LIMITED POPULARITY OF SOYBEAN CULTIVATION IN SOUTH AND SOUTHEAST ASIA

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Abstract

Soybean is an important food, feed, oil, and industrial crop in South and Southeast Asia. In 1981 Asian countries in the region (including Japan and Korea) imported more than 6.6 million tons of soybean. Although soybean consumption is growing, the area planted and yield per hectare have not increased significantly. The reasons for this situation vary. In Indonesia and Thailand, the price of soybean is attractive, but average yields are low. In Taiwan and the Philippines, price supports are insufficient to provide a good return compared with other crops. Poor yields are generally due to the use of non adapted cultivars, the lack of quality seeds, inadequate extension services, the absence of appropriate and economical management technology, risks due to pests and diseases, and the high cost of production. The low cost of imported soybean is also a factor.

Although there are many limitations for expanding soybean cultivation in the region, work has already begun at IITA, INTSOY, and AVRDC, and strong cooperative programs are being established at the international level. Through interdisciplinary and international efforts that link research with extension, the countries in South and Southeast Asia can resolve their soybean production problems.

Soybean, one of the oldest cultivated crops originated in northeastern China (Hymowitz, 1970). World soybean hectarage increased from 29.2 million hectares in 1969-71 to 52.2 million hectares in 1982. During this period, the area planted to soybean in the USA and Brazil increased by 11.66 million and 6.9 million hectares, respectively. Production for all of the Asian countries combined however, only increased by 876,000 hectares (Table 1). World soybean production increased by 52.6 million tons in the past decade, from 43.5 to 96.1 million tons. The increase was mainly from the USA (60%) and Brazil (22%). Six percent came from the Asian countries.

In Asia, only China and Thailand export soybean (Table 2), whereas most countries import soybean either as grain, meal or oil. Generally, the majority of the Asian nations have either maintained or increased their level of soybean imports during the past 10 years (Table 3). Soybean is one of the important traditional foods in Asia and a ready source of inexpensive protein (Shanmugasundaram and Selleck, 1983). Through nitrogen-fixing *Rhizobium*, soybean can produce a crop with a minimum of non renewable energy inputs. It can also enhance soil fertility and the short maturity duration of soybean makes it ideal for intercropping and farm diversification. Despite these qualities, soybean cultivation has made only limited progress in South and Southeast Asia.

Research emphasis

The importance of soybean in terms of providing protein in the Asian diet was not recognized until the early 1970s. Even then research priorities and programs to increase production centered mainly on staple foods such as rice, wheat and corn. Despite the "green revolution" and recommendations to speed up efforts in the legume crops, soybean remained a second or third priority in South and Southeast Asia (Borlaug, 1973).

High-yielding cereal cultivars and associated production technologies have demonstrated that

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Table 1 Soybean area, production and yield in South and Southeast Asia

Country	Area (10^3 ha)		Production (10^3 ton)		Yield (kg/ha)	
	1969—71	1982	1969—71	1982	1969—71	1982
Burma	19	24	12	17	644	695
China	7,873	7,712	8,131	10,017	1,033	1,299
India	4	680	2	650	545	956
Indonesia	643	770	468	750	728	974
Japan	100	150	128	213	1,286	1,420
Korea (DPR)	278	310	255	360	918	1,161
Korea (Rep.)	292	202	228	259	780	1,282
Philippines	1	11	1	11	846	966
Sri Lanka	1	2	1	2	1,000	1,000
Thailand	53	129	51	135	965	1,051
Vietnam	45	100	26	100	578	1,000
Taiwan	41	8	63	12	1,544	1,548
USA	17,036	28,700	31,174	62,584	1,830	2,181
Brazil	1,314	8,202	1,547	12,810	1,178	1,562
World	29,247	52,209	43,487	96,103	1,487	1,841
Asia[1]	9,334	10,210	9,329	12,702	999	1,244

[1] Includes Iran, Kampuchea, Laos, Malaysia and Turkey.
Source: FAO monthly bulletin of statistics, 1983. 6 (10): 17.

Table 2 Soybean exports

Country	1979 (10^2 ton)	1981 (10^2 ton)
USA	209,045	218,597
Brazil	6,385	14,497
China	2,970	4,000
Thailand	97	25

production can exceed the rate of population growth in Asia (Chang, 1983). Administrators and politicians should therefore consider putting emphasis on crops such as soybeans to diversify agricultural production, meet the demand for protein in the diet, and avert overproduction of staple crops.

Socio-economic aspects

Soybean is a key protein source in China, Japan, and Korea. In most other areas however, it is unknown. For people from the Indian subcontinent its beany flavor is undesirable. It is therefore necessary to develop methods by which soybean and soybean products can be blended to enrich the nutritive value of traditional foods. Although there has been a sudden jump in soybean production in India (Table 1), almost all of the crop is used for oil production; the nutritious soybean meal is exported.

Table 3 Asian soybean imports

Country	1979 (10^2 ton)	1981 (10^2 ton)
Bangladesh	435[1]	400[1]
China	16,638	16,810
Indonesia	1,766	14
Japan	41,318	41,967
Korea (Rep.)	4,280	4,943
Malaysia	273	1,552
Philippines	117	470
Singapore	624	264
India	2,452[1]	6,353[1]
Pakistan	2,346[1]	3,128[1]

[1] Refers to soybean oil.

Is it profitable to grow soybean in Southeast Asia ? To the farmer, the word soybean should mean a reliable, low-risk crop that provides an equitable return for his investment in land, capital, and labor (Shanmugasundaram, 1976). In the Southeast Asian countries, soybean is a traditional crop, while in South Asia it is fairly new. In Thailand and the Philippines the area planted and overall production are increasing. Soybean farming in Indonesia, however, is stagnating. In other areas, i.e. Taiwan, there has been a conspicuous decrease in production area. In contrast, India, Pakistan, and Sri Lanka have sharply increased production, mainly because of the development of new marketing channels (Suzuki and Konno, 1982; von Oppen, 1982).

The average yield of soybean in the South and Southeast Asian countries is about 1 ton/ha. As a result soybean is an unattractive choice for the farmer. In a survey conducted by AVRDC in 1974, the average net return for soybean in Thailand and the Philippines was US$18-80/ha, while in Taiwan there was a negative net return (Table 4). In a 1980 survey in Taiwan (Liu *et al*., 1982), green vegetable soybean and adzuki bean proved more attractive (Calkins *et al*., 1978; Liu *et al*., 1982), in terms of net return, than grain soybean (Table 5). However, in 1983 the price of adzuki bean dropped considerably below the price of grain soybean. Therefore, the main competitors for grain soybean at the moment are green vegetable soybean and maize. As a result, the area planted

Table 4 Soybean production costs and returns in Thailand, Philippines, and Taiwan

Area surveyed	Average yield (ton/ha)	Average price (US$/ton)	Average production costs (US$/ha)	Net returns (US$/ha)
Sukhothai, Thailand	1.4	100	84	56
Chiang Mai, Thailand	0.9	100	72	18
North Luzon, Philippines	0.5	190	65	30
South Cotabato, Philippines	0.8	330	184	80
South Taiwan	1.7	290	527	−34
Hualien, Taiwan	1.1	330	396	−33

Source: AVRDC. 1976. Soybean Report 1975. Shanhua, Taiwan, ROC.

Table 5 Comparison of production factors between grain soybean and its competing crops-vegetable soybeans, pods, seeds and adzuki bean in Taiwan, 1980—80 (in US$/ha)

	Grain soybean			Vegetable soybean 1980		Adzuki bean 1978 Autumn
	1979 Autumn	1980 Spring	1980 Summer	Pods	Seeds	
Yield (kg/ha)	2,092	1,806	1,677	21,060[1]	2,380	2,244
Price (US$/ton)	431	409	480	56[1]	747	498
Revenue	924	751	817	1,186	1,799	1,129
Total expenses	731	663	630	827	1,064	571
Net return to land	193	88	187	497	735	558

On whole plant basis.

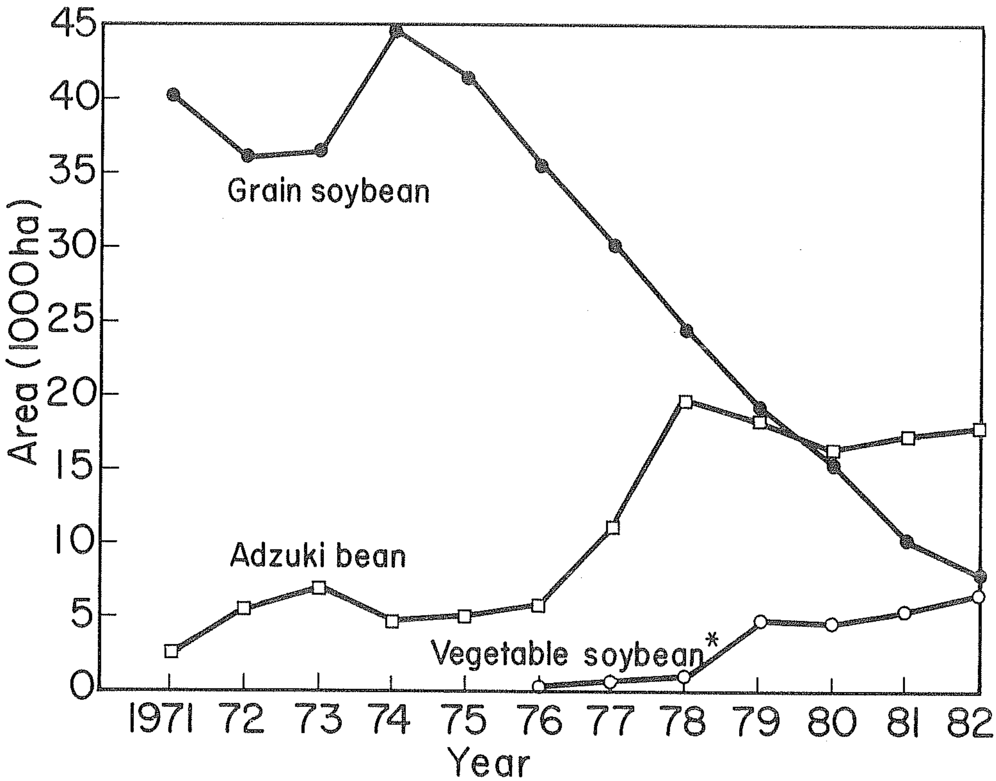

Fig. 1 Area planted to soybean, adzuki bean and vegetable soybean in Taiwan (*Kaohsiung district only).

to grain soybean has sharply decreased while the land devoted to green vegetable soybean has steadily increased (Fig. 1).

In the Philippines, the price of mungbean is US$0.87/kg, while the price of soybean is only US$0.41/kg. Farmers prefer mungbean. Maize hybrids are also emerging as important competitors.

Another factor attributed to the stagnation of soybean production in tropical Asia is the price of imported soybean. Soybean production costs, in general, are higher in the USA than in most South and Southeast Asian countries (Table 6), but the price per ton in the USA is considerably lower than in these countries (Nepal is an exception). This is mainly due to higher yields per unit area in the USA. Net returns per ha from soybean in Sri Lanka and Thailand are low, but in Indonesia and Nepal they are fairly attractive (Table 6).

Table 6 Production costs and returns for soybeans in selected South and Southeast Asian countries and the USA[1]

Country	Cost of production US$/ha	Yield kg/ha	Cost of crop US$/ton	Net profit US$/ha
Indonesia (Java)	219	951	375	139
Lampang and South Kalimantan	189	735	404	109
Nepal	148	2,318	202	321
Sri Lanka	238	845	320	32
Thailand	154	629	329	54
USA	299	2,200	222	190

[1] Soybean Digest 1983. 43 (4): 12—14.

Major causes for low yield and future prospects

Varietal development

Until 1972, the number of soybean cultivars available to Asian farmers was small (Table 7), and the majority of these were low-yielding.

In the past decade, a small number of improved cultivars were released by plant breeders in these countries (Table 8), but acceptance by farmers has been limited. As with cereal crops, there is little or no machinery available for seed production and extension. Therefore, to obtain short-

Table 7 Major soybean cultivars grown by farmers in different countries until 1972

Country	Major cultivar
Taiwan	Sankuo, Palmetto, Shih Shih, Wakajima, TK 5, Chung Hsing 2, Tainung 3, Tainung 4, Kaohsiung 3
Indonesia	No. 16, 27, 29, 317, 452, 520, 945, 1248
Japan	Kitamusume, Toyosuzu, Raiden, Okushirome, Shirotae, Tachisuzunari, Akiyoshi, Hyuge, Enrei
Korea (Rep.)	Chungbukbaek, Keumagangdaerib, Buseok, Kwangdoo, Keumdoo, Kwangkyo, Bongeui, Eundaedoo, Hill
Nepal	Native cultivars
Philippines	Improved Pelican, Acadian, Ogden, Lee, Sankuo
Sri Lanka	Taichung E26 and E32, Tainung (R) 1, TK 5, Hernon
Thailand	SJ—1, SJ—2

Source: Symposium on Food Legumes, 1972. Tropical Agriculture Reseach Center, Ministry of Agriculture and Forestry, Tokyo.

Table 8 Major soybean cultivars developed after 1972 and grown by farmers until 1982

Country	Major cultivar
Taiwan	Hwalien No. 1, Kaohsiung No. 8, Kaohsiung No. 9
India	Ankur, UPSM—19, PK 71—21, Pb—1, Co 1, KM—1
Indonesia	Orba, Lokon, Guntur, Galungkung, G 2120
Japan	Karumai, Himeyntaka, Nanbushirome, Dewamusume, Kitakomachi, Tanrei, Nakasennari, Miyagioojiro, Yahime and Akishirome
Korea (Rep.)	Kanglim, Baekcheon, Suweon 85 (Essex), Suweon 86
Nepal	Hardee, Hill
Philippines	Tiwala (UPL—SY 2), L 114, TK 5, Clark 63
Sri Lanka	Pb—1
Thailand	SJ—4, SJ—5

Source: Personal communications and other sources.

AVRDC SELECTION NO.	YIELD (ton/HA) SOWING TIME FEBRUARY	JULY	SEPTEMBER
AGS 19	2.6	2.8	2.2
AGS 66	3.4	3.1	
AGS 129	4.0	3.4	2.6
AGS 130	3.8	3.0	2.5
AGS 131	3.8	2.9	
AGS 133	3.5	3.3	
AGS 135	3.8	3.0	2.5
AGS 144	4.3	3.0	2.2

Fig. 2 **AVRDC selections with high yield potential that are adapted to different seasons.**

term gains in soybean production, national programs must purify existing soybean cultivars which are often mixtures of several different cultivars. Efforts must also be made to produce good quality seed and provide for their efficient distribution.

International programs such as that developed by the Asian Vegetable Research and Development Center have demonstrated yield potentials of up to 7 ton/ha in about 100 days under

Table 9 AVRDC soybean cultivars released by national programs

Country	Year	Cultivar released
India	1980	KM—1
Indonesia	1980	ROC 2120
Honduras	1980	Darco—1
Malaysia	1981	T 30050
Taiwan	1982	Kaohsiung Selection No. 9

Table 10 Yield of G 2261 in three different densities at IRRI in the dry season

Treatments	Grain yield (ton/ha)	100 seed wt (g)	Days to maturity
G—2261 300,000 pph[2] 50 cm row	2.43 B[1]	19.71	72
G—2261 300,000 pph 25 cm row	2.65 AB	19.42	72
G—2261 600,000 pph 25 cm row	2.75 A	19.16	72

[1] Values followed by the same letter are not significantly different according to Duncan's multiple range test at the 5% level.
[2] Plants per hectare.

Table 11 Yield of selected AVRDC genotypes at Sukamandi in West Java, Indonesia

Genotypes	Yield ton/ha	Days to maturity	100 seed wt (g)
AGS 17	2.3 a	83 d	14 de
G 2261	2.0 ab	70 f	15 bcd
AGS 135	2.0 ab	78 e	15 bcd
AGS 144	2.0 ab	78 e	19 a
Orba (Check)	1.6 bc	86 b	12 e

Latitude of location : 6°21′S.
Altitude of location : 16 m.
Date planted : March 15, 1982.
Values followed by the same letters are not significantly different at the 5% level according to Duncan's multiple range test.

subtropical conditions (AVRDC, 1975). Using disruptive seasonal selection for the segregating population derived from crosses between photoperiod insensitive and photoperiod sensitive germplasm, AVRDC has been able to develop genotypes adapted to the spring, summer, and autumn seasons (Fig. 2). A number of improved selections have been evaluated by national

Table 12 Cultivars with high yield potential in the tropics.

Cultivar	Country	Latitude	Elevation (m)	Yield ton/ha	Days to maturity
Bossier	Sri Lanka	9°2′N	9	5.2	94
	Venezuela	10°14′N	450	5.4	109
Bragg	Sri Lanka	9°6′N	1	5.7	105
Calland	Ecuador	2°21′S	17	4.1	98
		1°4′S	44	4.4	98
Clark 63	Sri Lanka	9°6′N	1	5.7	91
Davis	Sri Lanka	9°2′N	9	5.4	99
Forrest	Sri Lanka	9°6′N	1	5.3	97
Hardee	Sri Lanka	9°6′N	1	6.0	113

Source: Whigham. 1975. INTSOY Series No. 8, University Illinois, Ill., USA.

programs and new cultivars have been released in several countries (Table 9). Many of these selections are able to produce 2 ton/ha yield in about 70 to 80 days (Tables 10 and 11). The International Soybean Program (INTSOY) has demonstrated yield potentials of 4 to 6 ton/ha in different tropical regions (Table 12). It is necessary to develop a strategy for the rapid deployment of newly developed cultivars in the farmers' fields so that soybean production can be rapidly increased.

Agronomic aspects

Monocropping is a common practice in the tropics because the climate is conducive to crop growth for as much as 250 days per year (Brady, 1977). The potential to double or even triple crop production, as practiced in Taiwan (Shanmugasundaram *et al*., 1980), should be explored in other tropical and subtropical Asian areas.

Seed quality and plant stand establishment are a major problem. Soybean seeds deteriorate rapidly under hot humid conditions. Furthermore, if soybean is harvested during the rainy season, seed quality is generally poor.

In cropping systems that include cereals and soybean, the planting method dictates plant stand and yield. There is merit in determining whether the no-tillage rice-stubble soybean culture can be introduced in specific locations and seasons (Shanmugasundaram *et al*., 1980).

Even though the benefit of *Rhizobium* in soybean production is well recognized, it is hardly taken advantage of in practice, partly because the availability of appropriate natural *Rhizobium* in the soil is taken for granted. There is much to gain by focussing attention on the symbiotic relationship between *Rhizobium* and soybean.

Much of the research on tropical soybean presently revolves around varietal development and varietal evaluation. In order for a cultivar to express its full genetic potential, it is necessary to develop appropriate packages of technology. Management practices contribute nearly 56% to the variability in yield between sites (Whigham *et al*., 1978). The yield gap between the farmer's soybean and the researchers' trial plots may be attributed both to cultivar and management. Attention must therefore be directed to research on both maximum yield and maximum economic yield. A better understanding of the responses to fertilizers, weed control, irrigation, insecticides, and fungicides is also needed.

The response of soybean to plant population density in the tropics and subtropics has been well demonstrated (AVRDC, 1974, 1981). Because soybean matures earlier in the tropics and subtropics than in temperate zones, yield per plant is often lower in the tropics. Therefore, the key to high yield is to increase unit area yield by increasing plant population density or plant arrangement. Table 10 shows that plant arrangement may hold more promise than increasing plant population density.

Disease and insect problems

There are disease and insect problems which are unique to the tropics and subtropics. Soybean rust and beanflies for example, have been known to cause yield losses of 80 to 100% respectively (AVRDC, 1975 ; Chiang and Talekar, 1980). Resistant cultivars are not yet available to farmers, but efforts are underway to incorporate available genetic resistance into new productive cultivars. It is important that the national programs join in this effort because pathogen, pest type, and environment may vary from location to location and between seasons. In order to solve this problem, an international research effort involving national program scientists and an inter-disciplinary approach using multi-locational and multi-seasonal trials could be effective. AVRDC is mobilizing its research towards this objective.

Adaptability to unfavorable environments

Soybean is generally grown during the off-season or on marginal lands where staple crops cannot be grown. High temperature, limited moisture, and low fertility all limit soybean production. Salinity and acidity are also problematic. When soybean is grown during the rainy season, excess moisture (flooding) is a problem, whereas drought stress is often evident during the dry season. Daylength is generally short in the tropics and subtropics. Because soybean is a short-day plant, it usually flowers and matures too early. Similarly, high temperature hastens flowering, while low temperature delays it. Therefore, insensitivity to photoperiod and temperature are desirable characters.

At AVRDC genotypes have been identified that are insensitive to photoperiod and temperature and tolerant to flooding and drought. The Center's breeding program includes parents to transfer these traits to highly productive backgrounds. Similar attempts need to be made to minimize salinity and acidity problems. Physiology studies to determine the basis of adaptability should help to develop better screening techniques, either in the laboratory or in the field.

Conclusion

Efforts should be made to develop high-yielding soybean cultivars that carry genetic resistance to yield-reducing diseases and insects and which can provide the farmer with a high economic return. Development of cost effective management technology packages should be available along with good quality seeds. The cost of production should be minimized, and/or Government should be prepared to subsidize soybean to a level where it can compete with imported soybean. Another alternative is to tax imported soybeans and equalize prices. The tax revenue could then be used to stimulate research and enhance production.

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Discussion

Thulasidass, G. (India): There is technical collaboration between India and several countries in the field of industrial production. Could there be a collaboration between India and China for soybeans ? We would like more collaboration between AVRDC and INTSOY on the one hand and India, on the other hand to manufacture soybean products at a lower cost.
Answer: INTSOY and AVRDC will make their utmost efforts to extend their cooperation in this field.
Dutt, A.K. (India): I would like to know how much nitrogen is returned and added to the soil for the next crop after soybeans are cultivated.
Answer: Information about this problem will be provided later on during the symposium.
Bhatnagar, P.S. (India): In reference to the possibility of cooperation with INTSOY, I would like to emphasize that India welcomes this proposal. However, details pertaining to specific aspects should be decided at the government level. Would you like to elaborate how low cost soybean products could fit within a cottage industry concept so as to disseminate the consumption of soybeans ?
Answer: Socio-economic and cultural aspects should be taken into consideration prior to transferring technology for the manufacture of a product from one country to another. Training programs in home economics are most important in promoting the dissemination of soybean products among farmers' households.
Galal, S. (Egypt), **Comment**: Direct use of soybeans in the human diet is a short cut to improve the daily diet in the developing countries. In Egypt we were confronted with the problem of marketing soybean products in the late fifties when I introduced the crop in cropping systems in 1957. Using soybean to enrich corn bread of the rural families resulted in improving the corn bread quality and nutritive value, in addition to solving the early marketing problem. During the 1984 INTSOY

Meeting at Ames Iowa I shall supply a sample of that bread for a panel test on taste, quality and appeal. In the developing countries there is no need to industrialize highly sophisticated soybean proteins at high cost when they can be consumed directly in the daily diet of low income communities at no additional industrial cost.

Bhatnagar, P.S. (India), **Comment:** I thank my friend from Egypt for providing the information regarding soybean use in Egypt in bakery. However, I would like to mention that during the past decade in India efforts have been made to use whole soybean for home and bakery products but the only area in soybean production that has registered a sizeable expansion is the use of soybean for the oil industry. Hence there is a need for product process development based on defatted soy flour. Definitely, local socio-economic conditions determine the utilization pattern but the information from other countries available in such international meetings can be used after being modified to suit the requirements of a given country and community.