

World Distribution and Significance of Soybean

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The fascinating early history of the soybean [*Glycine max* (L.) Merr.] has been thoroughly reviewed in several texts. Probst and Judd (1973) presented an extensive review of the origin and early history of this crop with highlighted references to soybean in books written over about 4500 yrs. The early Chinese history is particularly interesting.

The history of soybean in the USA has been recently expanded by Hymowitz and Harlan (1983). They have evidence that Henry Yonge first planted soybean on his farm in Thunderbolt, GA in 1765. Samuel Bowen, a former seaman employed by the East India Company, brought soybean to the USA from China via London.

From 1804 to 1890 in the USA, occasional references to soybean were made in experiment station publications and scientific literature. Virtually without exception these references were positive. The soybean was highly praised for its high productivity and yield, ability to grow in many different climates and soils, and quality as a silage and forage crop. After 1890, soybean research intensified. The U.S. Department of Agriculture (USDA) published three early bulletins devoted solely to soybean (Ball, 1907; Morse, 1918; Piper and Nielsen, 1909).

In the USA, soybean was primarily a forage crop and grown for hay and silage with cowpea (*Vigna sinensis* L.), millet (*Panicum* spp.), or sorghum [*Sorghum bicolor* (L.) Moench]. Soybean was frequently grown with corn (*Zea mays* L.) to increase soil N and to improve the quality of silage.

Successful use of soybean as an oilseed in Europe from about 1900 to 1910 promoted interest in its use in the USA. Limited U.S. production necessitated imports of oil and meal from the Orient for processing in

Table 1-1. World production of major oilseeds (Tg). Source: USDA Foreign Agricultural Service (1983).

Year	Soybean	Cottonseed	Peanut	Sunflowerseed	Rapeseed	Flaxseed	Copra	Kernel	Total
1964-1965	28.3	22.1	16.5	8.6	4.4	3.4	3.4	0.9	87.7
1965-1966	32.4	22.5	15.7	8.1	4.8	3.4	3.6	0.9	91.4
1966-1967	35.0	20.7	16.4	9.4	4.7	3.0	3.3	0.8	93.3
1967-1968	36.4	20.7	16.9	9.7	5.8	2.5	3.4	0.8	96.4
1968-1969	40.2	22.6	15.8	9.8	5.5	2.9	3.5	0.8	101.2
1969-1970	40.9	21.8	16.8	10.2	5.2	3.5	3.5	0.9	103.1
1970-1971	42.4	21.9	17.6	9.6	7.4	4.0	4.0	0.9	108.1
1971-1972	46.4	24.5	18.3	9.8	7.9	2.8	4.6	0.9	115.5
1972-1973	51.4	25.4	15.4	9.6	7.7	2.3	3.9	0.9	116.8
1973-1974	63.9	26.1	16.5	12.1	7.5	2.4	3.6	1.0	133.3
1974-1975	56.6	26.6	17.0	10.6	8.0	2.4	4.6	1.1	127.0
1975-1976	67.9	22.5	18.9	9.9	8.8	2.4	5.3	1.1	136.9
1976-1977	61.3	23.2	17.2	10.1	7.5	2.2	4.7	1.2	127.4
1977-1978	74.6	25.2	16.9	12.9	8.1	2.9	4.9	1.2	146.9
1978-1979	77.4	23.7	17.6	12.8	10.7	2.5	4.4	1.3	150.4
1979-1980	93.7	25.1	17.2	15.3	10.1	2.7	4.6	1.5	170.1
1980-1981	80.8	25.6	16.1	13.1	11.1	2.1	5.0	1.5	155.3
1981-1982	86.3	28.2	19.9	14.7	12.4	2.1	4.7	1.9	170.2
1982-1983	93.9	27.3	17.5	16.5	15.1	2.6	4.5	1.8	179.3
1983-1984	80.3	27.5	18.8	15.7	14.6	2.2	4.3	2.0	165.4

the USA. In 1911, the first oil and meal was processed in the USA from Manchurian soybean by a crushing plant in Seattle, WA. Not until 1915 was oil processed from domestically grown soybean by a cottonseed (*Gossypium hirsutum* L.) oil mill in Elizabeth City, NC. Nearly 30 000 t were processed the 1st yr, owing to the combination of surplus soybean seed and high cottonseed prices.

Processors reverted to using Manchurian soybean during the 1916 to 1917 processing season because of limited availability of domestically grown seed. Southern cottonseed oil mills saw a potential for soybean as an oilseed and contracted with producers for their 1917 crop. These contracts led to increased plantings. Another factor promoting increased soybean acreage was damage to the cotton crop associated with the spread of the boll weevil (*Anthonomus grandis* Boh.) through the South. Soybean was an alternative crop to cotton.

Not until 1920 was domestic soybean processed in the Midwest, by a linseed mill in Chicago Heights, IL. In 1928, several farm groups and an Illinois processor agreed to take production of 20 000 ha to guarantee the availability of enough soybean to operate a processing plant. This agreement helped convince Midwest farmers that the soybean industry wanted a dependable supply of soybean, thus facilitating expansion of soybean production in the Midwest.

Even though interest in soybean production was on the rise during the 1920s and 1930s, most planted soybean acres were used for forage. Large quantities of meal were imported in the 1920s for use as fertilizer. During the mid-1920s soybean meal became an accepted ingredient of livestock and poultry feed rations. Significant quantities of soybean, oil, and meal continued to be imported until the mid-1920s when domestic meal production finally exceeded meal imports. Soybean acreage and yields have consistently increased, making soybean a major U.S. crop.

1-1 WORLD SOYBEAN PRODUCTION

There are eight major oilseeds traded in international markets: soybean, cottonseed, peanut (*Arachis hypogaea* L.), sunflower (*Helianthus annuus* L.), rapeseed (*Brassica napus* L.), flaxseed (*Linum usitatissimum* L.), copra (*Cocos nucifera* L.), and palm kernel (*Elaeis guineensis* L.). They account for over 97% of all world oilseed production. Table 1-1 shows the world production of these oilseeds since 1965.

Soybean production has dominated world oilseed production. It is followed by cottonseed, peanut, and sunflower. Since 1970, soybean production has been at least double that of any other oilseed. The share of soybean in world oilseed production has increased from 32% in 1965 to over 50% in the 1980s. Peanuts' share of production, by contrast, has experienced a reduction of world oilseed share from 18% to only 11% during the same period. Soybean will probably maintain its dominant role for the foreseeable future.

Relatively few countries produce soybean, thus giving soybean-producing countries significant economic power in world oilseed trade. Table 1-2 presents world soybean production by country. Until 10 yrs ago, the USA and the People's Republic of China had long been the only major producers and world suppliers of soybean.

Remarkable increases of soy production in Brazil since 1970 have changed the soybean market structure tremendously. Brazil is now a major producer, having surpassed the People's Republic of China in 1974. At present, Brazil is the second largest soybean producer and world supplier.

Argentina recently became the newest major soybean producer. Soybean production in Argentina has continued to increase rapidly since 1975. Their pattern of production expansion resembles that of Brazil.

The four major producers, USA, Brazil, China, and Argentina together account for 90 to 95% of the world production. Figure 1-1 shows soybean production of these countries since 1965. Prior to the 1970s, the USA and China were the only major soybean producers. The USA's production share climbed yearly at the expense of China's share, because the USA increased soybean production at a much faster rate. The U.S. share of world soybean production increased from 60% in 1960 to its peak share of 75% in 1969. China's production share had decreased from 32 to 16% over the same period.

Recently, from 1980 to 1983, the USA has produced 63% of world soybean. Brazil and China, the second and third largest producers, have shares of 16 and 9%, respectively, of world production. Argentina continues the persistent strong increase of soybean production annually with a 6% share.

1-1.1 United States Soybean Production

World demand for cooking and salad oil and red meat increased substantially during and immediately after World War II. These demands stimulated the rapid expansion of soybean production, and made soybean second only to corn in generating farm income.

The expansion of soybean acreage has come primarily from the diversion of land from other cultivated crops and the development of new cropland. Soybean acreage has increased from less than 5.6 million ha (Mha) in the early 1950s to over 17 Mha in 1971 to 1972, and a record 28.5 Mha in 1979 to 1980. The USA is now producing, consuming, and exporting more soybean than any other country.

There are five major soybean production regions according to the USDA: Western Corn Belt, Eastern Corn Belt, Southeast, Delta, and Atlantic states (Hazera and Fryar, 1981). Soybean production areas are illustrated in Fig. 1-2. One can see production is concentrated in the Midwest and Mississippi Valley.

Corn Belt states, with their rich agricultural land, have the highest soybean yields and also produce the most soybean in the nation. Soybean

Table 1-2. World soybean production. Source: USDA-Foreign Agricultural Service, 1983.

Continent and country	Area			Production		
	1980-1981	1981-1982	1982-1983	1980-1981	1981-1982	1982-1983
	1 000 ha			1 000 t		
North America						
Canada	283	279	364	713	607	857
Mexico	150	370	390	280	680	550
USA	27 461	26 858	28 645	48 772	54 435	61 969
South America						
Argentina	1 740	1 985	2 000	3 500	4 000	3 400
Bolivia	27	45	45	40	78	79
Brazil	8 534	8 293	8 300	15 200	12 800	14 600
Chile	1	1	1	1	1	1
Columbia	44	50	56	89	100	110
Ecuador	21	21	21	31	33	20
Paraguay	400	420	370	600	600	550
Peru	10	12	14	8	10	11
Uruguay	35	17	20	45	20	25
Venezuela	0	0	0	0	0	0
Africa						
Egypt	35	46	62	32	130	175
Morocco	1	1	0	1	1	0
Nigeria	165	165	165	56	60	65
South Africa	22	22	25	26	21	20
Cimbabwe	38	60	70	65	86	100
Europe						
Bulgaria	94	94	90	107	113	120
Czechoslovakia	5	5	5	5	5	5
France	8	10	9	14	18	20
Hungary	20	25	25	39	45	50
Romania	364	310	315	448	268	325
Spain	7	4	5	14	7	9
Yugoslavia	17	47	77	34	93	180
Soviet Union	854	864	800	525	450	480
Asia						
China						
Mainland	7 226	8 024	8 300	7 940	9 330	8 700
Taiwan	10	10	10	16	15	15
India	500	500	550	450	500	650
Indonesia	811	725	780	687	609	620
Iran	34	50	50	50	80	80
Japan	142	149	147	174	212	226
North Korea	300	300	300	330	330	330
Republic of Korea	188	202	183	216	257	233
Philippines	10	11	12	10	10	12
Thailand	128	130	112	131	117	110
Turkey	3	17	25	3	15	50
Oceania						
Australia	46	46	45	73	79	69
World total	49 734	50 168	52 417	80 784	86 215	94 843

acreage has increased at a remarkable rate in Corn Belt states. The acreage has doubled nearly every 20 yrs since the early 1920s. Over half of the soybean acreage increase in the Corn Belt came from acreage reductions

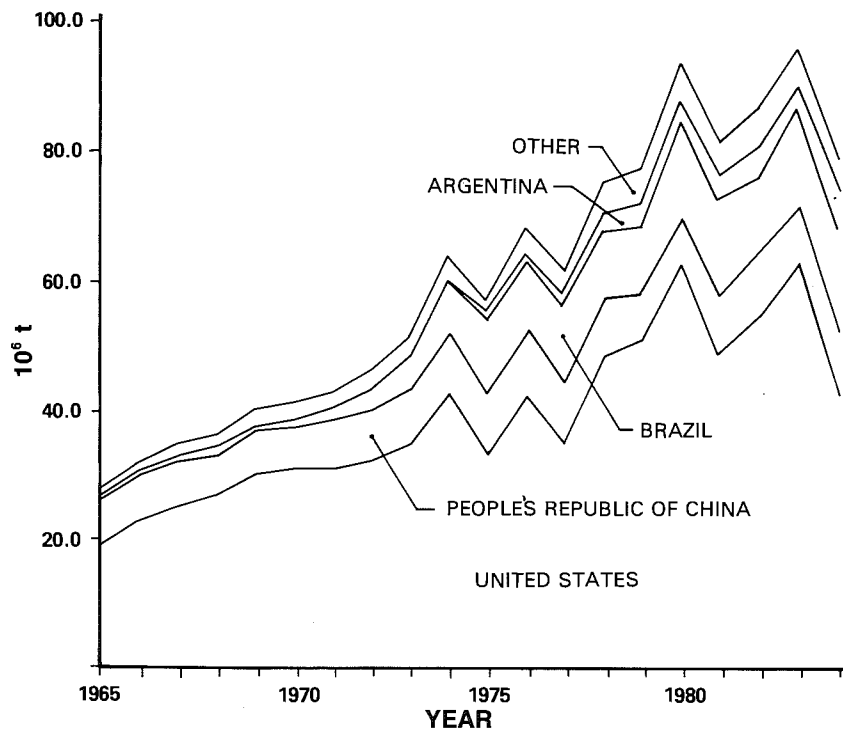


Fig. 1-1. World soybean production, 1965-1984.

in oat (*Avena sativa* L.), hay, and barley (*Hordeum vulgare* L.). While there have been acreage controls on wheat and corn production, there has been no such restriction on soybean acreage, a situation that has allowed soybean expansion to new cultivated land as well as to land diverted from other crops.

Western Corn Belt states have produced about 35% of the U.S. soybean during each of the past three decades. Soybean account for 25% of the total cropland in the region, while corn makes up approximately 40%. Past acreage increases have been made at the expense of oat. This displacement appears completed, so any future acreage increases must come from new cropland or from corn acreages.

Delta States, which include Arkansas, Louisiana, and Mississippi, have expanded soybean harvested acreage for beans at an impressive rate. Soybean acreage has more than doubled every 10 yrs, with increases occurring at the expense of acreage reductions for cotton, corn, small grains, and roughage. Double cropping soybean and wheat (*Triticum aestivum* L.) also contributed to acreage increases. Further expansion of soybean acreage in this region depends upon the government programs for cotton, which competes with soybean for land.

Atlantic states—Virginia, Maryland, Delaware, and North and South Carolina—also expanded their soybean acreage steadily, though at a slower

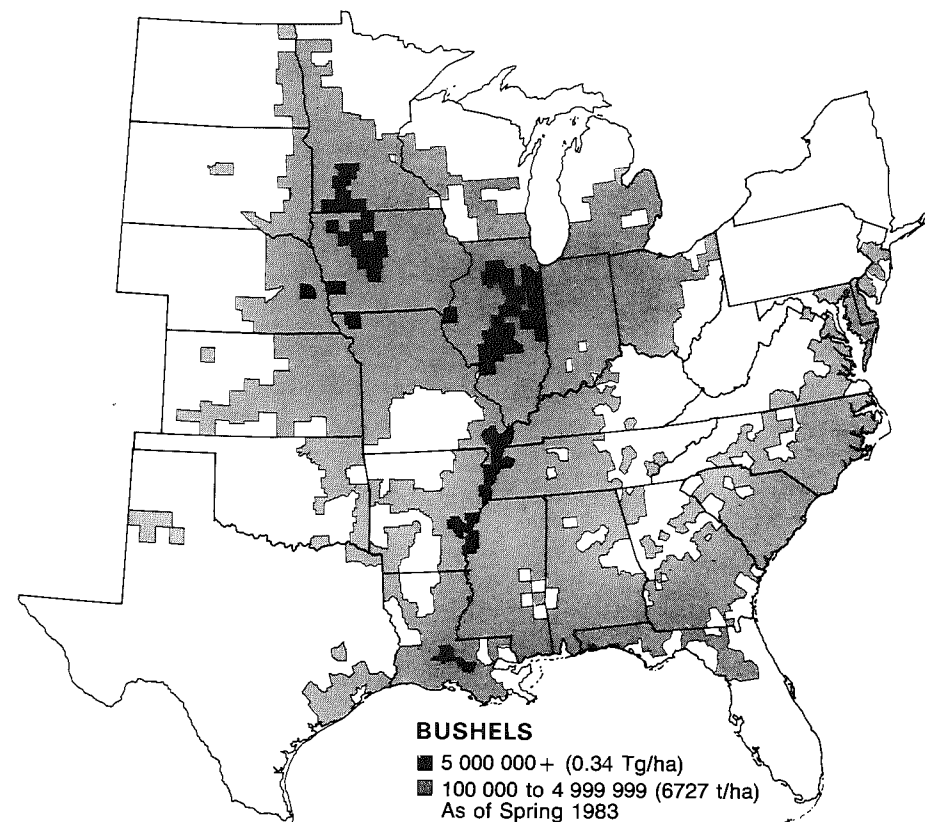


Fig. 1-2. Soybean production in the USA. Courtesy American Soybean Association.

rate than the other regions. New acreage has come from reduction of small grains and roughage production as well as new cultivated land. Access to port facilities on the Atlantic gives incentive for soybean production to satisfy the increasing export demand.

Soybean production in the Southeastern region has expanded rapidly. Acreage increases came from new lands being put into production, from lands previously planted to cotton, corn, and small grains, and from expansion of double-cropped soybean and wheat.

Soybean yields increased rapidly during the period of 1920s to 1940s, and at a slower rate since the 1960s. Yields continue to climb upward as a result of new and better varieties in all regions, improved weed, insect, and disease control, and improved management practices by growers. The trendline for yields may reach about a 20 kg ha^{-1} annual increase based on historical yields. There has been no major genetic breakthrough like hybrid corn for soybean, and no major technological change is expected in the foreseeable future.

The Corn Belt region has the highest soybean yields in the country, between 2.02 to 2.35 t ha⁻¹. States with the highest annual yields are Illinois, Iowa, and Indiana.

Soybean production has continued to increase year after year at an impressive rate. Table 1-3 presents U.S. soybean production, acreage, and utilization data.

Table 1-3. Soybean production and disappearance (local market years).
Source: USDA, Foreign Agricultural Service (1983).

Crop year	Harvested area	Yield	Production	Market year export	Crush†
	Mha	kg ha ⁻¹		Tg	
USA‡					
1963-1964	12.46	1531	19.08	5.77	13.04
1965-1966	13.94	1651	23.01	6.82	14.63
1966-1967	14.79	1709	25.27	7.12	15.23
1967-1968	16.11	1650	26.58	7.26	15.69
1968-1969	16.75	1800	30.13	7.81	16.49
1969-1970	16.73	1843	30.84	11.77	20.07
1970-1971	17.10	1794	30.68	11.81	20.69
1971-1972	17.28	1852	32.01	11.34	19.61
1972-1973	18.49	1870	34.58	13.05	19.65
1973-1974	22.53	1870	42.12	14.67	22.35
1974-1975	20.78	1593	33.10	11.45	19.09
1975-1976	21.70	1942	42.14	15.11	23.55
1976-1977	19.99	1754	35.07	15.35	21.51
1977-1978	23.40	2055	48.10	19.06	25.22
1978-1979	25.76	1974	50.86	20.12	27.70
1979-1980	28.48	2189	61.54	23.82	30.57
1980-1981	27.45	1807	48.94	19.71	27.17
1981-1983	26.79	2053	54.14	25.28	28.03
1982-1983	28.11	2148	59.60	24.63	30.16
1983-1984	25.03	1725	42.65	20.69	26.40
Brazil§					
1965	0.43	1211	0.52	0.08	0.28
1966	0.49	1212	0.59	0.12	0.40
1967	0.61	1170	0.72	0.31	0.42
1968	0.72	906	0.65	0.07	0.47
1969	0.91	1167	1.06	0.31	0.61
1970	1.32	1144	1.51	0.29	0.93
1971	1.72	1210	2.08	0.23	1.70
1972	2.84	1291	3.67	1.01	2.13
1973	3.62	1386	5.01	1.79	2.71
1974	5.14	1531	7.88	2.86	4.30
1975	5.82	1698	9.89	3.52	5.52
1976	6.42	1750	11.23	3.33	6.37
1977	7.07	1770	12.51	2.58	8.67
1978	7.78	1226	9.53	0.66	8.88
1979	8.26	1240	10.24	0.64	9.09
1980	8.77	1727	15.16	1.53	13.01
1981	8.49	1791	15.20	1.50	13.80
1982	8.20	1565	12.84	0.81	12.73
1983	8.23	1793	14.75	1.32	12.87

(continued on next page)

Table 1-3. Continued.

Crop year	Harvested area	Yield	Production	Market year export	Crush†
	Mha	kg ha ⁻¹		Tg	
1984	9.25	1643	15.20	1.50	12.90
Argentina#					
1965	0.02	1063	0.02	—	0.02
1966	0.02	1125	0.02	—	0.02
1967	0.02	1176	0.02	—	0.02
1968	0.03	1100	0.02	—	0.01
1969	0.03	1143	0.03	—	0.02
1970	0.03	1038	0.03	—	0.02
1971	0.04	1639	0.06	—	0.04
1972	0.07	1147	0.08	—	0.05
1973	0.16	1732	0.27	0.05	0.20
1974	0.34	1442	0.50	0.08	0.28
1975	0.36	1362	0.48	—	0.53
1976	0.43	1601	0.70	0.11	0.50
1977	0.66	2121	1.40	0.62	0.59
1978	1.25	2160	2.70	1.98	0.68
1979	1.60	2313	3.70	2.83	0.64
1980	2.03	1773	3.60	2.79	0.72
1981	1.74	2011	3.50	2.19	1.00
1982	1.98	2091	4.15	2.15	1.91
1983	2.12	1688	3.57	1.35	2.05
1984	2.58	2252	5.80	2.45	3.10

† Includes meal exported. ‡ Crop year (September-August). § Crop year (February-January).
Crop year (April-March).

1-1.2 Soybean Production in Brazil

Japanese immigrant farmers introduced soybean to Brazil over 65 yrs ago, but soybean production did not become an important crop in Brazil until the late 1960s. Since the mid-1960s, Brazil has remarkably increased soybean production and become an important world soybean and soybean meal producer and supplier. Four main reasons explain the boom in soybean production and trade in Brazil (Broadbent and Dixon, 1976).

First, high soybean prices during the late 1960s to the late 1970s made soybean a more profitable crop than alternatives such as corn, cotton, rice (*Oryza sativa* L.), pasture, and beef production on the basis of profit per hectare. Therefore, land previously used for these operations was shifted to soybean production.

Second, the U.S. embargo on soybean exports in 1973 forced soybean importers to seek alternative sources for soybean, an action that stimulated Brazilian production.

Third, Brazilian soybean production has been encouraged and assisted through many government policies and a favorable market environment. The Brazilian government offered liberal credit at interest rates lower than current inflation rates for acquisition of machinery and production inputs such as fertilizer. These loans make it easier for farmers

to start or expand soybean production to take advantage of high soybean prices and cheaper production costs.

Fourth, multinational firms that saw economic opportunity assisted soybean farmers by transferring personnel, proven industry technology, capital, and management to develop a new agricultural industry in Brazil.

These motivating forces successfully pushed up Brazilian soybean production from an insignificant 1.8% share of world soybean production in 1965 to more than 15% in 1985. Table 1-3 shows Brazilian soybean production. A dramatic increase in soybean production during the 15 yrs from 1965 to 1980 resulted from vast soybean acreage expansion rather than yield increases. Brazil planted only 432 000 ha of soybeans in 1965 compared to 8.774 Mha in 1980, thus producing 0.52 Tg compared to 15.2 Tg, respectively. The annual rate of production growth has been impressive, especially during the late 1960s to the early 1970s. On the average, soybean production increased more than 25% per year during this past 20 yrs.

Soybean yields in Brazil have not changed much over the past 20 yrs (Huyser, 1983). Some increase in yields in the early 1970s resulted from improved cultural practices, a shift to more fertile virgin soils, and introduction of soybean varieties adaptable to local conditions. Brazilian yields on the average are lower than U.S. yields. In 1975, Brazilian yield was 1.48 t ha⁻¹ (22 bushels acre⁻¹) compared to 1.88 t ha⁻¹ (28 bushels acre⁻¹) for the USA.

Soybean yields in Brazil also vary considerably from area to area. Average yields reported during the 1975 to 1977 period were as follows; Parana 2.10 t ha⁻¹; Sao Paulo, 1.78 t ha⁻¹; Rio Grande do Sul, 1.57 t ha⁻¹; Mato Grosso, 1.50 t ha⁻¹; Santa Catarina, 1.28 t ha⁻¹; and others 1.23 t ha⁻¹ (Williams, 1981). The major factors affecting these yield differences are the soil quality and climate conditions.

Weather has, in the past, played an important role in production. For example, the reduction of soybean production in 1978 and 1979 was due to severe drought in most southern states which reduced yield considerably and, in turn, drastically reduced soybean production.

Most of the Brazilian soybean supply is domestically crushed for meal and oil. Table 1-3 provides data on Brazilian soybean production and disappearance. Soybean crush demand has increased continuously from only 0.282 Tg in 1965 to 5.516 Tg in 1975 and 13.300 Tg in 1981. The crush demand is a dominant soybean use and export is a residual demand. During a year of low soybean supply, soybean exports decrease while soybean crush maintains its increasing trend level. The Brazilian government has policies to encourage the domestic crushing industry and exports of soybean meal and soybean oil, rather than exports of soybean.

1-1.3 Soybean Production in Argentina

Soybean, a relatively new crop in Argentina, has been produced in significant quantity only since 1961 to 1962 as a result of government

encouragement (Huyser, 1983). Since 1962, soybean production has steadily expanded every year. (Table 1-3) Production and acreage began to increase rapidly during the 1970s, as illustrated in a comparison of acreage: 0.03 Mha in 1970, 0.16 Mha in 1973, 0.43 Mha in 1976, and 2.12 Mha in 1983. Production also increased dramatically over this period from only 27 000 t in 1970 to 5.80 Tg in 1984.

Soybean yield, which had been about 1.1 t ha⁻¹ during the 1960s, improved during the early 1970s. By 1979 Argentina's average yields reached a record of 2.313 t ha⁻¹.

Soybean crops are mainly produced in the provinces of Misiones, the southern part of Santa Fe, the northern part of Buenos Aires, Tucuman, and the eastern part of Cordoba. These areas contain about 96% of the total soybean land. During 1964 to 1965 to 1967 to 1968, Misiones soybean land averaged 48% of the total soybean production area. This area of soybean production is located in the corn-wheat-soybean belt of Argentina. Most soybean land was switched from grains and pasture.

Soybean crops are frequently double-cropped with wheat, especially in the major provinces. Soybean also competes with corn production depending upon weather conditions and soil moisture levels. Future expansion of soybean acreage in Argentina is more limited than in Brazil because of land constraints. Expanding soybean acreage means less land is available for other crops. The government does not exercise any supporting policy for wheat-soybean production as in Brazil. Thus, the future of soybean expansion depends upon the soybean-corn price relationship.

Traditionally, all soybean supplies were for domestic consumption to satisfy crush demand. Less than 50 000 t were crushed annually prior to 1973. Since 1973, soybean crush demand has increased from around 200 000 t in 1973 to 3.1 t in 1984. In 1985, there is sufficient crushing capacity in Argentina for domestic supply of soybean meal and oil. Most existing firms crush several types of seed, mainly sunflower and other oilseeds. The soybean crushing industry in Argentina has the disadvantage of higher operating costs than in other countries, especially in the major producing provinces of Santa Fe and Buenos Aires.

At times, these costs are partly offset by financial incentives such as tax rebates on exports of oilseed products. Since 1980, Argentina has expanded its soybean crushing rapidly to domestically capture the industry value added. The 1984 soybean crushing level is more than four times its 1980 level. The expansion has been encouraged by recent unusually high vegetable oil prices. Current indications are that Argentina will continue to expand its domestic crushing industry rather than export whole beans as in the 1970s.

1-2 WORLD TRADE IN SOYBEAN

Twenty-five percent of total world soybean production enters the international trade market in the form of whole beans. The major soybean

exporters are the USA, Brazil, and Argentina. Numerous countries import soybeans both for human food products and for processing into soybean meal and oil. The major traditional soybean importers include European Economic Community (EEC): West Germany, United Kingdom, France, Netherlands, Belgium, Luxemburg, Italy, Denmark, Ireland, and Greece; Japan; Eastern European countries (Poland, Bulgaria, Czechoslovakia, East Germany, Hungary, Romania, and Yugoslavia); and Spain. Tables 1-4 and 1-5 present the amount of soybean trade by country.

After World War II, the USA and the Mainland China were the major soybean exporters with the USA having a much larger share of the export market—around 70% of the trade. The Chinese population explosion and a leveling of soybean production forced China to turn nearly all domestic production to fill demand at home. China reduced exports and by 1965 the export share was only 10% of the world trade. In 1974 for the first time, China became a soybean importer and has continued to import soybeans to meet domestic needs.

The USA has been the largest soybean exporter since the end of World War II. United States soybean exports have increased rapidly from 1.89 Tg in 1955 to 5.8 t in 1965, 11.8 Tg in 1970, and 23.8 Tg in 1980. The USA dominated the soybean export market with a share of 90% or more until 1972 when the share started to drop because of the increase in Brazilian soybean exports. Table 1-4 shows the soybean export share of major soybean exporters.

Major importers of U.S. soybean are the EEC, Japan, and Spain. The EEC is the USA's biggest customer. The EEC soybean imports ac-

Table 1-5. Soybean imports by major trading blocks (Tg). Source: USDA-Foreign Agricultural Service (1983).

Year†	European Economic Community	Japan	Spain	Eastern Europe	Other	Total
1964-1965	3.07	1.85	0.34	0.12	1.05	6.43
1965-1966	3.53	2.17	0.64	0.08	1.07	7.49
1966-1967	3.72	2.17	0.81	0.11	1.18	7.99
1967-1968	3.62	2.42	0.92	0.07	0.86	7.89
1968-1969	3.98	2.59	1.03	0.21	0.79	8.60
1969-1970	5.69	3.24	1.23	0.16	2.10	12.42
1970-1971	5.79	3.21	1.31	0.20	1.99	12.50
1971-1972	6.53	3.40	1.43	0.16	1.21	12.73
1972-1973	7.12	3.64	0.83	0.18	3.17	14.94
1973-1974	9.12	3.24	1.59	0.24	3.41	17.60
1974-1975	8.25	3.33	1.74	0.13	1.81	15.26
1975-1976	9.27	3.55	1.94	0.35	3.59	18.70
1976-1977	9.20	3.60	1.84	0.25	3.67	18.56
1977-1978	11.20	4.26	2.18	0.63	3.34	21.61
1978-1979	12.17	4.13	2.24	0.56	4.23	23.33
1979-1980	12.28	4.17	3.10	0.85	6.71	27.11
1980-1981	10.70	4.21	2.79	0.54	8.75	26.99
1981-1982	12.26	4.47	3.20	0.57	8.82	29.32
1982-1983	11.54	4.87	3.04	0.76	7.89	28.10
1983-1984	10.18	4.70	2.80	0.75	7.86	26.29

† Crop year (September-August).

count for about 40 to 45% of U.S. soybean exports. Japan and Spain import significant amounts of soybean from the USA, accounting for 20 and 8%, respectively. It is anticipated Spain and Eastern Europe will increase their percentage share of soybean imports from the USA.

The U.S. soybean export embargo during 1973 motivated importing countries to look for soybean from alternative sources. This action was a major factor in expanding the Brazilian export market.

Brazil's share of soybean in the world market fluctuates considerably since its actual exports fluctuate from year to year. Since 1965, its export share in the world soybean market varied from less than 1 to 23%. Soybean exports increased from around 300 000 t in 1969 to 1 Tg in 1972 and peaked in 1975 at 3.5 Tg. Due to a drought during 1978 to 1979, soybean exports were restricted to about 650 000 t. Major Brazilian soybean customers include the EEC, Japan, Spain, and more recently, the USSR, the People's Republic of China, and some Eastern European countries.

Brazilian soybean exports enjoy a seasonal advantage of high world prices since its harvest season, March to May, differs from the U.S. major soybean export season of September and October. The annual world price fluctuation has been influenced mainly by the USA because of its domination of world supplies. The normal world soybean price reaches its peak in August, just before the U.S. harvest, and decreases until February when the price starts increasing again. To take advantage of these seasonal prices, Brazil exports soybean slowly in April and accelerates exports from July to August.

Table 1-4. Soybean exports by major trading countries (Tg). Source: USDA-Foreign Agricultural Service (1983).

Year†	USA	Brazil	People's Republic of China‡	Argentina
1964-1965	5.77	0.08	0.58	0.00
1965-1966	6.82	0.12	0.55	0.00
1966-1967	7.12	0.30	0.56	0.00
1967-1968	7.26	0.07	0.57	0.00
1968-1969	7.80	0.31	0.49	0.00
1969-1970	11.77	0.29	0.37	0.00
1970-1971	11.81	0.23	0.46	0.00
1971-1972	11.34	1.20	0.37	0.00
1972-1973	13.05	1.78	0.06	0.05
1973-1974	14.67	2.86	-0.28	0.08
1974-1975	11.45	3.52	0.29	0.00
1975-1976	15.11	3.33	0.15	0.11
1976-1977	15.35	2.58	-0.13	0.62
1977-1978	19.06	0.57	-0.10	1.98
1978-1979	20.12	0.38	0.00	2.83
1979-1980	23.82	1.15	-0.81	2.31
1980-1981	19.71	1.80	-0.54	2.70
1981-1982	25.28	0.86	0.00	1.88
1982-1983	24.63	1.32	0.00	1.42
1983-1984	20.69	1.50	0.00	2.80

† Crop year (September-August).

‡ Negative numbers indicate import of soybean.

The Brazilian government exercises a number of trade policies to control the quantity of soybean exports, in addition to some domestic policies discussed previously. The objectives of these policies are to encourage the domestic crushing industry, to control domestic soybean meal and soybean oil prices, and to take advantage of seasonal price fluctuations. The trade policies include export quota and licenses, export taxes and subsidies, export embargoes, and bilateral trade agreements.

Argentina is the newest major soybean exporter. Argentina did not export any soybean until 1973 when the first 50 000 t were exported. Soybean exports have increased dramatically since 1976 from only 111 000 t to nearly 3 Tg in 1981. The marked increase in soybean production in the late 1970s was primarily for export purposes. The major markets for Argentine soybean exports are the EEC, especially the Netherlands, the USSR, Brazil, and to some extent, Mexico. The USSR recently became a major soybean importer from Argentina. In 1981, the USSR made a trade agreement with Argentina in 1981 to purchase a minimum of 500 000 t of soybean annually until 1985—about 25% of total Argentine soybean exports. Most soybean is exported during May to July each year.

Argentina has exercised a variety of trade policies to manipulate the quantity of soybean and soybean meal exports. These policies include export quotas, issuance of export licenses and export taxes (Huyser, 1983).

Major soybean importers are EEC, Japan, Spain, and Eastern Europe. Table 1–5 presents soybean import shares of major importers. The EEC has always imported the most soybean, since these countries are heavily dependent upon oilseed imports for supplying needed protein for the feed industry. Despite the steady increase in EEC oilseed production, mainly rapeseed and olive (*Olea europaea* L.) the EEC demand for oilseed protein has increased much faster, thus their self-sufficiency in oilseeds has not changed. The EEC is only a little more than 8% self-sufficient in oilseeds. Currently, soybean imports account for nearly 90% of all EEC oilseed imports, which include peanuts, rapeseed, copra, and palm kernels. The USA had long been the only soybean exporter to this region until recently when Brazil and Argentina captured significant market shares in the EEC.

The European soybean-processing industry has increased continuously from 2.5 Tg in 1960, 5.3 Tg in 1970 to 10.2 Tg in 1978 (Williams, 1981). Currently, EEC produces more oil than domestic demand, so EEC exports some soybean oil competing with the USA, Brazil, and Argentina.

The rapid increase of high protein feeds and the low oilseed self-sufficiency of the EEC have led to a heavy reliance on the USA as the major supplier of soybean and soybean meal.

The U.S. soybean embargo in 1973 made the EEC aware of its dependence upon a single supplier. As a result, the EEC attempts to decrease its vulnerability by encouraging greater domestic protein meal production, and substituting other forms of domestically produced high protein feeds for imported protein.

Soybean have also been included under Common Agricultural Policy to encourage domestic oilseed output. The EEC has also tried to diversify

import sources by using bilateral trading agreements. Agreements with India now provide for the supply of peanut meal, and agreements with Brazil and Argentina provide for soybean and soybean meal. Finally, some attempt has been made to improve the community stocking policies and to participate in negotiations in international forums which aim to improve the overall performance of world commodity markets.

The second largest soybean importer is Japan. Like the EEC, Japan relies heavily upon imported soybean to satisfy domestic consumption. Japan has continuously decreased agricultural land and concentrated more on industrialization. The area of agricultural land has declined from a peak of 6.1 Mha in 1961 to about 5.4 Mha in 1978. The acreage for oilseeds has decreased even more because more existing agricultural land is devoted to orchards, permanent plantations, and arable grasslands. This decrease was due to the change of consumption preference in Japan from cereal products to meats, fruits, vegetables, and vegetable oil as personal income increased. The area planted to soybean has declined from 385 000 ha in 1955 to 1956 to 79 000 ha in 1977 to 1978.

Japan has increasingly relied upon soybean imports. Soybean imports were around 1 Tg in the late 1950s and early 1960s, reached 2.2 Tg in 1966, 3.2 Tg in 1970. Imports have totaled more than 4 Tg annually since 1978. At present, soybean imports account for 90 to 95% of the total soybean supply available to Japanese oilseed crushers. Japan also imports some soybean from Brazil and Argentina in an attempt to diversify import sources to reduce dependence upon the U.S. soybean imports.

Traditionally Japanese soybean imports were primarily from the USA, supplemented by imports from the People's Republic of China. While U.S. soybean are mainly crushed for soybean meal, Japanese and Chinese soybean imports are processed for human consumption. Chinese soybean exports have declined due to tremendous increases in domestic demand, which make the People's Republic of China a net soybean importer.

Spain is the third largest soybean importer. Soybean importers account for over 99% of domestic soybean consumption. Since 1965, Spain has increased soybean imports at an impressive average rate of 15% per year. Soybean imports have increased from only 340 000 t in 1965 to 1.2 Tg in 1970 and over 3 Tg in 1980. Peak soybean imports were reported in 1982 at 3.2 Tg. Currently, imports have decreased to an estimated 2.5 Tg for 1983. The increased soybean meal demand by the developing poultry industry have created a growing Spanish market for soybean. The Spanish government has encouraged development of the poultry industry as a means to increase per capita meat consumption. The USA has been a major soybean supplier to Spain.

Another fast-growing soybean importer is Eastern Europe. These countries have imported some soybean for crushing in order to make optimum use of existing crushing capacity in the years when sunflower seed or rapeseed production (domestic oilseeds) is low. Table 1–5 shows soybean imports. Recently, soybean imports have increased substantially,

ranging from 120 000 t in 1965 to over 800 000 t in 1981. Eastern Europe has attempted to increase its crushing industry. The soybean imports are still relatively small compared to soybean meal equivalent consumption. The USA has been the traditional soybean exporter to Eastern Europe. Brazil has recently expanded its soybean export market to Eastern Europe.

A number of high income developing countries, like the Republic of Korea and Taiwan, have increased their soybean imports rapidly in recent years. Taiwan imported 161 000 t of soybean in 1978. The peak Taiwanese import of 1.111 Tg was in 1979. The Republic of Korea started importing soybean in 1967 and its imports have gradually increased. In 1976 its imports were 129 000 t and this reached 500 000 t in 1981. These countries can be strong potential soybean importer markets as their economies improve.

1-3 IMPORTANCE OF SOYBEAN MEAL AND OIL

The demand for soybean is derived mainly from the oil and meal products, and to only a small extent from whole bean products. Houck et al (1972) have summarized soybean utilization (Fig. 1-3). Soybean meal and oil are the most produced, traded, and utilized meal and oil in the world. Table 1-6 compares utilization of soybean meal and oil to other major meals and oils. Soybean meal is 60 to 65% of the total. Soybean meal accounts for an even higher share in the high protein

Table 1-6. World meal and oil utilization (Tg).
Source: USDA-Foreign Agricultural Service (1983).

	1979-1980	1980-1981	1981-1982	1982-1983
<u>Protein meal consumption</u>				
Soybean	58.24	56.92	59.58	61.01
Cottonseed	9.19	9.70	10.24	9.96
Rapeseed	5.32	6.02	7.22	8.54
Sunflower	5.77	5.48	5.78	6.46
Fish	4.61	4.35	4.84	4.76
Peanut	4.22	3.86	4.96	4.35
Copra	1.54	1.61	1.59	1.43
Palm kernel	0.69	0.75	0.89	0.98
Total	89.58	88.70	95.10	97.48
<u>Major vegetable and marine oil consumption</u>				
Soybean	12.42	12.62	13.09	13.55
Palm	4.43	4.95	5.47	5.99
Sunflower	4.66	4.51	5.06	5.42
Rapeseed	3.28	3.36	4.55	5.30
Cottonseed	3.15	3.26	3.36	3.33
Peanut	3.10	2.92	3.40	3.34
Coconut	2.59	2.99	2.88	2.61
Olive	1.66	1.69	1.61	1.68
Fish	1.07	1.11	1.18	1.07
Palm kernel	0.06	0.06	0.77	0.80
Total	36.39	38.62	41.60	42.99

Table 1-7. Soybean meal: World production trade and consumption (Tg).
Source: USDA-Foreign Agricultural Service (1983).

	1979-1980	1980-1981	1981-1982	1982-1983
<u>Production</u>				
USA	24.59	22.06	22.36	24.00
Brazil	8.12	10.62	9.64	10.60
Argentina	0.56	0.72	1.03	1.69
European Economic Community	9.31	8.22	9.40	8.71
Portugal	0.18	0.22	0.41	0.52
Mexico	1.02	1.21	1.19	1.12
Japan	2.70	2.70	2.78	3.00
Spain	2.44	2.25	2.53	2.40
China				
Mainland	2.84	2.92	3.43	3.08
Taiwan	0.67	0.68	0.80	0.81
Soviet Union	0.94	0.99	1.30	1.16
Eastern Europe	1.13	0.87	0.79	1.08
Other	3.13	3.22	3.47	3.74
Total	57.64	56.68	59.45	61.12
<u>Gross exports</u>				
USA	7.20	6.15	6.27	6.45
Brazil	5.44	7.74	8.35	8.24
Argentina	0.26	0.41	0.74	1.50
European Economic Community	3.57	3.91	4.45	5.32
Other	0.70	0.72	1.10	1.42
Total	17.16	18.93	20.90	22.92
<u>Gross imports</u>				
European Economic Community 10	9.42	10.56	11.46	11.95
Portugal	0.27	0.29	0.03	0.00
Mexico	0.16	0.15	0.04	0.18
Japan	0.26	0.29	0.10	0.18
Spain	0.09	0.11	0.12	0.47
Soviet Union	0.44	1.00	1.38	2.63
Eastern Europe	3.92	4.16	3.19	2.75
Other	3.17	3.53	4.13	4.28
Total	17.73	20.08	20.45	22.43
<u>Consumption</u>				
USA	17.43	15.96	16.08	17.52
Brazil	2.46	2.55	2.05	2.29
Argentina	0.32	0.29	0.21	0.19
European Economic Community	15.30	14.82	16.38	15.31
Eastern Europe	5.08	5.03	3.98	3.82
Portugal	0.45	0.50	0.45	0.39
Mexico	1.13	1.22	1.37	1.17
Japan	2.99	2.93	2.93	3.18
Spain	2.50	2.30	2.40	2.30
China				
Mainland	2.78	2.75	3.23	2.85
Taiwan	0.67	0.68	0.77	0.81
Soviet Union	1.38	1.99	2.68	3.79
Other	5.67	6.28	7.03	7.41
Total	58.15	57.30	59.57	61.02

†Preliminary data.

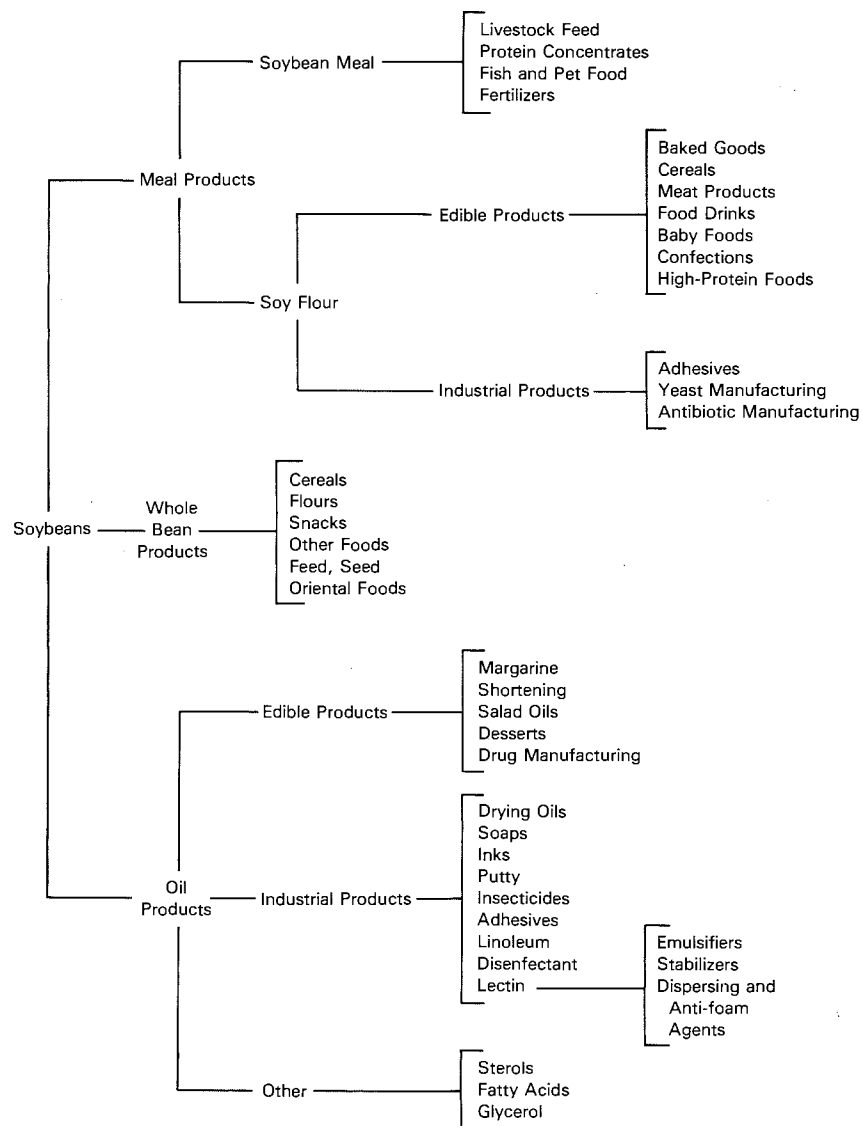


Fig. 1-3. Soybean utilization. Source: Hauck et al. (1972).

international trade, i.e., between 70 and 75%. Major soybean meal competitors include cottonseed meal, fish meal, sunflower meal, and rapeseed meal.

Soybean meal is used mainly in developed countries and some higher income developing countries. Table 1-7 presents soybean meal production, trade, and utilization by country. The USA, EEC, and Brazil are

the major soybean meal producers, while the major soybean meal consumers are the USA, EEC, Eastern Europe, Japan, and the People's Republic of China. Brazil produces soybean meal mainly for exports. Currently, Brazil has about the same market share as the USA in the soybean meal export market. The EEC re-exports significant amounts of soybean meal, and some soybean meal export goes to Eastern Europe.

Soybean meal is a major protein component in livestock feed. Livestock and poultry feeds containing soybean meal as their major protein ingredient are used worldwide. The relative importance of soybean meal in the international market has increased over the years as seen by comparing percentage of soybean meal net trade in the international market to total soybean meal production.

Soybean oil accounts for 20 to 25% of total world fats and oils production and 30 to 35% of total edible vegetable oil production (Table 1-6). Tallow and grease, butter, sunflower, and palm oils are the next most produced fats and oils. The production of these competing oils is much smaller than soybean oil. However, the production and trade of palm oil has increased dramatically during recent years. Palm oil's competition in the markets is anticipated to become more intense in future years.

The USA, EEC, and Brazil produce the most soybean oil accounting for 43, 16, and 13% of total world soybean oil production. Table 1-8 presents soybean oil production, trade, and consumption by country. Major soybean oil exporters are the USA, Brazil, EEC, and Spain.

The EEC and Spain normally import soybean to crush for soybean meal for domestic consumption, thus producing more soybean oil than can be absorbed domestically. Major soybean oil importers include India, Middle Eastern and African countries, and Pakistan.

Historically, soybean meal accounts for approximately 60 to 70% of the value of the soybean with the balance coming from soybean oil. Soybean oil has many more substitute products such as vegetable oil, palm oil, and animal fats, whereas soybean meal dominates the feed protein market. These competitive factors imply that soybean is relatively more dependent upon meal markets than upon oil markets.

1-4 WORLD PRODUCTION TRENDS

World soybean production will increase at a slower rate over the next 20 yrs than it has in the past (Sharpe, 1983). Elanco Product Company and the American Soybean Association (1983) have conducted an extensive study of the prospect of soybean production and markets involving over 200 experts in various relevant fields. The study projects a 4% annual increase in soybean production and demand of soybean over the next 20 yrs. World soybean production and demand are estimated to be about 190.5 Mt (7×10^9 bushels) by 2002.

Table 1-8. Soybean meal: World production trade and consumption.
Source: USDA-Foreign Agricultural Service (1983).

	1979-1980	1980-1981	1981-1982	1982-1983†
<u>Production</u>				
USA	5.49	5.11	4.98	5.46
Brazil	2.00	2.60	2.41	2.56
Argentina	0.12	0.16	0.22	0.35
European Economic Community	2.04	1.81	2.02	1.90
Mexico	0.24	0.27	0.26	0.26
Japan	0.62	0.63	0.63	0.68
Spain	0.53	0.48	0.54	0.52
China				
Mainland	0.40	0.41	0.48	0.43
Taiwan	0.15	0.15	0.17	0.17
Soviet Union	0.22	0.23	0.28	0.25
Eastern Europe	0.25	0.20	0.18	0.24
Other	0.73	0.75	0.86	0.95
Total	12.78	12.79	13.04	13.78
<u>Gross exports</u>				
USA	1.22	0.74	0.94	0.82
Brazil	0.53	1.15	0.85	1.02
Argentina	0.11	0.06	0.12	0.28
European Economic Community	0.90	0.89	0.96	0.94
Portugal	0.02	0.03	0.05	0.04
Spain	0.37	0.41	0.48	0.42
Other	0.09	0.09	0.10	0.13
Total	3.24	3.38	3.61	3.73
<u>Gross imports</u>				
European Economic Community	0.49	0.48	0.52	0.51
Mexico	0.03	0.03	0.08	0.03
Brazil	0.13	0.00	0.01	0.01
India	0.64	0.60	0.42	0.40
Pakistan	0.22	0.26	0.32	0.24
China (Mainland)	0.10	0.07	0.03	0.04
Soviet Union	0.05	0.08	0.20	0.23
Eastern Europe	0.09	0.20	0.12	0.23
Mid-East/N. Africa	0.68	0.73	0.79	0.85
Latin America	0.34	0.46	0.47	0.48
Other	0.44	0.40	0.45	0.50
Total	3.21	3.31	3.42	3.53
<u>Consumption</u>				
USA	4.07	4.13	4.32	4.47
Brazil	1.42	1.53	1.50	1.65
Argentina	0.01	0.08	0.80	0.07
Latin America	0.44	0.52	0.58	0.61
European Economic Community 10	1.60	1.47	1.49	1.35
Mexico	0.25	0.32	0.32	0.29
Japan	0.62	0.63	0.69	0.69
Spain	0.11	0.10	0.10	0.90
China				

(continued on next page)

Table 1-8. Continued

	1979-1980	1980-1981	1981-1982	1982-1983†
<u>Tg</u>				
Mainland	0.50	0.48	0.51	0.47
Taiwan	0.14	0.14	0.18	0.17
Soviet Union	0.27	0.30	0.48	0.48
Eastern Europe	0.34	0.39	0.29	0.47
India	0.75	0.66	0.49	0.48
Pakistan	0.18	0.28	0.32	0.25
Mid-East/N. Africa	0.81	0.86	0.92	1.01
Other	0.78	0.74	0.79	0.91
Total	12.31	12.65	13.07	13.62

†Preliminary data.

This projection of production growth is based on several factors, including an estimated world economic growth rate of 3% per year in the future, which is lower than the post-World War boom of 1950 to 1972. The U.S. soybean production share will probably continue to decrease as production in Brazil, Argentina, and other countries increases.

Slower world economic growth will slow growth in consumption of soybean meal and high protein meals. The same study estimates growth in soybean meal consumption to be 4.6% per year during the next 20 yrs. This amount is substantially lower than the past 20-yr rate of 7.5% per year.

Soybean acreage could be altered significantly by government controls, trade restrictions or sanctions, soybean reserve policies, world trade protectionism, and other policies under administrative control. The actions could regulate both the supply and demand for soybean and soybean products.

Soybean yields will reflect research advancements and will be one of the determining factors in the future of soybean. Main contributors to higher yields will be new cultural practices; more productive varieties; better herbicides, insecticides and nematocides; new plant growth regulators; and more effective grower education programs.

The impact of biotechnology, genetic engineering, and molecular biology studies on basic plant processes is an unknown factor in the future of soybean. These basic tools may open a new chapter in soybean expansion. They may greatly improve soybean production through improved insect and disease resistance. Biotechnology may also be important in improving quality characteristics of soybean. These scientific advances could improve both the efficiency of soybean production and the utilization of soybean products.

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2

Taxonomy and Speciation

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The genus *Glycine* Willd. is a member of the family Leguminosae subfamily Papilionoideae, and tribe Phaseoleae. The Phaseoleae is the most economically important tribe of the Leguminosae. It contains members that have considerable importance as sources of food and feed, e.g. *Glycine max* (L.) Merr.—soybean; *Cajanus cajan* (L.) Millsp.—pigeon pea; *Lablab purpureus* (L.) Sweet—hyacinth bean; *Phaseolus* spp.—common bean, lima bean, tepary bean; *Psophocarpus tetragonolobus* (L.) DC.—winged bean; and *Vigna* spp.—cowpea, mung bean, urd, black gram, adzuki bean, Bambarra groundnut. Within the tribe Phaseoleae, *Glycine* is a member of the subtribe Glycininae along with allied genera *Eminia* Taub., *Pseudeminia* Verdc., *Pseudovigna* (Harms) Verdc., *Nogra* Merrill, *Sinodolichos* Verdc., and *Pueraria* DC. *Nogra*, *Sinodolichos*, and *Pueraria* are essentially of Asian origin, *Eminia*, *Pseudeminia*, and *Pseudovigna* are African, and *Glycine* is of Asian and Australian origin (Lackey, 1981).

2-1 TAXONOMIC HISTORY

Glycine has a confused taxonomic history which dates back to the time of its first inception. The name *Glycine* was originally introduced by Linnaeus in the first edition of his *Genera Plantarum* (Linnaeus, 1737) and based on *Apios* of Boerhaave (Linnaeus, 1754). *Glycine* is derived from the Greek *glykys* (sweet) and probably refers to the sweetness of the edible tubers produced by *G. apios* L. (Henderson, 1881), now *Apio. americana* Medik. In the *Species Plantarum* of 1753, Linnaeus listed eight *Glycine* spp. (Table 2-1). All of these were subsequently moved to other genera, although *G. javanica* remained as the lectotype for the genus until 1966 (Hitchcock and Green, 1947). Thus, when *G. apios* became *A. americana*, the original justification for the name *Glycine* was removed from the genus. Therefore, the Greek *glykys* does not refer to any of the current *Glycine* spp.

The soybean was described by Linnaeus (1753, p. 725) as both *Phaseolus max* based on specimens that he saw, and *Dolichos soja* (1753, p.