UNITED STATES SOYBEAN QUALITY

Annual Report 2022

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QUALITY REPORT: 2022

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.

2022 AREA, YIELDS, AND TOTAL PRODUCTION

Spring planting was greatly delayed across much of the US in 2022. Nearly every state saw delays in plantings intended for late April and early May. Significant soybean-producing states Ohio, Missouri, and Arkansas did not see active planting until the second week of May. The greatest delays, however, were in the northwestern areas of the Corn Belt, especially North and South Dakota, and Minnesota, but extending into the northcentral states of Wisconsin and Michigan. These states experienced much below average temperatures and above average rainfall in April and early May; very little planting progress was made in these states until mid-May. The late start caused Minnesota and North Dakota to be about three weeks off their normal planting rate. The primary soybean-producing states of Iowa and Illinois were also one to two weeks behind normal planting progress and even further behind the 2021 record planting pace.

Planting date is an important determinant of yield potential, and therefore, yields were essentially capped across major soybean production areas. If weather conditions would have been perfect for soybean production later in the summer, delayed planting would have been the primary limiter of yields. However, limited rainfall across most of the US Corn Belt in 2022 turn out to be the primary determinant of yields.

Intense drought was evident in the western states of Nebraska and Kansas and it limited early-season growth and development in dryland soybeans in those states. With spring rains across most of the other soybean-producing states, drought was held off until mid-summer.

QUALITY REPORT: 2022

Most soybean-producing states experienced moderate to severe drought in 2022. Eastern Corn Belt states tended to experience mid-summer droughts, but received rainfall in the late summer. The central soybean-producing states, from Arkansas to Missouri, Iowa, and Minnesota, experienced more lingering drought that impacted yields. The duration of the drought in various states tended to play the largest role in soybean development and ultimately in yield.

The total area and average yields of the 2022 crop appear to closely mimic those of 2021, and to a lesser extent, 2020, but the current year's yields are expected to be lower than 2020 and 2021. This leaves the expected total 2022 production to be slightly larger than 2020, but 3.5% smaller than 2021.

As in both 2020 and 2021, widespread drought reduced yields to a greater extent than any other cause in 2022. States with the longest and most severe drought conditions were primarily in the extreme western regions. Kansas saw yield reductions of more than 40% from 2021 and Nebraska was nearly 30% down. Iowa was down in 2022 by about 9% over the previous year. Few states fared better in 2022 than the previous year; however, because yields were extremely low in 2021, Minnesota and North Dakota will see yield increases in 2022. Of the expected 117 MMT US crop, the ten largest producing states are expected to be Illinois (18.6 MMT), Iowa (15.8 MMT), Minnesota (10.0 MMT), Indiana (9.4 MMT), Ohio and Nebraska (7.6 MMT each), Missouri (7.4 MM), South Dakota (5.5 MMT), North Dakota (5.4 MMT), and Arkansas (4.5 MMT).

QUALITY OF THE 2022 US SOYBEAN CROP

Sample kits were mailed to 5,737 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 25 October 2022, 1,188 samples were received. This preliminary report will serve as the November report for the 2022 US soybean crop.

Samples were analyzed for protein, oil, and amino acid concentration by near-infrared spectroscopy (NIRS) using a PerkinElmer DA7250 diode array instrument (PerkinElmer Inc., Waltham, MA, USA) equipped with calibrations developed in collaboration with PerkinElmer. A subset of samples was sent to two commercial laboratories for assessment by AOCS-approved analytical chemical methods in order to validate NIR quality constituent predictions. 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.

PROTEIN AND OIL

The 2021 US soybean crop had record low protein levels of 33.5 percent, but also had oil levels of 20.0 percent, the first time US oil levels hit that high mark (Table 5). Thankfully, the 2022 US crop shows increased protein at 33.9 percent and good oil concentration of 19.5 percent (Table 2). Compared with the prior ten-year average, 2022 protein was 0.3 points lower and oil was 0.3 points higher. Overall, the average protein and oil profile demonstrates a bit of a moderation in the lower protein and increased oil trend of the past few years. While the weather was highly variable across the US in 2022, the main weather story was the same over the past three years.

Overall, changes in protein and oil levels in the 2022 US crop, when compared with the previous one, tended to moderate regional differences. While southern and southeastern regions continued to have higher protein concentrations, the regional differences were a bit flatter compared with historical norms. The largest year-over-year changes in soybean composition were found in the Western Corn Belt states, and the most northern and western states saw the largest changes. Minnesota had protein levels that increased by one percentage point, whereas North and South Dakota saw protein increases of 1.6 and 1.5 points, respectively (Table 2).

As was noted in 2021, planting date can be the single greatest management factor to affect soybean composition. Delayed planting tends to limit soybean yields through reductions in oil concentration in the final seed while increasing the portion of the seed made up of protein. 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. In fact, the three states noted above with significant protein increases, Minnesota, North Dakota, and South Dakota, did see oil concentrations go down by 0.7 to 1.0 points.

While delayed planting likely played a role in increased protein levels, it is likely that any putative increases were moderated by other factors, especially the severe and lingering drought experienced across much of the Corn Belt. Other states in the Western Corn Belt, such as Iowa and Kansas, saw protein levels only increase by 0.2 points, but oil levels were reduced by about one-half point. Missouri had slight decreases in both protein and oil, while Nebraska tended to behave between these extremes. There, protein increased by 0.6 points and oil decreased by the same amount.

On average, the Western Corn Belt states saw protein increase by 0.6 points to 33.7, and oil decrease by 0.6 points to 19.4, relative to 2021. The Eastern Corn Belt saw no change in protein compared with 2021, but oil decreased by 0.5 points. An average Eastern Corn Belt soybean was quite similar in protein and oil to those in the Western Corn Belt, with values of 33.8 and 19.5, respectively.

Illinois soybeans tended to behave a bit more like their Western Corn Belt neighbors and had slight increases in protein to 33.7% and 0.6 points decreases in oil to 19.6%. Michigan and

Ohio produced soybeans that were about one-half point lower in protein than in 2021, with oil levels that were also off by 0.3 points.

The Midsouth states had variable changes from the previous year, by state, but these changes tended to bring the composition values more in line with one another. On average, protein increased slightly to 34.3 and oil decreased by 0.4 points to 20.0.

Due to long growing seasons in the Southeast and East Coast regions, harvest is routinely delayed and relatively few samples are received in time for the November report. These relatively few samples do support the same overall trends with similar protein levels as in 2021 and slightly lower values for oil. Southeast protein and oil values were 35.3 and 19.1%, respectively, and those from the East Coast were 34.0 and 19.6%, respectively.

SEED WEIGHT, TEST WEIGHT, FOREIGN MATERIAL, AND SOYBEANS OF OTHER COLORS

Seed weight in soybean is important for some food uses but tends to impact value of conventionally processed soybeans relatively little. 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 increased from 16.6 in 2021 to 16.8 g 100 seeds^{-1} in 2022 (Table 3). Most of the increase came from the Eastern Corn Belt, where average seed size was 16.5 in 2021 and increased to 17.4 in 2022, an increase of 0.9 g 100 seeds^{-1}. Seed size increased the most in Illinois and Indiana. This increased seed size demonstrates the importance of late-season rains in these states. This increase in seed size is directly proportional to additional yields that will be realized relative to mid-season estimates, as seed size is not considered when yield estimates are calculated prior to harvest.

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 US TW increased from 56.3 pounds per bushel in 2021 to 57.2 in 2022 (Table 3). Test weight increased across all regions over 2021; it increased by 0.7 to 1.2 pounds per bushel in the Western and Eastern Corn Belt regions, respectively, and by 1.3 in the Midsouth. It increased by 0.8 and 0.4 in the East Coast and Southeast regions, respectively. The long-term trend for slightly higher TWs in the north continued in 2022.

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 0.3% in 2022 (Table 3), 0.1 point higher than in 2021. Of 1,188 samples, only 17 had FM levels of greater than 2% and 30 had FM levels between 1-2%. Contamination with FM was less than 1% in 96% of samples (1,141 of 1,188).

Soybean seed coats can vary in color based on genetics of the seeds, the environment where they are produced, or through infections by disease-causing organisms. The presence of colored seed coats is not uncommon, and the US Federal Grain Inspection Service (FGIS) includes a measure of seed coat color in its soybean grading standards. US #1 yellow soybeans are allowed up to 1% soybeans of other colors (SBOC), a general term to note any soybean with off-colored seed coats. US #2 soybeans may contain up to 2% SBOC.

Following the 2021 harvest season, it became clear that Enlist E3® soybeans can produce soybean seed containing some off-colored soybeans, and the percentage of the seed with this SBOC appearance can be very large. Not all varieties produce this trait and this trait may not express itself in all fields. Moreover, seed coat color is unlikely to have any effect on the quality of soybean meal or oil produced from these soybeans. In 2022, we initiated a test to evaluate soybean samples for SBOC.

While 133 of 1,188 samples did show some discoloration of the seed coat, only 40 samples had discoloration that covered 50% or greater of the surface area of the seed. The latter is the threshold for classifying any seed as decolored by the FGIS. Five of these samples had discoloration of 1%, seven were 2%, fourteen were between 3 and 5%, and seven samples were between 6 and 10%. These four classes correspond with FGIS grades of US #1, #2, #3, and #4 yellow soybeans, respectively. Only seven samples had more than 50% surface coverage and had more than 10% of the seed in the sample that were discolored.

Origin of samples containing SBOC were widely distributed across the Corn Belt; however, 31 of 40 samples were found in the central Corn Belt states of Nebraska, Iowa, Illinois, Indiana, and Ohio. These are all large soybean-production states that each contributed many samples to the survey, so there is little surprise that SBOC might be found there. Overall, however, the report of SBOC in the US crop should be received by purchasers as an assurance that the presence of SBOC is rare.

SUCROSE

Soybean meal provides not only protein, and therefore amino acids, 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 2022 (Table 3), were slightly lower than those in 2021 at 4.9. 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, moderate north to south differences were evident, with the Midsouth region averaging 0.6-0.7 points lower sucrose than the Western Corn Belt, Eastern Corn Belt, and East Coast regions, respectively. Soybeans from North Dakota and (one sample from) Georgia averaged over 5% sucrose. The highest regional sucrose averages were in the East Coast and Eastern Corn Belt.

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).

In whole soybeans, lower crude protein translates to 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 increased from 6.8 in 2021 to 6.9 in 2022 (Table 4). This increase occurred in the Western and Eastern Corn Belt regions, while the other regions remained at 6.8. The sum of the five essential amino acids (5 EAAs, expressed as a percent of the 18 primary amino acids) increased from 14.8% in 2021 to 14.9% in 2022. There was relatively little variation between states or regions for this measure of protein quality. More northern states tended to have slightly higher levels in 2022.

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 11.

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. As expected, protein and oil were negatively correlated (r = -0.5), but because this is not a perfect correlation, it is possible to find soybeans that have both high protein and oil or that are low in both. As is often the case, the sum of protein and oil was much more highly correlated with protein than with oil. Numerically, protein has a greater opportunity to drive this sum value. However, it appears that the greater variation in protein over all environments is the root of these correlations. Variation in protein leads to variation in the residual (mostly carbohydrate) fraction of soybeans.

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 2022, sucrose was negatively correlated with both the sum value and oil at r = -0.4, but only loosely negatively correlated with protein (r = -0.1).

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 2022, protein was correlated with 5 EAAs at r = -0.6, and lysine at r = -0.8. Lysine is correlated with the 5EAAs at r = 0.6, so while it is a mathematically big contributor to the sum of these five amino acids, the other four certainly play their own independent roles.

Test weight is not highly correlated with any measured compositional factor or seed weight. As in previous years, TW was moderately negatively correlated with oil (r = -0.3) and positively correlated with sucrose (r = 0.2) in 2022. Surprisingly, seed size does not correlate well with any of our measured seed constituents. This indicates that factors driving seed size do not affect deposition of protein, oil, or any secondary constituents. Seed size is slightly positively correlated with sucrose levels (r = 0.2). One could speculate that in 2022, some of the conditions that allowed for continued seed growth did not favor deposition of either protein or oil, allowing sucrose to accumulate. However, this is only speculation.

Correlation Matrix

	Protein (13%)	Oil (13%)	Protein + Oil (13%)	Sucrose (db)	Lysine (% 18AA)	5 EAAs (% 18AA)	TW (lb/bu)	Seed Weight (g 100 seeds^{-1})
Protein (13%)	1	**-0.52**	**0.77**	**-0.08**	**-0.76**	**-0.57**	**0.01**	**-0.03**
Oil (13%)		1	**0.15**	**-0.40**	**0.28**	**0.33**	**-0.29**	**-0.08**
Protein + Oil (13%)			1	**-0.39**	**-0.68**	**-0.41**	**-0.20**	**-0.09**
Sucrose (db)				1	**0.32**	**0.12**	**0.19**	**0.24**
Lysine (% 18AA)					1	**0.64**	**-0.03**	**0.08**
5 EAAs (% 18AA)						1	**-0.15**	**-0.02**
TW (lb/bu)							1	**0.00**
Seed Weight (g 100 seeds^{-1})								1

WEATHER AND CROP SUMMARY

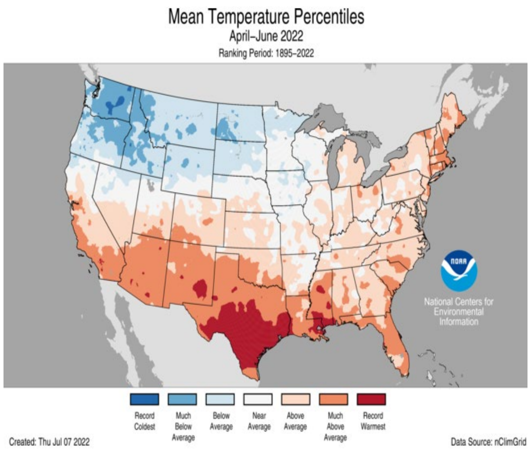
Overall, the 2022 growing season was quite different for two large groups of soybean-producing states. Growing conditions in states west of the Mississippi River were generally warm/hot and very dry during the summer months (June-August); growing conditions in states to the east of the Mississippi were warm/hot as well, but moisture was average to above average early (May), dried up later (June-early July), then saving rainfall occurred later in the summer (late July-August).

Planting: Conditions were generally cool and wetter than average in northern parts of the Western Corn Belt, and cool but drier in the more southerly states of the Western Corn Belt, including Nebraska and Iowa (Weather Figures 1 and 2). Wet conditions slowed planting progress in the upper Western Corn Belt in early May, but drier conditions in the more southerly states (Iowa, Kansas, Nebraska) made it possible for farmers to plant soybeans faster than the 5-year average. Conditions in the Eastern Corn Belt and Midsouth were variable for moisture, but generally planting conditions were good and progress was ahead of the 5-year average. The Southeast and East Coast regions were warm with variable rainfall early in the season.

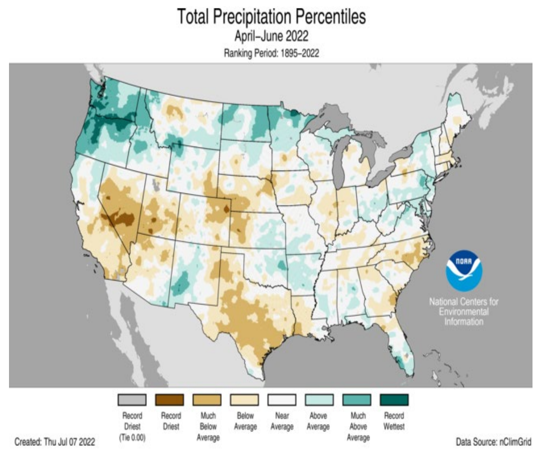
Mid-Season: Conditions in virtually every major soybean-producing region were warm/hot, but precipitation was very mixed (Weather Figures 3 and 4). Conditions in June were dry nearly everywhere, then in July a 'split' occurred whereby rainfall in states west of the Mississippi River dried up, but was higher than average in states to the east of the Mississippi. In August, the higher than average rainfall pattern moved east, but conditions west of the Mississippi stayed very dry. The overall June-August precipitation pattern was: (1) dry from the Western Corn Belt south to Texas, (2) wet/dry but mostly wet from the Eastern Corn Belt states south to parts of the Midsouth and Southeast, and (3) wet/dry but mostly dry from the East Coast to the Southeast.

Harvest: The September US Drought Monitor (Weather Figure 5) clearly shows the 'split' along the Mississippi for drought conditions. Mean temperatures in September followed a similar trend, with warmer temperatures west of the Mississippi and more average temperatures to the east (Weather Figure 6). In October, drought conditions worsened in many states, but the dry fall allowed rapid harvest progress. By October 23, 80% of the US crop was harvested, well ahead of the 5-year average of 67%.

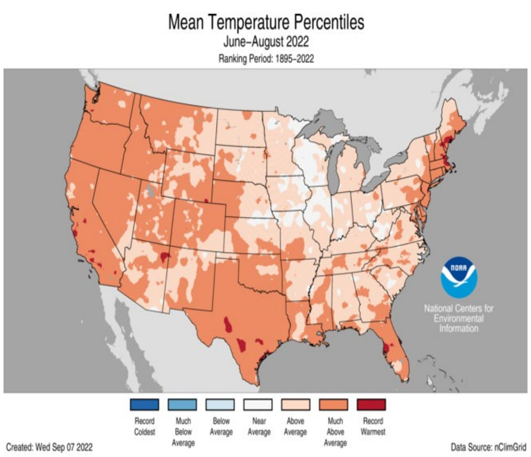
Weather Figure 1



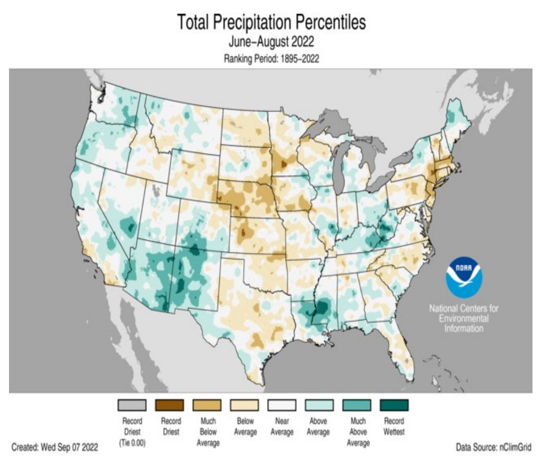
Weather Figure 2



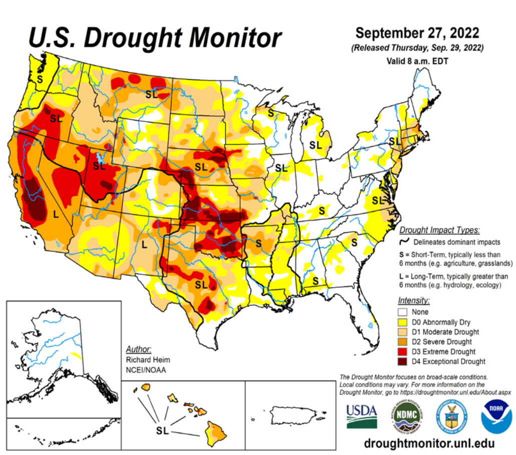
Weather Figure 3



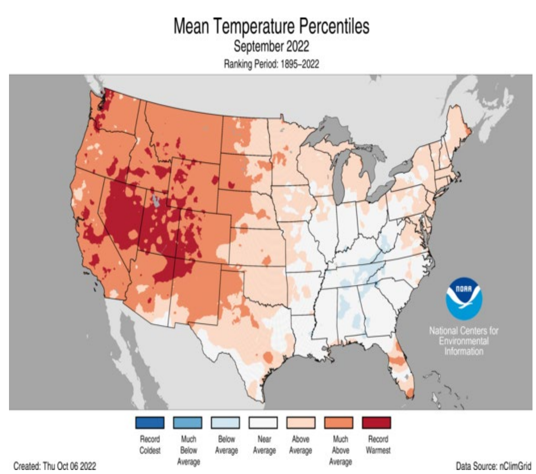
Weather Figure 4



Weather Figure 5



Weather Figure 6



REFERENCES

Egli, D.B., and P.L. Cornelius. 2009. A Regional Analysis of the Response of Soybean Yield to Planting Date. Agron. J. 101(2):330-335.

Federal Grain Inspection Service. 2004. Test Weight. *In* Grain Inspection Handbook II (Chapter 10). Washington DC: USDA-GIPSA-FGIS.

Helms, T.C., and J.H. Orf. 1998. Protein, oil, and yield of soybean lines selected for increased protein. Crop Sci. 38:707-711.

Medic, J., C. Atkinson, and C.R. Hurburgh Jr. 2014. Current knowledge in soybean composition. J. Am. Oil Chem. Soc. 91(3):363-384.

Mourtzinis, S., A.P. Gaspar, S.L. Naeve, and S.P. Conley. 2017. Agron. J. 109:2040-2049.

National Agricultural Statistics Service: NASS. 2022. Available at: <nass.usda.gov>

NOAA National Centers for Environmental Information, State of the Climate: National Climate Report, published online, retrieved October 29, 2022 from https://www.ncdc.noaa.gov/sotc/national/2022.

Pfarr, M.D., M.J. Kazula, J.E. Miller-Garvin, and S.L. Naeve. 2018. Amino acid balance is affected by protein concentration in soybean. Crop Sci. 58:1-13.

Ravindran, V., M.R. Abdollahi, and S.M. Bootwalla. 2014. Nutrient analysis, metabolizable energy, and digestible amino acids of soybean meals of different origins for broilers. Poultry Sci. 93:2567-2577.

Stein, H.H., L.L. Berger, J.K. Drackley, G.F. Fahey, Jr., D.C. Hernot, and C.M. Parsons. 2008. Nutritional properties and feeding values of soybeans and their coproducts. pp. 613-660 *In* Soybeans, Chemistry, Production, Processing, and Utilization. L.A. Johnson, P.J. White, and R. Galloway, eds. AOCS Press, Urbana, IL.

Thakur, M., and C.R. Hurburgh. 2007. Quality of US soybean meal compared to the quality of soybean meal from other origins. J. Am. Oil Chem. Soc. 84:835-843.

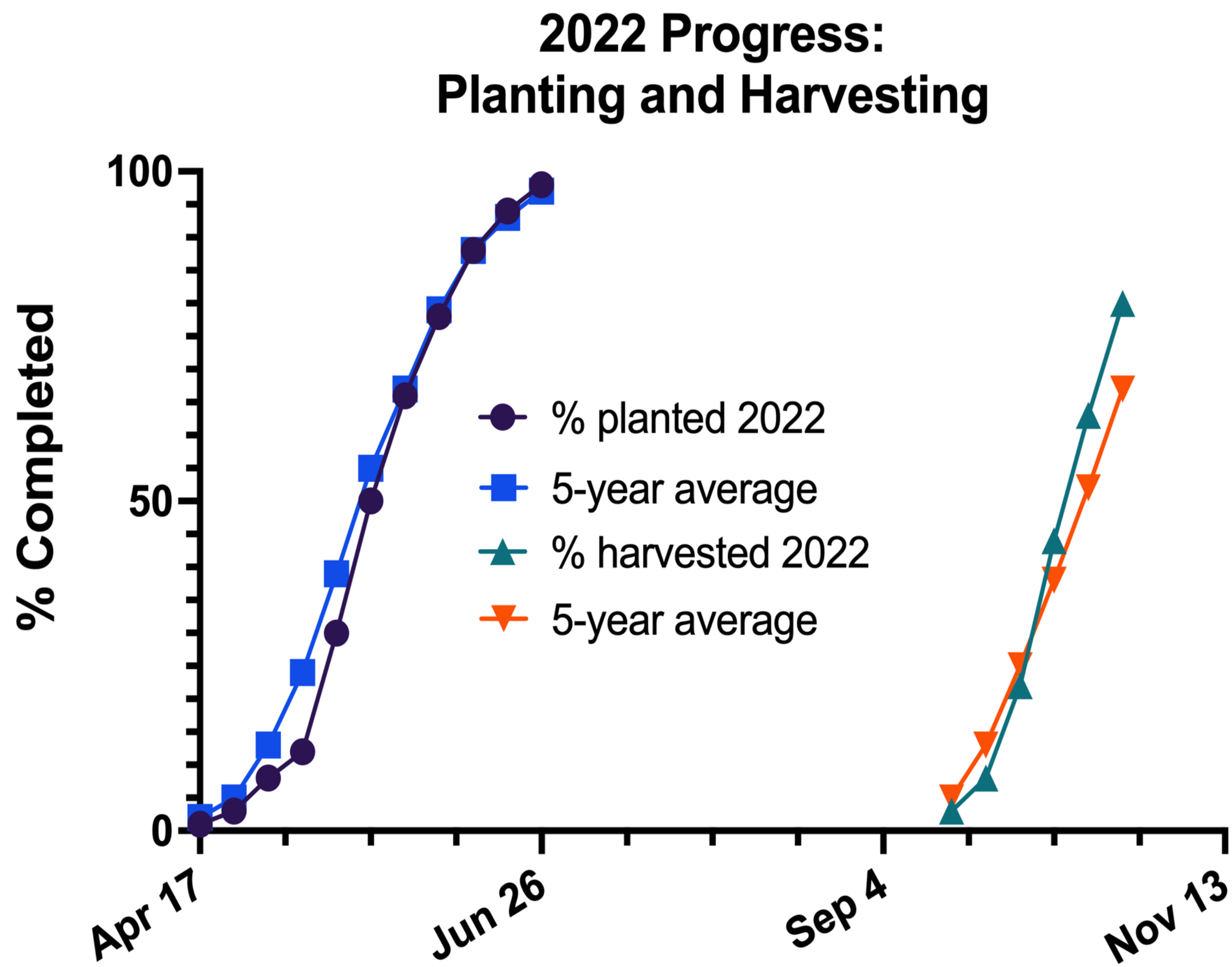


Figure 1 Source: USDA NASS

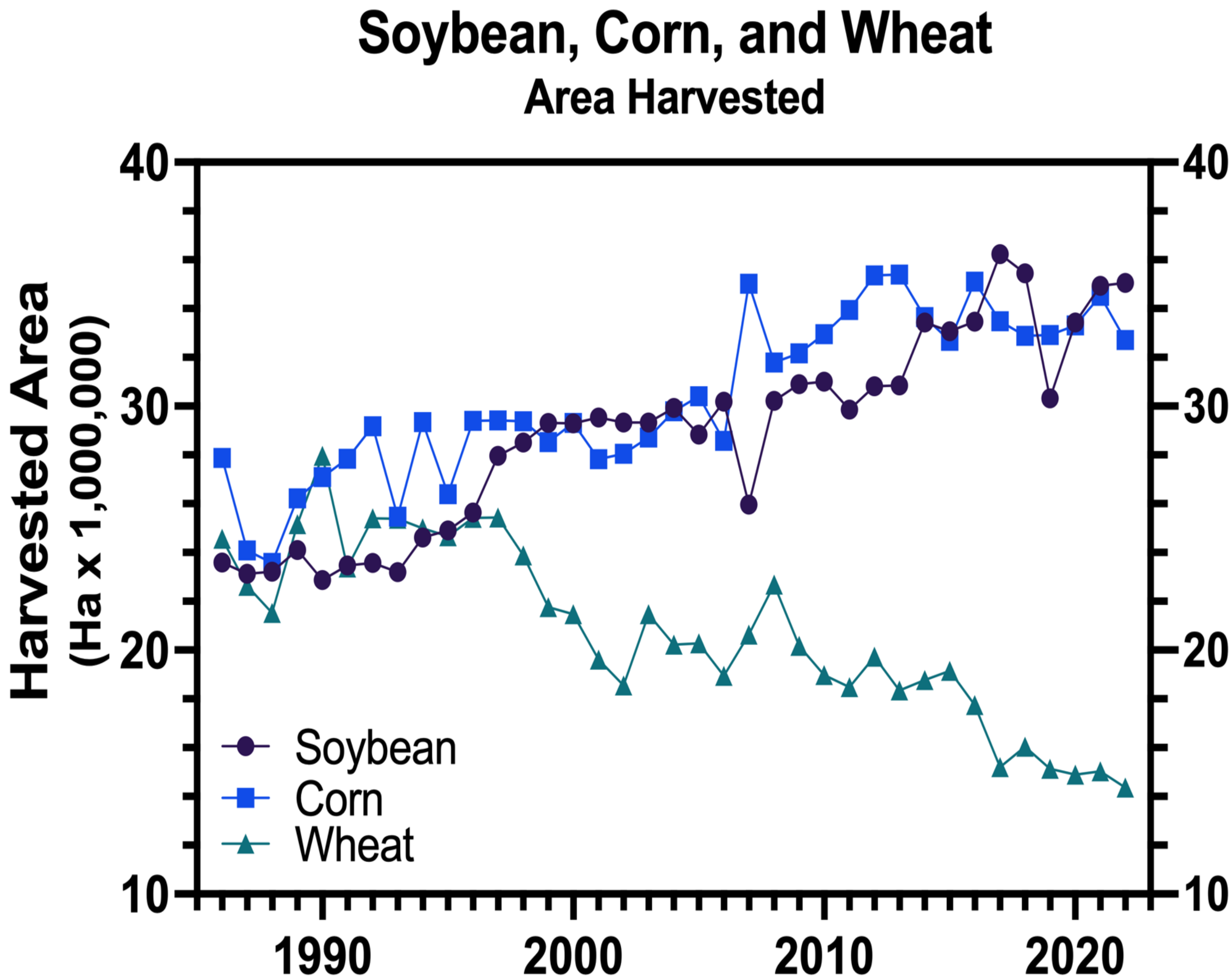


Figure 2 Source: USDA NASS

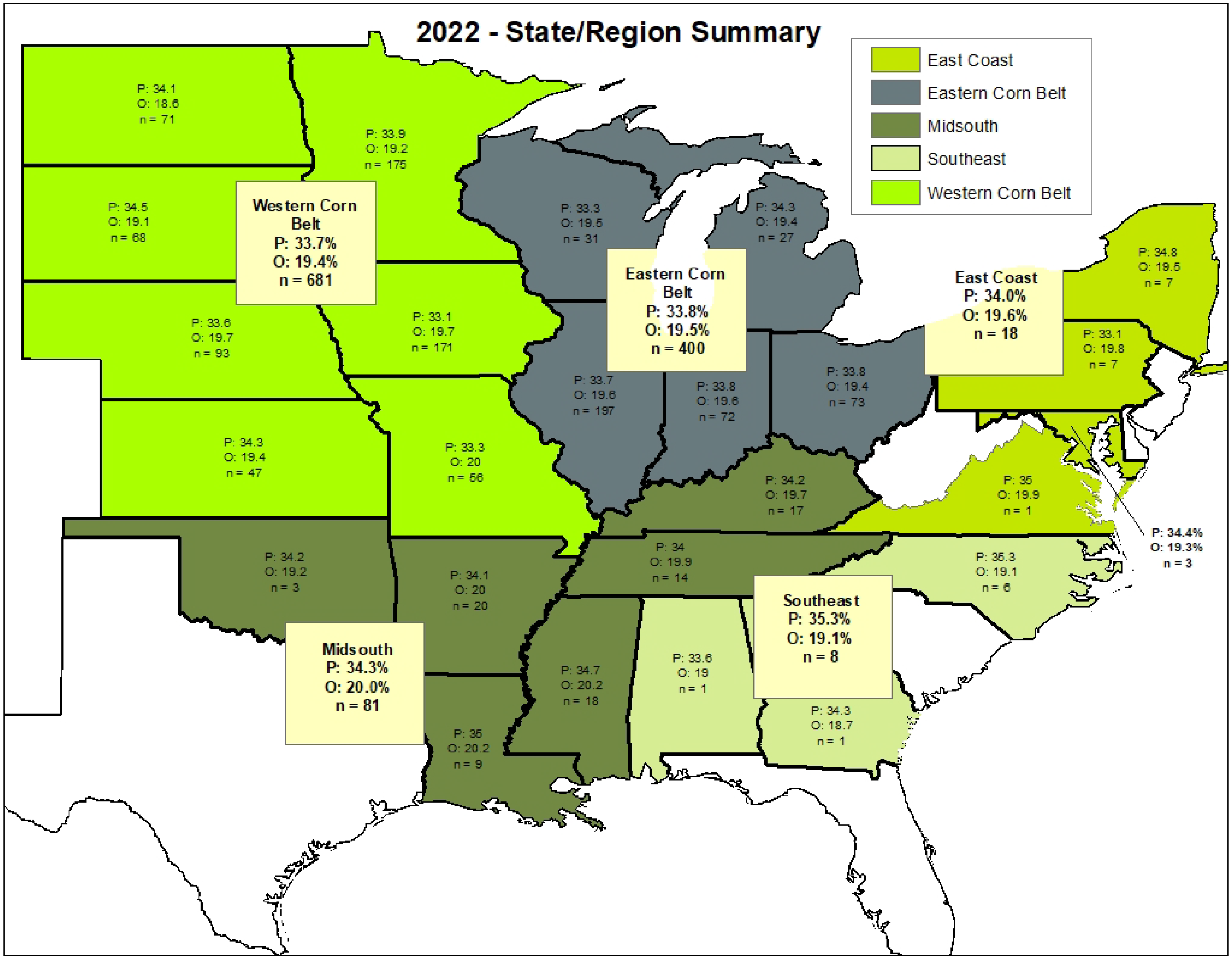

2022 - State/Region Summary
East Coast
Eastern Corn Belt
Midsouth
Southeast
Western Corn Belt
P: 34.1 O: 18.6 n= 71
P: 33.9 O: 19.2 n= 175
P: 34.5 O: 19.1 n= 68
Western Corn Belt P: 33.7% O: 19.4% n = 681
P: 33.3 O: 19.5 n= 31
P: 34.3 O: 19.4 n= 27
P: 33.6 O: 19.7 n= 93
P: 33.1 O: 19.7 n= 171
Eastern Corn Belt P: 33.8% O: 19.5% n = 400
East Coast P: 34.0% O: 19.6% n = 18
P: 34.8 O: 19.5 n= 7
P: 33.1 O: 19.8 n= 7
P: 33.7 O: 19.6 n= 197
P: 33.8 O: 19.6 n= 72
P: 33.8 O: 19.4 n= 73
P: 34.3 O: 19.4 n= 47
P: 33.3 O: 20 n= 56
P: 34.2 O: 19.7 n= 17
P: 35 O: 19.9 n= 1
P: 34.4% O: 19.3% n = 3
P: 34.2 O: 19.2 n= 3
P: 34.1 O: 20 n= 20
P: 34 O: 19.9 n= 14
P: 35.3 O: 19.1 n= 6
Southeast P: 35.3% O: 19.1% n = 8
Midsouth P: 34.3% O: 20.0% n = 81
P: 34.7 O: 20.2 n= 18
P: 33.6 O: 19 n= 1
P: 34.3 O: 18.7 n= 1
P: 35 O: 20.2 n= 9

Figure 3

Table 1. Soybean production data for the United States, 2022 crop

Region	State	Yield (MT ha^{-1})	Area Harvested (1000 ha)	Production (MMT)
Western Corn Belt (WCB)	Iowa	3.9	4,058	15.8
	Kansas	1.9	2,025	3.8
	Minnesota	3.4	2,989	10.1
	Missouri	3.0	2,450	7.4
	Nebraska	3.3	2,309	7.6
	North Dakota	2.4	2,288	5.4
	South Dakota	2.7	2,045	5.5
	Western Corn Belt	2.9	18,164	55.6
				47.3%
Eastern Corn Belt (ECB)	Illinois	4.3	4,334	18.7
	Indiana	4.0	2,361	9.4
	Michigan	3.1	903	2.8
	Ohio	3.7	2,057	7.6
	Wisconsin	3.6	863	3.1
	Eastern Corn Belt	3.7	10,518	41.6
				35.4%
Midsouth (MDS)	Arkansas	3.6	1,276	4.5
	Kentucky	3.6	786	2.8
	Louisiana	3.2	502	1.6
	Mississippi	3.8	923	3.5
	Oklahoma	1.1	213	0.2
	Tennessee	3.1	656	2.0
	Texas	2.2	57	0.1
	Midsouth	2.9	4,412	14.8
				12.6%
Southeast (SE)	Alabama	2.8	144	0.4
	Georgia	3.0	65	0.2
	North Carolina	2.5	684	1.7
	South Carolina	2.6	158	0.4
	Southeast	2.7	1,051	2.7
				2.3%
East Coast (EC)	Delaware	2.9	64	0.2
	Maryland	3.0	209	0.6
	New Jersey	2.0	44	0.1
	New York	3.4	140	0.5
	Pennsylvania	3.1	237	0.7
	Virginia	2.8	247	0.7
	East Coast	2.9	940	2.8
				2.4%
US 2022		3.4	35,086	117.5
US 2021		3.5	34,956	121.6

Source: United States Department of Agriculture, NASS 2021 Crop Production Report (October 2022)

Table 2. USB 2022 Soybean Quality Survey Data

Region	State	Number of Samples	Protein (%)*	Std. Dev.	Oil (%)*	Std. Dev.
Western Corn Belt (WCB)	Iowa	171	33.1	1.0	19.7	0.7
	Kansas	47	34.3	1.4	19.4	0.8
	Minnesota	175	33.9	1.1	19.2	0.6
	Missouri	56	33.3	1.3	20.0	0.7
	Nebraska	93	33.6	1.1	19.7	0.8
	North Dakota	71	34.1	1.1	18.6	0.8
	South Dakota	68	34.5	1.1	19.1	0.6
Averages†	Western Corn Belt	681	33.7	1.1	19.4	0.7
Eastern Corn Belt (ECB)	Illinois	197	33.7	1.0	19.6	0.7
	Indiana	72	33.8	1.1	19.6	0.7
	Michigan	27	34.3	0.6	19.4	0.7
	Ohio	73	33.8	1.1	19.4	0.6
	Wisconsin	31	33.3	1.3	19.5	0.8
Averages†	Eastern Corn Belt	400	33.8	1.0	19.5	0.7
Midsouth (MDS)	Arkansas	20	34.1	1.2	20.0	0.6
	Kentucky	17	34.2	1.5	19.7	0.8
	Louisiana	9	35.0	1.7	20.2	0.9
	Mississippi	18	34.7	0.9	20.2	0.5
	Oklahoma	3	34.2	1.1	19.2	1.0
	Tennessee	14	34.0	0.9	19.9	0.8
	Texas	0				
Averages†	Midsouth	81	34.3	1.2	20.0	0.7
Southeast (SE)	Alabama	1	33.6		19.0	
	Georgia	1	34.3		18.7	
	North Carolina	6	35.3	1.4	19.1	0.5
	South Carolina	0				
Averages†	Southeast	8	35.3	1.4	19.1	0.5
East Coast (EC)	Delaware	0				
	Maryland	3	34.4	0.5	19.3	0.5
	New Jersey	0				
	New York	7	34.8	1.5	19.5	0.6
	Pennsylvania	7	33.1	1.0	19.8	0.6
	Virginia	1	35.0		19.9	
Averages†	East Coast	18	34.0	0.9	19.6	0.6
US	Averages	1,188	33.8		19.5	
	Average of 2022 Crop†		**33.9**	**1.1**	**19.5**	**0.7**
	US 2012-2021 avg.†		34.2	1.2	19.2	0.8

* 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 (October 2022)

Table 3. USB 2022 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	171	17.8	57.2	0.2	4.6
	Kansas	47	15.2	57.3	0.5	4.3
	Minnesota	175	17.6	57.5	0.2	4.7
	Missouri	56	16.2	57.0	0.2	4.4
	Nebraska	93	16.5	56.8	0.6	4.5
	North Dakota	71	16.8	58.6	0.2	5.2
	South Dakota	68	15.7	57.7	0.2	4.5
Averages†	Western Corn Belt	681	16.7	57.4	0.3	4.6
Eastern Corn Belt (ECB)	Illinois	197	17.8	57.2	0.2	4.6
	Indiana	72	17.2	57.3	0.3	4.7
	Michigan	27	17.1	57.5	0.1	4.7
	Ohio	73	16.8	57.9	0.1	4.8
	Wisconsin	31	17.8	57.3	0.2	4.9
Averages†	Eastern Corn Belt	400	17.4	57.4	0.2	4.7
Midsouth (MDS)	Arkansas	20	14.7	56.1	0.5	3.9
	Kentucky	17	16.9	56.8	0.3	4.4
	Louisiana	9	15.2	53.5	0.7	3.4
	Mississippi	18	15.3	56.0	0.8	3.7
	Oklahoma	3	13.9	55.7	1.6	4.5
	Tennessee	14	16.3	56.6	0.3	4.3
	Texas	0				
Averages†	Midsouth	81	15.5	56.0	0.6	4.0
Southeast (SE)	Alabama	1	14.6	54.4	2.5	4.5
	Georgia	1	15.1	57.9	0.5	5.1
	North Carolina	6	15.1	57.1	0.2	4.2
	South Carolina	0				
Averages†	Southeast	8	15.1	57.1	0.2	4.2
East Coast (EC)	Delaware	0				
	Maryland	3	17.9	56.2	0.5	4.9
	New Jersey	0				
	New York	7	18.4	57.4	0.1	4.9
	Pennsylvania	7	17.8	57.1	0.2	4.5
	Virginia	1	12.9	55.8	1.5	3.0
Averages†	East Coast	18	18.0	56.9	0.3	4.7
US	Averages	1,188	17.0	57.3	0.3	4.6
	Average of 2022 Crop†		**16.8**	**57.2**	**0.3**	**4.5**

† Regional and US average values weighted based on estimated production by state as estimated by USDA, NASS Crop Production Report (October 2022)

Table 4. USB 2022 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	171	33.1	6.9	14.9	25.0
	Kansas	47	34.3	6.8	14.9	25.0
	Minnesota	175	33.9	6.9	14.9	24.9
	Missouri	56	33.3	6.9	15.0	25.0
	Nebraska	93	33.6	6.9	15.0	25.0
	North Dakota	71	34.1	6.9	14.9	24.9
	South Dakota	68	34.5	6.8	14.8	24.9
Averages†	Western Corn Belt	681	33.7	6.9	14.9	25.0
Eastern Corn Belt (ECB)	Illinois	197	33.7	6.9	14.9	25.0
	Indiana	72	33.8	6.9	14.9	24.9
	Michigan	27	34.3	6.9	14.8	24.9
	Ohio	73	33.8	6.9	14.9	24.9
	Wisconsin	31	33.3	6.9	15.0	25.0
Averages†	Eastern Corn Belt	400	33.8	6.9	14.9	24.9
Midsouth (MDS)	Arkansas	20	34.1	6.8	14.9	25.0
	Kentucky	17	34.2	6.8	14.8	24.9
	Louisiana	9	35.0	6.8	14.8	24.9
	Mississippi	18	34.7	6.8	14.8	24.9
	Oklahoma	3	34.2	6.8	14.9	25.0
	Tennessee	14	34.0	6.8	14.9	25.0
	Texas	0				
Averages†	Midsouth	81	34.3	6.8	14.8	24.9
Southeast (SE)	Alabama	1	33.6	6.9	15.0	25.1
	Georgia	1	34.3	6.8	14.6	24.7
	North Carolina	6	35.3	6.8	14.8	24.8
	South Carolina	0				
Averages†	Southeast	8	35.3	6.8	14.8	24.8
East Coast (EC)	Delaware	0				
	Maryland	3	34.4	6.8	14.9	24.9
	New Jersey	0				
	New York	7	34.8	6.8	14.9	24.8
	Pennsylvania	7	33.1	6.9	14.9	25.0
	Virginia	1	35.0	6.8	14.8	24.9
Averages†	East Coast	18	34.0	6.8	14.9	24.9
US	Averages	1,188	33.8	6.9	14.9	25.0
	Average of 2022 Crop†		**33.9**	**6.9**	**14.9**	**25.0**

* 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 (October 2022)

Table 5. Historical Summary of Yield and Quality Data for US Soybeans

Year	Yield (kg ha^{-1})	Protein* (%)	Oil* (%)	Sum† (%)	Harvested (M ha^{-1})	Production (M MT)	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	54.1	1.4	0.9
1992	2530	35.6	17.3	52.8	23.6	59.7	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	68.5	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	64.8	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	74.7	1.5	0.8
1999	2463	34.6	18.6	53.2	29.3	72.3	1.9	1.1
2000	2564	36.2	18.7	54.9	29.3	75.1	1.7	0.9
2001	2665	35.0	19.0	54.0	29.6	78.7	2.0	1.1
2002	2557	35.4	19.4	54.8	29.4	75.1	1.6	0.9
2003	2281	35.7	18.7	54.3	29.4	66.8	1.7	1.2
2004	2840	35.1	18.6	53.7	30.0	85.1	1.5	0.9
2005	2900	34.9	19.4	54.3	28.9	83.6	1.5	0.9
2006‡	2887	34.5	19.2	53.7	30.2	87.1	1.6	1.0
2007‡	2806	35.2	18.6	53.9	26.0	72.9	1.2	0.8
2008‡	2671	34.1	19.1	53.2	30.2	80.8	1.4	0.8
2009‡	2961	35.3	18.6	53.9	30.9	91.6	1.2	0.9
2010‡	2927	35.0	18.6	53.6	31.0	90.7	1.4	1.2
2011‡	2826	34.9	18.1	53.0	29.9	84.4	2.2	1.8
2012‡	2692	34.3	18.5	52.8	30.8	82.9	1.6	0.9
2013‡	2961	34.7	19.0	53.7	30.9	91.4	1.1	1.0
2014‡	3196	34.4	18.6	53.0	33.5	107.0	1.3	0.9
2015‡	3230	34.3	19.8	54.1	33.1	107.0	1.1	0.8
2016‡	3492	34.5	19.3	53.8	33.5	117.0	1.2	0.7
2017‡	3317	34.1	19.1	53.2	36.3	120.2	1.2	0.9
2018‡	3405	34.1	19.0	53.1	35.5	120.6	1.1	0.7
2019‡	3190	34.1	19.0	53.1	30.4	96.8	1.1	0.6
2020‡	3432	33.9	19.5	53.4	33.5	114.9	1.1	0.7
2021‡	3479	33.5	20.0	53.5	35.0	121.6	1.2	0.8
2022‡	3351	33.9	19.5	53.4	35.1	117.5	1.1	0.7
Averages (2012-2021)	**3239**	**34.2**	**19.2**	**53.4**	**33.2**	**107.9**	**1.2**	**0.8**
Averages (1986-2021)	**2736**	**35.0**	**18.8**	**53.8**	**28.8**	**80.0**	**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 - 2022 quality estimates are weighted by yearly production estimates by state

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