UNITED STATES SOYBEAN QUALITY

Annual Report 2020

Corrected May 2021

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CORRECTED 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 soybean crop since 1986. This survey is intended to provide new crop quality data to aid international customers with their purchasing decisions.

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.

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QUALITY OF THE 2020 US SOYBEAN CROP

Sample kits were mailed to 5,800 producers that were selected based on total land devoted to soybean production, so that response distribution would closely match that of soybean production at a fine geographical resolution. By 7 December, 2020, 1,586 samples were received. This corrected report will serve as a final report for the 2020 US soybean crop.

Samples were 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. A subset of samples was sent to two laboratories for assessment by AOCS-approved analytical chemical methods in order to validate NIR quality constituent predictions. *[Note: A mistake during routine maintenance after these validations led to erroneous predictions and required this corrected report.]* Regional and national average quality values were determined by computing weighted averages using state and regional soybean production estimates, so that average values best represent the crop as a whole. Results are in Tables 2 through 5.

PROTEIN AND OIL

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 (Table 5). 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 (Table 2).

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.

SEED WEIGHT, TEST WEIGHT, AND FOREIGN MATERIAL

Seed weight in soybean is important for some food uses but tends to impact value relatively little for conventional processing. However, seed weight does help paint a picture of the production environment and potential yield-limiting phases in crop growth. Seed weight is an indicator of the relative differences in growing environment in midsummer vs. late summer. Under favorable early- and mid-season conditions, soybeans set large numbers of seeds per plant. If late-season conditions deteriorate, the plant cannot fully fill the extra seeds resulting in lower seed weight. Alternatively, if conditions improve from mid-season to the seed-filling period in the late summer, the resulting seed weight will be higher.

Average seed weights decreased from 16.9 in 2019 to 16.0 g per 100 seed in 2020 (Table 3). Kansas tended to produce small soybeans in 2020; however, the northern states of Minnesota, Wisconsin, Michigan, and Ohio produced much above average sized seeds.

Test weight (TW) is a measure of density of grains. It is an important quality factor in cereal grains, but it affects soybean quality little and is not a good indicator of value to the processor. We report it here as it is often measured and reported with little context, which can lead to confusion. Average TW increased from 56.8 pounds per bushel in 2019 to 57.1 in 2020 (Table 3). This follows a 0.7 pound increase from 2018 to 2019. Test weight did not increase uniformly across regions; it increased by about 0.3 in the Western and Eastern Corn Belt regions, stayed the same as in 2019 in the Midsouth, and decreased by 0.2 and 0.6 in the East Coast and Southeast regions, respectively. Again in 2020, TW tended to be higher in more northern environments.

Foreign material (FM) in soybeans sampled at the farm level continues to be very low in the US. Average FM level in US soy was 0.2% in 2020 (Table 3), similar to the long-term trend. Of 1,586 samples, only 15 had FM levels of greater than 2% and 32 had FM levels between 1-2%. Contamination with FM was less than 1% in 97% of samples.

SUCROSE

Soybean meal provides not only protein for animal feed, but it also adds to a ration's energy (Stein et al., 2008). Sucrose in soybean and soybean meal contributes to total Metabolizable Energy (ME) in livestock feed. Although soybean meal is an important contributor to a ration's total ME, nutritionists often use 'book values' for energy from soybean meal across origins. Our work highlights the potential variation in ME in soybean meal based on varying sucrose levels in soybeans. This variation tends to have a strong geographical basis to it. We have found that soybeans from the US have higher sucrose than soybeans from Brazil (Naeve, unpublished data), which is desirable since sucrose is positive for ME. In studies of soybean meal quality by origin, the apparent ME in US soybean meal was significantly higher than that in meal from Argentina and Brazil, and the higher sugar level in US soybean meal is likely a primary driver of differences in metabolizable energy (Ravindran et al., 2014).

Average US sucrose levels, at 4.5 in 2020 (Table 3), 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.

AMINO ACIDS

Amino acids are the "building block" organic compounds linked in various combinations to form unique proteins. Optimal animal performance occurs when the feed protein contains an ideal amount and proportion of all essential amino acids (those amino acids which cannot be produced by animals).

CORRECTED QUALITY REPORT: 2020

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), indicating that meal made from those soybeans will likely be of higher feed quality for a given feed ration than meal made from higher crude protein soybeans (Thakur and Hurburgh, 2007; Medic et al., 2014; Naeve, unpublished data). We have even detected this relationship in the thousands of samples from highly variable US regions, varieties, and management tactics.

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 (Table 4). 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.

CORRELATIONS

Understanding how soybean compositional factors are related to one another can help us understand not only the trade-offs between attributes, but it can also lead to a better understanding of the fundamental biology behind these factors. The relatedness of two factors can be measured by the Pearson correlation coefficient expressed as a number between +1 and -1, where 1 is a perfect positive linear correlation, 0 is no linear correlation, and −1 is a perfect negative linear correlation. Correlations do not demonstrate causation. Correlations between factors can be found in the correlation matrix on page 9.

Because most of the attributes that we describe here are expressed as a percent of the seed basis, trade-offs between factors naturally result in negative regressions. In 2020, protein and oil were negatively correlated (r = -0.5). This indicates that the typical trend is to see a trade-off between these important constituents, but because this is not a perfect correlation, it is possible to produce soybeans that have both high protein and oil or that are low in both.

Historically, we have noted that the 5 EAAs value is negatively correlated with protein. This has also been supported by experimental research (Pfarr et al., 2018) where lower protein soybeans produce protein that is enriched in these five essential amino acids. There is clearly a trade-off between protein quantity and quality. In 2019, protein was negatively correlated with 5 EAAs (r = -0.8) and lysine abundance (r = -0.8), but as noted, 2020 was a unique year. Expression of high oil in the soybean seed required unique environmental conditions. It is clear that this also affected the trade-offs between protein quantity and quantity (relative abundance of lysine and 5 EAAs). In 2020, protein was correlated with 5 EAAs at r = -0.5, and lysine at r = -0.6. Our work described in Pfarr et al. (2018) describes how environmental conditions that affect oil deposition directly, rather than protein, affect amino acid deposition differentially. We speculate that soybean composition was driven by oil deposition to a larger extent in 2020 than normal. Lower protein this year may be due in part to indirect effects of higher oil rather than solely on direct effects on protein deposition itself.

Likewise, sucrose is part of the residual fraction in soybean and therefore tends to be negatively correlated with both protein and oil. Soybeans that are lower in both protein and oil tend to have higher sucrose levels. In 2020, sucrose was only loosely negatively correlated with protein and with oil (r = -0.4 and -0.3, respectively). Test weight is not highly correlated with any measured compositional factor or seed weight. In both 2019 and 2020, it was moderately negatively correlated with oil and positively correlated with sucrose.

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Correlation Matrix

	Protein (13%)	Oil (13%)	Protein + Oil (13%)	Sucrose (db)	Lysine (% 18AA)	5 EAAs (% 18AA)	TW (lb/bu)	FM (%)
Protein (13%)	1	-0.50	0.74	-0.36	-0.59	-0.52	-0.06	0.04
Oil (13%)		1	0.21	-0.33	0.13	0.32	-0.29	0.03
Protein + Oil (13%)			1	-0.66	-0.57	-0.34	-0.29	0.07
Sucrose (db)				1	0.51	0.31	0.35	-0.11
Lysine (% 18AA)					1	0.71	0.16	-0.02
5 EAAs (% 18AA)						1	0.05	0.03
TW (lb/bu)							1	-0.29
FM (%)								1

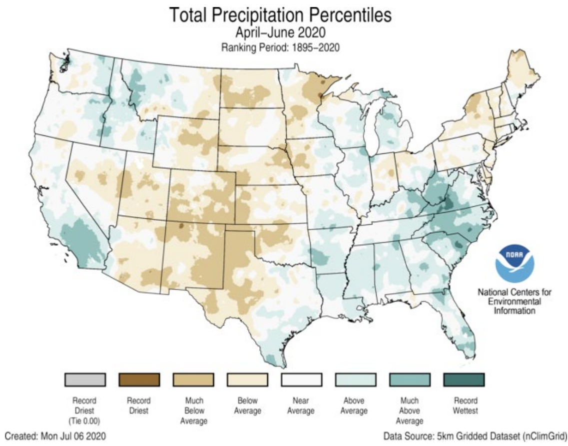
WEATHER AND CROP SUMMARY

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.

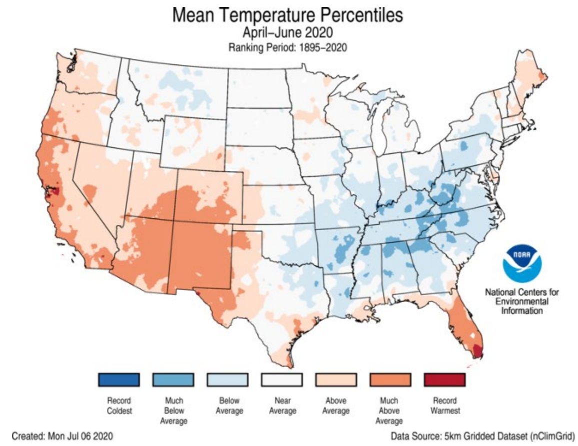
Mid-Season: The weather conditions in August (Weather Figures 3 and 4) were largely reflective of the July-September growing period; many soybean-producing states experienced much below average rainfall as well as average to above average temperatures. A number of growers in major soybean-producing states 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.

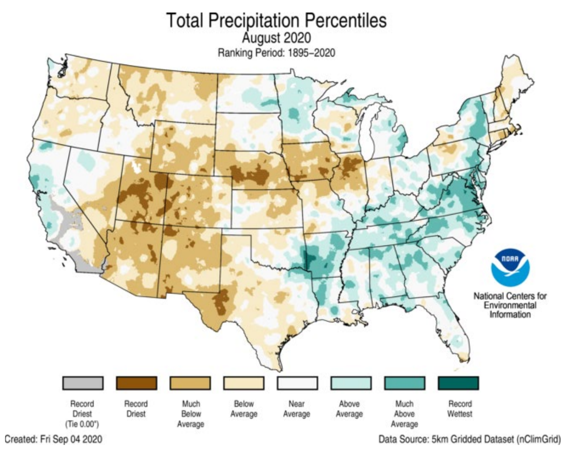
Weather Figure 1



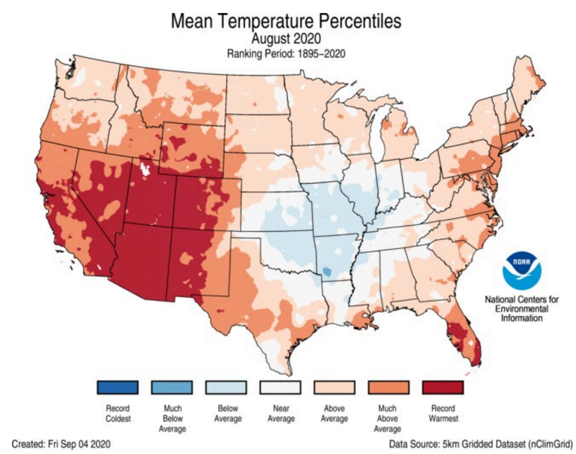
Weather Figure 2



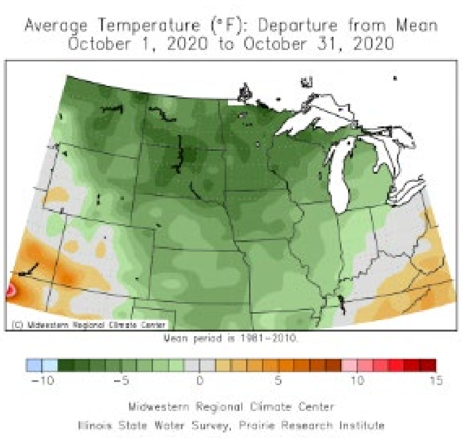
Weather Figure 3



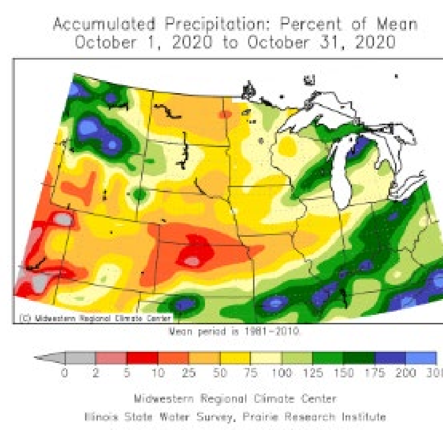
Weather Figure 4



Weather Figure 5



Weather Figure 6



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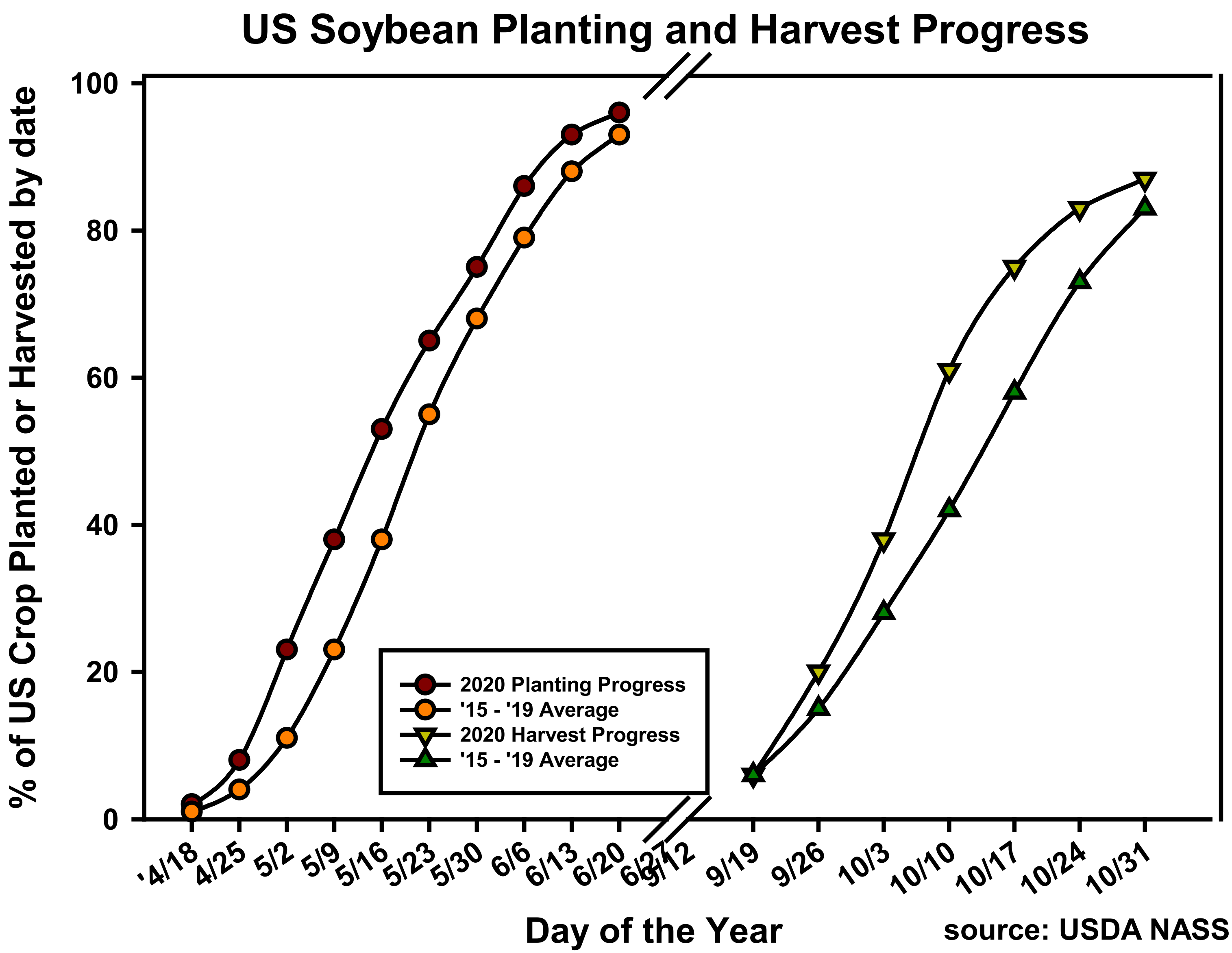

US Soybean Planting and Harvest Progress
% of US Crop Planted or Harvested by date
0
20
40
60
80
100
'4/18
4/25
5/2
5/9
5/16
5/23
5/30
6/6
6/13
6/20
6/27
9/12
9/19
9/26
10/3
10/10
10/17
10/24
10/31
Day of the Year
source: USDA NASS
2020 Planting Progress
'15 - '19 Average
2020 Harvest Progress
'15 -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

Figure 1

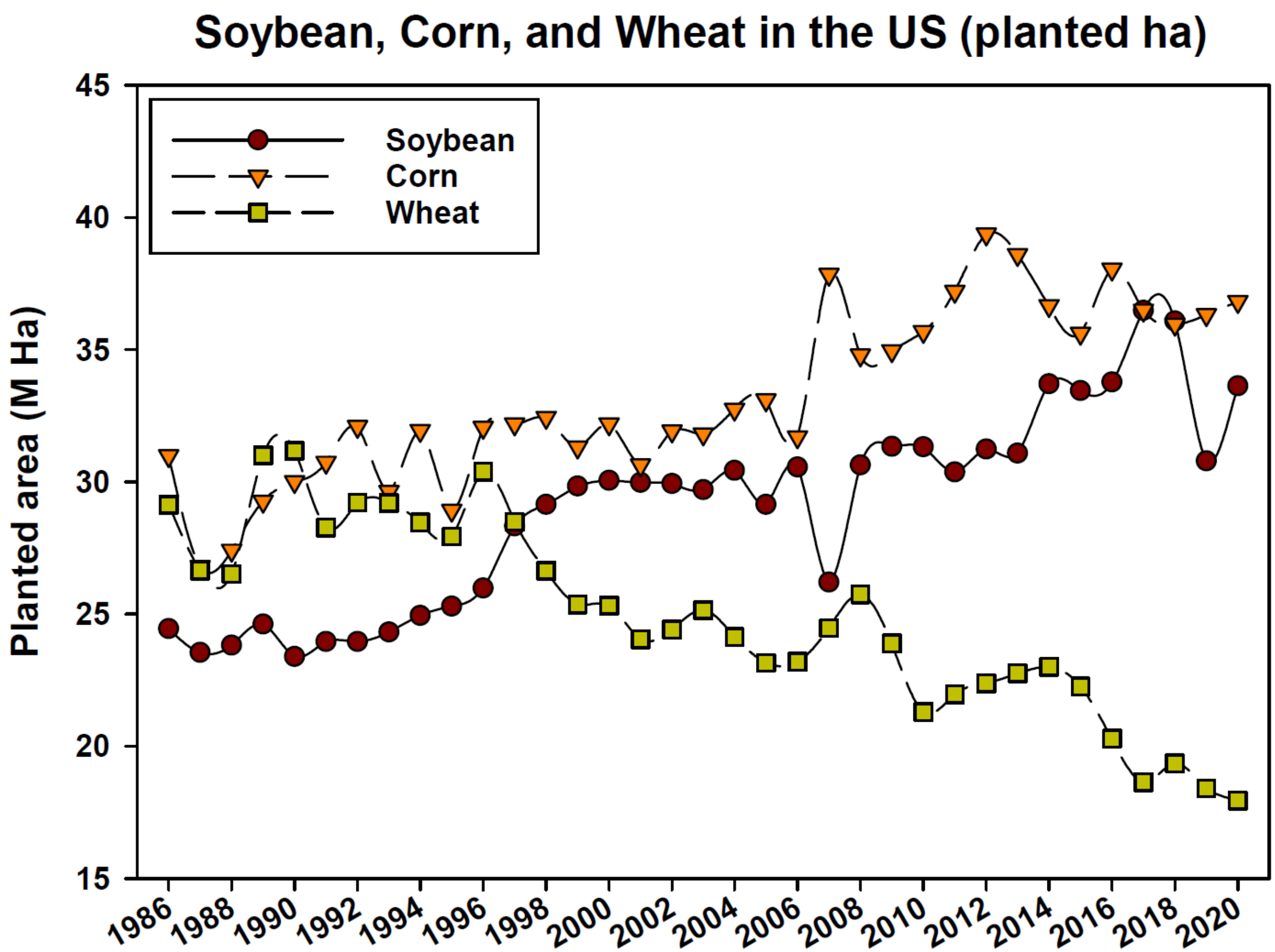

Figure 2 source: USDA NASS

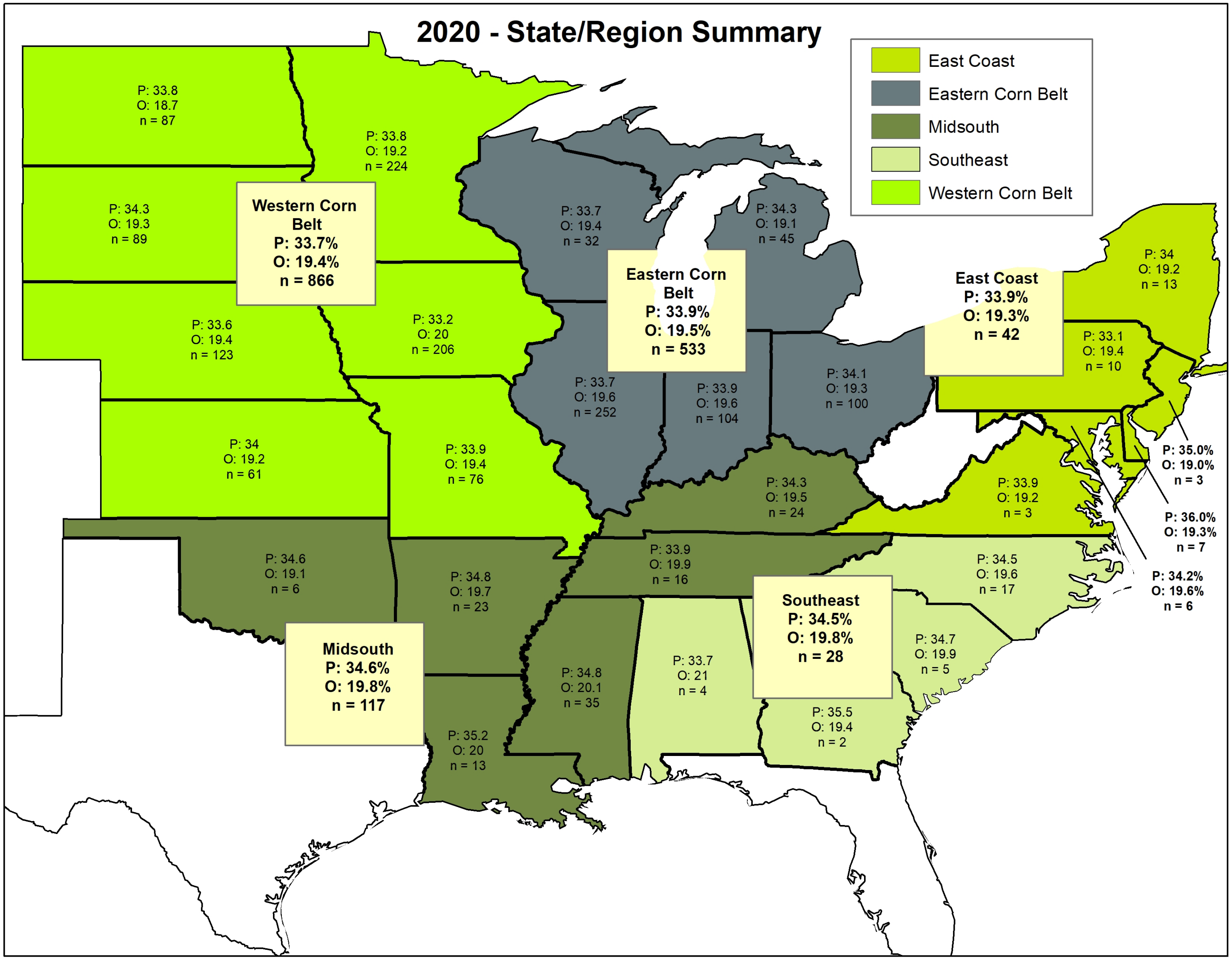
2020 - State/Region Summary
East Coast
Eastern Corn Belt
Midsouth
Southeast
Western Corn Belt
P: 33.8
O: 18.7
n = 87
P: 33.8
O: 19.2
n = 224
P: 34.3
O: 19.3
n = 89
Western Corn Belt
P: 33.7%
O: 19.4%
n = 866
P: 33.6
O: 19.4
n = 123
P: 33.2
O: 20
n = 206
P: 34
O: 19.2
n = 61
P: 33.9
O: 19.4
n = 76
P: 33.7
O: 19.4
n = 32
P: 34.3
O: 19.1
n = 45
Eastern Corn Belt
P: 33.9%
O: 19.5%
n = 533
P: 33.7
O: 19.6
n = 252
P: 33.9
O: 19.6
n = 104
P: 34.1
O: 19.3
n = 100
East Coast
P: 33.9%
O: 19.3%
n = 42
P: 34
O: 19.2
n = 13
P: 33.1
O: 19.4
n = 10
P: 35.0%
O: 19.0%
n = 3
P: 36.0%
O: 19.3%
n = 7
P: 34.2%
O: 19.6%
n = 6
P: 33.9
O: 19.2
n = 3
P: 34.3
O: 19.5
n = 24
P: 33.9
O: 19.9
n = 16
P: 34.6
O: 19.1
n = 6
P: 34.8
O: 19.7
n = 23
Midsouth
P: 34.6%
O: 19.8%
n = 117
P: 34.8
O: 20.1
n = 35
P: 35.2
O: 20
n = 13
P: 33.7
O: 21
n = 4
Southeast
P: 34.5%
O: 19.8%
n = 28
P: 34.5
O: 19.6
n = 17
P: 34.7
O: 19.9
n = 5
P: 35.5
O: 19.4
n = 2

Figure 3

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 Soybean Quality Survey Data

Region	State	Number of Samples	Protein (%)*	Std. Dev.	Oil (%)*	Std. Dev.
Western Corn Belt (WCB)	Iowa	206	33.2	1.1	20.0	0.7
	Kansas	61	34.0	1.3	19.2	0.9
	Minnesota	224	33.8	0.9	19.2	0.6
	Missouri	76	33.9	1.0	19.4	0.7
	Nebraska	123	33.6	1.1	19.4	0.7
	North Dakota	87	33.8	1.0	18.7	0.6
	South Dakota	89	34.3	1.0	19.3	0.8
Averages†	Western Corn Belt	866	33.7	1.0	19.4	0.7
Eastern Corn Belt (ECB)	Illinois	252	33.7	1.0	19.6	0.7
	Indiana	104	33.9	1.1	19.6	0.6
	Michigan	45	34.3	1.0	19.1	0.6
	Ohio	100	34.1	1.1	19.3	0.8
	Wisconsin	32	33.7	1.0	19.4	0.6
Averages†	Eastern Corn Belt	533	33.9	1.0	19.5	0.7
Midsouth (MDS)	Arkansas	23	34.8	1.5	19.7	0.7
	Kentucky	24	34.3	1.0	19.5	0.5
	Louisiana	13	35.2	1.1	20.0	0.6
	Mississippi	35	34.8	1.0	20.1	0.6
	Oklahoma	6	34.6	1.7	19.1	1.0
	Tennessee	16	33.9	0.9	19.9	0.7
	Texas	0				
Averages†	Midsouth	117	34.6	1.2	19.8	0.6
Southeast (SE)	Alabama	4	33.7	0.6	21.0	0.4
	Georgia	2	35.5	1.4	19.4	0.6
	North Carolina	17	34.5	1.6	19.6	0.8
	South Carolina	5	34.7	1.0	19.9	0.6
Averages†	Southeast	28	34.5	1.4	19.8	0.7
East Coast (EC)	Delaware	7	36.0	1.5	19.3	0.5
	Maryland	6	34.2	0.7	19.6	0.8
	New Jersey	3	35.0	0.6	19.0	0.2
	New York	13	34.0	0.7	19.2	0.8
	Pennsylvania	10	33.1	1.2	19.4	0.9
	Virginia	3	33.9	0.3	19.2	0.4
Averages†	East Coast	42	33.9	0.8	19.3	0.7
US	Averages	1,586	33.9		19.5	
	Average of 2020 Crop†		**33.9**	**1.1**	**19.5**	**0.7**
	US 2010-2019 avg.†		34.4	1.3	18.9	0.9

* 13% moisture basis

† Regional, US, and 10-year average values weighted based on estimated production by state as estimated by USDA, NASS Crop Production Report (November 2020)

Table 3. Corrected USB 2020 Soybean Quality Survey Seed Data

Region	State	Number of Samples	Seed Weight (g 100 seeds^{-1})	Test Weight (lb bu^{-1})	Foreign Material (%)	Sucrose (db)
Western Corn Belt (WCB)	Iowa	206	15.5	57.1	0.2	4.5
	Kansas	61	14.8	57.5	0.3	4.6
	Minnesota	224	17.0	57.5	0.2	4.8
	Missouri	76	15.9	56.8	0.2	4.5
	Nebraska	123	15.4	56.9	0.3	4.7
	North Dakota	87	15.1	58.3	0.3	5.3
	South Dakota	89	15.1	57.6	0.2	4.6
Averages†	Western Corn Belt	866	15.6	57.4	0.2	4.7
Eastern Corn Belt (ECB)	Illinois	252	16.3	57.0	0.2	4.5
	Indiana	104	16.2	57.1	0.2	4.5
	Michigan	45	17.1	57.7	0.2	4.8
	Ohio	100	17.3	57.6	0.1	4.6
	Wisconsin	32	17.0	57.1	0.2	4.7
Averages†	Eastern Corn Belt	533	16.6	57.2	0.2	4.6
Midsouth (MDS)	Arkansas	23	15.7	56.0	0.3	3.8
	Kentucky	24	16.4	56.3	0.2	4.3
	Louisiana	13	15.6	55.1	1.0	3.3
	Mississippi	35	16.6	54.8	0.5	3.4
	Oklahoma	6	15.0	56.6	0.4	4.0
	Tennessee	16	15.9	55.8	0.2	4.1
	Texas	0				
Averages†	Midsouth	117	16.0	55.7	0.4	3.8
Southeast (SE)	Alabama	4	15.3	54.5	0.1	3.7
	Georgia	2	17.2	57.3	0.2	4.2
	North Carolina	17	15.2	56.2	0.2	4.0
	South Carolina	5	16.1	56.4	0.2	4.2
Averages†	Southeast	28	15.4	56.1	0.2	4.0
East Coast (EC)	Delaware	7	16.6	56.1	0.1	3.4
	Maryland	6	16.9	55.3	0.4	4.2
	New Jersey	3	15.5	57.3	0.5	4.3
	New York	13	18.0	57.4	0.1	4.9
	Pennsylvania	10	16.1	57.9	0.1	4.9
	Virginia	3	16.5	56.6	0.3	4.1
Averages†	East Coast	42	16.6	56.8	0.2	4.4
USA	Averages	1,586	16.1	57.1	0.2	4.6
	Average of 2020 Crop†		**16.0**	**57.1**	**0.2**	**4.5**

† Regional and US average values w eighted based on estimated production by state as estimated by USDA, NASS Crop Production Report (November 2020)

Table 4. Corrected USB 2020 Soybean Quality Survey Amino Acid (AA) Data

Region	State	Number of Samples	Protein (%)*	Lysine (%18 AAs)	5 EAAs‡ (%18 AAs)	7 EAAs§ (%18 AAs)
Western Corn Belt (WCB)	Iowa	206	33.2	6.7	14.7	24.8
	Kansas	61	34.0	6.6	14.6	24.6
	Minnesota	224	33.8	6.7	14.6	24.7
	Missouri	76	33.9	6.6	14.5	24.6
	Nebraska	123	33.6	6.7	14.6	24.7
	North Dakota	87	33.8	6.7	14.7	24.7
	South Dakota	89	34.3	6.7	14.6	24.7
Averages†	Western Corn Belt	866	33.7	6.7	14.6	24.7
Eastern Corn Belt (ECB)	Illinois	252	33.7	6.6	14.6	24.7
	Indiana	104	33.9	6.6	14.6	24.6
	Michigan	45	34.3	6.6	14.5	24.6
	Ohio	100	34.1	6.6	14.5	24.6
	Wisconsin	32	33.7	6.7	14.6	24.7
Averages†	Eastern Corn Belt	533	33.9	6.6	14.6	24.6
Midsouth (MDS)	Arkansas	23	34.8	6.6	14.5	24.5
	Kentucky	24	34.3	6.6	14.5	24.5
	Louisiana	13	35.2	6.6	14.6	24.6
	Mississippi	35	34.8	6.6	14.5	24.6
	Oklahoma	6	34.6	6.6	14.5	24.6
	Tennessee	16	33.9	6.6	14.5	24.6
	Texas	0				
Averages†	Midsouth	117	34.6	6.6	14.5	24.6
Southeast (SE)	Alabama	4	33.7	6.6	14.5	24.6
	Georgia	2	35.5	6.6	14.3	24.4
	North Carolina	17	34.5	6.6	14.4	24.5
	South Carolina	5	34.7	6.6	14.4	24.5
Averages†	Southeast	28	34.5	6.6	14.4	24.5
East Coast (EC)	Delaware	7	36.0	6.5	14.2	24.2
	Maryland	6	34.2	6.6	14.3	24.4
	New Jersey	3	35.0	6.6	14.4	24.4
	New York	13	34.0	6.6	14.6	24.7
	Pennsylvania	10	33.1	6.7	14.6	24.6
	Virginia	3	33.9	6.6	14.3	24.5
Averages†	East Coast	42	33.9	6.6	14.4	24.5
US	Averages	1,586	33.9	6.6	14.6	24.7
	Average of 2020 Crop†		**33.9**	**6.6**	**14.6**	**24.7**

* 13% moisture basis

‡ Five essential amino acids (also known as CAAV): cysteine, lysine, methionine, threonine, and tryptophan

§ Seven essential amino acids: five listed above and isoleucine, valine

† Regional and US average values weighted based on estimated production by state as estimated by USDA, NASS Crop Production Report (November 2020)

Table 5. Corrected Historical Summary of Yield and Quality Data for U.S. Soybeans

Year	Yield ($kg\ ha^{-1}$)	Protein* (%)	Oil* (%)	Sum† (%)	Harvested ($M\ ha^{-1}$)	Production (MMT)	Protein Std. Dev.	Oil Std. Dev.
1986	2241	35.8	18.5	54.3	23.6	52.9	1.4	0.7
1987	2281	35.5	19.1	54.6	23.2	52.8	1.6	0.7
1988	1817	35.1	19.3	54.4	23.2	42.2	1.5	0.8
1989	2173	35.2	18.7	53.9	24.1	52.4	1.5	0.8
1990	2295	35.4	19.2	54.6	22.9	52.5	1.2	0.7
1991	2301	35.5	18.7	54.1	23.5	54.0	1.4	0.9
1992	2530	35.6	17.3	52.8	23.6	59.6	1.4	1.0
1993	2194	35.7	18.0	53.8	23.2	50.9	1.2	0.9
1994	2786	35.4	18.2	53.6	24.6	68.6	1.4	0.9
1995	2375	35.5	18.2	53.6	24.9	59.2	1.4	0.9
1996	2530	35.6	17.9	53.5	25.7	64.9	1.3	0.9
1997	2618	34.6	18.5	53.0	28.0	73.2	1.5	1.0
1998	2618	36.1	19.1	55.3	28.5	74.6	1.5	0.8
1999	2456	34.6	18.6	53.2	29.4	72.1	1.9	1.1
2000	2557	36.2	18.7	54.9	29.6	75.6	1.7	0.9
2001	2651	35.0	19.0	54.0	30.0	79.6	2.0	1.1
2002	2490	35.4	19.4	54.8	29.1	72.2	1.6	0.9
2003	2288	35.7	18.7	54.3	29.4	67.2	1.7	1.2
2004	2826	35.1	18.6	53.7	30.0	84.6	1.5	0.9
2005	2893	34.9	19.4	54.3	29.2	83.4	1.5	0.9
2006‡	2873	34.5	19.2	53.7	30.2	86.8	1.6	1.0
2007‡	2806	35.2	18.6	53.9	26.0	72.9	1.2	0.8
2008‡	2644	34.1	19.1	53.2	30.1	79.6	1.4	0.8
2009‡	2961	35.3	18.6	53.9	30.9	91.5	1.2	0.9
2010‡	2954	35.0	18.6	53.6	31.1	91.9	1.4	1.2
2011‡	2793	34.9	18.1	53.0	29.8	83.4	2.2	1.8
2012‡	2678	34.3	18.5	52.8	30.8	82.6	1.6	0.9
2013‡	2961	34.7	19.0	53.7	30.9	91.5	1.1	1.0
2014‡	3196	34.4	18.6	53.0	33.8	107.8	1.3	0.9
2015‡	3176	34.3	19.8	54.1	33.1	105.9	1.1	0.8
2016‡	3459	34.5	19.3	53.8	33.6	116.3	1.2	0.7
2017‡	3331	34.1	19.1	53.2	36.2	120.5	1.2	0.9
2018‡	3573	34.1	19.0	53.1	35.8	127.7	1.1	0.7
2019‡	3156	34.1	19.0	53.1	30.6	96.7	1.1	0.6
2020‡	3412	33.9	19.5	53.4	33.3	113.6	1.1	0.7
Averages (2010-2019)	**3128**	**34.4**	**18.9**	**53.3**	**32.6**	**102.4**	**1.3**	**0.9**
Averages (1986-2019)	**2691**	**35.0**	**18.7**	**53.8**	**28.5**	**77.9**	**1.4**	**0.9**

Sources: US Dept. of Agriculture, Iowa State University, and University of Minnesota

*Protein and oil concentrations expressed on a 13% moisture basis

†Sum represents sum of protein and oil concentrations

‡2006 - 2020 quality estimates are weighted by yearly production estimates by state

CORRECTED QUALITY REPORT: 2020

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