

## ***Soybean Checkoff-funded Research***

**Project Title:** Quality of the United States Soybean Crop: 2011

**Investigators:** Seth. L. Naeve, Dr. James H. Orf, and Tracy O'Neill

**Institutions:** Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108

**Reference:** American Soybean Association and U.S. Export Council, 16305 Swingley Ridge Road, Suite 200, Chesterfield, MO 63017

### **Summary**

The American Soybean Association and the 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.

### **2011 Acreage, Yields, and Total Production**

According to the 9 November, 2011 United States Department of Agriculture, National Agricultural Statistics Service (USDA-NASS) crop report, the total US soybean production area decreased slightly from last year to 29.8 million hectares harvested (Table 1). Average yields decreased as well, to 2.77 MT per ha. With a smaller production area than in 2010 and smaller yields, total US soybean production is estimated to be 83.0 million MT. This makes the 2011 crop 9% smaller than the crop of 2010.

### **Quality of the 2011 US Soybean Crop**

By 30 August, 2011 sample kits were mailed to 10,637 producers that were selected based on total land devoted to soybean production in each state, so that response distribution would closely match soybean production. By 22 December, 2011, 2047 samples were received. These were analyzed for protein, oil, and amino acid concentration by near-infrared spectroscopy (NIRS) using a Perten DA7200 diode array instrument (Huddinge, Sweden) equipped with calibration equations developed by Perten in cooperation with the University of Minnesota. Regional and national average quality values were determined by computing weighted averages using state and regional soybean production values, so that average values better represent the crop as a whole. Results are in Tables 2 and 3.

### **Interpretation of Protein and Oil Results**

Average protein and oil concentrations for the 2011 US soybean crop dropped slightly from that of the 2010 US crop and were both lower than the long-term US averages. Average US soybean protein concentration was 0.1 percentage points lower in 2011, at 34.9%, and average oil concentration was 0.5 percentage points lower at 18.1% when compared with 2010 (Table 4). As is noted in most years, Western Corn Belt states showed lower protein concentrations than the US crop as a whole. Soybeans grown in the Southeast and East Coast states tended to have higher protein concentrations. Midsouth, Southeastern, and East Coast states produced a

soybean crop with higher oil concentration than the main soybean production regions of the Eastern and Western Corn Belt.

Compared with the 2010 crop, protein concentrations from the Western and Eastern Corn Belt regions, decreased slightly. Protein levels increased slightly in the Midsouth, but were significantly higher in the Southeast and East Coast region. Oil concentrations were lower throughout all of the regions, except the MidSouth, where there was a slight increase.

As was the case in 2010, seed from the 2011 crop tended to be dryer than normal at harvest time. The average moisture of samples received in 2011 was 10.8%. The driest soybeans were found in the Western states (Kansas, Nebraska, and South Dakota). The Western Corn Belt region as a whole had average moisture levels of 10.1%. When protein levels are adjusted to an ‘as-is’ basis rather than a 13% moisture basis, the protein level of the average US soybean increased from 34.9 to 35.6%. Similarly, oil values increased from 18.1 to 18.5%, on an ‘as-is’ basis.

### **Interpretation of Seed Size 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. Seed size can also be correlated with changes in protein and oil concentration due to these same environmental conditions. 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.

In 2011, seed size was 8% larger than in 2010, with the average seed size increasing from 14.3 grams per 100 seeds in 2010 to 15.1 in 2011 (Table 3). Seed size tended to be largest in the East Coast region, where the soybean crop received abundant late-season rainfall.

### **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, or 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 formed by animals) – this is an “ideal protein”. Typically, feed diet formulation, seeking to achieve an ideal feed protein, is based on knowing crude protein then adding “insurance” levels of amino acids in order to avoid any amino acid shortage. Often this approach results in an excess of nitrogen compounds because the protein supply does not ideally match the animals’ needs; the excess is excreted and lost, and can pose an environmental contamination risk. Additionally, this approach involves higher production costs.

Preferably, the use of a high quality protein source with an excellent balance of amino acids to meet the most limiting amino acid requirements at a lower protein concentration is a far more efficient option than using a lower quality protein source. In a comparison of soybean meal from US and other origins, US 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). Although soybeans from the US are generally lower in crude protein, both US soybeans and soybean meal contained higher concentrations of essential amino acids (Thakur and Hurburgh, 2007), thus making their protein fraction of higher quality.

We have recently investigated the relative abundance of amino acids found in soybean protein within the US by evaluating Soybean Quality Survey samples from 2006-2009. We identified approximately 100 samples each year which collectively represented the US crop. These samples were evaluated with HPLC (High Performance Liquid Chromatography) for total amino acids. In 2009 and 2010, more than 1,500 samples were evaluated for total amino acids using NIRS. Lysine, expressed as percent of the protein, is evaluated since lysine is an often limiting amino acid in vegetarian diets. If the first limiting amino acid is not supplied in adequate amounts in feed diets, the remaining essential amino acids are not efficiently used. For these analyses we considered the ten essential amino acids to include: leucine, histidine, isoleucine, lysine, methionine and cysteine, phenylalanine, threonine, tryptophan, and valine. The eight non-essential amino acids included: alanine, arginine, aspartic acid, glutamic acid, glycine, proline, serine, and tyrosine. While the relative abundance of each of the amino acids varied from sample to sample and average values varied across years, the same general trends noted in previous work that compared US and Brazilian soybean samples was noted within US soybeans.

Soybean samples with lower crude protein levels tend to have a protein fraction that is enriched in essential amino acids relative to higher protein samples

The largest and most consistent increase in relative abundance of the essential amino acids appears to be lysine. In other words, lysine appears to be an important factor driving this increase in the sum of the essential amino acids in lower protein samples

### **2011 Amino Acid summary**

The 2011 amino acid results supported results obtained from previous years discussed above. When analyzed as a percent of crude protein, lysine appeared to be slightly more abundant in samples with lower overall protein concentrations, but this was not always the case in 2011. The sum of ten essential amino acids appeared to be a more consistent measure of protein quality. Soybean samples from Minnesota, Iowa, Missouri, and Illinois tended to have slightly higher levels of essential amino acids relative to other major soybean producing states.

### **Climate Summary**

Planting: precipitation for the period covering March, April, and May was 200% of normal from southwestern Missouri through the Ohio Valley. Temperatures were generally below normal in Iowa, Minnesota, and Wisconsin, and above normal farther south. In *May*, the temperature trend was generally cooler in the west and warmer in the east. Persistent wet weather and flooding impacted spring planting progress; at the end of May in Ohio only 7% of soybeans were planted compared to the average 76%. As of May 29, 51% of the intended US soybean acreage was

planted, 20% behind normal pace. Iowa and some other Midwestern areas, however, were ahead of the normal pace of planting and the soybean crop there benefited from frequent rains.

Mid-season: *June* precipitation was either 2 to 3x normal rainfall in parts of Iowa, Illinois, and Michigan or <50% of normal in Missouri and along the Michigan-Ohio border. Temperatures were slightly below normal in the northwest and above normal in the south. *July* was much warmer and more humid than normal across the Midwest. Missouri experienced its hottest month in more than 30 years. Flooding continued along the Missouri River in Iowa and Missouri in July. *August* rainfall was very variable across the Midwest, from <25% of normal to almost 200% of normal. Temperatures were mostly normal to above normal. A record drought continued throughout the summer in Texas, Oklahoma, Southern Kansas, and Western Louisiana. Drought conditions continued to intensify through the state of Georgia throughout the late summer. A moderate drought stressed the soybean crop from August through harvest time in Indiana, Illinois, Iowa, and Minnesota. This widespread drought had the largest effect on the US soybean crop of any weather event in 2011.

Harvest: *September* started out hot but ended cooler than average. In regions from Wisconsin and Illinois eastward through Ohio and Kentucky there was excessive rainfall, but in areas west of the Mississippi River rainfall was well below normal (Figure 1). In addition to the dry conditions, the upper Midwest had a freeze on September 15. At the time of the freeze, only a small proportion of the soybeans were fully mature and yield losses were realized. Growers were harvesting across much of the major soybean growing region by September 25. By *October 30*, 87% of the soybean crop had been harvested, 8% behind last year's pace but 8% ahead of the 5-year average (Figure 2); 56% of the crop was rated in good or excellent condition as of October 9.

Overall the 2011 season was marked by a slower planting pace than normal because of excess moisture and cool temperatures; this led to slower crop development. Later in the season, drought and mid-September freezing temperatures impacted the crop in some major production areas.

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**Table 1. Soybean production data for the United States, 2011 crop**

Region	State	Yield (MT ha <sup>-1</sup> )	Area Harvested (1000 ha)	Production (MMT)
Western Corn Belt (WCB)	Iowa	3.39	3,750	12.7
	Kansas	1.81	1,539	2.8
	Minnesota	2.69	2,839	7.6
	Missouri	2.49	2,126	5.3
	Nebraska	3.56	1,964	7.0
	North Dakota	1.88	1,600	3.0
	South Dakota	2.55	1,640	4.2
	Western Corn Belt	2.63	15,459	42.7 51.4%
Eastern Corn Belt (ECB)	Illinois	3.09	3,584	11.1
	Indiana	2.82	2,142	6.1
	Michigan	2.96	786	2.3
	Ohio	3.09	1,839	5.7
	Wisconsin	3.16	648	2.0
	Eastern Corn Belt	3.02	8,999	27.2 32.8%
Midsouth (MDS)	Arkansas	2.49	1,316	2.8
	Kentucky	2.62	595	1.6
	Louisiana	2.49	397	1.0
	Mississippi	2.75	721	2.0
	Oklahoma	1.14	101	0.1
	Tennessee	2.28	506	1.2
	Texas	1.01	45	0.0
	Midsouth	2.11	3,681	8.6 10.4%
Southeast (SE)	Alabama	2.22	117	0.3
	Georgia	1.55	59	0.1
	North Carolina	2.08	547	1.1
	South Carolina	1.75	146	0.3
	Southeast	1.90	869	1.7 2.1%
East Coast (EC)	Delaware	2.62	68	0.2
	Maryland	2.62	186	0.5
	New Jersey	2.35	35	0.1
	New York	2.89	112	0.3
	Pennsylvania	2.69	196	0.5
	Virginia	2.62	219	0.6
	East Coast	2.63	816	2.2 2.6%
USA 2011		2.77	29,839	83.0
USA 2010		2.95	31,113	91.9

Source: United States Department of Agriculture, NASS 2011 Crop Production Report (November 9, 2011)

**Table 2. ASA-IM 2011 Soybean Quality Survey Data**

Region	State	Number of Samples	Protein (%)*	Oil (%)*	Seed Wt. g/100 seeds
Western Corn Belt (WCB)	Iowa	271	33.8	18.5	15.2
	Kansas	70	35.3	17.8	14.9
	Minnesota	268	34.0	17.8	14.7
	Missouri	107	34.4	18.3	14.8
	Nebraska	148	35.1	17.6	15.2
	North Dakota	70	35.3	17.3	14.9
	South Dakota	97	34.8	17.1	14.4
Averages <sup>†</sup>	Western Corn Belt	1031	34.5	17.9	14.9
Eastern Corn Belt (ECB)	Illinois	366	34.2	18.5	15.3
	Indiana	139	34.6	18.1	15.3
	Michigan	62	36.0	17.3	16.0
	Ohio	135	36.1	17.1	15.7
	Wisconsin	48	35.3	17.5	15.9
Averages <sup>†</sup>	Eastern Corn Belt	750	34.9	17.9	15.5
Midsouth (MDS)	Arkansas	64	35.7	18.7	15.4
	Kentucky	30	34.7	18.8	15.4
	Louisiana	21	37.8	19.1	15.0
	Mississippi	28	36.8	19.1	14.7
	Oklahoma	6	35.0	17.7	14.4
	Tennessee	26	34.3	19.4	14.6
	Texas	1	30.4	17.4	10.9
Averages <sup>†</sup>	Midsouth	176	35.7	18.9	15.0
Southeast (SE)	Alabama	1	40.1	18.3	16.3
	Georgia	1	38.6	14.0	16.5
	North Carolina	20	35.2	19.4	14.4
	South Carolina	7	36.3	18.4	15.3
Averages <sup>†</sup>	Southeast	29	36.3	18.7	14.9
East Coast (EC)	Delaware	9	36.9	18.7	16.9
	Maryland	19	36.1	18.9	16.9
	New Jersey	6	37.2	18.5	16.1
	New York	6	36.4	17.7	16.9
	Pennsylvania	9	37.5	17.3	15.8
	Virginia	12	36.3	18.5	16.6
Averages <sup>†</sup>	East Coast	61	36.7	18.2	16.5
USA	Averages	2047	34.8	18.1	15.2
	<b>Average of 2011 Crop<sup>†</sup></b>		<b>34.9</b>	<b>18.1</b>	<b>15.1</b>
	US 1986-2011 avg.		35.3	18.7	

\* 13% moisture basis

† Regional and US average values weighted based on estimated production by state as estimated by USDA, NASS Crop Production Report (November 9, 2011)

**Table 3. ASA-IM 2011 Soybean Quality Survey Data**

Region	State	Number of Samples	Protein (%) <sup>*</sup>	Lysine (as % of P)	Essential Amino Acids <sup>††</sup> (as % of P)	Non-Essential Amino Acids <sup>‡</sup> (as % of P)
Western Corn Belt (WCB)	Iowa	271	33.8	6.0	40.4	58.4
	Kansas	70	35.3	6.0	39.5	57.4
	Minnesota	268	34.0	6.0	40.3	58.4
	Missouri	107	34.4	6.2	40.0	57.8
	Nebraska	148	35.1	5.9	39.3	57.0
	North Dakota	70	35.3	5.8	39.2	57.1
	South Dakota	97	34.8	6.0	39.8	57.7
Averages <sup>†</sup>	Western Corn Belt	1031	34.5	6.0	39.9	57.8
Eastern Corn Belt (ECB)	Illinois	366	34.2	6.1	40.0	57.6
	Indiana	139	34.6	6.2	39.8	57.2
	Michigan	62	36.0	6.0	38.8	56.2
	Ohio	135	36.1	6.0	38.7	56.0
	Wisconsin	48	35.3	6.0	39.4	57.2
Averages <sup>†</sup>	Eastern Corn Belt	750	34.9	6.1	39.5	57.0
Midsouth (MDS)	Arkansas	64	35.7	5.9	39.3	57.2
	Kentucky	30	34.7	6.0	39.8	57.9
	Louisiana	21	37.8	5.5	38.2	56.9
	Mississippi	28	36.8	5.9	38.6	56.0
	Oklahoma	6	35.0	6.5	39.5	56.3
	Tennessee	26	34.3	6.3	40.1	57.7
	Texas	1	30.4	6.3	43.2	63.0
Averages <sup>†</sup>	Midsouth	176	35.7	6.0	39.3	57.1
Southeast (SE)	Alabama	1	40.1	5.1	36.8	55.3
	Georgia	1	38.6	6.4	37.9	54.1
	North Carolina	20	35.2	6.3	39.6	56.4
	South Carolina	7	36.3	6.5	38.9	55.0
Averages <sup>†</sup>	Southeast	29	36.3	6.2	39.0	55.9
East Coast (EC)	Delaware	9	36.9	5.8	38.3	55.6
	Maryland	19	36.1	5.8	38.9	56.2
	New Jersey	6	37.2	5.9	38.1	55.3
	New York	6	36.4	6.1	38.3	55.1
	Pennsylvania	9	37.5	6.0	37.7	53.7
	Virginia	12	36.3	6.2	38.5	54.5
Averages <sup>†</sup>	East Coast	61	36.7	6.0	38.3	54.9
USA	Averages	2047	34.8	6.0	39.7	57.4
<b>Average of 2011 Crop<sup>†</sup></b>			<b>34.9</b>	<b>6.0</b>	<b>39.6</b>	<b>57.4</b>

<sup>\*</sup> 13% moisture basis

<sup>†</sup> Regional and US average values weighted based on estimated production by state as estimated by USDA NASS Crop Production Report (November 9, 2011)

<sup>††</sup>Essential amino acids: leucine, histidine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan, valine, and cysteine

<sup>‡</sup>Non-essential amino acids: alanine, arginine, aspartic acid, glutamic acid, glycine, proline, serine, and tyrosine



**Table 4. Historical Summary of Yield and Quality Data for US Soybeans**

Year	Yield (kg ha <sup>-1</sup> )	Protein* (%)	Oil* (%)	Sum <sup>†</sup> (%)	Harvested (Mha)	Production (MMT)	Protein Std. Dev.	Oil Std. Dev.
1986	2237	35.8	18.5	54.3	23.6	52.9	1.39	0.70
1987	2278	35.5	19.1	54.6	23.2	52.8	1.59	0.71
1988	1814	35.1	19.3	54.4	23.2	42.2	1.50	0.83
1989	2170	35.2	18.7	53.9	24.1	52.4	1.51	0.82
1990	2291	35.4	19.2	54.6	22.9	52.5	1.22	0.66
1991	2298	35.5	18.7	54.1	23.5	54.0	1.38	0.86
1992	2526	35.6	17.3	52.8	23.6	59.6	1.38	0.97
1993	2190	35.7	18.0	53.8	23.2	50.9	1.24	0.87
1994	2782	35.4	18.2	53.6	24.6	68.6	1.36	0.93
1995	2372	35.5	18.2	53.6	24.9	59.2	1.39	0.86
1996	2526	35.6	17.9	53.5	25.7	64.9	1.25	0.87
1997	2614	34.6	18.5	53.0	28.0	73.2	1.51	0.96
1998	2614	36.1	19.1	55.3	28.5	74.6	1.50	0.81
1999	2452	34.6	18.6	53.2	29.4	72.1	1.88	1.05
2000	2553	36.2	18.7	54.9	29.6	75.6	1.68	0.94
2001	2647	35.0	19.0	54.0	30.0	79.6	1.95	1.07
2002	2486	35.4	19.4	54.8	29.1	72.2	1.58	0.93
2003	2284	35.7	18.7	54.3	29.4	67.2	1.71	1.19
2004	2822	35.1	18.6	53.7	30.0	84.6	1.47	0.90
2005	2889	34.9	19.4	54.3	29.2	83.4	1.46	0.87
2006 <sup>‡</sup>	2869	34.5	19.2	53.7	30.2	86.8	1.64	1.01
2007 <sup>‡</sup>	2802	35.2	18.7	53.9	26.0	72.9	1.23	0.76
2008 <sup>‡</sup>	2641	34.1	19.1	53.2	30.1	79.6	1.40	0.82
2009 <sup>‡</sup>	2956	35.3	18.6	53.9	30.9	91.5	1.23	0.88
2010 <sup>‡</sup>	2950	35.0	18.6	53.6	31.1	91.9	1.38	1.19
2011 <sup>‡</sup>	2775	34.9	18.1	53.0	29.8	83.0	2.20	1.79
<b>Averages (1986-2011)</b>	<b>2532</b>	<b>35.3</b>	<b>18.7</b>	<b>53.9</b>	<b>27.1</b>	<b>69.2</b>	<b>1.50</b>	<b>0.93</b>

Sources: United States Department of Agriculture  
Iowa State University  
University of Minnesota

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

<sup>†</sup>Sum represents sum of protein and oil concentrations

<sup>‡</sup>2006 - 2011 quality estimates are weighted by yearly production estimates by state