2019 North Dakota Soybean Quality Survey

Northern Crops Institute

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Summary

2019 will go down in the record books as one of the most difficult years for many North Dakota soybean farmers. During the first half of 2019, most areas in North Dakota were in a strong drought. However, in the latter part of the year, statewide precipitation accumulation averages were 4.92 inches wetter than normal, making the last half of the year the wettest on record since 1895. Early snow in October blanketed much of the state that resulted in a delayed harvest. In October, 65 daily snowfall records were set across the state of North Dakota.

Even with adverse weather conditions from planting through harvest that reduced the volume of soybeans harvested, test weight, protein content, and oil content in submitted samples were essentially at 10-year average levels. The Critical Amino Acid Value of the 2019 soybean crop was slightly lower than the 2018 crop and the 10-year average. The essential fatty acids in soybean oil, linoleic acid and linolenic acid, were higher than the 10-year average. Soluble sugar contents, sucrose, raffinose, stachyose, were quite similar to soluble sugar contents of the 10-year average.

Sample Collection

Nine agricultural districts serve as the basis for a comparison of crop quality data (Figure 1). A total of 244 samples were collected from 43 counties and eight agricultural districts in North Dakota by the United States Department of Agriculture-National Agricultural Statistics Service (USDA-NASS) (Table 1). The number of samples collected from each county is based on the soybean production from previous year which is calculated by the NASS.
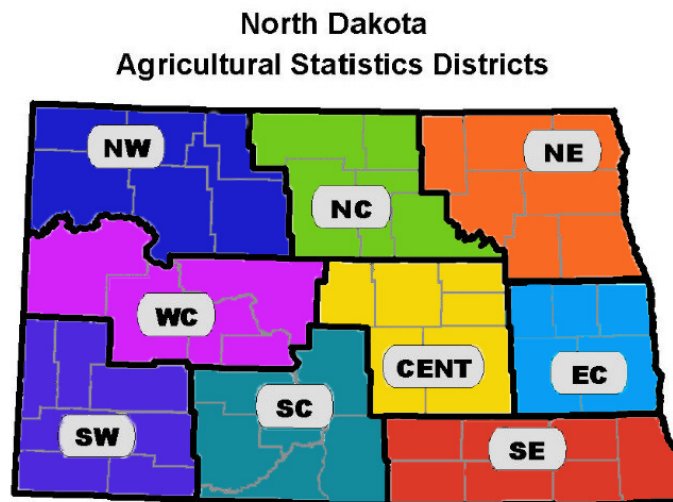

Figure 1. North Dakota agricultural districts

District	Abbreviation	Number of Sample	% Distribution
Central	CENT	32	13
East Central	EC	50	20
North Central	NC	18	7
North East	NE	38	16
North West	NW	16	7
South Central	SC	13	5
South East	SE	65	27
West Central	WC	8	3
South West	SW	4	2
	Total	244	100

Table 1. North Dakota agricultural districts, number of samples and percent distribution

Analysis Method

Moisture; color; test weight; proximate protein, oil, ash, and fiber; soluble sugar; fatty acid profile; and amino acid profile were analyzed as quality attributes that characterize North Dakota soybeans. Test weight and moisture were analyzed using a DICKEY-John Grain Analysis Computer GAC 2500 UGMA (Auburn, IL), employing the AACC method 55-10 (AACC, 1999). These tests were done immediately after the soybean samples were received.

Color analyses were performed with a Minolta Color Analyzer CR-410 (Ramsey, NJ). CIE 1976 (L*, a*, b*) color space, where brightness (L*), redness (a*) and yellowness (b*) values were determined. Proximate, soluble sugar, fatty acid and amino acid profiles were evaluated using a Perten DA7250 Near-InfraRed Analyzer (NIRS) (Huddinge, Sweden), with a calibration developed at the University of Minnesota and funded by the Minnesota Soybean Research and Promotion Council. Submitted soybean samples were ground into coarse flour using a Perten Laboratory Mill 3600, and analyzed on the NIR to obtain proximate, soluble sugar, fatty acid and amino acid profiles.

Whole beans were used to obtain initial moisture, test weight and color. The NIR method was also utilized by Miller-Garvin and Naeve (2019) for the United States Soybean Crop Quality Report funded by the United States Soybean Export Council (USSEC). Through a collaborative effort as a soybean consortium, the North Dakota soybean quality data collected from the Perten DA 7250 contributes to the soybean calibration along with various universities in the nation. The calibration is updated annually reflecting the data collected from the previous crop year's samples.

2019 Soybean Production

According to the USDA National Agricultural Statistics Service (USDA- NASS), national soybean production for 2019 was 3,558,281,000 bushels (96.84 million metric tons), which was calculated to be 80% of the 4,428,150,000 bushels (120.51 million metric tons) record harvest production in 2018. Nationally, soybean acres harvested dropped by 15% from 2018, which were at at 87.6 million acres compared to 75.0 million acres in 2019. Soybean yields in the U.S. had been steadily increasing since 2013 to a record high in 2016 at 51.9 bushels per acre.

The national soybean yield average in 2019 was 47.4 bushels per acre compared to 50.5 bushels per acre in 2018.

Volume, yield, and acres harvested in North Dakota for 2019 followed national soybean harvest trends. The 2019 North Dakota production quantity, harvested acres, and yield data are presented in Figure 2. North Dakota soybean production in 2019 at 174,400,000 bushels (4.75 million metric tons) was lower than 2018 at 239,400,000 bushels (6.52 million metric tons), resulting in 2019 production being 72.8% of production in 2018.

The area harvested in 2019 at 5.45 million acres (2.21 million hectares) was 80% of the 2018 acres at 6.84 million acres (2.77 million hectares). The average soybean yield in 2019 was 32.0 bushels per acre (2.1 metric tons per hectare), which was lower than 2018 at 36 bushels per acre (2.35 metric tons per hectare). In 2019, North Dakota dropped to 9th place among states in soybean production, 5th in acres of soybeans harvested, and 26th in bushels per acre. (USDA-NASS, 2019)
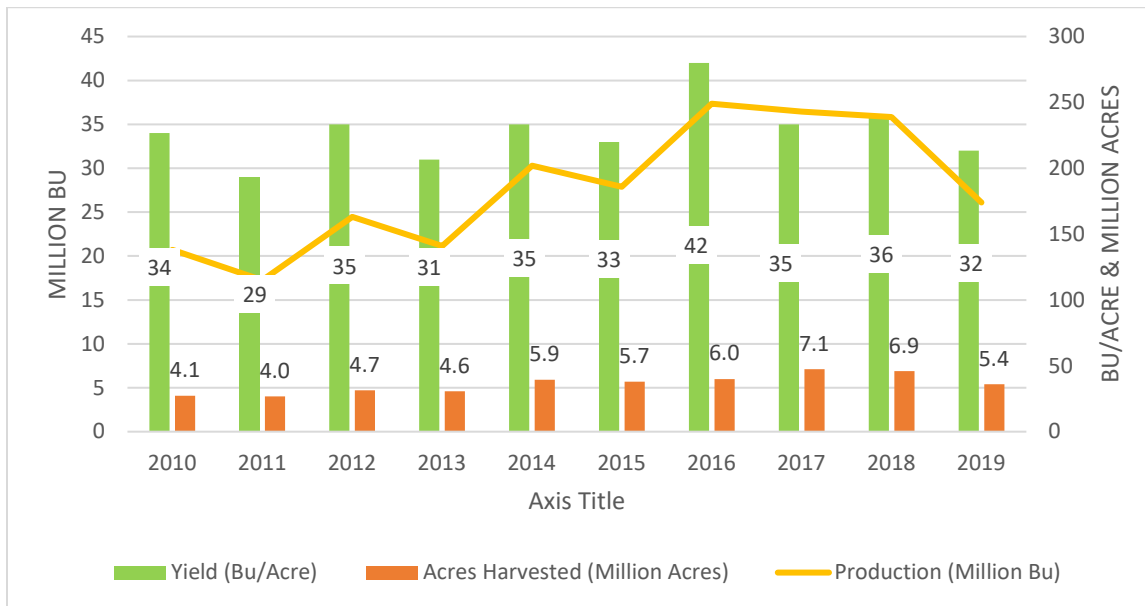

Figure 2. North Dakota soybean yield, harvest and production data between 2010 and 2019

2019 North Dakota Weather and Crop Summary

Above-average annual precipitation was observed across much of the nation. North Dakota, South Dakota, Minnesota, Wisconsin and Michigan each had areas within their states that had their wettest year on record during 2019, with much of the Central U.S. experiencing above- to much-above-to-record average precipitation as shown in Figure 3 below (National Oceanic and Atmospheric Administration - NOAA). NOAA published data that illustrated overly wet conditions in North Dakota by highlighting that Grand Forks (28.13 inches of precipitation, 7.32 inches above normal – Wettest in 76 years) and Bismarck (29.63 inches of precipitation, 11.78 inches above normal – Wettest in 72 years) were communities that were indicative of the increase in precipitation in many areas of the state.
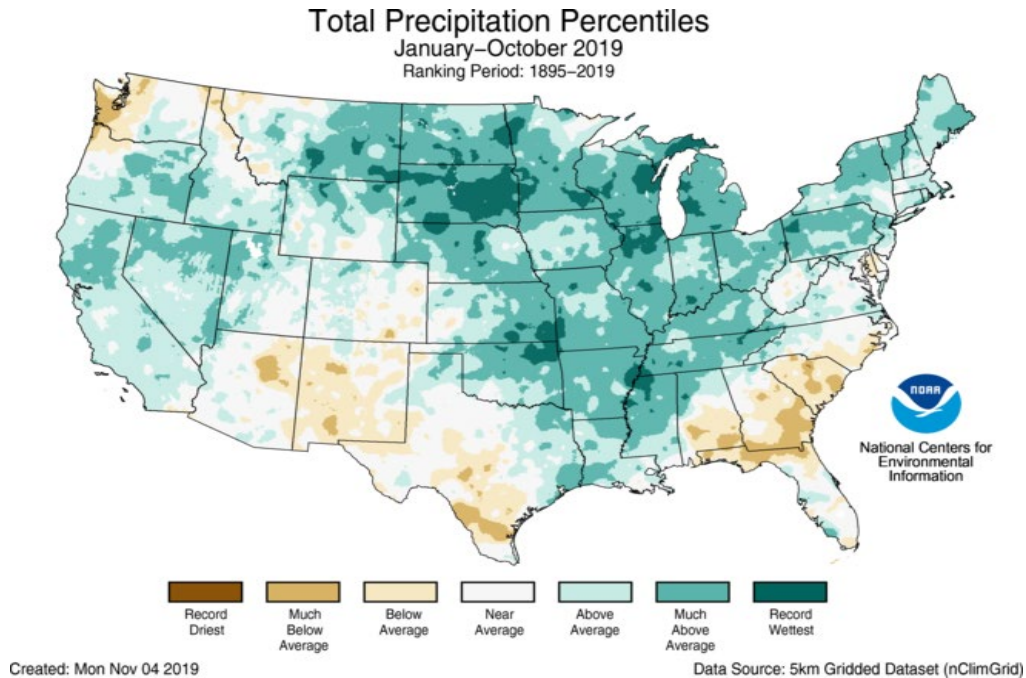
Figure 3. Total U.S. precipitation percentiles in January to October 2019

Soybean planting in North Dakota lagged behind averages in most areas as shown in Figure 4. According to the USDA-NASS, June 3, 2019 Crop Progress and Condition Report, soybeans planted at that time were at 70 percent, behind 86 percent in 2018 and 83 percent for the five-year average. Emerged soybeans were at 13%, well behind 42 percent in 2018 and 45 percent for the five-year average.

During harvest, the USDA-NASS, November 4, 2019 report stated that the North Dakota soybean condition rated 6 percent very poor, 12 percent poor, 34 percent fair, 46 percent good, and 2 percent excellent. Soybeans harvested at that time were 56 percent, well behind 85 percent in 2018 and 95 percent for the five-year average as shown in Figure 5. The December 2, 2019 report stated that 92 percent of soybeans in the state were harvested.

The 2019 North Dakota soybean crop year experienced cool springtime temperatures that delayed planting activities (Figure 4). Relatively normal temperatures and rainfall late in the summer led into a cool and wet September that slowed soybean maturity. Cold weather and significant snowfall in regions in North Dakota delayed soybean harvest. Delayed planting and harvest time periods reduced yields and harvested acres. The USDA-NASS reported that 150,000 acres of soybeans were not harvested in 2019 and that average soybean yields were lower in 2019 at 32 bushels per acre compared with 36 bushels per acre in 2018.
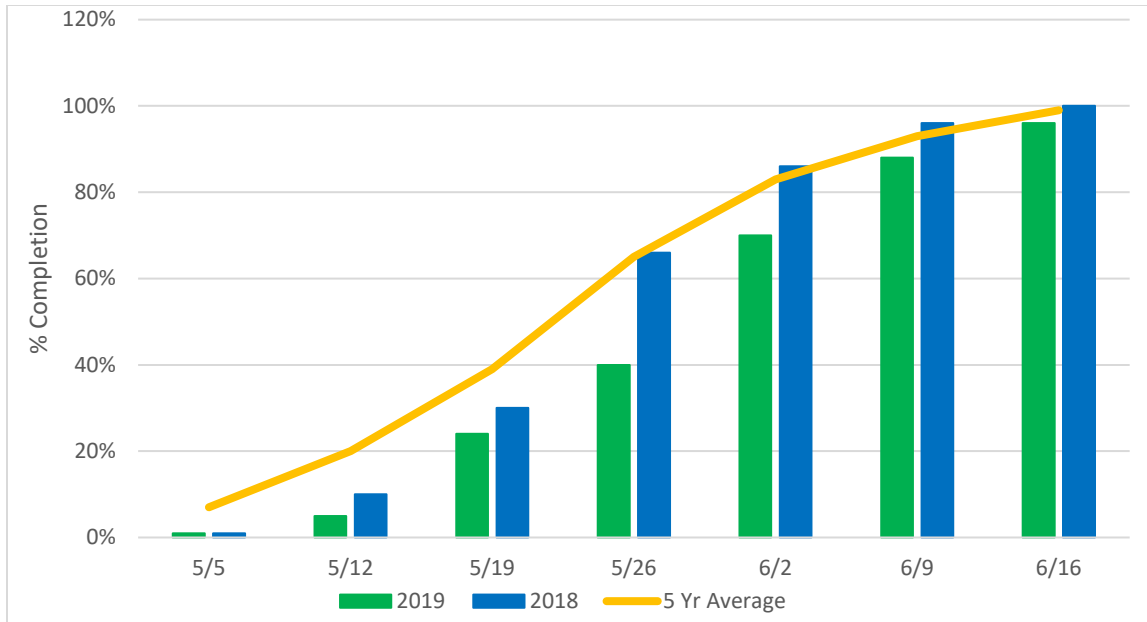
Figure 4. Planting progress of 2019 North Dakota soybeans presented by % completion
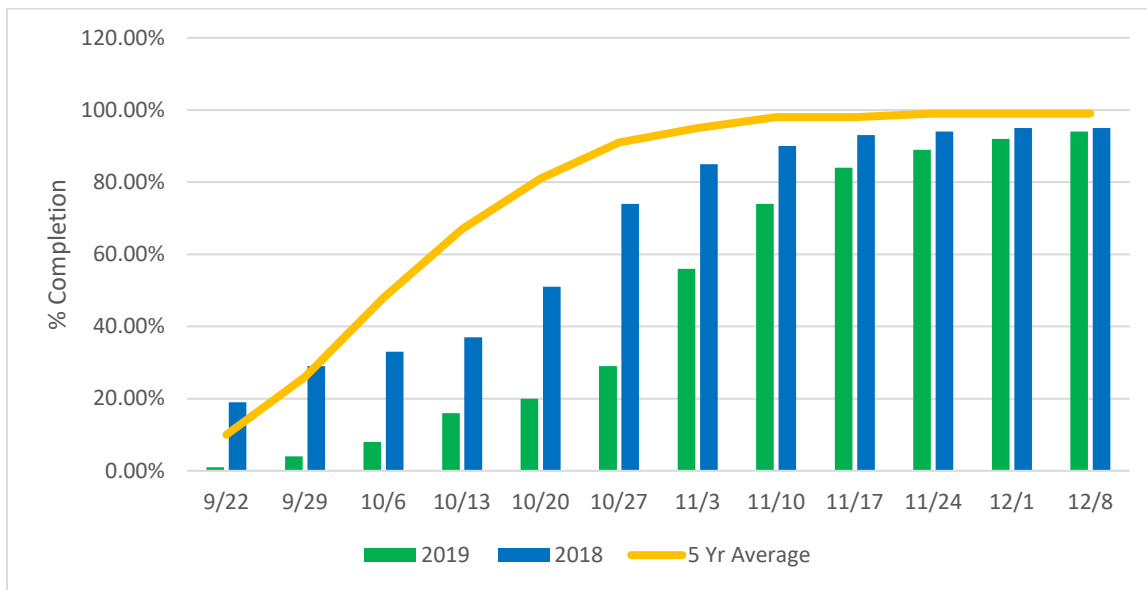
Figure 5. Harvest progress of 2019 North Dakota soybeans presented by % completion

2019 North Dakota Soybean Quality Results

A summary of the 2019 ND soybean quality results is presented in Table 2 with average, maximum, minimum and standard deviation (STDEV) for each parameter. It is worth noting that the initial moisture content of samples received varied greatly from a minimum of 8.3% to a maximum of 22.7% with eight submitted samples above 20% moisture content.

	Average	Maximum	Minimum	STDEV
Proximate				
Moisture (%)	14.5	22.7	8.3	2.10
Test weight (lb/bu)	57.2	61.3	53.7	1.72
Protein[1]	33.5	36.3	28.1	1.21
Oil[1]	18.0	20.0	16.3	0.62
Fiber[2]	5.5	6.6	4.9	0.28
Ash[2]	5.1	5.5	4.8	0.11
Color				
L*	59.7	63.2	54.8	1.46
a*	3.8	5.3	2.1	0.59
b*	19.4	23.4	14.0	1.67
Fatty Acid				
Palmitic[2]	12.5	13.7	11.1	0.45
Stearic[2]	4.4	4.8	3.6	0.22
Oleic[2]	18.6	30.8	12.8	2.77
Linoleic[2]	59.4	66.9	51.4	2.77
Linolenic[2]	12.3	14.2	10.0	0.71
Soluble Sugars				
Sucrose[2]	7.0	8.3	4.4	0.58
Raffinose[2]	0.6	0.8	0.4	0.10
Stachyose[2]	4.1	4.6	3.3	0.28
Amino Acid				
Aspartic acid[2]	4.0	4.4	3.4	0.15
Threonine[2]	1.4	1.5	1.3	0.04
Serine[2]	1.7	1.8	1.4	0.06
Glutamic acid[2]	6.0	6.7	4.8	0.27
Proline[2]	1.6	1.7	1.3	0.06
Glycine[2]	1.5	1.6	1.3	0.05
Alanine[2]	1.6	1.7	1.4	0.04
Cysteine[2]	0.5	0.6	0.5	0.02
Valine[2]	1.8	1.9	1.5	0.06
Methionine[2]	0.5	0.5	0.5	0.01
Isoleucine[2]	1.6	1.8	1.4	0.06
Leucine[2]	2.7	2.9	2.3	0.09
Tyrosine[2]	1.3	1.4	1.1	0.04
Phenylalanine[2]	1.8	1.9	1.5	0.06
Lysine[2]	2.5	2.7	2.2	0.06
Histidine[2]	0.9	1.0	0.8	0.03
Arginine[2]	2.5	2.9	1.9	0.13
Tryptophan[2]	0.5	0.6	0.4	0.03
[1]-13% moisture basis, [2]-percent dry matter basis				

Table 2. Summary of 2019 North Dakota soybean with average, maximum, minimum and standard deviation (STDEV)

Soybean Quality Results Comparison by Year

Comparison of soybean quality by crop year from 2010 to 2019 is presented in Table 3. Average moisture of initially submitted 2019 crop is 14.5%, 2.2 and 2.9 percentage points higher than the previous year and the 10-year average, respectively. Test weight is 57.2 pounds per Bu, 0.2 percentage points lower than the previous year and the 10-year average, respectively. Protein content is 33.5%, which is 0.3 percentage points higher than the previous year and 0.2 percentage points higher than the 10-year average. A relatively large rebound is seen within oil results where the 2019 average is 1.4 percentage points higher than the previous year and is equal to the 10-year average.

The fatty acids, palmitic, linoleic, and linolenic acids, are higher in 2019 than samples tested for 2018 and the 10-year average. The fatty acids, stearic and oleic acids, are lower in 2019 than samples tested for 2018 and the 10-year average. The most notable increases in fatty acids are for the essential fatty acids, linoleic and linolenic acids. Linoleic acid in 2019 is 2.0 percent higher than 2018 and is 0.5 percent higher than the 10-year average. Linolenic acid in 2019 is 2.9 percent higher than 2018 and is 2.8 percent higher than the 10-year average.

Soluble sugars in 2019 are lower than the previous year and are higher than the 10-year average. Stachyose content is 1.9 percentage points lower than the previous year and equal to the 10-year average.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	AVG[3]	STDEV
Proximate												
Moisture (%)	9.8	9.7	9.2	13.2	12.7	10.6	12.3	11.5	12.3	14.5	11.6	1.7
Test weight (lb/bu)	57.6	57.2	57.1	56.8	57.6	57.6	57.8	57.3	57.4	57.2	57.4	0.3
Protein[1]	31.4	34.6	33.2	32.9	33.7	33.4	33.7	33.5	33.2	33.5	33.3	0.8
Oil[1]	18.6	18.1	18.0	18.1	16.5	17.1	16.8	19.4	16.6	18.0	18.0	1.3
P + O average[1]	50.0	52.7	51.2	51.0	50.2	50.6	50.5	52.9	49.8	51.5	51.3	1.5
Fiber[2]	5.7	5.1	5.6	11.4	13.7	7.0	6.9	6.4	7.9	5.5	7.5	2.8
Ash[2]	4.2	5.2	5.0	5.3	5.1	5.4	5.1	5.1	4.9	5.1	5.0	0.3
Fatty Acid												
Palmitic[2]	11.3	11.0	12.4	11.4	11.0	12.4	12.6	11.4	12.2	12.5	11.8	0.6
Stearic[2]	4.1	4.9	5.0	4.6	3.8	4.3	5.3	4.7	5.3	4.4	4.7	0.5
Oleic[2]	20.9	20.0	21.8	19.2	15.8	20.3	20.8	19.5	22.9	18.6	20.0	1.9
Linoleic[2]	54.0	53.2	52.0	51.9	55.0	51.5	59.0	50.9	57.4	59.4	54.4	3.2
Linolenic[2]	8.7	9.9	7.7	9.4	10.7	8.4	9.5	8.8	9.4	12.3	9.5	1.3

Soluble sugar												
Sucrose[2]	6.5	6.6	5.5	6.1	7.3	6.1	6.4	6.4	7.2	7.0	6.5	0.5
Raffinose[2]	0.4	0.5	0.5	0.6	0.6	0.6	0.5	0.5	0.5	0.6	0.5	0.1
Stachyose[2]	4.1	5.5	1.8	5.9	3.6	2.8	4.3	2.9	6.0	4.1	4.1	1.4
[1]-13% moisture basis, [2]-percent dry matter basis [3]-10-year average												

Table 3. Proximate, fatty acid and soluble sugar content of 2019 North Dakota soybean between 2010 and 2019 with average and standard deviation (STDEV)

Amino Acids

Comparison of 18 amino acids between 2018 and 2019 along with 10-year average and standard deviation (STDEV) are presented in Table 4. Table 8, later in this survey, presents amino acids by ND agricultural districts. Table 4 also lists total amino acids as well as the sum of 5 and 10 essential amino acids and critical amino acid values. These values can be used as an indicator of protein *quality* whereas crude protein percentage indicates protein *quantity*.

Northern grown soybeans especially in the four-state-region (MN, MT, ND and SD) tend to have a favorable essential amino acid profile. Research indicates that soybeans with lower crude protein content tend to have a higher proportion of the 5 essential amino acids (5 EAA: Threonine, Cysteine, Methionine, Lysine, and Tryptophan) (Miller-Garvin and Naeve, 2018). The value for 5 EAA in 2019 is 15.7% which is 0.7 and 0.8 percentage points higher than the 2018 and 10-year average, respectively, and crude protein content is 0.2 percent higher than the 10-year average. The 10 EAA value in 2019 is higher than last year and the 10-year average. The critical amino acid value is slightly lower than the previous year as well as the 10-year average.

	2018	2019	AVG[5]	STDEV
Aspartic acid[1]	4.3	4.0	4.3	0.2
Threonine[1]	1.5	1.4	1.5	0.0
Serine[1]	1.8	1.7	1.7	0.1
Glutamate[1]	6.7	6.0	6.7	0.5
Proline[1]	2.0	1.6	1.9	0.1
Glycine[1]	1.7	1.5	1.6	0.1
Alanine[1]	1.6	1.6	1.7	0.1
Cysteine[1]	0.6	0.5	0.6	0.1
Valine[1]	1.8	1.8	1.9	0.1
Methionine[1]	0.5	0.5	0.5	0.0
Isoleucine[1]	1.8	1.6	1.8	0.1
Leucine[1]	2.9	2.7	3.0	0.2
Tyrosine[1]	1.4	1.3	1.4	0.1
Phenylalanine[1]	2.0	1.8	2.0	0.1
Lysine[1]	2.5	2.5	2.5	0.2
Histidine[1]	1.0	0.9	1.0	0.1
Arginine[1]	2.7	2.5	2.8	0.1
Tryptophan[1]	0.4	0.5	0.4	0.1
Total AA[2]	37.4	34.4	37.4	1.7
5 EAA[3] (% of 18 AA)	15.0	15.7	14.9	0.5
10 EAA[4] (% of 18 AA)	40.5	41.3	40.9	0.7
Critical amino acid value	4.5	4.4	4.5	0.2

[1]-Percent dry matter basis, [2]-Sum of 18AA, [3]-Sum of threonine, cysteine, methionine, lysine, tryptophan, [4]-Sum of the 5 EAA plus valine, isoleucine, leucine, phenylalanine and histidine, [5]-10-year average

Table 4. Amino acid contents of 2019 North Dakota soybean in 2018 and 2019 with average and standard deviation (STDEV)

Protein

A summary of crude protein percentage between 2010 and 2019 along with 10-year average of the U.S. and ND soybeans is presented in Figure 6. Soybean protein content in 2019 by agricultural districts is shown in Table 5. The 2019 soybean protein content average was 0.2 percentage point higher than 2018 and equal to the 10-year average. The 2019 North Dakota soybean protein content average was 0.9 percentage point lower than the US average.

Figure 6. Percent protein (13% moisture basis) of North Dakota soybean between 2010 and 2019 and the 10-year average of ND and the U.S.

Oil

A summary of oil percentage between 2010 and 2019 along with the 10-year average of the U.S. and ND soybeans is presented in Figure 7. Soybean oil content in 2019 by agricultural districts is shown in Table 5. The difference between the U.S. and ND average is 0.9 percentage points and the 2019 oil percentage is 1.4 percentage points higher than the previous year.
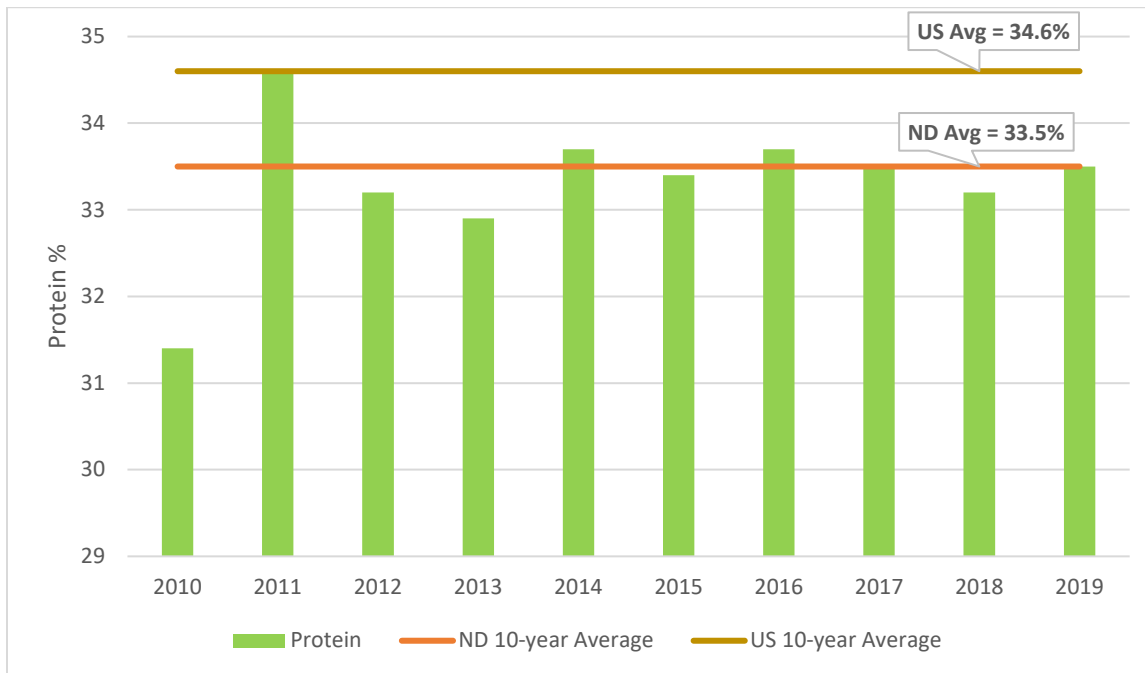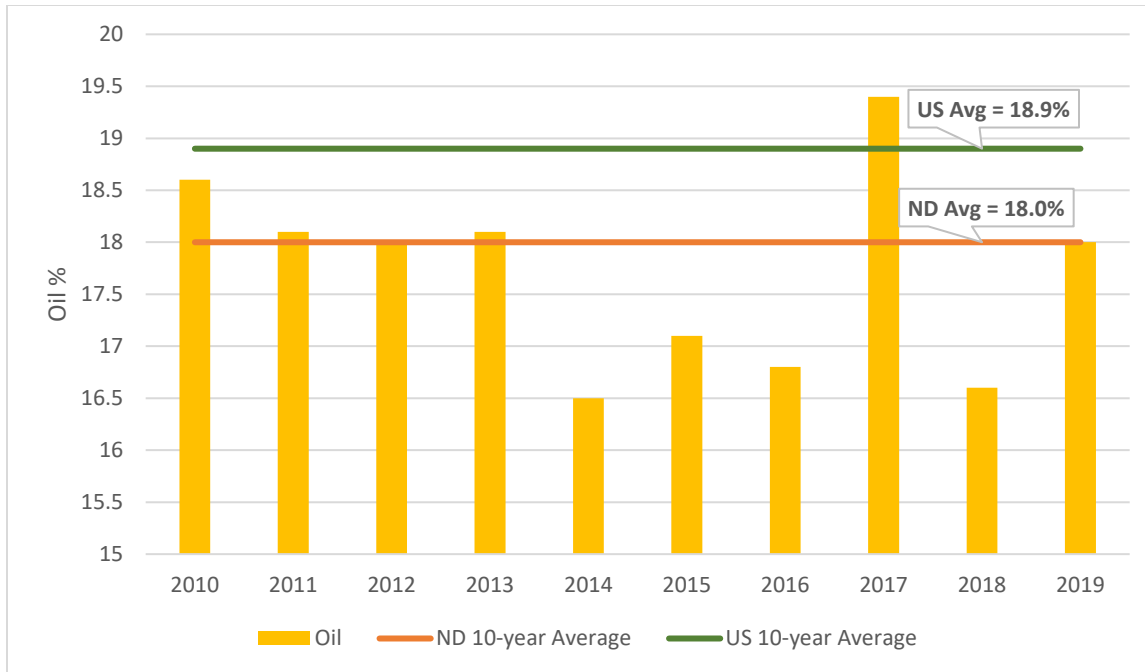
Figure 7. Percent oil (13 % moisture basis) of North Dakota soybean between 2010 and 2019 and the 10-year averages of ND and the U.S.

Fatty Acids

Comparison of fatty acid content by year is provided in Table 3, and comparison of averages by ND agriculture districts is provided in Table 6. Table 3 shows the 2019 crop has an increase in fatty acids are for the essential fatty acids, linoleic and linolenic acids. Linoleic acid in 2019 is 2.0 percent higher than 2018 and is 0.5 percent higher than the 10-year average. Linolenic acid in 2019 is 2.9 percent higher than 2018 and is 2.8 percent higher than the 10-year average.

Comparing across districts, the unsaturated fatty acids (Oleic, Linoleic and Linolenic) are the major fatty acids that impact nutrition through the consumption of soybeans. There is more variation across the districts with the unsaturated fatty acids compared to the saturated fatty acids (Palmitic and Stearic).

Soluble Sugars

A year by year comparison of soluble sugar content is provided in Table 3 and comparison of soluble sugar averages by ND agriculture districts is provided in Table 7. Soluble sugars in 2019 are lower than the previous year and are higher than the 10-year average. Stachyose content is 1.9 percentage points lower than the previous year and equal to the 10-year average.

Both sucrose and stachyose have increased yet raffinose remained the same from the previous year and the 10-year average. The 2018 average of stachyose was at 6.0%, which was 2.9 percentage points higher than 2019. Comparison by districts shows sucrose values of 2018 crops ranged from 6.8% to 7.3% whereas stachyose values ranged from 3.9% to 4.2%.

2019 North Dakota Soybean Quality by Agricultural Districts

A summary of proximate, protein, oil, fiber, ash, fatty acids, soluble sugars and fatty acids across North Dakota agricultural districts are presented in Table 5, 6, 7, and 8, respectively.

	District	CENT	EC	NC	NE	NW	SC	SE	WC	SW
Protein[1]	2019	33.7	33.7	32.9	32.7	33.5	33.5	33.9	32.0	33.4
	Average[3]	33.5	33.4	32.9	33.0	33.1	33.2	33.5	33.4	33.4
	STDEV	0.7	0.9	1.0	0.7	1.0	1.2	0.9	1.5	--
Oil[1]	2019	17.6	17.7	18.3	18.1	18.2	18.3	17.9	19.0	18.0
	Average[3]	17.8	18.0	18.0	18.0	17.5	19.6	19.7	19.0	18.0
	STDEV	1.3	1.4	1.4	1.2	1.5	5.1	5.2	4.8	--
Fiber[2]	2019	5.5	5.5	5.5	5.5	5.4	5.5	5.5	5.5	5.7
	Average[3]	7.5	7.5	7.5	7.5	7.1	7.6	7.5	7.5	5.7
	STDEV	2.9	2.8	2.8	2.8	2.6	2.8	2.8	2.9	--
Ash[2]	2019	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
	Average[3]	5.0	5.0	5.0	5.0	5.0	5.0	5.1	5.0	5.1
	STDEV	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	--
[1]-13% moisture basis, [2]- Percent dry matter basis [3]-10-year average										

Table 5. Proximate of 2019 North Dakota soybeans as well as 10-year average and standard deviation (STDEV) by the North Dakota agricultural districts

	Districts	CENT	EC	NC	NE	NW	SC	SE	WC	SW
Palmitic[2]	2019	12.6	12.5	12.4	12.4	12.5	12.4	12.5	12.3	12.6
	Average[3]	11.8	11.8	11.8	11.7	11.9	11.9	11.9	11.7	12.6
	STDEV	0.7	0.6	0.7	0.8	0.9	0.7	0.6	0.6	--
Stearic[2]	2019	4.4	4.3	4.5	4.4	4.6	4.4	4.3	4.4	4.5
	Average[3]	4.6	4.6	4.7	4.7	4.7	4.7	4.6	4.6	4.5
	STDEV	0.5	0.5	0.6	0.5	0.7	0.5	0.5	0.6	--
Oleic[2]	2019	18.6	18.0	17.9	17.6	18.5	18.6	19.4	19.8	20.1
	Average[3]	19.8	19.9	19.8	19.7	19.4	20.4	20.0	19.9	20.1
	STDEV	2.2	2.2	2.5	2.2	2.6	2.6	1.7	2.3	--
Linoleic[2]	2019	58.8	59.8	60.2	60.0	59.5	59.8	58.9	59.2	58.8
	Average[3]	54.4	54.6	54.3	54.5	54.9	54.0	54.5	54.2	58.8
	STDEV	3.1	3.4	3.2	3.4	2.8	3.1	3.2	3.0	--
Linolenic[2]	2019	12.5	12.4	12.1	12.3	11.8	11.7	12.4	11.7	11.9
	Average[3]	9.7	9.4	9.5	9.6	9.7	9.3	9.4	9.7	11.9
	STDEV	1.3	1.4	1.3	1.2	1.1	1.3	1.4	1.2	--
[1]-13% moisture basis, [2]- Percent dry matter basis [3]-10-year average										

Table 6. Fatty acids of 2019 North Dakota soybeans along with 10-year average and standard deviation (STDEV) by North Dakota agricultural districts

District		CENT	EC	NC	NE	NW	SC	SE	WC	SW
Sucrose[2]	2019	7.2	7.1	7.1	7.1	7.0	6.9	6.8	7.3	7.1
	Average[3]	6.6	6.4	6.7	6.7	6.9	6.6	6.3	6.7	7.1
	STDEV	0.5	0.6	0.6	0.4	0.7	0.6	0.6	0.8	--
Raffinose[2]	2019	0.6	0.6	0.7	0.6	0.7	0.7	0.6	0.7	0.5
	Average[3]	0.5	0.5	0.6	0.5	0.6	0.6	0.5	0.6	0.5
	STDEV	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	--
Stachyose[2]	2019	4.1	4.1	4.1	4.1	4.1	4.2	4.1	4.1	3.9
	Average[3]	4.3	4.2	4.4	4.3	4.2	4.3	4.2	4.3	3.9
	STDEV	1.6	1.7	1.6	1.6	1.6	1.7	1.7	1.6	--
[1]-13% moisture basis, [2]- Percent dry matter basis [3]-10-year average										

Table 7. Soluble sugar of 2019 North Dakota soybeans as well as 10-year average and standard deviation (STDEV) by North Dakota agricultural districts

Amino acid	District	CENT	EC	NC	NE	NW	SC	SE	WC	SW
Aspartic acid[2]	2019	4.0	4.1	4.0	3.9	4.0	4.0	4.1	3.8	4.0
	Average[3]	4.3	4.3	4.2	4.3	4.2	4.3	4.3	4.3	4.0
	STDEV	0.2	0.1	0.2	0.2	0.1	0.2	0.2	0.2	--
Threonine[2]	2019	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
	Average[3]	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.4
	STDEV	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.1	--
Serine[2]	2019	1.7	1.7	1.6	1.6	1.7	1.7	1.7	1.6	1.7
	Average[3]	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	STDEV	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	--
Glutamic acid[2]	2019	6.1	6.0	5.9	5.8	6.0	6.0	6.1	5.7	6.0
	Average[3]	6.7	6.7	6.6	6.6	6.5	6.6	6.6	6.7	6.0
	STDEV	0.5	0.5	0.4	0.5	0.3	0.5	0.3	0.6	--
Proline[2]	2019	1.6	1.6	1.5	1.6	1.6	1.6	1.6	1.5	1.6
	Average[3]	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.6
	STDEV	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2	--
Glycine[2]	2019	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.5
	Average[3]	1.6	1.7	1.6	1.6	1.6	1.6	1.7	1.6	1.5
	STDEV	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	--
Alanine[2]	2019	1.6	1.6	1.5	1.5	1.6	1.6	1.6	1.5	1.6
	Average[3]	1.7	1.7	1.6	1.6	1.6	1.6	1.7	1.6	1.6
	STDEV	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	--
Cysteine[2]	2019	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Average[3]	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5
	STDEV	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	--
Valine[2]	2019	1.8	1.8	1.7	1.7	1.8	1.8	1.8	1.7	1.8
	Average[3]	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8
	STDEV	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	--
Methionine[2]	2019	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Average[3]	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	STDEV	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--

Isoleucine[2]	2019	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.6	1.6
	Average[3]	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.6
	STDEV	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	--
Leucine[2]	2019	2.7	2.7	2.7	2.6	2.7	2.7	2.7	2.6	2.7
	Average[3]	3.0	3.0	3.0	3.0	2.9	3.0	3.0	3.0	2.7
	STDEV	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	--
Tyrosine[2]	2019	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.3
	Average[3]	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3
	STDEV	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.1	--
Phenylalanine[2]	2019	1.8	1.8	1.7	1.7	1.8	1.8	1.8	1.7	1.8
	Average[3]	2.0	2.0	1.9	1.9	1.9	2.0	2.0	2.0	1.8
	STDEV	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	--
Lysine[2]	2019	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.4	2.5
	Average[3]	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.5
	STDEV	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	--
Histidine[2]	2019	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
	Average[3]	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	0.9
	STDEV	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	--
Arginine[2]	2019	2.5	2.5	2.4	2.4	2.5	2.5	2.5	2.3	2.5
	Average[3]	2.8	2.8	2.7	2.7	2.7	2.8	2.8	2.8	2.5
	STDEV	0.2	0.1	0.2	0.2	0.1	0.2	0.1	0.2	--
Tryptophan[2]	2019	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	Average[3]	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5
	STDEV	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	--

[1]-13% moisture basis, [2]- Percent dry matter basis [3]-10-year average

Table 8. Amino acid of 2019 North Dakota soybean as well as 10-year average and standard deviation (STDEV) by North Dakota agricultural districts

Acknowledgements

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