BREEDING SOYBEANS IN THAILAND

Arwooth Na Lampang*

Present status and problems to be solved

There is no definite record when soybeans were first introduced into Thailand. However, it is believed that Chinese Immigrants brought seeds with them for their own use sometime in the past two or three centuries. Soybean products such as soy sauces, bean curds and pastes have long been popular with Thai people but soybean cultivation was not documented until the end of the First World War.

The first record of soybean production appeared in 1930 when the Governor of Chiangmai, after proper study, promoted soybean cultivation in the paddy field after rice harvest (3). The initial results were successful and this practice has continued to the present. Annual production reached 20,000 tons of grain during this period. Within the past thirty years, soybean cultivation has been introduced to the upland conditions in the Upper Central Plains. The principal method is to plant soybeans in the early rainy season followed by an intercrop of cotton. This was well accepted and resulted in an increase in national annual production amounting to 50,000 tons.

Due to the lack of strong market demand during the early years, soybean production remained stagnant. In 1970, the Thai Government decided to include a soybean acceleration program in its Third National Economic Plan (1972-1976) and a production goal of 300,000 tons was set for 1976. To accomplish the work, several agencies of the Ministry of Agriculture and Cooperatives were reorganized to work on soybeans. One of these, the "Oil Crops Project" was charged with the responsibility for research and development aspects within the Department of Agriculture (4).

It is recognized that several disciplines are necessary to conduct soybean research, but this discussion will be confined to varietal improvement in keeping with the objective of this paper. Furthermore, the presentation will be restricted to those aspects of soybean breeding that are considered major constraints to production at present.

Previous research

In 1951, H. W. Ream (11), a field crop specialist assigned to USOM/THAILAND, introduced about 41 soybean varieties from the United States. Screening tests in cooperation with the Department of Agriculture, indicated that only those lines which originated from the Southern USA such as Palmetto and Acadian would be promising when grown in Northern Thailand (latitude 17° N). The same varieties yielded less when they were moved to the lower latitudes. The results led Ream to search for varieties cultivated in similar latitudes. Collection of indigenous cultivars as well as introductions from Southeast Asian countries were made thereafter. Subsequent studies and yield trials revealed a superior line collected from one farmer field in Chiangmai area which was later named Usaha (S. B. 60 in the collection) and released as a standard variety which was well accepted by farmers.

On his trip to Japan and Taiwan in 1960, Vadhanavasin (10) brought from these countries F_2 seeds of 21 crosses which were planted at the Mae Joe Experiment Station, Chiangmai. Selection in segregating generations and appropriate yield trials resulted in three promising lines, named S.J.1., S.J.2 and S.J.3. S.J.1 has indeterminate plant type with black hilum

* Chief, Oil Crop Branch, Field Crop Division, Department of Agriculture, Bangkhen, Bangkok, Thailand.

(Black Eye) and moderate shattering resistance which makes it popular for planting in the early rainy season in the Upper Central Plain. Its relative, S.J.2 has determinate growth, reddish brown hilum (red eye) and resistance to shattering. This makes it well adapted for dry season cropping. These two varieties were very popular and rapidly replaced the old cultivars. On the other hand, S.J.3 did not gain popularity due to easy shattering and compact plant type and has been dropped from the recommended list.

Recent remarkable results

At the beginning of the soybean acceleration program, the Japanese Government through the Colombo Plan, provided valuable assistance for a period of seven years, starting in 1970. The assistance included provision of experts and technical equipment necessary to initiate the basic research work. Mr. Takashi Sanbuichi of Tokachi Experiment Station, Hokkaido is credited for starting the first soybean hybridization work in Thailand.

The soybean breeding program is arbitrarily divided into two phases according to the needs. The first one is aimed at solving some major problems or "bottle necks" that limit optimum yields. Most breeding conducted at present is in this category. The second step or long range program is expected to be implemented in the near future. Some of the breeding research is illustrated as follows.

Breeding for disease resistance

Studies on soybean diseases conducted by pathologists in the Department of Agriculture rank them according to economic importance and provide guidelines for the breeding program (9).

Soybean rust: (*Phakopsora pachyzhiri* syd.) was reported by Puckdeedindan in 1966 (5, 9). Severity of the disease seemed to be greatest during late rainy season (September to October) which is characterized by heavy rains and cool nights. Yield reductions were reported to range from 10 to 100 percent (9). In addition, there was loss in seed weight and size, chemical composition and germination capacity. Furthermore, this disease also imposed serious problems in seed production since most seeds produced during the rainy season are intended for planting in the following dry season (5).

Sanbuichi (8) was able to identify line 64-104 (Tainung 4) as highly rust resistant. Crosses were made to adapted cultivars in 1970. Subsequent selection and testing over a number of years and locations resulted in the naming and release of S.J. 4 in 1976. Details of studies are given in Table 1.

Table 1. Some characteristics of soybean varieties infected with rust (1).

Variety	Mae Jo Station						Srisamrong station	
	Rust scores* in days after planting				Yield	Seed size	yield	Seed size
	30	50	70	90	kg/ha.	gm/100 seeds	kg/ha	gm/100 seeds
S.J. 1	1	2.55	4.10	5.00	769 g	7.77 de **	2,243 bc	14.25 d
S.J. 2	1	3.05	4.40	5.00	705 g	7.62 e	2,292 ab	13.30 e
S.J. 4	0	1.35	2.30	2.45	1,696 ab	12.75 a	2,408 ab	16.80 bc
64-104	0	1.95	2.50	2.75	–	–	–	–
					C.V. = 18.11	C.V.7.53	C.V.14.09	C.V.6.23

* Scores, were averaged from three leaves taken from the middle of each of five plants; 0 = no disease 1 = 1–15; 2 = 16–25; 3 = 26–50; 4 = 51–75 and 5 = 76–100 percent respectively. Planted at Mae Jo July 1975 and at Srisamrong May 1975.

** Significant differences according to Duncan's Multiple Range Test.

At present, it seems that soybean rust is partly under control. However, its biology is not well understood and it is logical to expect that pathogenic changes and/or new physiological races may occur in the future. A search for sources of rust resistance other than that of P.I. 200492 (parent of 64-104) is needed.

Downy mildew. In the 1977 dry season there was a severe outbreak of downy mildew (*Peronospora* spp.) at the Mae Jo Expt. Station. It was observed that several rows in a S.J. 4 seed multiplication field were free from this disease while adjacent rows were heavily infected. Closer investigation revealed that resistance was of a nearly immune type. Reselection was immediately employed for further verification.

Bacterial pustule and blight. These two diseases appear to be prevalent in soybean fields during the rainy season (9). Identification of sources of resistance to *Xanthomonas phaseoli* and *Pseudomonas glycines* is being conducted in this rainy season. The breeding program will begin hybridization as soon as a source of resistance is confirmed.

Other diseases. According to the plant pathologists' reports (9), several diseases are listed for future investigations; such as soybean mosaic, anthracnose, purple stain and root knot nematodes.

Insect resistance

Preliminary work on screening for resistance to bean flies (*Melanagromyza phaseoli*) has been initiated (1). The results obtained thus far do not appear promising. Systemic insecticides such as dimethoate spray are now recommended for effective control.

Plant types

Indeterminate and V.S. determinate habit. There is no definite information about the advantages of either plant type. However, the determinate habit tends to be more popular under Thailand conditions because the shorter stature is more resistant to lodging during the late growth stage in the rainy season. Furthermore, there may be some association between determinate stem and number of branches. Fifty samples randomly obtained from a varietal collection at Srisamrong Experiment Station in 1976 (1) showed that indeterminate plant type possesses 4.8 branches per plant while the determinate type had 6.4 branches. Branching types are desirable for space compensation due to poor seed germination and improper stands. Another advantage is that more photosynthate may move to seeds instead of to vegetative growth which occurs in the indeterminate type. Uniform flowering and pod maturing are additional advantages of determinate plant types.

Photo-and Thermosensitivity. It did appear that soybean varieties introduced from higher latitudes clearly showed photosensitivity when grown in Thailand. Very little work has been devoted to this subject up to now. From a practical standpoint, soybeans can be grown three times a year in May, August and January plantings. Subsequent selections and yield trials made at all three planting times automatically eliminate photosensitivity if present in the breeding lines. This method has given satisfactory results in the development of varieties which mature in about 90 days and fit the existing cropping patterns. However, it may be necessary to breed for photosensitivity to fit each specific growing season in the future.

Low temperatures play an important role in delaying flower initiation. Table 2 illustrates the difference in days to flower and maturity of four soybean varieties as a result of low temperature at the Mae Jo Experiment Station (1) during the dry season.

It should be noted that when soybeans are grown in the dry season (cool season) they require about 20 days longer to flower and mature. Plant heights at harvest time are also affected due to low temperature but vary according to variety.

Table 2. Effect of low temperature on four soybean varieties grown in the Rainy (R) and Dry (D) Seasons (1).

Variety	Days to HF		Days to M		Ht at HF(cm)		Ht at M(cm)		Yields (kg/ha)	
	Season		Season		Season		Season		Season	
	R	D	R	D	R	D	R	D	R	D
SJ. 1	42	62	91	111	41.62	40	81.12	68.92	767.50*	1,321.87
SJ. 2	42	61	95	113	39.97	38	67.35	55.90	707.37*	1,222.50
SJ. 4	42	61	95	113	37.00	–	54.55	57.60	1,695.25	1,390.00
Clark 63	37	60	83	109	–	–	49.10	67.47	1,250.87	1,597.50

HF = 50 percent flowering; M = Maturity; Ht = Height R = grown in rainy season (July);
D = Dry season (January) * = Rust infested at pod filling stage

Table 3. Interrelationship between soybean varieties and natural Rhizobium at Roi-et Experiment Station in 1971 (7) (8).

Variety	Origin	Nodule * scores	Dry Wt. (g/plant)	Number of pods	Seed Wt. ** (g/plant)
SJ. 1	Thai recom. var.	0	–	16	–
SJ. 2	Thai recom. var.	0	4.5	25	2.5
SB 60	Thai native	3	13.6	91	12.8
Pakchong	Thai native	4	17.6	112	12.1
Bonminori	Japan	0	–	–	–
Lincoln	USA	0	–	–	–
RO-8-282	Off-type of SJ. 2	3	–	–	–
SJ. 2 ***	Thai	0	–	–	–
SB 60	Thai	5	–	–	–

*Scored on 0 to 5 basis, 5 indicating heavy nodulation
**On the basis of these plant yields and with a recommended population of 200,000 plants/ha the SJ. varieties would be expected to yield 500 kg/ha, while S.B. 60 and Pakchong would be expected to produce up to 2,500 kg/ha
***Placing one seed of S.B. 60 along with one seed of SJ. 2 in the same hill in the virgin soils of the Northeast at Roi-et Experiment Station.

Nodulation. Nodulation has never been a problem for soybean production in the Northern and Central parts of Thailand. However, when this crop is grown in the Northeast where the soils are acidic and low in fertility, no nodulation occurs. Close examination revealed that there is specific interrelationship between host genotype and the local Rhizobium races. Table 3 shows genetic compatibility of the Glycine: Rhizobium system which exists in the virgin soils of the Northeast Roi-et Experiment Station without artificial inoculation.

Crosses between SB. 60 and SJ. 2 were made to transfer nodulation ability from native to standard varieties. Segregation for normal plant growth in Northeast virgin soils was employed as a basis for selection. It was found that there was a good correlation between normal growth and nodulation. In the F6 generations serious rust outbreak damaged the entire set of materials since neither parent was resistant to rust.

Screening soybean varieties for tolerance to high aluminum and acidic soils was initiated in 1976 (2) Soybean plants grown at the Chiengrai Experiment Station where aluminum content is as high as 450 ppm. and a pH value about 4.5 resulted in abnormal growth and low

Table 4. Evaluation of soybean varieties growing in acidic and high Al content soils at the Chiengrai Experiment Station 1976 * (2).

Variety	Height (cm)	Dry Wt. (g/plant)	No. of Pods (per plant)	Seed Wt. (g/plant)
Davros	42.0	16.37	101.1	20.11
Dalat	40.8	11.16	60.9	11.23
No. 1248	51.7	13.29	95.7	23.86
CHOSEN OIARUKON	57.5	16.00	88.1	20.14
Kurkur	62.5	21.40	77.5	24.23
SJ. 2	28.5	8.10	40.0	9.84

* Data averaged from ten plants

yield. About one thousand lines from the collection were randomly selected and sown in rows. Only 11 varieties had normal growth and were saved for crossing to improved varieties. Table 4 indicates the performance of some selected varieties.

Seed size and germinability. There is general agreement that small seed size and low oil content tend to prolong seed viability in humid tropical regions. Singh (7) clearly illustrated that seeds weighing less than 10 grams per one hundred seeds could be kept for more than one year with 90 percent germination. However, there is a strong market demand for medium sized seed size beans which weigh 12 to 17 grams per one hundred seeds and possess an oil content ranging from 18 to 20 percent. Thus, the problems of planting seed must be solved by means of seed technology rather than breeding.

Considerations for advanced breeding phase

Even if the problems stated earlier could be partly solved by the breeding program, it is realized that further varietal improvement is needed to raise yield levels. Breeding to improve quantitative characters such as moisture stress, nutritional response and oil and protein content are examples of factors that will confront the breeder in the future. At the Regional Seminar on Use of Induced Mutations in Improvement of Grain Legume Production in Southeast Asia held in Colombo, Sri Lanka on 8–12 December 1975 and the Conference on Expanding the Use of Soybeans held at Chiengmai, Thailand on February 23–26, 1976, valuable suggestions were made to develop soybean cultivars for tropical environments. The suggestions should be studied carefully and the most promising used as guideline for future breeding programs. Breeding Philosophy always emphasizes clear cut objectives before starting a program.

Conclusion

Movement of exotic crops, such as soybeans, from cool, temperate regions to the humid tropics imposes several problems that challenge breeders. In the first place, they must reconstruct new plant genotypes to adapt to the new environments. To this, we should add different pests, physiological factors and grain quality characteristics which may have to be considered at the same time. We should expect that new technology will be required in the breeding program if the new varieties are to be successful.

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Discussion

S. Konno, Japan: Among the two promising sister lines of SJ4, one is resistant to downy mildew disease. How about the yield potential and other agronomic characters, as compared with the lines already selected for resistance?

Answer: We do have two promising sister lines of SJ4 whose performances are not superior to those of SJ4. The new line which is resistant to downy mildew is obtained by segregation in SJ4 seed multiplication field. Yielding potential and other desirable agronomic characteristics are not different from those of SJ4.

K. Hashimoto, Japan: I believe you have a number of promising lines of advanced generations, in addition to the new variety SJ4. Will they be released soon?

Answer: According to the latest data obtained there is at least one line which is expected to be released soon. This line comes from the cross between SJ2 and 64-104. We are waiting for some additional information before we submit it to the Varietal Approval Board.