United States Food Soybean Quality

Annual Report 2020

Corrected May 2021

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CORRECTED FOOD QUALITY REPORT: 2020

We are issuing a corrected 2020 US Soybean Quality Report after identifying errors in protein an oil values that were reported earlier. While conducting additional quality control measures after the publication of the December report, we found our NIR instrument to be underpredicting protein and overpredicting oil concentrations. After investigating the disparity, we determined that our NIR instrument supplier had replaced the instrument's hard drive but failed to transfer a 'normalization' file. That company has since worked closely with us to fix the issue, repredict all sample analyses, and develop a robust quality control plan going forward. ***We apologize for any inconvenience this has caused and our primary mission remains providing the highest quality data possible.***

SUMMARY

The American Soybean Association, United Soybean Board, and US Soybean Export Council have supported a survey of the quality of the US commodity soybean crop since 1986. That survey is intended to provide new crop quality data to aid international customers with their purchasing decisions. The Food Soybean Survey was first conducted in 2007, and is intended to assist international buyers, as well as to provide food manufacturers valuable information about the quality of specialty soybeans. Due to both the wide range of food bean types (tofu, natto, etc.) and the range of varieties grown for each type across different geographic regions of the US, it is difficult to provide generalized conclusions regarding the 2020 United States food soybean crop as a whole. This report provides examples of state by state food soybean quality data (protein and oil), regional quality averages by seed size, and quality trends for the entire US food soybean crop. The larger commodity soybean crop summary is provided as context for understanding the regional environmental influences that affect both commodity and food soybean crops.

2020 AREA, YIELDS, AND TOTAL PRODUCTION

Record early planting pace for Iowa and Minnesota, and unusually early planting in other important soybean producing states, led to an early planted US soybean crop (Figure 1). This positioned the US for record yields and total production. Unfortunately, severe drought conditions and extreme weather across the center of the Corn Belt reduced yields significantly from their potentials, to average 3.5 MT per ha.

In 2020, US soybean area rebounded after low plantings in 2019. US farmers planted 33.6 million hectares of soybeans, up from 30.8 in 2019. Soybean area in 2020 (Figure 2) is similar to that planted in 2014, 2015, and 2016, but down by nearly 10% from 2017 and 2018. When yields are multiplied by an expected harvest area of 33.3 M ha, total production is expected to be 116 M MT. This equals 2016 production and falls behind record harvests of 2017 and 2018, where production equaled 121 and 128 M MT, respectively.

QUALITY OF THE 2020 US FOOD SOYBEAN CROP

Participating food soybean exporting companies provided a total of 477 samples analyzed by April 2021. Sample numbers were up in 2020 as a result of timely harvests and an increased outreach effort by the US Soybean Export Council to food soybean companies.

Typically, samples are analyzed for protein, oil, and amino acid concentration by near-infrared spectroscopy (NIRS) using a Perten DA7250 diode array instrument (PerkenElmer Inc., Waltham, MA, USA) equipped with calibrations developed by the University of Minnesota in cooperation with PerkenElmer. However, due to the NIR data issue noted above, we sent all 477 samples to a commercial laboratory for 'wet chemistry' assessment of protein and oil. The amino acid and soluble sugar data are based on corrected NIR values. Additionally, we determined average seed size (grams per 100 seeds) for each sample to facilitate equitable comparisons. The food soybean samples are also grouped using the same geographical categories as in the commodity soybean quality report. In 2020, we received food soybean samples from regions categorized as Western Corn Belt (WCB), Eastern Corn Belt (ECB), and East Coast (EC) (see Table 1 for a complete list of states in these regions). We realize that food soybeans are purchased partly based on relationships with contracting companies rather than on quality trends we note in states or regions. Because food soybean production statistics by state are not available, we cannot weight the regional data by estimated state production as we do in the commodity soybean quality report; therefore, we note that regional quality differences are relative and should be viewed as such.

Average protein values for the food bean samples by growing region (Table 2) indicate that samples received from the WCB region (Iowa, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota) had nearly identical protein as samples from the ECB region (Illinois, Indiana, Michigan, Ohio, and Wisconsin); WCB regional protein average was 36.5 and ECB's was 36.7. Typically, ECB protein levels are higher than WCB, but even the larger survey of commodity soybeans showed ECB and WCB regional protein averages to be very similar. The five samples grown in Maryland and Virginia (East Coast region) had an average protein of 38.3, higher protein than either the ECB or WCB regional averages. When we examined the protein concentration data using both regional and seed size categories to group the data (Table 3), proteins in the WCB and ECB regions remained similar when comparing similarly-sized seed categories. The protein differences in this food soybean survey are not large and the considerable difference in sample size numbers for the two regions (ECB 356, WCB 116) may help explain the results. The variation in protein values (indicated by the range) in WCB and ECB samples were somewhat different, particularly for the average-seeded samples (ECB protein range 11.5 percentage points vs. WCB range of 8.4), but again, the sample numbers differed significantly. In previous food soybean surveys, we found that the small-seeded samples are typically lower in protein than the larger-seeded samples which is beneficial since lower protein concentrations are desirable for making natto.

Overall, oil concentrations in the ECB (18.5) were only slightly higher than those in the WCB (18.2) (Table 2); this is a fairly typical result for soybeans grown in these regions though the difference is often larger. When the data were grouped by seed size category and region (Table 3), the average-seeded WCB samples were virtually identical in oil to the average-seeded ECB samples (WCB 18.4, ECB 18.5), and the large-seeded WCB samples were similar but lower in oil than the ECB large-seeded samples (WCB 18.0 < ECB 18.4), although again the sample numbers within the groups were not well-balanced. Within each of the WCB and ECB regions, oil concentrations were relatively similar between the average- and large-seeded samples, eg, WCB average-seeded samples had oil of 18.4 points and large-seeded had oil 18.0. Within the ECB, the small-seeded samples had the lowest average oil concentration (18.1) relative to the other two seed size categories which were 18.5 and 18.4 for average and large seed size categories, respectively; this trend is evident in the WCB as well.

Results of the 2020 US commodity soybean survey paint a picture of a unique soybean crop. Details regarding the 2020 US commodity crop can be found on page 6, but overall, the US commodity crop will be very large, high in oil, but low in protein. Protein averaged 0.2 percentage points below the 2019 crop, while oil was 0.5 points higher. As with previous years, we see the quality of US food soybeans follow the commodity soybean trends, but the results are often attenuated. Food soybean purchasers should be aware that minimum protein levels will be more difficult to source and oil concentrations may be higher than most food companies are accustomed to.

SOLUBLE SUGARS

Typically, we find that more northerly, cooler WCB region samples have higher sucrose concentrations than samples from the more southerly ECB region; this trend held true in 2020 (Table 4). When we compared sucrose values in similarly-sized samples between those regions, eg, within average- and large-seeded samples, the WCB samples were slightly higher in sucrose compared to the ECB as expected. These results generally comport well with published findings that cooler regions produce soybeans with higher sucrose concentrations (Kumar et al., 2010). Sucrose concentrations in 2020 were lower than those in 2019.

While soybeans with average or large size seeds can be suitable for making natto, soybeans with lower sucrose and higher stachyose concentrations are considered desirable for making natto since they result in a more gradual fermentation process, and high stachyose is generally associated with small soybeans (Wei and Chang, 2004).

AMINO ACIDS

Amino acids are the "building block" organic compounds linked in various combinations to form unique proteins. In humans, dietary proteins are critical for a number of vital functions; these needs are fulfilled by the essential and non-essential amino acids in dietary proteins. Soy in human nutrition is often part of a diet comprised of other protein sources. When soy was studied along with other foods (rice, corn flour, milk solids), its nutritive value was high, close to that of cow's milk and similar to that for high quality animal protein (Young and Scrimshaw, 1979). Additionally, Young and Scrimshaw concluded in their review of studies evaluating the use of soybean in human diets, "When well-processed soy products serve as the major or sole source of the protein intake, their protein value approaches or equals that of foods of animal origin, and they are fully capable of meeting the long term essential amino acid and protein needs of children and adults."

In whole soybeans, lower crude protein soybeans have a higher relative proportion of the five most critical essential amino acids (lysine, cysteine, methionine, threonine, and tryptophan) (Thakur and Hurburgh, 2007; Medic et al., 2014; Naeve unpublished data). We have even detected this relationship in the thousands of commodity and food soybean samples from highly variable US regions, varieties, and management tactics. In a 2018 study (Pfarr et al., 2018), designed to minimize environmental and genetic variation to very precisely characterize changes in relative abundance of critical essential amino acids across a range of soybean concentrations, we found a highly significant negative relationship (R^2 = -0.94) between the concentration of the 5 critical essential amino acids and protein and a similarly strong positive relationship between arginine, glutamic acid and protein (R^2 = 0.93, R^2 = 0.92, respectively). What this means is that critical amino acids (5 EAAs) tend to be diluted at high seed protein concentrations by the non-essential amino acids, arginine and glutamic acid. In a recent study, Ravindran et al. (2014) found crude protein to be a poor predictor of overall feed quality of soybean meal; their finding, in conjunction with the results in Pfarr et al. (2018), strongly argue for direct measurement of amino acid concentrations in addition to measurement of protein alone.

Table 5 contains amino acid data from the 2020 food soybean samples, grouped by seed size and growing region. Typically, lower protein samples have higher concentrations of 5 EAAs, and this is true in 2020. For example, in the WCB region, the lower protein (36.1) average seed size samples have a slightly higher sum of the 5 EAAs (14.3) than do the large-seeded samples (protein 37.2, 5 EAAs 14.2). Similarly, in the ECB, the lower protein (34.6) small samples have the highest 5 EAAs (14.4) compared to the average-seeded samples (protein 36.6, 5 EAAs 14.2). The East Coast samples with the highest average protein of 38.5 have the lowest average 5 EAAs (14.1).

US COMMODITY SOYBEAN SURVEY

Following three years of very stable average protein and oil concentrations in the US crop, the 2020 crop is unique in its composition. Protein set a record low value of 33.9, based on survey data going back 34 years. Average US protein was 0.2 points lower than the previous low of 34.1% (found in 2008, 2017-2019). Conversely, oil was second highest at 19.5, behind the previous record high of 19.8 set in 2015. Compared with 2019, protein decreased by 0.2 points to 33.9% and oil increased by 0.5 to 19.5. Compared with the prior ten-year average, protein decreased by 0.5 points and oil increased by 0.6 points.

While low protein concentrations may dismay some purchasers, overall, this year's unique composition profile is quite positive. Oil concentration increases can help offset losses in protein. This will lead to increased oil yields that will benefit processors. Additionally, increased oil removal from whole soybean concentrates protein in the remaining soybean meal, thus largely mitigating the negative impact of lower seed protein.

Soybean composition is sensitive to the environment in which it is grown. Unfortunately, production environments affect yield and seed composition traits differentially. Various environmental factors such as temperature, water stress, nutrients, and competition impact each of these independently. Timing and strength of these environmental factors plays a large role in their cumulative effects, and yield and seed composition traits have significant trade-offs. This makes prediction of soybean yield and composition based on weather extremely difficult.

It has been observed that delayed planting can increase seed protein concentration although yield decreases. Mourtzinis et al. (2017) and Helms et al. (1998) found seed protein to increase with delayed planting, while oil concentration decreased at the same rate. It is likely that the early planting that occurred in large portions of the US affected protein and oil in the final crop. However, it is quite unlikely that planting date itself could have caused the significant protein-to-oil shift as was noted this year.

Repeatedly, we have noted that geographical areas that receive excessive rainfall at planting time through June often produce slightly lower protein seed. Likewise, areas where drought strikes during August and September also seemed to produce lower protein soybeans. When excessive rainfall early is coupled with drought conditions late in the season, significant reductions in protein content are often noted. These conditions were widespread in 2020 and likely resulted in a large portion of the protein-to-oil shift.

Variation in soybean protein and oil by region was similar to historical trends. The Corn Belt regions had the lowest protein and the Midsouth and Southeast regions had the highest protein. This year, Eastern Corn Belt and the East Coast regions were similar in protein to the Corn Belt regions. Since together the Western and Eastern Corn Belt regions produced more than 81% of the US production in 2020, their average composition values weigh heavily on the US crop as a whole. Average proteins in these regions were 33.7 and 33.9, respectively. The Midsouth, producing about 12% of the US crop, had a significantly higher protein level at 34.6%. Fewer soybeans are produced in the East Coast and Southeast regions; these two regions averaged 33.9 and 34.5% protein, respectively.

Oil concentration in the Corn Belt was relatively high in 2020. The Western Corn Belt produced 19.4% oil, and the Eastern Corn Belt 19.5%. The Midsouth had higher oil concentrations yet at 19.8%. Coupled with higher protein in this region, the sum of protein and oil in the Midsouth was a high 54.4%. Average oil in the Southeast was also 19.8 but was lower in the East Coast region at 19.3%.

Compared with 2019, Eastern Corn Belt states tended to have a greater loss in protein (0.6 points year-over-year) when compared with the Western Corn Belt states (0.1 points lower than 2019). The Midsouth protein increased by 0.1 points, while the Southeast and East Coast regions both decreased by 0.4 points from 2019. In 2020, regional oil improved from 2019 by 0.1 in the Midsouth region, by 0.4 in the East Coast region, and by 0.6 in the Western Corn Belt, Eastern Corn Belt, and Southeast regions.

Numerically, the largest soybean producing states, Iowa and Illinois, produced soybeans with less protein in 2020 compared to 2019, however, the greatest reductions in protein in large production regions were noted in Kansas, Ohio, and Indiana. These states had reductions in protein of 0.7 to 0.9 points. Oil concentrations in Western Corn Belt states increased by 0.1 to 0.9 points. Increases in the Eastern Corn Belt were slightly larger, 0.5 to 1.1.

Average US sucrose levels, at 4.5 in 2020, were lower than those in 2019 at 4.8. Within the US, we have found that soybeans produced in cooler regions have lower protein without offsetting increases in oil, but higher sucrose levels. This year, north to south differences were evident, with the Midsouth region averaging nearly one point lower sucrose than the

Corn Belt regions. Soybeans from North Dakota had very high sucrose at 5.3, 0.8 above the US average. More than a dozen samples from North Dakota had sucrose values 6.0 or higher.

The relative abundance of lysine (expressed as a percent of the 18 primary amino acids) within the soybean protein fraction decreased from 7.1 in 2019 to 6.6 in 2020. This decrease was uniform across regions and there was virtually no variation in this value across states and regions. The sum of the five essential amino acids (5 EAAs, expressed as a percent of the 18 primary amino acids) was quite high in 2019 (15.5) and decreased in 2020 (14.6).

Generally, lower protein levels support increases in the relative abundance of lysine, cysteine, methionine, threonine, and tryptophan. However, 2020 was an exceptional year. Increases in oil concentration in the seed indicates that abundant energy was available to produce high-energy constituents. This alteration in energy to nitrogen availability to the seed (commonly termed the C:N ratio) likely caused the unique amino acid profiles and trade-offs noted in the 2020 crop.

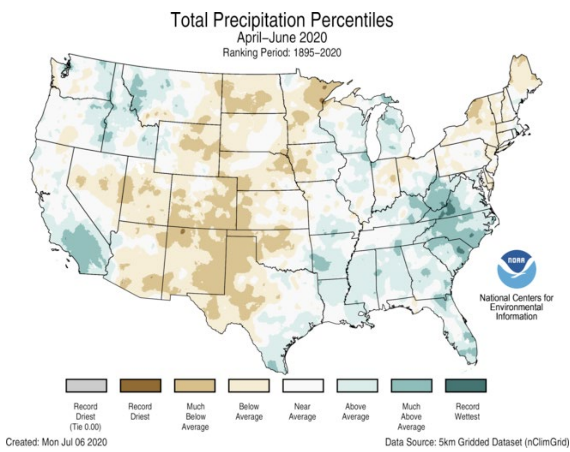
WEATHER AND CROP SUMMARY

Planting: From April to June, soybean-producing states north and west of a line from Oklahoma to Pennsylvania were below average for precipitation, but states south and east of that line were above or much above average for precipitation (Weather Figure 1). This regional split also was evident for temperature (Weather Figure 2). The overall percent of the crop planted in the 18 largest soybean-producing states in mid-May was 15 percentage points higher at 53% than the previous 5-year average of 38%. Farmers in Iowa were able to plant more than two weeks ahead of normal. Farmers in Illinois, Wisconsin, Minnesota, South Dakota, and Nebraska were able to plant more than one week earlier than normal. Heavy spring rains delayed planting in North Dakota and northern Minnesota.

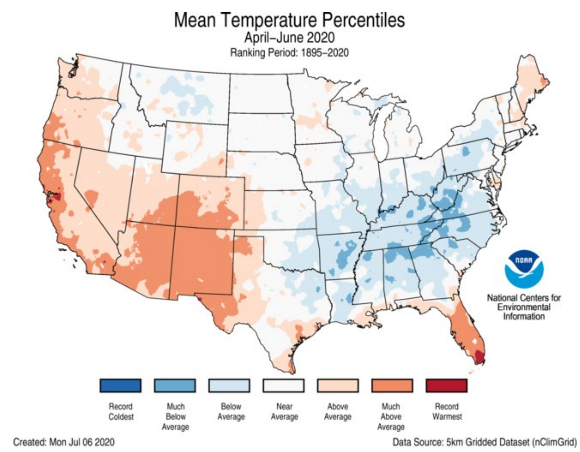
Mid-Season: The weather conditions in August (Weather Figures 3 and 4) were largely reflective of the July-September growing period; many soybean-producing states experienced much below average rainfall as well as average to above average temperatures. A number of growers in major soybean-producing states wrote comments on their sample bags, "hot and dry August and September." Nebraska suffered a record dry August. Crop development in August 2020 was ahead of 2019; in mid-August, soybeans setting pods was 20 percentage points ahead of 2019 and 5 points ahead of the five-year average. An August 10 windstorm, or derecho, damaged soybeans, and even more so corn, in Iowa and surrounding states.

Harvest: September 8-10, there was a hard freeze in the Northern Plains, about a month earlier than normal, and it affected crop development. Overall in October, the Central US, including 9 of the top 10 soybean-producing states, experienced much cooler than normal temperatures (Weather Figure 5), and again, mixed amounts of precipitation, in which states from Oklahoma to Ohio received above average precipitation and states north and west of that line were below average for precipitation (Weather Figure 6). By October 18, the percent of the soybean crop harvested was 75%, 35 percentage points ahead of 2019 and 17 points ahead of the five-year average.

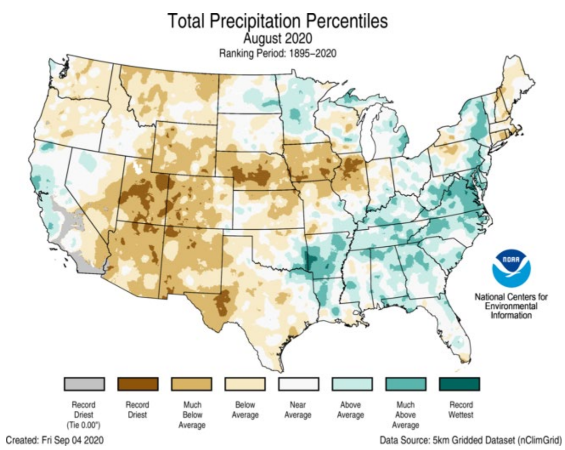
Weather Figure 1



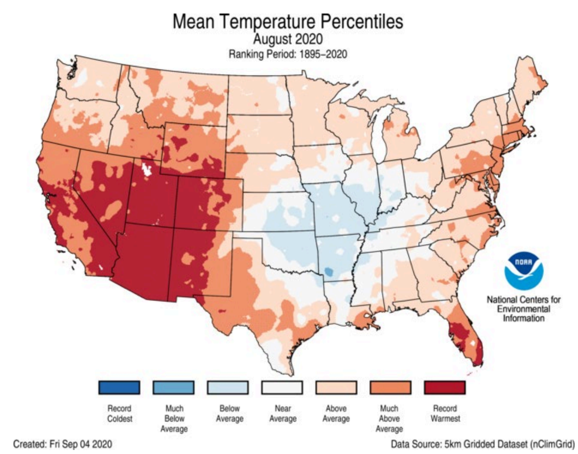
Weather Figure 2



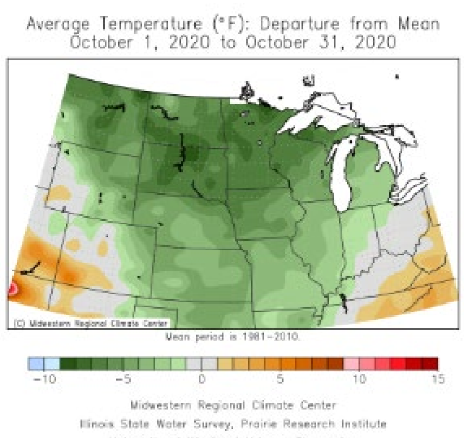
Weather Figure 3



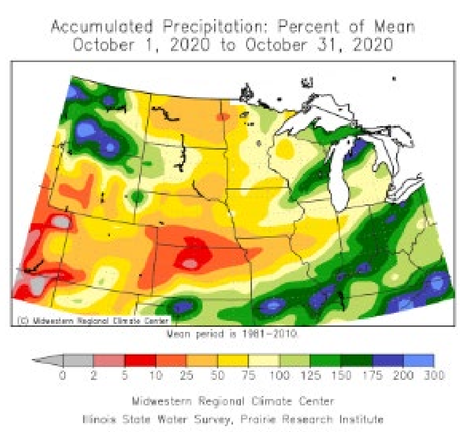
Weather Figure 4



Weather Figure 5



Weather Figure 6



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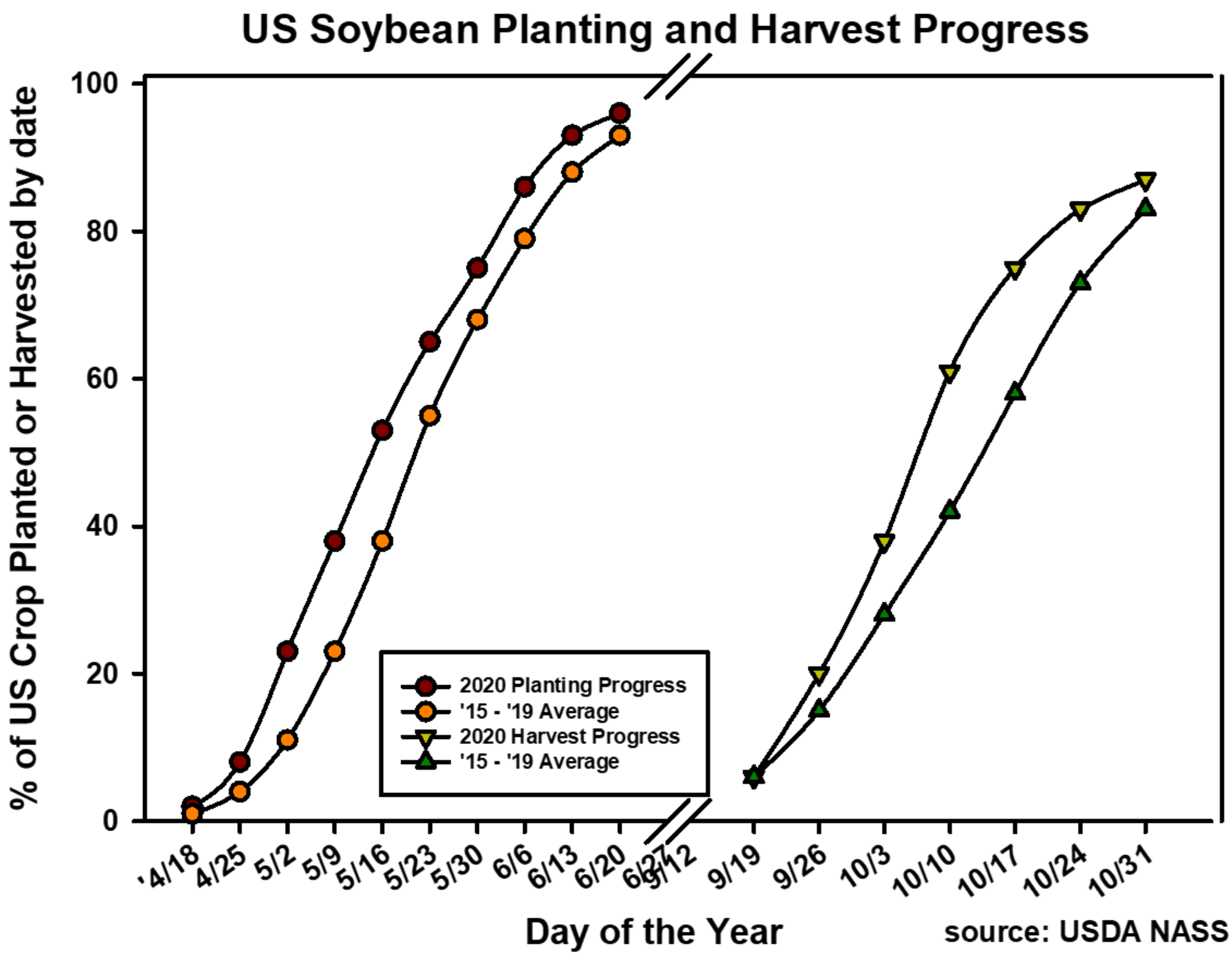
US Soybean Planting and Harvest Progress
% of US Crop Planted or Harvested by date
100
80
60
40
20
0
2020 Planting Progress
'15 - '19 Average
2020 Harvest Progress
'15 - '19 Average
'4/18
4/25
5/2
5/9
5/16
5/23
5/30
6/6
6/13
6/20
6/27
9/12
9/19
9/26
10/3
10/10
10/17
10/24
10/31
Day of the Year
source: USDA NASS

Figure 1

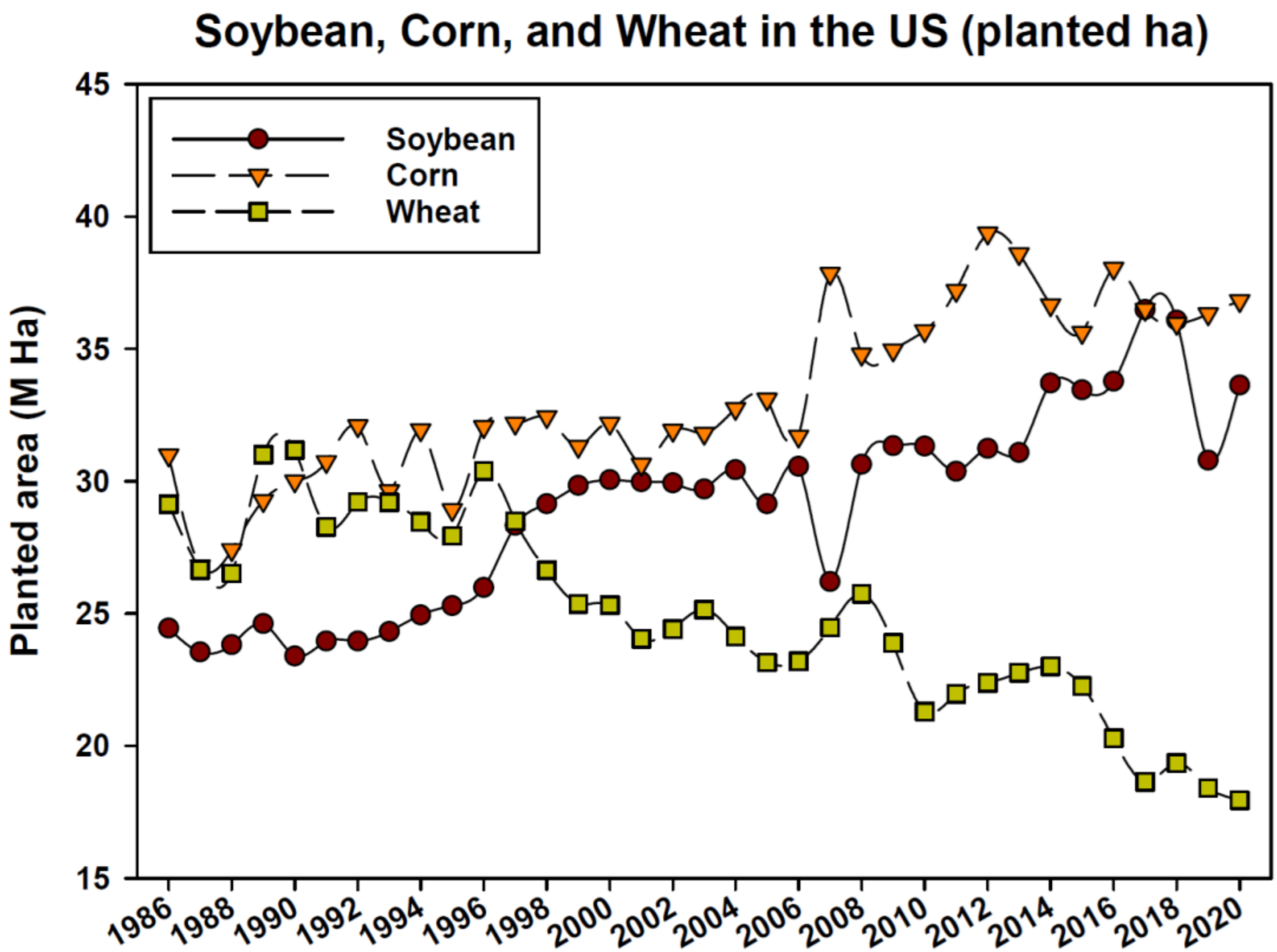

Figure 2 source: USDA NASS

Table 1. Soybean production data for the United States, 2020 crop

Region	State	Yield (MT ha^{-1})	Area Harvested (1000 ha)	Production (MMT)
Western Corn Belt (WCB)	Iowa	3.6	3,775	13.7
	Kansas	2.8	1,924	5.4
	Minnesota	3.4	2,969	10.2
	Missouri	3.3	2,341	7.7
	Nebraska	3.9	2,086	8.1
	North Dakota	2.2	2,309	5.1
	South Dakota	3.2	1,985	6.3
	Western Corn Belt	3.2	17,387	56.6
				48.7%
Eastern Corn Belt (ECB)	Illinois	3.9	4,151	16.2
	Indiana	3.9	2,300	9.0
	Michigan	3.2	887	2.9
	Ohio	3.6	1,976	7.2
	Wisconsin	3.6	802	2.9
	Eastern Corn Belt	3.6	10,117	38.1
				32.7%
Midsouth (MDS)	Arkansas	3.4	1,126	3.8
	Kentucky	3.7	745	2.8
	Louisiana	3.8	413	1.6
	Mississippi	3.6	834	3.0
	Oklahoma	2.0	215	0.4
	Tennessee	3.3	656	2.2
	Texas	2.7	43	0.1
	Midsouth	3.2	4,032	13.9
				11.9%
Southeast (SE)	Alabama	2.6	111	0.3
	Georgia	2.9	38	0.1
	North Carolina	2.6	636	1.7
	South Carolina	2.4	119	0.3
	Southeast	2.6	904	2.4
				2.0%
East Coast (EC)	Delaware	3.2	60	0.2
	Maryland	3.2	196	0.6
	New Jersey	2.6	38	0.1
	New York	3.4	122	0.4
	Pennsylvania	3.3	245	0.8
	Virginia	2.8	227	0.6
	East Coast	3.1	887	2.8
				2.4%
US 2020		3.5	33,327	116.3
US 2019		3.2	30,350	96.8

Source: United States Department of Agriculture, NASS 2020 Crop Production Report (November 2020)

Table 2. Corrected USB 2020 Food Soybean Quality Survey Protein and Oil Data by State and Region§

State (# of samples)	Region	Protein * (%)	Protein Range	Regional Protein Average	Oil * (%)	Oil Range	Regional Oil Average
Iowa (34)	WCB	36.56	31.57 – 39.38		18.29	16.81 – 19.66	
Minnesota (55)	WCB	36.72	32.90 – 39.95		18.17	15.21 – 21.24	
Missouri (7)	WCB	35.73	33.19 - 37.51		19.09	18.33 - 20.68	
North Dakota (13)	WCB	34.74	32.66 - 37.96		17.91	14.52 - 21.54	
Nebraska (5)	WCB	37.28	35.16 – 38.41		18.12	17.58 – 18.70	
South Dakota (2)	WCB	38.41	38.07 - 38.75	36.45	17.88	17.80 - 17.95	18.22
Illinois (119)	ECB	36.27	32.18 – 40.10		18.67	16.17 – 23.31	
Indiana (29)	ECB	38.13	35.22 - 41.29		17.94	16.22 - 19.77	
Michigan (31)	ECB	36.58	33.19 – 39.06		18.29	16.48 – 19.92	
Ohio (61)	ECB	38.13	33.84 – 43.68		17.98	14.48 – 20.49	
Wisconsin (116)	ECB	36.05	32.57 – 39.54	36.69	18.69	16.56 – 21.50	18.47
Maryland (1)	EC	37.68			18.79		
Virginia (4)	EC	38.51	36.82 – 39.84	38.34	17.21	15.40 – 18.84	17.53

Data as of May 10, 2021

§ WCB: Western Corn Belt; ECB: Eastern Corn Belt; EC: East Coast (see Table 1 for a complete list of states included in these regions)

* 13% moisture basis

Table 3. Corrected USB 2020 Food Soybean Quality Survey Protein and Oil by Seed Size‡ & Region§

Region	Seed Size	Number Samples	Seed Size (g/100 seeds)	Protein* (%)	Protein Range	Oil* (%)	Oil Range
WCB	Small	3	8.6	35.22	34.95 - 35.36	16.67	14.52 - 17.80
	Average	72	17.8	36.06	31.57 - 39.95	18.39	16.24 - 21.54
	Large	41	23.4	37.21	33.58 - 38.91	18.04	15.21 - 19.93
ECB	Small	4	8.8	34.60	33.65 - 36.81	18.05	16.48 - 18.93
	Average	277	18.2	36.60	32.18 – 43.68	18.50	14.48 – 23.31
	Large	75	23.0	37.17	33.19 – 40.43	18.38	16.17 – 21.35
EC	Average	1	20.0	37.68		18.79	
	Large	4	26.7	38.51	36.82 - 39.84	17.21	15.40 - 18.84

Data as of May 10, 2021

‡ Small seed: ≤13.0 g/100 seeds; Average: 13.1-21.0 g/100 seeds; Large: >21 g/100 seeds (unofficial categories)

§ WCB: Western Corn Belt (Iowa, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota); ECB: Eastern Corn Belt (Illinois, Indiana, Michigan, Ohio, and Wisconsin); EC: East Coast (Maryland and Virginia)

* 13% moisture basis

Table 4. Corrected USB 2020 Food Soybean Quality Survey Carbohydrate Data by Seed Size‡ & Region§

Region	Seed Size	Number Samples	Seed Size (g/100 seeds)	Sucrose (% DM basis)	Raffinose (% DM basis)	Stachyose (% DM basis)
WCB	Small	3	8.6	4.80	1.12	3.98
	Average	72	17.8	4.21	1.19	3.79
	Large	41	23.4	4.28	1.22	3.82
ECB	Small	4	8.8	4.68	1.11	3.82
	Average	277	18.2	3.90	1.14	3.93
	Large	75	23.0	4.11	1.14	3.86
EC	Average	1	20.0	3.74	1.23	4.04
	Large	4	26.7	4.53	1.51	3.37

Data as of May 10, 2021

‡ Small seed: ≤13.0 g/100 seeds; Average: 13.1-21.0 g/100 seeds; Large: >21 g/100 seeds (unofficial categories)

§ WCB: Western Corn Belt (Iowa, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota); ECB: Eastern Corn Belt (Illinois, Indiana, Michigan, Ohio, and Wisconsin); EC: East Coast (Maryland and Virginia)

Table 5. Corrected USB 2020 Food Soybean Quality Survey Amino Acid (AA) Data by Seed Size‡ & Region§

Region	Seed Size	Number Samples	Seed Size (g/100 seeds)	Protein* (%)	Lysine (% of 18 AAs)	Five Limiting Essential¶ Amino Acids (% of 18 AAs)
WCB	Small	3	8.6	35.22	6.6	14.3
	Average	72	17.8	36.06	6.5	14.3
	Large	41	23.4	37.21	6.5	14.2
ECB	Small	4	8.8	34.60	6.6	14.4
	Average	277	18.2	36.60	6.5	14.2
	Large	75	23.0	37.17	6.5	14.3
EC	Average	1	20.0	37.68	6.5	14.2
	Large	4	26.7	38.51	6.4	14.1

Data as of May 10, 2021

‡ Small seed: ≤13.0 g/100 seeds; Average: 13.1-21.0 g/100 seeds; Large: >21 g/100 seeds (unofficial categories)

§ WCB: Western Corn Belt (Iowa, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota); ECB: Eastern Corn Belt (Illinois, Indiana, Michigan, Ohio, and Wisconsin); EC: East Coast (Maryland and Virginia)

* 13% moisture basis

¶ Five limiting essential amino acids: cysteine, lysine, methionine, threonine, and tryptophan

CORRECTED FOOD QUALITY REPORT: 2020

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