QUALITY OF THE 2000 SOYBEAN CROP FROM THE UNITED STATES [1/]

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Quality, as measured in several ways, is of increasing importance to soybean markets. Since 1972, customers have reported differences in protein and oil contents among soybeans of different origins (Hurburgh, et al., 1990). Geographic differences in composition are primarily caused by weather and environmental factors. In recent years, soybean component variations have been studied extensively (Westgate, et al., 1999). From a customer perspective, monitoring of crop quality on an annual basis is important to estimate outputs and value.

Since 1986, Iowa State University (ISU) and the American Soybean Association (ASA) have been surveying the quality of new crop soybean harvests. In response to a mailed request from ASA, approximately 1000-1500 producers per year, representing all 29 soybean production states, provided samples for analysis. Samples were analyzed for protein and oil contents using an Infratec 1220 series near infrared instrument (Foss North America, Eden Prairie, Minn.). From other sources, data on the yield and physical quality (U.S. Grade factors) of U.S. soybeans has been collected. Advances in instrumentation are allowing us to track subunits (amino acids, fatty acids, sugars) as well as total protein and oil. Most recently, with the introduction of biotechnology, Roundup Ready™ soybeans have been compared to traditionally developed soybeans.

The 2000 U.S. Soybean Crop

The United States produced a record 2.774 billion bushels of soybeans in 2000, according to the November 1 USDA production estimates (USDA, 2000a). Soybean yields, at 38.0 bushels per acre, were the third highest ever and harvested acreage was at an all time high. Table 1 summarizes production statistics for the 2000 crop, by state and growing region. USDA also surveyed producers as to their plantings of GMO varieties, primarily Roundup Ready™ soybeans (USDA, 2000b). Approximately 53% of U.S. soybeans were GMO in 2000. However, there are no known clear-hilum food grade varieties that are genetically modified. Seed companies have recognized the need to maintain a standard of identity for all customers in the food market.

Composition data is given in Table 2. Protein content is the highest in the 15 years of the survey, and oil is right at the average for the same period. We estimate that U.S. soybeans will produce 43.8 lbs of 48% protein meal and 10.9 lbs of oil per bushel, compared to long-term averages of 43.4 and 10.8 lb per bushel, respectively. The usual pattern of increasing protein from north to south in the U.S. was present in the 2000 data.

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There have been reports of purple and brown staining of seed coats in the 2000 crop. This is caused by viruses but does not affect crushing value. The discoloration is an acceptance problem for food uses, and some firms have reported a bitter taste in soyfood products when discolored soybeans were used. The increased incidence of discoloration is attributed to three consecutive warm winters with little snow cover.

Historical Performance

Soybean yields and acreage have been increasing steadily in the last 15 years. Table 3 shows a combination of USDA production (USDA, 2000c) and survey composition data. The same data is shown graphically in Figure 1. Yields have been increasing at approximately 0.5 bu/acre/year at the same time soybean acreage was also increasing, with little effect on average protein and oil content. The conclusion is that U.S. soybean breeders have continued to improve yield, which is the primary factor determining producer income, but have been successful in preventing a loss of quality. This was the primary request of many international customers at the time ASA initiated the survey and supporting research emphasis on composition.

The result of this trend is a consistent increase in the output per acre of nutrients. Figure 2 shows this impact. Greater amounts of useful product are being produced which creates more affordable and abundant supplies. Concentration of nutrients is important, however. The processing chart in Figure 3 shows the combinations of protein and oil content that will produce 47.5%-48.5% protein soybean meal. Only once (1997) did U.S. soybeans fall outside 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 long term U.S. averages are regularly in the middle of this area.

The USDA Grain Inspection Packers and Stockyards Administration (GIPSA) has been collecting results from Official soybean export inspections. Official inspections establish Grade based on a set of physical factors and, on request, will report protein and oil contents. GIPSA also uses an Infratec whole-grain near-infrared analyzer to measure protein and oil, but uses a different calibration equation than ISU. Comparative data is given in Table 4. The majority of inspections are for U.S. No. 2 soybeans. There has been little change in physical quality over time, and the GIPSA composition measurements line up well with the ASA-ISU survey data. Next year, the near-infrared calibration databases of GIPSA and ISU will be combined to produce an improved calibration that will measure specialty and/or high protein soybeans more accurately.

Changes in US Domestic Markets

One U.S. soybean processor has begun offering premiums for soybeans with improved composition. Initially, the premium has been for oil only, but expansion to protein is expected for the 2001 crop. The premium to growers has been approximately 50% of the value of increased oil compared to the long-term average oil content. The effect of this premium will be to alter growers' choices of varieties and to direct soybeans with the best composition to those markets.

As supporting data to develop this premium, a large number of samples were collected directly from producers, along with the estimated yield (bushels per acre). As in the national data, yield and composition were not related to each other. Therefore, a seed-selection and agronomic strategy was designed around circumstances causing both yield and composition (as measured by protein plus oil) to be above the average for the local area.

Approximately 20% of soybeans fell into the desirable category. Figure 4 demonstrates the data for samples collected at three locations in Iowa. Soybeans in quadrant I on the graph had both high yield and high composition. Both the processor and the producer would desire these soybeans. Likewise, those in III would be unfavorable to both. Results in quadrant II benefit the producer (high yield) but not the processor (low composition), and those in IV benefit the processor (high composition) but not the producer (low yield). With no payment for composition, soybeans from quadrants I and II are equally likely selections by the producer; a small but consistent (from year to year) payment will, over time, favor situations in quadrant I.

Subunit Modifications

For several years there have been specialty soybeans that produce unique oil properties, such as more or less saturated fats, or more of one particular fatty acid. One genetics company also offers soybeans with more sucrose sugars, and less of the long chain oligosaccharide sugars that are harder to digest. Because most soybean meal is used for animal feed, it is also important that amino acids be considered. Swine and poultry each have selected amino acids that are limiting to their growth and that must be provided in the diet.

We have been measuring the amino acid profiles of a wide range of soybeans, from the very low protein found in some northern states to very high protein specialty soybeans grown in longer season areas. The general assumption is that amino acid percentages track protein and that therefore meal of a given protein content is generally consistent in amino acid levels. Figure 5 shows trends in selected essential amino acids relative to protein. The general assumption is not always true.

Especially in the sulfur containing amino acids (cysteine and methionine, which are limited to poultry), the lower protein soybeans contain as much if not more than the higher protein soybeans. This means that lower protein soybeans may produce meal that is higher in value for certain uses even though it may have lower total protein content than meal from high protein soybeans. Rapid measurement methods for amino acids are being developed. It appears that specializing the meal market may offer an opportunity to solve the longstanding problem of low crude protein levels in far northern growing regions.

GMO Soybeans

In recent years, public yield trials have provided separate comparisons for Roundup Ready^{TM} and conventional soybeans. Table 5 summarizes the Iowa Soybean Yield Tests for 1998 and 1999, by GMO classification. There was no consistent difference in composition between the RR and non-RR soybeans. There were several thousand entries per classification in each year.

Environmental Effects

As mentioned earlier, several researchers have studied the impact of weather conditions on soybean composition. Westgate et al. (1999) summarized these findings. Table 6 is a qualitative presentation of the soybean quality changes to be expected from weather and agronomic factors. Interestingly, late season drought and depodding from insect attack were common in 2000 soybeans. Increased protein would be expected. As composition becomes more involved in marketing, there will be more study and development of management practices to improve composition.

Summary

The 2000 U.S. soybean crop has above average processing qualities even though yields were near record levels. The U.S. soybean industry has been successful at creating steady yield gains without sacrificing protein and oil content. As actual market practices begin to incorporate composition, producers will likely make specific choices in favor of high yield and high composition. These choices will require price incentives in world markets as well as in domestic U.S. practice if higher valued soybeans are to have an equal opportunity to be exported as to be domestically processed. More sophisticated measurements such as for amino acid levels will reduce the impact of chronic weather-related protein shortfalls in certain growing areas.

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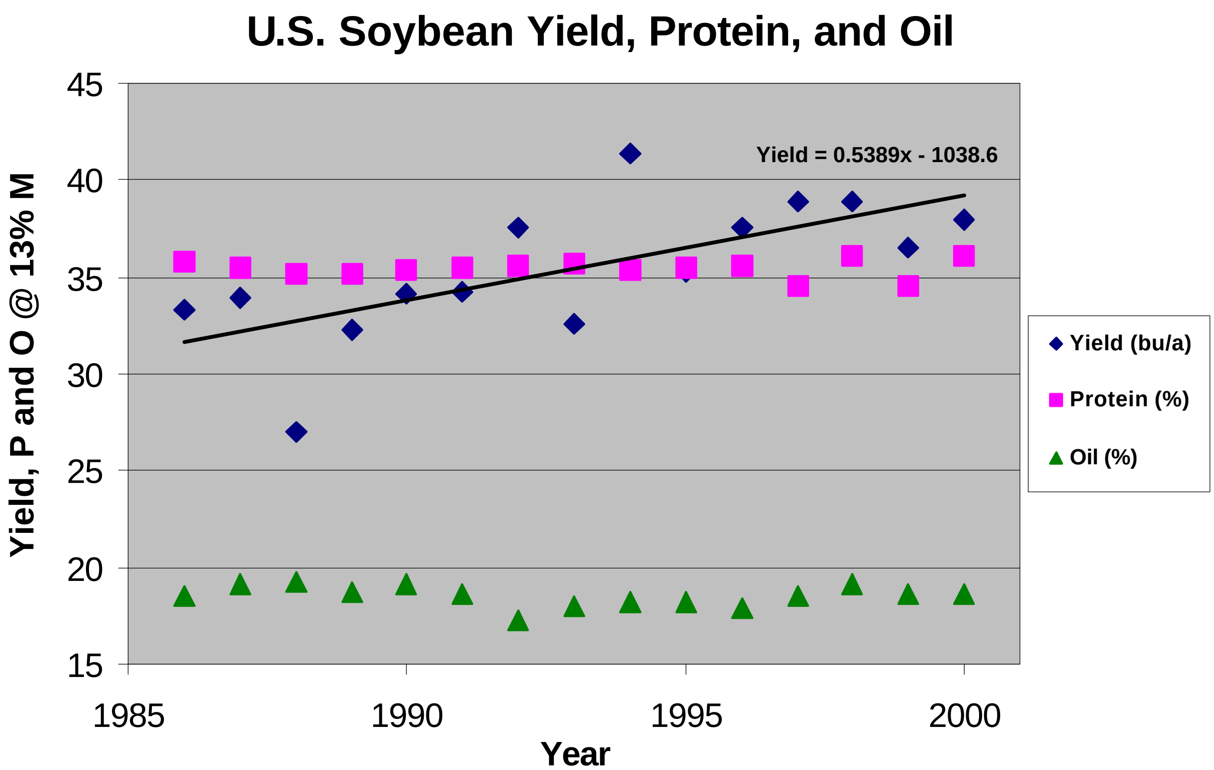

Figure 1. Trends in U.S. soybean yield, protein, and oil

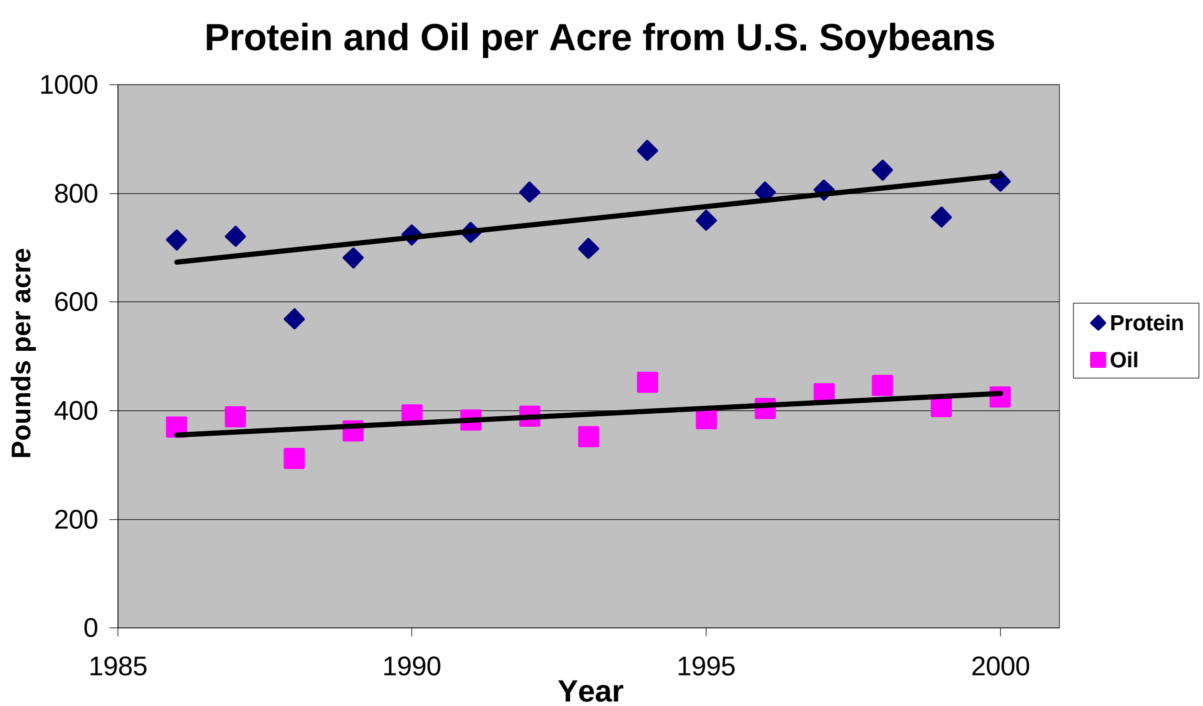

Figure 2. Output per acre of U.S. soybeans

Soybean Processing Relationships

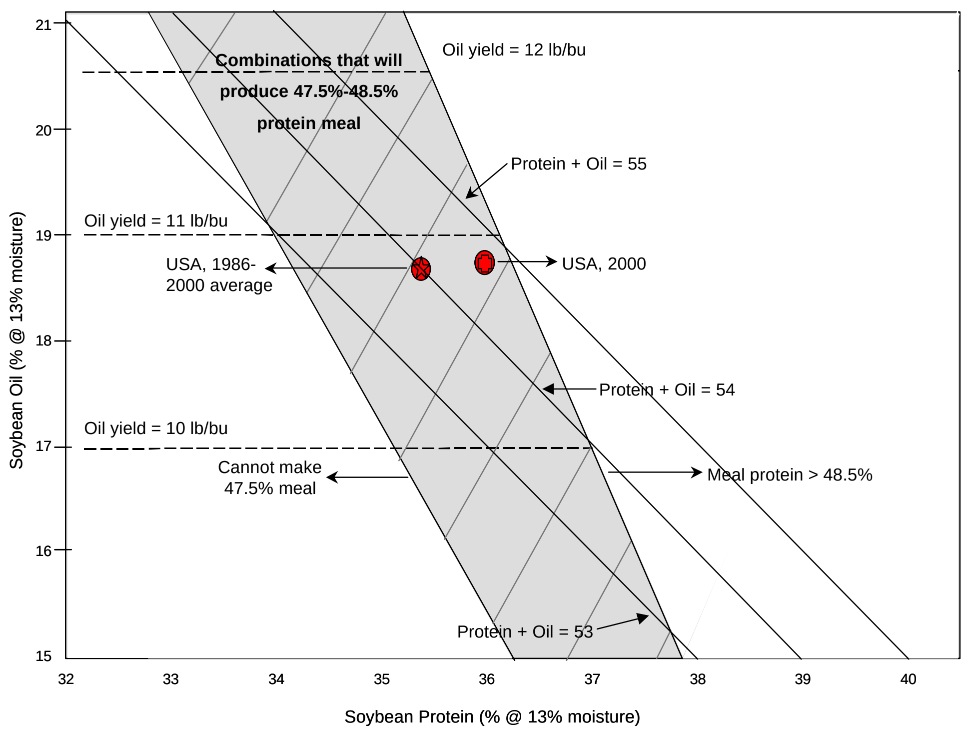

Figure 3. Protein and oil combinations that will produce 47.5%-48.5% protein meal

Identification of High-Value Soybeans

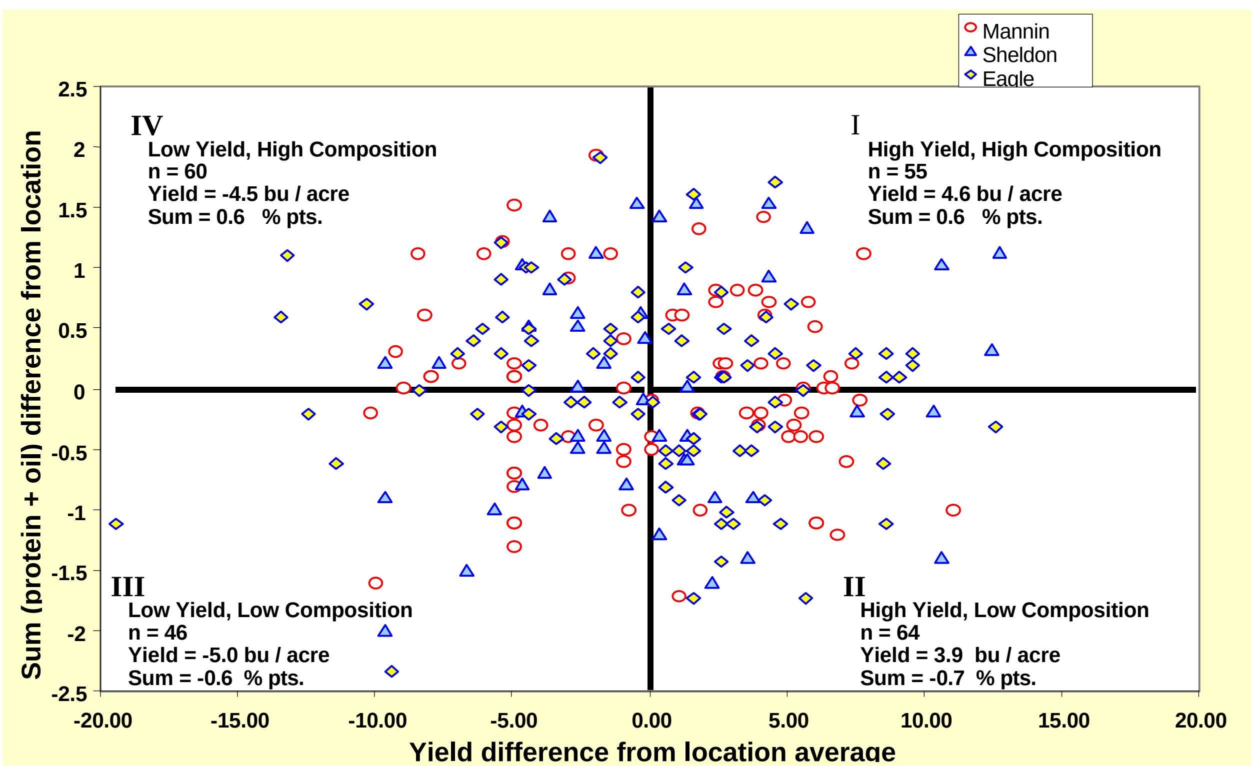

Figure 4. An example of soybean selection based on yield and composition, three Iowa locations, 1998 crop

Soybean Amino Acids versus Crude Protein

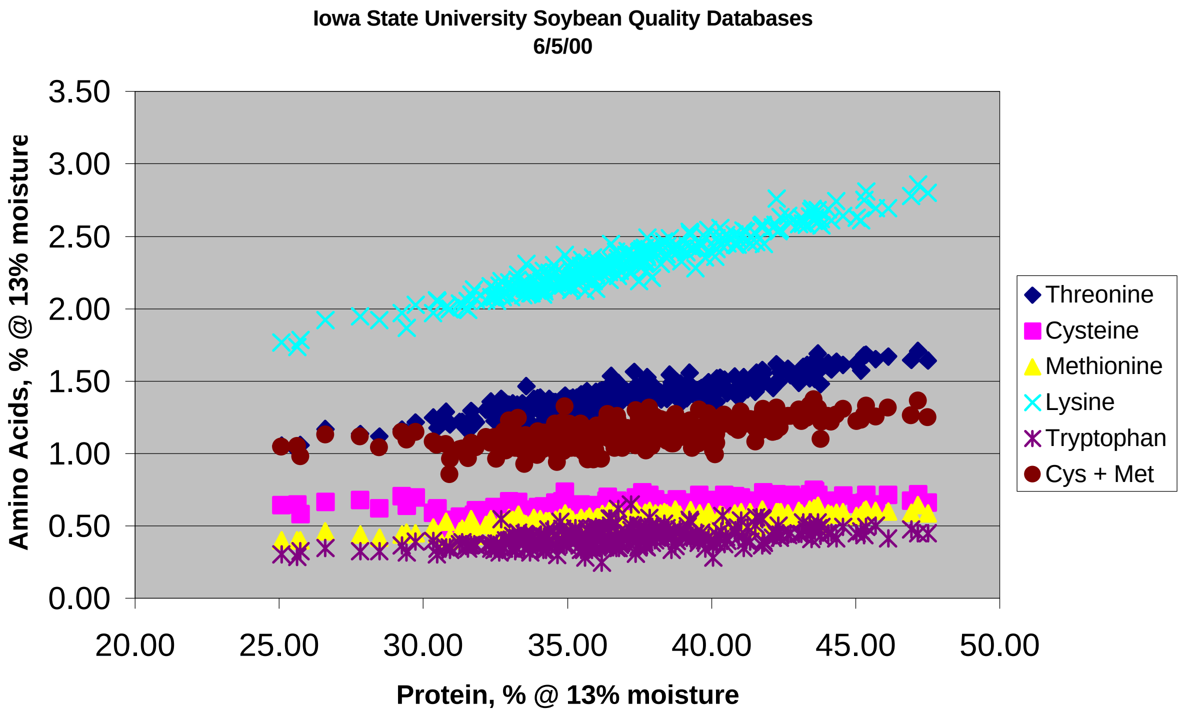

Figure 5. Relationship of soybean amino acid levels and protein content

Table 1. Soybean production data for the United States, 2000 crop

Region	State	Yield (bu/a)	Acreage (000 acres)	Production (000 acres)	Percentage of acres in GMO*
Western Corn Belt (WCB)	Iowa	43.0	10,550	453,650	59
	Kansas	21.0	2,700	56,700	66
	Minnesota	41.0	7,100	291,100	46
	Missouri	36.0	5,100	183,600	62
	Nebraska	37.0	4,600	170,200	72
	North Dakota	33.0	2,070	68,310	22
	South Dakota	34.0	4,250	144,500	58
	Western Corn Belt	37.6	36,370	1,368,060 49.3%	57
Eastern Corn Belt (ECB)	Illinois	44.0	10,250	451,000	44
	Indiana	46.0	5,660	260,360	63
	Michigan	39.0	2,190	85,410	50
	Ohio	44.0	4,390	193,160	48
	Wisconsin	40.0	1,440	57,600	51
	Eastern Corn Belt	43.8	23,930	1,047,530 37.7%	50
Midsouth (MDS)	Arkansas	25.0	3,350	83,750	43
	Kentucky	40.0	1,080	43,200	54
	Louisiana	24.0	880	21,120	54
	Mississippi	21.0	1,620	34,020	48
	Oklahoma	18.0	350	6,300	54
	Tennessee	26.0	1,160	30,160	54
	Texas	30.0	300	9,000	54
	Midsouth	26.0	8,740	227,550 8.2%	49
Southeast (SE)	Alabama	17.0	160	2,720	54
	Florida	28.8	40	1,152	54
	Georgia	24.0	180	4,320	54
	North Carolina	31.0	1,330	41,230	54
	South Carolina	24.0	450	10,800	54
	Southeast	27.9	2,160	60,222 2.2%	54
East Coast (EC)	Delaware	44.0	221	9,724	54
	Maryland	41.0	490	20,090	54
	New Jersey	40.0	93	3,720	54
	New York	34.0	165	5,610	54
	Pennsylvania	42.0	395	16,590	54
	Virginia	39.0	460	17,940	54
	East Coast	40.4	1,824	73,674 2.7%	54
USA		38.0	73,024	2,777,036	53
USA 1986-2000 averages		35.4	62,214	2,216,107	

Source: United States Department of Agriculture

* MDS except AR, MI and all SE, EC states were grouped in one estimate of GMO percentage

Table 2. American Soybean Association 2000 soybean quality survey data.

Region	State	Number of Samples	Protein Percent Average	Protein Std. dev.	Oil Percent Average	Oil Std. dev.
Western Corn Belt (WCB)	Iowa	168	36.00	1.23	18.67	0.75
	Kansas	32	35.81	2.26	18.48	1.47
	Minnesota	98	34.91	1.34	18.53	0.72
	Missouri	*	35.88	*	18.75	*
	Nebraska	69	35.80	1.32	18.88	0.75
	North Dakota	12	33.33	1.96	18.79	1.25
	South Dakota	46	34.93	1.79	18.53	0.82
Averages	Western Corn Belt	425	35.51	1.57	18.65	0.85
Ranges	Western Corn Belt		(28.3-40.8)		(15.6-20.9)	
Eastern Corn Belt (ECB)	Illinois	195	36.92	1.50	18.81	0.96
	Indiana	95	37.35	1.22	18.52	0.77
	Michigan	37	36.77	1.31	17.65	1.04
	Ohio	53	36.91	1.60	18.34	0.77
	Wisconsin	15	35.82	1.64	18.65	0.77
Averages	Eastern Corn Belt	395	36.96	1.47	18.56	0.95
Ranges	Eastern Corn Belt		(30.7-40.5)		(14.7-21.5)	
Midsouth (MDS)	Arkansas	50	36.32	1.53	18.75	1.07
	Kentucky	9	35.90	3.17	18.86	0.46
	Louisiana	9	36.47	0.76	19.48	1.20
	Mississippi	31	35.72	1.53	18.98	1.27
	Oklahoma	1	34.20	–	20.10	–
	Tennessee	15	35.79	1.24	18.74	1.36
	Texas	2	33.50	4.10	19.80	1.13
Averages	Midsouth	118	36.01	1.72	18.90	1.14
Ranges	Midsouth		(28.7 - 41.4)		(15.1 - 21.5)	
Southeast (SE)	Alabama	5	37.02	2.31	19.20	2.09
	Florida	0	–	–	–	–
	Georgia	1	37.70	–	19.50	–
	North Carolina	13	36.21	1.67	19.15	1.24
	South Carolina	5	36.22	1.58	18.96	0.86
Averages	Southeast	24	36.44	1.73	19.14	1.31
Ranges	Southeast		(32.8-39.9)		(15.7-21.4)	
East Coast (EC)	Delaware	2	36.60	1.27	19.55	0.64
	Maryland	9	37.44	1.09	18.54	0.88
	New Jersey	8	37.13	1.48	18.56	0.81
	Pennsylvania	10	36.66	1.52	18.40	0.58
	Virginia	6	36.25	1.14	18.98	0.64
Averages	East Coast	35	36.89	1.33	18.64	0.75
Ranges	East Coast		(34.3-39.9)		(16.7-20.0)	
USA	Averages	997	36.22	1.68	18.65	0.94
	Ranges		(28.3-41.4)		(14.7-21.5)	
	US 1986-2000 avg.		35.43		18.53	

Basis 13% moisture

*Estimated from long term trend. MO sample requests lost because of mailing error.

Table 3. Summary of Yield and Quality Data for US 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
Averages	35.4	35.44	18.53	53.97	62,214	2,216,107
Std. Dev.	3.5	0.47	0.55	0.71	5,991	383,306

Sources: United States Department of Agriculture and Iowa State University
Protein and oil contents basis 13% moisture

Table 4. Summary of GIPSA Grain Inspection Data for Soybeans

Calendar Year	Crop Years	Percent No. 2YSB	Moisture (%)	Foreign Material (%)	Damaged Kernels (%)	Protein (%)	Oil (%)	ISU Survey Results Protein (%)	ISU Survey Results Oil (%)
1990	89,90	86.1	11.7	1.8	1.1	35.5	18.6	35.3	19.0
1991	90,91	86.4	12.1	1.7	1.1	35.5	19.0	35.4	18.9
1992	91,92	75.3	12.0	1.7	1.2	35.2	18.9	35.5	18.0
1993	92,93	86.2	12.5	1.7	1.1	35.4	18.3	35.6	17.5
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

Sources: USDA Grain Inspection Packers and Stockyards Administration and Iowa State University
Protein and oil basis 13% moisture

Table 5. Comparison of Roundup Ready™ and conventional soybeans, Iowa Soybean Yield Tests; 1998 and 1999

Factor	Average value in			
	1998		1999	
	RR	Conv.	RR	Conv.
Yield (bu/a)	56.6	60.4	52.6	55.4
Protein (%)	36.3	35.9	35.8	35.7
Oil (%)	19.4	19.4	18.1	18.2

Yield, protein and oil basis 13% moisture
Data averaged across districts and maturities

Table 6. Soybean component response to weather and non-agronomic variables

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

[a] After Westgate et al. (1999)
+ = increase; – = decrease