QUALITY OF THE 2003 SOYBEAN CROP FROM THE UNITED STATES [1/]

DR. THOMAS J. BRUMM[2/]
DR. CHARLES R. HURBURGH, JR. [2/]

Quality continues to be an important soybean marketing issue. This report summarizes current knowledge on the following soybean quality topics:

- Protein and oil composition of the 2003 U.S. soybean crop
- The 2003 crop in historical and geographic perspective
- Weather conditions affecting the 2003 crop
- Programs by growers and U.S. processors to improve quality

The data and analyses in this report are intended to assist customers in the sourcing and use of U.S. soybeans.

The Quality Survey

Since 1986, Iowa State University (ISU) and the American Soybean Association (ASA) have been surveying the quality of new crop soybean harvests. U.S. soybean producers, representing 30 soybean production states, in response to a mailed request, provided samples of 2003 crop soybeans for analysis. Samples received by November 7, 2003 were analyzed for protein and oil contents using an Infratec near-infrared instrument (Foss North America, Eden Prairie, Minn.). A geographically distributed subset was sent to the University of Missouri for amino acid analysis. From other sources, data on the yield and physical quality (U.S. Grade factors) of U.S. soybeans have been collected. Data were organized by state and region (groups of states). Weather data for the 2003 growing season were collected to demonstrate the impact of unusual environment on soybean composition.

The 2003 U.S. Soybean Crop

The United States produced 2.468 billion bushels (66.9 million metric tons) of soybeans in 2003, according to the October 14, 2003 USDA production estimates (USDA, 2003). This is a decrease of 6.9 percent from 2002, and the lowest since 1996. The average soybean yield was 34.0 bushels per acre, down from 37.5 bushels per acre in 2002 and the lowest per acre yield since 1989. An estimated 72.5 million acres (29 million hectares) of soybeans were harvested, a 1% increase from 2002. Table 1 summarizes production statistics for the 2003 crop, by state and growing region.

Production decreases occurred across the entire Corn Belt, with production increases only in the southeast and east coast regions. Generally dry weather conditions persisted across the Corn Belt, and were most severe in August and September, during the soybean pod filling period.

Composition data are given in Table 2. Average U.S. protein and oil contents for 2003 were 35.65% and 18.66% respectively (on a 13% moisture basis). These are slightly above the long-

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[1/] Prepared for the American Soybean Association Quality Mission to Japan, November 15-17, 2003

[2/] Assistant Professor and Professor, respectively, Agricultural and Biosystems Engineering Department, Iowa State University, Ames, IA 50011

term U.S. averages of 35.42 % protein and 18.60 % oil. The soybeans from the 2003 crop will produce, on average, 43.8 lbs of 48% protein meal and 10.9 lbs of oil per bushel.

The variability (standard deviation) within states, regions, and the U.S. was substantially higher than in 2002. This means that regional or other forms of geographic buying for higher protein and oil will yield more uncertain results. The higher variability was particularly pronounced in the oil, with a standard deviation of 1.02 percentage points as compared to an 18-year average of 0.89 percentage points.

The north to south protein pattern (lower north, higher south) was present, but was not consistent. For example, Minnesota soybeans were very close to the national averages in protein and higher in oil. This is very unusual; it has happened only one other time (1991). Likewise, Midsouth soybeans were lower in protein than those in the Eastern Corn Belt. Harvest temperatures were at or above average throughout harvest, so there should be little frost damaged soybeans which cause oil refining problems. Expect moistures under 12% this year, below the historical average. Soybeans will be small, which may require resetting of cracking rolls and other equipment to prevent abnormal oil loss into meal.

Weather Conditions in 2003

The severity of dry weather in the U.S. is shown in Figure 1. The U.S. Drought Monitor is a visual summary of moisture-related conditions averaged across a broad array of time scales and impact indicators (NDMC, 2003). It approximates drought-related impacts that respond to precipitation.

The Western U.S. has experienced severe drought for two years, but in 2003 the dry area expanded into the Western Corn Belt. The timing of dry weather is also important; in soybean growing areas the dry period was in August and September which are crucial for pod filling. Most central U.S. areas were actually above normal for moisture until early August.

There have been many studies relating soybean protein and oil content to environmental conditions. Table 3 is a qualitative summary of soybean composition in response to weather and non-agronomic variables (Westgate, et al., 1999). In 2003, the crop results reinforced previous findings about the timing effect of dry weather.

Historical Performance and Geographical Perspective

Soybean yields and acreage, which increased steadily in the 1990s, appear to have stabilized in recent years. Table 4 shows a combination of USDA production and survey composition data. The yield, protein and oil data is shown graphically in Figure 2. In the 1990s, yields increased by 0.5 bushels/acre/year, with little change in average protein and oil content. In recent years, there has been little yield increase but constant protein and oil levels. Breeding programs continue to emphasize yield, apparently without creating quality loss. The net result is a steady increase in the production of protein and oil per unit of area (Figure 3). From a consumer perspective, this has meant a steadier, more abundant supply from the same inputs (land, seed, fertilizer and so on). The overall supply impact of the 18-year composition data is in Figure 4.

The regional north-to-south protein trend has been reasonably consistent over the 18 years of the survey. Figures 4 and 5 show the regional averages for these years. The regional differences for protein were much larger than those for oil, but the different growing seasons created more overall change in oil than in protein. The range among individual samples in any state was about twice as large as the range across regions or years. This means that buying patterns established to capture forecasted differences in composition without testing will have a large margin of error, and therefore cannot provide substantial premiums to growers or handlers.

The processing chart in Figure 6 shows the combinations of protein and oil content that will produce 47.5% to 48.5% protein soybean meal. Only once (1997) did U.S. soybeans fall to the left of the optimal area, shown by the shading. Soybeans from individual states and regions often fall to the far right, above 48.5% meal, and the U.S. averages are regularly in the middle of this area. In 2003, the U.S. average falls almost exactly on the 18-year average of the survey.

The USDA Grain Inspection Packers and Stockyards Administration (GIPSA) provides a variety of optional services for soybean inspections (GIPSA, 2003a) as described below (from the GIPSA website):

> Soybean Protein & Oil
> To provide information concerning intrinsic properties of soybeans related to user economics, GIPSA offers protein and oil testing of soybeans as an optional service. Protein and oil contents determine the amount and quality of end products, soybean meal and soybean oil, that can be produced from a bushel of raw soybeans. Upon request, GIPSA tests soybeans for their protein and oil content using Near-infrared Transmittance (NIRT). Using NIRT allows GIPSA to provide a simple, timely, repeatable and cost effective means of determining the oil and protein content in soybeans.
>
> Soybean Cracked Seedcoats
> The Soybean Cracked Seedcoats assessment was added to GIPSA's optional quality assessment services in response to increasing trade requests. The purpose of this test is to determine the percent of cracked seedcoats of sound soybeans. The determination is made on approximately 125 grams after the removal of foreign material and damaged kernels. Soybeans with cracked seedcoats are sound soybeans which have readily discernible cracked seedcoats, sound soybeans which have all or part of the seedcoat removed, or sound soybeans which are ¾ or more of a whole soybean.
>
> Soybean Seed Count
> The Soybean Seed Count assessment was added to GIPSA's optional quality assessment services in response to increasing trade requests for the service. GIPSA reports the number of whole soybeans contained in a specified weight. The determination of the seed count per gram is made on approximately 25 grams after the removal of foreign material and non-whole soybeans. This is then mathematically converted to the requested number per weight.
>
> Soybean Seed Sizing
> The Soybean Seed Sizing assessment was added to GIPSA's optional quality assessment services in response to increasing trade requests for the service. Seed sizing is a measurement of the percentage of soybeans passing through or remaining on top of a sieve size specified by the applicant for service. The test is run on a sample of approximately 125 grams after the removal of foreign material.
>
> Soybean White Hilum
> The Soybean White Hilum assessment was added to GIPSA's optional quality assessment services in response to increased trade requests. The purpose of this test is to determine the percent of whole soybeans with a clear white hilum. Upon request, tests for other hilum color (buff, brown, etc.) can be provided. The determination is made on approximately 125 grams after the removal of foreign material and non-whole soybeans.

Any of these can be requested at an export inspection. The protein and oil analysis can be particularly useful for buyers with contract specifications on composition. The GIPSA tests are done at the time of vessel loading and therefore can be used like any of the other Official Grade factor tests to control variation in the quality being loaded. There are breakpoints and other parameters for use in loading to protein and/or oil specifications.

GIPSA collects results from Official soybean export inspections (GIPSA, 2003b). Official inspections establish Grade based on a set of physical factors and, on request, will report protein and oil contents. Historical data is given in Table 5. The majority of inspections (>93%) were for U.S. No. 2 soybeans in 2002. There has been little change in physical quality over time, and the GIPSA composition measurements agree with the ASA-ISU survey data. This means that exports are generally an average of the U.S. production.

The GIPSA data is not separated by export location. The Gulf South ports are generally served by the Corn Belt state areas along the Mississippi-Ohio-Illinois-Missouri river system. Pacific Northwest (PNW) ports are more likely to receive grain from the states classified as Western Corn Belt in the survey. Export quality at any port will tend to mirror the quality of production areas that serve it. Over the 18 years of the survey, the percentage of U.S. crop produced in the Western Corn Belt has gradually increased from about 40% to just over 50%. This shift is toward areas of potentially lower protein content. The previous data showing a constant level of U.S. average protein and oil is a real credit to the U.S. soybean genetics industry when viewed in the context of this geographic shift in production. However, shipments from PNW ports will tend to be of lower protein than those from Gulf South ports.

Grower and Processor Programs

The U.S. domestic soybean market is beginning to create incentives for improving protein and oil contents. At least four major soybean processors have followed the lead of AgProcessing Inc. (AGP), in offering some form of premium for higher composition levels. The AGP premium scale has been described in the last two years' discussion papers (Brumm and Hurburgh, 2002; Hurburgh, 2001). The AGP scale rewards above average oil content, and then provides a protein premium in cases where both the oil and protein are above average (AGP, 2003). Other strategies in use are minimum levels with discounts for below standard composition, processor subsidy for producers to purchase varieties from an approved list, and direct production volume or acreage contracts. The variety list concept has advantages in that testing of each delivery is not required; the program assumes that the varieties on the list will always be above average in composition for the year. Variety trial data support that assumption; the relative ranking of varieties stays the same regardless of the overall changes created by year-to-year weather conditions. In all cases, the objective of the processor is to raise the overall average composition of beans purchased. It is not necessary to segregate high protein and/or oil beans for separate processing runs. A solvent extraction plant recovers the amounts of protein and oil present on a mass balance basis.

The potential for incrementally increasing average oil and protein contents is shown by the example data in Figure 7. This was a situation where we measured protein, oil and grain yield for samples arriving at processing plants. The data is referenced to the average at the respective plant location. Samples falling in the upper right quadrant are above average in both grain yield and quality. Consistently 20% of data points fall in this category, which means that a producer could increase composition by both choosing those varieties and cultural practices and by eliminating the situations in lower left (below average yield, below average composition). The total of protein and oil is the best measure of value to use, rather than either component alone.

The United Soybean Board has begun two programs to increase producer awareness and improve measurement methods for soybean composition. The Select Yield and Quality program (SYQ) is a producer education effort targeted at the Western Corn Belt, to increase understanding of the possibilities for improved composition with improved or constant grain yield (USB, 2003). The Soybean Quality Traits program (SQT) is a research oriented association of analytical laboratories and plant breeders, to create uniform, standardized methods for measuring soybean quality traits (protein, oil, fatty acid profile, amino acid profile).

SYQ is a print and media education program targeted at processors, to illustrate the benefits of including composition in pricing policies, and at growers, to demonstrate the potential for composition increase without yield loss. In the growers' case, USB is also explaining the benefits to U.S. competitiveness of increasing composition with or without price incentives, as South American production shifts toward the equator (probable higher protein). The major emphasis is on variety selection. Price incentives must expand to support the information in order for SYQ to be a long-term success.

SQT has organized approximately 20 analytical laboratories, 10 plant breeding organizations (private and public) and three USDA labs for proficiency evaluation of fundamental reference chemical methods. Iowa State University is providing the coordination and standardization for rapid method calibration – in this case for near infrared measurements. Thirteen models of near infrared analyzers are represented in the SQT program. The first SQT report on accuracy of laboratory methods, and on the potential for accurate NIR measurements across models will be completed in 2004. The plant breeding industry has committed to providing a continuing supply of samples representing new genetics for improved soybean quality traits. The overall organizer of SQT is the American Oil Chemists Society. Funding is being provided by the U.S. soybean producers, through the United Soybean Board.

Summary

The 2003 U.S. soybean crop has average protein (35.7%) and oil (18.7%) contents. The variability in protein and oil content was quite high across and within soybean growing regions. Yields and total production were down sharply from 2003 due mainly to drought conditions in the Western Corn Belt. There are continuing efforts on the part of many U.S. groups to improve soybean quality through education, price premiums and inspections. If widespread incentives develop in U.S. markets, importers will need to respond in a competitive way.

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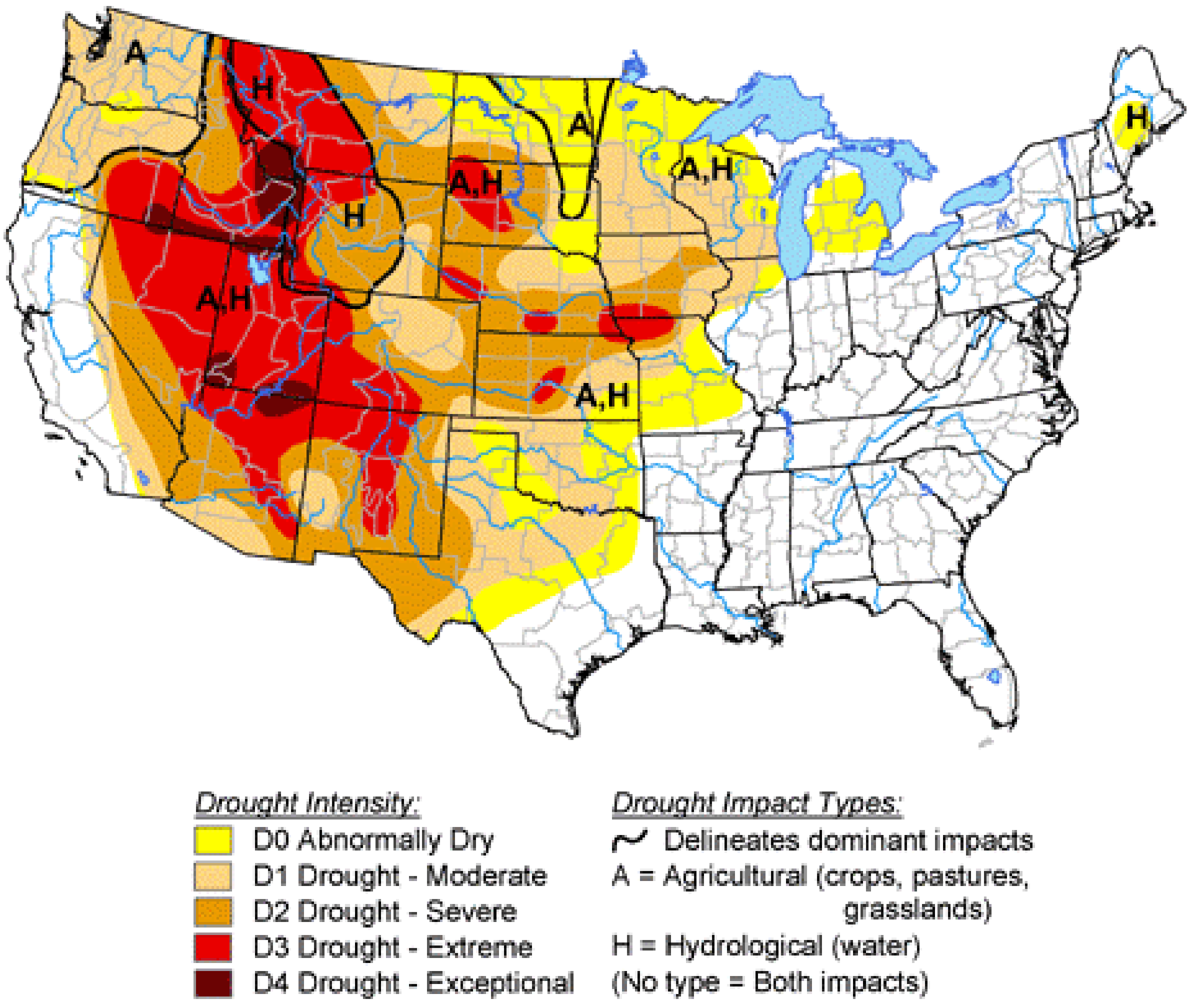
Figure 1. U.S. Drought Monitor as of September 2, 2003.



Source: NDMC (2003).

Figure 2. Historical Summary of Yield and Quality Data for U.S. Soybeans

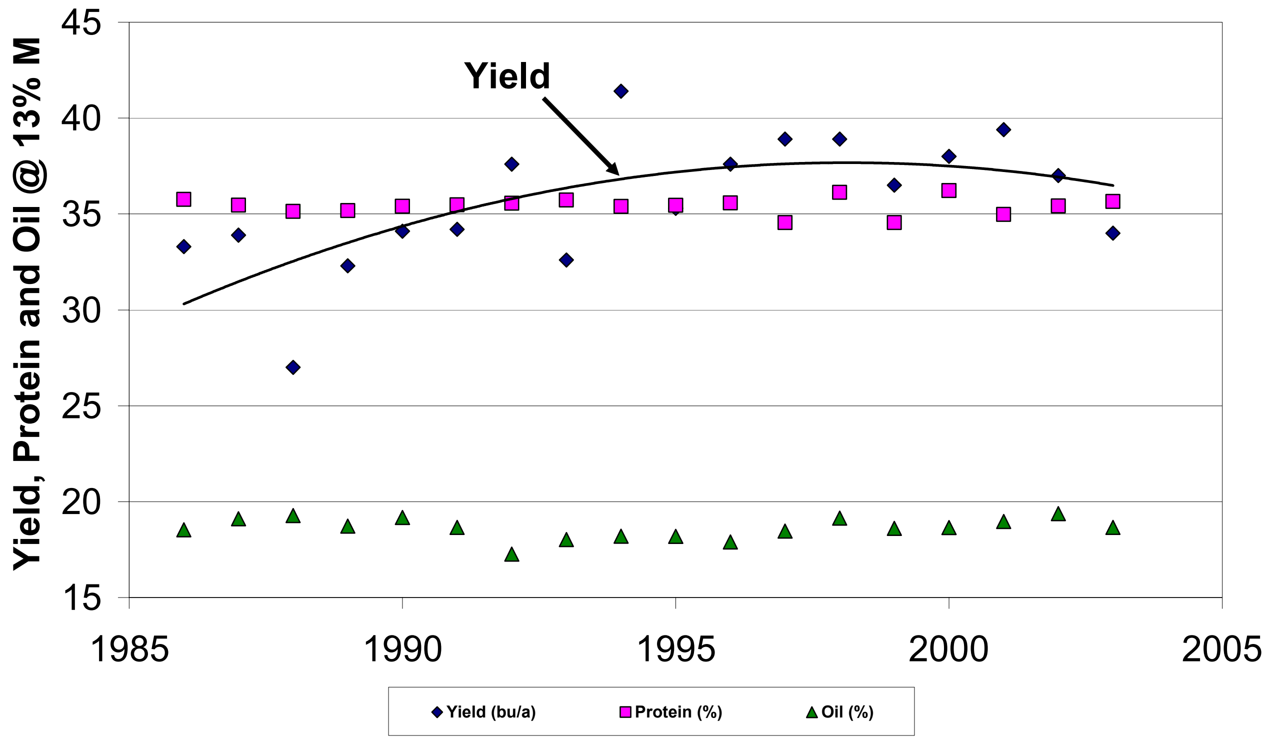


Figure 3. U.S. Production of Soybean Protein and Oil per unit area.

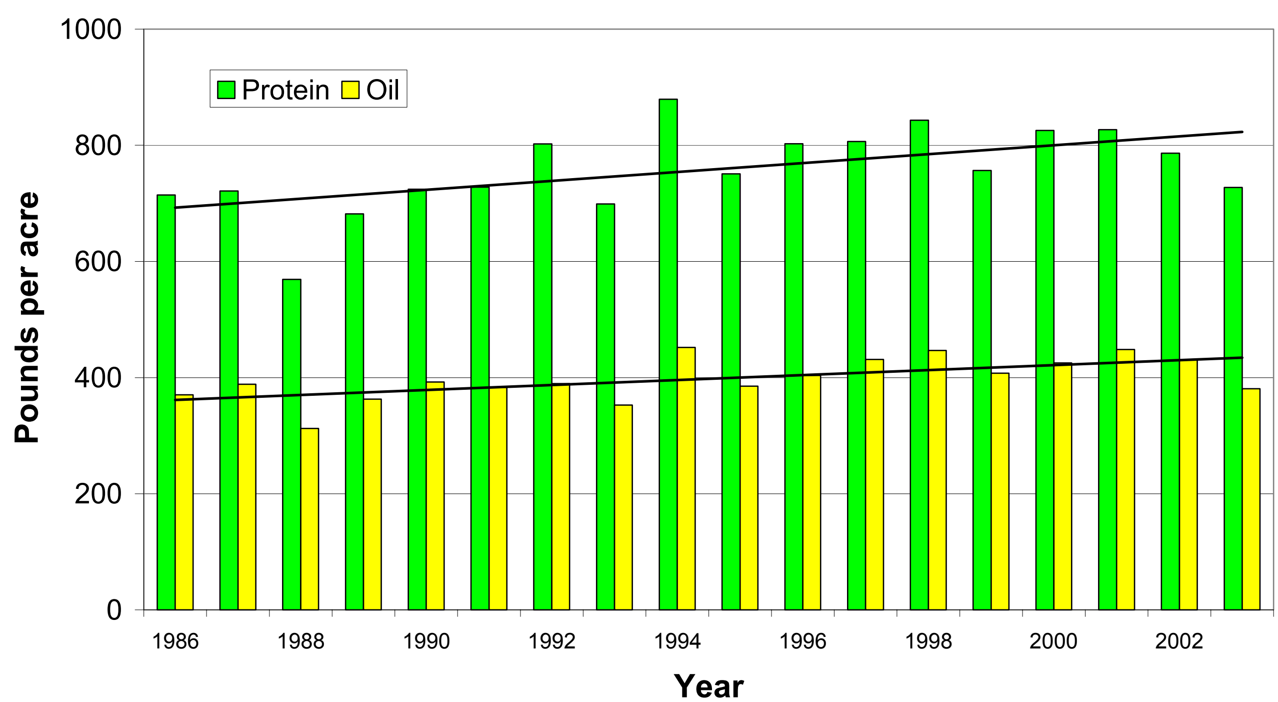


Figure 4. Historical U.S. Soybean Protein Content by Region.

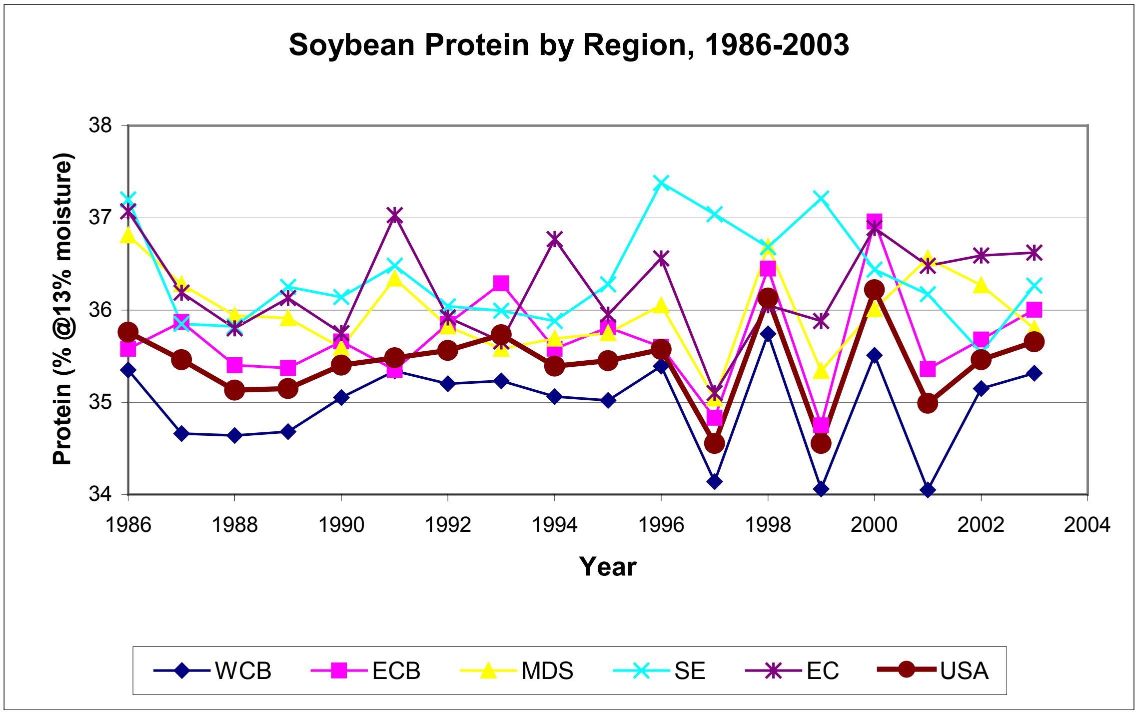


Figure 5. Historical U.S. Soybean Oil Content by Region.

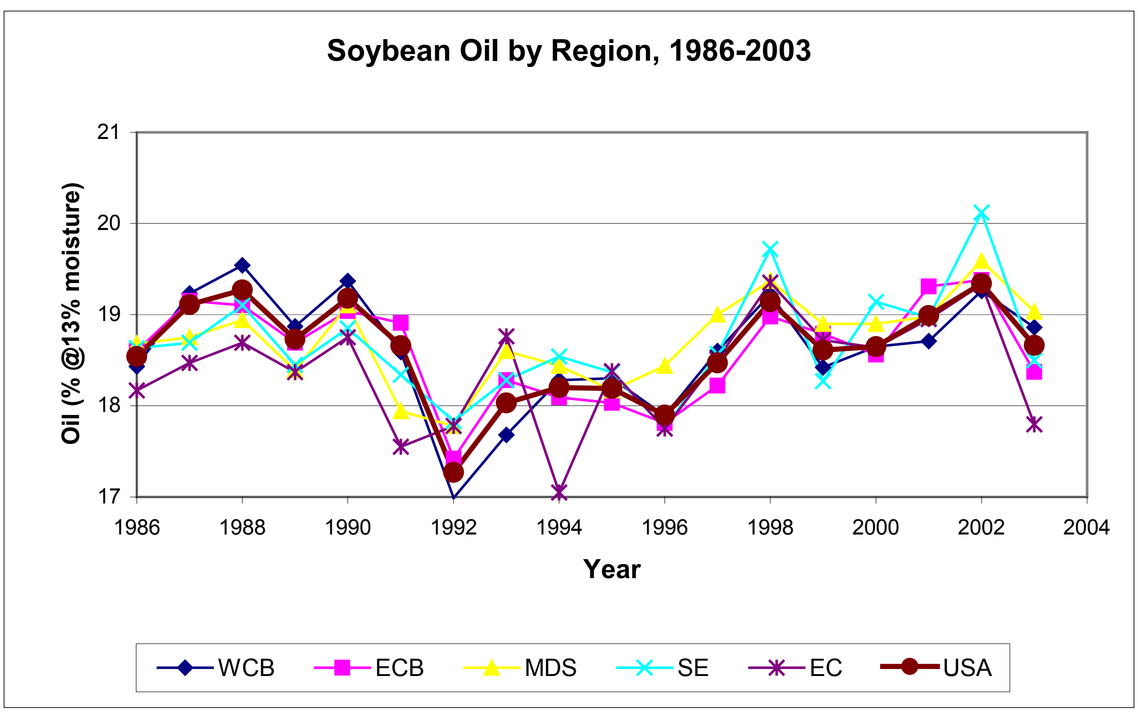


Figure 6. Protein and oil combinations that will produce 47.5% to 48.5% protein meal.

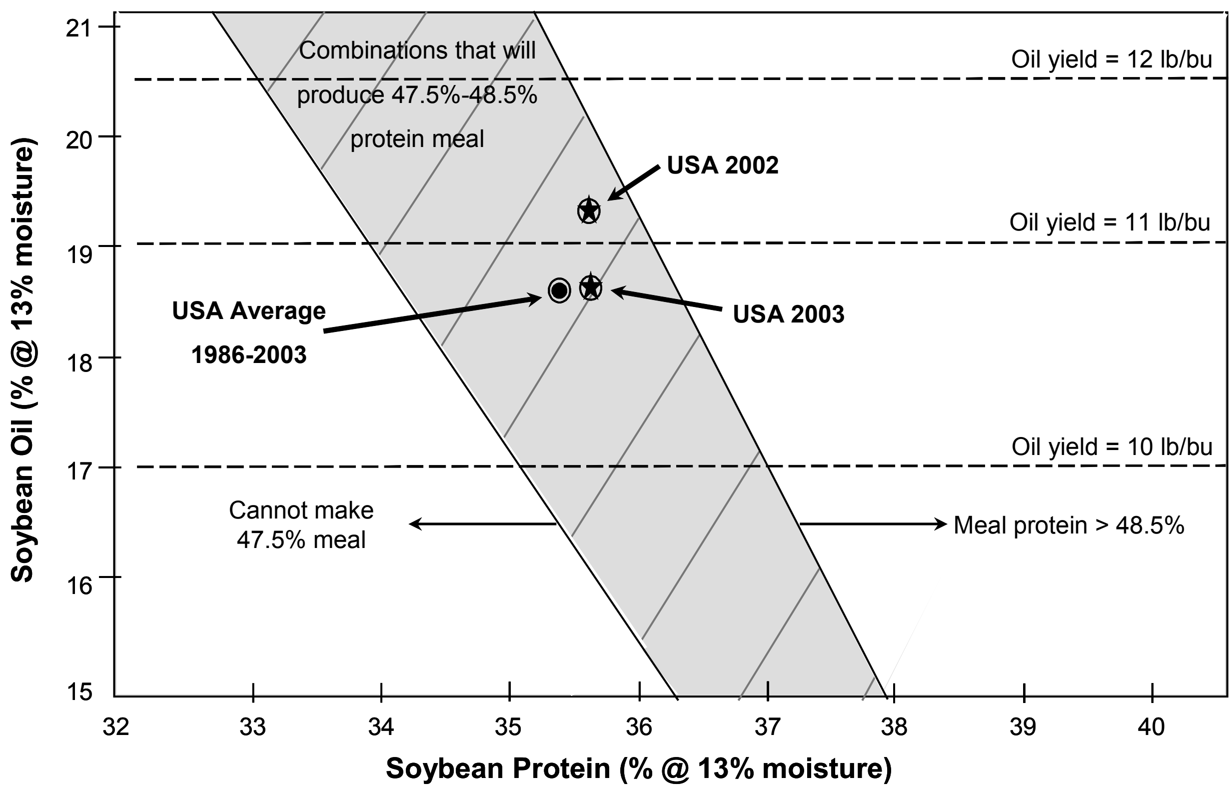


Figure 7. Identification of High-Value Soybeans.

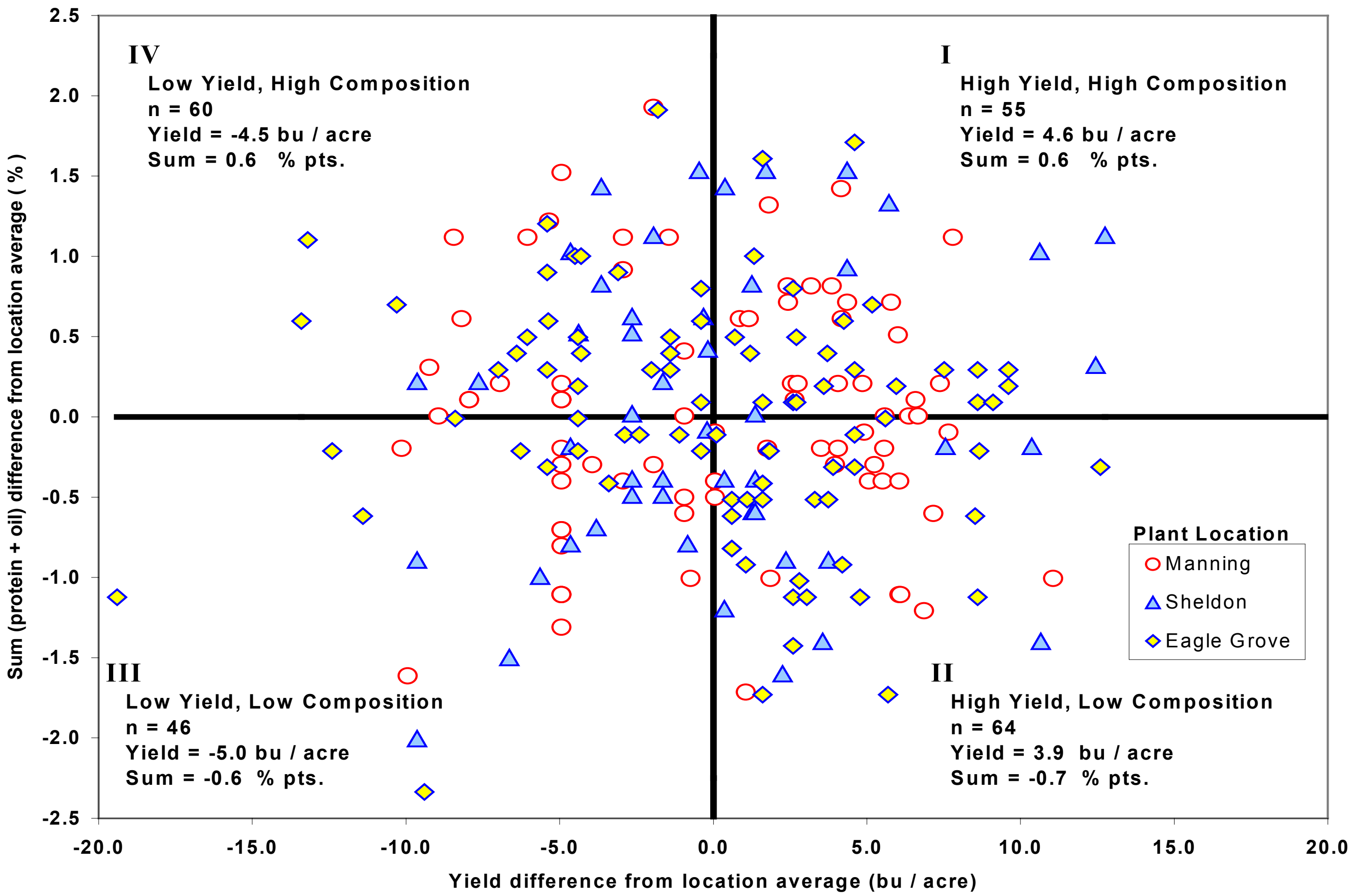


Table 1. Soybean production data for the United States, 2003 crop.

Region	State	Yield (bu/a)	Acreage (1000 acres)	Production (1000 bu)
Western Corn Belt (WCB)	Iowa	34.0	10,550	358,700
	Kansas	22.0	2,500	55,000
	Minnesota	32.0	7,400	236,800
	Missouri	28.0	4,950	138,600
	Nebraska	39.0	4,500	175,500
	North Dakota	28.0	3,100	86,800
	South Dakota	30.0	4,200	126,000
	Western Corn Belt	31.7	37,200	1,177,400 47.7%
Eastern Corn Belt (ECB)	Illinois	37.0	10,350	382,950
	Indiana	40.0	5,350	214,000
	Michigan	32.0	1,990	63,680
	Ohio	41.0	4,280	175,480
	Wisconsin	30.0	1,710	51,300
	Eastern Corn Belt	37.5	23,680	887,410 36.0%
Midsouth (MDS)	Arkansas	35.0	2,850	99,750
	Kentucky	40.0	1,250	50,000
	Louisiana	34.0	730	24,820
	Mississippi	36.0	1,410	50,760
	Oklahoma	25.0	255	6,375
	Tennessee	38.0	1,150	43,700
	Texas	26.0	180	4,680
	Midsouth	35.8	7,825	280,085 11.3%
Southeast (SE)	Alabama	31.0	155	4,805
	Florida	34.9	28	977
	Georgia	33.0	180	5,940
	North Carolina	30.0	1,390	41,700
	South Carolina	24.0	410	9,840
	Southeast	29.2	2,163	63,262 2.6%
East Coast (EC)	Delaware	36.0	175	6,300
	Maryland	36.0	420	15,120
	New Jersey	30.0	88	2,640
	New York	37.0	142	5,254
	Pennsylvania	40.0	365	14,600
	Virginia	34.0	480	16,320
	East Coast	36.1	1,670	60,234 2.4%
USA		34.0	72,538	2,468,391
USA 1986-2003 averages		35.7	63,981	2,293,495

Source: United States Department of Agriculture (14-Oct-03)

Table 2. United Soybean Board/American Soybean Association 2003 Soybean Quality Survey Data.

Region	State	Number of Samples	Protein Percent Average	Protein Std. dev.	Oil Percent Average	Oil Std. dev.
Western	Iowa	268	35.82	1.41	18.69	0.85
Corn	Kansas	30	35.48	2.10	18.76	1.29
Belt	Minnesota	104	35.66	1.60	19.04	0.85
(WCB)	Missouri	67	34.75	2.17	19.09	1.09
	Nebraska	105	34.31	1.10	19.24	0.82
	North Dakota	30	35.13	1.98	18.81	0.94
	South Dakota	58	34.88	1.62	18.49	0.93
Averages	Western Corn Belt	662	35.32	1.67	18.86	0.93
Ranges	Western Corn Belt		(26.2 - 41.8)		(15.1 - 21.6)	
Eastern	Illinois	234	35.55	1.60	18.75	1.00
Corn	Indiana	110	36.12	1.42	18.29	0.86
Belt	Michigan	38	36.57	1.33	17.83	0.86
(ECB)	Ohio	84	36.76	1.38	17.73	0.84
	Wisconsin	38	36.21	1.62	18.25	1.02
Averages	Eastern Corn Belt	504	36.00	1.57	18.37	1.02
Ranges	Eastern Corn Belt		(31.2 - 42.0)		(15.2 - 21.0)	
Midsouth	Arkansas	46	36.15	1.39	18.76	1.01
(MDS)	Kentucky	12	34.94	1.67	19.05	1.05
	Louisiana	6	36.28	1.57	19.40	0.52
	Mississippi	24	35.64	1.81	19.36	1.41
	Oklahoma	1	36.90	—	16.80	—
	Tennessee	10	35.87	1.15	19.12	1.07
	Texas	4	34.05	0.61	19.85	1.20
Averages	Midsouth	103	35.80	1.56	19.03	1.15
Ranges	Midsouth		(30.9 - 40.1)		(16.8 - 22.5)	
Southeast	Alabama	3	36.70	2.37	17.90	1.17
(SE)	Florida	0	—	—	—	—
	Georgia	1	36.30	—	19.00	—
	North Carolina	8	36.16	1.45	18.59	0.96
	South Carolina	2	36.05	0.49	18.85	0.92
Averages	Southeast	14	36.26	1.44	18.50	0.95
Ranges	Southeast		(34.5 - 39.2)		(16.6 - 20.7)	
East	Delaware	2	36.80	1.41	18.20	0.42
Coast	Maryland	6	36.18	1.57	18.12	0.99
(EC)	New Jersey	4	36.53	1.11	18.33	0.73
	New York	7	36.96	1.86	17.31	1.02
	Pennsylvania	4	36.50	1.35	17.38	0.87
	Virginia	2	37.05	0.92	17.90	0.42
Averages	East Coast	25	36.62	1.41	17.80	0.91
Ranges	East Coast		(33.3 - 40.5)		(15.6 - 19.9)	
USA	Averages	1308	35.65	1.65	18.66	1.02
	Ranges		(26.2 - 42.0)		(15.1 - 22.5)	
	US 1986-2003 avg.		35.41		18.60	

Basis 13% moisture

Data as of November 7, 2003

Table 3. Soybean composition response to weather and non-agronomic variables.

Variable	Impact on	
	Protein	Oil
High temperatures	Inconclusive	Inconclusive
Early season drought	–	+
Late season drought	+	–
Early frost/cold temperatures	–	–[b]
Additional soil nitrogen	+	–
Increased fertility (P, S)	+	+
Late planting	+	–
Insect defoliation	–	–
Insect depodding	+	Inconclusive
Inoculation with Rhizobia (N-fixing bacteria)	+	–

After Westgate et al. (1999)
[b] Oil reduced because of additional refining needs
+ = increase; – = decrease

Table 4. Historical Summary of Yield and Quality Data for U.S. Soybeans.

Year	Yield (bu/a)	Protein (%)	Oil (%)	Sum (%)	Harvested (000 acres)	Production (000 bu)
1986	33.3	35.76	18.54	54.30	58,312	1,941,790
1987	33.9	35.46	19.11	54.57	57,172	1,938,131
1988	27.0	35.13	19.27	54.40	57,373	1,549,071
1989	32.3	35.18	18.73	53.91	59,538	1,923,077
1990	34.1	35.40	19.18	54.58	56,512	1,927,059
1991	34.2	35.48	18.66	54.14	58,011	1,983,976
1992	37.6	35.56	17.27	52.83	58,233	2,189,561
1993	32.6	35.73	18.03	53.76	57,307	1,868,208
1994	41.4	35.39	18.20	53.59	60,809	2,517,493
1995	35.3	35.45	18.19	53.64	61,544	2,172,503
1996	37.6	35.57	17.90	53.47	63,349	2,381,922
1997	38.9	34.55	18.47	53.02	69,110	2,688,379
1998	38.9	36.13	19.14	55.27	70,441	2,740,155
1999	36.5	34.55	18.61	53.16	72,476	2,645,374
2000	38.0	36.22	18.65	54.87	73,024	2,774,912
2001	39.4	34.98	18.97	53.95	74,100	2,922,914
2002	37.0	35.42	19.38	54.80	71,800	2,650,000
2003	34.0	35.65	18.66	54.31	72,538	2,468,390
Averages	35.7	35.42	18.61	54.03	63,981	2,293,495
Std. Dev.	3.4	0.44	0.54	0.67	6,800	398,572

Sources: United States Department of Agriculture and Iowa State University
Protein and oil contents basis 13% moisture
Yield Data for 2003 estimated October 14, 2003
Protein and oil data for 2003 as of Nov 7, 2003

Table 5. Summary of GIPSA Grain Inspection Data for Soybeans.

		GIPSA Export Inspection Data						ISU Survey Results	
Calendar Year	Crop Years	Percent No. 2YSB	Moisture (%)	Foreign Material (%)	Damaged Kernels (%)	Protein (%)	Oil (%)	Protein (%)	Oil (%)
1994	93,94	90.3	12.6	1.7	1.1	35.5	18.4	35.5	18.1
1995	94,95	92.3	12.2	1.7	1.0	35.2	18.5	35.4	18.2
1996	95,96	92.2	12.1	1.7	1.1	35.1	18.5	35.5	18.0
1997	96,97	90.9	12.6	1.6	0.8	35.3	18.4	35.0	18.2
1998	97,98	90.0	12.2	1.6	1.0	35.5	18.8	35.3	18.8
1999	98,99	89.4	12.0	1.6	0.9	35.3	18.8	35.3	18.9
2000	99,00	90.0	11.4	1.7	1.0	35.0	18.5	35.4	18.6
2001	00,01	89.5	11.5	1.7	1.3	35.8	18.5	35.6	18.8
2002	01,02	93.1	12.1	1.5	1.4	35.2	18.8	35.5	19.0
2003	02,03							35.4	19.0
Averages		90.9	12.1	1.6	1.1	35.3	18.6	35.4	18.6

Source: USDA Grain Inspection Packers and Stockyards Administration, Iowa State University
Protein and oil basis 13.0% moisture