United States Food Soybean Quality

# Annual Report 2015

Dr. Jill Miller-Garvin and Dr. Seth L. Naeve

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# FOOD QUALITY REPORT: 2015

## SUMMARY

The American Soybean Association has supported a survey of the quality of the US commodity soybean crop since 1986. That survey is intended to provide new crop quality data to aid international customers with their purchasing decisions. The Food Soybean Survey was conducted for the first time in 2007, and is intended to assist international buyers, as well as to provide producers valuable information about the quality of these specialty soybeans. Due to both the wide range of food bean types (tofu, natto, edamame, etc.) and the range of varieties grown for each type in different geographic regions of the US, it is difficult to provide generalized conclusions regarding the 2015 United States food soybean crop as a whole. This report provides state by state food soybean quality information (protein and oil), regional quality averages by seed size, and quality trends for the entire US food soybean crop. The commodity soybean crop information is provided as a guide for better understanding the regional environmental influences affecting both commodity and food soybean crops.

## 2015 ACREAGE, YIELDS, AND TOTAL PRODUCTION

According to the November 2015 United States Department of Agriculture, National Agricultural Statistics Service (USDA-NASS) Crop Production report, area harvested and yields will change only slightly from 2014. The total US soybean harvested area decreased by 1% to 33.4 million hectares (Table 1). Average yield remained at 3.2 MT per hectare. Together, 2015 yield and area harvested will result in a US crop that is about 0.65% higher than the record 2014 crop. The USDA expects the US crop to be 108.5 million MT.

## QUALITY OF THE 2015 US FOOD SOYBEAN CROP

Participating companies provided a total of 265 samples by December 1, 2015. Samples were analyzed for protein and oil concentration by near infrared spectroscopy (NIRS) using a Perten DA7250 diode array instrument (Huddinge, Sweden) equipped with calibration equations developed at the University of Minnesota. The 265 samples were scanned ground. Additionally, we determined average seed size (grams per 100 seeds) for each sample. The

food soybean samples are grouped using the same categories as in the commodity soybean quality report. In 2015, we received food soybean samples from regions categorized as ECB (Eastern Corn Belt), WCB (Western Corn Belt), and MDS (Midsouth).

Average protein values for the food bean samples by region (Table 2) indicate that samples received from the WCB region (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota) had lower protein concentrations when compared with the samples received from the ECB growing region (Illinois, Indiana, Michigan, Ohio, and Wisconsin) and the samples from the MDS growing region (Arkansas and Texas); WCB protein averaged 35.6, ECB 36.2 and MDS 36.7. When we examined the protein concentration data using both regional and seed size categories to group the data (Table 3), the WCB-ECB protein differences were mixed. Protein was lower in the average-seeded WCB samples (35.6) compared to the average-seeded ECB samples (36.0). This lower WCB protein vs. ECB protein trend within the same seed size category was reversed for the large-seeded samples, such that large-seeded WCB protein of 37.6 was slightly higher than the large-seeded ECB protein of 36.8. The ranges in protein values for samples from the ECB were larger than for samples from the WCB for both average- and large-seeded samples. As is typical of what we have found in previous food soybean surveys, the small-seeded samples were lower in protein at 34.5 in the WCB and 36.4 in the MDS than in the other seed size categories within each region. Lower protein concentrations are desirable for making natto.

Overall, oil concentrations in the WCB, ECB, and MDS regions were identical at 18.9 (Table 2), and when the data were grouped by seed size category and region (Table 3), the average-seeded WCB, ECB, and MDS samples were very similar in oil (19.0, 19.1, and 18.9, respectively); however, the sample numbers in the three groups were not very comparable. Within the ECB region, oil concentrations were higher in the average-seeded samples than in the large-seeded samples, and that trend is the same in the WCB. Ranges in oil values in ECB samples were higher than in WCB samples.

## SOLUBLE SUGARS

In previous reports, we have noted that within a given region, sucrose concentrations are typically higher in the small-seeded samples than in the large- or average-seeded samples; this trend is evident in 2015 as well in the WCB and MDS regions. Typically we have found that more northerly WCB region samples had higher sucrose concentrations than samples from the more southerly ECB and MDS regions. In 2015, the sucrose concentrations in the WCB and ECB were virtually identical, and both were higher than sucrose in average-seeded samples from the MDS. Raffinose and stachyose concentrations were higher in the MDS region than in the WCB and ECB regions.

## AMINO ACIDS

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

In soybeans, those with lower crude protein have a higher proportion of the five most critical essential amino acids (lysine, cysteine, methionine, threonine, and tryptophan), (Thakur and Hurburgh, 2007; Medic et al., 2014; Naeve unpublished data). Table 5 contains amino acid data from the 2015 food soybean samples, grouped by seed size and growing region. Within the WCB, the trend for the sample size categories was the same: lower protein samples have higher concentrations of the five limiting essential amino acids. For example, in the WCB, the

average-seeded samples had an average protein of 35.6 compared to 37.6 for the large-seeded samples; the samples with the lower protein of 35.6 had higher concentrations of the five limiting essential amino acids (14.5), and the samples with the higher protein of 37.6 had lower concentrations of the five limiting amino acids (14.3). The protein in lower protein samples is more concentrated in those five amino acids than is the protein in higher protein samples. We have found this to be the case in the US commodity soybean survey results as well.

## US COMMODITY SOYBEAN SURVEY

The quality of the overall US soybean crop is estimated yearly by a separate project supported by the United States Soybean Export Council (USSEC) and the International Marketing Committee of the American Soybean Association (ASA-IM). By the end of August, sample kits were mailed to 5,094 producers that were selected based on total land devoted to soybean production in each state, so that response distribution would closely match projected soybean production. By 4 December, 2015, 1,789 samples were received. These 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. 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.

Overall, the 2015 US soybean crop quality, as measured by protein and oil concentration, increased significantly from that of the excellent 2014 crop. Although protein concentrations were similar to those in 2014, oil concentration was higher in every region of the US. Due to a unique set of weather conditions, there tended to be less variation in both protein and oil than is evident in most years. Compared with the long-term average, 2015 US soybeans were 0.8 of a point lower in protein, but 1.0 percentage points higher in oil.

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Average US soybean protein concentration was only 0.1 percentage points lower in 2015, at 34.3%; however, average US oil concentration was 1.1 percentage points higher at 19.7% when compared with 2014. This oil level represents a record high for US soybeans, and will allow soybean processors to simultaneously achieve both high soybean oil yields and good protein concentrations in soybean meal produced. As is noted in most years, WCB states showed lower protein concentrations than the US crop as a whole but differences were much smaller in 2015; WCB oil was near the US average. Soybeans grown in the ECB were lower in protein than usual, and their protein concentration was very similar to the national average. Nearly every state in the ECB region produced much lower protein soybeans than in 2014. The MDS, SE, and EC had higher protein concentrations than the US average. Regional oil levels increased over 2014 levels from 0.6 percentage points in the MDS to 1.5 percentage points in the EC region. In the WCB region, where proteins were similar to 2014, average oil values increased by 1.1 percentage points. Oil levels increased by 1.3 points (a 7% increase) in the ECB, covering some of the losses from lower protein values in this region. A dramatic example of this is Wisconsin, where oil increased by 1.7 points while protein dropped by 0.6 points. Another extreme example is North Dakota where protein increased by 0.3 points and oil increased by 1.5. This change will make these normally protein-challenged soybeans quite valuable to processors.

Warm and dry late-season conditions resulted in a drier soybean crop than in 2014. In fact, average moisture levels of incoming samples were lower in every region compared with last year. The average moisture of samples received in 2015 was 11.6%, down 0.8 percentage points from 2014. Western Corn Belt and Midsouth soybeans tended to be the driest of all of the regions, so protein and oil levels on an as-is basis tended to increase the most in those regions. For WCB soybeans, an as-is composition of 34.8% protein and 20.0% oil is quite extraordinary for a region that generally produces low protein soybeans.

The 2015 commodity soybean amino acid results were similar to those found in 2014, in that there was little regional variation for lysine (expressed as a percent of the 18 primary amino acids). Additionally, in 2015 there was little regional variation for the five most limiting amino acids (cysteine, lysine, methionine, threonine, and tryptophan), with the WCB, ECB, MDS, and SE at 14.6 and the EC at 14.5. 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 amino acid concentration differences across regions, rather than region *per se*.

## WEATHER AND CROP SUMMARY

*Planting:* In late April and early May, northern parts of the US Midwest were dry and warm, allowing growers to complete fieldwork and planting earlier than average; soybean planting in Minnesota and Wisconsin was nearly 20% ahead of the 5-year average for those states. However, in late May, heavy rainfall moved into the upper Midwest (Weather Figure 1), and in June lingered in parts of the ECB, WCB, EC, and the MDS, leading to flooding and delays in fieldwork in parts of those regions. The contiguous US experienced its wettest May on record (Weather Figure 1). By June 7, 79% of the nation's soybean crop was planted, 7% behind 2014, likely due to the excess rainfall.

*Mid-Season:* July was cooler and wetter than average for many soybean-growing states, particularly in the middle of the US soybean-growing region; the Midwest region had its 8$^{th}$ wettest July on record. August was cooler than average, and the excessive rainfall ended, but conditions then became much drier than normal, especially in the ECB and EC, further stressing plants that had earlier been flooded.

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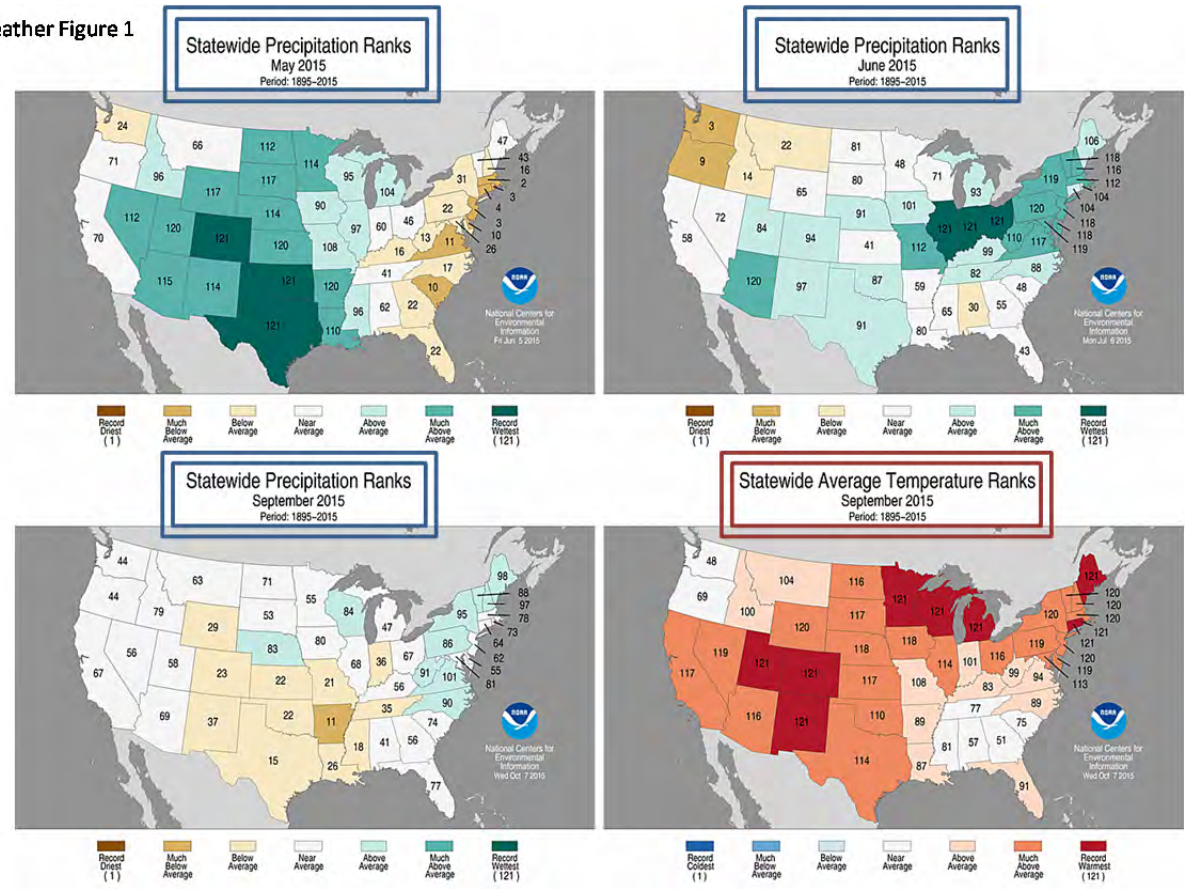
*Harvest:* September temperatures for the Midwest were among the warmest on record; those higher than average September temperatures, combined with dry conditions in most areas west of the Mississippi River (Weather Figure 1), led to rapid harvest progress. By October 25, growers harvested 87% of the US soybean crop, 19% points more than the same time period in 2014.

Overall, weather during the 2015 growing season was generally wetter than normal in some large soybean-producing states, then turned drier and warmer than average in September, though some states did experience near ideal growing conditions.

**Weather Figure 1**



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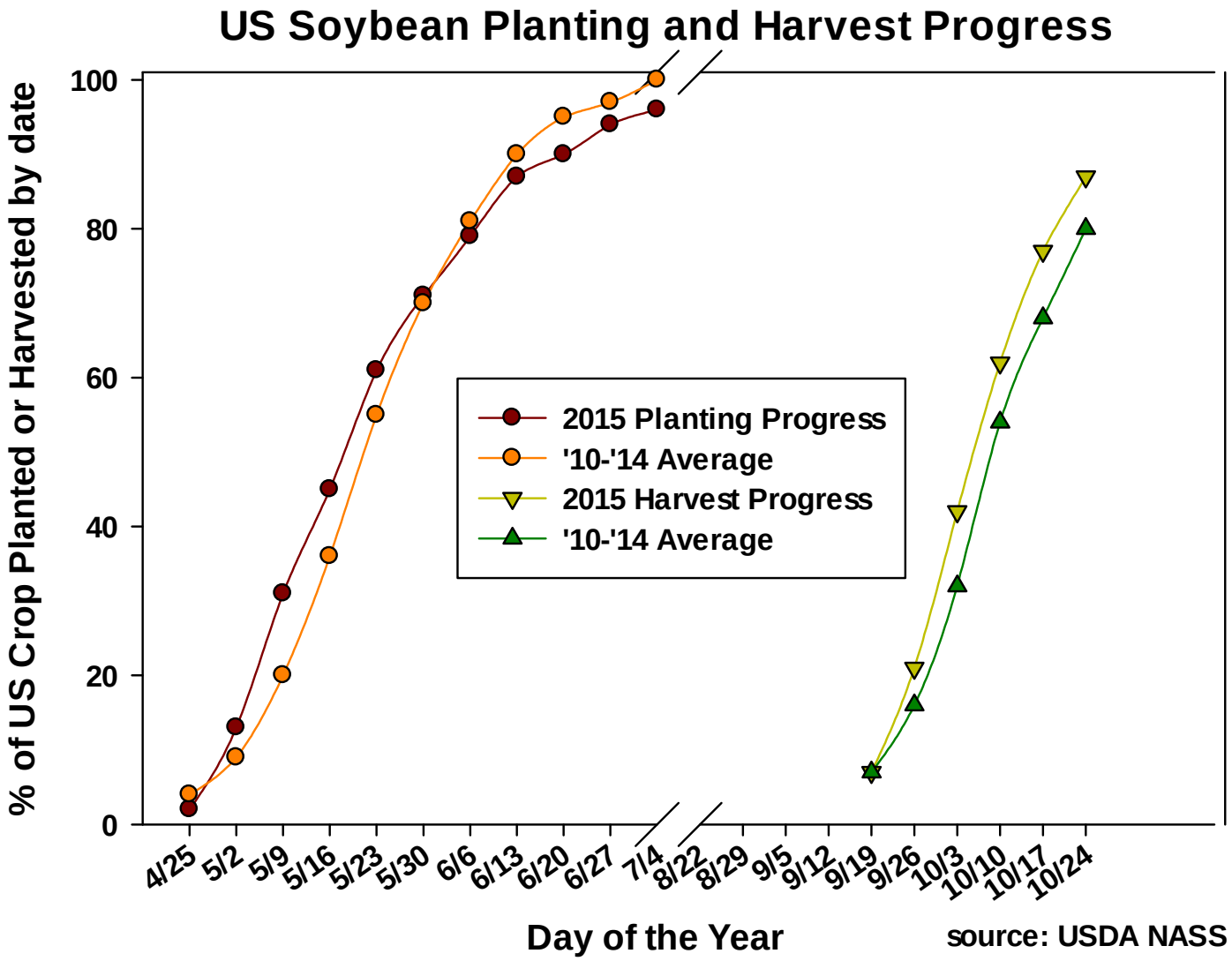
US Soybean Planting and Harvest Progress
% of US Crop Planted or Harvested by date
100
80
60
40
20
0
2015 Planting Progress
'10-'14 Average
2015 Harvest Progress
'10-'14 Average
4/25
5/2
5/9
5/16
5/23
5/30
6/6
6/13
6/20
6/27
7/4
8/22
8/29
9/5
9/12
9/19
9/26
10/3
10/10
10/17
10/24
Day of the Year
source: USDA NASS

Figure 1

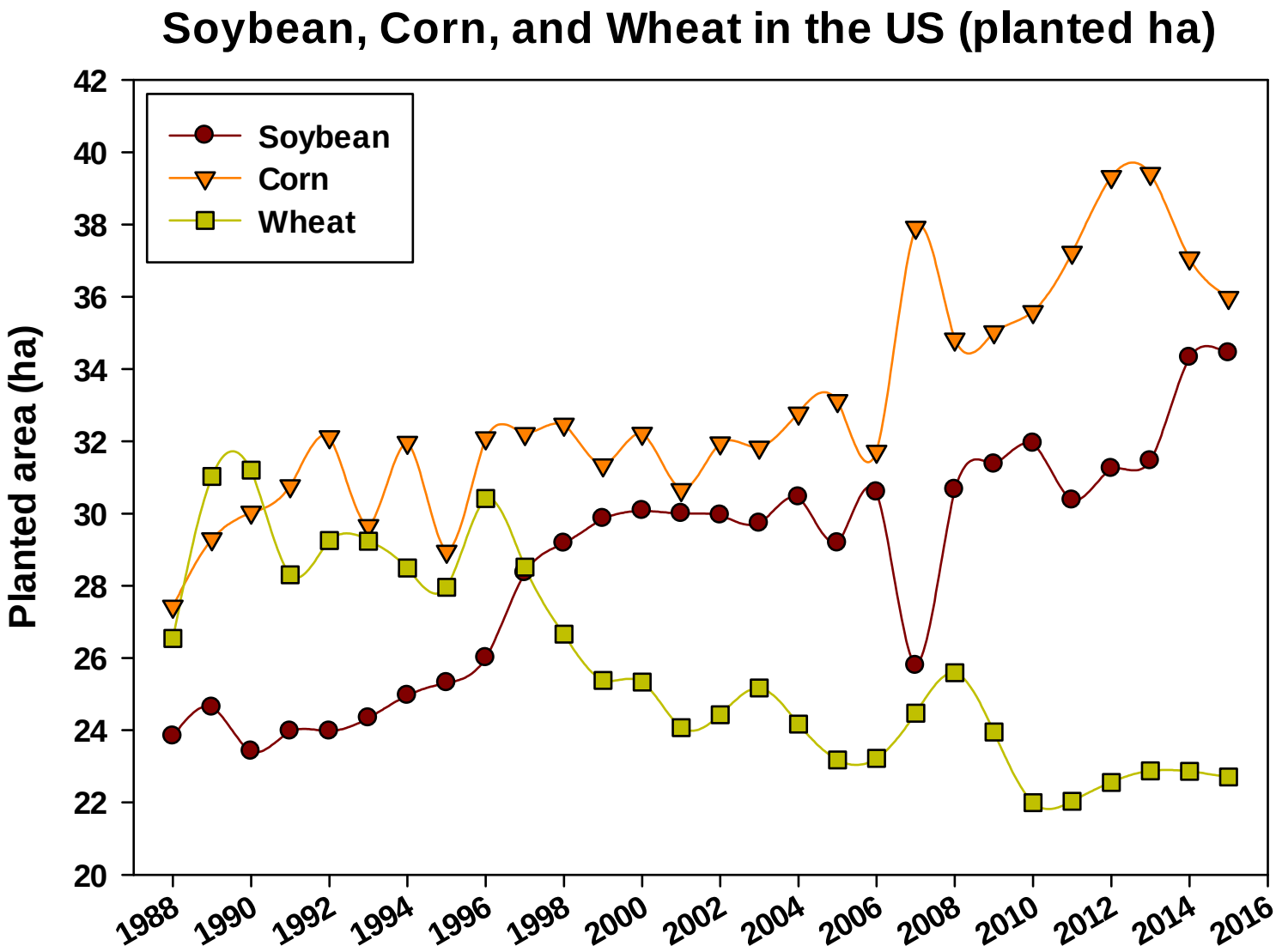
Soybean, Corn, and Wheat in the US (planted ha)
Planted area (ha)
Soybean
Corn
Wheat
42
40
38
36
34
32
30
28
26
24
22
20
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016

Figure 2

**Table 1. Soybean production data for the United States, 2015 crop**

| Region | State | Yield (MT ha$^{-1}$) | Area Harvested (1000 ha) | Production (M MT) |
|---|---|---|---|---|
| Western Corn Belt (WCB) | Iowa | 3.8 | 3,977 | 15.0 |
| | Kansas | 2.6 | 1,580 | 4.0 |
| | Minnesota | 3.4 | 3,070 | 10.3 |
| | Missouri | 2.9 | 1,871 | 5.4 |
| | Nebraska | 3.8 | 2,106 | 7.9 |
| | North Dakota | 2.2 | 2,337 | 5.2 |
| | South Dakota | 3.1 | 2,070 | 6.4 |
| | Western Corn Belt | 3.1 | 17,010 | 54.3 |
| | | | | 50.0% |
| Eastern Corn Belt (ECB) | Illinois | 3.8 | 3,981 | 15.0 |
| | Indiana | 3.4 | 2,260 | 7.8 |
| | Michigan | 3.2 | 826 | 2.7 |
| | Ohio | 3.4 | 1,940 | 6.5 |
| | Wisconsin | 3.4 | 753 | 2.5 |
| | Eastern Corn Belt | 3.4 | 9,761 | 34.5 |
| | | | | 31.8% |
| Midsouth (MDS) | Arkansas | 3.4 | 1,280 | 4.4 |
| | Kentucky | 3.5 | 737 | 2.6 |
| | Louisiana | 2.8 | 571 | 1.6 |
| | Mississippi | 3.1 | 923 | 2.9 |
| | Oklahoma | 1.9 | 154 | 0.3 |
| | Tennessee | 3.2 | 701 | 2.2 |
| | Texas | 2.2 | 47 | 0.1 |
| | Midsouth | 2.9 | 4,412 | 14.0 |
| | | | | 12.9% |
| Southeast (SE) | Alabama | 2.8 | 198 | 0.6 |
| | Georgia | 3.0 | 130 | 0.4 |
| | North Carolina | 2.3 | 733 | 1.7 |
| | South Carolina | 1.9 | 188 | 0.4 |
| | Southeast | 2.5 | 1,249 | 3.0 |
| | | | | 2.7% |
| East Coast (EC) | Delaware | 2.9 | 68 | 0.2 |
| | Maryland | 3.0 | 205 | 0.6 |
| | New Jersey | 2.3 | 42 | 0.1 |
| | New York | 3.1 | 122 | 0.4 |
| | Pennsylvania | 3.1 | 241 | 0.7 |
| | Virginia | 2.5 | 251 | 0.6 |
| | East Coast | 2.8 | 928 | 2.6 |
| | | | | 2.4% |
| US 2015 | | 3.2 | 33,384 | 108.5 |
| US 2014 | | 3.2 | 33,778 | 107.8 |

Source: United States Department of Agriculture, NASS 2015 Crop Production Report (November 2015)

**Table 2. USSEC 2015 Food Soybean Quality Survey Protein and Oil Data by State and Region[§]**

| State (# of samples) | Region | Protein [*] (%) | Protein Range | Regional Protein Average | Oil [*] (%) | Oil Range | Regional Oil Average |
|---|---|---|---|---|---|---|---|
| Iowa (28) | WCB | 36.5 | 33.4 – 40.8 | | 18.6 | 17.1 – 19.9 | |
| Kansas (1) | WCB | 35.3 | | | 20.0 | | |
| Minnesota (50) | WCB | 35.6 | 31.7 – 39.5 | | 18.9 | 17.4 – 21.4 | |
| Missouri (3) | WCB | 34.6 | 32.8 – 35.9 | | 19.6 | 18.6 – 20.9 | |
| Nebraska (1) | WCB | 38.0 | | | 18.1 | | |
| North Dakota (20) | WCB | 34.5 | 31.1 – 37.3 | | 19.3 | 17.8 – 21.4 | |
| South Dakota (1) | WCB | 35.9 | | 35.6 | 18.9 | | 18.9 |
| Illinois (30) | ECB | 35.7 | 33.3 – 43.1 | | 19.3 | 15.7 – 21.2 | |
| Indiana (8) | ECB | 36.7 | 32.9 – 38.5 | | 19.2 | 18.2 – 20.3 | |
| Michigan (56) | ECB | 36.7 | 33.3 – 41.0 | | 18.3 | 16.5 – 20.1 | |
| Ohio (31) | ECB | 37.1 | 35.0 – 38.8 | | 19.1 | 17.8 – 20.1 | |
| Wisconsin (32) | ECB | 34.7 | 31.9 – 37.1 | 36.2 | 19.3 | 17.8 – 21.1 | 18.9 |
| Arkansas (1) | MDS | 35.3 | | | 19.3 | | |
| Texas (3) | MDS | 37.2 | 35.9 – 39.2 | 36.7 | 18.8 | 18.7 – 18.9 | 18.9 |

Data as of December 1, 2015

[§] WCB: Western Corn Belt; ECB: Eastern Corn Belt; MDS: Midsouth (see Table 1 for complete list of states included in these regions)

[*] 13% moisture basis

**Table 3. USSEC 2015 Food Soybean Quality Survey Protein and Oil by Seed Size[‡] & Region[§]**

| Region | Seed Size | Number Samples | Seed Size (g/100 seeds) | Protein[*] (%) | Protein Range | Oil[*] (%) | Oil Range |
|---|---|---|---|---|---|---|---|
| WCB | Small | 16 | 9.9 | 34.5 | 32.8 – 35.9 | 19.0 | 17.8 – 20.9 |
| | Average | 78 | 17.4 | 35.6 | 31.1 – 40.8 | 19.0 | 17.4 – 21.4 |
| | Large | 10 | 23.1 | 37.6 | 36.3 – 38.9 | 18.1 | 17.1 – 19.2 |
| ECB | Average | 110 | 17.6 | 36.0 | 31.9 – 43.1 | 19.1 | 15.7 – 21.2 |
| | Large | 47 | 23.1 | 36.8 | 33.5 – 38.8 | 18.5 | 17.3 – 20.1 |
| MDS | Small | 1 | 11.7 | 36.4 | | 18.9 | |
| | Average | 3 | 14.1 | 36.8 | 35.3 – 39.2 | 18.9 | 18.7 – 19.3 |

Data as of December 1, 2015

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

[§] WCB: Western Corn Belt (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota); ECB: Eastern Corn Belt (Illinois, Indiana, Michigan, Ohio, and Wisconsin); MDS: Midsouth (Arkansas and Texas)

[*] 13% moisture basis

**Table 4. USSEC 2015 Food Soybean Quality Survey Carbohydrate Data by Seed Size[‡] & Region[§]**

| Region | Seed Size | Number Samples | Seed Size Average (g/100 seeds) | Sucrose (% DM basis) | Raffinose (% DM basis) | Stachyose (% DM basis) |
|---|---|---|---|---|---|---|
| WCB | Small | 16 | 9.9 | 6.00 | 0.65 | 3.20 |
| | Average | 78 | 17.4 | 5.79 | 0.61 | 3.37 |
| | Large | 10 | 23.1 | 5.74 | 0.60 | 3.41 |
| ECB | Average | 110 | 17.6 | 5.70 | 0.63 | 3.47 |
| | Large | 47 | 23.1 | 5.73 | 0.60 | 3.42 |
| MDS | Small | 1 | 11.7 | 5.72 | 0.83 | 2.90 |
| | Average | 3 | 14.1 | 4.81 | 0.78 | 3.91 |

**Data as of December 1, 2015**

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

[§] **WCB: Western Corn Belt (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota); ECB: Eastern Corn Belt (Illinois, Indiana, Michigan, Ohio, and Wisconsin); MDS: Midsouth (Arkansas and Texas)**

**Table 5. USSEC 2015 Food Soybean Quality Survey Amino Acid (AA) Data by Seed Size[‡] & Region[§]**

| Region | Seed Size | Number Samples | Seed Size Average (g/100 seeds) | Protein[*] (%) | Lysine (% of 18AAs) | Five Limiting Essential[¶] Amino Acids (% of 18AAs) |
|---|---|---|---|---|---|---|
| WCB | Small | 16 | 9.9 | 34.5 | 6.68 | 14.6 |
| | Average | 78 | 17.4 | 35.6 | 6.62 | 14.5 |
| | Large | 10 | 23.1 | 37.6 | 6.58 | 14.3 |
| ECB | Average | 110 | 17.6 | 36.0 | 6.62 | 14.4 |
| | Large | 47 | 23.1 | 36.8 | 6.63 | 14.4 |
| MDS | Small | 1 | 11.7 | 36.4 | 6.54 | 14.2 |
| | Average | 3 | 14.1 | 36.8 | 6.65 | 14.5 |

Data as of December 1, 2015

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

[§] WCB: Western Corn Belt (Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota); ECB: Eastern Corn Belt (Illinois, Indiana, Michigan, Ohio, and Wisconsin); MDS: Midsouth (Arkansas and Texas)

[*] 13% moisture basis

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

## Contact Information

DR. SETH L. NAEVE
SOYBEAN EXTENSION AGRONOMIST

Naeve002@umn.edu

DR. JILL MILLER-GARVIN
SCIENTIST

mille443@umn.edu

University of Minnesota
Department of Agronomy & Plant Genetics
411 Borlaug Hall
1991 Upper Buford Circle
St. Paul, MN 55108

**Tel** 612-625-4298

**Fax** 612-624-3288

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