Quality of the United States Soybean Crop: 2006[1]

Dr. Seth. L. Naeve and Dr. James H. Orf[2]

Summary

The American Soybean Association has 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 for the upcoming year. With some regional exceptions, 2006 was an excellent production year with excellent yields. Soybean quality should to be very similar to that of the 2005 harvest.

2006 Acreage, Yields, and Total Production

The United States Department of Agriculture (USDA) estimates that soybean was produced on 30.2 M ha in 2006 (Table 1). This represents a 4.4% increase over the area planted in 2005. Average yields are expected to be 2.89 Mg/ha, which would tie 2005 for largest yields in US history (2.89 Mg/ha). Thus, the US is expected to produce a record soybean crop in 2006. It is estimated to be 87.3 M MT; an increase of 4.7% in total production over 2005. Yields in Western and Mid-South states were limited by drought conditions.

Quality of the 2006 US Soybean Crop

On August 21, 2006 sample kits were mailed to 5036 producers. Producers were selected based on total land devoted to soybean production in each state, so that response distribution would closely match soybean production. One thousand five hundred ninety three samples were received by November 3, 2006. These were analyzed for protein and oil concentration by near-infrared spectroscopy (NIRS) using a Perten DA7200 diode array instrument (Huddinge, Sweden) equipped with calibration equations developed at the University of Minnesota. Results can be found in Table 2.

Interpretation of Protein and Oil Results

Average protein and oil concentrations for the US soybean crop were similar, but slightly lower than those described in the 2005 quality survey. The region-by-region analysis indicates that the Western Corn Belt states produced a crop with a very similar protein and oil profile to that produced in 2005, while Eastern Corn Belt states produced seed with lower protein and oil

---

[1] Prepared for the American Soybean Association and the United States Soybean Export Council Quality Mission to Asia, 13-21 November, 2006

[2] Assistant Professor and Professor, respectively, Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN 55108

concentrations than last year. The Southern regions tended to produce soybean crops with lower protein and slightly higher oil concentrations than were produced in 2005.

Soluble sugars

Some international customers have expressed interest in soluble sugar concentrations within the US soybean crop. Soluble sugars are difficult to accurately quantify by tradition wet chemical analysis and NIRS technology. A small subset (40) of early harvested samples representing a wide range of protein concentrations and states of origin were analyzed for soluble sugar concentrations using wet chemistry. Total soluble sugars within these samples showed a very broad range (22.1 to 141.0 mg g^{-1}on a dry matter basis). The analogous ranges for individual sugars were 2.36 - 83.8, 4.27 - 9.51, and 15.5 - 55.9 mg g^{-1} for sucrose, raffinose, and stachyose, respectively. Table 4 shows average protein, oil, and soluble sugar concentrations among 22 samples from the Northern portion of the US and 18 samples from the Southern portion of the US. Although this is a very small sample size, large differences in sugars were noted between Southern and Northern grown soybeans. Average sucrose concentration of the Southern samples was only 40% of that among the Northern samples. While this may be due to some undetermined environmental effects, we also can not rule out soybean varietal effects.

Midwest climate summary

April weather conditions were generally perfect for positioning the Midwest for an excellent soybean production year. Temperatures were roughly ~2^{o}C above average. Rainfall tended to be above normal across Nebraska, Iowa, Illinois and Indiana. This greatly reduced drought conditions in Illinois where 2005 rainfall was far below average.

May brought a wide variety of weather to the Midwest including extreme cold, snow, hail, flooding and extreme heat. These conditions delayed soybean planting in the northernmost states. Across the entire month temperatures were about 2^{o}C cooler in Indiana, Kentucky, and Illinois, while Iowa and Missouri tended to be drier than normal.

June temperatures tended to be below average across the Midwest and several areas received much less rainfall than average. The Dakotas and Northwestern Minnesota remained dry as did central Iowa and central Illinois.

July was warm across the entire Midwest with Minnesota and Wisconsin averaging 2-3^{o}C above average. Minnesota and the Dakotas tended to be much dryer than normal, while Indiana, Ohio, and Michigan received up to two times their normal rainfall.

August saw above normal temperatures in all states and significantly warmer temperatures than normal in the southern ranges of the Midwest (Missouri, Kentucky, and the southern portions of Illinois, Indiana, and Ohio). Rainfall was normal across the Midwest except in Iowa and South Dakota where above normal rainfall helped reduce stresses from the existing drought.

September was cooler and wetter than normal across the entire Midwest. Iowa, western Minnesota, Kentucky and the southern portions of Illinois, Indiana, and Ohio all received much

above average rainfalls. These rains did little to increase soybean yields, but caused delays in soybean harvest for many producers.

October tended to be significantly cooler than normal (especially in Wisconsin and Eastern Minnesota and Iowa). Excess rainfall events occurred in Illinois, Indiana, and Ohio, that delayed soybean harvest.

Drought in Western and Mid-South states

Few Midwestern states were seriously affected by drought in 2006. However, western states (North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma) and some Mid-South states (Louisiana and Mississippi) were greatly affected by drought. Drought in these states ranged from light to severe, but tended to last throughout the entire season. These states saw below average yields due to the lack of timely rainfall.

Drought conditions in the Mid-South and Western states greatly affected the condition of the soybean crop in these areas. The crop condition deteriorated rapidly beginning in late June and continued through early August when rains began in several production areas. This drought affect can be clearly seen in the USDA weekly crop condition report (see Figure 1). Crop conditions tended to mirror those noted in 2005 when midseason drought affected the eastern Corn Belt.

Soybean Rust

Soybean Rust (*Phakopsora pachyrhizi*) is a fungal pathogen of soybean that is know to cause very large yield losses in South America. Soybean rust was first reported in the continental US in November of 2004. Soybean rust is spread by spores, but it requires a living host to remain viable over winter periods. In the US it is known to over-winter on a weedy plant - kudzu - in areas of Florida and extreme southern Texas. Outbreaks of soybean rust on commercially produced soybean crops were noted in both 2005 and 2006. So far, the spread of soybean rust in 2006 has been more extensive that that in 2005. In both years, soybean rust has been confined, primarily, to Florida through June, and with only a few confirmations in surrounding states through July. In both years, August confirmations were relatively few. In September of 2006, soybean rust appeared to be moving somewhat beyond the boundaries of its findings in 2005. By 7 November 2006, soybean rust had been found in 227 counties in 15 states. Because most soybean rust identifications have been made late in the growing season, few soybean fields have been treated with fungicides for soybean rust in the US.

Low Linolenic soybeans

Soybean oil is made up of five major fatty acids, palmitic, stearic, oleic, linoleic and linolenic. On average, conventional soybean oil is composed of about 8% linolenic acid. This fatty acid is oxidatively unstable; therefore, soybean oil is often partially hydrogenated to reduce linolenic levels and thereby reduce potential rancidity. This process creates trans-isomers of the resulting fatty acids. Interest in trans-fat increased significantly when the U.S. government began requiring packaged-food companies to disclose trans-fat content of their products beginning in

January 2006. The U.S. government was concerned about the adverse effects of trans-fats in the American diet, which is high in overall high fat content, including a significant portion that is from packaged foods. The government has not banned trans-fats (although some U.S. cities are contemplating doing this), as it wanted consumers to simply be aware of the trans-fats in their food so they could voluntarily lower or eliminate the consumption of these fats.

Several US Universities and seed companies have developed soybean varieties that are naturally low (1 to 3%) in linolenic fatty acids. The oil from these soybeans can be utilized in food and baking industries without partial hydrogenation. Therefore, these varieties can be used to make products labeled "trans-fat free." In 2006 Monsanto, Pioneer, and Asoyia companies contracted with farmers to produce about 750,000 acres of low linolenic soybeans. Next year this number is expected to triple. While the growth rate of these special use soybeans is tremendous, these varieties currently represent only about 1% of US production.

2007 US Soybean Production Outlook

The US ethanol industry is currently experiencing tremendous growth. There are more than 100 ethanol plants in the US that utilize corn grain to produce this biofuel, while about 50 additional plants are under construction. These plants will use more than 54 M MT of the 2006 corn crop. This has supported the US corn price and may cause US farmers to convert some soybean production land to corn production. The extent of this transfer is unknown. It is important to know that changing crop rotations or cropping systems is difficult for many farmers. Producing corn-after-corn (rather than corn after soybeans) results in lower corn yields and causes additional yield losses from diseases and insects. Additional input costs from fuel, fertilizers, and pesticides will keep most farmers from making large changes in their farming operations. Despite yearly predictions of vast changes in land devoted to soybean, US production tends to change little over time.

Table 1. Soybean production data for the United States, 2006 crop

Region	State	Yield (MT ha^{-1})	Area Harvested (1000 ha)	Production (M MT)
Western Corn Belt (WCB)	Iowa	3.36	4,070	13.7
	Kansas	2.08	1,215	2.5
	Minnesota	2.89	2,936	8.3
	Missouri	2.69	2,086	5.8
	Nebraska	3.43	2,025	6.9
	North Dakota	2.08	1,539	3.0
	South Dakota	2.35	1,580	3.5
	Western Corn Belt	2.7	15,451	44
				50.3%
Eastern Corn Belt (ECB)	Illinois	3.36	4,070	14.0
	Indiana	3.43	2,300	7.9
	Michigan	2.89	802	2.2
	Ohio	3.09	1,871	5.8
	Wisconsin	2.96	656	1.9
	Eastern Corn Belt	3.1	9,700	32
				36.5%
Midsouth (MDS)	Arkansas	2.42	1,239	3.0
	Kentucky	3.02	551	1.7
	Louisiana	2.15	336	0.7
	Mississippi	1.75	664	1.2
	Oklahoma	1.28	105	0.1
	Tennessee	2.55	458	1.2
	Texas	1.41	81	0.1
	Midsouth	2.1	3,434	8
				9.2%
Southeast (SE)	Alabama	1.14	61	0.1
	Florida	n/a	n/a	n/a
	Georgia	1.61	61	0.1
	North Carolina	2.15	547	1.1
	South Carolina	1.88	158	0.3
	Southeast	1.7	826	2
				1.8%
East Coast (EC)	Delaware	2.08	72	0.1
	Maryland	2.35	186	0.4
	New Jersey	2.22	35	0.1
	New York	3.02	80	0.2
	Pennsylvania	2.69	178	0.5
	Virginia	2.08	203	0.4
	East Coast	2.4	755	2
				2.1%
Other Sts		2.53	9	0.02
				0.03%
USA 2006		2.89	30,175	87.3
USA 2005		2.89	28,857	83.4

Source: United States Department of Agriculture (9 November, 2006)
n/a = not available

Table 2. United Soybean Board/American Soybean Association 2006 Soybean Quality Survey

Region	State	Number of Samples	Protein (%)*		Oil	
			Average	Std. dev.	Average	Std. dev.
Western Corn Belt (WCB)	Iowa	233	34.45	1.44	19.06	0.98
	Kansas	31	35.21	2.08	18.56	0.95
	Minnesota	389	33.36	1.24	19.50	0.93
	Missouri	82	35.20	1.98	18.90	0.98
	Nebraska	108	34.75	1.47	18.96	0.96
	North Dakota	79	33.45	1.43	19.60	0.81
	South Dakota	68	33.22	1.54	19.15	0.98
Average*	Western Corn Belt		34.27		19.12	
Ranges	Western Corn Belt		(27.87 - 41.39)		(16.03 - 22.45)	
Eastern Corn Belt (ECB)	Illinois	205	34.59	1.47	19.01	1.03
	Indiana	82	34.91	1.42	18.80	0.83
	Michigan	39	34.72	0.95	19.04	0.64
	Ohio	93	35.07	1.52	19.11	0.93
	Wisconsin	33	33.13	1.64	19.44	0.81
Averages†	Eastern Corn Belt		34.68		19.00	
Ranges	Eastern Corn Belt		(28.06 - 38.80)		(16.02 - 22.15)	
Midsouth (MDS)	Arkansas	40	34.69	1.45	19.99	1.05
	Kentucky	8	34.92	1.85	19.27	0.94
	Louisiana	12	35.89	1.80	20.46	0.92
	Mississippi	22	35.60	1.83	19.64	1.06
	Oklahoma	4	34.22	1.93	19.15	0.58
	Tennessee	20	33.80	1.84	20.64	1.30
	Texas	3	35.59	0.85	19.39	1.25
Averages	Midsouth		34.85		19.90	
Ranges	Midsouth		(30.41- 39.26)		(17.51 - 22.69)	
Southeast (SE)	Alabama	3	34.99	1.32	19.81	1.17
	Florida	0				
	Georgia	2	36.02	2.50	18.87	0.91
	North Carolina	7	35.14	1.90	20.08	0.76
	South Carolina	2	36.63	0.74	20.76	0.51
Averages	Southeast		35.46		20.12	
Ranges	Southeast		(32.31 - 37.78)		(18.23 - 21.12)	
East Coast (EC)	Delaware	3	35.08	1.19	18.56	0.87
	Maryland	4	35.62	1.20	19.23	1.14
	New Jersey	5	37.03	1.99	18.44	1.22
	New York	3	34.92	0.86	17.74	0.91
	Pennsylvania	8	35.11	0.95	18.64	0.75
	Virginia	5	33.38	1.14	20.45	0.39
Averages	East Coast		34.89		19.08	
Ranges	East Coast		(31.63 - 39.05)		(16.93 - 20.94)	
USA	Averages	1593	34.26		19.23	
	Ranges		(27.87 - 41.39)		(16.02 - 22.69)	
	Average of 2006 Crop†		**34.51**		**19.17**	
	US 1986-2006 avg.		35.34		18.67	

Data as of November 3, 2006

* 13% moisture basis

† Regional and US average values weighted based on estimated (Oct 12, 2006) production by state

Table 3. Historical Summary of Yield and Quality Data for US Soybeans.

Year	Yield (kg ha^{-1})	Protein* (%)	Oil* (%)	Sum† (%)	Harvested (M ha)	Production (M MT)	Protein Std. Dev.	Oil Std. Dev.
1986	2237	35.76	18.54	54.30	23.62	52.9	1.39	0.7
1987	2278	35.46	19.11	54.57	23.15	52.8	1.59	0.71
1988	1814	35.13	19.27	54.40	23.24	42.2	1.50	0.83
1989	2170	35.18	18.73	53.91	24.11	52.4	1.51	0.82
1990	2291	35.40	19.18	54.58	22.89	52.5	1.22	0.66
1991	2298	35.48	18.66	54.14	23.49	54.0	1.38	0.86
1992	2526	35.56	17.27	52.83	23.58	59.6	1.38	0.97
1993	2190	35.73	18.03	53.76	23.21	50.9	1.24	0.87
1994	2782	35.39	18.20	53.59	24.63	68.6	1.36	0.93
1995	2372	35.45	18.19	53.64	24.93	59.2	1.39	0.86
1996	2526	35.57	17.90	53.47	25.66	64.9	1.25	0.87
1997	2614	34.55	18.47	53.02	27.99	73.2	1.51	0.96
1998	2614	36.13	19.14	55.27	28.53	74.6	1.50	0.81
1999	2452	34.55	18.61	53.16	29.35	72.1	1.88	1.05
2000	2553	36.22	18.65	54.87	29.57	75.6	1.68	0.94
2001	2647	34.98	18.97	53.95	30.01	79.6	1.95	1.07
2002	2486	35.42	19.38	54.80	29.08	72.2	1.58	0.93
2003	2284	35.65	18.66	54.31	29.38	67.2	1.71	1.19
2004	2822	35.06	18.61	53.67	29.97	84.6	1.47	0.9
2005	2889	34.92	19.41	54.33	28.86	83.4	1.46	0.87
2006‡	2896	34.51	19.17	53.67	30.18	87.3	1.64	1.01
Averages (1986-2006)	2464	35.34	18.67	54.01	26.45	65.7	1.50	0.90

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

*Protein and oil concentrations expressed on a 13% basis moisture
†Sum represents sum of protein and oil concentrations
‡2006 quality estimates are weighted by 2006 production estimates
§2006 production estimates as of 9 November, 2006

Table 4. Carbohydrate analysis of a small number of samples from Northern and Southern U.S.*

	Protein %	Oil %	Fiber %	Sucrose mg g-1	Raffinose mg g-1	Stachyose mg g-1	total sugars mg g-1
Northern states†	36.2	20.8	4.78	57.8	7.63	43.4	108.8
Southern states‡	38.3	21.0	5.05	23.1	7.94	30.3	61.4

* Wet chemistry analysis conducted at the University of Missouri Analytical Laboratories
† Northern states represent 22 samples from Illinois, Indiana, Iowa, Minnesota, Nebraska, N Dakota, Ohio, and S. Dakota
‡ Southern states represent 18 samples from Arkansas, Kansas, Louisiana, Mississippi, Missouri, and Texas

Figure 1.
US Soybean Crop Conditions (2003-2006)

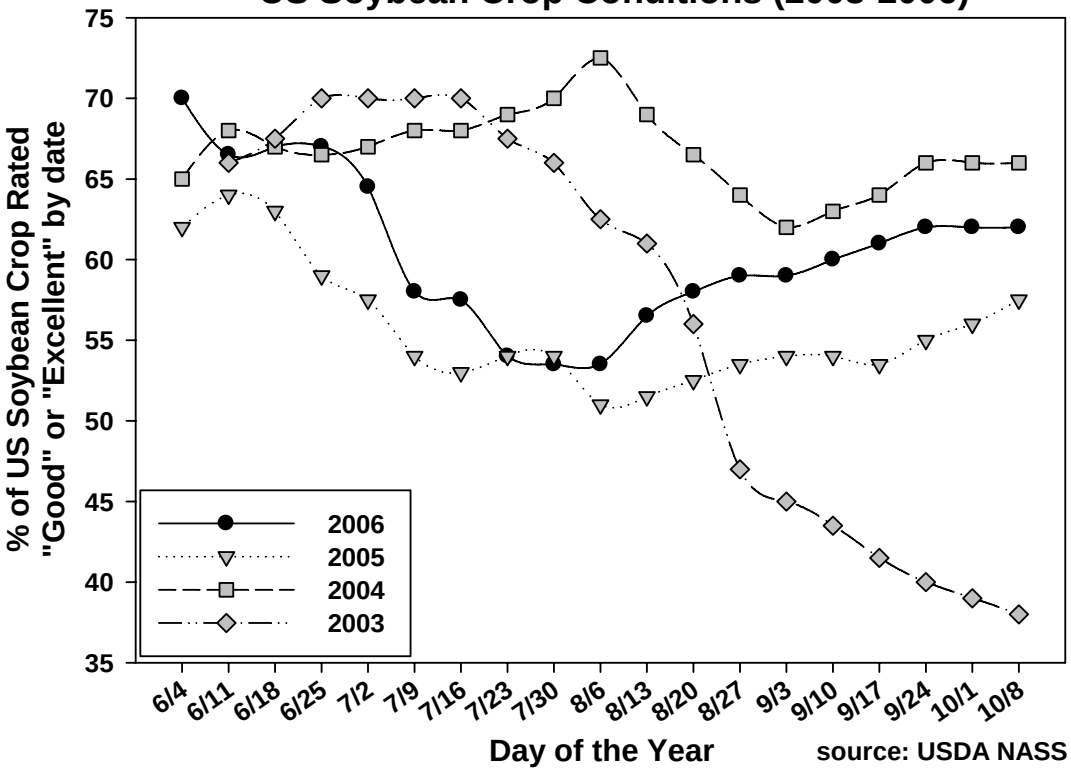

Figure 2. 2006 US Soybean quality by state