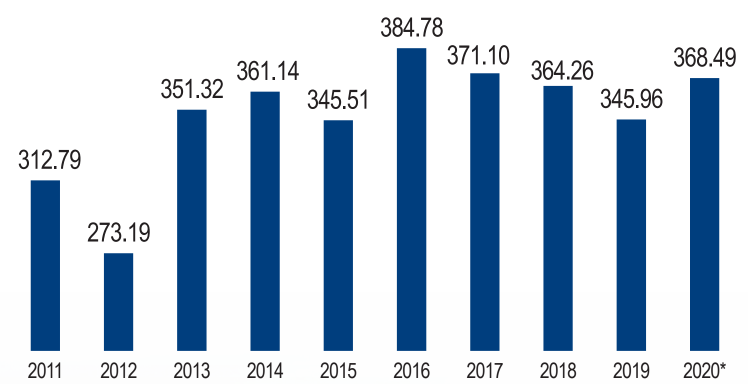
[2] A good rating means that yield prospects are normal. Moisture levels are adequate and disease, insect damage and weed pressures are minor. An excellent rating means that yield prospects are above normal, and the crop is experiencing little or no stress. Disease, insect damage and weed pressures are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

A. U.S. CORN PRODUCTION

U.S. Average Production and Yields

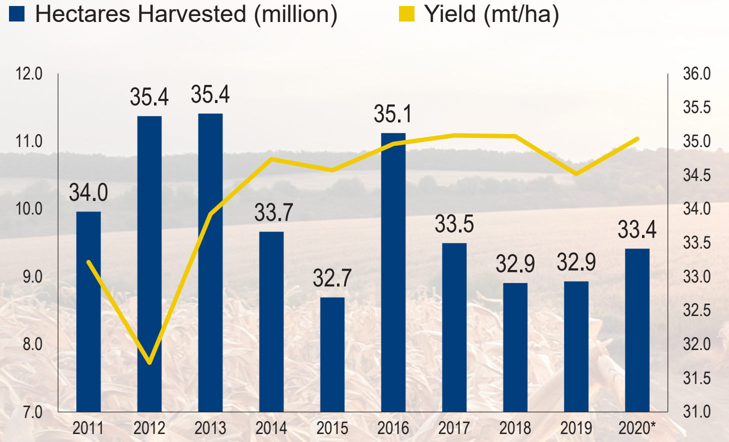
According to the November 2020 USDA World Agricultural Supply and Demand Estimates (WASDE) report, U.S. corn production in 2020 is projected to be 368.49 million metric tons (14,507 million bushels). If realized, this year's crop would be the third largest on record, trailing only the 2016 and 2017 crops. This large projected production in 2020 is primarily the result of historically high average yield rather than an increase in harvested hectares. In terms of harvested hectares, the projected 33.41 million (82.5 million acres) harvested is slightly less than the 5YA of 33.43 million hectares (82.6 million acres). However, the 2020 crop's projected average yield of 11.04 mt/ha (175.8 bu/ac) would be the third highest average U.S. corn yield on record.

U.S. Corn Production (mmt)



**Projected*
Source: USDA NASS

U.S. Corn Yield and Harvested Area

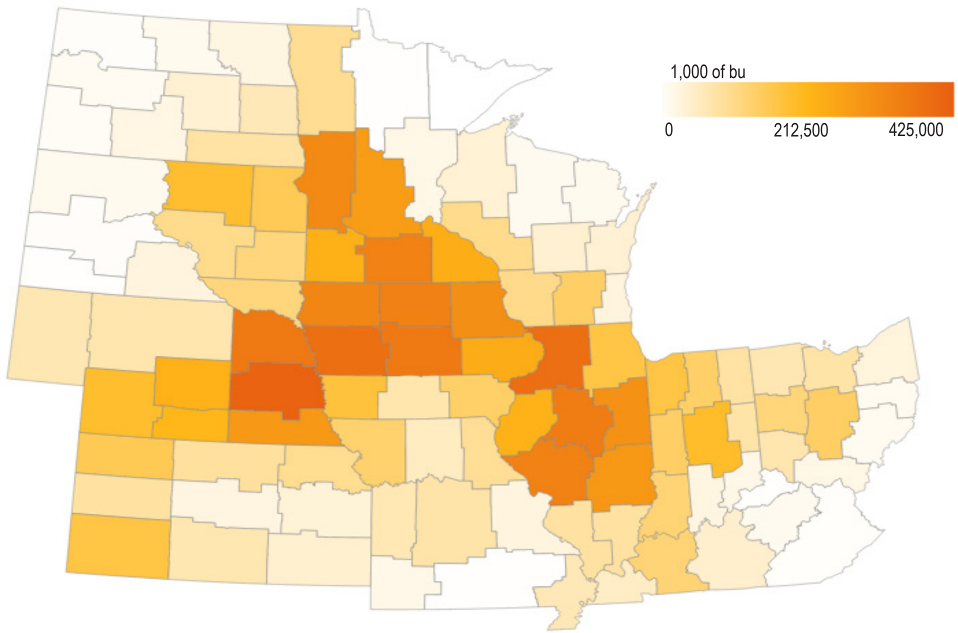


**Projected*
Source: USDA NASS

ASD and State-Level Production

The geographic areas included in the *2020/2021 Corn Harvest Quality Report* encompass the United States' highest corn-producing regions. The map below shows the projected 2020 corn production by USDA Agricultural Statistical District (ASD). These states represent over 90% of U.S. corn exports.[1]

Projected 2020 U.S. Corn Production by ASD



Source: USDA NASS and Centrec Estimates

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

The U.S. Corn Production by State chart and table summarize the production changes between each state's 2019 and projected 2020 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 2019 to projected 2020.

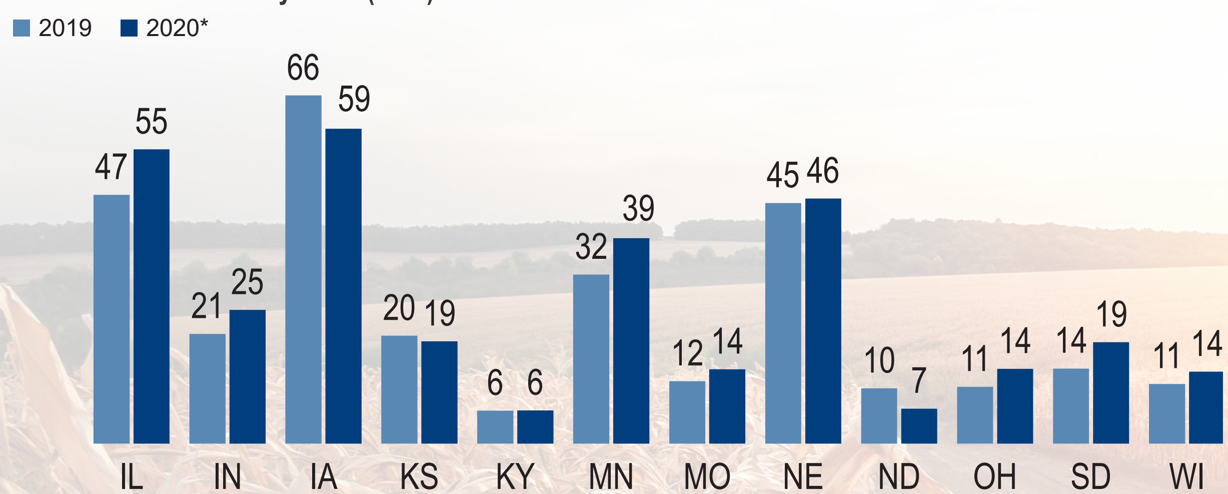
Seven of the 12 key corn-producing states expect large increases (greater than 18%) in production relative to their 2019 crops. It is important to note that delayed planting of the 2019 crop contributed to production declines in key states last year. Relative to their 2018 crops, Illinois, Indiana, Ohio, South Dakota and Wisconsin, all experienced production declines of over 15% in 2019. These five states were among the seven states projecting increases in production of over 18% in 2020 relative to 2019. Only North Dakota and Iowa are projected to have year-over-year reductions of over 5% production in 2020.

U.S. Corn Production by State

			Difference		Relative % Change†	
State	**2019**	**2020***	**MMT**	**Percent**	**Acres**	**Yield**
Illinois	46.9	55.5	8.6	18.3%		
Indiana	20.7	25.2	4.5	21.8%		
Iowa	65.6	59.4	(6.3)	-9.6%		
Kansas	20.3	19.3	(1.1)	-5.2%		
Kentucky	6.2	6.3	0.0	0.5%		
Minnesota	31.9	38.7	6.9	21.6%		
Missouri	11.8	14.0	2.2	18.9%		
Nebraska	45.3	46.2	0.8	1.9%		
North Dakota	10.4	6.6	(3.8)	-36.7%		
Ohio	10.7	14.1	3.4	31.5%		
South Dakota	14.2	19.1	5.0	35.0%		
Wisconsin	11.3	13.6	2.3	20.4%		
Total U.S.	**345.9**	**368.5**	**22.5**	**6.5%**		

†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 State (mmt)



**Projected*
Source: USDA NASS

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. After stagnating from marketing year 16/17 through marketing year 18/19, domestic gasoline consumption fell in marketing year 19/20 during the COVID-19 pandemic. Annual increases in ethanol exports contributed to increases in corn consumption for ethanol production. This reduction in domestic gasoline consumption, coupled with a slight decline in ethanol exports, led to a 9.8% decline in the amount of corn used for ethanol in marketing year 19/20 compared to marketing year 18/19.

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 two largest U.S. crops in history in 2016 and 2017. A steady domestic consumption and lower production in 2019 left less corn available for export in marketing year 19/20.

Ending stocks have remained steady since the record 2016 U.S. corn crop.

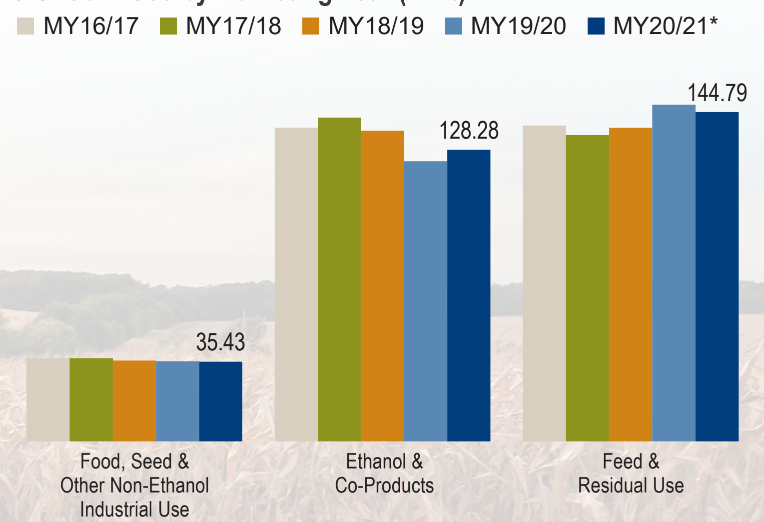
C. OUTLOOK

U.S. Outlook

The 2020 U.S. corn crop is projected to trail only the 2016 and 2017 crops for the largest crop on record. If realized, this year's crop size will provide an ample supply of corn available for domestic consumption and exports in marketing year 20/21 and 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 20/21 compared to marketing year 19/20, continuing the pattern of the previous four marketing years.

U.S. Corn Use by Marketing Year (mmt)



**Projected*
Source: USDA WASDE and ERS

Projected marketing year 20/21 corn use for ethanol is slightly greater than marketing year 19/20 but lower than marketing years 16/17 through 18/19. Following a 9.8% year-over-year decline in marketing year 19/20, the projected increase in corn use for ethanol in marketing year 20/21 will be dependent on domestic gasoline demand recovering from the previous year.

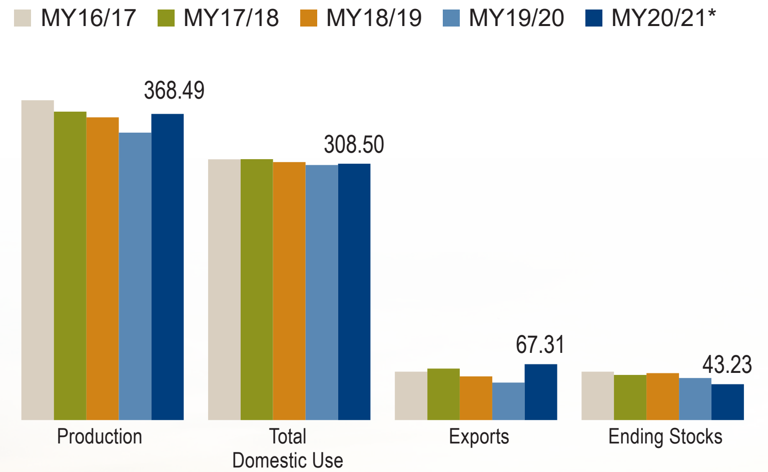
Domestic corn use for feed and residual use in marketing year 20/21 is expected to be 3.23 million metric tons lower (2.2% decrease) compared to marketing year 19/20. This year's projected 144.79 million metric tons for domestic corn use for feed and residual use is still expected to be 6.88 million metric tons higher (5.0% higher) than the 5YA (137.91 million metric tons).

Higher U.S. corn exports are projected for marketing year 20/21 due to the larger corn crop anticipated. U.S. corn exports are projected to be 67.31 million metric tons in marketing year 20/21, which is an increase of 22.14 million metric tons (49.0% increase) from marketing year 19/20 and 14.09 million metric tons higher (26.5% higher) compared to the 5YA (53.22 million metric tons).

U.S. ending stocks are also projected to be lower in marketing year 20/21 as the larger corn crop anticipated is more than offset by projected increases in exports and total domestic use. Ending stocks are projected to be 43.23 million metric tons, which is 7.45 million metric tons lower (14.7% lower) than the previous marketing year and 9.53 million metric tons lower (18.1% lower) compared to the 5YA (52.77 million metric tons).

In terms of the stocks-to-use ratio, marketing year 20/21 is projected to have a ratio of 11.5%. This is the lowest projected stocks-to-use ratio since the marketing year 13/14 (9.2%).

U.S. Corn Production & Disappearance (mmt)



*Projected
Source: USDA WASDE and ERS

International Outlook[2]

Global Supply

Global corn production during marketing year 20/21 is expected to be 1,144.63 million metric tons. This 28.44 million metric ton (2.5%) increase from marketing year 19/20 production is mainly due to higher U.S. production.

In addition, global corn exports during marketing year 20/21 are expected to be 184.77 million metric tons. This 13.76 million metric ton (8.0%) increase from marketing year 19/20 production is primarily due to higher U.S. exports as total non-U.S. exports are projected to be 8.38 million metric tons lower (6.7% lower) than marketing year 19/20.

Global Demand

Global corn consumption is expected to increase from 1,132.68 million metric tons in marketing year 19/20 to 1,156.54 million metric tons in marketing year 20/21, a 2.1% annual increase. Argentina, Brazil, China, Iran, Russia, Vietnam and the U.S. are all anticipated to consume at least 1.00 million metric tons more corn in marketing year 20/21 than in the previous year. In comparison, none of the major corn-consuming countries and areas are anticipated to have reductions in corn consumption over 0.40 million metric tons relative to the previous marketing year.

Following the higher anticipated consumption, a 23.86 million metric ton increase in global corn imports in year-over-year imports is expected globally in marketing year 20/21, a 7.5% increase. Increases in year-over-year imports of at least 1.00 million metric tons are anticipated in China, the European Union, Iran and Vietnam. The largest increase in year-over-year imports is anticipated in China (5.40 million metric ton increase). None of the major corn-consuming countries and areas are anticipated to have reductions in corn imports over 0.50 million metric tons relative to the previous marketing year.

[2] *USDA/Foreign Agricultural Service- Production, Supply and Distribution Database. Data retrieved November 2020.*

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

Metric Units	16/17	17/18	18/19	19/20	20/21*
Acreage (million hectares)					
Planted	38.06	36.50	35.99	36.32	36.84
Harvested	35.12	33.50	32.91	32.93	33.41
Yield (mt/ha)	10.96	11.09	11.07	10.51	11.04
Supply (million metric tons)					
Beginning stocks	44.12	58.25	54.37	56.41	50.68
Production	384.78	371.10	364.26	345.96	368.49
Imports	1.45	0.91	0.71	1.06	0.64
Total Supply	**430.35**	**430.27**	**419.34**	**403.44**	**419.81**
Usage (million metric tons)					
Food, seed, other non-ethanol industry use	36.92	36.88	35.93	35.54	35.43
Ethanol and co-products	137.98	142.37	136.61	123.26	128.28
Feed and residual	138.89	134.73	137.91	148.02	144.79
Exports	58.31	61.92	52.48	45.17	67.31
Total Use	**372.10**	**375.90**	**362.93**	**351.99**	**375.81**
Ending Stocks	58.25	54.37	56.41	50.68	43.23
Average Farm Price ($/mt**)	132.28	132.28	142.12	140.15	157.47

English Units	16/17	17/18	18/19	19/20	20/21*
Acreage (million acres)					
Planted	94.0	90.2	88.9	89.7	91.0
Harvested	86.7	82.7	81.3	81.3	82.5
Yield (bu/ac)	174.6	176.6	176.4	167.5	175.8
Supply (million bushels)					
Beginning stocks	1,737	2,293	2,140	2,221	1,995
Production	15,148	14,609	14,340	13,620	14,507
Imports	57	36	28	42	25
Total Supply	**16,942**	**16,939**	**16,509**	**15,883**	**16,527**
Usage (million bushels)					
Food, seed, other non-ethanol industry use	1,453	1,452	1,415	1,399	1,395
Ethanol and co-products	5,432	5,605	5,378	4,852	5,050
Feed and residual	5,468	5,304	5,429	5,827	5,700
Exports	2,296	2,438	2,066	1,778	2,650
Total Use	**14,649**	**14,798**	**14,288**	**13,857**	**14,795**
Ending Stocks	2,293	2,140	2,221	1,995	1,702
Average Farm Price ($/bu**)	3.36	3.36	3.61	3.56	4.00

**Projected*
***Farm prices are weighted averages based on the volume of farm shipment.*
The average farm price for 20/21 based on WASDE November projected price.*
Source: USDA WASDE and ERS

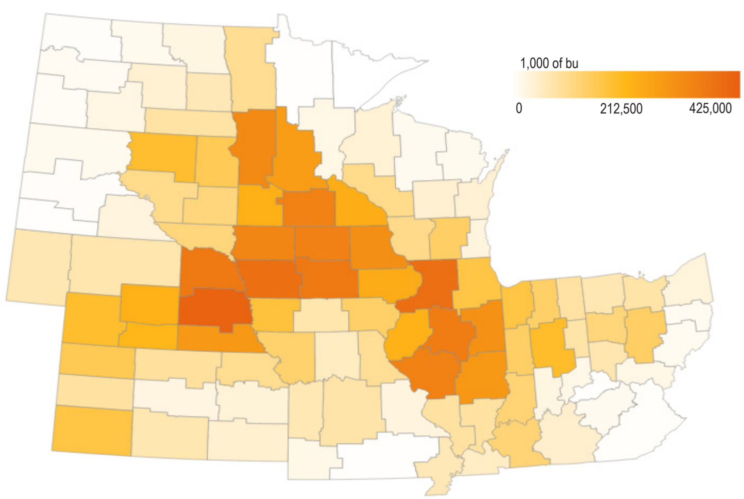
U.S. GRAINS COUNCIL

A. OVERVIEW

The key points for the survey design, sampling methodology and statistical analysis for this *2020/2021 Harvest Report* are as follows:

- Following the methodology developed for the previous nine *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 600 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.

Projected 2020 U.S. Corn Production by ASD



- A total of 601 unblended corn samples were received and tested for the report. These samples were pulled from inbound farm-originated trucks by local elevators from September 2 through November 13, 2020.
- 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, fumonisin, ochratoxin A, T-2 and zearalenone.
- 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 Pacific Northwest ECA's relative margin of error for total damage was 14.7%. While this level of precision is less than desired, it does not invalidate the estimate.
- Two-tailed t-tests at the 95.0% confidence level were calculated to measure statistical differences between this year's quality factor averages and those from the previous two reports.

B. SURVEY DESIGN AND SAMPLING

Survey Design

For this *2020/2021 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 market channel. Three key characteristics define the sampling technique: the ***stratification*** of the population to be sampled, the ***sampling proportion*** per stratum and the ***random sample*** selection procedure.

Stratification involves dividing the survey population of interest into distinct, non-overlapping 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 *2020/2021 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 *2020/2021 Harvest Report* was a relative margin of error no greater than ±10.0%, estimated at a 95.0% level of confidence.

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. Greater variation among the levels or values of a quality factor requires more samples 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 quality factor for the same level of precision.

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

Since the population variances for the 17 quality factors evaluated for this year's corn crop were unknown, the variance estimates from the *2019/2020 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 13 quality factors were calculated using the 2019 results of 623 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.

While the relative margin of error for stress cracks was not higher than ±10.0% in the 2019 results for the U.S. Aggregate, this quality factor has had a relative margin of error slightly higher than ±10.0% in three of the nine previous reports. Given the 2020 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 past reports.

The testing of the grade, moisture, chemical and physical characteristics used the same proportionate stratified sampling approach 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, ochratoxin A, T-2 and zearalenone for this year's report. 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.

Beginning with the *2019/2020 Harvest Report*, only the samples tested for mycotoxins would be tested for horneous endosperm. This testing protocol was extended to 100-k weight, kernel volume and kernel true density in the *2020/2021 Harvest Report*. These quality factors' relative margin of errors have never exceeded 0.6%, well below the targeted level of precision of ±10.0%, in the samples tested from the nine previous reports. Thus, reducing the number of samples tested for horneous endosperm, 100-k weight, kernel volume and kernel true density would likely keep the precision of these quality factors' estimates well below the targeted level ±10.0%.

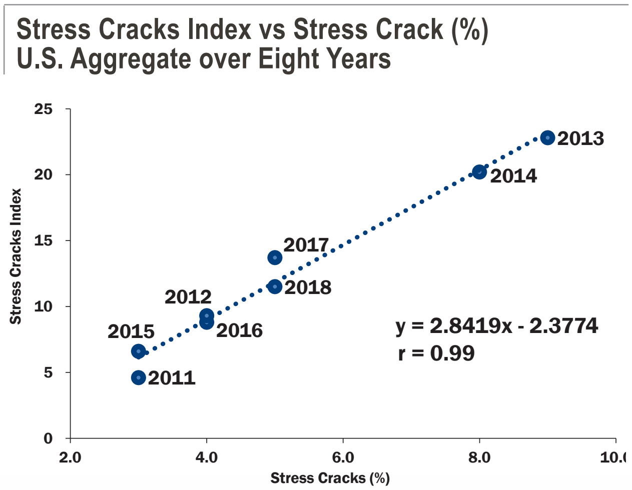
In the first eight years of the *Harvest Report*, the stress crack index was reported in addition to the percent stress cracks to indicate the severity of stress cracking. The stress crack index is determined using the following calculation:

[SSC x 1] + [DSC x 3] + [MSC x 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 to the right. 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*.



Sampling

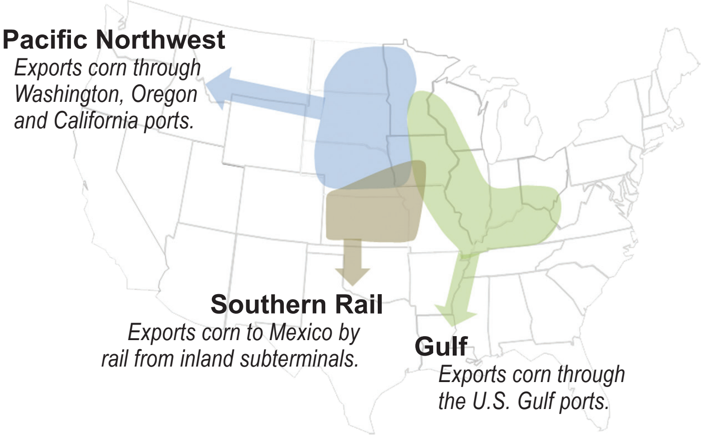
Soliciting local grain elevators in the 12 states by email and phone provided the ***random selection*** process. Postage-paid sample kits were mailed to elevators agreeing to provide the 2,050 to 2,250-gram corn samples requested. Elevators were told to avoid sampling loads of old crop corn from farmers 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 601 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 September 2 through November 13, 2020, 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 three composite groups that supply corn to each of three major ECAs.

In analyzing the sample test results, the Council followed the standard statistical techniques employed for proportionate stratified sampling, including ***weighted averages*** and ***standard deviations***.[2] 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.

Export Catchment Areas



The *2020/2021 Harvest Report* contains a simple average of the quality factors' averages and standard deviations of the previous five *Harvest Reports (2015/2016, 2016/2017, 2017/2018, 2018/2019 and 2019/2020)*. 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. References to the "10YA" are also made throughout the report. The 10YA represents the simple average of the quality factors' averages from the *2011/2012 Harvest Report* through this *2020/2021 Harvest 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 Pacific Northwest ECA's relative margin of error for total damage was 14.7%. While this level of precision is less than desired, it 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.

Two-tailed t-tests validated references in the "Quality Test Results" section to statistical or significant differences between results in the *2019/2020 Harvest Report* and the *2020/2021 Harvest Report* and in the *2018/2019 Harvest Report* and the *2020/2021 Harvest Report* at the 95.0% confidence level.

[2] *The reported standard deviations for horneous endosperm, 100-k weight, kernel volume and kernel true density were not weighted due to the reduced number of samples tested.*

The *2020/2021 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 grain sample's attributes even 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 17025:2017 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 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 test cup's sides. 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 protein, oil and starch concentrations in the sample. This procedure is nondestructive to the corn.

Chemical composition tests for protein, oil and starch were conducted using a 550 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* before 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 each kernel's stress crack damage 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 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.

Whole Kernels

In the whole kernels test, 50 grams of cleaned (BCFM-free) corn are inspected by the 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 the 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 *2020/2021 Harvest Report's* 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 *2020/2021 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 (two-pound) sample from trucks to grind for aflatoxin testing, approximately a 200-gram sample to grind for DON testing and a 908-gram (two-pound) sample for fumonisin testing. For this study, a 1,000-gram laboratory sample was subdivided from the two-kilogram survey sample of shelled kernels for the aflatoxin analysis. The one-kilogram survey sample was ground in a Romer Model 2A mill so that 60 to 75% would pass through 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 411 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 QuickScan system quantified the mycotoxins.

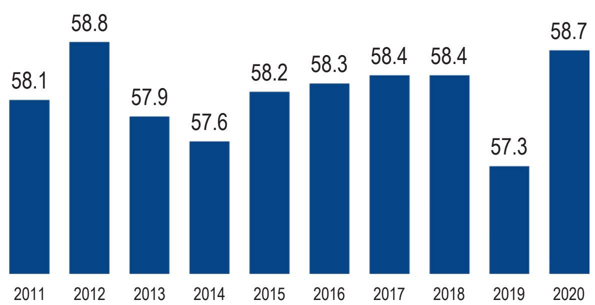
The EnviroLogix quantitative test kits report specific concentration levels of the mycotoxin if the concentration level exceeds a specific level called a "Limit of Detection." The limit of detection is defined as the lowest concentration level that can be measured with an analytical method that is statistically 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 411 BG has a limit of detection of 0.1 parts per million. FGIS has issued a letter of performance for the quantification of aflatoxin, DON and fumonisin using the Envirologix AQ 309 BG, AQ 304 BG and AQ 411 BG kits, respectively.

The *2020/2021 Harvest Report* also tested harvest samples for ochratoxin A, T-2 and zearalenone. The testing for these three additional mycotoxins is on a provisional basis. These tests are intended to complement the information provided by the test results from the three mycotoxins tested on an annual basis (aflatoxin, DON and fumonisin). EnviroLogix AQ 113 BG, AQ 314 BG, and AQ 412 BG quantitative test kits were used for ochratoxin A, T-2 and zearalenone, respectively. The EnviroLogix AQ 113 BG quantitative test kit used for the ochratoxin A tests has a limit of detection of 1.5 parts per billion. The ochratoxin A was extracted with a grain buffer (five milliliters per gram). For the T-2 tests, the AQ 314 BG quantitative test kit has a limit of detection of 50 parts per billion. T-2 was extracted with water (five milliliters per gram). The EnviroLogix AQ 412 BG quantitative test kit used for the zearalenone tests has a limit of detection of 50 parts per billion. The zearalenone test uses a 25-gram test portion of corn. The zearalenone was extracted using a reagent of EB17 extraction powder and a water buffer of 75 milliliters per sample.

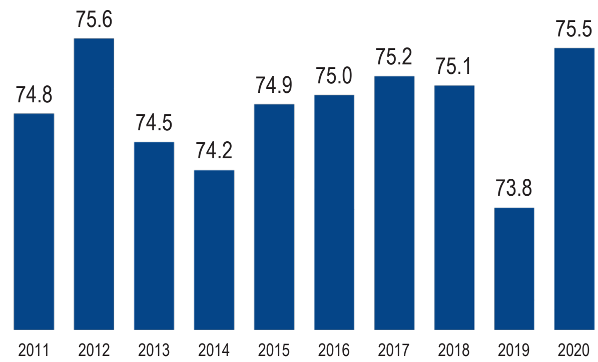
A. GRADE FACTORS AND MOISTURE

Since 2011, the Council's *Harvest Quality Reports* have provided clear, concise and consistent information about each U.S. crop's quality 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.

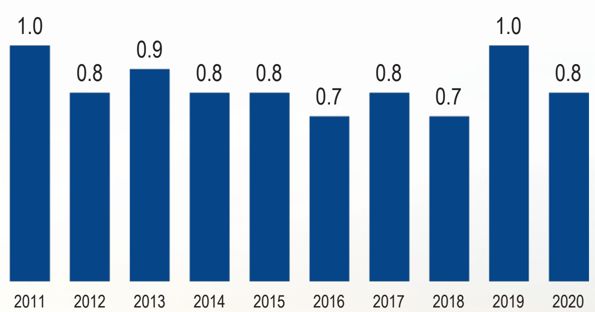
Test Weight (lb/bu) by Crop Year



Test Weight (kg/hl) by Crop Year



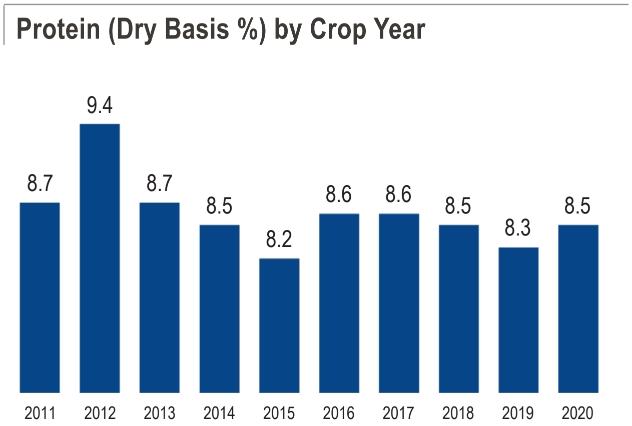
BCFM (%) by Crop Year

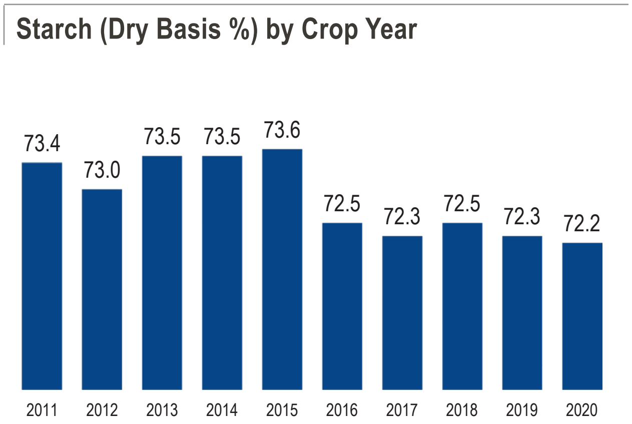


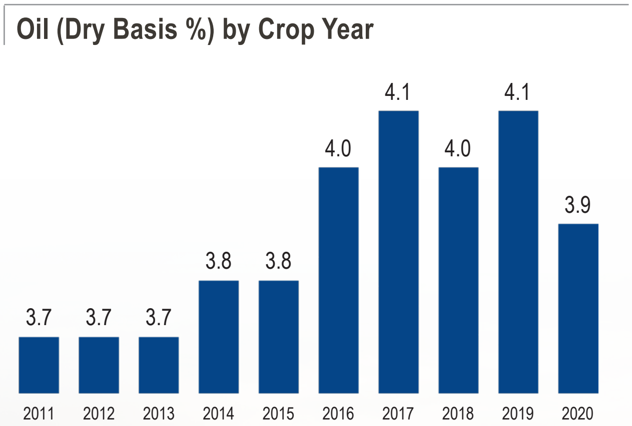
Total Damage (%) by Crop Year

Moisture (%) by Crop Year

B. CHEMICAL COMPOSITION

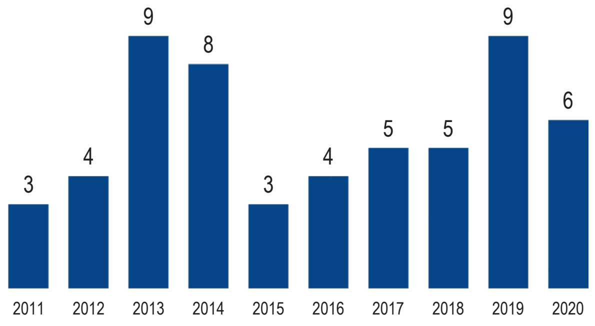




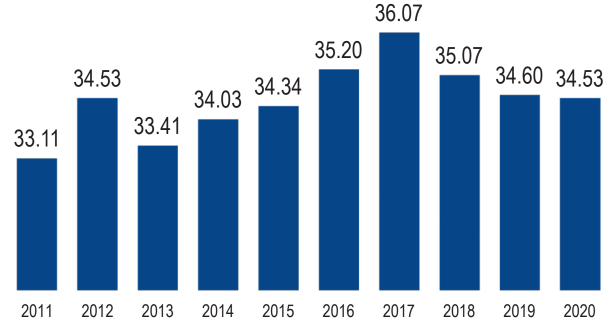


C.PHYSICAL FACTORS

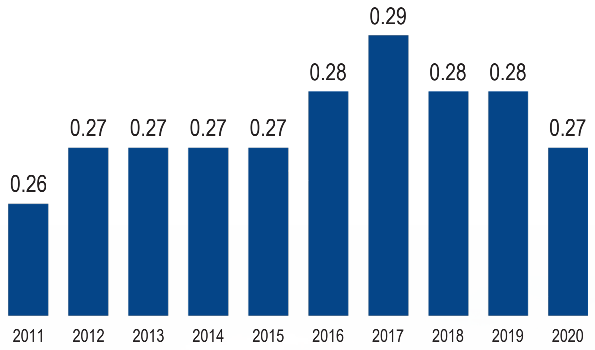
Stress Cracks (%) by Crop Year



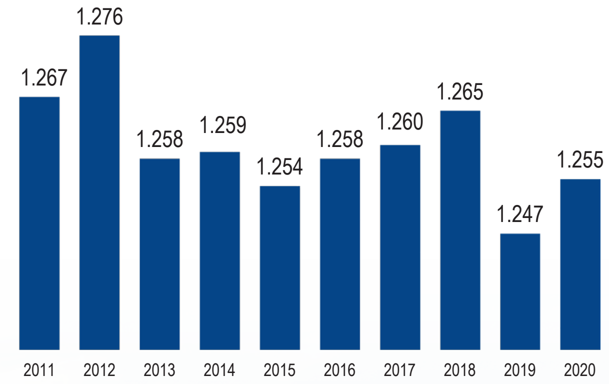
100-Kernel Weight (g) by Crop Year



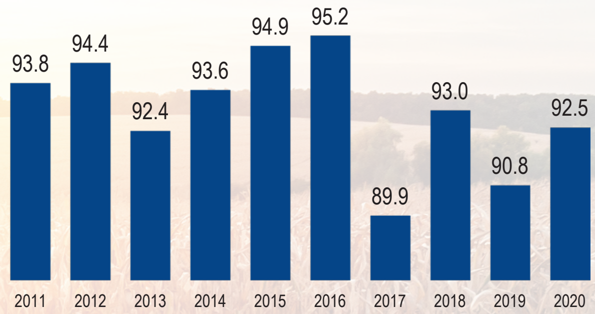
Kernel Volume (cm³) by Crop Year



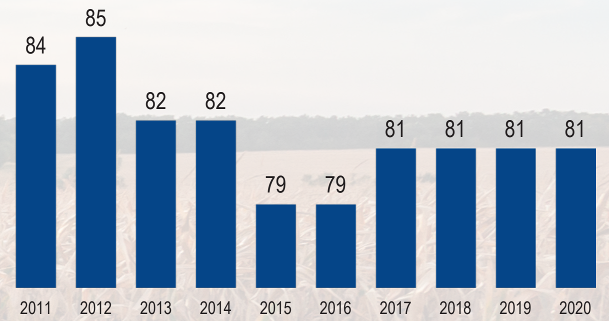
True Density (g/cm³) by Crop Year



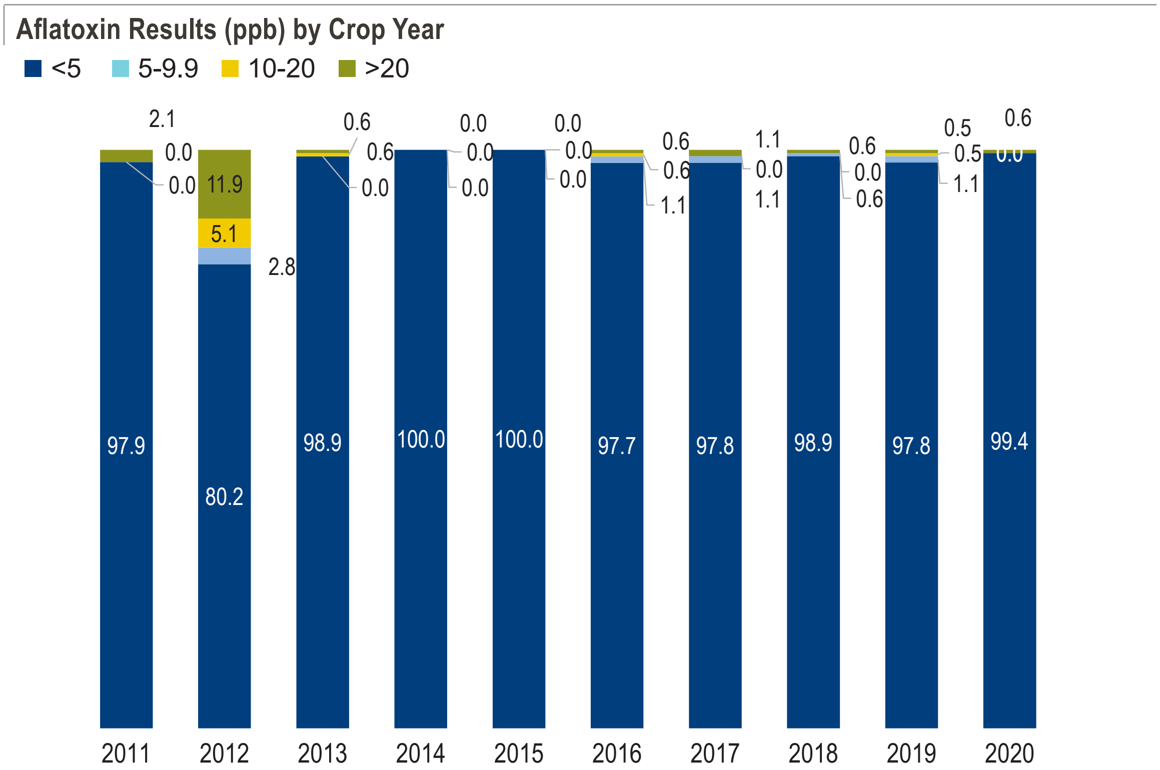
Whole Kernels (%) by Crop Year

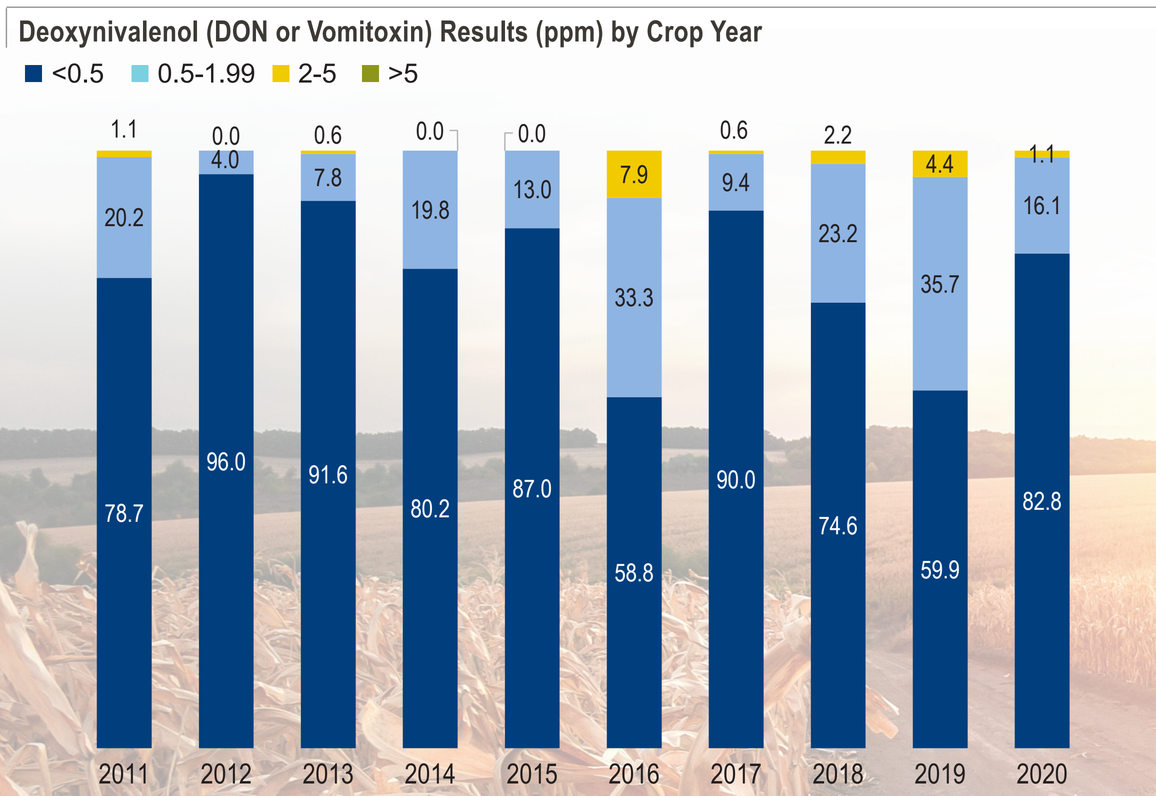


Horneous Endosperm (%) by Crop Year



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 cockleburs (*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

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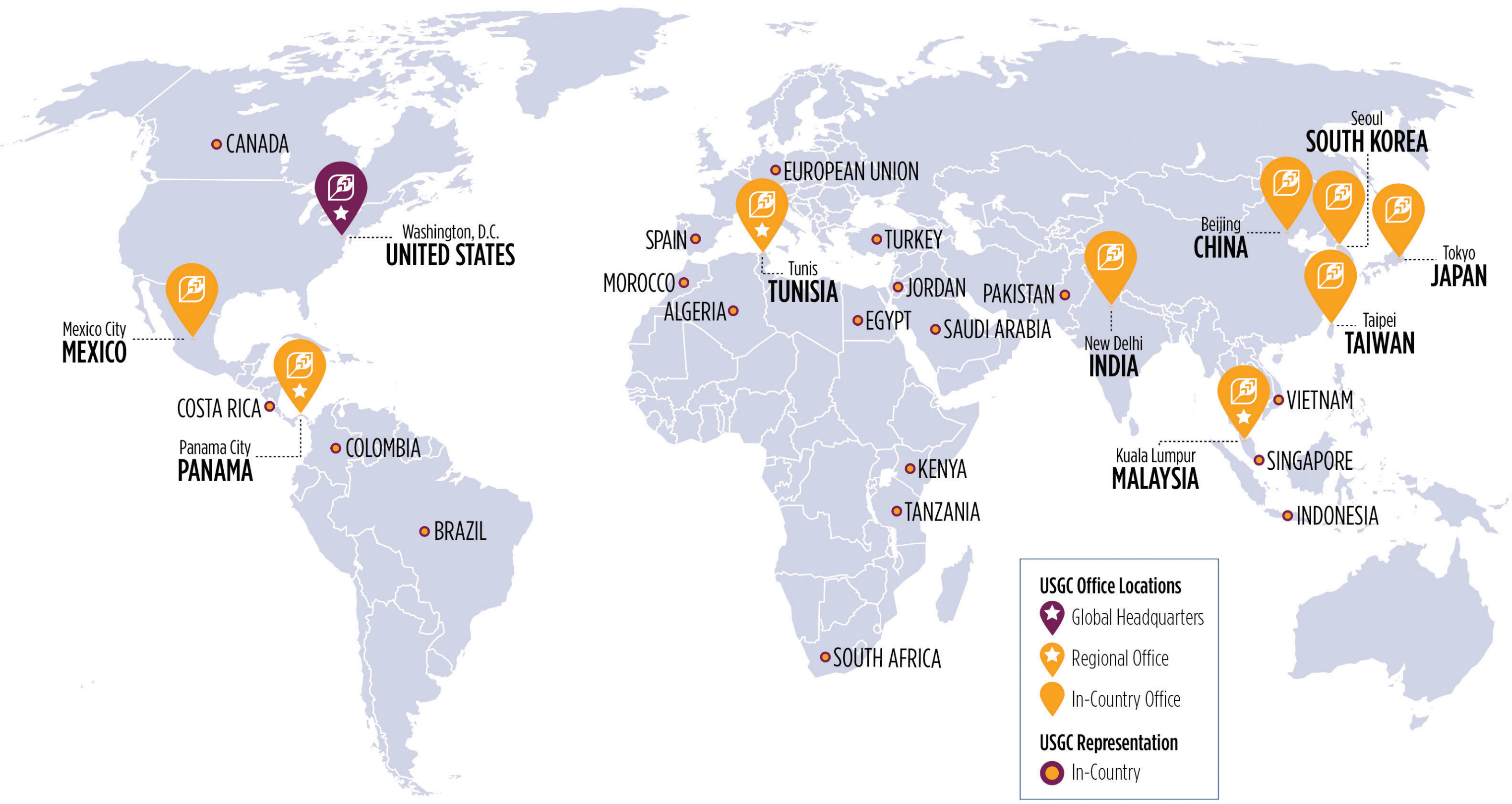

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