UNITED STATES SOYBEAN QUALITY ANNUAL REPORT 2017

PREPARED FOR:

The U.S. Soybean Export Council (USSEC) U.S. Soy Outlook Conferences December, 2017 Dr. Jill Miller-Garvin and Dr. Seth L. Naeve





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SUMMARY

The U.S. Soy Family, which includes the American Soybean Association, United Soybean Board, and U.S .Soybean Export Council, has supported a survey of the quality of the U.S. soybean crop since 1986. This survey is intended to provide new crop quality data to aid international customers with their purchasing decisions.

2017 ACREAGE, YIELDS, AND TOTAL PRODUCTION

According to the November 2017 United States Department of Agriculture, National Agricultural Statistics Service (USDA-NASS) Crop Production report, the U.S. is expected to produce another record soybean crop at 120.6 MMT. If realized, this will be a 3% increase over the record 2016 crop of 117.0 MMT. The increased production is the result of an extremely large area planted to soybeans this year (Table 1). Reduced expected profits coupled with high production costs for corn convinced U.S. farmers to convert some corn acres to soybean acres; this resulted in an expected 8% increase in harvested area in 2017 relative to 2016. However, yields are expected to be 5% lower than in 2016. Farmers should produce soybean yields of about 3.3 MT per Ha on average.

Together the three largest soybean-producing states, Illinois, Iowa, and Minnesota, increased harvested acres by about 6%, decreased yields by about 7%, and produced about 1% fewer tons of soybeans in 2017 compared with 2016. Across the ten largest soybeanproducing states, increased area outweighed yield declines to produce a net increase in production compared with last year.

The largest increases in harvested acres occurred in Kansas and North Dakota. Kansas increased harvested area by 441,000 ha and North Dakota increased area by 449,000 ha. States with the largest increases in total production tended to be MDS states that had increased area devoted to soybeans coupled with increased yields over 2016. Arkansas increased total production by 893,000 MT. Mississippi, Kentucky, Tennessee, and Louisiana increased production by 432,000, 376,000, 263,000, and 252,000 MT, respectively. Nearby, the WCB states of Kansas and Missouri increased total production by 452,000 and 507,000, respectively, due to increases in area.

QUALITY OF THE 2017 U.S. SOYBEAN CROP

Sample kits were mailed to 6,688 producers that were selected based on total land devoted to soybean production in each state, so that response distribution would closely match that of soybean production. By 5 December, 2017, 1,837 samples were received.

Samples were analyzed for protein, oil, and amino acid concentration by near-infrared spectroscopy (NIRS) using a Perten DA7250 diode array instrument (Huddinge, Sweden) equipped with calibration equations developed by the University of Minnesota in cooperation with Perten. 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. Regional and national average quality values were determined by computing weighted averages using state and regional soybean production data, so that average values best represent the crop as a whole. Results are in Tables 2 through 5.

INTERPRETATION OF PROTEIN AND OIL RESULTS

Overall, when compared with the good quality 2016 crop, protein concentrations noted in the 2017 crop were somewhat disappointing (Table 2). Protein was 0.4 of a point lower than that of the 2016 crop, 0.6 of a point

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lower than the previous ten-year average, and 1.0 points lower than the long-term historical average. On the other hand, oil concentrations were nearly equal to 2016 levels and were 0.3 - 0.4 point higher than the historical averages.

Although lower overall, protein concentrations were unusually consistent across the U.S. in 2017. Among the three primary production regions (WCB, ECB, and MDS), regional averages varied by only 0.4 percentage point. There tended to be more variation between states than between regions; this indicates that localized weather events were more important for affecting protein levels in mature soybean seed than the larger environmental gradients caused by latitude, soil type, and historical rainfall patterns. Among these same three production regions, oil concentration varied by 0.5 point. As with protein, oil concentrations varied more between states than between regions.

In most years, soybeans produced in the WCB states have protein levels that are at least 0.5 point lower than the U.S. average and are often nearly one point lower than those from the ECB. This year, these two regions had identical protein concentrations at 34.0. In 2017, North Dakota, Iowa, Missouri, and Nebraska had the lowest protein of the western states. Minnesota and South Dakota soybeans had higher protein in 2017 than 2016, with South Dakota increasing protein by nearly one percentage point.

The largest numerical decreases in protein, year-overyear, occurred in the ECB states of Ohio, Michigan, Indiana, and Illinois. Protein levels in these states decreased by about one percentage point relative to last year. Wisconsin-grown soybeans produced protein levels similar to those grown in 2016.

Regional oil concentrations were similar in 2017 when compared with 2016. All major regions had oil concentrations within 0.3 of a point of last year's values. Midsouth oil concentrations averaged 19.5% and were slightly higher than the average values from the ECB (19.1%) and the WCB (19.0%). The north-south gradient appears stronger for oil in 2017 than in most years. More northerly states tended to have lower oil concentrations.

We have noted over years of conducting this survey that rainfall patterns can have a large effect on protein and oil. However, because the final seed quality is dependent on the sum of weather events throughout the growing season, it is difficult to predict seed protein and oil concentrations. Moreover, overall yield levels can impact seed quality as well. Excess rainfall early in the growing season coupled with drought or neardrought conditions during seed fill can lead to reduced protein concentrations. This phenomenon was evident in southern lowa in 2017. Although spring rains were not excessive, a strong drought lingered through much of the later growing season.

Timing and severity of the excess rainfall and drought conditions greatly affect the end protein concentrations. For instance, ECB states of Illinois, Indiana, and Ohio sustained above-average rainfall after planting and a mid-season drought that reduced protein levels; however, the drought was not severe enough to drastically reduce protein. The largest single factor affecting soybean protein appears to be timely rains during the seed-filling period. Regions with abundant rainfall during August appeared to produce seed with above trend- line protein concentrations for their area.

The clear north to south gradient in oil in 2017 is likely due to the extreme low temperatures noted across much of the Corn Belt for several weeks during seed filling. Oil deposition in the seed is directly related to ambient temperatures, and it appears that cool temperatures limited oil throughout the upper Midwest. Increased oil did balance losses in protein in many areas.

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SEED SIZE AND TEST WEIGHT RESULTS

While seed size may not be important for most commodity soybean purchasers, seed size does provide some insight into the environmental conditions present during the production season. In general, environmental stresses such as drought in the early seed-filling period (late July and early August) tend to reduce the number of seeds on individual plants; if conditions return to normal, these remaining seeds can expand, resulting in larger than average seed size. Alternatively, stresses at the end of the seed-filling period (late August through September) reduce the energy available for each seed and seed size may be smaller than average. Average seed size increased from 16.3 grams per 100 seeds in 2016 to 17.1 in 2017 (Table 3). This is primarily an indication of improved growing conditions later in the summer. For instance, late season rains in Iowa, Minnesota, and South Dakota allowed the seed to continue to acquire additional yield on the limited number of seeds per plant. Interestingly, the soybeans in Iowa tended to acquire additional oil with a heat wave in mid- September. Soybeans in South Dakota, Minnesota, Wisconsin, and Nebraska appeared to utilize early September ainsto add additional protein to their seed. Except those from Kentucky, Mid south soybeans tended to be smaller in size than other regions due to late- season drought stress and late-season disease pressure caused by frequent mid-season rain events.

Test weight, or the density of soybeans measured in pounds per bushel, is an important measure of quality in cereal grains. There is continued interest in soybean test weight even though test weight does not correlate well with any of our other measured quality traits. Test weight data are provided here for the reader to interpret as they wish. There is one interesting, if not useful, observation from the 2017 test weight data. There was a tendency for test weights to be higher in more northerly climates. It is important to note, however, that test weight can be affected by seed size, seed shape, seed coat roughness, as well as moisture content. Since these factors do not contribute to soybean quality in any meaningful way, it is important to interpret soybean test weight with a great deal of caution.

AMINO ACIDS

Amino acids are the "building block" organic compounds linked in various combinations to form unique proteins. In human diets, amino acids are supplied by the variety of plant and animal proteins ingested. In animal feed, amino acids come from feed proteins such as soybean meal, and possibly from synthetic amino acid supplements. Soybean meal is the major feed protein source in poultry, swine, and cultured fish diets because of its high nutritional quality including its balanced amino acid profile. 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) – this is an "ideal protein".

In a recent study, Ravindran et al. (2014) found crude protein to be a poor predictor of overall feed quality of soybean meal. In whole soybeans, lower crude protein soybeans have a higher 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). Lysine, cysteine, methionine, and threonine were all higher in soybeans from the U.S. compared to soybeans from Brazil (Naeve, unpublished data). So, although Brazilian soybeans typically have higher average protein content than U.S. beans, the lower protein U.S. soybeans can be expected to produce a higher quality meal, based on the presence



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and balance of critical amino acids, assuming the meal is processed properly. Studies comparing soybean meal from the U.S. and other origins found that U.S. soybean meal had lower protein content than Brazilian soybean meal, but better quality of protein – higher concentrations of essential amino acids (Park and Hurburgh, 2002; Thakur and Hurburgh, 2007; Bootwalla, 2009). We support complete and independent analysis of soybeans, soybean meal, and feeds throughout the value chain to ensure that the end user has access to the highest quality feed, not based on protein alone, but the full quality package that includes amino acid balance, energy, and more.

In 2017, amino acid results varied very little by state and region. Average lysine (expressed as a percent of the 18 primary amino acids) (Table 4) was the same in every region. Regional differences in the sum of the five most limiting amino acids (also known as CAAV), cysteine, lysine, methionine, threonine, and tryptophan, were very small, with WCB at 15.2 and all other regions at 15.1. The U.S. average CAAV was 15.1 this year, 0.6 higher than last year's U.S. average. The lower average protein in the U.S. in 2017 likely led to higher average CAAV in the U.S. Moreover, the range in protein in the U.S. in 2017 was smaller than last year, likely leading to a smaller CAAV range.

In 2017 we added an additional soybean protein quality measure, 7 EAA's. After animal diets have been supplemented with synthetic amino acids, the next most limiting amino acids are often valine and isoleucine. Therefore, we have added these two amino acids to the five primary limiting amino acids for which synthetics are available. This 7 EAA value may have additional utility for end users who have been feeding lower protein diets with high inclusion rates of synthetic amino acids. As with the 5 EAA measure, there was relatively little variability in protein quality between states and regions in 2017.

Regional differences alone do not fully explain amino acid concentration differences in the samples; when we evaluated the samples based on protein level rather than region, we found that the protein in lower protein samples is more concentrated in the five critical amino acids than is the protein in higher protein samples. Thus, protein concentration differences may account for the amino acid concentration differences across regions, rather than region per se.

SUCROSE

Soybean products provide not only protein in animal feed, but also energy (Stein et al., 2008). We have found that soybeans from the U.S. have higher sucrose than soybeans from Brazil (Naeve, unpublished data), which is desirable since sucrose is positive for metabolizable energy. In studies of soybean meal quality by origin, the apparent metabolizable energy in U.S. soybean meal was significantly higher than that in meal from Argentina and Brazil, and the higher sugar level in U.S. soybean meal is likely a primary driver of differences in metabolizable energy (Ravindran et al., 2014).

Within the U.S., we have found that soybeans produced in cooler regions have a lower sum of protein + oil, but higher sucrose levels; the higher sucrose levels appear to be related to geography. In 2017, samples from the WCB, ECB, and EC regions had sucrose levels at or near 6.8 (db), while samples from the MDS and SE had sucrose levels of 5.0 and 6.0, respectively. These results comport well with published findings that cooler regions generally produce soybeans with higher sucrose concentrations (Kumar et al., 2010).

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WEATHER AND CROP SUMMARY

The largest crop weather stories for 2017 revolved around three main themes. The first was a severe drought that affected ND and SD for the entire season. This drought affected all western states from NE and KS through IA, IL, IN, and MO from mid- to late-summer. The second weather anomaly in 2017 was extreme cool conditions in early August that continued through late August and early September. Lastly, although weather data aggregated across regions or time gives the appearance of a relatively normal summer, it was actually a season of extremes. For instance, more than 1,500 local record low and record high temperatures were broken from June through August in the Midwest. Moreover, extreme rain events were common even with drought conditions occurring between rain events or in nearby regions. More than 1,200 daily rainfall records were broken in the Midwest in 2017.

Planting: Precipitation in mid-April was above normal across much of the U.S.; temperatures were above normal as well. By mid-May, continued average to above average temperatures allowed near-normal planting progress. Many important soybean-growing states (IL, IN, OH, and NE) received above average precipitation (Weather Figure 1). By early June, more than 80% of the U.S. crop was planted due to very favorable conditions in the central Corn Belt region. While planting progress was good, early season growth and development was hindered and the overall USDA crop ratings were historically low starting in May.

Mid-Season: The Midsouth experienced below normal temperatures in June, while temperatures in most of the ECB and WCB were average or slightly above average. Rainfall in June was above normal in many soybean-growing regions, particularly in the MDS. In July, parts of the the WCB were dry and warm while

parts of the ECB (especially IL, IN, and OH) were much wetter than average. Illinois, IN, and OH were drier than normal in August, while states to their west and south were wetter than average; except in ND and SD where drought conditions continued. August was cooler than normal across most of the central and northeastern U.S., especially in NE, IA, and IL (Weather Figure 1).

Harvest: September brought above average temperatures to the Corn Belt region but rainfall patterns split such that some WCB states (ND, SD, and MN) were wetter than normal, but all ECB states were much drier than average (Weather Figure 1). By late October, warm/hot and dry weather accelerated harvest in the central U.S., allowing 83% of the 2017 harvest to be completed.

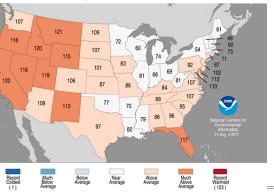


WEATHER FIGURE 1.

STATEWIDE AVERAGE PRECIPITATION RANKS May 2017 - Period 1895 - 2017



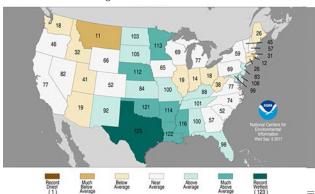
STATEWIDE AVERAGE TEMPERATURE RANKS July 2017 - Period 1895 – 2017



STATEWIDE AVERAGE TEMPERATURE RANKS

August 2017 - Period 1895 - 2017

STATEWIDE AVERAGE PRECIPITATION RANKS August 2017 - Period 1895 - 2017

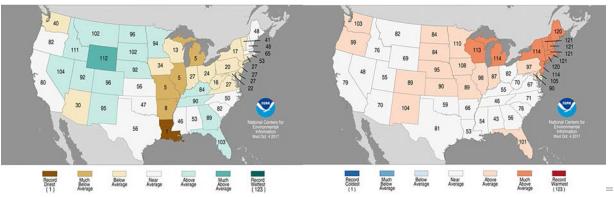


STATEWIDE AVERAGE PRECIPITATION RANKS September 2017 - Period 1895 – 2017





STATEWIDE AVERAGE TEMPERATURE RANKS September 2017 - Period 1895 – 2017



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U.S. SOYBEAN PLANTING AND HARVEST PROGRESS

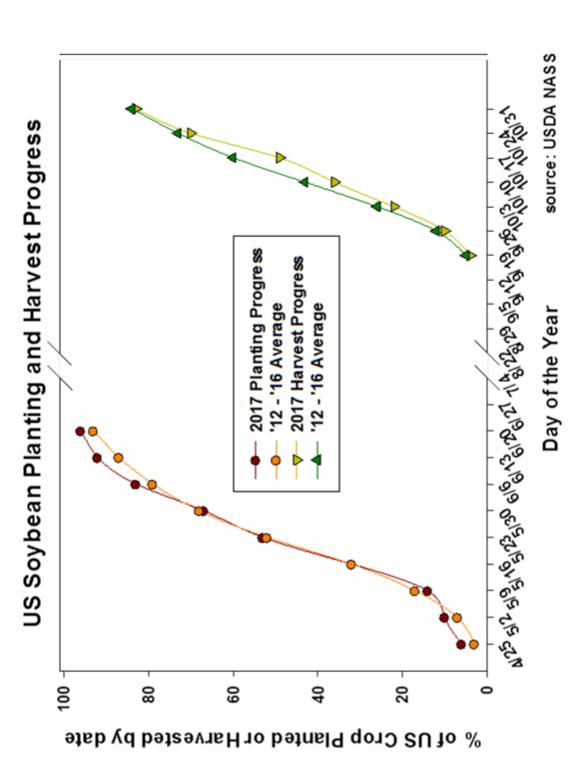
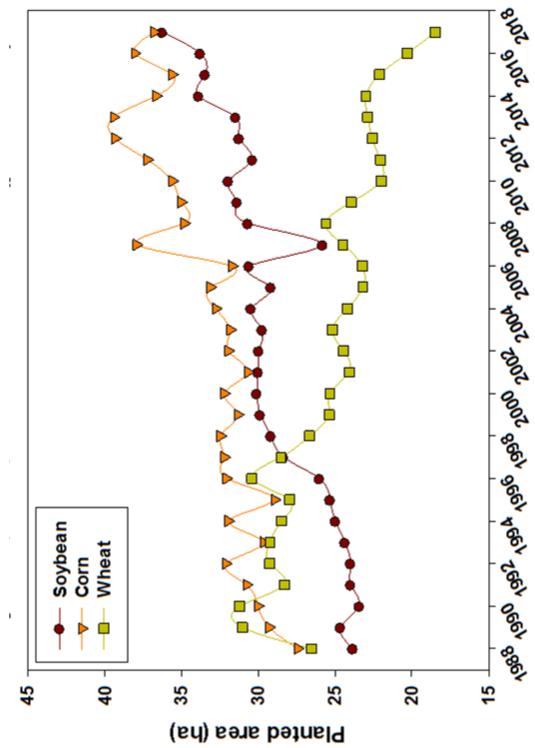


FIGURE 1

SOYBEAN, CORN, AND WHEAT IN THE U.S.

(planted ha)







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2017: STATE / REGION SUMMARY

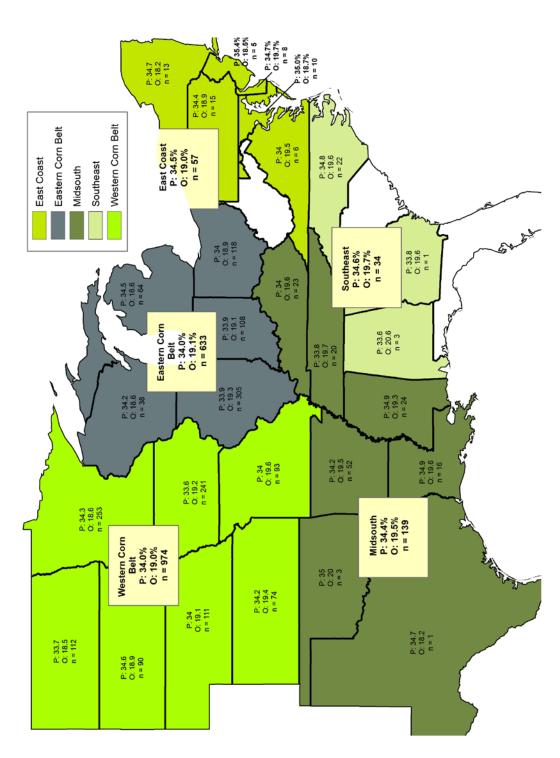


FIGURE 3



TABLE 1. SOYBEAN PRODUCTION DATA FOR THE UNITED STATES, 2017 CROP

REGION	STATE	YIELD (MT ha⁻¹)	AREA HARVESTED (1000 ha)	PRODUCTION (M MT)
	lowa	3.8	4,030	15.2
	Kansas	2.7	2,066	5.6
	Minnesota	3.1	3,281	10.1
	Missouri	3.3	2,398	7.9
Western Corn Belt (WCB)	Nebraska	3.9	2,288	8.9
(WCD)	North Dakota	2.4	2,876	6.8
	South Dakota	3.0	2,272	6.9
	Western Corn Belt	3.2	19,209	61.4
				50.9%
	Illinois	3.9	4,269	16.7
	Indiana	3.7	2,406	8.9
	Michigan	3.0	923	2.8
Eastern Corn Belt	Ohio	3.4	2,041	7.0
(ECB)	Wisconsin	3.1	867	2.7
	Eastern Corn Belt	3.4	10,506	38.0
				31.5%
	Arkansas	3.4	1,418	4.8
	Kentucky	3.5	786	2.7
	Louisiana	3.6	502	1.8
	Mississippi	3.5	879	3.1
Midsouth	Oklahoma	2.0	255	0.5
(MDS)	Tennessee	3.4	672	2.3
	Texas	2.6	75	0.2
	Midsouth	3.1	4,587	15.4
				12.8%
	Alabama	3.0	138	0.4
	Georgia	2.7	59	0.2
Southeast	North Carolina	2.8	676	1.9
(SE)	South Carolina	2.5	158	0.4
	Southeast	2.7	1,031	2.8
				2.4%
	Delaware	3.4	64	0.2
	Maryland	3.4	200	0.7
	New Jersey	2.8	40	0.1
East Coast	New York	3.2	107	0.3
(EC)	Pennsylvania	3.4	237	0.8
	Virginia	3.0	239	0.7
	East Coast	3.2	887	2.9
				2.4%
U.S. 2017		3.3	36,236	120.5
U.S. 2016		3.5	33,492	117.0

Source: United States Department of Agriculture, NASS 2017 Crop Production Report (November 2017)

TABLE 2. USSEC 2017 SOYBEAN QUALITY SURVEY DATA

REGION	STATE	NUMBER OF SAMPLES	PROTEIN (%)*	STD. DEV.	OIL (%)*	STD. DE\
	lowa	241	33.6	1.2	19.2	0.8
	Kansas	74	34.2	1.1	19.4	0.8
	Minnesota	253	34.3	1.1	18.6	0.6
Western Corn Belt (WCB)	Missouri	93	34.0	1.0	19.6	0.7
(WCB)	Nebraska	111	34.0	1.2	19.1	1.0
	North Dakota	112	33.7	1.3	18.5	0.7
	South Dakota	90	34.6	1.1	18.9	0.7
<i>Averages</i> ^t	Western Corn Belt	974	34.0	1.2	19.0	0.9
	Illinois	305	33.9	1.1	19.3	0.8
	Indiana	108	33.9	1.2	19.1	0.9
Eastern Corn Belt	Michigan	64	34.5	1.3	18.6	0.9
(ECB)	Ohio	118	34.0	1.0	18.9	0.7
	Wisconsin	38	34.2	1.5	18.6	0.8
<i>Averages</i> [†]	Eastern Corn Belt	633	34.0	1.2	19.1	0.8
	Arkansas	52	34.2	1.4	19.5	1.1
	Kentucky	23	34.0	0.9	19.6	0.7
	Louisiana	16	34.9	1.1	19.6	1.0
Midsouth	Mississippi	24	34.9	1.5	19.3	1.1
(MDS)	Oklahoma	3	35.0	1.0	20.0	0.5
	Tennessee	20	33.8	0.8	19.7	0.7
	Texas	1	34.7		18.2	
Averages [†]	Midsouth	139	34.4	1.2	19.5	0.9
	Alabama	3	33.6	0.8	20.6	0.3
Southeast	Georgia	1	33.8		19.6	
(SE)	North Carolina	22	34.8	1.7	19.6	1.0
	South Carolina	8	34.4	0.7	19.5	0.5
Averages [†]	Southeast	34	34.6	1.4	19.7	0.8
	Delaware	8	34.7	0.7	19.7	0.7
	Maryland	10	35.0	1.0	18.7	0.5
East Coast	New Jersey	5	35.4	1.2	18.5	0.8
(EC)	New York	13	34.7	0.9	18.2	0.6
	Pennsylvania	15	34.4	1.0	18.9	0.9
	Virginia	6	34.0	1.6	19.5	1.0
<i>Averages</i> [†]	East Coast	57	34.5	1.1	19.0	0.8
U.S.	Averages	1,837	34.1		19.1	
	Average of 2017 Crop [†]		34.1	1.2	19.1	0.9
	U.S. 2006 – 2015 avg.†		34.7	1.4	18.8	1.0

* 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 2017)

TABLE 3. USSEC 2017 SOYBEAN QUALITY SURVEY SEED DATA

REGION	STATE	NUMBER OF SAMPLES	SEED WEIGHT G 100 SEEDS ⁻¹	TEST WEIGHT	SUCROSE DB
	lowa	241	17.7	56.4	6.8
	Kansas	74	16.5	56.3	6.1
	Minnesota	253	18.3	56.6	7.0
Western Corn Belt (WCB)	Missouri	93	17.3	55.7	6.3
(WCB)	Nebraska	111	17.8	56.4	6.5
	North Dakota	112	16.3	57.6	7.3
	South Dakota	90	17.5	57.2	6.6
<i>Averages</i> ^t	Western Corn Belt	974	17.4	56.6	6.7
	Illinois	305	17.1	56.3	6.6
Frank and the Park	Indiana	108	17.0	56.3	6.8
Eastern Corn Belt (ECB)	Michigan	64	16.8	56.8	6.7
(ECD)	Ohio	118	17.0	56.7	6.9
	Wisconsin	38	17.6	56.5	7.1
<i>Averages</i> [†]	Eastern Corn Belt	633	17.1	56.4	6.8
	Arkansas	52	15.6	54.6	4.6
	Kentucky	23	17.7	55.4	6.5
	Louisiana	16	16.6	53.9	3.6
Midsouth	Mississippi	24	15.7	54.5	4.2
(MDS)	Oklahoma	3	15.4	57.7	5.6
	Tennessee	20	16.7	55.3	5.9
	Texas	1	17.5	52.2	2.5
<i>Averages</i> ^t	Midsouth	139	16.2	54.9	5.0
	Alabama	3	16.3	56.0	5.5
Southeast	Georgia	1	16.1	58.7	6.2
(SE)	North Carolina	22	16.4	56.0	6.0
	South Carolina	8	17.6	57.4	6.6
<i>Averages</i> ^t	Southeast	34	16.6	56.2	6.0
	Delaware	8	17.6	54.6	6.5
	Maryland	10	17.5	55.9	7.2
East Coast	New Jersey	5	16.6	56.6	6.4
(EC)	New York	13	17.4	56.9	7.2
	Pennsylvania	15	17.4	56.5	6.9
	Virginia	6	18.2	56.5	6.5
<i>Averages</i> [†]	East Coast	57	17.6	56.3	6.8
U.S.A.	Averages	1,837	17.3	56.4	6.6
	Average of 2017 Crop [†]		17.1	56.3	6.5

† Regional and US average values w eighted based on estimated production by state as estimated by USDA, NASS Crop Production Report (November 2017)



TABLE. 4 USSEC 2017 SOYBEAN QUALITY SURVEY AMINO ACID (AA) DATA

REGION	STATE	NUMBER OF SAMPLES	PROTEIN (%)*	LYSINE (%18 AAs)	5 EAAs [‡] (%18 AAs)	7 EAAs⁵ (%18 AAs)
	Iowa	241	33.6	6.8	15.2	25.5
	Kansas	74	34.2	6.8	15.1	25.4
Western Corn Belt	Minnesota	253	34.3	6.8	15.1	25.4
(WCB)	Missouri	93	34.0	6.8	15.2	25.5
(1100)	Nebraska	111	34.0	6.8	15.2	25.5
	North Dakota	112	33.7	6.9	15.2	25.5
	South Dakota	90	34.6	6.8	15.1	25.4
Averages [†]	Western Corn Belt	974	34.0	6.8	15.2	25.5
	Illinois	305	33.9	6.8	15.2	25.5
F	Indiana	108	33.9	6.8	15.1	25.4
Eastern Corn Belt (ECB)	Michigan	64	34.5	6.8	15.1	25.4
(ECD)	Ohio	118	34.0	6.8	15.1	25.4
	Wisconsin	38	34.2	6.8	15.1	25.4
<i>Averages</i> [†]	Eastern Corn Belt	633	34.0	6.8	15.1	25.4
	Arkansas	52	34.2	6.8	15.1	25.4
	Kentucky	23	34.0	6.8	15.2	25.5
	Louisiana	16	34.9	6.7	14.9	25.3
Midsouth (MDS)	Mississippi	24	34.9	6.8	15.0	25.3
(MDS)	Oklahoma	3	35.0	6.8	15.2	25.4
	Tennessee	20	33.8	6.8	15.2	25.5
	Texas	1	34.7	6.6	15.0	25.3
Averages [†]	Midsouth	139	34.4	6.8	15.1	25.4
	Alabama	3	33.6	6.8	15.1	25.4
Southeast	Georgia	1	33.8	6.8	15.1	25.5
(SE)	North Carolina	22	34.8	6.8	15.1	25.4
	South Carolina	8	34.4	6.8	15.2	25.5
<i>Averages</i> [†]	Southeast	34	34.6	6.8	15.1	25.4
	Delaware	8	34.7	6.7	15.0	25.3
	Maryland	10	35.0	6.7	14.9	25.2
East Coast	New Jersey	5	35.4	6.8	14.9	25.2
(EC)	New York	13	34.7	6.8	15.2	25.4
	Pennsylvania	15	34.4	6.8	15.1	25.4
	Virginia	6	34.0	6.8	15.2	25.5
<i>Averages</i> [†]	East Coast	57	34.5	6.8	15.1	25.4
U.S.A.	Averages	1,837	34.1	6.8	15.1	25.4
	Average of 2017 Crop [†]		34.1	6.8	15.1	25.4

* 13% moisture basis

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

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

† Regional and US average values w eighted based on estimated production by state as estimated by USDA, NASS Crop Production Report (November 2017)



TABLE 5. HISTORICAL SUMMARY OF YIELD AND QUALITY DATA FOR U.S. SOYBEANS

YEAR	YIELD (kg ha⁻¹)	PROTEIN* (%)	OIL* (%)	SUM [‡] (%)	HARVESTED (Mha ⁻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	54.0	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	36w.2	120.5	1.2	0.9
Averages (2006 - 2016)	2963	34.7	18.8	53.5	31.0	92.3	1.4	1.0
Averages (1986 - 2016)	2626	35.1	18.7	53.8	27.9	74.3	1.5	0.9

Sources: U.S. 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 – 2017 quality estimates are weighted by yearly production estimates by state



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