(AF) 52-30

GENERAL REPORT
ON
SOYBEAN DEVELOPMENT COOPERATION PROJECT
IN
THAILAND

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JAPAN INTERNATIONAL COOPERATION AGENCY
AGRICULTURAL DEVELOPMENT COOPERATION DIVISION

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PREFACE

To correct the unbalance of trade between Thailand and Japan, it was planned to provide technical cooperation with a view toward developing the primary products in Thailand, and this possibility was explored by several subsequent surveys. As a part of this program, the project for cooperation in the development of soybeans in Thailand was put into practice in April 1970.

In the beginning, three Japanese experts specializing in marketing, cultivation and plant breeding were sent to Thailand to carry out a fact-finding survey on the cultivation and marketing of soybeans and to conduct experiments on their cultivation and breeding. Subsequently, the cooperative effort on the right track, it was decided to give priority to plant breeding, concentrating efforts primarily on the breeding of new varieties of soybeans. In April 1976, it was concluded that the objectives of this project had been generally fulfilled since the technical standards of the Thai staff had been upgraded to a level where they could carry on the project by themselves and since a new variety of soybean, an achievement of the cooperative project, had been developed to a point where it could be registered as such, it was decided to terminate the project.

During this time, nine Japanese experts had been dispatched to Thailand. Also ¥130,000,000 worth of equipment distributed over the six-years project period, was given to Thailand. Two or three members of the Thai staff for this project had been sent to agricultural experiment stations in Japan for 6 to 9 months each year to undergo training in the breeding of soybeans. These trainees totaled 12 during the project. It was decided that the offering of equipment and the acceptance of trainees for fiscal 1976, which had not been carried out due to a delay in clerical procedure, would be conducted later, and a schedule has been made to accept four trainees in fiscal 1976.

Meanwhile, there was a large increase in the production of soybeans in Thailand. The output which stood at about 40,000 tons at the outset of the cooperative project, exceeded 200,000 tons at the end of the cooperative project. The cooperative activity during this period was classified in detailed reports prepared by each expert. In this general report, an attempt will be made to summarize the circumstances leading to this cooperative project and its achievements and at the same time recommend a policy that should be established for plant breeding in case Thailand intends to breed soybeans in the future. Also, we want to point out the problems to the Thailand and Japanese parties concerned on which attention should be focused in the future for reference or the basis of the experiences and introspections gained from the soybean breeding experiments carried out in Thailand.

This general report gives the background for this soybean development cooperative project, substance of the cooperation as well as the achievements of surveys and research with special reference to the substance of the breeding project on which the cooperative efforts were concentrated, policy for breeding methods, problems and recommendations on the breeding of soybeans in Thailand.

On the occasion of the termination of the six-year project for cooperation in the development of soybeans in Thailand, we wish to present this general report with our deepest gratitude to the Thai and Japanese parties concerned for the cooperation rendered to us during the course of execution of this cooperative project. Any criticism on this general report would be greatly appreciated and we would be extremely pleased if this report servs as a reference. We would also be very happy if this report could be used by parties concerned with projects for the development of soybeans to step up the production of soybeans in Thailand.

December 1976

Japanese experts dispatched for the project for cooperation in soybean development in Thailand

Shoshin Konno
Haruhiko Seto
Hisashi Yarimizu
Takashi Sanbuichi
Kijiro Kokubun
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CHAPTER 1. CIRCUMSTANCES LEADING TO TECHNICAL COOPERATION

1. Background and Start of Technical Cooperation

As of 1967, trade between Thailand and Japan had been increasing year after year, but Japan registered an excess of exports over imports as indicated in Table 1-1. For this reason, the Government of Thailand had repeatedly called for Japan to boost the purchase of primary products. In response to this request, Japan expressed its readiness to offer technical cooperation in relation to the production and importation of primary products. Japan sent the first survey mission in February 1968 and the second survey mission in March of the same year to negotiate with related officials of the Government of Thailand and carry out an on-the-spot survey. The primary products on which the survey was conducted were feed crops, such as maize, sorghum and cassava; oil crops, such as castor bean, cotton seed, soybean and sea-same; kenaf, tobacco and substitute orops of rubber.

Table 1-1. Trade between Japan and Thailand

($ 1,000)

Year	*Import*	*Export*	*Balance*	Ratio
1960	117,666	72,306	+ 45,360	' 6:1
1961	133,868	78,314	+ 55,554	1.7:1
1962	148,548	71,673	+ 76,875	2.1:1
1963	181,000	90,719	+ 90,281	2.0:1
1964	213,275	130,605	+ 82,670	1.6:1
1965	219,148	30,780	+ 88,368	1.7:1
1966	300,838	153,225	+147,613	2.0:1
1967	340,991	160,039	+180,952	2.1:1

The following is what the survey mission pointed out in relation to soybeans. In Thailand, soybeans should be developed in an aggressive manner as a crop succeeding maize and sorghum and mixing with them. It would be increasingly possible to cultivate soybeans in the dry season upon completion of an irrigation project. As things then stood, the output of soy-beans in Thailand stood at about 10,000 tons. The soybeans produced in Thailand were small in seed size, not uniform in shape and poor in quality. It was pointed out, therefore, that there would be a need to introduce and select the optimum varieties and step up physiological and ecological studies on soybeans under the tropical conditions. The survey mission decided to designate kenaf, oil seeds, cassava, maize, sorghum and tobacco as the subject items of a project for cooperation in the development of primary products. At the same time, they compiled a report on the problems posed for each item and their concept about the execution of technical cooperation, presented it to the Thai side and obtained its concurrence.

Of the oil seeds, another survey mission was sent to Thailand in January 1969 in relation to cooperation in the development of soybeans. The production and marketing of soybeans in Thailand were extensively surveyed, and a field cultivation experiment was conducted with soybean varieties and root nodule bacteria brought in from Japan. As a result, the survey mission to realize that the soybeans in Thailand were a minor crop, their cultivation measured about 50,000 hectares, their output stood only about 40,000 tons and they are small in seed size and inconsistent in shape, that most of the output was consumed at home with the exports standing only at about 10-20%, and that although there were many problems that had yet to be solved for a boost in production and expor', the development of soybeans in Thailand was promosing. To step up the production of soybeans, it was considered necessary to (1) introduce varieties from many countries to select suitable varieties for actual cultivation and breed excellent and highly yielding varieties by means of hybridization in the future; (2) grasp the optimal planting season for each area and the characteristics and local adaptability of varieties with experiments on the growing behavior; (3) carry out research for the maintenance of seed viability and streamline storage facilities; (4) conduct experiments on soil moisture, fertilizer application and maintenance of ample leaf area associated with an improvement of the cultivation method; (5) survey and study the setting of root nodules in northeast Thailand; and (6) conduct ecological studies on major insect pest, such as leaf roller, leaf catapillar, stem miner and bean bug including stored grain insect, and carry out experiments on their control method. Also suggested was the possibility of increasing the production and export in a stable manner with a lower production cost by means of (1) breeding of excellent and highly yielding varieties and improvement of the cultivation method, (2) mechanization of agriculture, (3) improvement and streamlining of the marketing, and (4) establishment of support prices for products.

In April 1970, three Japanese experts specializing cultivation, breeding and marketing were dispatched to Thailand to cooperate in the development of soybeans, thus marking the initiation of substantial cooperation (Table 1-2).

2. Overall Aspect of Cooperation

The Japanese experts, stationing in Bangkok in the initial phase, visited experiment stations, related agencies and farm households, wherever necessary, to carry out surveys and experiments. In view of the increasing gravity of the experiments, they later moved to Chiengmai to station at the Mae Jo Agricultural Experiment Station for subsequent cooperation. With the activity of cooperation making progress, the problems posed for the cooperation, priority targets of technical cooperation and field of cooperation were clarified, main efforts were concentrated on the breeding of soybeans, and related experts were sent (Table I-3).

Table I-2. The Japanese survey mission for the development of agricultural products in Thailand

Dispatched time	Personnel organization
1968 Feb. 19 - 28	Leader Motonaga Ohto (Executive Director, Oversea Technical Cooperation Agency (OTCA))
	Member Yoshio Matsubara (Chief, Primary Products Development Cooperation Office, OTCA)
	Member Mutsuo Iwamoto (Assistant Chief, Div. Agriculture & Fishery, International Trade & Industry (MITI))
	Member Haruhiko Seto (Div. Economic Cooperation Policy, Internat'l Trade Improvement Bureau, MITI)*
1968 Mar. 25 - April 31	Leader Motonaga Ohto (Executive Director, OTCA)
	Member Yoshio Matsubara (Chief, Primary Products Development Cooperation Office, OTCA)
	Member Shigeo Harada (Director, Miyazaki Prefectural Agr. Exp. Sta.)
	Member Takashi Sato (Professor, Faculty of Agriculture, Kobe Univ.)
	Member Fumio Uryu (Agricultural Chemist, The Japan Soybean Association)
	Member Tatsuro Takahashi (Director, Utsunomiya Tabacco Exp. Sta. Japan Monopoly Corporation)
	Member Takahira Sawaki (Deputy Manager, Industrial Textile Department, Marubeni-Iida Co., Ltd.)
	Member Shigeaki Chiba (Deputy Director, Research and Development Div. Yoshihara Oil Mill Ltd.)
	Member Tadayoshi Fujita (Technical Officer, Chemical Fertilizer Div., MITI)
	Member Koichi Nonaka (Current Affair Div., The Institute of Asian Economic Affairs)
	Member Tsuguo Yashima (Primary Products Development Cooperation Office, OTCA)
1969 Jan. 21 - Mar. 31	Leader Yoshito Furutani (Chief, Land Utilization Div., Shikoku Nat'l Agr. Exp. Sta.)**
	Member Haruhiko Seto (Div. Economic Cooperation Policy, Internat'l Trade Improvement Bureau, MITI)
	Member Shoshin Konno (Senior Researcher, Dep. Physiology & Genetics Nat'l Institute of Agricultural Sciences)
	Member Kazuo Kegasawa (Chief, Laboratory of Upland Insect Pest, Upland Farming Div., Hokkaido Nat'l Agr. Exp. Sta.)

* : Feb. 19 - Mar. 25, ** : Jan. 21 - Feb. 19.

Table I-3. Japanese experts have been engaged in the project.

Fields Names	Years 1970	1971	1972	1973	1974	1975	1976
Breeding							
Tokashi Sanbuichi (Hokkaido Pref. Tokachi Agr. Exp. Sta.)	May 18		May 19				
Kijiro Kokubun (Tohoku Nat'l Agr. Exp. Sta.)			May 9		May 8		
Yoshimitsu Tanimura (Hokkaido Pref. Central Agr. Exp. Sta.)			June 20	June 19			
Koji Hashimoto (Hokkaido Nat'l Agr. Exp. Sta.)					Feb. 25	Apr. 24	
Koichi Sasaki (Hokkaido Pref. Tokachi Agr. Exp. Sta.)						Jan. 11	Jan. 10
Masataka Saito (Hokkaido Pref. Central Agr. Exp. Sta.)						June 1 July 31	
Agronomy							
Hisashi Yarimizu (Oita Pref. Agr. Exp. Sta.)	Apr. 27		Apr. 26				
Shoshin Konno (Nat'l Inst. Agr. Sci.)	Apr. 27 May 11			July 4 Sept. 1		Dec. 23	Apr. 30
Marketing							
Haruhiko Seto (Int'l Trade Impr. Bureau MITI)	Apr. 27			Apr. 26			
Expenses for Japanese experts (Unit: thousand yen)	10,656	9,782	13,036	8,943	6,169	14,027	

Table I-4. Donated machinery and equipments

Year	Major machinery and equipments	Value (¥1,000)
1969	Truck (T620, L350) 2. Jeep (J20D, J30D) 2. Soybean seeds (Bonminori) 3 t. A set of oil analyzing equipment. Grain moisture tester 3. etc.	34,222
1970	Tractor (L350) 6, (55HP) 1. Seed drying machine (virtical type) 2, (holizontal type) 7. Truck (1 t) 5, (6 t) 2. Station wagon 2. Thresher (large) 7, (medium) 2, (small) 2. Sprayer. Trencher (14 HP). Seed cleaner. Peanut cleaner. Water pumping set 2. etc.	44,742
1971	Tractor (mF-185). Seed driller. Disk plow. Planter 4. Tension meter 20. etc.	5,570
1973	Jeep (J34). Station wagon (A112VS). Truck (T-120HS) 2. Electric balance 2. Thresher (small) 4. Soybean harvester 3. etc.	7,153
1974	Sprinkler set 10. Submersible morter pump. Vacuum packing machine. Hygro & thermo recoder (EHT-176). SSB Radio equipment (SS 16B) 1, (SS 15A) 2. Electronic ricopy. Air conditi ner for seed storage. etc.	13,661
1975	Truck (BMA61-F) 2. Vacuum packing machine. Low temperature thermostat. Hand tractor 2. Seed counter 3. etc.	7,509
1976	Sprinkler set 3. Work tools and equipment 1.	

Table 1-5. List of trainees sent to Japan

Name	Place of work	Time	Place of training	Field of training
Vibul Yodteerak	Div. Res. Exp. Sta. Dep. Agr.	1971 June - Nov.	Tokachi Agr. Exp. Sta. & Nat'l Inst. Agr. Sci.	Soybean breeding & Agronomy
Sujin Cheevaprasert		1971 June - Nov.	Tokachi Agr. Exp. Sta. & Nat'l Inst Agr. Sci.	Soybean breeding & Agronomy
Dhanit Sophanodora	Kalasin Seed Mult. Sta.	1971 June - Nov.	Tokachi Agr. Exp. Sta. & Nat'l Inst. Agr. Sci.	Soybean breeding & Agronomy
Rangsan Keereetaveep	Mea Jo Agr. Exp. Sta.	1972 July - Dec.	Tokachi Agr. Exp. Sta. & Nat'l Inst. Agr. Sci.	Soybean breeding & Agronomy
Somyot Pichitporn	U-thon Agr. Exp. Sta.	1972 July - Dec.	Tokachi Agr. Exp. Sta. & Nat'l Inst. Agr. Sci.	Soybean breeding & Agronomy
Vudhisak Pornprompratan	Kalasin Field Crop. Exp. Sta.	1974 Mar. - Nov.	Natl. Tohoku Agr. Exp. Sta.	Soybean breeding
Monthon Saevatanonta	Div. Field Crop, Dep. Agr.	1974 Mar. - Nov.	Natl. Tohoku Agr. Exp. Sta.	Soybean breeding
Bhanas Sonaserm	KhonKaen Field Crop. Exp. Sta.	1974 April - Nov	Natl. Hokkaido Agr. Exp. Sta.	Agronomy
Viroon Sakultab	Mae Jo Agr. Exp. Sta.	1975 May - Nov.	Natl. Tohoku Agr. Exp. Sta.	Soybean breeding
Somsak Srisonbun	Srisamrong Agr. Exp. Sta.	1975 May - Nov.	Natl. Tohoku Agr. Exp. Sta.	Soybean breeding
Khonthong Puangpralone	Phraphutthabat Agr. Exp. Sta.	1975 July - Dec.	Hokkaido Central Agr. Exp. Sta.	Soybean breeding
Waravich Rungrattanakasin	Soil Microbiol., Dep. Agr.	1975 July - Dec.	Natl. Hokkaido Agr. Exp. Sta.	Root nodule
Pinporn Sema	Mae Jo Agr. Exp. Sta.	1977 Mar. - Oct.	Tokachi Agr. Exp. Sta.	Soybean breeding
Thewa Maolanont	Kalasin Agr. Exp. Sta.	1977 Mar. - Oct.	Tokachi Agr. Exp. Sta.	Soybean breeding
Anat Watanasit	Phraphutthabat Agr. Exp. Sta.	1977 Mar. - Oct.	Tokachi Agr. Exp. Sta.	Soybean breeding
Kanokporn Wichitkarn	Kalasin Agr. Exp. Sta.	1977 May - Oct.	Tokachi Agr. Exp. Sta.	Soybean breeding

Simultaneously with the dispatch of the experts, trucks, tractors and various experimental equipment were offered. In the initial phase of the cooperation, ¥70,000,000 worth of equipment was offered to facilitate the effective start of the cooperative activity. The offering of equipment was continued. In the end about ¥130,000,000 worth of equipment had been offered to contribute greatly to the upgrading of the standards of experiment and research facilities in Thailand (Table I-4).

Starting in 1971, two or three members selected from the Thai staff engaged in the project for the development of soybeans in Thailand were sent to Japan six or nine months every year to train themselves primarily in the breeding of soybeans (Table I-5).

The pariod of cooperation in this project was initially set at five years, but it was made longer due to a delay in the dispatch of experts. The period of cooperation was further postponed later to some extent with consideration given to the progress of the cooperation. In 1976, it was concluded that the purposes of the cooperation project were generally fulfilled, because the research and technical standards of the Thai colleagues had been developed to a point where they could carry on the project by themselves, and because the time had come when "SJ-4", Thailand's first hybridized soybean variety, could be registered. It was decided, therefore, to terminate the cooperation in the form of a dispatch of experts as of the end of April 1976. In respect of the offering of equipment and the acceptance of trainees for fiscal 1976, however, it was decided to carry them out after the termination of the cooperation project, as they had not been accomplished due to a delay in clerical procedure.

In the meantime, the soybean production in Thailand greatly increased. Statistics in 1974 indicate that the cultivation measured about 160,000 hectares and the production stood at about 190,000 tons. The production later continued to rise.

3. Achievements of Circuit Guidance and Survey

Since the initiation of this soybean development cooperation project, a circuit guidance and survey team had been sent five times to provide guidance for technical and managemental improvement in association with the development of soybeans. The period of dispatch of these circuit guidance and survey teams and their organization are shown in Table I-6.

In August 1971 after a lapse of one-and-a-half years from the initiation of cooperation in the development of soybeans, the first circuit guidance and survey mission was dispatched. In those days, emphasis was put on clarification of the direction of cooperation in research and familiarization with the future policy of the Government of Thailand. It was at that time that the Government of Thailand was about to implement the third five-year program (1972-76) for a boost in the production of soybeans, and suggestions were made about the concept of a Soybean Research Center, which would be staffed by experts in various fields and work out an ideal system of technical cooperation.

The second guidance and survey mission was sent in March 1973. At that time, it

Table I-6. The circuit guidance and survey team for the soybean development project

Dispatched time		Personnel Organization
1971 Aug. 15 - Sept. 4	Leader	Kaoru Ozaki (Chief, Upland Farming Div., Kyushu Nat'l Agr. Exp. Sta.)
	Member	(Breeding) Masataka Saito (Chief, 1st Lab. Legumes, Hokkaido Pref. Tokachi Agr. Exp. Sta.)
	Member	(Pathology & Entomology) Tsutomu Hasegawa (Chief, 2nd Lab. Entomology, Environment Div., Tohoku Nat'l Agr. Exp. Sta.)
	Member	(Liaison Officer) Sinya Masuda (Primary Products Development Cooperation Office, OTCA)
1973 Mar. 28 - Apr. 10	Leader	Kan'ichi Murakami (Chief, Div. Genetics, Dep. Physiology & Genetics, Nat'l Inst. Agr. Sci.)
	Member	(Agronomy) Masashi Yamamoto (Chief, 3rd Lab. Upland Crops, 1st Crop Div., Hokkaido Nat'l Agr. Exp. Sta.)
	Member	(Breeding) Shigeo Matsumoto (Chief, 3rd Lab., 2nd Agronomy Div., Tohoku Nat'l Agr. Exp. Sta.)
	Member	(Planning & Liaison Officer) Tsuguo Yashima (Primary Prod. Dev. Office, OTCA)
1973 May 25 - Jun. 24	Leader	Shoshin Konno (Chief, 2nd Lab. Upland Crops, 2nd Div. Physiology, Dep. Physiology & Genetics, Nat'l Inst. Agr. Sci.)
1975 Mar. 19 - Apr. 4	Leader	Shiro Okabe (Dep. Physiology & Genetics, Nat'l Inst. Agr. Sci.)
	Member	(Research Planning) Shoshin Konno (Chief, 2nd Lab. Upland Crops, 2nd Div. Physiology, Dep. Physiology & Genetics, Nat'l Inst. Agr. Sci.)
	Member	(Coordination & Planning) Hiroshi Takasawa (Int'l Cooperation Section, Div. General Affairs, Agr. For. & Fisheries Res. Council Secretariat, Min. Agr. & Forest.)
	Member	(Liaison Officer) Mineo Kawabe (Agr. Develop. Cooper. Dep., JICA)
1976 Feb. 19 - Mar. 4	Leader	(Entomology) Takashi Kobayashi (Chief, 1st Lab. Entomology, Environment Div., Tohoku Nat'l Agr. Exp. Sta.)
	Member	(Breeding) Takashi Sanbuichi (Research Staff, 1st Lab. Legumes, Hokkaido Pref. Tokachi Agr. Exp. Sta.)
	Member	(Coordination & Planning) Teruhide Fujita (Agr. Develop. Cooper. Dep., JICA)
	Member	(Liaison Officer) Ken Kinoshita (Agr. Develop. Cooper. Dep., JICA)

was decided to confine the cooperation project to technical cooperation, primarily in breeding, for the time being and limit cooperation in cultivation to experiments on seed production, so that a research program could be worked out to assure certain achievements in about two years (five years in total) and this program could be postponed for another year, wherever necessary. The concrete measures to step up the experiments and to work for better mutual communication were pointed out.

Initially, no record of discussion (R.D.) was prepared for this cooperation at the time of its initiation, so that there arose many inconveniences in the promotion of this project. Even though some span of time had lapsed since its initiation, it became necessary to explore the possibility of preparing a record of discussion and find substantial solutions to the problems the settlement of which had been somewhat delayed. In view of this necessity, Konno, who was scheduled to be assigned to the next team of experts, was dispatched in May 1973 for circuit guidance and survey. Both Thai and Japanese sides saw it necessary to prepare a record of discussion for an efficient implementation of the cooperation in the future. It happened that the Government of Thailand filed the Japanese Government with a request for assistance in the establishment of a Legume Center and there arose the possibility of the cooperation project being merged into the Legume Center project, so much so that the call for the preparation of a record of discussion tapered off. In the end, it was decided that the cooperation be carried on in the remaining period without a record of discussion but with a negotiation each time a problem arose. The concept of a Legume Center was later transformed into that of a Soybean Research Center, and a formal request was filed with the Japanese side for assistance.

In March 1975, the fourth guidance and survey mission was dispatched to provide necessary guidance in preparation for the termination of the cooperation project and to exchange views on the concept of establishing a Soybean Research Center. It was then decided to complete the cooperation project by March 1977 to get everything accomplished by the time on which agreement would be reached between both sides. With primary priority given to the execution of a performance test, the settlement of a procedure for the registration of new varieties, measures for the propagation of seeds, and establishment of a basic pattern for the breeding system were pointed out. In respect of the Soybean Research Center, it was pointed out that there were some questions yet to be clarified before its realization, and the Thai side consented to it. The survey mission proposed that a research project for the qualitative improvement of soybean seed in Thailand be studied after its return.

The fifth guidance and survey mission was sent in February 1976. Agreement was reached between both countries on the decision to terminate the cooperation as of the end of April 1976, while taking note of the facts that the abilities of the persons associated with the project to develop soybeans in Thailand had developed to a point where they could run the project by themselves, and that the registration of a new variety was now possible under this project. During the stay of this survey team, the Conference for Expanding the Use of Soybeans was held in Thailand with the participation of about 230 delegates from 17 countries of the world. Members of the survey mission and the Thai staff introduced the cooperation project in symposia and national reports. On the last day of the Conference, participants visited the Mae Jo Agricultural Experiment Station. With its data given to them, the participants inspected the experiment conducted on the field and highly rated our project.

CHAPTER 2. OUTLINE OF ACHIEVEMENTS OF SURVEYS AND RESEARCH

1. Survey on Marketing of Soybeans in Thailand (conducted in 1970 - 1972)

1) Marketing Channels of Soybeans in Thailand

The Marketing channels of soybeans in Thailand are shown in Fig. II-1. This figure represents the results of a survey conducted at Chiengmai, Sukhothai and Bangkok, strategic points for the marketing of soybeans. In areas where the production is inconsistent or at times when there is a great increase in the production in the future, some of the areas may not coincide with the pattern of this figure and may become more complicated.

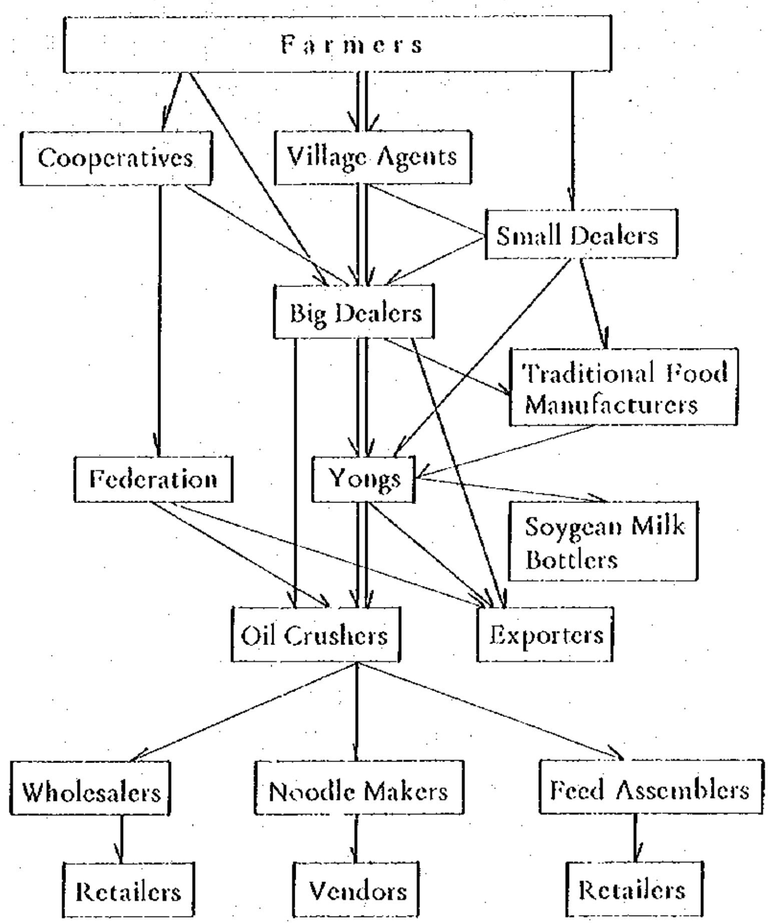


Fig. II-1. Schema of trade channels for Thai soybean

Buyers in rural communities are those from rural Thailand, some being partly engaged in farm work and others being exclusively engaged in buying. Whichever category they belong to, they are men of business ability and gain their credit with farmers. They purchase an average 250 bags (about 30 tons) of soybeans from 30-60 farmers. Usually, they stock them in their own storage for about three months and sell them to Chinese merchants in local towns when the terms get remunerative. Buyers in villages offer funds and information about farm prices to farmers and supply new seeds.

The dealers are Chinese residents, buying soybeans from farmers to turn them over to big dealers or sell them for local consumption. Many of them concurrently operate farm implement or general merchandise stores, and some also purchase cotton and other crops.

Through buyers in communities and dealers, the big dealers close their full grip on the buying of products in a fairly extensive area. One big dealer is tied in with about 500 sub-buyers and two to four Yong, business connections in Bagkok. About 80% of yong are fixed for each season. Big dealers have a granary of more than 2,000 tons in capacity and sell soybeans according to the price information supplied by Yong every day.

The word "Yong" appears to imply "comission agent" in Chinese, but some of them actually take on the character of something like a correspondent. Located along the Songward Road in Bangkok, their stores number more than 100, about 20 of them dealing in beans. They have their own particular trade field to some extent, depending on the use and their related production center. Each Yong has 10-20 dealers as their clients and distributes information about the prices to 50-60 dealers.

Yong serves a pivot for producers and ultimate users including exporters and plays an important role in the distribution of upland crops and in the bidding of prices. Yong's granaries are not large in capacity, and their freight is often transferred to the warehouses of exporters directly from dealers.

There are several influential oil mills (three engaged in the extraction of solvents) and about 40 smaller oil mills. About 20 firms are able to more than 15 tons of raw materials a day, and the total capacity of the oil mill facilities is estimated at more than 100,000 tons. They are concentrated in Bangkok, Nonthaburi and Ayuthaya, using coconuts, peanuts, rice barn, soybeans, cotton seeds and others as the materials.

The exporters have agents and clients abroad. They purchase farm products through Yong and export them, depending on the tone of business in foreign markets. More than 10 exporters deal in soybeans. The Thai soybeans are comparatively high in price and not standardized in quality. Being weak in international competition, they are exported chiefly to Malyasia, Singapore and Hongkong. They are used mainly for the production of food and many of them are of Saraburi's products. As the output of soybeans in Thailand is so small in quantity that the exports sometimes soar the domestic prices.

Thus, the marketing network established by Chinese residents is efficient, and no major problems are posed. Some apprehension is entertained about the adverse effects caused as a result of the excessive competition made by many smaller businesses on the Bangkok market.

In terms of distribution, some problems are presumably posed on the roads, railways, cargo booking terminals, rivers, port and harbor facilities and other transport facilities. It is surmisable, therefore, that their improvement would strengthen the power to compete on international markets and become a key to development and promotion at home.

2) Production Cost of Soybeans in Thailand (Surveyed in May through October 1971 and January through April 1972)

A questionnaire survey was conducted on farm households in soybean producing area through the good offices of agricultural schools, agricultural cooperatives and provincial agricultural extension service officials.

The survey covered the area of cultivation, area of the land owned, average yield, selling price, transport method, settlement of accounts, work, expenditures classified by material, familial labor, farm implements owned, years of experience, hopes and views of farmers on production, etc., in respect of soybeans, maize, mungbeans and peanuts.

Table II-1 shows the percentage of the cost required for production by crop and area, total cost including the values of labor offered by family members (Cost A), total cost excluding the values of labor offered by family members (Cost B), average yield per rai (1 rai = 0.16 ha.), selling prices, gross and net incomes, etc. The percentage of the production cost does not include the values of labor offered by family members and represents what was actually spent in cash (Cost B).

Of the items of expenditure, the plowing cost proved the largest of them all, which was followed by the costs of harvesting, threshing and seeds. The fertilzer and pesticide costs were small.

The percentage of the plowing cost for soybeans in Phetchabun was low, not because the plowing cost was small but because other types of management practices were expensive. For maize in Sawankhalok County, the harvesting and threshing costs were extraordinarily small, but there is no other choice but to ascribe it to dependence on family labor almost in every instance. The percentage of pesticides was high for mungbean in terms of cost. The harvesting cost was extremely high for peanuts.

The earning rate classified by crop and region is given in Table II-2. *When family* labor was included in terms of money, this table suggests that the earning rate for soybeans is low. The earning rate is high for maize in Phetchabun, mungbeans in the north center and peanuts in Phetcbabun. When the cost of family labor is excluded, soybeans in Chiengmai in the rainy season registered the highest earning rate, in spite of the fact that the crop failed at the time of the survey. Regional differentials are observed. In Phetchabun, permanent workers are employed. If they are not landed agricultural workers, problems will be posed in terms of rural community and possibly become a barrier to production. The proprietors get considerably large earnings from single crops, so much so that they would presumably lose their interest in multiple cropping due to the barriers existent in terms of labor and technology.

Table II-1. Comparison by items of cost and income (par rai)

Item	Soybean			Maize			Mungbean		Peanut
	CH	SW	PE	SW	PI	PE	CN	PE	PE
Seeds %	24	14	19	–	17	3	19	24	16
Plowing	42	49	18	79	39	50	33	18	10
Seeding	8	1	10	10	4	2	1	9	11
Weeding and Intertillage	16	6	16	9	3	12	7	7	14
Harvesting and Threshing	9	29	29	1	32	25	27	27	42
Fertilizer	–	–	–	–	1	–	–	–	–
Insecticide	–	–	7	–	5	–	12	15	7
Transportation	–	–	–	–	–	7	–	–	–
%	100	100	100	100	100	100	100	100	100
Total cost B ฿	37	77	187	71	62	163	59	195	316
cost A ฿	197	130	198	127	108	177	125	236	318
Yield Kg	121.93	175.24	149.50	295.28	30.22	522.72	11.43	9.71	281.45
Selling price ฿	2.55	1.56	2.24	0.93	12.80	0.92	36.49	40.11	3.78
Gross income	311	273	335	275	387	481	417	389	1,064
Rettern cost B	274	196	148	204	326	318	358	184	748
cost A	114	143	137	148	279	304	292	158	746

CH: Chiengmai, SW: Sawankhalok, PE: Phetchabun, PI: Phitsanulok, CN: Central North

cost A: Included the cost of family labor, cost B: excluded the cost of family labor.

Table II-2. Returns to cost by crops and locations

Crop	Place	Return/cost A	Return/cost B	No. of family labor/rai	Cash income/farmer
Soybean	Chiengmai (rainy)	0.58 ฿	7.41 ฿	0.30	821 ฿
	Sawankhalok (black)	1.10	2.55	0.12	2,064
	Phetchabun	0.69	0.79	0.04	2,963
Maize	Sawankhalok	1.16	2.87	0.08	4,669
	Phitsanulok	2.57	5.27	0.15	1,827
	Phetchabun	1.61	1.95	0.03	31,510
Mungbean	Central North	2.35	6.07	0.06	2,968
	Phetchabun	0.65	0.94	0.06	5,434
Peanut	Phetchabun	2.35	2.37	0.03	7,928

cost A: included the cost of family labor, cost B: excluded the cost of family labor.
฿: Baht, 1 ฿ ≒ ¥15. ≒ US$0.05.

Of the demands from farmers, the greatest number is associated with financing, which is followed by fertilizer, pesticides and excellent varieties. Demands are also made about tractors, excellent seeds and reasonable selling prices.

The greatest ammount of debts to middle men is registered by farmers engaged in planting soybeans and mungbeans in Phetchabun, who are followed by farmers of the Sawankhalok agricultural cooperative who are engaged in the cultivation of soybeans and maize and those in Phetchabun who are engaged in plantating maize and peanuts in terms of debts. The debts of soybean producing farmers in Chiengmai and others are small in amount. The demands for financing are strong, presumably because these farmers hope to clear themselves from debts to middlemen. The smaller the experience they have in cultivation, the greater the debts; the greater the experience, the smaller the debts. It might be said that the calls for the availability of financing institutions are particularly strong in newly reclaimed areas.

A survey of this nature will become more accurate as it is held one after another, and it will become possible to analyze production in terms of farm household management, providing a reliable foundation for the formulation of an agricultural policy.

2. Surveys and Experiments on Soybean Cultivation in Thailand

1) Weather Conditions

Table II-3 indicates the temperature and precipitation at major places in Thailand (see Fig. II-2 for the locations).

The temperature is lowest in December and January but highest in April. The rainy season falls in May through October and the dry season in November through April. The precipitation is greatest in September. There is practically no precipitation in the dry season with the exception of south Thailand and the coast along the Gulf of Thailand in central Thailand. The figures given in the table are the mean values for the last 20 years. The difference between years is great, and the start of the rainy season differs, depending on the year.

Thailand lies between lat. 5°30' and 21°, with Bangkok situated in about 14° and Chiengmai in 19°. The changes in day length in the year are shown in Fig. II-3. The day length is 11 hours to 13 hours and 17 minutes in Chiengmai and 11 hours and 18 minutes to 12 hours and 56 minutes in Bangkok, indicating that it is by far shorter than in Japan.

The cultivation of soybeans in Japan is carried out in May through October when the day length is long. In Thailand, the cultivation is conducted not only in the rainy season but also in the dry season of December through April, suggesting that soybeans are cultivated in Thailand at shorter day length and at higher temperatures.

2) Fact-finding Survey on Cultivation

Before start of experiments and research for the cultivation of soybeans in Thailand,

Table II-3. Climatological data for the period 1951 - 1970 at selected locations

Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Year	Remark
Chiengmai														
Temp. (°C) Mean	21.1	23.0	26.1	28.8	28.7	27.9	27.4	27.0	26.9	26.2	24.3	21.7	25.8	18°47'N
Mean max.	29.1	32.2	35.2	36.4	34.5	32.2	31.5	30.8	30.9	30.7	30.0	28.6	31.8	98°59'E
Mean min.	13.4	13.9	17.0	21.1	23.3	23.5	23.3	23.2	22.8	21.5	18.6	14.8	19.7	313.13 m
Rainfall (mm)	9.8	8.4	19.1	51.3	168.1	156.3	175.0	235.4	257.8	133.8	30.9	15.4	1261.3	
Phitsanulok														
Temp. (°C) Mean	24.7	26.9	29.4	31.1	30.3	39.1	28.5	28.3	28.2	28.1	26.8	24.7	28.0	16°50'N
Mean max.	31.7	33.8	36.0	37.4	35.7	33.6	32.8	32.3	32.1	32.4	32.0	31.1	33.4	100°16'E
Mean min.	17.7	20.0	22.7	24.7	25.0	24.6	24.3	24.3	24.3	23.8	21.5	18.5	22.6	44.11 m
Rainfall (mm)	7.9	13.8	37.8	55.3	205.5	169.9	192.1	226.0	264.7	140.6	21.9	6.5	1342.0	
Lopburi														
Temp. (°C) Mean	25.8	28.2	30.1	30.9	30.0	28.9	28.3	28.1	27.8	27.5	26.5	25.4	28.1	14°48'N
Mean max.	32.7	34.6	36.4	37.1	35.3	33.7	32.7	32.2	31.6	31.6	31.5	31.5	33.4	100°37'E
Mean min.	19.0	21.9	23.8	24.8	24.8	24.2	23.9	24.0	23.9	23.6	21.4	19.1	22.9	13.00 m
Rainfall (mm)	11.2	16.0	62.0	73.2	170.9	154.6	185.5	170.1	279.3	172.6	39.5	8.3	1343.2	
Bangkok (Donmuang)														
Temp. (°C) Mean	26.2	27.7	29.2	30.4	30.0	29.4	28.9	28.7	28.2	28.3	27.5	26.0	28.4	13°55'N
Mean max.	32.1	33.3	34.7	35.6	34.6	33.5	32.8	32.5	32.0	31.6	31.1	30.9	32.9	100°36'E
Mean min.	20.3	22.1	23.8	35.1	25.3	35.3	25.0	25.0	24.8	24.9	23.8	21.1	23.9	12.20 m
Rainfall (mm)	4.8	21.0	35.7	67.2	178.0	170.6	173.8	239.2	329.1	250.5	38.7	15.3	1523.9	
Sakhonnakhon														
Temp. (°C) Mean	21.5	23.9	27.1	29.1	28.8	28.0	28.1	27.6	27.1	26.2	24.1	21.7	26.1	17°10'N
Mean max.	29.3	31.1	33.7	35.4	33.7	32.3	32.0	31.4	31.0	31.1	30.5	29.2	31.7	104°09'E
Mean min.	13.6	16.8	20.5	23.1	24.1	24.2	24.1	23.9	23.3	21.2	17.8	14.3	20.6	172.00 m
Rainfall (mm)	7.0	15.2	48.0	77.4	222.0	266.6	198.8	287.9	274.9	60.4	6.6	0.9	1465.7	
Khonkaen														
Temp. (°C) Mean	23.2	25.7	28.8	30.2	29.8	28.6	28.2	28.1	27.6	26.7	25.2	23.1	27.1	16°20'N
Mean max.	30.5	32.7	35.6	36.5	34.9	33.1	32.6	32.1	31.5	31.5	31.0	30.1	32.7	102°51'E
Mean min.	15.8	18.7	21.9	24.0	24.6	24.6	24.1	24.0	23.6	22.2	19.4	16.1	21.6	164.63 m
Rainfall (mm)	9.2	19.8	39.6	63.0	166.0	187.6	149.5	176.9	277.6	95.7	11.4	1.5	1197.8	
Nakhonratchasima														
Temp. (°C) Mean	23.4	26.3	28.9	29.9	29.4	28.8	28.2	28.0	27.4	26.4	24.7	23.0	27.0	14°58'N
Mean max.	30.9	33.5	35.8	36.4	34.8	33.8	33.1	32.7	31.8	30.7	30.1	29.7	32.8	102°07'E
Mean min.	16.0	19.2	21.9	23.3	23.9	23.8	23.4	23.2	23.0	222.	19.4	16.3	21.3	188.00 m
Rainfall (mm)	3.6	27.8	55.6	71.1	177.4	109.3	143.2	133.2	261.1	176.0	29.9	2.7	1190.9	
Chanthaburi														
Temp. (°C) Mean	25.8	26.8	27.6	28.4	28.1	27.6	27.3	27.2	27.1	27.2	26.5	25.6	27.1	12°37'N
Mean max.	32.0	32.6	32.9	33.5	32.4	31.1	30.6	30.4	30.5	31.4	31.4	31.2	31.7	102°07'E
Mean min.	19.6	21.0	22.4	33.3	23.9	24.2	23.9	23.9	23.6	23.0	21.6	19.9	22.5	4.00 m
Rainfall (mm)	13.3	50.1	75.2	115.4	362.2	509.9	502.4	548.8	578.2	312.5	74.1	10.9	3153.0	
Chumphon														
Temp. (°C) Mean	24.9	26.0	27.1	28.3	28.3	27.7	27.3	27.3	27.2	26.8	25.9	24.8	26.8	10°27'N
Mean max.	29.7	30.9	32.3	33.6	33.0	31.8	31.2	30.9	31.0	30.5	29.5	29.1	31.1	99°15'E
Mean min.	20.1	21.1	21.9	23.1	23.7	23.6	23.4	23.5	23.5	23.1	22.2	20.4	22.5	2.89 m
Rainfall (mm)	118.5	67.7	68.6	84.7	178.8	159.0	197.0	191.6	164.8	345.9	332.5	166.7	2075.8	
Songkhla														
Temp. (°C) Mean	26.8	27.1	27.6	28.4	28.7	28.4	28.1	28.1	27.9	27.3	26.7	26.6	27.6	07°11'N
Mean max.	29.5	30.2	31.4	32.7	33.0	32.8	32.6	32.5	32.3	31.1	29.8	29.3	31.4	100°37'E
Mean min.	23.9	23.9	23.9	24.2	24.3	24.0	23.6	23.6	23.6	23.5	23.7	23.9	23.8	9.00 m
Rainfall (mm)	141.3	38.6	41.8	55.9	130.9	101.6	120.6	113.7	121.6	305.0	540.9	437.1	2149.0	

Source : Climatological data of Thailand, 20 year period (1951 - 1970), Meteorological Department, Ministry of Communications, Bangkok, Thailand.

Temperature of Chiengmai & Nakhonratchasima: 1952 - 1970

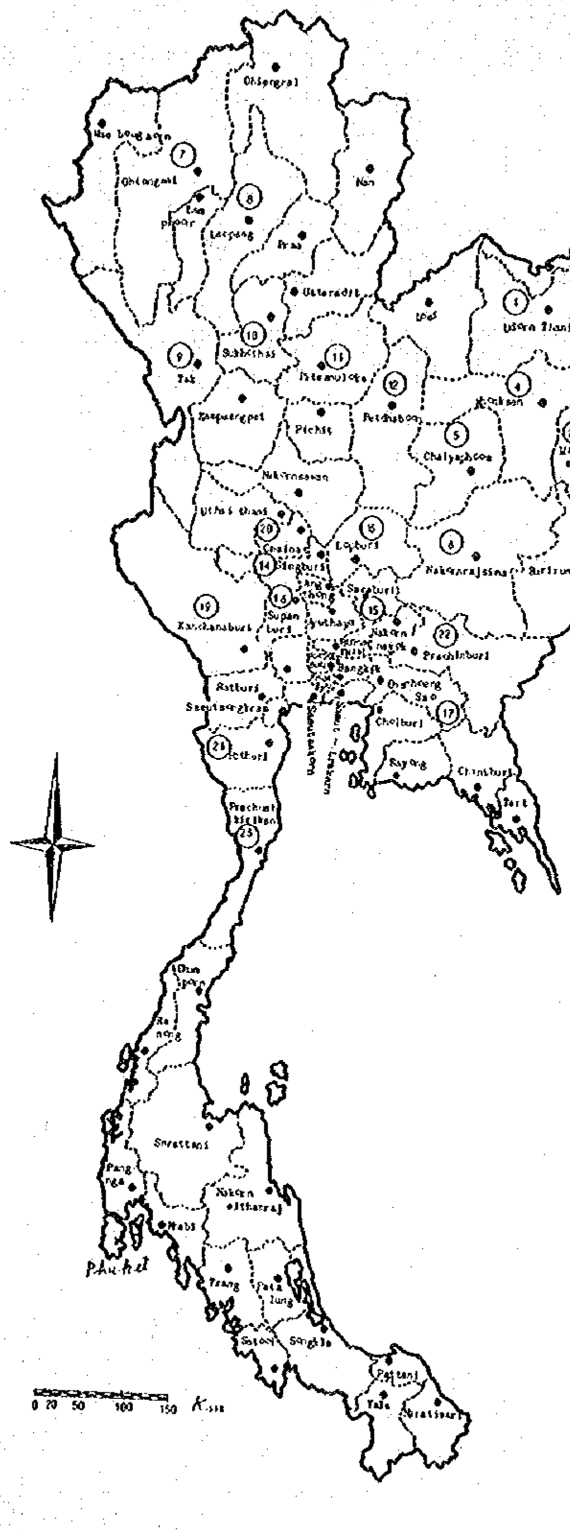


Fig. II-2. Thailand

○: Places of fact-finding survey of soybean cultivation in rainy season 1970

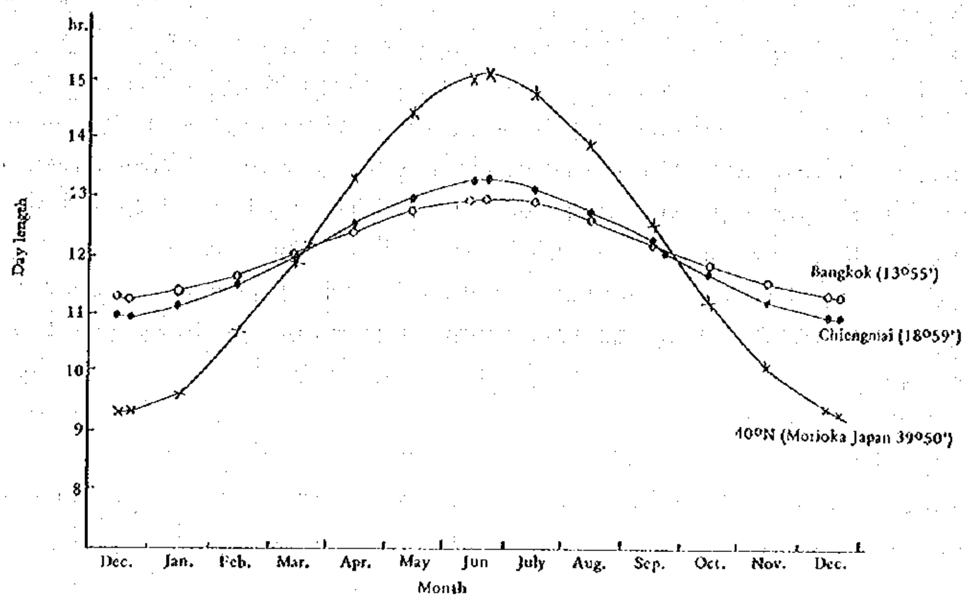


Fig. II-3. Day length at selected places

it was considered important to familiarize with the actual state of soybean cultivation in Thai land and clarify what problems are posed. Following the survey conducted by a survey team in January through March 1969, another elaborate survey was carried out on the soybean cultivating areas in the rainy season in 1970 and those in the reiny and dry seasons in 1971.

a. Soybeans in Rainy Season, 1970

The results of an extensive survey on 24 provinces in the major soybean cultivation areas are as follows (Fig. II-2):

i) In respect of damage by insects, the damage caused by stink bugs was alarmingly widespread.. The damage caused by podworms, aphids, leaf rollers, stem miners was considerably observed. Root knot nematodes ere also observed at some places.

ii) As regards damage by diseases, the purple seed stain was considerably observed in Sukhothai. The severe incidence of rust was observed at many places in Chiengmai Province. The sporadic incidence of viral diseases was observed at agricultural experiment stations and on the fields of some farmers in Kanchanaburi.

iii) Concerning nodule bacteria, the setting of root nodules was not observed in most places of northeast Thailand as reported in the past surveys, while the setting was fairly good in some places. Even in one and the same place, the differed, depending on the variety. In central Thailand, no setting was observed in some newly developed areas.

iv) Under the conditions of high temperature and humidity, it is difficult to keep the germinating capacity of seeds till the planting season of the following year, so that it is made a general practice for farmers to purchase seeds from seed dealers. In Chiengmai, Nakornratchasima and Chaiyaphun, there were places where seeds were successfully stored for use in cultivation in the following rainy season. In Sukhothai and Chiengmai, there were cases in which planting was done in September to obtrain necessary seeds.

v) The cropping of 'SB60' 'Packchong', 'Sansai' and other local varieties is done in many cases, and the propagation of the improved varieties of 'SJ-1' and 'SJ-2' is conducted.

vi) Planting is extensively done as it extends from May to September. In Sawankhalok County of Sukhothai Province, a major producing center of soybeans for cropping in the rainy season, mostly, planting is done in May, and the intercropping of cotton is later done or the cropping of mungbeans or black soybeans is carried out after the harvesting of the soybeans. In the upland field areas of Tak and Chiengmai, soybeans are cultivated on the basis of only one crop a year. In the maize cropping areas in Lopburi and other provinces, some farmers carry out planting in September as its succeeding crop, whereas planting is done in July as its succeeding crop by some farmers in the peanut cropping areas.

vii) There are many cases of lodging for planting in May and June. Excessively wide spacing was observed for planting in August and September, although the growth was poor. In general, the number of seeds per hill is too many for planting. It exceeds 10, so that the plants are apt to lodge. Some farmers put off the planting period to avoid an over luxuriant growth and possible rain damage in the harvesting time.

viii) Weeding is done only one time two or three weeks after planting in many cases. Fertilizer application is not done by farmers, and the average yield is small, standing at 155 kg/rai (97 kg/10 a in 1968).

b. Soybeans in Rainy Season, 1971

A questionnaire survey was requested to be carried out and an on-the spot survey conducted on quadrant sampling at several places in the provinces of Sukhothai and Chiengmai.

(a) Sukhothai Province

i) Situated in the north of central Thailand, this area is fertile, featuring an alluvian and a thick cultivated soil layer.

ii) The area placed under the management of a farmers is large, averaging 41.7 rai (about 6.7 ha). Soybeans are cultivated in about 61%, cotton in 29% and maize in about 4% of the area.

iii) With regard to the soybean varieties, 'SJ-1' constitutes the majority. In addition, 'SJ-2' is cultivated. In either case, the mixing of different varieties was frequently observed. Besides, black soybeans are cultivated as the second crop in the rainy season. 'SJ-1' tends to shatter, and it is understood that 'SJ-1' is easy to separate the seeds from the shalls by beating with a pole. There will presumably be a change in the demand of varieties, should threshing machines be introduced in the future.

iv) Sixty-three percent of the farm households covered in the survey made it a practice to grow seeds by themselves. In many cases, small-area cultivation is conducted in September to obtain the seeds. From seed dealers, seeds are purchased at 3.9฿/kg.

v) Cattle are frequently used for plowing, and about 16% make use of tractors on a rental basis. Fertilizer application is not done. Roughly in the middle of the growth of soybeans, the intercropping of cotton is started, so that the row spacing is broad, measuring about 120 cm. The distance between plants is 30-40 cm. Planting is done in the early period and middle of May. As the number of seeds per hill is large, lodging frequently takes place. There is a need to re-examine the planting density and breed the varieties resistant to lodging.

vi) Weeding is conducted at least once, it is rare that weeding is carried out two or three times. Only one time of weeding is insufficient, and hilling is presumably necessary.

vii) The occurrence of soybean rust was observed, but no big damage was inflicted. The occurrence of stinkbugs is frequent and they come in various kinds. The farmers who spray pesticides at least once accounted for 41% of those covered in the survey. This measure alone, however, is not adequate for their control.

viii) The soybean plants in their maturity measure more than 80 cm in stem length and are large in size. They yield exceeds 200 kg/rai (125 kg/10 a) in most instances, being of a high standard. Harvested soybeans are piled up in barns. When succeeding cropping has generally come to an end, the plants are dried in the sun. They are beaten with a pole for threshing. In some instances, threshing is done by having cattle or a tractor separate the soybeans. They are sometimes damaged by rain moisture when harvested plants are stored in stacks.

ix) Many farmers sell soybeans to merchants immediately after their threshing (October). The remains sell in November at the latest (2 ฿/kg).

(b) Chiengmai Province

i) In Chiengmai Province, rainy season soybeans are cultivated on the upland fields situated at the base of hills, and the soil is somewhat sterile. The area placed under the management of farm households averages 10 rai (1.6 ha). The planting area of soybeans measures 1-5 rai (16-90 a). As for other crops, the planting of tobacco is relatively popular.

ii) Most farmers provide the seeds for the rainy season with soybeans harvested in the previous dry season, while some farmers use the seeds which were harvested in the dry season of the preceding year and stored by themselves. In case the seeds are purchased from merchants the price is 2.2 – 3.2 ฿/kg. The "SJ-1" and "SJ-2" varieties are cultivated to the same extent.

iii) Plowing is manually done in many instances. No fertilizer application is conducted. For June planting, the row space is 30 - 50 cm and the distance between plants 25 - 40 cm. Two to four plants are standing in a hill.

iv) Weeding is done at least once. Some farmers carry out weeding two times. In cases where weeding is done only one time, weeds grow rank.

v) Soybean rust is found frequent after the flowering season, and there are many places where a big decrease in yield is observed. Leaf rollers and aphids occur in great numbers. The occurrence of stinkbugs is reported from Hangdong. The spraying of pesticides is done by some farmers.

vi) For harvesting, sickles are used and threshing is done with poles. Grain selection is done by rolling around soybeans in a basket. The yield is small at many places due to the infection of soybean rust. The yield stood at 70 - 133 kg/rai (44-83 kg/10 a) in the quadrant sampling and 36-203 kg/rai (22.5-127 kg/10 a) in the farmer interview. The seed yield by many farmers does not reach 100 kg/rai (62.5 kg/10 a) of seed yield.

vii) Generally, there are many cases in which the seeds produced in this area during the rainy season are sold as seeds to be grown in the following season. The seeds are transacted at relatively high prices, averaging 2.6 ฿/kg.

c. Soybeans in Dry Season, 1971

The main dry-season soybean producing center is Chiengmai Province, and these soybeans are cultivated on the paddy fields with well maintained irrigation facilities. In the counties (ampur) of Maerim, Maetaeng, Sansai and Sanpatong, a questionnaire survey was asked to be conducted and an on-the-spot quadrant sampling survey carried out.

i) The area placed under the management of a farm household averages 17 rai (2.72 ha). The paddy field owned by a farm household averages roughly 10 rai (1.6 ha), of which the cultivation of soybeans averages 6.6 rai (1.06 ha). Other crops include, tobacco, peanuts and garlics.

ii) In regard to the variety, 'SJ-2' constitutes the majority. Seeds are purchased from merchants in many cases at 2.5 – 5 ฿/kg.

iii) The fields are flooded without plowing. After the water has percolated the underground, holes are made at the place of rice stubbles with a stick for planting. In some cases, planting is done without making holes, and the seeds are not covered up with soil. Most farmers, are using, dried barn yard manure made of droppings of cattle, pigs and chickens to cover the planted seeds. Some farmers mix rice straw ash with barnyard manur for the coverings and only a few farmers apply chemical fertilizer.

iv) Planting is done in the early period and middle of January. The planting density of soybeans is tied in with that of rice. The row spacing is 25-42 cm and the distance between plants 25-36 cm, one hill consisting of two to five plants.

v) The soil is clayey. Most farmers do not carry out either weeding or intertillage, because it is difficult to conduct. The growth is poor due to the rankness of weeds, so a high seed yield cannot be expected. There seems to be a need to work out comprehensive measures, including the selection of herbicides.

vi) There is no precipitation at all during the cultivation period, so that ditches, about 30 cm in width, are dug in and around paddy fields, which will be fully flooded with water poured into them two or three times a month. Soybeans suffer from a reptition of excessive moisture and dryness. Irrigation is not carried out after the middle of the ripening period. There is a need to narrow the interval between irrigations and postpone the time to stop the irrigation.

vii) No significant insect damage was observed. The frequent occurrence of leaf rollers, aphids and stinkbugs is observed, and the spraying of pesticides is done in some places. There is a need to survey seasonal prevalence of insects and diseases by region throughout the year.

viii) For harvesting, sickles are used and threshing is done with poles. The yield stands at 125-200 kg/rai (78-125 kg/10 a). Grain selection is done by rolling around soybeans in a basket in many instances and put on sale. The price is roughly 2.2 ฿/kg. For a raise in seed yield, it seems to be important to make plants grow vigorously for soybeans in the dry season.

3) Studies for Maintenance of Viability of Seeds

The temperature and humidity of Thailand are so high that the lowering of the germinating capacity of seeds in storage is serious, thus hindering the maintenance of seeds for use in the next season. Studies were conducted on this problem with the belief that it would be important to establish a method of maintaining the viability of seeds so as to assure the availability of large quantities of excellent seeds in the future.

The seeds of 22 varieties of Thailand, Japan, Taiwan and the United States harvested at the Mae Jo Agricultural Experiment Station in the rainy season of 1970 and in the dry season of 1971 were used in conducting a survey on varietal differences in the maintenance of the germinating capacity and also on the seed storing method, and the following points were clarified:

i) 'SB 60' is the variety the germinating capacity of which hardly reduces and seems to be usable as the parent for hybridization.

ii) The drop in the germination percentage under natural conditions seems to be related mainly to the increase in water content of the seeds under the influence of humidity.

iii) Under the natural conditions given to Thailand, it would be possible to maintain a high germination percentage over a period of more than 10 months by setting the water content of the seeds at 5-6%, enclosing the seeds in plastic bags without being explosed to the open air and storing them indoors.

iv) The water content of the seeds may be easily and certainly lowered with a heated air dryer.

4) Experiments on Cultivation Methods

a. Planting Time

The soybean is a crop which is sensitive to day length and temperature, so that a survey was conducted on the planting time to check growth reactions with a shift in the cultivation time under the natural conditions of Thailand, clarify the optimum cultivation time for soybeans and secure data on the incorproation of soybeans in a crop rotation system.

At the Mae Jo Agricultural Experiment Station, 'SJ-2' was planted five times in every 15 days from December 16, 1970, to February 14, 1971, and 'SJ-2' was planted five times in every 15 days from December 16, 1970, to February 14, 1971, and 'SJ-1' and 'SJ-2" were planted six times at an interval of half a month from June 1, 1971, to August 15, 1971 to observe their growth and yield. The following findings were obtained (Tables II-4, 5 and 6).

i) When the seeds were planted in December through February for cropping in the dry season, the more belated the planting time, the longer the number of days to flowering, but the ripening period was greatly reduced and the growing period was shortened. The fact that although long-day conditions were created for planting at a later time, the short ripening period was associated with high temperature and dryness.

ii) The growth conditions were better for planting at a later time, but the plant growth seemed to have been retarded by dryness.

iii) The seed yield was great for planting on December 31 January 15 (the second and third plantings). The seed yield was also big for planting on December 16 (the first planting). If the soil moisture content was sufficient, the results would be different even for planting at a later time.

iv) In the case of planting in June through August for cropping in the rainy season, the more belated the planting time, the shorter the number of days to flowering and ripening for 'SJ-1'. In the case of 'SJ-2', however, the number of days was not so much influenced to flowering, but the ripening period was shortened by a great margin and then the growing period was shortened.

v) The tendency was also was noted that the more belated the planting, the smaller the growth.

vi) Soybean rust occurred extensively. Particularly, the plants planted on June 15 through July 15 (2nd-4th-plantings) were damaged seriously, reducing their seed size and yield. Consequently, no studies were conducted on the seeds of these plants.

Table II-4. Growth and yield of 'SJ-2' at different time of planting during the dry season

No.	Planting date	Days to flowering		Ripening period		Growing period		Germinating	Flowering	Leaf yellowing	Maturity
1	16 Dec.	42	100%	63	100%	105	100%	21 Dec.	27 Jan.	15 Mar.	31 Mar.
2	31 Dec.	44	105	55	87	99	94	6 Jan.	13 Feb.	28 Mar.	9 Apr.
3	15 Jan.	45	107	51	81	96	91	23 Jan.	1 Mar.	10 Apr.	21 Apr.
4	30 Jan.	44	105	47	75	91	87	5 Feb.	15 Mar.	22 Apr.	1 May
5	14 Feb.	46	110	44	70	90	86	20 Feb.	1 Apr.	1 May	15 May

No.	Lodging before harvest	Stem length (cm)	No. of nodes on the main stem	No. of branches	No. of pods	Seed weight (g/100)	Stem weight (kg/rai)	Yield (kg/rai)	Leaf area index at the flowering
1	0	34.9 c	9.4 c	5.5 c	89.4 b	13.99	320.5	212.4 a	2.73
2	0	48.7 b	10.0 b	10.4 a	122.7 a	14.7	369.7	243.4 a	2.95
3	0	49.7 b	10.4 b	8.4	120.4 a	13.3	337.5	228.7 a	2.27
4	0	59.2 a	12.2 a	8.3	107.1 ab	13.6	248.3	163.4 b	1.26
5	0	53.2 a	9.4 b	5.4 c	90.4 b	13.4	217.8	143.4 b	1.44
C.V. %		8.02**	8.30*	11.73**	9.59**	N.S.		10.13**	

Table II-5. Growth and yield of 'SJ-1' at different times of planting during the rainy season

No.	Planting date	Days to flowering		Ripening period		Growing period		Flowering	Maturity	Stem length (cm)	No. of nodes on the main stem	No. of branches	No. of pods	Yield (kg/rai)
1	1 June	50	100%	56	100%	106	100%	21 July	14 Sep.	78.2 a				54.4 b
2	16 June	50	100	52	92	102	96	4 Aug.	24 Sep.	77.7 a	15.4 a	10.8 a	100.2 a	54.3 b
3	1 July	48	96	47	84	95	90	17 Aug.	3 Oct.	82.3 a	14.4 a	11.3 a	77.2 b	47.0 b
4	16 July	45	90	49	88	94	89	29 Aug.	18 Oct.	40.8 b	9.9 b	6.9 b	41.0 c	21.9 c
5	1 Aug.	43	86	47	84	90	85	12 Sep.	29 Oct.	25.6 c	10.1 b	4.3 b	48.5 c	83.1 a
6	16 Aug.	41	82	52	93	93	88	25 Sep.	17 Nov.	32.9 bc	11.5 b	6.8 b	76.7 b	102.6 a
C.V.%										9.79**	8.16**	23.66**	21.14**	25.97**

Table II-6. Growth and yield of 'SJ-2' at different time of planting during the rainy season

No.	Planting date	Days to flowering		Repening period		Growing period		Flowering	Leaf yellowing	Maturity
1	1 June	41	100%	64	100%	105	100%	12 July	– (rust)	14 Sep.
2	16 June	47	115	54	84	101	96	1 Aug.	– (rust)	24 Sep.
3	1 July	48	117	46	72	94	90	18 Aug.	– (rust)	3 Oct.
4	16 July	45	110	50	78	95	91	29 Aug.	– (rust)	18 Oct.
5	1 Aug.	44	107	45	70	89	85	14 Sep.	20 Oct.	29 Oct.
6	16 Aug.	44	107	50	78	94	90	28 Sep.	10 Nov.	17 Nov.

No.	Loding before harvest	Stem length (cm)	No. of nodes on the main stem	No. of branches	No. of pods	Seed weight (g/100)	Stem weight (kg/rai)	Yield (kg/rai)	Leaf area index flowering time	Leaf area index after flowering
1	small	94.4 a	16.7 a	13.3 a	138.9 a	10.4 ab	163.7 a	150.3 a	3.7	2.7
2	medium	75.3 b	16.4 a	10.1 b	97.9 bc	7.4 c	107.8 c	90.3 c	3.3	2.7
3	small	74.0 b	16.9 a	10.0 b	118.9 ab	7.5 c	109.4 c	103.4 b	3.7	2.3
4	small	57.3 c	13.7 b	8.9 b	78.7 cd	9.7 b	131.4 b	106.7 b	1.6	0.7
5	non	28.0 d	12.4 b	5.6 c	58.9 d	11.8 a	129.3 b	148.1 a	0.7	0.6
6	non	30.3 c	10.3 c	6.2 c	74.7 cd	12.1 a	96.7 d	159.3 a	1.0	0.7
C.V.%		6.36**	6.06**	15.74**	14.29**	10.38**	6.97**	5.55**		

vii) From the foregoing findings, it seems appropriate to plant soybeans from late December to mid-January in the Chiengmai area for cropping on paddy fields in the dry season, when consideration is given to the distribution of farm labor and the lack of water in the late March.

Insofar as croppingin the rainy season is concerned, the tendency is that the more belated the planting, the smaller the growth. Although it is desirable not to postpone the planting too long, this problem requires a further study. To avoid damage from soybean rust, ti is better to postpone the planting.

b. Planting Density

As the result of an on-the-spot survey conducted on farmer's fields, it was strongly felt that there would be a need to check the existence of many cases of inappropriate planting density. For this reason, an experiment of four and three replications with 'SJ-2' at the Mae Jo Agricultural Experiment Station in the dry and rainy seasons of 1971 with the row spacing set at 25, 50 and 75 cm, the distance between hills at 15, 30 and 45 cm and the number of plants per hill at 1, 3 and 5. The results are as follows:

For cropping in the dry season, it would seem appropriate to set the two spacing at 50 cm, the distance between hills at 15-30 cm and the number of plants per hill at three to avoid lodging and increase the stem weight and the number of pods.

For cropping in the rainy season, the relations between stem height and lodging and the growth were the same as in the case of the dry season, but soybean rust massively broke out after the flowering stage, the seed yield was low and no differences were observed among the experiment plots. For this reason, a further study was required.

c. Intertillage and Molding

To solve the problems observed in the fact-finding survey, such as the damage caused by weeds and the adverse effects of weding and intertillage in the flowering stage, the effects of the time of intertillage and molding on soybeans were investigated.

In the dryseason, 'SJ-2' was used at the Mae Jo Agricultural Experiment Station, intertillage and molding were carried out 0-5 times in every two weeks from the second week after planting.

The results revealed that the yield was highest for two times of intertillage and molding but low for the cases in which neither intertillage nor molding was conducted and those in which inter.illage and molding were continued to a later stage. Therefore, intertillage and molding after the flowering stage under the conditions of dryness and high temperature would lend to the cuting of roots, thus bringing about an increase in shedding flower and pods, and retarding pod filling. It was ascertained, therefore, that intertillage and molding should be put to an end before the flowering stage.

d. Planting Method for Dry Season Soybeans

For dry season, soybeans cultivation without plowing is done almost in every case, so that problems are posed on weeds and irrigation. To realize a method for their solution, plowing before planting, cut-away or burn-up of the stubbles of the preceeding rice crop, weeding or non-weeding, and use of herbicides were carried out and their effects on the growth of soybeans were investigated.

When rice stubbles had been cut away, weeds grew fast, bringing about adverse effects on the growth of soybeans. When plowing had been conducted before planting, particularly, when ridging had been done, the root quantity was big but because of the rankness of weeds, the growth above the ground was hampered and no difference was observed in yield from others. Thus, it was clarified that whether weeds germinated earlier or later would not produce major differences in their growth at the flowering stage of soybeans, that the planting method alone would not control weeds and that there would be a need to check their rankness with weeding or treatment of herbicides.

e. Selection of Herbicides

Studies were carried out on the effectiveness of 13 kinds of herbicides and their influences on soybeans in the dry season of 1971, and those of 12 kinds in the rainy season of 1971.

The Lasso hydrate, M0338, Trifran, Planavin and Herban were promising. Also observed were some reagents which would deserve a further study.

From the standpoint of effectiveness of weed control, the proper dosage in the rainy season is higher than in the dry season.

f. Amount and Time of Fertilizer Application

A fertilizer application experiment was carried out on soybeans, because there had been no worthwhile experiment on fertilizer under the natural conditions of Thailand.

Both in the dry and rainy seasons of 1971, experiments were conducted on the harvested paddy field and upland field of the Mae Jo Agricultural Experiment Station with 'SJ-2' and 'Bonminori' and also with 3 kg/rai of N, 12 kg/rai of P_2O_5 and 12 kg/rai of K_2O and double their respective quantities as basal fertilizer or additional fertilizer for applying in the second week after planting.

Both in the dry and rainy seasons, the hampering of the germination was observed in spite of the fact that soil insulation was performed. Consequently, additional fertilizer would be preferable for the sake of safety. For cropping in the dry season, however, the application of basal fertilizer proved more effective in growth after the germination. Presumably because of the runoff of fertilizer by precipitation, the standard quantity of basal fertilizer proved insufficient, and effects made their appearance by applying double the quantity. In the case of an application of the standard quantity, top dressing seems more advantageous.

Incidentally, there is a need to carry out a further study on the balance between investment in fertilizer application and the effects of an increased yield.

3. Surveys and Research on Breeding

1) Characteristics of Thai Soybean Varieties

At present, 'SJ-1' is the variety which is recommended for cropping in the rainy season and 'SJ-2' in the dry season, and it is reported that these two varieties have been selected from the crossed materials introduced from Japan and Taiwan, but it was impossible to have access to a detailed description on experimental results.

'SJ-1' is a variety of the indeterminate growth type with tall plant height., and the growing period is about 100 days in the rainy season.

The weight per 100 grains is 12-13 grams. The color of seed coat is yellow and the hilum is black. At present, 'SJ-1' occupies most of the cultivation in the rainy season primarily in Sukhothai situated in the central part of Thailand. Its defects are susceptibility to lodging, no resistance to soybean rust and inferior seed quality.

'SJ-2' is a variety of the determinate growth type. The growing period is about 100-105 days. It matures later than 'SJ-1'. The weight per 100 grains is 12-13 g. The color of seed coat is yellow and the hilum is dark brown. 'SJ-2' presently occupies most of the cultivation in the dry season primarily in Chiengmai situated in the north of Thailand. It has defects, such as susceptibility to lodging, no resistance against soybean rust and inferior seed quality, but it resists shattering and features a very small loss in harvest.

The yield of the above-mentioned two varieties is still insufficient and there are many demerits, but their yeild is by far larger than that of local varieties. For this reason, the use of these two varieties has rapidly permeated into farmers since about 1970 under a system of propagaton insituted by the Department of Agriculture and the Department of Extension.

'SJ-3' has also been selected from the hybridizing materials introduced from outside Thailand. This variety is practically the same as 'SJ-2' in terms of morphological and ecological characteristics, and they can hardly be distinguished in appearance.

'SB 60' and 'Pakchong' are the varieties which have been selected from local varieties. 'SB 60' bears a very close parallel to the local varieties, 'Sansai' and 'Pitsanulok'. These three varieties are tall in plant height, featuring a determinate growth. The weight per 100 grains is 8-10 g. The seed coat is yellow and the hilum light brown. They are very susceptible to loding and their yield is small, but they are hard to shatter like 'SJ-2'. These three varieties are cultivated in the north as dry season crops, but they have very much reduced in area, replaced by 'SJ-2'.

'Pakchong' is a variety of short plant which features a determinate growth. The weight per 100 grains is about 15-16 g and the seeds are somewhat large. Primarily in the province of Saraburi, this variety is cultivated for cropping during late rainy season after maize and sorghum

The main characteristics of Thai varieties are shown in Table II-7.

With respect to 'SJ-2', some off-types, such as extremely late maturing, long stems and white pubescence, were mixed in the beginning of 1970 when the seed multiplication was started, and an attempt was made to remove these off-types in the fields during the growing stage.

2) Fluctuations in Growing Period and Plant Type of Soybean Varieties by Cropping Season

The cropping seasons of soybeans may roughly be divided into two in Thailand. One is cropping in the rainy season and the other in the dry season. Soybeans in the early rainy season are planted in May or June and those in the late rainy season are planted at the end of July or in the beginning of August. The planting of dry season soybeans is done from the end of December to the beginning of February.

The weather conditions differ to a great extent, depending on each cropping season described above and there are great differences in soybean growth between cropping seasons.

To realize the changes brought about by different soybean growing seasons in Thailand, an experiment was conducted in the following method:

(a) Place and period: Mae Jo Agricultural Experiment Station. From August 1971 to July 1972.

(b) Materials: Thai varieties: 'SJ-1', 'SJ-2', 'Pakchong' and 'SB 60'.
Introduced varieties: 'Tainung 3', 'Chung Hsing (Unknown)*', 'Tousan No. 26' and 'Acadian'.

* Preserved at the Mae Jo Agricultural Experiment Station, this seemes to be Chung Hsing No. 2.

(c) Time of planting: Planting was done 12 times at an interval of one month from August 1971 to July 1972. Planting was done on the last day of each month or the day preceeding to the last day.

(d) Planting method: Planting was done is 1/2,000 a. Wagner pots at a rate of two plants per pot. The fertilizer applied were 0.75, 0.3 and 0.3 kg/a. of N, P_2O_5 and K_2O, respectively.

(e) Day Length and Mean Temperature

Table II-7. Major characteristics of Thai varieties

Variety	Growing period (days)	Plant height (cm)	No. of nodes on the main stem	Lodging score	100 grains weight (g)	Seed yield (kg/rai)	Color of pubescence	Color of flower	Leaf shape
SJ-1	96	69	15.4	1.4	12.8	317	Brown	Purple	Broad
SJ-2	104	60	14.8	2.0	12.4	358	Brown	Purple	Broad
SB 60	108	84	18.0	2.7	9.3	235	Gray	White	Broad
Pakchong	102	45	13.0	1.6	14.5	256	Brown	Purple	Broad

Note: 1) Average of following four sites but the values for growing period, 100 grains weight and seed yield are averages of three excluding Exp. 2 which had serious damages by the soybean rust.

Exp. 1 Dry season of 1971 at Mae Jo Agr. Exp. Sta.

2 Rainy season of 1971 at Mae Jo Agr. Exp. Sta.

3 Late rainy season of 1971 at Mae Jo Agr. Exp. Sta.

4 Rainy season of 1971 at Srisamrong Agr. Exp. Sta.

2) Lodging score 0 : Erect 4 : Very serious

Table II-8. The daylengths and mean air temperatures in each month

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.
Daylength(hr:mi)	12:45	12:15	11:44	11:15	11:01	11:08	11:32	12:02	12:35	13:01	13:16	13:09
Mean air temperature (°C)	25.5	26.8	24.8	21.7	21.0	20.3	22.4	24.4	26.4	28.5	27.8	27.8

(f) Experiment results: Fig. II-4 shows changes in day from planting to flowering, days from flowering to maturity and the growing period, whreas changes in the plant height and in the number of nodes on the main stem are shown in Fig. II-5.

For Planting in August, the temperature is high and the day length is short during the growing period, so that the growing period is very short. As planting is delayed to September, October and November, the temperature gets lower though the day length gets shorter, so that the growing period gets rapidly long. In January and February which coincides with the planting time by farmers for cropping in the dry season, the soybeans are grown under short-day conditions and the temperature is low at the early stage and high at the late stage, so that the period from planting to flowering is long but the period from flowering to maturing is short.

In the case of planting in March and April, the day length is long though the temperature is high, so that the growing period is long. In the case of planting in May and June, which coincides with the time of planting by farmers for cropping in the rainy season, the day length is long at the early stage but gets gradually short at the late stage, so that the number of days from planting to flowering is relatively large, whereas the number of days from flowering to maturity is smaller than in the case of planting in March and April.

The plant height is short for planting in August and September but gets increasingly longer as the planting is delayed to October, November and December. It is short for planting in January, February and March. For planting in May and June, which coincides with the planting time for cropping in the rainy season, the plant height is longest and there are many nodes on the main stem. On the other hand for planting in December, the plant height is tall and the number of nodes on the main stem is not large. This is presumably caused by the different effects of the temperature and day length on the plant height and number of nodes on the main stem. (Fig. II-5).

In this experiment, soybeans were cultivated in pots and water was adequately

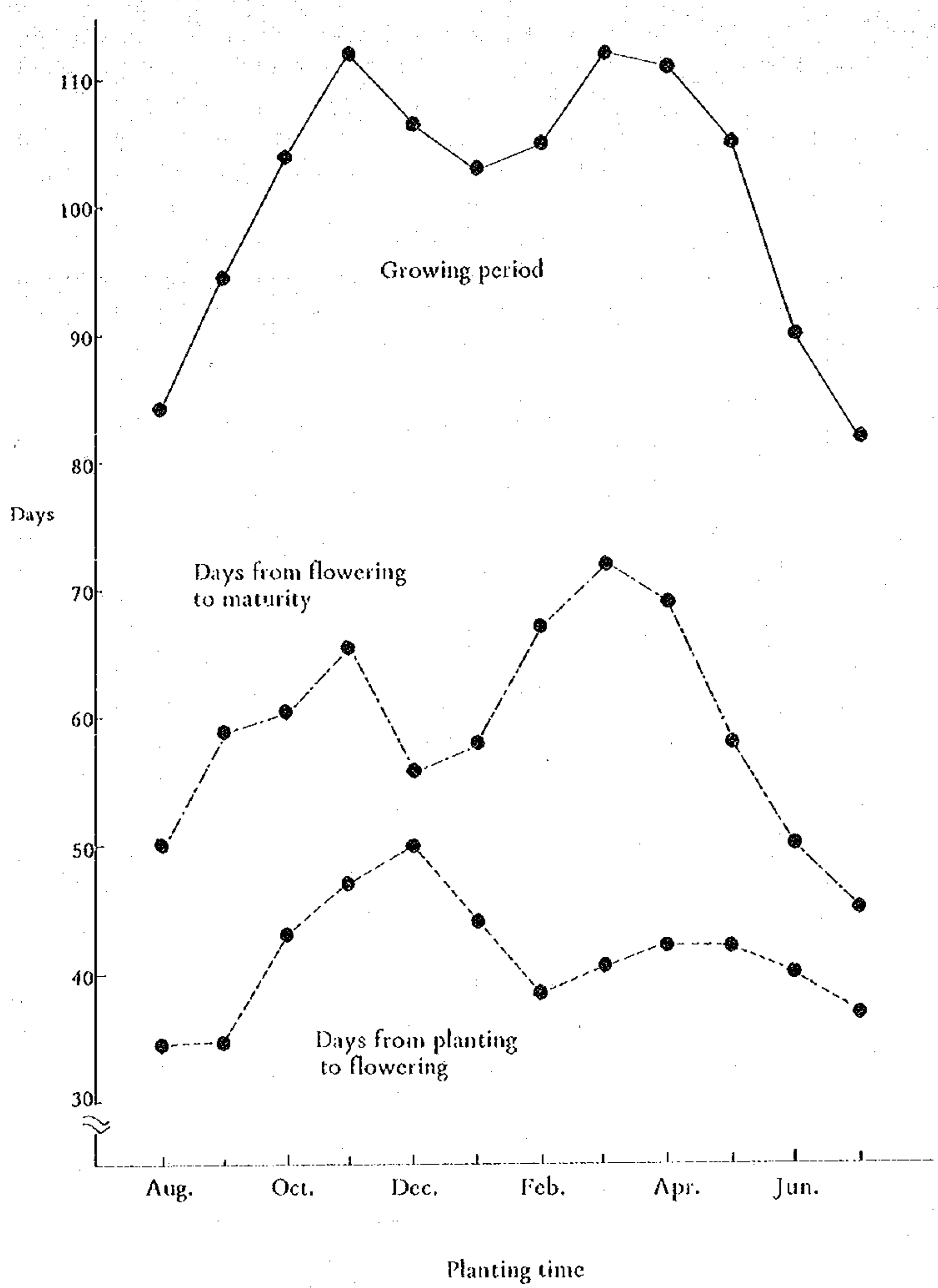
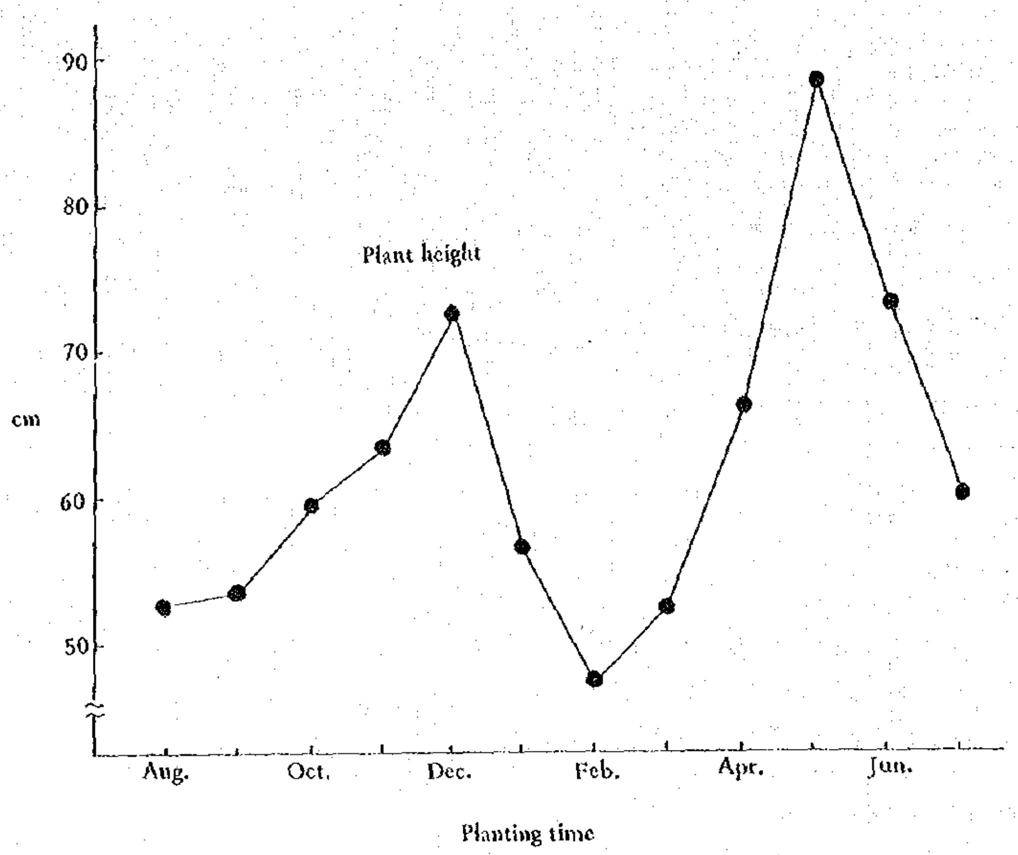


Fig. II-4. Fluctuations of number of days from planting to flowering, from flowering to maturity and growing period shown by the averages of eight varieties at different planting times through a year



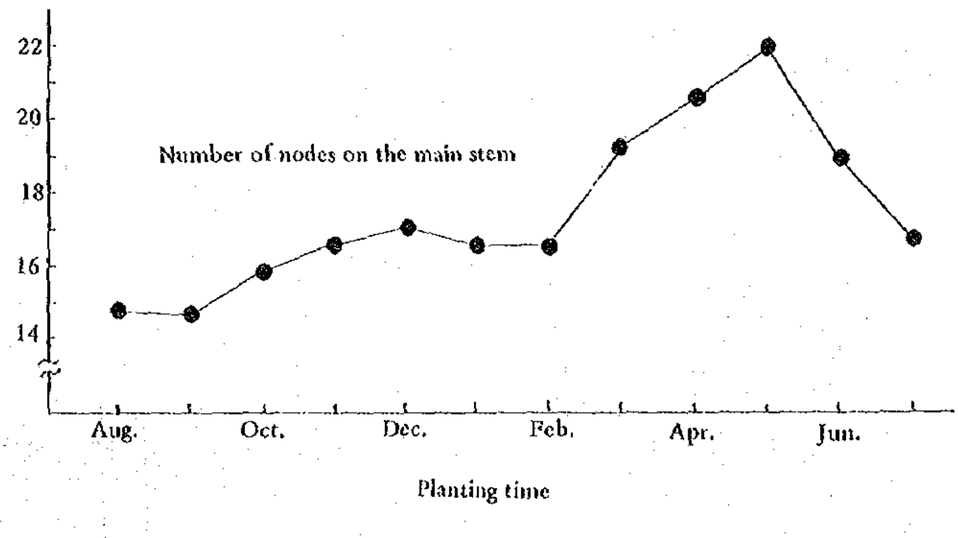


Fig. II-5. Fluctuations of plant height and number of nodes on the main stem shown by the averages of eight varieties at different planting times through a year supplied, so that the growth may be different in some aspects from actually cultivation. In the actual case of cropping in the dry season, soybeans are grown in paddy fields without plowing after harvesting of rice and there is a shortage of water in many cases, so that the plant height is usually very short. Soybeans grown by farmers in the rainy season frequently show much lodging caused by torrential rains.

Table II-9 shows increasing gradients in the growing period of each variety for plantings in August, September, October and November and decreasing gradients for plantings in April, May, June and July in terms of linear regression coefficients. In the same way, increasing gradients in the plant height of each variety for plantings in September, October, November and December and decreasing gradients for plantings in May, June and July are shown in Table II-10 in terms of linear regression coefficients.

As shown in Table II-9, the difference between varieties in b_1 is not large but the difference between varieties in b_2 is large. b_2 of the Japanese variety "Tousan No. 26" is the smallest, whereas b_2 is generally large for Thai varieties. No correlations were observed between b_1 and b_2.

As shown in Table II-10, b'_1 of "Tousan No. 26" is the smallest and that of the Thai variety 'SB 60' is the largest, b'_2 is large for the Thai varieties with the exception of 'Pakchong' and that of the American variety 'Acadian' is the largest. The correlations between $b('_1$ and b'_2 were insignificant.

It is conceivable that b_1 and b'_1 and influenced mainly by the temperature and b_2 and $b'2$ by the day length. b_2 and b'_2 of the Thai varieties are large presumably because of their high photosensitivity.

For any single variety, high yield and small fluctuations in the planting time are desirable. 'Tousan No. 26', which features small fluctuations in the planting time, is an early maturing variety, plant height is extremely short and its yield is small, so that it cannot be accepted in Thailand for practical cultivation.

It will be a major task in the future to incorporate photo-insensitive factors into tropical soybean varieties and equip them with a wide adaptability to the planting season and area.

Table II-9. The increasing gradients (b_1) shown by linear regression coefficients from August to November plantings and the decreasing gradients (b_2) from April to July plantings in the growing period of each variety

Variety	Growing period on the average days	Variance between planting times	b_1	b_2
SJ-1	99	138	12.2	-10.4
SJ-2	104	106	9.4	-9.6
Pakchong	99	153	8.0	-14.4
SB 60	109	179	9.4	-11.8
Tainung 3	92	105	8.2	-7.2
Chung Hsing (Unknown)	106	127	10.6	-9.2
Tousan No. 26	91	85	8.8	-2.2
Acadian	103	149	8.4	-13.8

Table II-10. The increasing gradients (b'_1) shown by linear regression coefficients from September to December plantings and the decreasing gradients (b'_2) from May to July plantings in the plant height of each variety

Variety	Plant height on the average cm	Variance between planting times	b'_1	b'_2
SJ-1	77	225	7.4	-21.0
SJ-2	65	331	5.0	-17.2
Pakchong	43	117	5.1	-10.9
SB 60	81	247	11.0	-17.0
Tainung 3	42	138	6.0	-7.4
Chung Hsing (Unknown)	85	205	9.9	-8.9
Tousan No. 26	30	31	0.5	-3.7
Acadian	77	317	3.4	-26.5

3) Oil and Protein Content of Thai Soybean Varieties

The four Thai varieties and 19 introduced varieties which were grown in the four yield tests conducted in 1971 were analyzed for the chemical components of seeds. Some of the data are shown in Tables II-11 and II-12.

As is discernible from Table II-11, Thailand's recommended varieties "SJ-1" and "SJ-2", which showed an oil content of 21-22%, might be described as belonging to a high oil content group as compared with those wheih are available on the world market for distribution. On the other hand, the oil content of the local Thai varieties "Packchong" and "SB 60" showed low oil contents. The introduced variety "K.S. 252" showed the highest oil content, and it was found in yield tests that this variety marked a high yield. It was used as the parents for crossing to breed the varieties which would feature a high oil content and high yield.

The materials used in the experiment excluding "64-104" showed a higher oil content in the dry season than that in the rainy season.

The protein content of "SJ-1" and "SJ-2" was not so high, whereas the local varieties "Packchong" and "SB 60" showed high protein contents. There were indications that the protein content was generally higher in the rainy season than in the dry season.

Table II-11. Oil contents(%)of Thai varieties and some introduced materials

Variety	A Dry season	B Dry season	C Rainy season	D Late rainy season	Average
SJ - 1	21.33	-	20.63	-	-
SJ - 2	22.65	22.79	21.43	21.62	22.12 ab
Pakchong	18.80	19.44	17.37	18.51	18.53 c
SB 60	19.55	19.02	15.04	18.29	17.98 c
K.S. 252	24.24	24.26	21.94	22.62	23.27 a
NTU K.S. No. 5	21.13	22.45	21.12	21.29	21.50 b
Tainung 3	21.54	21.14	19.92	21.07	20.92 b
64 - 104	16.60	18.63	19.80	19.26	18.57 c
Average	20.64 ab	21.10 a	19.52 c	20.38 b	

Note: 1) Exp. A: Dry season of 1971 at Mae Jo Agr. Exp. Sta.

Exp. B: Dry season of 1971 at Kalasin Agr. Exp. Sta.

Exp. C: Rainy season of 1971 at Srisamrong Agr. Exp. Sta.

Exp. D: Late rainy season of 1971 at Mae Jo Agr. Exp. Sta.

2) "SJ-1" is not included in the calculation of average.

3) Values of average oil contents followed by the same letter are not significantly different; those not followed by the same letter are significantly different at the 5% level.

Table II-12. Protein contents (%) of Thai varieties and some other introduced materials

Variety	A Dry season	B Dry season	C Rainy season	D Late rainy season	Average
SJ - 1	39.69	-	44.31	-	-
SJ - 2	41.81	42.94	44.00	42.06	42.70 bc
Pakchong	42.94	44.31	46.25	41.25	43.69 b
SB 60	40.25	42.81	48.13	43.38	43.64 b
K.S. 252	40.88	39.94	43.06	40.88	41.19 c
NTU K.S. No.5	41.25	41.25	44.00	42.06	42.14 bc
Tainung 3	42.56	44.00	43.50	42.25	43.08 bc
64 - 104	47.19	47.69	45.56	44.88	46.33 a
Average	42.41 b	43.28 b	44.93 a	42.39 b	

Note: 1) Protein contents (%) = Total nitrogen contents (%) x 6.25

2) 'SJ-1' is not included in the calculation of average.

3) Values of average protein contents followed by the same letter are not significantly different; those not followed by the same letter are significantly different at the 5% level.

The fluctuations caused by a cropping season in the chemical content of "64-104" was different from those of other varieties, but it was worthwhile to note that "64-104" showed the highest protein content.

Thailand hopes to breed soybean varieties with high oil contents as oil materials. But, when it is taken into consideration that undernourishment among the inhabitants of the northeast and north of Thailand --- particularly, the lack of protein sources --- is at issue, it is important to extend soybean-made protein foods among the Thai people and consider the breeding of soybean varieties with high protein contents in a longrange perspective.

4) Varietial Differences in Root Nodule Setting

The soil conditions of the northeast region of Thailand are extremely bad and the yield of crops is by far lower than in the central and north regions. The soil of the northeast region is generally sandy soil, gray or redish brown in color, or sandy loam with extremely little organic content, with the exception of some newly cultivated areas. The pH level is also low, standing at 5.0-5.5 in many places. From the rainy season of 1970, seed multiplication and variety comparison experiments including "SJ-1" and "SJ-2" were carried out at the Kalasin, Roi-Ed and Khonken Agricultural Experiment Stations, but the nodules of most of the varieties excluding some local Thai varieties rarely set or did not set at all on their roots. Particularly in the rainy season of 1971, the seed multiplication of "SJ-2" was carried out with the inoculation of root nodule bacteria, but the setting of nodules was observed only in some parts of the Mahasarakan seed multiplication field, which is a newly cultivated and fertile place.

Even in the northeast region, the following phenomena were observed. In regard to "SJ-2" planted with the inoculation of root nodule bacteria on the fertile paddy field of some farmers in Khonken in the dry season of 1971, 100% plants of nodule setting were observed, but the setting of nodules was not practically observed for "SJ-2" which was planted with the inoculation of nodule bacteria on the poor paddy field of the same farmer that was adjacent to the above field. In the seed multiplication of "SJ-2", some off-types, such as late maturing, very tall, white pubescent and white flower, were found and some of them showed good nodule setting in the fields regardless of whether the root nodules were inoculated or not. In the root nodule bacteria inoculation test conducted by the Chemical Division of the Department of Agriculture at the Roi-Ed Agricultural Experiment Station with a local variety (which seemed to be "Pakchong") brought from the province of Saraburi, the setting of root nodules was observed both in the inoculated and non-inoculated plots.

From the foregoing observation results, it may be concluded that the low fertility of soils is the main reason for the extremely bad setting of root nodules in this area. As it was surmised that there should be some varieties, depending on their inherited characteristics, the root nodules of which would be fully able to set even in this region, the following two experiments were carried out to clarify varietal defferences in nodule setting and look for materials for the breeding of varieties fitted to this region.

Experiment 1:

At the Roi-Ed Agricultural Experiment Station in the dry season of 1971, soil were collected from a field where soybeans had not been cultivated for more than five year and 11 varieties of soybeans were grown without the inoculation of root nodule bacteria in 1/2,000 a. Wagner pots to observe the setting of the nodules. The results of this experiment are given in Table II-13.

Table II-13. Index of nodule setting

Variety	Origin	Index of nodule setting	
		Non-fertilizing	Fertilizing*
SJ-1	Thailand	0	0
SJ-2	Thailand	0	0
SB 60	Thailand	3	2
Pakchong	Thailand	4	1
Taichung No. 12	Taiwan	0	0
E 27	Taiwan	1	0
Tokachi-nagaha	Japan	0	0
Bon-minori	Japan	0	0
Lincoln	U.S.A.	0	0
Ro-8-282	Offtype from SJ-2	3	2
Ro-15-289	Offtype from SJ-2	3	2

Note: 1) Four plants in a pot. Duplication

2) * N:3.8g, P_2O_5:15g and K_2O:15g were applied in each pot.

3) Index of nodule setting 5:very good -- 0: zero.

Experiment 2:

On a field of the Roi-Ed Agricultural Experiment Station where soybeans had not been cultivated for more than five years, the off-types selected from "SJ-2" as well as "SJ-2" and "SB 60" were grown without the inoculation of nodule bacteria in the rainy season of 1971 to check the nodule setting and yield. As for "SJ-2" and "SB 60", the mixed planting plot (B) where "SJ-2" and "SB 60" were grown on the same hill and single planting plot (A) were prepared.

The results of this experiment are shown in Table II-14.

Table II-14. Index of nodule setting and yield

Variety	Nodule setting	Total weight per hill g	Seed weight per hill g	100 grains weight g
SJ - 2A	0	7.0	2.5	8.5
SB 60A	5	25.9	12.8	9.6
SJ - 2B	0	-	-	-
SB 60B	5	-	-	-
Ka-6-258	5	17.6	7.7	8.2
Ro-6-280	5	22.7	11.2	9.9
Ro-7-281	5	23.1	10.6	8.5
Ro-8-282	4	24.6	12.1	6.9
Ro-9-283*	5	-	-	-
Ro-11-285	5	33.8	16.2	8.2
Ro-12-286	5	13.5	6.0	7.2
Ro-15-289	5	17.1	8.1	8.0

Note: 1) 50cm x 20cm, two plants per hill. The size of a plot = 6.0 m^2, no replication

2) * showed segregation in pubescence and hilum color

In Experiment 1, the nodules set for the local variety "SB 60" as well as the off-types from "SJ-2" both under fertilizing and non-fertilizing conditions,but the nodules did not set for "SJ-2" and most of the introduced varieties.

In Experiment 2, the nodules did not set for "SJ-2" either under single or mixed planting conditions, whereas the setting of nodules was excellent for "SB 60" and the off-types selected from "SJ-2". Their yield was by far better than that of "SJ-2".

From the foregoing results, it was clarified that the differences in nodule setting between "SB 60" and "SJ-2" were not only caused by the soil conditions but also by the inherited characteristics. The race of bacteria in the soil of this region is compatible with "SB 60" and some other local varieties, but it was surmised that it does not have a compatibility with "SJ-2".

From the results of the observations thus far carried out, it has been ascertained that an improvement of the soil may encourage the setting of the nodules of "SJ-1" and "SJ-2" and their growth. As it is considered that it would be exceedingly difficult for farmers to improve the soil at an early stage, however, there is a need to work immediately for the breeding of varieties which are fitted to this region and the nodules of which are easy to set.

5) Damage of Soybean Rust and its Varietal Differences

In Thailand, the damage caused by soybean rust (Phakopsora Pachyrhizi Sydow) is conspicuous for cropping in the north region during the rainy season, but there is little damage in the dry season. Even in the rainy season, the damage is very serious for planting in May and June, and the damage may be reduced with late planting after the middle of July.

At present, practically no damage is observed for the rainy season crops primarily in the province of Sukhothai situated at the center of Thailand. However, damage is sometimes observed for the dry season crops in the province of Chainat and in the northeast region.

The differences in the damage of soybean rust between cropping seasons and areas are considered to depend primarily on weather conditions. As there are indications that the damage of soybean rust would increase and expand from year to year, however, there is a need to grope for measures in all aspects to control soybean rust, which is one of the most serious disease damages to the cropping of soybeans in the future.

In the soybean breeding experiment conducted at the Mae Jo Agricultural Experiment Station in the rainy season of 1970 and 1971, the following matters were observed.

First, the symptom does not make their appearance until a certain growing stage (at about the time of flowering) for any variety. In other words, the earlier the maturity, the earlier the infection. Even if there exists in an adjacent area an early maturing variety which is showing clear symptoms of soybean rust, late maturing varieties will not show any lesions till the afore-mentioned stage.

The progress of the symptom is rapid for the varieties which grow excessively vigorous or the lodging of which is conspicuous.

Another thing to which attention ought to be paid is the fact that among the introduced varieties (which were kept at the Mae Jo Agricultural Experiment Station but believed to have been introduced from Taiwan), some were found to be resistant to soybean rust. The lesions were observed on the leaves of these varieties, but there was no progress in the symptom unlike other varieties. Even in an exceedingly high prevalence of soybean rust, it was found that there was practically no yield decrease in these varieties.

These varieties (or strains) include "64-4" (large seed), "64-62", "64-64", "64-104" and "0-38"(small seed). Presumably, the first four are originated from the same cross.

In the rainy season of 1971, the damage caused by soybean rust was conspicuous even at the Mae Jo Agricultural Experiment Station. The data on the yield and 100-grain weight of resistant varieties and Thai varieties used in the yield trial experiment carried out at that time and on those of the Srisamrong Agricultural Experiment Station in the same season where no rust damage was compared in Table II-15.

Table II-15. Seed yield and 100 grains weight of Thai varieties and the resistant strains under the occurrence of soybean rust

Variety	Rust occurred (Chiengmai)			No rust (Sukhothai)		
	Yield		100 grains weight	Yield		100 grains weight
	kg/rai	(%)	g	kg/rai	(%)	g
SJ-1	163	(100)	8.7	267	(100)	14.7
SJ-2	112	(69)	8.6	259	(97)	13.2
Pakchong	91	(56)	10.6	165	(62)	15.5
SB 60	34	(21)	6.4	138	(52)	10.7
64 - 104	309	(189)	19.3	203	(77)	17.4
64-4 (Large seed)	259	(159)	12.4	158	(59)	16.3

As indicated in Table II-15, there was a large decrease in 100-grain weight and in yield for the Thai varieties which suffered from serious damage of soybean rust. In respect of the resistant varieties, on the other hand, the yield was lower than that of "SJ-1" and "SJ-2" at Sukhothai where there was no incidence of soybean rust, whereas the yield was by far greater than that of "SJ-1" and "SJ-2" at Chiengmai where soybean rust broke out.

Of the resistant varieties, "64-104" and "0-38" (small seed) were used as parents for the breeding of varieties resistant to soybean rust.

CHAPTER 3. SOYBEAN BREEDING PROJECT IN THAILAND

In 1970, the first group of Japanese experts was sent for a long period. These experts surveyed the facilities, scale and composition of research workers at the agricultural experiment stations and seed multiplication stations throughout the nation which belong to the Thai Department of Agriculture and selected the Mae Jo Agricultural Experiment Station as the center for their field experiments. The Mae Jo Agricultural Experiment Station was selected mainly because it is situated in the province of Chinegmai, a dry season soybean producing center, because it is relatively close to the province of Sukhothai, a rainy season soybean producing center, because irrigation facilities are available and the cultivation of soybeans is feasible throughout the year, and because there are many promising research co-workers for soybean projects.

A breeding experiment was initiated in the rainy season of 1970. On the basis of the survey and research on breeding, to which reference was made in Chapter 2, the collection, introduction and selection of varieties, an experiment on the pure line selection as well as cross breeding were started.

The collection and introduction of varieties were aggressively stepped up for two years from 1970 to 1971, and it was possible to collect about 1,500 varieties in the two years. However, emphasis was put on the selection of promising parents for hybridization, because most of the introduced varieties were from areas at high latitudes and because their maturity was too early for practical cultivation in Thailand.

In the rainy season of 1971, the most advanced crossing materials reached F_3 and there was an increase in the number of F_1 and F_2 materials, so that emphasis was put on hybridization breeding in the breeding experiment from that time on.

The breeding objectives were made different, depending on the cropping seasons such as rainy season and dry season. The main breeding method was a pedigree method. With consideration given to the relationship of parents as well as the work load, a bulk method was concurrently used.

In order to breed varieties for the rainy season, some of the hybridization materials were also planted at the Srisamrong Agricultural Experiment Station in the province of Sukhothai in the rainy season and the selection was conducted.

Regional yield tests and preliminary yield tests on breeding lines were conducted at the Srisamrong and Kalasin Agricultural Experiment Stations in addition to the Mae Jo Agricultural Experiment Station, but there were many experiments which were not highly reliable as yield trials because of extraordinary weather conditions and bad field controls. For this reason, consideration was given, so that attention might be focused on highly reliable data in the evaluation of breeding lines.

Fig. III-1 shows the location of the Mae Jo Agricultural Experiment Station and

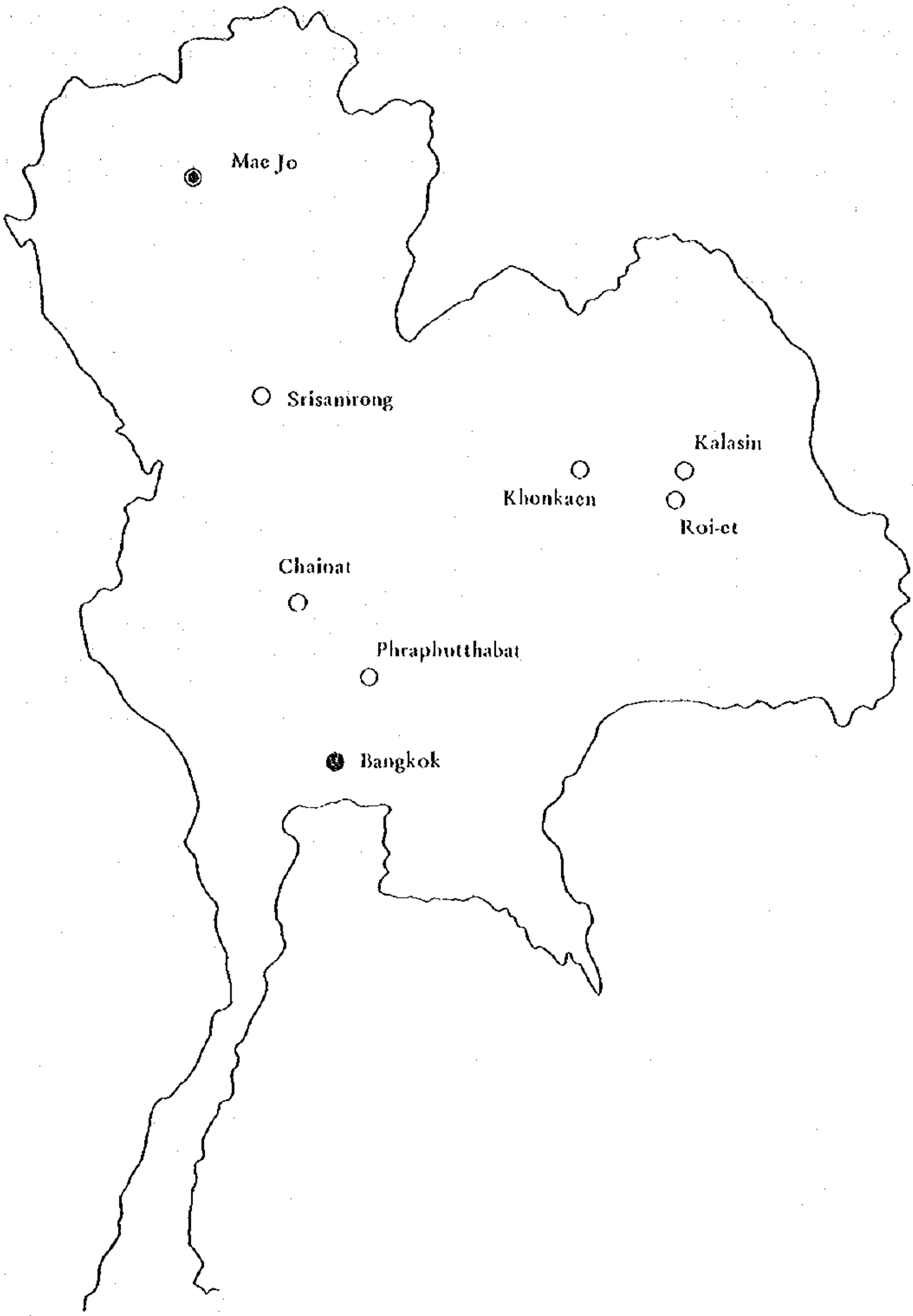


Fig. III-1. Locations where soybean breeding works were conducted other agricultural experiment stations which took charge of the soybean breeding tests.

1. Breeding Objectives

With the initiation of the breeding test, basic surveys and experiments were conducted. On the basis of their results, the following breeding objectives were set up:

1) High Yield

The average yield of soybeans in Thailand at present is about one ton per hectare. This yield must be described as a fairly low one, when consideration is given to the average yield of about 1.5 tons in Japan. The yield of Thailand's recommended varieties 'SJ-1' and 'SJ-2' is greater than that of the local varieties, but the results of the yield tests conducted in Thailand show that the average yield of these two varieties stands at about two tons per hectare.

It was made a objective, albeit ambiguous, to breed a variety which would yield upwards of 20% larger than these recommended varieties.

2) Adaptability to Each Cropping Season with Special Reference to Growing Period and Plant Type

As described earlier (3-2, Chapter 2), the soybean cropping season is generally divided into two --- that is, the rainy and dry seasons. The conditions of soybean cultivation and the weather conditions are different between the two seasons. For cropping in the rainy season primarily in the province of Sukhothai, the period in which soybeans are cultivatable extends for about 150 days from the middle of May to that of October. In this district, however, there are cases in which soybeans are cultivated as a single crop and there also are cases in which the intercropping of cotton is done during the growth of soybeans, so that the establishment of a desirable maturity stage is extremely complicated. Even in the single cropping of soybeans in the rainy season, it is presumable, when the growing period extends as long as 150 days, that the soybeans become particularly large, get conspicuously rampant and inferior in pod setting, and show lodging due to the torrential rains which are frequent in the rainy season, and tend to suffer from damage of insects and diseases.

For the time being, the selection objective was set at 100 - 105 days fo growing period for the rainy season in the same way as 'SJ-1' which is cultivated at present. Even for cropping in the rainy season, the day length during the growing of soybeans will become short when planting is done in July and August, so that a variety whose maturity is later than that of 'SJ-1' would be suitable in this case.

In the case of rainy-season cropping in the province of Sukhothai, the soybeans which become excessively rampant or elongate or which suffer from severe lodging due to torrential rains are often observed at present. 'SJ-1' is indeterminate and its stem long, so that it tends to lodge. For this reason, it was made an important breeding objective that the variety to be selected for this purpose would have to feature a short and strong stem and a strong resistance to lodging.

In the case of cropping in the dry season, the period in which soybeans are cultivatable is limited by the cultivation of paddy rice, because soybeans are planted after the harvesting of rainy-season paddy rice and field preparations are made for the subsequent planting of paddy rice after the harvesting of the soybeans. In the case of the province of Chiengmai situated in the north of Thailand, the period in which fields are usable for soybeans extends from the beginning of December to the end of April. In Chiengmai, however, the minimum temperature frequently dropped to 10 - 12°C from the end of December to the middle of January, so that when the floral differentiation and flowering stages fall in this period, the setting of pods is hampered, resulting in a drop in yield. For this reason, it is advisable to carry out planting in or after the end of December for precaution's sake. Consequently, the period in which soybeans are cultivatable is 120 days.

In the case of cropping in the dry season, the day length is short. Besides, there is no danger of excessive growth and lodging because there are no rains, so that it was considered desirable to set the growing period at 105 - 110 days, somewhat later than in the case of 'SJ-2'. In the event that one and the same variety is to be cultivated primarily in the province of Chainat situated in the middle of Thailand in the dry season, it must be taken into consideration that the growing period gets longer for reasons of the day length. Under short-day conditions, the stems of soybeans get short, so that it was considered desirable to select a variety with long stems for cropping in the dry season.

3) Good Quality and Big Grains

The grains of 'SJ-1' are elliptic in shape and the color of the hilum is black. The grains of 'SJ-2' are also elliptic, and the hilum is large and dark brown. The quality of the seeds are not good for both varieties. For an improvement of the quality, it was made a objective to breed a variety which would be almost globular in shape, the hilum of which would not be so big, and the color of which would be either yellow or dark brown.

Every variety available in Thailand is extremely small in seed size, and the 100-grain weight is 12 - 15 g both for 'SJ-1' and 'SJ-2'. At first, the idea was set forth of making the weight of the seed to 18 - 20 g as in the case of the soybeans distributed to the world markets. Once materials with big grains had been introduced and grown in Thailand, however, these materials remarkablly reduced in grain size. It was considered that the temperature was extremely high during the ripening period — particularly at night and it was feared soybean varieties of big seed size should not be adaptable to the tropical zone. At present, Thailand strongly hopes to develop soybeans as an oil resource and it was considered preferable not to set forth severe conditions for the selection of varieties in big seed size. It was because there was apprehension that if the selection of those in big seed size was made severe, the selection of highly yielding materials, a more important objective, would not be realized.

4) Resistance to Soybean Rust

The damage caused by soybean rust in Thailand is particularly serious for the rainy-season crops in the north region, and the damage is small for the crops in the dry season. The damage caused to the rainy-season crops in central Thailand is small, but the tendency is that the damage caused by soybean rust is increasing from year to year in terms of area.

'SJ-1' and 'SJ-2', the varieties recommended at present, are not resistant to soybean rust. Due to the occurrence of soybean rust, they suffer from severe damage with the yield dropped by more than 50%.

Of the introduced varieties, several varieties were fortunately found to be resistant to soybean rust. With these varieties used as parents for hybridization, the breeding of a resistant variety was started.

Soybean rust is considered to continue as one of the most serious diseases in the future, so that resistance to soybean rust was made one of the most important objectives for the breeding of varieties in the rainy season.

5) Resistance to Shattering

The maturity and harvesting stages of soybeans for cropping in the dry season normally fall in the period between the middle and end of April, which features an extremely high temperature and low humidity. For this reason, the shattering varieties suffer from a great loss due to a marked shattering during the harvesting stage in the cropping of the dry season. 'SJ-2' and 'SB-60' are less shattering and the loss is extremely small. Being resistant to shattering is one of th conditions that should be furnished to the soybean varieties to be cropped in the dry season.

6) High Oil Contents

As described earlier, Thailand hopes to produce soybeans with high oil contents. As the result of an analysis of the oil content of the materials used in the yeild tests, it was found that 'SJ-1' and 'SJ-2' are high in oil content, and several varieties with high oil contents were also found among the introduced varieties. With these varieties used as parents for hybridization, several combinations were prepared. Due to a lack of manpower, the oil content of the materials in the early and middle generations of hybridization could not be analyzed. In respect of the promising later generation, however, their seed components could be analyzed to assess their oil content.

7) Nodule Setting Ability in Northeast Region

As described in 3-4), Chapter 2, the soil conditions in the northeast region are generally unfavorable, and the setting of root nodules is exceedingly poor for 'SJ-1' and 'SJ-2'. Even under such unfavorable soil conditions, it was recognized that the setting of root nodules is good for local varieties, such as 'SB-60' and 'Pakchong', and off-types selected from 'SJ-2'. With these varieties used as parents for crossing, several combinations were prepared to set up one objective for the breeding of a variety fitted to the northeast region.

8) Germination Capacity

In Thailand, there are not a few cases in which a long spell of dry weather leads to a lack of water in the soil and the soil gets compact after a torrential rain, thus bringing about a serious decrease in soybean germination. A good germinating ability is one of the important characters.

To sum up the foregoing, the important breeding objectives for soybean varieties for cropping in the rainy season are:

* High yield and good quality;
* Growing period of 100 - 105 days like as in the case of 'SJ-1';
* Somewhat short but strong stems, being resistant to lodging; and
* Resistant to soybean rust.

The important breeding objectives for soybean varieties for cropping in the dry season are:

* High yield and good quality;
* A somewhat longer growing period than in the case of 'SJ-2' --- that is, 105 - 110 days;
* Somewhat long stems and large plant type;
* Resistance to shattering.

In addition, a high oil content and a high germination capacity may be cited as objectives common to both seasons.

What extent of adaptability may be anticipated for a variety under various environmental conditions in Thailand is a major question. If a single variety could cover every cropping season and area, it would be most desirable, but is practically impossible to breed such a variety within a short period of time. Particularly, as the climate and cultivation conditions between the dry and rainy seasons are extremely different, the breeding objectives were divided for the two different cropping seasons to step up a breeding experiment.

2. Introduction and Selection of Varieties

The introduction and selection of varieties were conducted mainly in the period of two years from 1970 to 1971. In this period, a total of about 1,500 varieties came in our hands, including Thai varieties and the foreign varieties which had earlier and newly been introduced. For the storing of these materials and other breeding materials, one of the research rooms of the

Mae Jo Agricultural Experiment Station was used as a temporary storing room and air-conditioner was used to regulate the temperature and humidity. In February 1972, a 95-square-meter seed storehouse was completed with a Thai Government budget. From then on, breeding materials were stored in this house.

Table III-1 is a list of varieties introduced and collected in the aforementioned two-year period.

The selection tests of introduced varieties were carried out in the following three phases, in principle:

1) Selection on Introduced Varieties

Upon introduction, the seeds were kept for the variety preservation, and their planting was done at the Mae Jo Agricultural Experiment Station in each cropping season at a rate of one variety per row and 2.0 m^2 per plot.

2) Preliminary Yield Trials on Introduced Varieties

The varieties selected from those which were in the variety preservation were used for preliminary yield trials on introduced varieties, and the trials were carried out at the Mae Jo Agricultural Experiment Station and two or three other agricultural experiment stations. 1 plot = 6.0 m^2 with two replications.

3) Yield Trials on Introduced Varieties

The varieties which were considered promising as a result of the preliminary yield trials were offered for yield trials on introduced varieties. The trials were conducted at the Mae Jo Agricultural Experiment Station and four or five other agricultural experiment stations. 1 plot = 6.0 m^2 with four replications.

Table III-2 indicates the methods used in the preliminary yield trials and yield trials of introduced varieties conducted during the period from 1971 to 1976.

Most of the introduced varieties were too early in maturity and their stems were too short to be put to use as practical varieties in Thailand. Of the varieties introduced from areas in the same latitude as Thailand, however, some grew well and promising. In general, the varieties which matured early in the rainy season and the stems of which were short were not suitable in the dry season because their stems became extremely short. The varieties which matured late and became rampant in the dry season were not suitable in the rainy season, because their maturity and rampancy became excessive. Even among the varieties which became extremely rampant in the rainy season, some took on a desirable plant type in the dry season when the day length was short. Even among the varieties which featured early maturity and short stems in the dry season, some grew exceedingly well in the rainy season when the day length was long.

Table III-1. A list of collected and introduced varieties during 1970 to 1971

Time	Source	Number of varieties
May, 1970	National Institute of Agricultural Sciences, Japan	216
	Tohoku National Agr. Exp. Sta., Japan	7
	Kyuushuu National Agr. Exp. Sta., Japan	7
	Nagano Prefectural Agr. Exp. Sta., Japan	7
	Hokkaido Tokachi Agr. Exp. Sta., Japan	15
June	Mae Jo Agr. Exp. Sta. and Kalasin Agr. Exp. Sta., Thailand	116
September	Kathmandu, Nepal	8
October	Para, Brasil	3
	San Juan Agr. Exp. Sta., Bolivia	3
	Comilla, E. Pakistan	2
	Taiwan Chung Hsing University, Taiwan	3
November	Peru	1
	Paro, Bhutan	2
	Instituto Agronomics, San Paulo	19
	National Agr. Exp. Sta., Mexico	8
December	Louisiana State University, U.S.A.	6
	National Institute of Agricultural Sciences, Japan	866
	Hokkaido Tokachi Agr. Exp. Sta. and Hokkaido Central Agr. Exp. Sta., Japan	93
	Tohoku National Agr. Exp. Sta.	58
	Mae Jo Agr. Exp. Sta. and Kalasin Agr. Exp. Sta., Thailand	23
	Indonesia	10
	Philippines	4
January, 1971	Indonesia	2
	Department of Primary Industries, Brisbane, Australia	1
March	Nagano Prefectural Agr. Exp. Sta., Japan	24
	The source is not authenticated	3
	Chanderer Seed Farm, Maharashtra State, India	3
June	The N.I. Vavilov all-union Institute of Plant Industry, U.S.S.R.	10
	University of Hawaii, U.S.A.	1
November	Ryuukyuu University, Japan	52

Table III-2. The Methods of Preliminary Yield Tests and Yield Tests of Introduced Varieties Conducted during 1971 to 1976

Year	Season	Names of experiments	Location	Number of varieties	A plot size (m^2)	Replication
1971	Dry	Preliminary yield test	Mae Jo	50	6.0	2
			Kalasin	50	6.0	2
	Rainy	Preliminary yield test	Mae Jo	45	6.0	2
		Yield test	Mae Jo	32	12.0	4
			Srisamrong	32	12.0	4
			Phraphutthabat	28	12.0	3
1972	Dry	Preliminary yield test	Mae Jo	20	6.0	2
			Kalasin	20	6.0	2
		Yield test	Mae Jo	20	12.0	4
			Kalasin	20	12.0	4
			Chainat	20	12.0	4
	Rainy	Preliminary yield test	Srisamrong	18	6.6	2
		Yield test	Mae Jo	18	8.8	4
			Srisamrong	18	8.8	4
			Kalasin	18	8.8	4
			Phraphutthabat	18	8.8	4
1973	Dry	Preliminary yield test	Mae Jo	25	8.8	3
		Yield test	Mae Jo	16	8.8	4
			Kalasin	16	8.8	4
			Chainat	16	8.8	4
	Rainy	Yield test	Srisamrong	16	8.8	4
1974	Dry	Preliminary yield test	Mae Jo	33	6.0	2
		Yield test	Mae Jo	16	8.0	4
			Chainat	16	8.0	4
			Kalasin	16	8.0	4
	Rainy	Preliminary yield test	Srisamrong	26	6.0	2
			Phraphutthabat	26	6.0	2
		Yield test	Srisamrong	16	8.0	4
			Phraphutthabat	16	8.0	4
1975	Dry	Preliminary yeild test	Mae Jo	30	6.6	2
			Chinat	30	6.6	2
		Regional yield trial	Mae Jo	13	8.8	4
			Kalasin	13	8.8	4
			Chinat	13	8.8	4
	Rainy	Regional yield trial	Mae Jo	15	8.8	4
			Srisamrong	15	8.8	4
			Kalasin	15	8.8	4
			Phraphutthabat	15	8.8	4
1976	Dry	Regional yield trial	Mae Jo	13	8.8	4
			Kalasin	10	8.8	4
			Chinat	13	9.0	4

Notes: 1) * Includes the number of standard varieties.
2) Planting density was 50 cm x 20 cm, 2 plants on a hill in all cases.

In some parts of the aforementioned experiments, reliable data could not be secured due to the damage caused by torrential rains or droughts and to the inconsistent control of the fields.

Over a period of six years, two or three promising varieties had been developed to a point where they could be set aside as propagation seeds. In the long run, however, we could not select from the introduced varieties the promising ones which could be used as recommended varieties. Among the introduced varieties, however, those which featured high yields, strong stems, good quality, large seed size, resistance to soybean rust and high oil content were discovered, and they were used as parents for hybridization.

The major characteristics of introduced varieties by country of origin and the typical varieties used for hybridization are shown below:

Japanese varieties:

Big in seed size and good in quality, they grew with vigor in the early stage. One defect is that their maturity in Thailand is extremely early and their yield is low because their stems are short. Their pods are extremely easy to shatter and their germination is not good.

The varieties 'Bon-minori', 'Shin No. 4', 'Tousan No. 26', 'Jukoku-mame', 'Nema-shirazu' and 'Karikachi' were put to use, because they were large in size and good in quality, grew with vigor and had a potentially high yield judging from the data available in Japan.

'Ooura' and 'Kyushu 47', which were introduced later, were resistant to soybean rust.

Taiwanese varieties:

They grow well and their yields are generally high. Their growing period is similar to that of Thai varieties. Varieties resistant to soybean rust and those of high oil content were discovered. Of all the introduced varieties, the Taiwanese varieties contained many promising ones, and their usefulness as crossing parents was high. One defect is that the quality was generally poor and their pods are easy to shatter.

'K.S. 252' featured a high yield and a high oil content but its seed coat was green. '64 - 104', 'PI 200492' and 'Kaoshung 32' were resistant to soybean rust.

American varieties:

Particularly, 'Acadian' and 'Jupiter' from the south were high in yield and highly rated. In addition, 'Lincoln' and 'Wayne' were put to use as they were regarded as having high-yielding factors.

Table III-3. Remarkable characteristics of promising introduced varieties selected as a parent for hybridization breeding

Variety	Origin	Remarkable characteristics
Bon-minori	Japan	Fine quality of seed with big size
Shin No.4	Japan	High yield
Karikachi	Japan	Vigorous growth and big seed size
Tousan No.26	Japan	Fine quality of seed with big size
Acadian	U.S.A.	High yield
K.S. 252	Taiwan	High yield and high content of oil
64--104	Taiwan	Resistant to the soybean rust and high protein
0--38 (Small seed)	Taiwan	Resistant to the soybean rust
Jupiter	U.S.A.	High yield and vigorous growth
Jukkoku-mame	Japan	High yield and vigorous gorwth
Kinoshita-mame	Japan	High yield and vigorous gorwth
Tainung 3	Taiwan	High yield
Sanjuan	Bolivia	High yield
PI 200492	Taiwan	Resistant to the soybean rust
Kyuushuu 47	Japan	Resistant to the soybean rust
Ooura	Japan	Resistant to the soybean rust
Kaohsiung E32	Taiwan	Resistant to the soybean rust
Wayne	U.S.A.	High yield
Williams	U.S.A.	High yield
CES 16--103	Philippines	High yield

3. Pure Line Selection

1) 'SJ-2'

(a) Purpose

'SJ-2' is a variety recommendable for the dry season; its yield is higher than the local varieties. It is hard to shatter and the loss at the harvesting time is extremely small. But the seeds are by far smaller than those distributed in the world, as their 100-grain weight stands at 12.0 - 15.0 g. In 1970 when the Department of Agriculture started the propagation of 'SJ-2' seeds, the mixture of many off-types featuring long stems, late maturity, white pubescence and white flowers -- those which are much different from 'SJ-2' in plant type, maturity time and other visible characteristics -- was found.

This experiment was designed to study whether it would be possible to select the original 'SJ-2' types whose 100-grain weight was about 18.0 g, investigate the causes to the incidence of off-types and select promising plants from them.

(b) Place and Cropping Season

Mae Jo Agriculture Experiment Station in the dry season of 1973.

(c) Materials

Lines of the original 'SJ-2':	352
Lines of off-types:	38
Standards:	10

(d) Results

The differences among lines of the original 'SJ-2' were extremely small, and we could not select from them any lines having large grains.

In respect of the causes to the incidence of off-types, it was hypothesized in the phase prior to the execution of this experiment (i) that the segregation took place because of inadequate fixing at the time when 'SJ-2' became a variety, (ii) that different varieties were mechanically mixed, and (iii) that natural crossing took place between different varieties. However, because the differences among lines of the original 'SJ-2' were extremely small and because the difference among off-types was great but segregation was observed in three lines of off-types in terms of color of pubescence, flower and hilum, it was surmised that the possibility of the causes to the incidence of off-types being associated with natural crossing was greatest.

With the growth, maturity time, resistance to lodging, seed quality and degrees of virus damage taken into cnsideration, 18 lines of off-types were selected. As mentioned in Chapter 3, some of these off-type lines, like the local variety 'SB-60', featured the good setting of root nodules even on the infertile soil of the northeast region and a higher yield than 'SJ-2'. Of them, the two most promising lines were used as crossing parents for the breeding of varieties in the northeast region.

1) '64 - 62', '64 - 64' and '64 - 104'

(a) Purpose

From the results of experiments conducted at the Mae Jo Agricultural Experiment Station in the rainy seasons of 1970 and 1971, it was recognized that '64 - 62', '64 - 64' and '64 - 100' were resistant to soybean rust. For these three strains, however, the seed coats were cracked in many places and their quality was poor. Differences were also found between '64 - 62' and '64 - 64' in maturity time and stem length.

This experiment was designed to select lines whose seed quality was good and which were hard to crack, ascertain whether there would be differences in the degree of resistance to rust and select those whose resistance was high. In conducting the selection, attention was also focused on the maturity time, plant type and resistance to lodging.

(b) Place and Cropping Season of Experiment

Mae Jo Agricultural Experiment Station in the dry and rainy seasons of 1972.

(c) Results

The numbers of lines planted and selected as classified by cropping season are shown in Table III-4.

Table III-4 Number of lines planted and selected

Materials	Dry season		Rainy season	
	Planted	Selected	Planted	Selected
64 – 62	162	47	47	11
64 – 64	162	39	39	4
64 – 104	217	101	101	20

In the dry season of 1972, planting was conducted on January 15. Because of the short-day conditions, each material became short in stem height and the differences between lines in maturity time and plant type were insignificant, so that stress was put on the selection of lines good in seed quality. In the rainy season of 1972, it was hoped that clear differences between lines in resistance against soybean rust could be observed. In that year, however, the incidence of soybean rust was insignificant and the planting was done belatedly on July 17, so that the incidence of soybean rust among the materials was very small, making it impossible to clarify differences in the degree of resistance to soybean rust. It was observed, however, that the occurrence of soybean rust among these materials was clearly less than that of the standard varieties "SJ-1" and "SJ-2" which were planted for comparison's sake.

Differences were also observed between lines in the degree of lodging. A selection was done in respect of resistance to lodging in fields. After their harvesting, another selection was done in respect of the seed quality.

In the long run, lines highly resistant to soybean rust could not be selected, but those resistant to lodging and good in seed quality were selected. And they were used as crossing parents for hybridization.

4. Breeding by Hybridization

Only with the selection of introduced varieties and the selection of pure lines, there would be a limit to the materials which could be bred, so that simultaneously with the start of a breeding in the rainy season of 1970, Thai varieties and the introduced varieties which had once been successfully used as crossing parents in foreign countries were grown as crossing plants for artificial crossing. As no data were available to indicate that the artificial crossing of soybeans had ever been conducted in Thailand, it was feared at first lest the crossing rate should be low, but it was known after the start of crossing that there would be no major problems.

Full irrigation makes it possible to grow soybeans in any season of the year in Thailand. As a result of the acceleration of generations, the growing of crossing parents, F_1 and F_2 was carried out in some crosses within the first year. As there was a rise in the number of materials in the third and subsequent years, there was a need for the availability of greater manpower, so that it was decided to grow each material once each in the rainy and dry seasons.

The main selection method was the pedigree method in the F_3 and subsequent generations. Depending on the combination, however, the bulk method was used till the F_3 or F_4 selection.

The lines which were found to be promising in the pedigree selection of the F_3 and subsequent generations were tested in preliminary yield tests to check the productivity. The lines which were found to be promising in these tests were tested in the regional yield trials. The lines tested in these trials were also grown at agricultural experiment stations other than the Mae Jo Agricultural Experiment Station to study the productivity and regional adaptability.

1) Crossing

From 1970 through 1976, a total of 96 crossing combinations were prepared, and these crossings may be roughly divided into three periods.

The first period extended from 1970 to 1971 with 33 combinations. As this period fell immediately after the start of a breeding trial, full information could not be secured on the prospect of the crossing parents, but either a Thai or Taiwanese variety was used as one parent of each combination with the hope that the ecological characteristics would prove compatible with the environmental conditions of Thailand and a Japanese variety was used as the other parent in order to prepare many combiantions with due attention focused on the good quality, large size and strong stems of Japanese varieties. Using some introduced varieties --- '64 - 104' and '0 - 38' (small seed) --- resistant to soybean rust, several combinations were prepared to breed the resistant varieties, and introduced varieties high in oil content 'K.S. 252' and high in yield ' Acadian' and 'L-356' were also used as parents.

The second period extended from 1972 to 1973 with 41 combinations. In this period, a greater number of combinations to breed resistant varieties to soybean rust were prepared. To breed varieties adaptable to the infertile soil of the northeast region, the local variety 'SB-60' whose root nodules are particularly easy to set in this region and off-types from 'SJ-2' ('R_0-11' and 'R_0-15') were used as parents to prepare several combinations. In addition, introduced varieties high in yield ('Jupiter' and 'Sanjuan') and promising breeding lines were also put to use as crossing parents.

The third period was 1975 with 22 combinations. In this period, many combiantions were prepared with newly introduced varieties resistant to soybean rust ('PI 200472', 'Kaohsiung E32', 'Kyushu 47' and 'Ooura'). Many combinations were also prepared with highly yielding lines in the late generations.

2) Selection

As we came across the hybridization breeding of soybeans in Thailand for the first time, our knowledge and information about the selection of crossing parents were extremely limited in the early phase. Among the 33 combinations prepared from 1970 to 1971, there were many combinations which proved less promising and were discarded in F_2 and F_3. With the progress of the trial, pieces of new information were piled up and the materials became rich, facilitating the selection of promising crossing parents.

Even among the aforementioned 33 combinations, there were combinations whose prospects were ascertained as high in an early generation, such as '7001' ('Bon-minori' x 'SJ-2'), '7005' ('Shin No. 4' x 'SJ-2'), '7012' ('Karikachi' x 'SJ-2'), '7019' ('Acadian' x '64 - 104'), '7020' ('SJ-2' x 'K.S. 252'), '7021' ('K.S. 252' x 'SJ-2') and '7024' ('64 - 104' x 'SJ-2'). It might be said, therefore, that breeding work has thus far been stepped up primarily with these combinations of materials advanced in generation.

To increase the seed yield in F_1 as much as possible, planting was done in pots or cultivated on fields for full control.

Because the soil of the Mae Jo Agricultural Experiment Station's fields was sandy and less organic, the surface soil gets exceedingly hard after irrigation in the dry season and after

Table.III-5. The combinations and results of crossings

Crossing number	Crossing parents	Number of flowers crossed	Number of pods harvested	Number of seeds harvested	Percentage of succesful crossing
7001	Bon-minori x SJ-2	89	31	48	34.8
7002	SJ-2 x Tokachi-nagaha	114	21	35	18.4
7003	SJ-2 x Nema-shirazu	103	13	20	12.6
7004	Hougyoku x K.S. 167 (Tall type)	73	12	20	16.4
7005	Shin no. 4 x SJ-2	63	10	17	15.9
7006	SJ-2 x Kogane-jiro	131	6	10	4.6
7007	SJ-1 x Nema-shirazu	43	5	7	11.6
7008	Taichung no. 12 x Nema-shirazu	171	8	14	4.7
7009	SJ-2 x Hougyoku	51	10	22	19.6
7010	SJ-2 x Shin no. 4	25	5	11	20.0
7011	Shirodaibachirin x Nema-shirazu	43	6	12	14.0
7012	Karikachi x SJ-2	71	7	10	9.9
7013	Tousan no. 26 x SJ-2	116	16	23	13.8
7014	Aki-yoshi x Taichung no. 12	53	8	11	15.1
7015	Lincoln x SJ-2	10	1	2	10.0
7016	E-27 x 7001 (F_1)	56	6	12	10.7
7017	7001 (F_1) x E-27	42	11	22	26.2
7018	E-27 x 7002 (F_1)	53	17	34	32.1
7019	Acadian x 64-104	21	4	7	19.0
7020	SJ-2 x K.S.252	80	22	43	27.5
7021	K.S. 252 x SJ-2	30	9	13	30.0
7022	L-356 x Acadian	59	19	37	32.2
7023	L-356 x SJ-2	30	7	7	23.3
7024	64-104 x SJ-2	49	8	12	16.3
7025	SJ-2 x 64-104	91	13	21	14.3
7026	SJ-2 x Acadian	86	24	41	27.9
7027	K.S.252 x E-27	97	20	19	20.6
7028	0-38 (Large seed) x E-27	31	10	12	32.3
7029	Fusanari x SJ-2	45	5	6	11.1
7030	0-38 (Small seed) x SJ-2	17	4	5	23.5
	30 comb.	1943	338	553	17.4
7101	Ouhouju x SJ-2	8	0	0	0
7102	SJ-2 x Taichung no. 12	24	5	8	20.8
7103	SB60 x SJ-2	-	0	0	0
	3 comb.	-	5	8	-
7201	SB60 x SJ-2	114	64	107	56.1
7202	Ro-15 x SJ-2	94	25	44	26.6
7203	SJ-1 x 64-104	152	88	170	57.9
7204	64-104 x SJ-1	128	33	52	25.8
7205	SB60 x SJ-1	160	52	80	32.5
7206	K.S. 252 x 64-104	149	89	134	59.7
7207	K.S. 252 x 7024 (F_4)	175	15	25	8.6
	7 comb.	972	366	612	37.7
7301	SJ-2 x Jupiter	103	7	11	6.8
7302	SJ-2 x Lincoln	119	23	33	19.3
7303	SJ-2 x Tainung 3	155	41	64	26.5
7304	SJ-2 x Jukkoku-mame	126	12	20	9.5
7305	SJ-2 x Raiden	104	5	8	4.8
7306	IAC-2 x SJ-2	76	14	25	18.4
7307	SJ-1 x Jupiter	167	49	87	29.3
7308	SJ-1 x Jukkoku-mame	106	45	83	42.5
7309	64-104 x 7024 (F_6)	34	1	3	2.9
7310	64-104 x 7013 (F_6)	56	16	33	28.6

Crossing number	Crossing parents	Number of flowers crossed	Number of pods harvested	Number of seeds harvested	Percentage of succesful crossing
7311	64-104 x Jupiter	53	11	16	20.8
7312	64-104 x Lincoln	78	17	24	21.8
7313	Raiden x 64-104	104	47	104	45.2
7314	Tainung 3 x 64-104	81	15	24	18.5
7315	Tousan no. 26 x 64-104	232	50	81	21.6
7316	Kinoshita-mame x 64-104	84	31	54	36.9
7317	K.S. 252 x Jupiter	127	44	76	34.7
7318	7001 (F_7) x 7013 (F_6)	44	13	26	29.6
7319	7001 (F_7) x 7024 (F_6)	26	11	24	42.3
7320	7001 (F_7) x Nema-shirazu	19	7	14	36.8
7321	7013 (F_6) x 7024 (F_6)	64	14	21	21.9
7322	7013 (F_6) x Jupiter	23	9	14	39.1
7323	7013 (F_6) x Sanjuan	56	22	44	39.3
7324	7013 (F_6) x Yuuzuru	13	7	10	53.9
7325	7024 (F_6) x Nema-shirazu	27	9	15	33.3
7326	Raiden x Jupiter	112	28	61	25.0
7327	Tainung 3 x Raiden	52	8	14	15.4
7328	Tainung 3 x Nema-shirazu	23	3	7	13.0
7329	Yuuzuru x Jupiter	55	4	6	7.3
7330	Ro-15 x 64-104	71	15	27	21.1
7331	K.S. 252 x Ro-15	90	25	44	27.8
7332	Raiden x Ro-15	187	33	68	17.7
7333	K.S. 252 x Ro-11	127	33	64	26.0
7334	Jukkoku-mame x Ro-11	70	35	64	50.0
	34 comb.	2864	704	1263	24.6
7501	SJ-2 x PI200492	115	3	4	2.6
7502	Kyushu 47 x SJ-2	113	16	24	14.2
7503	SJ-2 x Wayne	125	2	3	1.6
7504	SJ-2 x Shiryuou	105	13	19	12.4
7505	Shin no. 4 x SJ-2	102	39	83	38.2
7506	CES 16-103 x SJ-2	114	22	35	19.3
7507	Sanjuan x 7019.P_2.49.P_4.3.P_6.1.FP_8.P_9.P_{10}	106	6	7	5.7
7508	Williams x 7019.P_2.49.P_4.3.P_6.1.FP_8.P_9.P_{10}	91	18	37	19.8
7509	Wayne x 7024.P_2.286.P_4.2(s).P_6.P_7.P_8.P_9.P_{10}	132	13	15	9.9
7510	7021.P_3.FP_5.3.P_7.P_8 x Kyushu 47	108	17	24	15.7
7511	7024.P_2.286.P_4.2(s).P_6.P_7.P_8.P_9.P_{10} x Clark 63	132	6	5	4.6
7512	SJ-2 x Kaohsiung E32	133	5	8	3.8
7513	7019.P_2.49.P_4.3.P_6.1.FP_8.P_9.P_{10} x 7020.P_3.65.1.5.P_7.P_8.P_9	121	1	1	0.8
7514	7019.P_2.49.P_4.3.P_6.1.FP_8.P_9.P_{10} x 7021.P_3.33.FP_5.1.5.P_8.P_9	134	5	9	3.7
7515	7012.P_3.200.50.3.6(S).P_7.P_8.P_9.P_{10} x Kyushu 47	-	3	4	-
7516	7020.P_3.65.1.5.P_7.P_8 x Kaohsiung E32	137	16	24	11.7
7517	7020.P_3.49.2.3.P_7.P_8.P_9 x Ooura	121	16	20	13.2
7518	7021.P_3.33.FP_5.1.5.P_8.P_9 x Ooura	150	9	13	6.0
7519	7012.P_3.200.50.3.6(S).P_7.P_8.P_9.P_{10} x Ooura	122	26	44	21.3
7520	7021.P_3.33.FP_5.3.P_7.P_8.P_9 x Kaohsiung E32	112	7	9	6.3
7521	7019.P_2.49.P_4.3.P_6.1.FP_8.P_9.P_{10} x Kaohsiung B32	124	2	4	1.6
7522	7012.P_2.200.50.3.6(S).P_7.P_8.P_9 x Kaohsiung B32	137	16	24	11.7
	22 comb.	2504	263	422	10.5

torrential rains in the rainy season, and the germination was frequently hampered. To prevent this germination hazard, three or four mung bean seeds were planted on the same hill and pulled off immediately after the germination in cases where there was a shortage of seeds for bulks and lines and only one or two soybean seeds could be planted on one hill. The germinating capacity of mung beans was by far stronger than that of soybeans, so that this method was very effective in maintaining the stand of breeding materials.

In F_2, it was made a standard to cultivate 1,500 - 2,000 plants per combination. As the seed yield for F_1 was small, however, some combinations had about 1,000 plants each. The combinations in which desirable types did not take place or plants infested by virus diseases were highly observed were cast aside.

The observation of the growth, maturity and plant type in F_2 made it possible to roughly classify the combinations into three types adaptable for the rainy season, for the dry season and for both seasons. When materials of the rainy season type are planted in the dry season, their stems become short owing to the short day length. In this case, therefore, strong selections were not conducted for the maturity time and plant type. When materials of the dry season are planted in the rainy season, their stems get long and they become rampant due to the long day length. For this reason, the same procedure was followed. To save labor, there were many combinations which were planted in bulks in F_3. For promising combinations, individual selections were normally done in F_2. In the combination of a white pubescence variety and a brown pubescence variety, and also in that of a green seed coat variety and a yellow seed coat variety, the selection of individuals was not conducted in F_2 but was done in F_3.

In respect of resistance to soybean rust, one of the important breeding objectives for varieties in the rainy season, the segregation of resistant and susceptible plants was clearly shown in F_2 and it was recognized that the resistance is controlled by a few number of genes. In the combinations designed for resistance to soybean rust, only resistant plants or lines were selected under conditions where the disease occurred in the rainy season.

As regards the selection of F_3 and subsequent generations, pedigree and individual selections were carried out in the dry season for the materials which were adaptable for the dry season, and the lines which were considered adaptable to the rainy season were made mass for seed production without doing strong selections. In the rainy season, on the other hand, pedigree and individual selections were done for the lines fitted to the rainy season, and lines of the dry season type were made mass. This method was not necessarily used by every experts, and the selection was stepped up with due consideration given at all times to the adaptability of each material to the cropping season.

7019 - P_2 - 49 - P_4 - 3 - P_6 - 1 - P_8 - P_9 - P_{10} - P_{11} is a strain bred as the rainy season type. Each generation of this strain and its cropping season and selection procedure are shown below:

Table III-6. Number of combinations, lines and bulks tested from the dry season of 1971 to the rainy season of 1976

Year	1971		1972		1973		1974		1975		1976
Season	D	R	D	R	D	R	D	R	D	R	D
Combination*	F_1:26	F_1:1	F_2:6	F_3:6	F_1:7	F_2:4	F_1:34	F_2:34	F_3:29	F_4:11	F_1:22
	F_2:6	F_2:10	F_3:7	F_4:7	F_4:6	F_2:3(K)	F_3:4	F_4:4	F_3:5(K)	F_4:14(S)	F_5:14
		F_3:3	F_4:3	F_5:3	F_5:6	F_5:6	F_6:6	F_4:2(K)	F_5:4	F_4:5(K)	F_5:5(K)
		F_3:1(S)			F_6:1	F_6:6	F_7:6	F_7:6	F_5:2(K)	F_6:4	F_7:4
						F_7:1	F_8:1	F_8:6	F_6:5	F_6:4(S)	F_7:3(K)
									F_9:6	F_9:5	F_{10}:3
										F_{10}:3	F_{11}:3
Line	26	498	1,271	469	1,140	965	552	286	529	1,534	1,508
Bulk	6	10	10	9	-	7	-	34	19	-	-

Note : * Number of combinations with the letters S and K are those of combinations which were grown at Srisamrong Agr. Exp. Sta. and Kalasin Agr. Exp. Sta. respectively.
All of the others were grown at Mae Jo Agr. Exp. Sta.

Table III-7. The methods of preliminary yield tests and regional yield trials conducted from 1973 to 1976

Year	Season	Names of experiments	Location	Number of strains *	A plot size m2	Replication	Planting date
1973	Dry	Preliminary yield test	Mae Jo	19 (2)	6.0	3	Jan. 16
	Rainy	Preliminary yield test	Srisamrong				
			Phraphutthabat				
1974	Dry	Preliminary yield test	Mae Jo	37 (2)	6.0	2	Jan. 5
			Chainat	37 (2)	6.0	2	Jan. 5
	Rainy	Preliminary yield test	Srisamrong	45 (2)	6.0	2	May 5
			Phraphutthabat	45 (2)	6.0	2	July 15
		Regional yield trial	Srisamrong	12 (4)	6.0	4	
			Phraphutthabat	12 (4)	6.0	4	July 16
1975	Dry	Preliminary yield test	Mae Jo	40 (2)	4.4	3	Dec. 11
			Chainat	40 (2)	4.4	3	
		Regional yield trial	Mae Jo	28 (2)	8.8	4	Dec. 23
			Chainat	28 (2)	8.8	4	
			Kalasin	24 (2)	8.8	4	Jan. 17
	Rainy	Preliminary yield test	Srisamrong	33 (2)	4.4	3	May 7
			Phraphutthabat	33 (2)	4.4	3	July 9
		Regional yield trial	Srisamrong	13 (2)	8.8	4	May 8
			Phraphutthabat	13 (2)	8.8	4	July 9
			Mae Jo	13 (2)	8.8	4	
			Kalasin	13 (2)	8.8	4	June 17
1976	Dry	Preliminary yield test	Mae Jo	30 (2)	4.4	3	Dec. 11
			Chainat	30 (2)	4.5	4	Dec. 20
		Regional yield trial	Mae Jo	14 (2)	8.8	4	Dec. 11
			Chainat	14 (2)	9.0	4	Dec. 20
			Kalasin	15 (2)	8.8	4	Dec. 25

Notes: 1) * Number in the parentheses are those of standard varieties.

2) Planting density is 50 cm x 20 cm, 2 plants on a hill in all cases.

7019 —	P_2 - 49 -	P_4 - 3 -	P_6 - 1 -	P_8 -	P_9 -	P_{10} -	P_{11}			
	F_2	F_3	F_4	F_5	F_6	F_7	F_8	F_9	F_{10}	F_{11}
	S	NS	S	NS	S	NS	NS	NS	NS	NS
	R	D	R	D	R	D	R	D	R	D

S — Selection
NS — Non-Selection
R — Rainy season
D — Dry season

The F_8 and later generations were made derivatives from F_6 without selection. This method was of effect in saving labor but some showed segregation in subsequent generations.

Table III-6 indicates the numbers of combinations, lines and bulks tested from the dry season of 1971 till the rainy season of 1976 by cropping season.

Preliminary yield tests were started in the dry season of 1973 and regional yield trials in the rainy season of 1974. These yield tests were carried out at the Srisamrong and Phraphuttabat Agricultural Experiment Stations, situated in rainy season soybean cultivation areas, in the rainy season at the Mae Jo, Chainat and Kalasin Agricultural Experiment Stations, situated in dry season soybean cultivation areas, in the dry season. The places where these tests and trials were conducted and the number of strains are shown in Table III-7 as classified by cropping season.

3) Selection of the "7019" and "7024", and the Promising Lines Bred Out from These Crossings

(a) Pedigree Selection of the Progeny from 7019 and that from 7024

As '64 - 104' was used as one of the crossing parents resistant to soybean rust in these combinations, it was considered that the material would be suitable for the cropping in the rainy season when the heavy occurrence of soybean rust is observed. For this reason, emphasis has been put on the experiments in the rainy season, and a strict selection has been carried out on the progeny from these crossings in respect to resistancy to soybean rust. In their subsequent generations, they were used in regional yield trials but the pedigree selection of the lines was temporarily called off in the F_8 and subsequent generations and mass seeds were used in these trials. In the rainy season of 1975, a leaf curling symptom happened to be observed in the progeny of these combinations and differences among the lines in the severity of this symptom were noted. For this reason, the pedigree selection was resumed, as the plants in which the leaf curling symptom was not observed or the symptom was light were selected in the population from mass seeds.

The crossing parents which were used in the combination of 7019 "Acadian" x "64 - 104") were the medium maturing 'Acadian' of indeterminate growth which was introduced from the United States and the stems of which were long, and the medium maturing "64 - 104" which was introduced from Taiwan and resistant to soybean rust and the stems of which were medium in length. The progeny from this combination is traced back to the seven seeds harvested from the 21 flowers artificially crossed at the Mae Jo Agricultural Experiments Station on November 27, 1970. The subsequent selections were shown in Table III-8 but an attempt will be made here to give a further explanation. At the Mae Jo Agricultural Experiment Station in the dry season of 1971, F_1 was grown and 1,098 seeds were obtained from six plants. In the rainy season of the same year, 1,000 plants in a population were cultivated at the Mae Jo Agricultural Experiment Station, and 208 plants out of the population highly resistant to soybean rust were selected as the heavy occurrence of soybean rust observed in the latter half of the growth. The seeds from these selected plants were planted in row (line) respectively at the Mae Jo Agricultural Experiment Station in the dry season of 1972. As it had been considered from the beginning that this progeny was suitable for cropping in the rainy season, a light selection was made, 110 lines were selected and harvested in mass by row (line). In the rainy season of the same year, the 110 F_4 lines derived from F_2 were planted at the Mae Jo Agricultural Experiment Station, and a strict selection was made in respect of the general characteristics and resistance to soybean rust, and 135 plants in 27 lines were selected. At the Mae Jo Agricultural Experiment Station in the dry season of 1973, 135 F_5 lines in 27 families, each family consisting of five lines, were grown, and 36 lines were selected from 17 families. About 10 plants were harvested from each line and threshed separately. In the rainy season of the same year, the pedigree selection of F_6 lines was conducted at the Mae Jo and Srisamrong Agricultural Experiment Stations. In the former, the seeds of the three best yielding plants out of about 10 plants harvested from each line and threshed, were mixed to prepare the seeds of 36 lines by three replicated trials. In the latter, two plants were selected out of the aforementioned plants, and 72 lines in 36 families, each family consisting of two lines, were grown. In this generation, the selection was separately done on the materials available at both agricultural experiment stations. In the experiment at the Mae Jo Agricultural Experiment Station, 23 plants in five lines were harvested, whereas 10 lines in 10 families were harvested at the Srisamrong Agricultural Experiment Station but the selection of individual plants was not conducted due to the failure of showing uniform growth. In F_7 generation, these materials were planted at the Mae Jo Agricultural Experiment Stationin the dry season of 1974 and 60 plants in six lines were selected. In the F_8 generation, the 60 plants in six lines selected in the former generation were halved and a group of 30 lines in six families was planted at each of the Mae Jo and Sriamrong Agricultural Experiment Stations in the rainy season of the same year and harvested in mass by family. Among the materials used in the Regional yield trials conducted in the

Table III-8. Pedigree selection conducted on the combinations of "7019" and "7024"

A. Crossing No. 7019 Parents: 'Acadian' x '64-104'

Year A.D.	Year B.E	Generation	Season	Location	Date of planting	Planted Fam.	Planted Lines	Planted Plts/line	Selected Fam.	Selected Lines	Selected Plts.	Note
1970	2513	Crossing	Dry	Mae Jo	(Nov. 27)			21 flws.		4 pods	7 seeds	( ) : Date of crossing
1971	2514	F_1	Dry	Mae Jo	Jan. 28			7 seeds		6 plts.	1,908 seeds	Plant type
		F_2	Rainy	Mae Jo	June 18			1000			208	
1972	2515	F_3	Dry	Mae Jo	Jan. 31		208	40		110	mass	
		F_4	Rainy	Mae Jo	July 14		110	40		27	135	Planted F_2 derived lines
1973	2516	F_5	Dry	Mae Jo	Jan. 20	27	135	40	17	36	Best 3 plts mixed	
											72	
		F_6	Rainy	Mae Jo			36			5	23	Planted F_4 derived lines with 3 rep.
				Srisamrong	June 12	36	72	40	10	10	mass	
1974	2517	F_7	Dry	Mae Jo	Dec. 4	5	23	40	5	5	50	
					Dec. 6		10	40		1	10	Planted F_5 derived lines
		F_8	Rainy	Mae Jo	June 25	6	30	40	6	mass	mass	
				Srisamrong	May 17	6	30	40	6	mass	mass	
1975	2518	F_9	Dry	Mae Jo	Dec. 12		6	250		6	95	
		F_{10}	Rainy	Mae Jo	July 4	6	95	40	3	11	55	

B. Crossing No. 7024 Parents: '64-104' x 'SJ-2'

Year A.D	Year B.E	Generation	Season	Location	Date of planting	Planted Fam.	Planted Lines	Planted Plts/line	Selected Fam.	Selected Lines	Selected Plts.	Note
1970	2513	Crossing	Dry	Mae Jo	(Nov. 25 & 1971 Jan. 2)			49 flws.		8 pods	12 seeds	( ) : Date of crossing
1971	2514	F_1	Dry	Mae Jo	Feb. 25			12		10 plts	3,416 seeds	Plant type
		F_2	Rainy	Mae Jo	June 18			1,700			314	
1972	2515	F_3	Dry	Mae Jo	Feb. 2		314	40		82	mass	
		F_4	Rainy	Mae Jo	July 14		82	40		20	78	Planted F_2 derived lines
1973	2516	F_5	Dry	Mae Jo	Jan. 20	20	78	40	11	23	Best 3 plts mixed	
											46	
		F_6	Rainy	Mae Jo	July 7		23			7	35	Planted F_4 derived lines with 3 rep.
				Srisamrong	June 12	23	46	40	2	2	mass	
1974	2517	F_7	Dry	Mae Jo	Dec. 4	7	35	40	7	7	70	
					Dec. 6		2	40		1	10	Planted F_5 derived lines
							(1)			(1)		( ) : Included in yield trial
		F_8	Rainy	Mae Jo	June 25	8	40	40	8	mass	mass	
							(1)			(1)		( ) : Included in yield trial
				Srisamrong	May 17	8	40	40	8	mass	mass	
1975	2518	F_9	Dry	Mae Jo	Dec. 12		9	250		9	135	
		F_{10}	Rainy	Mae Jo	July 4	9	135	40	6	23	115	

dry season of 1975, some failed to show uniform growth, so it was decided to resume the selection of lines using a large area of field for each line. As the leaf curling symptom was observed in the lines derived from this combination, attention was focused on it in conducting the individual plant selection. Summing up the 15 plants selected from each line, 95 F_{10} lines in six families were planted at the Mae Jo Agricultural Experiment Station in the subsequent rainy season, and 17 lines were selected in three families.

From the combination of '7024' ('64 - 104' x 'SJ-2'), the introduced variety '64 - 104' resistant to soybean rust and 'SJ-2' which was considered to be a standard Thai variety for cropping in the dry season were used as parents. This progeny was introduced from the eight seeds which were collected from the 49 flowers artificially crossed at the Mae Jo Agricultural Experiment Station on November 25, 1970, and January 2, 1971, and the subsequent selections were shownin Table III-8. An explanation on this combination is omitted here, as the process of the selection in this progeny was practically the same as the aforementioned '7019'.

(b) Selection of the Lines from '7019' and '7024' in Yield Trials

The breeding lines from these crossings had been incorporated in preliminary yield tests to test their yielding ability and other agronomic characteristics since the rainy season of 1973, as they had been considered resistant to soybean rust and suitable to the rainy season cropping. The number of lines selected from these combinations for testing in the yield trials are shown in Table III-9. In the first step of the yield trials, the control of the test fields could not be described as adequate, and the researchers in charge of the trials were not so experienced. So much so that fully reliable data could not be obtained. For this reason, the materials offered for testing in the yield trials since the rainy season of 1973 remained without any major selection until the dry season of 1975. As a result, the lines offered for testing in the yield trials conducted in the dry season of 1975 were six for the preliminary yield tests and six for the regional yield trials from '7019', but these six lines were the same. From '7024', nine lines were offered for testing in the preliminary yield tests and seven lines in the regional yield trials, but these seven lines were made the same in both trials. Upon completion of the trials in the dry season of 1975, it was decided to sort out these lines for various yield trials, depending on the degree to which they were promising.

A leaf curling symptom was observed on the lines derived from these crossings in the dry season of 1975. In conducting a selection, therefore, it was decided to focus attention on the lines in which the occurrence of the symptom was not high and which could assure high yield. As a result, it was decided to leave two lines from '7019' in the regional yield trials and put three lines back to the preliminary yield tests, and it was also decided to test their yielding ability on the former two lines at the farmer's fields. From '7024', three lines were offered to the regional yield trials but not tested in the farmer's field tests because problems were posed on their leaf curling symptom. It was decided to draw a conclusion after checking the prevalence of this symptom in the rainy season. In addition, four lines were used in the preliminary yield tests.

Table III-9. Number of breeding lines from '7019' and '7024' which were tested in yield trials

Year	Season	Generation	7019 (Acadian x 64–104)				7034 (64–104 x SJ–2)			
			P.Y.T*	R.Y.T**	F.F.T***	Total	P.Y.T*	R.Y.T**	F.F.T***	Total
1973	Dry	F_5								
	Rainy	F_6	9			9	4			4
1974	Dry	F_7	4			4	8			8
	Rainy	F_8	5	1		6	7	1		8
1975	Dry	F_9	6	6		6	9	7		9
	Rainy	F_{10}	3	2	2	5	4	3		7
1976	Dry	F_{11}		3	2	3	1	3		4
	Rainy									

Note: *P.Y.T = Preliminary yield test, **R.Y.T = Regional yield trial, ***F.F.T = Farmers field test

(c) Selection Conducted Thereafter

After the results of the trials conducted in the rainy season of 1975 were compiled, the reselection of the breeding lines which were to be used in yield trials was conducted. At that time, the results of the yield trials, results of the analysis of the components of the seeds produced in yield trials in the previous dry season, results of the tests on resistance to soybean rust, observations on the growth of the lines in the pedigree field and prevalences of the leaf curling symptom were used for reference purposes. An outcome is given in Table III-10. All these grew with vigor, their seeds were biger than those of the standard variety "SJ-1" and their resistance to soybean rust was just as the same degree as that of "64 - 104", so that they were considered suitable for the rainy season cropping.

Of them, two lines from '7019' were considered most promising and used in the farmer's field tests as the same as in the previous season. The results of yield trials performed on these lines until the rainy season of 1975 were summerized in Table III-11. It was difficult to select from "7024" the lines in the farmer's field tests.

4) Selection of "7020" and '7021' and the Promising Lines bred out from those Crossings

Table III-10. Allocation of breeding lines from the crossing of '7019' and '7024' to yield trials in the dry season of 1976

Experiments		Breeding lines
1.	Farmer's field test	7019 -- P_2. 49. P_4. 3. P_6. 1. FP_8. P_9. 4. P_{11} 7019 -- P_2. 49. P_4. 5. P_6. 5. FP_8. P_9. 12. P_{11}
2.	Regional yield trial	7019 -- P_2. 49. P_4. 2. P_6. 3. FP_8. P_9. 7. P_{11} 7019 -- P_2. 49. P_4. 3. P_6. 1. FP_8. P_9. 4. P_{11} 7019 -- P_2. 49. P_4. 5. P_6. 5. FP_8. P_9. 12. P_{11} 7024 -- P_2. 86. P_4. 3. P_6. 5. FP_8. P_9. 2. P_{11} 7024 -- P_2. 286. P_4. 6. P_6. 2. FP_8. P_9. 9. P_{11} 7024 -- P_2. 286. P_4. 2(S). P_6. P_7. P_8. P_9. 14. P_{11}
3.	Preliminary yield trial	7024 -- P_2. 310. P_4. 4. P_5. 3. FP_8. P_9. 14. P_{11}

(a) Pedigree Selection of the Progeny from "7020' and '7021'

'7020' ('SJ-2' x 'K.S. 252') and '7021" ('K.S. 252' x 'SJ-2') have the same parents and are noted to be at the reciprocal relation. Of the crossing parents, 'K.S. 252' was the one which had already been introduced from Taiwan and was preserved at the Mae Jo and Kalasin Agricultural Experiment Stations. Its vigorous growth was highly evaluated but its seed coat was green. Both parents were susceptive to soybean rust, and the selection of progeny from these combinations was targeted to bred soybean varieties for the dry season. With special stress put on the observations at the experiment conducted in the dry season, the selection was promoted with due consideration paid to the vigorousness of the growth, degree of resistance to shattering, and resistance to downy mildew.

The lines from '7020' were the off-spring from the 43 hybrid seeds that had been collected from the 80 flowers artificially crossed at the Mae Jo Agricultural Experiment Station on December 4 - 5 and December 16, 1970. In the dry season of 1971, 5,661 seeds were collected from the 17 F_1 plants which were grown at the Mae Jo Agricultural Experiment Staton. From the beginning, this combination had been designed to breed soybeans for cropping in the dry season. F_2 was planted at the Mae Jo Agricultural Experiment Station in the dry season of 1972 and mass selection was conducted. Pedigree selection was started from the plants which had been selected in the F_3 population planted at the Mae Jo Agricultural Experiment Station in the rainy season of the same year. The subsequent selecton conducted was indicated in Table III-12. According to that table, pedigree selections were made at the Mae Jo and Srisamrong Agricultural Experiment Stations in the rainy season, but in so far as the soybeans

Table III-11. The results of yield trials on selected lines (till the rainy season, 1975)

A. $7019.P_2.49.P_4.3.P_6.1.FP_8.P_9.P_{10}$

Name of lines	Year, Season	Experiment*	Location	Plant height	Number of pods	Growing period	Seed yield	Yielding ratio to SJ-2	100 grains weight	Lodging score	Shattering score	Seed quality
				cm		day	kg/rai	%	g			
$7019.P_2.49.P_4.3.P_6.1.FP_8.P_9.P_{10}$	1974, Dry	PYT	Mae Jo	87.1	34.3	119	387	117	13.8	1.5	1	4
	1974, Rainy	RYT	Phraphutthabat	61.0	41.1	98	179	118	9.8	1	1.3	3.4
	1975, Dry	PYT	Mae Jo	55.6	42.7	98	271	113	13.9	2	1.3	4
	1975, Dry	RYT	Kalasin	36.4	41.0	92	345	104	15.4			
	1975, Rainy	RYT	Mae Jo	63.9	60.2	99	241	213	12.6	3	1	3.5
	1975, Rainy	RYT	Srisamrong	95.3	75.3	105	419	114	16.9	4	1	3
	1975, Rainy	RYT	Phraphutthabat	57.4	50.5	100	368	100	13.4	1	1	3
	1975, Rainy	RYT	Kalasin	35.7	34	105	149	122	12.5	1	1	4.7
		Average		61.6	47.4	102	295	(117)	13.5	1.9	1.1	3.7
SJ - 1	1974, Dry	PYT	Mae Jo	71.3	47.4	109	303	92	11.9	1.5	2	3
	1974, Rainy	RYT	Phraphutthabat	75.9	54.7	98	151	100	6.4	1	1	3
	1975, Dry	PYT	Mae Jo	52.4	47.0	91	197	82	10.3	1.7	4	3
	1975, Dry	RYT	Kalasin	53.8	40.1	96	333	101	13.5			
	1975, Rainy	RYT	Mae Jo	81.1	41.7	91	123	108	7.8	2.5	1.5	3
	1975, Rainy	RYT	Srisamrong	151.2	79.6	104	359	98	14.3	5	1.5	3.5
	1975, Rainy	RYT	Phraphutthabat	110.2	57.2	98	381	104	12.0	3.5	1	3
	1975, Rainy	RYT	Kalasin	42.1	31	105	79	65	11.7	1	1	3.7
		Average		79.8	49.8	99	241	(95)	11.0	2.3	1.7	3.2
SJ - 2	1974, Dry	PYT	Mae Jo	83.7	34.9	119	330	100	11.8	2.5	1	3
	1974, Rainy	RYT	Phraphutthabat	75.9	54.7	98	151	100	6.4	1	1	3
	1975, Dry	PYT	Mae Jo	43.1	43.3	92	239	100	12.7	2	1.7	3
	1975, Dry	RYT	Kalasin	29.8	43.2	95	331	100	12.7			
	1975, Rainy	RYT	Mae Jo	67.4	59.6	95	113	100	7.6	3.5	1	3
	1975, Rainy	RYT	Srisamrong	102.2	104.6	110	367	100	13.2	5	1	3
	1975, Rainy	RYT	Phraphutthabat	78.3	64.8	110	368	100	11.4	2.5	1	3
	1975, Rainy	RYT	Kalasin	31.9	32	105	122	100	10.3	1	1	3.7
		Average		64.0	54.6	103	253	(100)	10.8	2.5	1.1	3.1

B. $7019.P_2.49.P_4.5.P_6.5.FP_8.P_9.P_{10}$

Name of lines	Year, Season	Experiment*	Location	Plant height	Number of pods	Growing period	Seed yield	Yielding ratio to SJ-2	100 grains weight	Lodging score	Shattering score	Seed quality
				cm		day	kg/rai	%	g			
$7019.P_2.49.P_4.5.P_6.5.FP_8.P_9.P_{10}$	1974, Dry	PYT	Mae Jo	90.9	61.9	109	366	111	13.5	3	1	4
	1974, Rainy	PYT	Phraphutthabat	72.4	51.3	91	329	133	12.3	1.5	1	3.5
	1975, Dry	PYT	Mae Jo	43.9	38.8	97	245	90	13.8	2	1.7	3
	1975, Dry	RYT	Kalasin	32.2	38.7	90	352	106	15.5			
	1975, Rainy	RYT	Mae Jo	68.2	53.9	96	277	245	12.8	2.5	1	3.5
	1975, Rainy	RYT	Srisamrong	75.7	70.1	102	331	90	16.8	5	1	3
	1975, Rainy	RYT	Phraphutthabat	60.1	47.3	94	352	96	13.3	2	1	3
	1975, Rainy	RYT	Kalasin	31.6	26	102	68	56	11.7	1	1	3.7
		Average		59.4	48.5	98	286	(108)	13.7	2.4	1.1	3.4
SJ - 1	1974, Dry	PYT	Mae Jo	71.3	47.4	109	303	92	11.9	1.5	2	3
	1974, Rainy	RYT	Phraphutthabat	90.9	44.1	83	198	80	10.2	1.5	5	3
	1975, Dry	PYT	Mae Jo	52.4	47.0	91	197	82	10.3	1.7	4	3
	1975, Dry	RYT	Kalasin	53.8	40.1	96	333	101	13.5			
	1975, Rainy	RYT	Mae Jo	81.1	41.7	91	123	108	7.8	2.5	1.5	3
	1975, Rainy	RYT	Srisamrong	151.2	79.6	104	359	98	14.3	5	1.5	3.5
	1975, Rainy	RYT	Phraphutthabat	110.2	57.2	98	381	104	12.0	3.5	1	3
	1975, Rainy	RYT	Kalasin	42.1	31	105	79	65	11.7	1	1	3.7
		Average		81.6	48.5	97	247	(93)	11.5	2.4	2.3	3.2
SJ - 2	1974, Dry	PYT	Mae Jo	83.7	34.9	119	330	100	11.8	2.5	1	3
	1974, Rainy	PYT	Phraphutthabat	67.8	58.7	94	248	100	10.1	1	1	3
	1975, Dry	PYT	Mae Jo	43.1	43.3	92	239	100	12.7	2	1.7	3
	1975, Dry	RYT	Kalasin	29.8	43.2	95	331	100	12.7			
	1975, Rainy	RYT	Mae Jo	67.4	59.6	95	113	100	7.6	3.5	1	3
	1975, Rainy	RYT	Srisamrong	102.2	104.6	110	367	100	13.2	5	1	3
	1975, Rainy	RYT	Phraphutthabat	78.3	64.8	100	368	100	11.4	2.5	1	3
	1975, Rainy	RYT	Kalasin	31.9	32	105	122	100	10.3	1	1	3.7
		Average		63.0	55.1	101	265	(100)	11.2	2.5	1.1	3.1

Note : * ; PYT = Preliminary yield test, RYT = Regional yield trial planted in the rainy season at the Mae Jo Agricultural Experiment Station were concerned, the damage caused by soybean rust was very severe, and there were many cases in which sufficient seeds could not be harvested.

The progeny from '7021' were the off-spring from the 13 seeds in nine pods obtained from the 30 flowers artificially crossed at the Mae Jo Agricultural Experiment Station on November 27, 1970. The subsequent process of selections was shown in Table III-12. The lines from this combination were considered more promising than those from '7020' to which reference has been made earlier, and many breeding lines have been incorporated in yield trials.

(b) Selection of the Lines from '7020' and '7021' in Yield Trials

The breeding lines from these combinations were tested in the preliminary yield tests since the rainy season of 1973. As is discernible from the number of breeding lines shown in Table III-13, the growth of the lines from '7021' was more vigorous, so that the breeding lines from '7021' was considered to be the mainstay of those for cropping in the dry season. In 1974, the breeding lines from '7021' began to be tested in regional yield trials but no major selection was conducted. In the dry season of 1975, six out of seven breeding lines were duplicatedly tested both in preliminary yield tests and regional yield trials. At the time when the yield trials in the drys cason of the same year had been compiled, the real location to yield trials of the breeding lines from these combinations was conducted. At that time, the severe selection on breeding lines primarily from '7021' was performed.

After the termination of the experiments in the rainy season of the same year, the allocation of breeding lines was reviewed. As a result, it was decided to use one line from '7020' in preliminary yield tests and two lines in regional yield trials. Of the two lines, which were to be tested in regional yield trials, it was also decided to use one in farmers' field tests. From '7021', three lines were used in regional yield trials. Of them, it was decided to use one line in farmers' field trials.

(c) Selected Lines

Shown in the following are the allocation of breeding lines in the yield trials of breeding lines from these combinations and the results of yield trials on selected lines which were to be used in farmer's field tests.

'7021 - P_3 - 88 - 4 - 2 - 1 - 4 - P_9' is a promising line, as it shows a very vigorous growth resistant to downy mildew, with larger seeds than thsoe of "SJ-2", and of relatively high oil contents. Although its resistance to shattering is slightly inferior to that of 'SJ-2'.

Table III-12. Pedigree selection conducted on the combinations of '7020' and '7021'

C. Crossing No. 7020

Parents 'SJ-2' x 'K.S. 252'

Year A.D	Year B.E	Generation	Season	Location	Date of planting	Planted Fam.	Planted Lines	Planted Plts/line	Selected Fam.	Selected Lines	Selected Plts	Note
1970	2513	Crossing	Dry	Mae Jo	(Dec. 4-5 & Dec. 16)			80 flws		22 pods	43 seeds	( ): Date of crossing
1971	2514	F_1	Dry	Mae Jo	Feb. 25			43 seeds		17 plts	5,661 seeds	Seedcoat color
1972	2525	F_2	Dry	Mae Jo	Jan. 28			1,780			mass	
		F_3	Rainy	Mae Jo	July 21			6,400			133	
1973	2526	F_4	Dry	Mae Jo	Jan. 20		133	40		7	35	
		F_5	Rainy	Mae Jo	July 5	4	20	40	3	3	15	
				Srisamrong	June 8	3	15	40	1	1	mass	
1974	2527	F_6	Dry	Mae Jo	Dec. 4	3	15	40	3	3	30	
							1	40				Planted F_4 derived lines
		F_7	Rainy	Mae Jo	June 25	3	15	40	2	2	10	
							(1)			(1)		( ): Included in yield trial
				Srisamrong	May 17	3	15	40				
1975	2528	F_8	Dry	Mae Jo	Dec. 12	2	10	40	2	2	20	
							(1)			(1)		( ): Included in yield trial
		F_9	Rainy	Mae Jo	July 4	2	10	40				
							1	1200		1	15	
				Srisamrong	May 12	2	10	40	2	4	20	

D. Crossing No. 7021

Parents 'K.S. 252' x 'SJ-2'

Year A.D	Year B.E	Generation	Season	Location	Date of planting	Planted Fam.	Planted Lines	Planted Plts/line	Selected Fam.	Selected Lines	Selected Plts.	Note
1970	2513	Crossing	Dry	Mae Jo	(Nov. 27)			30 flws		9 pods	13 seeds	( ): Date of crossing
1971	2514	F_1	Dry	Mae Jo	Feb. 25			13 seeds		11 plts	4,058 seeds	Plant type
1972	2515	F_2	Dry	Mae Jo	Jan. 28			1,580			mass	
		F_3	Rainy	Mae Jo	July 21			6,400			109	
1973	2516	F_4	Dry	Mae Jo	Jan. 20		109	40		22	165	
		F_5	Rainy	Mae Jo	July 5	17	85	40	10	10	50	
				Srisamrong	June 8	16	80	40	11	11	mass	
1974	2517	F_6	Dry	Mae Jo	Dec. 4	10	50	40	9	9	90	
							11	40				Planted F_4 derived line
		F_7	Rainy	Mae Jo	June 25	9	45	40	3	3	15	
				Srisamrong	May 17	9	45	40	4	4	20	
1975	2518	F_8	Dry	Mae Jo	Dec. 12	7	35	40	7	7	70	
		F_9	Rainy	Mae Jo	July 4	7	35	40			-	
				Srisamrong	May 12	7	35	40	3	6	30	

Table III-13. Number of breeding lines from '7020' and '7021', which were tested in yield trials

Year	Season	Generation	7020 (SJ-2xK.S252)				7021 (K.S252xSJ-2)			
			P.Y.T	R.Y.T	F.F.T	Total	P.Y.T	R.Y.T	F.F.T	Total
1973	Dry	F_4								
	Rainy	F_5	3			3	16			16
1974	Dry	F_6	3			3	7			7
	Rainy	F_7	1	2		3	8	1		9
1975	Dry	F_8	3			3	7	6		7
	Rainy	F_9	1	2		3	2	3	2	5
1976	Dry	F_{10}	1	2	1	3		3	1	3
	Rainy	F_{11}								

Table III-14. Allocation of breeding lines from the crossings of "7020" and "7021" to yield trials in the dry season of 1976

Experiments		Breeding lines
1.	Farmer's field test	7020 · P_3. 49. 2. 3. P_7. P_8. P_9. P_{10}
		7021 · P_3. 88. 4. 2. 1. 4. 4(S). P_{10}
2.	Regional yield trial	7020 · P_3. 49. 2. 3. P_7. P_8. P_9. P_{10}
		7020 · P_3. 65. 1. 5. 1. 3. 2(S0). P_{10}
		7021 · P_3. 79. 3. 2. 1. 5. 1(S). P_{10}
		7021 · P_3. 88. 4. 2. 1. 4. 4(S). P_{10}
		7021 · P_3. 78. FP_5. 3. 4(S). 4. 2(S). P_{10}
3.	Preliminary yield trial	7020 · P_3. 20. 2. 1. 3. P_8. P_9. P_{10}

5) "SJ-4"

At the time when the experiments in the dry season of 1976, were being carried out the most promising ones selected from the breeding lines were being used in farmer's field trials. They totaled four lines, including two lines from "7019" ('Acadian' x '64 - 104') and one line each from "7020" ('SJ-2' x 'K.S. 252') and '7021' ('K.S. 252' x 'SJ-2').

Immediately before his return to Japan, the writers discussed with Dr. Arwooth about the candidate lines for new varieties. As a result of the discussion, it was decided that one line from "7019" would be recommendedable as a rust-resistant line for cropping in the rainy season and one line from '7021' for cropping in the dry season. Later, Dr. Arwooth compiled the results of the past experiments on it and submitted them to the Variety Recommendation Committee of the Thai Department of Agriculture (Upland Crops Division).

The pedigree numbers of these two lines are:

1. '7019 - P_2 - 49 - P_4 - 3 - P_6 - 1 - FP_8 - P_9 - 4 - P_{11}'
2. '7021 - P_2 - P_3 - 88 - 4 - 2 - 1 - 4 - P_9 - P_{10}'

Of the aforementioned two lines, the one from "7019" was considered most promising and its propagation was already being stepped up at the Mae Jo Agricultural Experiment Station in the dry season of 1976. As it has been approved by the aforementioned Variety Recommendation Committee, this linehas been trially planted at several demonstration fields throughout Thailand for final decision. Now that this line has already been approved by the Variety Recommendation Committee, the variety name 'SJ-4' is given to it by Thai

Table III-15. The results of yield trials on selected lines (till the rainy season, 1975)

7020. P_3. 49. 2. 3. P_7. P_8. P_9 and "SJ-2"

Name of line	Year, Season	Experiment*	Location	Plant height	Number of pods	Growing period	Seed yield	Yielding ratio to SJ−2	100 grains weight	Lodging score	Shattering score	Seed quality
				cm		day	kg/rai	%	g			
7020.P_3.49.2.3.P_7.P_8.P_9	1974, Dry	PYT	Mae Jo	90.9	61.9	109	366	111	13.5	3	1	4
	1974, Rainy	RYT	Phraphutthabat	60.0	45.8	84	212	140	8.2	1.5	3.3	4
	1975, Dry	PYT	Mae Jo	52.6	41.1	92	267	112	13.7	2	2	4
	1975, Rainy	RYT	Mae Jo	58.7	51.7	86	132	117	8.9	3	2	3
	1975, Rainy	RYT	Srisamrong	98.9	71.6	99	445	121	17.4	5	2	3
	1975, Rainy	RYT	Phraphutthabat	67.9	50.0	93	387	105	13.3	2	1	3
	1975, Rainy	RYT	Kalasin	31.8	24	93	110	90	10.9	1	1.7	3.3
		Average		65.8	44.4	94	274	(114)	12.3	2.5	1.9	3.5
SJ−2	1974, Dry	PYT	Mae Jo	83.7	34.9	119	330	100	11.8	2.5	1	3
	1974, Rainy	RYT	Phraphutthabat	75.9	54.9	98	151	100	6.4	1	1	3
	1975, Dry	PYT	Mae Jo	43.1	43.3	92	239	100	12.7	2	1.7	3
	1975, Rainy	RYT	Mae Jo	67.4	59.6	95	113	100	7.6	3.5	1	3
	1975, Rainy	RYT	Srisamrong	102.2	104.6	110	367	100	13.2	5	1	3
	1975, Rainy	RYT	Phraphutthabat	78.3	64.8	100	368	100	11.4	2.5	1	3
	1975, Rainy	RYT	Kalasin	31.9	32	105	122	100	10.3	1	1	3.7
		Average		68.9	56.3	103	241	(100)	10.5	2.5	1.1	3.1

7021. P_3. 88. 4. 2. 1. 4. P_9 and "SJ-2"

Name of line	Year, Season	Experiment*	Location	Plant height	Number of pods	Growing period	Seed yield	Yielding ratio to SJ−2	100 grains weight	Lodging score	Shattering score	Seed quality
7021.P_3.88.4.2.1.4.P_9	1974, Dry	PYT	Mae Jo	89.0	36.2	115	323	98	13.6	3	2	4
	1974, Rainy	PVT	Phraphutthabat	87.0	49.0	85	270	109	12.1	2	3	2.5
	1975, Dry	PYT	Mae Jo	53.3	35.0	91	309	129	13.8	2	2	4
	1975, Dry	RYT	Kalasin	39.0	48.9	91	352	106	14.8			
	1975, Rainy	RYT	Mae Jo	64.8	47.9	86	148	131	9.3	4	2	3
	1975, Rainy	RYT	Srisamrong	113.4	57.3	101	377	103	17.9	5	2	3
	1975, Rainy	RYT	Phraphutthabat	72.5	50.3	92	365	99	11.9	1.5	1	3
	1975, Rainy	RYT	Kalasin	35.6	24	92	123	101	10.3	1	1.3	4
		Average		69.3	43.6	94	283	(113)	13.0	2.6	1.9	3.4
SJ−2	1974, Dry	PYT	Mae Jo	83.7	34.9	119	330	100	11.8	2.5	1	3
	1974, Rainy	PVT	Phraphutthabat	67.8	58.7	94	248	100	10.1	1	1	3
	1975, Dry	PYT	Mae Jo	43.1	43.3	92	239	100	12.7	2	1.7	3
	1975, Dry	RYT	Kalasin	29.8	43.2	95	331	100	12.7			
	1975, Rainy	RYT	Mae Jo	67.4	59.6	95	113	100	7.6	3.5	1	3
	1975, Rainy	RYT	Srisamrong	102.2	104.6	110	367	100	13.2	5	1	3
	1975, Rainy	RYT	Phraphutthabat	78.3	64.8	100	368	100	11.4	2.5	1	3
	1975, Rainy	RYT	Kalasin	31.9	32	105	122	100	10.3	1	1	3.7
		Average		63.0	55.1	101	251	(100)	11.2	2.5	1.1	3.1

Note: * PYT = Preliminary yield trials, RYT = Regional yield trial researchers following the existing standard varieties 'SJ-1', 'SJ-2' and 'SJ-3'.

In the following, the characteristics of the so-called 'SJ-4' will be outlined.

This line is resistant to soybean rust inherited from one parent and considered to be a line for cropping in the rainy season, because the high incidence of rust disease on the soybeans cropped in the rainy season constitutes a major barrier in Thailand. With determinate growth, this line has broad leaves, brown pubescences and purple flowers. It is somewhat shorter in stem length than 'SJ-2' but the degree of lodging is smaller. Its growth is somewhat conspicuous. The seeds have yellow seed coats and light brown hilums. This line is larger than the standard varieties 'SJ-1' and 'SJ-2' in terms of 100-grain weight. The results of an analysis of the seed contents suggests that the oil contents of 'SJ-4' is lower than these of the standard varieties 'SJ-1' and 'SJ-2' but the contents of protein is higher than those of standard varieties.

Fig. III-2 and Table III-16 indicate the process of the pedigree selection on 'SJ-4' and the data obtained in the yield trials on it.

$7019.P_2.49.P_4.3.P_6.1.FP_8.P_9.4.P_{11}$

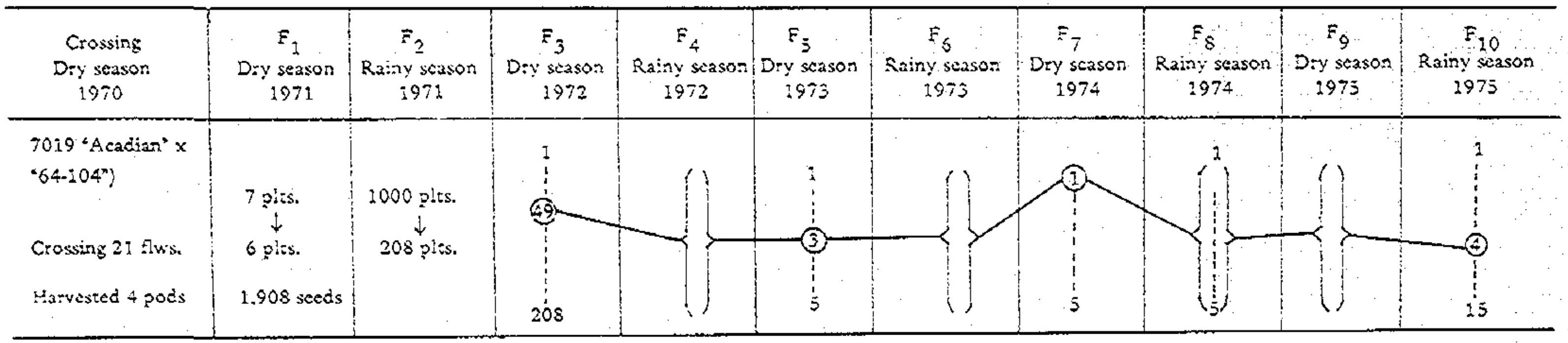


Fig. III-2. Pedigree selection conducted for 'SJ-4'

Table III-16. The data obtained in the yield trials on 'SJ-4'

$7019.P_2.49.P_4.3.P_6.1.FP_8.P_9.4.P_{11}$....determinate, broad leaf, brown pubescence, purple flower, yellow seedcoat, dark brown hilum

Name of lines	Plant height cm	Number of pods	Growing period day	Seed Yield kg/rai	Yielding ratio %	100 grains weight g	Shattering score	Downy* mildew	Soybean* rust	Protein** content %	Oil** content %
$7019.P_2.49.P_4.3.P_6.1.FP_8.P_9.P_{10}$	66.9	50.9	94	319	131	12.8	1	M.S	R	39.5	19.1
SJ-1	94.1	47.7	91	228	94	10.0	(2.5)	S	S	35.8	18.2
SJ-2	71.2	61.0	96	243	100	9.7	1	S-M.S	S	35.6	21.2

Notes: The data were shown in the average of (1) P.Y.T. at Phraphutthabat Agr. Exp. Sta. in the rainy season, 1974 and (2) R.Y.T. at Mae Jo and Phraphutthabat Agr. Exp. Sta. in the rainy season, 1975. These experiments were disturbed by the soybean rust.

* : Observation, R resistant, M.S modelately susceptable, S susceptable.

** : The average of the data analized at Oil Seed Lab., Division of Agricultural Chemistry.

CHAPTER 4. METHOD OF HYBRIDIZATION BREEDING

In this chapter, an attempt will be made to explain the so-called hybridization breeding in which varieties are selected and fixed while artificially crossed hybrid progenies go through generations by means of selfing.

The breeding step may be divided into the phase when heritable variations are produced in crops and the phase in which plants or lines with characteristics fitted to the purpose are selected. The breeding method in which new heritable variations are produced by means of hybridization is known as the hybridization breeding method. At present, the hybridization breeding method constitutes the principal crop breeding method.

When the hybridization breeding method is used in self-pollinated crops, there are two breeding methods -- pedigree method and bulk method -- depending on the method of selecting hybrid generations.

In the pedigree method, seed collection is performed for each plant in each hybrid generation, the line from each plant in subsequent generations are carried out, and the pedigree and individual selections are repeated. In this method, much labor is required for selections and surveys during the growth, but information can be obtained about each generation of one and the same material, thus making it possible to breed varieties in a relatively small number of years. In the bulk method, on the other hand, cultivation has been conducted from F_2 to about F_6 and after the fixing of heritable characteristics has made progress, pedigree selections are started. In this method, not much labor is required for each hybrid generation, but there is a need for the maintenance of a considerably large number of plants for each generation. A large area is also required.

It is difficult to determine which is better, the pedigree method or the bulk method. Whichever is more suitable should be adopted, depending upon the number and nature of characters set as objectives in the selection. Their combined use will sometimes be effective.

As breeding experts, the writers took charge of the soybean breeding tests and trials, and their main efforts were concentrated on the combination breeding which was designed to incorporate in Thai varieties the vigorous growth, resistance to soybean rust, large seed size and other characters equipped to introduced varieties by means of artificial crossing. In respect of the hybrid progenies, an attempt was made for their selection and fixing in the pedigree method. In the meantime, many difficulties, such as problems associated with the experience of persons in charge of breeding tests and the control of breeding fields, were encountered, and the selection did not necessarily make progress at a steady pace, although achievements in general were eventually accomplished. On the basis of what were expeirenced and pondered over while taking charge of soybean breeding tests on the spot, an attempt will be made here to introduce what the writers thought of the method of breeding soybeans in Thailand. In view of the existence of many difficulties, the writers regret that they could not afford to carry out the following plan as it was, but they would be happy if their description could serve as a guideline for the treatment of breeding materials in the future.

Incidentally, the description will be made on the following three premises:

(i) Breeding materials were planted twice a year -- the rainy and dry seasons -- to produce generations. For the sake of the future, materials can be naturally prepared both for the rainy and dry seasons. It would be possible to produce generations with the plantation done once a year, but priority was given to the shortening of the breeding period after artificial hybridization.

(ii) Selection and fixing were promoted by the pedigree method. One of the important breeding objectives for soybeans for cropping in the rainy season in Thailand is resistance to soybean rust. It is surmisable that the resistance is controlled by a small number of genes. Consequently, it is possible to remove susceptible lines from the early generations with the pedigree method. For example, even if it is targeted for the rainy season varieties, growing for the dry season comes in between, so that even if there is progress in generation, there are cases in which the number of substantial selections is small. However, the pedigree method makes it possible to carry out the selection on the basis of the results obtained in the dry season.

(iii) The yield trial of breeding lines is conducted both in the rainy and dry seasons. Depending on the breeding line, the allocation of degrees of importance for each cropping season should be done in assessing the results of the yield trial. However, the results of the yield trials carried out in the dry season are necessary even for the lines to be cropped in the rainy season in view of the present situation of soybean cultivation in Thailand.

1. Collection and Preservation of Germplasm

In respect of the introduction, collection and preservation of varieties, it is desirable to accurately record the name of the variety, the place from which it has been introduced and the time, etc., for each material so that correct information is available at any time, even if the man in charge of breeding is replaced by another. It is also desirable to print the results of a survey on the characteristics of any variety for permanent documentation.

Cultivation for variety preservation is of use not only in maintaining its seeds but also in discovering useful cross parents from an observation during the growth and a traits survey.

Cultivation for variety preservation would accomplish its purpose if about 30 plants for one variety are planted. While observing the growth, an attempt must be done to pull out the plants seized with diseases infectious to seeds and those of a heterogenous variety.

In harvest, 10 normally growing plants are reaped and threshed. Then they will be dried so that the water content in its seeds reduces to about 12% for stocking.

In Thailand, the temperature and humidity are high in naturally given conditions, so that the seed germinating capacity cannot be maintained for more than about three months. If the seed storage granary is equipped with an air-conditioner to maintain the temperature at about 18°C and the humidity at about 70% (relative), the seed germinating capacity may be maintained for more than two years. It is also possible to stock them over a long span of time by keeping them at low temperature and humidity.

For all the stocked varieties, a traits survey should be carried out at least once both in the rainy and dry seasons. Fairly large labor is required for variety stocking cultivation, so that about 200 presumably useful varieties should be selected from those after the character survey has been completed for observation in each cropping season, and other varieties should be stocked in a granary as long as their germinating capacity can be maintained.

2. Breeding Objectives

The breeding of soybeans at the Mae Jo Agricultural Experiemnt Station was stepped up with the breeding objectives set up for each cropping season in respect of the varieties recommended at present -- 'SJ-1' for cropping in the rainy season and 'SJ-2' for cropping in the dry season -- as mentioned in 1, Chapter 3.

The important objectives for the soybean varieties for cropping in the rainy season are:

* High yield and good quality;
* Growing period of 100-105 days as in the case of 'SJ-1';
* Somewhat short but strong stems and highly resistant to lodging; and
* Resistant to soybean rust.

The importance objectives for the soybean varieties for cropping in the dry season are:

* High yield and good quality;
* A somewhat longer growing period than in the case of 'SJ-2' -- i.e., 105-110 days;
* Somewhat tall height with a large plant type; and
* Hard to shatter.

In addition to these characteristics, the high oil content, the capacity of setting root nodules on the lean soil of the northeast region, the germinating capacity, etc., were taken up.

The aforementioned breeding objectives will also remain important in the future. In addition, there will be a need to set up higher breeding objectives and promote the selection for the new variety in the future.

The high yield is one of the most important breeding objectives which will have to be continuously maintained. An attempt will have to be made to grope for crossing parents higher in yield than the conventional parents.

In regard to strong stems, too, efforts will have to made to produce varieties with stronger stems. In the past dry season cultivation, practically no lodging took place as there were few rainfalls and the growth was generally small under the conditions of a short day length. In the event that the cultivation method is improved, however, the growth will become larger and there will arise a need for soybean varieties for cropping in the dry season to equip themselves with high resistance to lodging. As the damages by soybean rust are serious mostly in the rainy season at present, the breeding objective of resistance to soybean rust has been set for the rainy season types of varieties. There will be a need for dry season varieties to equip resistance to soybean rust in the future because the damage is increasing year by year. It will also be necessary to make efforts for a raise in the degree of resistance.

Up to now, a system for an analysis of the seed components has not been completed and any satisfactory achievements have not been realized for the objective set up for the high oil content. If an analysis of the content of the seeds from the F_4 lines in the combination targeted for a high oil content is initiated, it will be possible to step up the selection in an effective manner.

In respect of the components of Thai soybean varieties, emphasis has been placed on the high oil content. In Thailand, there are a number of soybean protein-containing foods, which will presumably take on an exceedingly important character in the future, so that the breeding of soybeans with a high protein content will be of use in the future. The contents of protein and oil in a soybean seed show a negative genetic correlation, so that it is exceedingly difficult to raise both contents in the same variety. For the objective of a high protein content and a high oil content, different combinations will be required.

In the past preliminary yield tests and regional yield trials, the same materials as used at the Mae Jo Agricultural Experiment Station were supplied to other agricultural experiment stations to carry out yield trials and character surveys. As the number of places where these trials and surveys were performed was limited and the accuracy of the tests was not high in many cases, the regional adaptability of each breeding line could not be verified to the full extent. In the future, it will be necessary to increase the number of places for yield tests and at the same time to provide guidance for the obtaining of more accurate data. This effort will make it possible to clarify the regional adaptability of each breeding line both in the rainy and dry season and eventually to breed the varieties which feature a wide regional adaptability and assure a stably high yield in any area.

In general, the tropical soybeans are of the late maturity type and their photosensitivity is high. Recently, attempts have been made by several breeding researchers to incorporate into tropical soybean varieties the low sensitivity of varieties in high latitude areas to the short day length and to raise their environmental adaptability. The low sensitivity of soybean varieties to the short day length is closely associated with their early maturity, and it would be very difficult to incorproate their factors in tropical soybeans. Even a small drop in the sensitivity of tropical soybean varieties to the short day length would be exceedingly useful in that it would broaden their planting area and season. It is practically impossible to accomplish such an objective over a short period of time, but it will be worthwhile to go forward step by step with the preparation of intermediate varieties. It would be an ideal image for Thai soybean varieties, if they were able to develop a variety which would be equipped with a high yield, a low photosensitivity and other characteristics, such as resistance to soybean rust and lodging, and which could cover any cropping season and any area by itself.

The selection of lines with a good root nodule setting capacity in the northeast region has not necessarily been stepped up in an effective manner. If the soil of this region is improved, such as by the application of organic matter with barnyard manure and green manure crops and the correction of the acidity with lime, even the varieties of the genotype, such as "SJ-1" and "SJ-2", will be able to set their root nodules to the full extent. Justifiable is the thought of settling of the problem of a low yield for soybeans in the northeast region with a soil improvement program. However, there remains apprehension about whether the soil improvement may be performed over a short period of time in that lean and vast region. It will be indeed worthwhile to work for the breeding of a variety with a root nodule setting capacity adaptable to that lean area in terms of breeding in parallel with the soil improvement.

In addition, the future objectives will include resistance to virus diseases, resistance to drought and resistance to insects and pests with attempts made to grope for gene sources.

3. Crossing and F_1 Growing

Depending on the breeding objectives, cross parents must be selected in such a manner as will make it possible to prepare a combination in which the characteristics accumulated by the parents may be complemented one another. If a variety put into practical use in Thailand is used as either of the parents and an attempt is made to add new characters while retaining its inherent excellent characters, it will be possible to raise the breeding efficiency, now that it already contains a number of genetic factors suitable for Thailand's environmental and cultivating conditions.

The varieties which, when used as cross parents, have produced a number of promising strains in their progenies according to the records of their past breeding may be surmised as having excellent genetic factors and are consequently suitable as cross parents.

As cross parents to be added with new characters, varieties with one or more than two of such characters as high yielding, resistance to insects and pests, strong stems, good quality, high protein content and high oil content should be selected.

As regards the crossing combination, there usually are many cases in which promising genetic factors may be accumulated with two parents in the form of A x B. If this combination proves insufficient, there will arise a need for multiple crossing in the form of A x B x C or (A x B) x (C x D). In the event it is desirable to compensate for the defect which is controlled by a few genes for a given excellent variety, back crossing is the form of (A x B) x B_n will be of effect.

Given the question of which should be made the maternal or paternal parent in the combination of A x B, it will be convenient in assessing whether the crossing is successful in F_1, that the variety equipped with one or two recessive genes of qualitative characters (e.g., white pubescence and white flowers) is made the maternal parent, because the important characters influenced by cytoplasmic genes are very small in number for soybeans. It would be difficult to use a cleistogamous variety as the paternal parent, and it is advisable not to use as the maternal parent a variety which tends to be damaged by insects and pests.

To have the flowering period of one parent coincide with that of the other, cross parents are planted for 3-4 times at an interval of about 10 days. Any heterogenous or insect-damaged plants detected in the cross plants should be eliminated.

In Thailand, the efficiency will be heightened if sowing is done in the rainy season and crossing somewhere between August and October. The hours between 8-11 a.m. in July and August are suitable for crossing. The later the crossing period, the later the suitable hours (Table IV-1).

Table IV-1. Proper time for the artificial crossing of soybeans in Thailand

Month	Time
July	8:00 - 11:00
August	8:00 - 11:00
September	9:00 - 12:00
October	10:00 - 13:00
November	11:00 - 14:00

In the afternoon of July through September, it is difficult to collect pollen, as it disperses. Even at about 6 a.m., the anthers are found dehiscent and pollen can be collected, but the possibility of assuring a successful crossing is low. In October through November, the anthers dehisce at later hours. It would be difficult to collect pollen unless it was done after 10 a.m.

If cross parents are planted in the dry season, some of them will undergo cleistogamy due to the existence of short day length conditions or heteromorphic pods, thus reducing the crossing rate.

The required number of crossing flowers is determined according to the crossing success rate, F_1 propagation rate and the number of plants scheduled for F_2. If it is assumed that the appropriate number of plants for F_2 is about 2,000 per combination, it will follow that the crossing of about 100 flowers per combination should be performed, because the F_1 propagation rate is about 100 times at the lowest, the crossing success rate, albeit big in fluctuation, is about 15% and the number of grains in a crossed pod is about 1.5.

The crossing procedure is such that pollination is performed immediately after the removal of the stamens. The pollinated flowers are fixed with a tag indicating the combination number and the names of the parents, and other flowers and flower buds in the same node are removed.

To raise the propagation rate in F_1, planting is done more spaced than usual. The planting of 50 cm x 50 cm with one plant per hill is proper. With respect to F_1, whether the crossing is successful is assessed according to the pubescence color, leaf shape, flower color, maturity period, stem height, grain color, hilum color, etc., during the growth and in the maturity period. If this assessment is difficult to accomplish, lines will be prepared in F_2 and an assessment will be made by observing their segregation.

4. Procedure of F_2 and F_3 Bulks

The number of plants in F_2 differs, depending on the relationships of the parents, number of characters to be selected and their inheritance. In normal circumstances, the appropriate number is 1,500-2,000 plants per combination. The proper planting density is 50 cm x 10 cm or 50 cm x 15 cm with one plant per hill. In case there are some worries about the germination, it is advisable to do planting at a rate of two grains per hill and thin off leaving one plant per hill after germination.

The vigorous growth of F_2 and F_3 owes much to the heterosis. The effects of the selection are not conspicuous in terms of yield. In these early generation bulks, emphasis is put on the selection of qualitative characters and the elimination of inferior characters. Even in F_2, the maturity period, plant height and grain size have a high heritability, and an individual selection is feasible for these characters. However, the characters, such as the yield, resistance to lodging and chemical components, are low in heritability, so that the selection should be performed when the generations get to F_3 or F_4 (Table IV-2).

Table IV-2. Expected heritability of various characters of soybeans when selection units are F_2 plants and means of F_4 or later generation lines in two replications in two environments

Character	Selection unit	
	F2 plant	Mean of F_4 or later generation lines in two replications within two environments
Yield	5	38
Height	45	75
Maturity	55	78
Flowering to maturity	40	65
Days to flowering	60	84
Seed weight	40	68
Resistance to lodging	10	54
% Oil	30	67
% Protein	25	63

* From Johnson H.W. and R.L. Bernard (1962) 'Soybean Genetics and Breeding'. (Advance in Agronomy 14)

It is surmisable that the resistance to soybean rust is influenced by a few genes, and the selection effects are high even in F_2. It will also be effective to select on shattering, seed quality, shape of seed and uniformity of grains in F_2.

As mentioned earlier, it is more effective to perform artificial crossing in the rainy season in Thailand, so that if crossing is done in the rainy season, F_1 will normally come in the dry season, F_2 in the rainy season and F_3 in the dry season. In the event a certain combination is prepared specifically to produce a variety for cropping in the rainy season, a selection on the maturity period, plant type, resistance to soybean rust, grain size, quality, etc., should be conducted in F_2 in the rainy season and only the elimination of inferior characteristics performed in F_3 in the dry season for bulk planting. In case a certain combination is prepared for cropping in the dry season, only the elimination of inferior characteristics should be carried out in F_2 in the rainy season and a selection on the maturity period and plant type performed in F_3 in the dry season.

In the combination designed for the breeding of a variety for cropping in the dry season, the method is conceivable of planting cross parents in the beginning of April, harvesting cross seeds in the end of July, planting F_1 in the beginning of August and harvesting it right before planting in the next dry season in order to cultivate F_2 in the dry season and carry out selection. There are cases in which there is a need for irrigation for the cultivation of crossing parents and F_1, but one merit is the feasibility of shortening the breeding period.

5. Selection of Breeding Lines in F_3 – F_7/F_8

1) Pedigree Selection of Breeding Lines for Cropping in the Rainy Season

For soybeans for cropping in the rainy season, resistance to soybean rust can be cited as one of the important breeding objectives. Therefore the main site for soybean breeding for cropping in the rainy season should be the Mae Jo Agricultural Experiment Station where the heavy occurrence of soybean rust is noted, by taking into consideration the situation of soybean breeding in Thailand. Stress should be also put on the Srisamrong Agricultural Experiment Station, which is located in the center for the cropping of soybeans in the rainy season. As for the breeding site of soybeans in the dry season, the Mae Jo Agricultural Experiment Station can be cited, because its irrigation and other facilities were kept in good order and the fertility levels of its field were relatively uniform.

The general concept about selection of breeding lines was as follows:

In the rainy season, plant the derived lines for early generations and lines for middle and late generations, carry out severe selection on resistance to rust disease, vigorousness of the growth, degree of lodging, pod setting, maturity and size and quality of seeds, and also observe the uniformity within the families for late generations. In the dry season, while the variability within the lines would be checked in respect of the plant type, vigorousness of the growth, maturity, size and quality of seeds for the early generacions, light selections would be performed but plants within each line harvested as a mass. For the middle and late generations, the uniformity within the families would be checked in addition to the selection on the aforementioned characteristics.

On the basis of the aforementioned points, a breeding program for the variety to the rainy season as shown in Table IV-3 and the selection schedule for the variety to the rainy season as indicated in Table IV-4 were formulated. The selection schedule in Table IV-3 is an example for dealing with the promising material (combination). The 150-200 lines in F_3 which are derived from the selected F_2 plants in the population would be selected and reduced to 5-6 lines by the time when they would be incorporated in Preliminary yield tests in F_8.

The selection of materials for cropping in the rainy season would be started with the selection of individual plants in F_2 population. In F_3 in the next dry season, the seeds collected from the each selected plant would be planted to each row, and the selection would be carried out on the plant type, maturity, the size and quality of seeds, etc., on the bases of line. The selection in this stage, however, would be moderate in intensity, and the plants within a line would be harvested as a mass. In regard to F_4, the planting of the lines derived from F_2 would be conducted both at the Mae Jo and Srisamrong Agricultural Experiment Stations. At the Mae Jo Agricultural Experiment Station, resistance to soybean rust, plant type, vigorousness of the growth, degree of lodging, pod setting, maturity, yield, the size and quality of seeds, etc., would be checked, whereas at the Srisamrong Agricultural Experiment Station, the materials would also be harvested by the base of line and the yield surveyed. The selection of this generation would be severe and the materials would be reduced by a great deal. Some families, each family consisting of five lines, from the lines and plants selected in the preceding generation (in a promising combination : 20 families) would be cultivated in the dry season and the selection on the basis of the line would be carried out on the plant type, vigorousness of the growth, maturity, the size and quality of seeds, etc., but the selection in this generation would be moderate in intensity. The plants in each line would be harvested as a mass. In the F_6 as in the case of F_4, the lines derived from F_4 plants would be planted both at the Mae Jo and Srisamrong Agricultural Experiment Stations, and the selection would follow the same procedure as in the case of F_4 but in addition, consideration would be given to the uniformity in each line. In respect of F_7, a little number of families, each family consisting of five lines, (in a promising combination: 10-12 families), would be cultivated, and the plant type, vigorousness of the growth, maturity, the size and quality of seeds, etc., would be evaluated on the basis of the family and serious note taken of the uniformity within each family while performing the selection. With due consideration given to that the families selected in this generation would be incorporated in the yield trials in the next generation, five plants would be selected from each of the two lines chosen out of five lines in a family. In the F_8, 10 lines of two families (each family consisting of five lines) out of a family selected from the preceding generation would be planted, and the selection of the families would depend mainly on the data obtained from the yield trials and others. Pedigree selection of lines within each family and plants within each line would be performed in the same manner as in the case of F_7. The F_9 and subsequent generations would be treated in the same

Table IV-3. Breeding program for the variety to rainy season (experiments & locations)

Year	Season	Generation	Pedigree selection		Preliminary yield test				Regional yield trial					Other tests				Uniformity test		Farmer's field test	Propagation
			M	S	M	S	P	C	M	S	P	C	K	F&D*	Protein & oil	Seed longe-vity	Rust	M	S		
1	dry																				
	rainy	Crossing	○																		
2	dry	F_1	○																		
	rainy	F_2	○																		
3	dry	F_3	○																		
	rainy	F_4	○	○																	
4	dry	F_5	○																		
	rainy	F_6	○	○																	
5	dry	F_7	○																		
	rainy	F_8	○			○	○								○						
6	dry	F_9	○		○			○							○	○	○				
	rainy	F_{10}	○							○	○				○						○ Pre. P
7	dry	F_{11}	○						○			○			○						○ Pre. P
	rainy	F_{12}	○						○	○	○		○	○		○	○	○		○	○
8	dry	F_{13}							○			○	○	○						○	○
	rainy	F_{14}																			

Notes: 1. M = Mae Jo Agr. Exp. Sta., S = Srisamrong Agr. Exp. Sta., P = Phraphutthabat Agr. Exp. Sta.
C = Chainat Rice Exp. Sta., K = Kalasin Agr. Exp. Sta.

2. * The test of response to the condition of non-fertilizer or heavy density of planting.

Table IV-4. Selection schedule of promising material (combination) for the variety to the rainy season (till F_{10})

Year	Season	Generation	Pedigree selection						Yield trial	
			Planting			Selection				
			Fam.	Lines	Plts.	Fam.	Lines	Plts.	P.Y.T*	R.Y.T**
1	dry									
	rainy	crossing								
2	dry	F_1								
	rainy	F_2			1500-2000			150-200		
3	dry	F_3		150-200			75-100	(mass)		
	rainy	F_4		75-100			20	100		
4	dry	F_5	20	100			50-60	(mass)		
	rainy	F_6		50-60			10-12	50-60		
5	dry	F_7	10-12	50-60		5-6	10-12	50-60		
	rainy	F_8	10-12	50-60		3-4	6-8	30-40	5-6	
6	dry	F_9	6-8	30-40		2-3	4-6	20-30	3-4	
	rainy	F_{10}	4-6	20-30						2-3

Notes: * P.Y.T = Preliminary yield test
** R.Y.T = Regional yield trial

way as F_8, and 10 lines in two families selected from the preceding generation would always be grown. That is, the selection of families would be carried out according to the data obtained primarily from the yield trials, while the selection of lines and individual plants within the families would be conducted in the pedigree field.

2) Pedigree Selection of Breeding Lines for Cropping in the Dry Season

At present, the selection of breeding lines for cropping in the dry season is being stepped up with the variety 'SJ-2' used as the standard, while consideration given to less shattering and resistance to the downy mildew in addition to the plant type, vigorousness of the growth, pod setting, maturity, the size and quality of seeds, etc. Around Chianat and Suphanburi, rust damage was observed on the soybeans for cropping even in the dry season. From the signs of prevalance of soybean rust in Thailand, could be predictable that resistance to soybean rust would be a point of soybean breeding even for the cropping in the dry season in the future.

One thing about which much care should be paid in the cultivation of soybeans in the dry season is water control. From this point of view, the Mae Jo Agricultural Experiment Station which is well accomodated with irrigation facilities may be counted as a center for breeding in the dry season. On the other hand, the Srisamrong Agricultural Experiment Station (or the Phraphutthabat Agricultural Experiment Station) may be looked upon as a promising place for cropping of the materials for dry season in the rainy season. In case the soybeans susceptive to soybean rust is planted at the Mae Jo Agricultural Experiment Station in the rainy season, for example, harvest of the sufficient amount of seeds will not be assured and it will be difficult to command the planting of subsequent generations. At the Srisamrong Agricultural Experiment Station, there is little damage from rust in the rainy season and an enough amount of seeds could be harvested. (At the Phtaphuttabat Agricultural Experiment Station, the damage is conspicuous and the growth is similar as that of soybeans planted in the dry season.)

The selection in the dry season is conducted on derived lines for the early generations and on the lines in the middle and late generations, and the severe selection covers the plant type, vigorousness of the growth, pod setting, maturity, yield, the size and quality of seeds, degree of shattering, resistance to downy mildew, etc. In this case, variability within the lines should also be included. In the rainy season, a moderate selection of lines is conducted on the plant type, vigorousness of the growth, maturity, and the size and quality of seeds, etc., and the uniformity in each family is also studied for the late generations. In the event that serious note is taken of resistance to rust even in respect of soybeans for cropping in the dry season in the future, derived lines should be planted at the Mae Jo Agricultural Experiment Station in the rainy season to make an assessment on their resistance against soybean rust.

As in the case of soybeans for cropping in the rainy season, a breeding program for the variety to the dry season as shown in Table IV-5 and selection schedule of promising material for the variety to the dry season were prepared. The selection of materials for the dry season will

Table IV-5. Breeding program for the variety to dry season (experiments & locations)

Year	Season	Generation	Pedigree selection		Preliminary yield test				Regional yield trial					Other tests				Uniformity test		Farmer's field test	Propagation
			M	S	M	S	P	C	M	S	P	C	K	F* & D	Protein & oil	Seed longevity	Shattering & Downy mildew	M	S		
1	dry																				
	rainy	crossing	◌																		
2	dry	F_1	◌																		
	rainy	F_2	◌																		
3	dry	F_3	◌																		
	rainy	F_4		○																	
4	dry	F_5	○																		
	rainy	F_6		○																	
5	dry	F_7	○		○			○							○						
	rainy	F_8		○		○	○								○						
6	dry	F_9	○						○			○			○	○	○				Pre. P
	rainy	F_{10}		○						○	○				○						Pre. P
7	dry	F_{11}	○						○			○	○			○	○	○		○	○
	rainy	F_{12}		○					○	○	○		○							○	○
8	dry	F_{13}																			
	rainy	F_{14}																			

Notes: 1. M Mae Jo Agr. Exp. Sta., S Srisamrong Agr. Exp. Sta., P Phraphutthabat Agr. Exp. Sta.
C Chainat Rice Exp. Sta., K Kalasin Agr. Exp. Sta.

2. * The test of response to the condition of non-fertilizer or heavy density of planting.

Table IV-6. Selection schedule of promising material (combination) for the variety to the dry season (till F_{10})

Year	Season	Generation	Pedigree selection						Yield trial	
			Planting			Selection			P.Y.T*	R.Y.T**
			Fam.	Lines	Plts.	Fam.	Lines	Plts.		
1	dry									
	rainy	crossing								
2	dry	F_1								
	rainy	F_2			1500-2000			(mass)		
3	dry	F_3			1500-2000			150-200		
	rainy	F_4		150-200			75-100	(mass)		
4	dry	F_5		75-100			10-15	50-75		
	rainy	F_6	10-15	50-75		5-6	10-12	50-60		
5	dry	F_7	10-12	50-60		3-4	6-8	30-40	5-6	
	rainy	F_8	6-8	30-40		2-3	4-6	20-30	3-4	
6	dry	F_9	4-6	20-30		2-3	4-6	20-30		2-3
	rainy	F_{10}	4-6	20-30						2-3

Note : * P.T.T = Preliminary yield test
** R.Y.T = Regional yield trial

be started with the selection of plants in the F_3 bulk population. In the case of a promising combination, 150-200 lines in F_4 will be reduced to 5-6 lines by the time when they are incorporated in the yield trials in F_7.

The seeds which are collected from the selected plant in the F_3 bulk population would be grown in lines at the Srisamrong Agricultural Experiment Station (or Phraphutthabat Agricultural Experiment Station) in the next rainy season. While the variability within lines is observed in respect of the aforementioned characteristics, a moderate selection in the intensity would be carried out and plants within each line would be harvested as a mass. In respect of F_5, the lines derived from F_3 would be planted at the Mae Jo Agricultural Experiment Station, and a strict selection would be carried out on the degree of shattering, resistance to downy mildew, plant type, vigorousness of the growth, pod setting, maturity, yield, the size and quality of seeds, etc. In the case of a promising combination, the selection of 10-15 lines and of five plants from each selected line would be performed. In the F_6, several families, each family consisting of five lines, would be planted, and in respect of the selection for the same characteristics as in the case of F_4 would be conducted primarily as the basis of family with due consideration given to the uniformity within each family. The families selected in this generation would be incorporated in the yield trials in the next generation. Out of the selected families, two lines would be selected and five plants from each line would be chosen. Consequently, it would follow that 10 lines in two families in F_7 (each family consisting of five lines) selected from the preceding generation would be grown. The selection in this generation would be performed primarily according to the data obtained from the yield trials. In pedigree field, emphasis would be put on pedigree and individual plant selections within each families.

6. Testing of Breeding Lines in Late Generations

As for the breeding lines selected in the aforementioned procedures, materials for use in the dry season would be incorporated in the preliminary yield tests from F_7 and those for use in the rainy season from F_8. At present, the preliminary yield tests include 30-40 lines, counting those of standard varieties and are carried out at the two locations of the Mae Jo Agricultural Experiment Station and Chainat Rice Experiment Station in the dry season and at the two locations of the Srisamrong and Phraphutthabat Agricultural Experiment Stations in the rainy season, the scale of the tests must probably be considered satisfactory when the present situation of the soybean breeding in Thailand and the quantity of seeds available for the test are taken into consideration. The materials are tested in the preliminary yield tests both in the dry and rainy seasons, as one testing cycle and some of the seeds produced in these preliminary yield tests will be used in an analysis of the protein and oil contents. The 5-6 breeding lines from an promising combination will be selected and reduced to 2-3 lines, which will be incorporated in the regional yield trials. In the selection, an overall evaluation will be made while the observations conducted on the pedigree fields as well as the results of an analysis of the seed components are taken into consideration.

The step subsequent to the preliminary yield tests is the regional yield trials. These trials, given 10-15 lines including those of the standard and other varieties, are highly evaluated in accuracy. The breeding lines selected in the aforementioned tests will be used in the regional yield trials, which will be held at the same places in the initial year as the preliminary yield tests. At the same time, the resistance to downy mildew and shattering will be checked for the materials in the dry season and the resistance to rust for those in the rainy season. Also there will be a need of the preliminary propagation of promising breeding lines for suppling the sufficient seeds to other tests and farmer's field trials in the future. As in the case of the preliminary yield tests, it will be necessary to use in an analysis of the seed components some of the seeds produced in the regional yield trials and compare them with those of the standard varieties in respect of decrease in the germinating rate after a certain period of storage. The selection should be under way after an overall analysis of the data obtained from the aforementioned tests and trials. Even in the case of a promising combination, the breeding lines to be selected should be limited to one or two in this step.

In the second year, the experiments will be conducted at the Kalasin Agricultural Experiment Station in the dry season and at the Kalasin and Mae Jo Agricultural Experiment Station in the rainy season in addition to the places to which reference has been made earlier. The selected lines will be used in the same tests and trials as in the initial year. At the same time, it is desirable to carry out (i) tests on the response to the planting density and the conditions without fertilizer application, (ii) tests on the degree of uniformity and (iii) farmer's field tests. The response to the planting density and the conditions without fertilizer application is greatly influenced by the difference between the control of breeding fields at agricultural experiment stations and the soybean cultivating conditions of farmers' field. At the level of farm households, the number of plants per hill is great (3-12 plants) and fertilizer is not applied, and it is necessary to ascertain the response of the breeding lines to these cultivating conditions. This test is tied in with farmer's field tests, but the writers are under the impression that many difficulties lie in carrying out the tests on the fields of farmers and that it is difficult to obtain fully reliable data, so that it would be advisable to put emphasis on the aforementioned tests which should be conducted at agricultural experiment stations. With respect to the tests on the degree of uniformity, reference will be made later. The breeding lines used in the tests should be propagated on a full scale.

7. Preparation of Seeds for Yield and Other Tests

In the late generations, promising breeding lines will be used in various tests, and the work of preparing seeds for these tests will become complicated. The reason for the preparation of this section on seeds for yield and other tests is because the propagating rate of soybeans is lower than that of rice, wheat and barley and there is a need for a preparing method of seeds different from that of these crops. In this section, an attempt will be made to describe the preparation of seeds for use in the tests on the basis of the conditions (i) that the pedigree

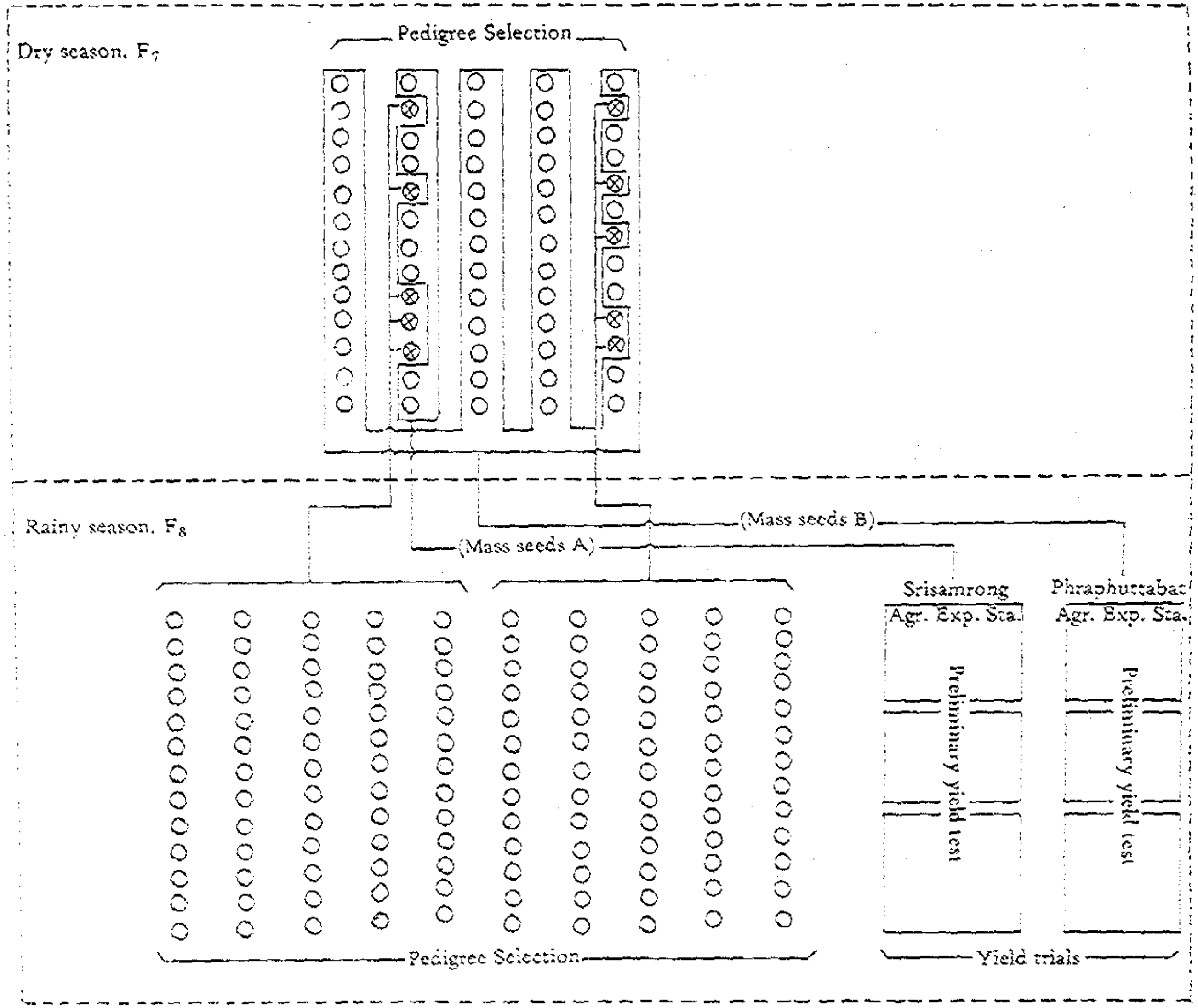


Fig. IV-1. Seed preparation from the material of rainy type F_7 for testing in the following rainy season

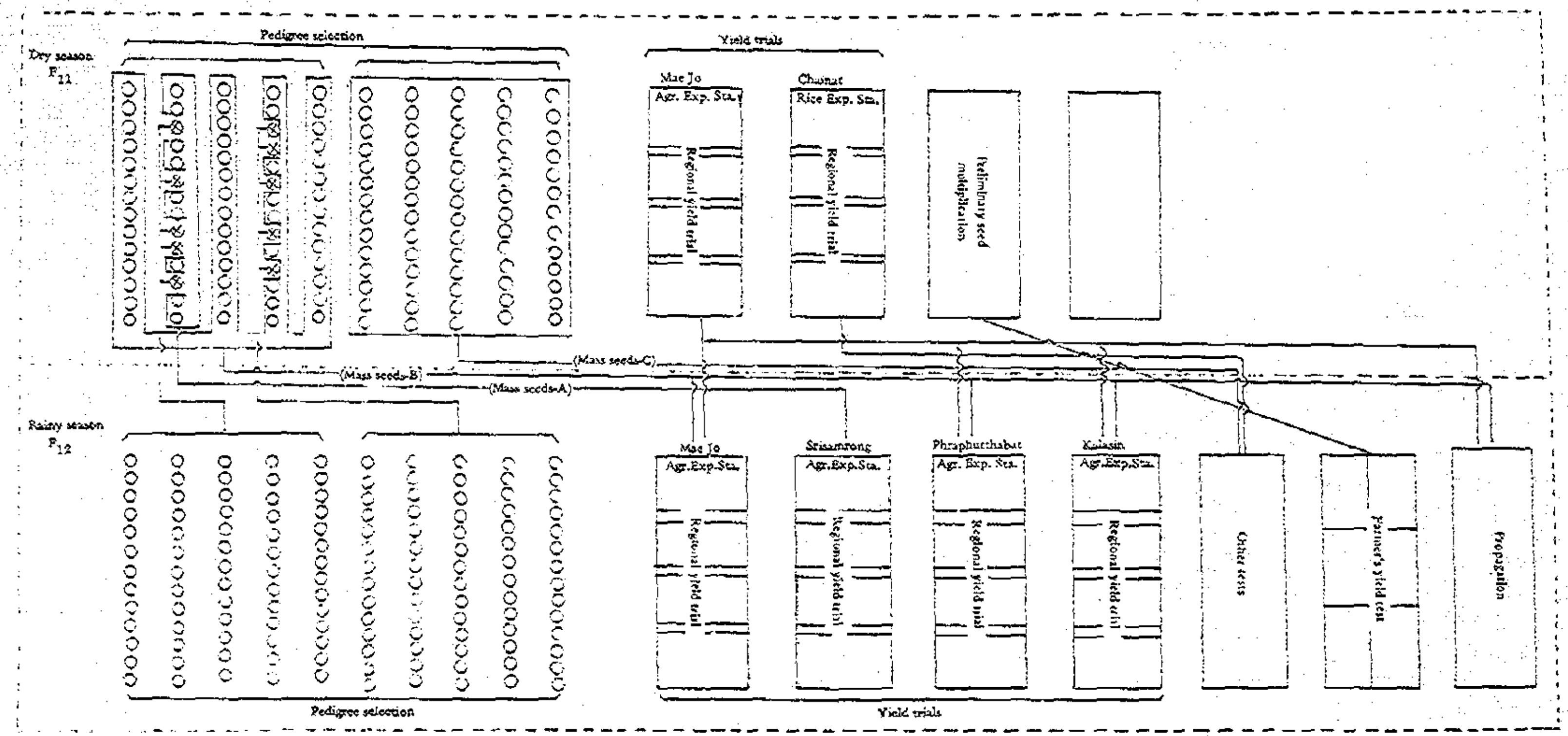


Fig. IV-2. Seed preparation from the material of rainy type at F_{11} for testing in the following rainy season selection, serving also for the propagation of seeds, will be carried on till late generations and (ii) that the seeds mixed from newer pedigrees will be used in the regional yield trial to be performed at an important place.

Fig. IV-1 represents an example of the cases where newly selected breeding lines are to be used for testing in the yield trials and shows the procedure in which seeds for pedigree fields in the following season and those for testing in the yield trials. As long as no problems are posed as to the uniformity within each family, the seeds of 10 lines in two families (each family consisting of five lines) for the following rainy season may be secured by selecting the most promising two lines from five lines in one family in the F_7 and also by choosing five plants from those of each line. Next, the mass seeds -A will be prepared by mixing the seeds collected from the remaining plants in the most promising one line, and these seeds will be used in the preliminary yield test which will be conducted at the Srisamrong Agricultural Experiment Station, which is considered to be the most important place for yield trials in the rainy season. The seeds collected from the non-selected plants in the secondarily line and from the remaining lines would be mixed to prepare the mass seeds -B. These seeds will be used in the preliminary yield tests which will be conducted at other agricultural experiment stations.

Fig. IV-2 represents an example of the case in which the generation of breeding lines advanced than that of the former. The figure indicates that the lines selected on the basis of the tests that have been carried out until the dry season should be tested at the increased number of places for yield trials in the rainy season. It also shows the procedure in which the seeds offered for farmers' field tests are treated. In the case shown in this figure, 10 lines in two F_{11} families are planted in the dry season. Of them, the treatment of those which are considered to be of the most promising is the same as in the case of the former, and the mass seeds -A are used in the regional yield trial carried out at the Srisamrong Agricultural Experiment Station, whereas the mass seeds -B are offered for regional yield trials at the agricultural experiment stations. In the case that the mass seeds -B are available in adequate quantity, they will be used for propagation purposes along with the remainders of the mass seeds -A. The seeds collected from the family which are considered to be of secondary promising will be made the mass seeds -C and used in tests on resistance to rust, etc. The seeds which will be produced in the regional yield trials at the Mae Jo Agricultural Experiment Station (which is considered to be an important place and supplied with mass seeds -A in the dry season) will be used in the regional yield trials in the rainy season at other agricultural experiment stations.

The seeds preliminarily propagaged in the previous dry season will be used in farmer's field tests, in principle. Now that more than 2 kg of seeds per line is required in farmer's field tests, the seeds produced in the aforementioned regional yield trials will be put to use in case the preliminarily propagated seeds are not sufficient.

8. Data Required for Determination of New Varieties

The data required for the determination of new varieties are tied in with the way in which the varieties are to be treated the business on seeds, and also controlled by the breeding organizations, authorization of varieties and their registration in the country as well as the maintenance, propagation and distribution system of seeds. In Thailand, too, there are the Regulation Concerning Crop Variety Recommendation Committee, Division of Upland Crops, Department of Agriculture, and other ordinances. Now that there seems to be little experience in their application, however, there would seem to be a need for some degree of systematization so as to prevent breeders from getting embrassed in compiling test data.

In Japan, there are some differences by crops in preparing data on new varieties. In respect of soybeans, as well as the rice and wheat, legislation on the authorization and registration of varieties is kept in order, and research organizations and relevant tests are systematized. Therefore, the necessary data will be controlled by them, and the data which will be submitted for the determination in the form of a 'report of reference data on breeding lines' encompass the following items in the ordinary case.

- (i) Process of breeding (crossing parents, the method and process of selection, execution of yield tests, etc.)
- (ii) Outline of the characteristics of breeding line.
- (iii) Test results (results of the observations on growth and other characteristics at the breeding place, results of tests on special agronomical characteristics (i.e. rust resistance, results of yield trials, etc.)
- (iv) Test results on degree of uniformity.
- (v) Results of tests at other places (results of test on special characteristics, results of the yield trials, results of tests on adaptability, results of farmer's field tests, etc.)
- (vi) Quantity of seeds distributable.
- (vii) Places where the new variety should be planted (with special reference to check varieties).
- (viii) Precautions on cultivation.
- (ix) Names of breeders.

Of those, the test on the degree of uniformity is carried out to ascertain the uniformity and continuity of the characteristics which are indispensable for the formation of a new variety. However, this test is considered difficult to perform in that the indication of the degree of uniformity in qualitative terms with respect to many characteristics require complicated tests and surveys. For this reason, serious note will be taken of the practical degree of uniformity observed and surveyed by the breeders. In the latest 'reports of reference data on breeding lines,' the following test results are contained on the degree of uniformity:

Table IV-7. An example of the data of uniformity test (from the data of newly released soybean variety; Himeyutaka (Toiku 161), Tokachi Agr. Exp. Sta.)

Name of line	Number of plants harvested	Number of days to flowering (from 1 July)	Number of days to maturity (from 1 October)	Plant height (cm) Average	Plant height (cm) Standard deviation	Plant height (cm) C.V.	Number of nodes on the main stem Average	Number of nodes on the main stem Standard deviation	Number of nodes on the main stem C.V.
Toiku 161-1	15	25	5	75.7	6.11	8	12.5	0.53	4
-2	15	26	5	70.5	5.53	8	12.3	0.65	5
-3	15	26	5	70.9	4.23	6	12.5	0.85	7
-4	15	25	5	77.7	3.77	5	12.7	0.46	4
-5	15	25	5	75.5	7.45	10	12.4	0.85	7
Average standard deviation	15	25.4 0.55	5.0 0	74.1 3.39			12.4 0.22		
Toyosuzu-1	15	23	17	50.0	5.88	2	10.9	0.51	5
-2	15	23	17	49.1	3.75	8	11.3	0.60	5
-3	15	21	17	47.3	2.82	6	10.9	0.60	6
-4	15	22	18	49.2	4.11	8	10.7	0.46	4
-5	15	23	18	49.3	3.77	8	10.7	0.60	6
Average standard deviation	15	22.4 0.89	17.4 0.55	49.0 1.05			10.9 0.17		

Name of line	Number of branches Average	Number of branches Standard deviation	Number of branches C.V.	Seed weight (g/plants) Average	Seed weight (g/plants) Standard deviation	Seed weight (g/plants) C.V.	100 grains weight (g) Average	100 grains weight (g) Standard deviation	100 grains weight (g) C.V.
Toiku 161-1	2.5	0.53	21	17.4	2.16	12	40.5	1.61	4
-2	2.5	0.53	21	16.0	3.25	20	40.7	2.09	5
-3	2.7	0.46	17	18.5	3.32	18	40.8	1.47	4
-4	2.8	0.65	23	17.2	3.74	22	41.2	1.55	4
-5	2.5	0.53	21	18.1	4.56	25	42.2	1.34	3
Average standard deviation	2.6 0.14			17.4 0.96			41.1 0.68		
Toyosuzu-1	3.9	0.93	24	16.6	3.64	22	34.8	1.31	4
-2	4.4	2.88	65	17.8	3.09	17	37.0	2.17	6
-3	4.7	0.89	19	17.3	3.93	23	35.0	2.85	8
-4	5.5	1.51	27	18.7	3.25	17	35.7	1.47	4
-5	4.6	0.65	14	16.3	3.50	21	34.6	1.85	5
Average standard deviation	4.6 0.58			17.3 0.96			35.4 1.95		

9. Bulk Method

We, the experts from Japan, used only the pedigree method in stepping up the selection on progeny from hybridization. But, in case emphasis is put on the characteristics which are controlled by the polygenes, such as the seed yield, and the selection of these characteristics in the early generations is considered to be of little effect or in case problems may arise on the need of laborers for surveys and others because of the necessity of taking care of many combinations, it is advisable to take the bulk method into consideration.

When the bulk method is used in advancing generations, the first thing to which consideration ought to be given is the selection intensity. In the bulk method, it is generally considered necessary to make the selection looser (in early generations) than in the pedigree method and to maintain many plants in population(s) in order not to lose promising types. In the present situation of soybean breeding in Thailand, however, a variety introduced from Japan with big seeds or an introduced variety resistant to soybean rust is used as one of the crossing parents, so that the variability in their progeny is great and they involve obviously inferior plants for the cultivating conditions in Thailand. Therefore, they should abandoned. For example, in case the characteristic of resistance to soybean rust is indispendable for materials for use in the rainy season and it is surmised that the resistance is controlled by a small number of gene pairs, the selection which is begun in the early generations is considered to be of effect. In the same way, the selection on seed size which is begun in the early generations will also be of effect. As for the materials for use in the rainy season, therefore, there will be a need to select on resistance to soybean rust, seed size, quality, etc., to bring up to certain level before the pedigree selection is started. Even for the materials for use in the dry season, there will be a need to carry out selections so as to bring resistance to downy mildew and shattering, seed size, quality, etc. But when the selection is carried out severely, the variability of the bulk population in advanced generations will be reduced greatly and the plants within the bulk will resemble too closely, thus not only making it difficult to carry out the final plant selection but losing fairly promising plants as well.

The plant selection of the materials for which pedigree selection will be continued is done in F_6 or F_7, and a general assessment is made on the selected promising plants for each line when the pedigree plantation of the following generation is completed. In general, the subsequent handling may be considered the same as in the pedigree method. In the bulk method, however, a larger number of materials (pedigree lines) are treated in the initial phase of the pedigree selection than in the pedigree method, and these lines have to be reduced while adequate useful information has to be made available on the materials, so that the accuracy of the tests held in the meantime poses an issue. In actuality, when the selection in this generation is carried out insufficient extent, the numbers of pedigrees in the late generations and materials for use in preliminary yield tests and other tests will not be decreased in some cases. When the bulk method is put to use, therefore, there is a need to exercise an adequate care about the execution of testing in pedigree fields, preliminary yield tests and others in order to raise the accuracy of selection of the late generations. When an obvious segregation is observed as to a certain characteristic within the pedigrees of these generations, it will be a common practice to go in for the abandonment with the exception of the cases where it is surmised that the characteristics will bring about a great effect on the seed yield and other important factors or where the seed yield and other important characteristics of these lines are highly evaluated even if the characteristics will not bring about a great effect on the seed yield and other important factors.

Selection schedule of promising materials for use in the dry and rainy seasons are shown in Tables IV-8 and -9. The bulk selection is carried out until F_5 for the materials in the rainy season and F_6 for the materials in the dry season. Individual plant selection will be conducted on the materials in F_6 and F_7 and seeds from the selected plants will be planted in rows to make pedigree lines, and the same treatment as to the pedigree method should be done for the subsequent generations. As it is difficult to reduce the number of materials in the phase of the pedigree selection all of a sudden, the number of pedigrees for use in preliminary yield tests is somewhat increased.

In the following, an attempt will be made to introduce an example of the bulk selection of materials for use in the rainy season on the premise that the selection will be carried out at the Mae Jo Agricultural Experiment Station. In F_2, 1,500-2,000 plants are grown with wide spacing (e.g., 1 plant in 50 cm x 20 cm) in a population. In this generation, 800-1,000 plants will be selected from not only resistant plants but susceptive ones, as though emphasis should be put on the resistance to soybean rust which is presumed to be controlled by recessive gene(s), while giving consideration to the plant type, vigorousness of the growth, pod setting, maturity, etc., and three pods will be taken out of each selected plant to produce mixed seeds. In the next dry season, 1,500-2,000 plants will be grown, the plants which are not suitable for a desired plant type or maturing period will be removed, and the plants which are inferior in pod setting will also be eliminated to take about three pods from 800-1,000 plants and produce mixed seeds. As F_4 coincides with the rainy season, a bulk population of 1,500-2,000 plants will be grown. In this generation, an attempt will be made to select only the plants resistant to soybean rust and a field selection on general characteristics will be conducted, and about five pods will be taken out of the selected 500 plants to prepare mixed seeds. Later, seeds with small size and inferior in quality will be removed out of them. As F_5 coincides with the dry season, inferior plants will be eliminated from the bulk population of 1,500-2,000 plants selecting 800-1,000 plants, and the seed from about five pods from each selected plant will be mixed to serve the selection on the size and quality of the seeds. In the following rainy season, a bulk of 1,000-2,500 plants will be subjected to a strict selection in respect of resistance to soybean rust and other general characteristics and about 400 plants will be selected in the field. After threshing, the final selection will be performed to select 200-300 plants, while taking consideration onto the seed yield, quality of seeds, etc.

In the case that resistance to soybean rust has no part, the bulk selection of materials for use in the dry season ought to be stepped up at the Mae Jo Agricultural Experiment Station (in the dry season) and at the Srisamrong Agricultural Experiment Station (in the rainy season). In F_2, 1,500-2,000 plants will be grown in a bulk population and a moderate selection

Table IV-8. Selection schedule of promising material (combination) by Bulk method for the variety to the rainy season

Year	Season	Generation	Selection schedule						Yield trial		Remark
			Planting			Selection					
			Fam.	Lines	Plts.	Fam.	Lines	Plts.	P.Y.T*	R.Y.T**	
1	dry										
	rainy	Crossing									
2	dry	F_1									
	rainy	F_2			1500-2000			800-1000			mass
3	dry	F_3			1500-2000			800-1000			mass
	rainy	F_4			1500-2000			500			mass
4	dry	F_5			1500-2000			800-1000			mass
	rainy	F_6			1000-1500			200-300			
5	dry	F_7		200-300			100-150	(mass)			
	rainy	F_8		100-150			10-15	50-65			
6	dry	F_9	10-15	50-65		5-6	10-12	50-60	10-15		
	rainy	F_{10}	10-12	50-60		2-3	4-6	20-30	5-6		
7	dry	F_{11}	4-6	20-30						2-3	

Notes: 1) Place of selection : Mae Jo Agr. Exp. Sta.
2) Planting density of population : 50 cm x 20 cm, 1 plt/hill
3) P.Y.T.* = Preliminary yield test, R.Y.T.** = Regional yield trial

Table IV-9. Selection schedule of promising material (combination) by Bulk method for the variety to the dry season

Year	Season	Generation	Selection schedule						Yield trial		Remark
			Planting			Selection					
			Fam.	Lines	Plts.	Fam.	Lines	Plts.	P.Y.T*	R.Y.T**	
1	dry										
	rainy	Crossing									
2	dry	F_1									
	rainy	F_2			1500-2000			800-1000			mass
3	dry	F_3			1500-2000			800-1000			mass
	rainy	F_4			1500-2000			800-1000			mass
4	dry	F_5			1500-2000			500			mass
	rainy	F_6			1500-2000			800-1000			mass
5	dry	F_7			1000-1500			200-300			
	rainy	F_8		200-300			100-150	(mass)			
6	dry	F_9		100-150			10-15	50-65			
	rainy	F_{10}	10-15	50-65		5-6	10-12	50-60	10-15		
7	dry	F_{11}	10-12	50-60		2-3	4-6	20-30	5-6		
	rainy	F_{12}	4-6	20-30						2-3	

Notes: 1) Place of selection : Mae Jo Agr. Exp. Sta. (dry season) and Srisamrong Agr. Exp. Sta. (rainy season)

2) Planting density of population : 50 cm x 20 cm 1 plt/hill

3) P.Y.T.* = Preliminary yield test. R.Y.T.** = Regional yield trial

will be performed in respect of the plant type, vigorousness of the growth, pod setting, maturity, etc. About three pods will be taken out of 800-1,000 selected plants to prepare mixed seeds. The subsequent F_3 coincides with the dry season, and a moderate selection will be performed on the aforementioned characteristics. As downy mildew is seen breaking out in or around the flowering period, the plants heavily affected by this disease will be pulled out, even if they are still in growth, and the selected plants should be left in the field for a certain period after their maturity to observe the degree of shattering and if the shattering is excessive, the plants should be abandoned. The same treatment will also be made in F_4 as is F_2, but there will be a need to bring their maturing periods in line with each other to perform a strict field selection of the plants resistant to shattering in the following generation (for a raise in the accuracy of the selection), that is, an attempt should be done to select plants matured within the desired maturing period. Even in cases where excessive lodging is observed in the rainy season, the growth may be highly evaluated for the dry season. Therefore, it is advisable to step up the selectionin such a manner that the plants which are inferior in growth will be abandoned. As F_5 coincides with the dry season, a more strict selection should be stepped up than in the previous dry season in respect of resistance to downy mildew and to shattering and other characteristics, and about five pods will be taken out of the 500 plants which are selected in the field so as to produce mixed seeds. The plants with smaller seeds and worse in quality scores will be eliminated. In F_6, the treatment will be the same as in F_4, but about five pods will be taken out of the selected 800-1,000 plants and those with smaller seeds will be eliminated. In the rainy season, a selection will not be made on the quality. In F_7, 1,000-1,500 plants will be grown. While carrying out a strict selection in respect of resistance to downy mildew and to shattering and also giving consideration to other general characteristics, about 400 plants will be harvested in field. For each plant, a strict selection will be performed in respect of the seed yield, seed size, quality, etc., after threshing to reduce them to 200-300 best plants.

The aforementioned cases are none other than a few examples. In general, there are many cases where a fewer number of plants are selected from a bulk population. When it is taken into consideration that the control of breeding fields is not adequate and that there is difference in yield, depending on the soybean cropping season, it is decided to select a larger number of plants. In any event, the method of preparing or selecting a bulk (including bulk planting) must be selected by the breeders, depending on the materials, and it might be said that this is a key to the success.

10. Derived Line Method and its Application

In the derived line method, subsequent generations are grown as lines after the selection of individual plants in the early generation; after fixation of each bulk line (derived lines) for practical characteristics without carrying individual selection within each line as in the case of pedigree breeding, the individual selection is conducted in a later generation, such as in F_5 or F_6, and the lines are bred to select excellent lines. It might be said that this method incorporates characteristics of the pedigree method in the sense that the selection is performed in respect of characteristics featuring a high heritability in the early generation, and also that it incorporates characteristics of the bulk method in the sense that bulk breeding is later performed over a certain period. In the derived line method, such an exceedingly large number of lines as in the case of pedigree method are not treated, nor is there any need for as large area as in the case of bulk breeding. In no cases will the breeding period become longer.

Frey (1954) carried out plant selections in F_2 and advocated the method of repeating bulk planting for derived F_2 lines. Insofar as soybeans are concerned, there are cases, judging from the writers' experiences, where the F_2 derived lines would be meaningless, depending on the combination, as there are too big segregations within each line. Depending on the combination, it would be more appropriate to use the derived progeny from F_3 or F_4 than from F_2

Table IV-10. An example of the modified derived-line method in a close combination which aims the rainy season type of variety

Generation	Season	Number of families to be grown	Number of lines to be grown	Number of lines to be selected	Number of plants to be selected	Other procedures
Crossing	Rainy	-	* 100	-	-	
F_1	Dry	-	** 15 - 20	-	-	
F_2	Rainy	-	** 1500 - 2000	-	150 - 200	
F_3	Dry	-	150 - 200	140 - 180	-	Each line is harvested in bulk
F_4	Rainy	-	140 - 180	50 - 60	-	do
F_5	Dry	-	50 - 60	50 - 60	-	do
F_6	Rainy	-	50 - 60	10 - 12	50 - 60	Yield tests start
F_7	Dry	10 - 12	50 - 60	50 - 60	-	Each line is harvested in bulk
F_8	Rainy	10 - 12	50 - 60	2 - 3	10 - 15	
F_9	Dry	2 - 3	10 - 15	10 - 15	-	Each line is harvested in bulk
F_{10}	Rainy	2 - 3	10 - 15	1 - 2	5 - 10	Purity test

Notes: * Number of flowers to be pollinated.

** Number of plants

Here, an attempt will be made to touch upon the practical procedure for the application of the derived line method and the points about which care must be exercised in respect of the breeding materials of the soybeans crossed in Thailand in the rainy season. First an example of the application of the derived line method to a combination which has close parents of crossing for the rainy season type of varieties are shown in Table IV-10.

The segregation of such close combination is not big even in early generation, and the fixing generation is relatively early in respect of yield component characteristics. In this instance, individual selections will be carried out in F_2 which coincides with the rainy season. The selections will be made in regard to the maturity, plant height, seed size, quality, resistance to rust, etc. In F_2, a combination of 1,500-2,000 plants will be planted to select about 10%.

In F_3 which coincides with the dry season, no selections will be made, and the bulk planting of each line will be performed. The lines and plants with particularly inferior characteristics should be eliminated.

In F_4 which coincides with the rainy season, a forced selection should be carried out in respect of the maturity, plant height, seed size, resistance to rust as well as pod setting and resistance to lodging. The seed contents will be analyzed and a selection will be performed in respect of the contents to reduce the number to 50-60 lines in the F_4 generation. In F_5, the bulk planting of each line will be conducted as in the case of F_3.

As it is observed tht the yield characteristics will be practically fixed in F_6 which coincides with the rainy season, pedigree and individual selections will be carried out. For promising lines, yield tests will be started in this generation. In F_6, 10-12 lines will be selected while giving consideration to the results of the yield tests.

In F_7 and F_9 which coincides with the dry season, bulk planting will be done for each line and forced selections will be carried out in F_8 and F_{10} which coincide with the rainy season. In the end, the most promising one or two lines will be selected as a potential new variety or varieties.

Secondly setting the goal at a variety for use in the rainy season, an attempt will be made to explain, as is shown in Table IV-11, the cases in which combinations of parents with distant relationships are selected by means of derived line method.

For combinations in distant parents for relationships, the segregation is big in the early generations, and the fixing generation is relatively late, so that the bulk planting of F_2, F_3 and F_4 will be carried out. In F_4 which coincides with the rainy season, individual selections will be performed. In F_2 and F_3, however, it is advisable to eliminate plants with particularly inferior characteristics to raise the efficiency of the selections.

In regard to the procedure for the F_5 and subsequent generations, the steps will be taken at a pace two generations behind combinations of parents with close relationships, so that the selection of the final promising lines will also be two generations behind.

The foregoing represents the procedure for selections with the goal set at the breeding of varieties for cropping in the rainy season. In the event that the breeding of varieties for cropping in the dry season is targeted, individual selections will be carried out in F_3 for

Table IV-11. An example of the modified derived-line method in a distant combination which aims the rainy season type of variety

Generation	Season	Number of families to be grown	Number of lines to be grown	Number of lines to be selected	Number of plants to be selected	Other procedures
Crossing	Rainy	-	* 100	-	-	
F_1	Dry	-	** 15 - 20	-	-	
F_2	Rainy	-	** 1500 - 2000	-	-	Discard of undesirable plants
F_3	Dry	-	** 1500 - 2000	-	-	do
F_4	Rainy	-	** 1500 - 2000	-	150 - 200	
F_5	Dry	-	150 - 200	140 - 180	-	Each line is harvested in bulk
F_6	Rainy	-	140 - 180	50 - 60	-	do
F_7	Dry	-	50 - 60	50 - 60	-	do
F_8	Rainy	-	50 - 60	10 - 12	50 - 60	Yield test start
F_9	Dry	10 - 12	50 - 60	50 - 60	-	Each line is harvested in bulk
F_{10}	Rainy	10 - 12	50 - 60	2 - 3	10 - 15	
F_{11}	Dry	2 - 3	10 - 15	10 - 15	-	Each line is harvested in bulk
F_{12}	Rainy	2 - 3	10 - 15	1 - 2	5 - 10	Purity test

Notes: * Number of flowers to be pollinated

** Number of plants

combinations of parents with close relationships, and the generations up to F_7 will be made F_3 derived lines. For combinations in distant relationships, individual selections will be conducted in F_5 and the generations up to F_9 will be maintained as F_5 derived lines. Other steps are practically the same as in the cases where the breeding of varieties for cropping in the rainy season is targeted. In the event that the goal is set at the breeding of varieties for cropping in the dry season, the period of individual selections will be one generation behind the cases where the breeding of varieties for cropping in the rainy season is targeted. If parents are planted in the beginning of April and crossed seeds are harvested in the end of July, it will be possible to plant F_1

in the beginning of August and harvest F_1 seeds by the following dry season, thus giving rise to the possibility of carrying out selections in an accelerated generation.

In the foregoing, reference has been made to the procedure for selections with the application of the derived line method for the breeding of soybeans in Thailand. The use of this method is not so widespread as the pedigree method and the bulk method. Judging from the facts that the cultivation of soybeans in Thailand is done both in the dry and rainy seasons, that there has been an increase in the number of combinations of parents with close relationships at the Mae Jo Agricultural Experiment Station and that the derived line method makes it possible to save manpower and area of the breeding field, the writers believe that the use of the derived line method is worthwhile as one way of breeding soybeans in Thailand.

CHAPTER 5. SUGGESTIONS FOR POLICY ON SOYBEAN BREEDING IN THAILAND

1. Establishment of Breeding Objectives

The breeding of new varieties with mutation or introduced varieties as well as hybridization breeding requires a long time and much labor and cost. Therefore, breeding objectives should be carefully set in a socioeconomic perspective. It is only natural that the breeding objectives should be endorsed by a national policy.

1) Establishment of Breeding Objectives for Supply and Demand of Soybeans

a. Domestic Demand

The immediate purpose for a raise in the production of soybeans in Thailand should be to satisfy the domestic demand. At present, emphasis is put on the soybeans as an oil resource. When consideration is given to the future course of livestock, freshwater and salt-water fish in Thailand, however, there seems to be a need to put more stress on the production of soybeans as a source of protein other than oil. For this purpose, it is necessary to give special insight to the utilization of soybean protein in food at a national level.

b. Exports

When the possibility of soybeans taking the place of rice, maize, cotton, kenaf and other export products, the improvement of visible characteristics, such as the size and shape of seeds, color of the seed coat and hilum, and the chemical components will be important breeding objectives.

2) Establishment of Breeding Objectives for Cultivating Conditions

a. Cultivating Regions

At present, emphasis is put on the cultivation of soybeans at Sukhothai and Chiengmai, but efforts will be made for the propagation of soybeans in the northeast region in the future, so that there will be an need to accelerate the breeding of varieties suitable for the northeast region. In this instance, it will be necessary to pay heed to its climatic conditions as well as the adaptability of these varieties to the inferior soil of the northeast region.

b. Cropping Season

At present, the breeding objectives are separated for the dry and rainy seasons. The separation is an appropriate step in that there is much difference in characteristics required between the varieties of both seasons. In the future, however, there will be a need to further raise the environmental adaptability of the varieties that should be bred and also to breed the varieties which may be cultivated in both seasons.

d. Relationship with Other Crops

In cultivating soybeans, there is a need to pay heed to their relationship with other crops. In the province of Sukhothai, there are many cases in which the intercropping of maize and cotton is done with soybeans. In actuality, the cultivation of soybeans is begun in the early and late days of the rainy season. The lodging and drought resistance which is fitted to these conditions will also be a breeding objectives.

e. Mechanization

In the cultivation of soybeans in the province of Sukhothai, the shifting from the working system making use of manpower and cattle power to the working system using hand tractors and large tractors already began to put into use. As it is anticipated that harvesting and threshing will be mechanized in the near future, there will arise a need for the selection of varieties whose characteristics are fitted to the mechanization.

f. Fertilizer and Chemicals

As long as circumstances permit, it is desirable to refrain from using fertilizer and chemicals as much as possible, but it is necessary to make use of them in the minimum quantity to raise the yield and better the quality. For the inferior soil of the northeast region, it is an urgent task to breed the varieties whose root nodule bacteria is easy to set. Even with the limited use of fertilizer, it is desirable to breed varieties whose yield there will be not so decrease. As the use of pesticides is minimized, one of the major breeding objectives will be to breed varieties resistant to diseases and insects.

g. Readiness of Cultivation for Fermers

The satisfaction of the conditions to which reference has thus far been made will not necessarily lead to the widespread use of varieties. For practical widespread use by farmers, it is important to foresee the varieties which are readily cultivable by farmers - the varieties whose yield is stable and for which the work is not complicated -- with few changes under various conditions.

2. Organization and System for Breeding

1) Overall Grasping and Liaison and Coordination by Department of Agriculture

In the existing system, it is only natural that the Department of Agriculture should hold itself responsible for establishment breeding objectives, making decisions on organization, system and budget and adjusting the liaison. Even in this case, however, such decisions should be made while fully incorporating the views of the breeders who actually take charge of breeding projects and also the conclusions drawn from the discussions in which they actually take part. It might be said that whether or not a breeding project may come to a successful end depends on whether it is possible to prepare the conditions in which these breeders may enthusiastically work.

2) Breeding Centers

It is desirable to set up breeding centers at the places which are the major producing center of a given crop. It is necessary that the testing environment is suitable for the selection of varieties and their breeding. To compensate for whatever the breeding centers cannot cover, there is hardly any need to point out the necessity of test nursery for selections in other areas, regional tests and adaptability tests to special conditions.

With a full understanding about the relations between these tests, the breeding centers must grasp the flow of these tests and step up breeding projects in a smooth manner. For example, the materials to be used in a regional yield test must be the ones selected in the previous preliminary yield tests, and there is a need to trace back to the pedigree and individual selections. As they are tied in with one another, it is necessary to have a full understanding about their mutual relations. The promising strains involved in a regional yield trial are also tested at other agricultural experiment stations, and the tests are under way in parallel with tests on the uniformity of the strains, resistance to diseases and insects, planting density, amount of fertilizer application and planting period as well as the multiplication of seeds, so that there is a need to coordinate all these movements.

3) Liaison Tests and Cooperation System

The breeding project is not something which could be done by a breeding center alone. The wide tests conducted with the cooperation of other experiment institutions, such as regional tests, adaptability tests to special conditions, yield tests on farmers' fields and seed multiplication, is indispensable. The persons who take charge of these tests should fully understand the purposes of these tests, keep close liaison with the breeding centers and upgrade the accuracy of the tests. In the tests thus conducted, a full evaluation should be made and the opinions of the men in charge of the tests should be reflected.

4) Stock Seed Multiplication System

For the multiplication of a given variety, the most important thing is to maintain its seeds. Even though the soybean is a selfing crop, natural crossing and a mechanical seed mixture is inevitable. For the maintenance of seeds pure and good in quality, there is a need to establish an stock seed multiplication system. As the stock seed multiplication project is closely tied in with the breeding project, an attempt should be made for their closer coordination.

3. Breeding in Practice

1) Breeding Fields

a. Scale

It is necessary for the breeding centers to keep enough area of test fields for the sake of the future as long as circumstances permit. At the same time, efforts should be made for the uniformity of soil fertility as far as practicable, and no efforts should be spared for a raise in the accuracy of the tests.

b. Crop Rotation

The consecutive planting of the same upland crop gives rise to the incidence of insect and disease damage and reduces the soil fertility. At breeding test fields, crop rotation should be thought of while particular attention is focussed on the upgrading of the soil fertility.

c. Irrigation Facilities

It is gratifying to note that irrigation facilities are fully equipped to the breeding centers and that tests may be conducted in the dry season even at other institutions. It is desirable that tests be carried out at all institutions both in the dry and rainy seasons. Even in the rainy season, there is much difference in precipitation and rainy time, thus hampering the breeding tests in many cases. Consequently, the availability of an irrigation facility should be made an indispensable condition.

d. Labor Saving

As the breeding scale is expanded in the future, it is only natural that there should be a rise in labor and cost. In preparation for this development, there is a need to think seriously of labor saving in respect of field work, control and surveys. For this reason, the wisdom and opinions of the men in charge of the actual work should be fully reflected and the projects of other countries referred to come up with a labor saving program fitted to the realities of a given area.

2) Breeding

a. Improvement of Breeding Methods

Up to now, the breeding of varieties has been stepped up with emphasis put on the pedigree breeding method, but it is anticipated that the number of breeding objectives will increase and the breeding scale will growingly expand in the future. For this reason, it is necessary to adopt a breeding method effective for the characteristics related in the breeding objectives and to devise methods attuned to the availability of manpower and the budget scale. In many cases, the bulk methods will be of much effect for selections on varieties with characters low in heritability and resistance to diseases and insects by means of natural selection.

b. Reasonable Preservation of Introduced Varieties

Up to now, many varieties and lines have been introduced from foreign countries and planted on a trial basis. Varieties are preserved for three purposes -- to preserve the seeds of these varieties, observe and survey their characteristics and select from them those which may be used parents for crossing. It would be excessive in terms of labor and other costs to plant and survey many varieties and collect their seeds in every season. For this reason, there is a need to update the observation and survey data to assure their usability at all times and to minimize the number of varieties to be planted in every season as far as possible. In this instance, it will be necessary to preserve the seeds in such a state as will assure a sustainable germinating ability The use of a card system is of effect in sorting out varieties.

When an attempt is made to select from the introduced varieties an effective variety fitted to Thailand, their comparison should be made with the promising strains from hybridization breeding in one and the same test area. Separated testing would not only require a spacious test field and much labor but also result in bringing about errors in the judgment of the selections.

c. Appellation of Breeding Lines

For the past promising breeding lines, the line number which includes the combination number and the line number in each generation has been given to indicate the selection process. The method is used for the persons engaged in the actual selection, but there are many cases in which they prove too complicated and therefore inconvenient for liaison tests and others. To make up for this, it is desirable that a selection name and a simple line number (a serial number, if possible) is given to indicate the line when the breeding materials are used in a preliminary yield test.

d. Method for Planting of Breeding Materials

For the breeding of varieties, a cultivation method close to that which is employed by farmers should be employed. A case in point is row spacing. At Sukhothai in the rainy season, the row spacing is 75-100 cm even when no intercropping is carried out by farmers. If it is assumed that intertillage will be conducted with large tractors in the future, it will be effective to cultivate and select soybeans with such a row spacing as will facilitate the intertillage. It is only natural that the varieties which are selected and tested in the conditions which are close to the actual cultivation of farmers are readily acceptable by farmers.

e. Indication of Measured Values

Measured values should be indicated in such a manner as may be readily understood and statistically analyzed. An example of the former is the indices of the yield for standard varieties and those indicating the grain quality. Examples of the latter are the susceptibility index and the lodging index, which make it possible to carry out a statistical analysis with the indices prepared according to a prescribed standard.

4. Qualitative Upgrading of Breeders

1) Breeders' Opinion

The correct judgement on the part of breeders actually working on the fields is indispensable for the achievement of good breeding results. It is very important to pay full heed to the decisions and views of the researchers who take charge of various experiments at the agricultural experiment stations. In this manner, they will develop a greater sense of responsibility and take a greater interest in breeding.

2) Self-learning

For the qualitative upgrading of breeders, it is important for them to accumulate much experience, check literature by themselves and deepen their knowledge about breeding. By so doing, it will become possible for them to work out a test design by themselves, carry out the test, sort out and assess its results and drawn a legitimate conclusion.

For the upgrading of breeders, it is indispensable to update the conditions for self-learning -- that is, the place, time and environment of learning.

3) Training

In addition to self-learning, it is necessary that breeders should be given chances to take part in seminars with other researchers and study both at home and abroad.

5. Experiments and Studies Associated with Breeding

To step up breeding in a more effective manner, it is necessary to simultaneously step up research in many related fields.

1) Physiology and Ecology of Soybeans

The physiology and ecology of soybeans constitute the basis for their breeding, so that it is desirable to carry out research work in parallel with or prior to breeding. Particularly, it is important to conduct studies on the growth reactions to the climate and area and on the characteristics of varieties.

2) Maintenance of Seed Germinating Ability

Under Thailand's climate conditions of high humidity and temperature, the fact that the seed germinating ability diminished over a short period of time is an extremely important problem in the step-up of breeding as well as in actual cultivation by farmers. It is strongly required to find practical methods for seed preservation.

3) Root Nodule Bacteria

Of all the amount of nitrogen required by soybeans, 70% is described as being fixed by root nodule bacteria. For this reason, it is only natural that the utilization of root nodule bacteria and the upgrading of their activity should be tied in with a raise in seed yield. In the northeast region of Thailand, problems are posed in respect of the non-setting of root nodules, so that their solution is of particular importance. It is an urgent task to study the compatibility of root nodule bacteria and varieties and the soil conditions which will raise the nitrogen fixing capacity of root nodule bacteria.

4) Various Insects and Diseases

In proportion to an increase in the cultivation area of soybeans, it is surmissable that there will be a rise in the damage caused by insects and diseases. No time should be lost in striving to find solutions in respect of their generation, control and the method of selecting resistant varieties.

CONCLUSION

I. Expectations on Thai Soybean Breeders

As six years or so have passed since Japanese soybean breeders and Thai soybean researchers got together for the first time at the Mae Jo Agricultural Experiment Station in the rainy season of 1970 in planting soybean breeding materials, the new variety 'SJ-4' is to be determined. This is an achievement of the collaborative research work of both Thai and Japanese researchers, and we wish to share the pleasure with our Thai colleagues.

Things have developed to a point where a new variety is to be bred, to be sure, but when viewed in a long-range perspective of the breeding of soybeans in Thailand, it might be said that the first step has been taken in that direction. The technical cooperation between Thailand and Japan has come to an end, but there remain many problems that have yet to be solved by Thai soybean breeders in the future, and high hopes are pinned on a great advance forward for the increased production of soybeans in Thailand. More than 50 years have passed since the hybridization breeding of soybeans was initiated at Japanese agricultural experiment stations. In the meantime, a large number of varieties have been bred, but breeding tests are still carried on in an attempt to breed from them the varieties which will be higher in yield and better in quality.

The task of breeders designed primarily to improve crop varieties is unpretentious -- a time and labor consuming task they have to accomplish, being wet with sweat and stained with mud. Besides, the breeding is not given due social credit in many countries. And yet we are highly proud of being soybean breeders.

In the past global development of agriculture, no one could deny the fact that the role played by the improvement of crop varieties has been exceedingly important. For a raise in the production of food in tropical agriculture, the improvement of crop varieties is one of the most effective agricultural technologies.

With new crop varieties widely disseminated, there will be no special outlays on the part of farmers in accepting them. It might also be said that the development will neither disrupt the natural environment nor give rise to environmental pollution. The life of people in the tropical zone is closely tied in with nature. For example, the river water is used for bathing and laundry and sometimes for cooking. And river fish are important side dishes for dinner. Tropical agriculture couldn't sustain itself in utter disregard of these essentials.

There has been a rapid rise in the production of soybeans in Thailand in recent years, but their production is still behind that of rice, maize and other products. The Thais do not take in much soybean food. As protein accounts for 40% of the soybean seed and oil 20%, no other farm products could stand comparison with soybeans in terms of nutrition. They say that soybeans could become a crop which would save the world from a famine.

It is our sincere hope that the Thai soybean breeders will also take pride in their soybean breeding work wet with sweat and stained with mud and continue to work for the further development of soybeans in Thailand, aiming at the breeding of 'SJ-5' and 'SJ-6' greater in yield and better in quality than the 'SJ-4'.

2. Acknowledgement

The project for cooperation in the development of soybeans in Thailand, which was started with a survey in 1968 and in which the dispatch of experts began in April 1970, came to an end in April 1976 with successful achievements in six years.

The project started with a great pomp. After going through a long period of steady and hard efforts, the project came to a brilliant end, as the production of soybeans in Thailand had increased about five times the output registered at the outset of the project and as 'SJ-4', Thailand's first hybridized soybean variety, could be released.

Availing ourselves of this opportunity, we wish to express our most sincere appreciation to all the parties concerned both at home and abroad for their enthusiastic encouragement in each phase of the cooperation period as well as the related officials of the Ministry of Foreign Affairs, Ministry of International Trade and Industry and Ministry of Agriculture and Forestry and the Thai experts associated with this project for their warm support. Many thanks are also due to the Japan International Cooperation Agency's headquarters and Bangkok office and the Japanese Embassy in Bangkok, which closely collaborated with us in stepping up the project for cooperation in the development of soybeans in Thailand. At the same time, we wish to share our deep gratitude at the completion of the cooperation project with them.

In association with the project for cooperation in the development of soybeans, the friendly consideration and cooperation of the Director General of the Department of Agriculture and other Department of Agriculture officials -- particularly, M.C. Chakraphand, Phensiri Chakraphand, Dr. Phit Pamyalakashana, Dr. Bhakdi Lusanandana and Dr. Prakob Kanjanasoon, who had assume the director-generalship of the Department of Agriculture in the past; The late Dr. Samai Chareornrachata, Division Chief of Research and Experiment; and Mr. Tomya Bunyaket, Division Chief of Field Crops. This cooperation project could not have been brought to a successful conclusion without the friendly and enthusiastic cooperation rendered both publicly and privately by many of those who worked under them, such as Dr. Arwooth NaLampang, oil crops project leader; Mr. Amnuay Tongdee, Mr. Kasem Sukhaband, Mr. Sunam Laongsri and many young research staff members who are associated with research and experiment on soybeans. Mr. Chote Suvipakit, who is presently serving as Division Chief of Sericulture, was of much help to us with his friendship and fluent Japanese. We are deeply grateful that the cooperation project has come to an end with the collaboration of all these people and this general report has been finally completed.

The Japanese experts sent to Thailand under the Project for Cooperation in the Development of Soybeans in Thailand acquired many new good friends through their cooperaton activity in Thailand, provided guidance and learned many things during their assign-

ment before their return to Japan. Returning to their respective posts, they are now devoting themselves to experiment and research for the breeding and cultivation of soybeans in Japan with their broadened knowledge. And they are taking a strong interest in the moves associated with the production, experiment and research of soybeans in Thailand. It is our sincere hope that the young Thai staff with whom we worked will make full use of their acquired technology in the manner best fitted to Thailand and overcome all difficulties to make their appearance in the future in their attempt to work for a further step-up of the production of soybeans in Thaialnd.

The Project for Cooperation in the Development of Soybeans in Thailand officially came to an end in April 1976, but we are hopeful that private perpetual cooperation may last between both countries for a development of the production, research and experiment of soybeans. It is our sincere hope that we will able to keep good company with our Thai colleagues in the future.

Note: The following individuals were engaged in writing this general report:

Shoshin Konno --	§1. §2, 1 ~ 2·2). Conc. 2. Generation.
Takashi Sanbuichi --	§2, 2·3). §3, 1 ~ 4·1). §4, 1 ~ 4, 10. Conc. 1.
Koichi Sasaki --	§3, 4·2) ~ 4·5). §4, 5 ~ 9.
Masataka Saito --	§5.

SUPPLEMENTARY ILLUSTRATIONS AND PHOTOGRAPHS

Table VI-1. Trend of production and export of soybeans in Thailand

Year	Planted area 1000 ha	Production 1000 tons	Average yield t/ha	Export tons
1962	28	30.0	1.08	1,909
1963	34	33.0	0.98	4,401
1964	34	31.3	0.92	4,285
1965	19	19.1	1.19	1,610
1966	46	37.9	0.83	5,608
1967	64	52.8	0.83	5,897
1968	53	44.8	0.85	3,552
1969	48	48.2	1.01	5,018
1970	59	50.4	0.86	6,290
1971	57	54.3	0.94	6,099
1972	80	72.0	0.90	7,240
1973	143	152.3	1.07	13,715**
1974	161*	188.3*	1.17*	8,610**

Calculated from Agricultural Statics No.33

A.D. 1975 Thailand.

* : Data from Dep. Ext. (Ministry of Agriculture and Co-operatives)

** : From 'The investor' July, 1975 (source: Dep. Customs)

Table VI-2. Soybean production in Thailand classified by province 1974 (Calculated from the data of Dep. Extension MOAC Thailand)

Province	Planted area (ha)	Yield (kg)	Average yield (t/ha)
Bangkok	2	2,250	1.13
Ayutthaya	132	181,885	1.38
Lop Buri	4,869	4,444,255	0.91
Chai Nat	725	3,829,000	
Singburi	542	5,775,500	
Angthong	382	1,911,200	
Saraburi	7,178	6,721,000	0.94
Chachoengsao	3,717	2,908,400	0.78
Nakhon Nayok	31	28,950	0.93
Prachin Buri	1,749	1,585,200	0.91
Chon Buri	26	23,850	0.92
Rayong	–	–	–
Trat	–	–	–
Chanthaburi	70	66,000	0.94
Ratchaburi	133	123,118	0.93
Nakorn Patom	17	16,850	0.99
Suphan Buri	1,724	1,939,860	1.13
Kanchanaburi	1,420	1,668,688	1.18
Phetchaburi	341	296,198	0.87
Prachuab Khiri Khan	209	238,056	1.14
Lampang	1,527	1,380,492	0.90
Mae Hong Son	1,943	2,186,100	1.13
Chiang Rai	1,547	856,680	0.55
Chiang Mai	29,988	28,113,750	0.94
Nan	318	238,140	0.75
Lamphun	602	677,160	1.12
Phrae	2,086	1,822,240	0.87
Phitsanulok	3,229	3,914,622	1.21
Sukhothai	58,857	77,250,390	1.31
Tak	2,566	3,493,380	1.36
Kamphaeng Phet	4,032	3,780,000	0.94
Phichit	702	701,600	1.00
Phetchabun	18,984	29,633,000	1.56
Nakhon Sawan	4,375	4,634,260	1.06
Uthai Thani	202	233,490	1.16
Uttaradit	4,639	4,841,998	1.04

Province	Planted area (ha)	Yield (kg)	Average yield (t/ha)
Nakhon Ratchasima	1,071	1,177,526	1.10
Chaiyaphum	250	208,940	0.84
Buri Ram	55	55,920	1.04
Surin	–	–	–
Si Sa Ket	16	20,000	1.25
Ubon Ratchathani	65	48,480	0.75
Udon Thani	196	191,977	0.98
Nong Khai	38	47,400	1.25
Loei	1,308	2,124,980	1.62
Sakon Nakhon	58	43,560	0.75
Nakhon Phanom	33	20,600	0.62
Khon Kaen	141	98,395	0.70
Maha Sarakham	–	–	–
Roi Et	19	10,320	0.54
Kalasin	26	20,770	0.80
Nakhon Si Thammarat	34	23,760	0.70
Chumphon	36	31,594	0.88
Surat Thani	66	65,240	0.99
Ranong	6	6,000	1.00
Krabi	–	–	–
Phangnga	1	1,250	1.25
Phuket	–	–	–
Songkhla	104	78,120	0.75
Trang	4	2,000	0.50
Phathalung	–	–	–
Satun	–	–	–
Pattani	–	–	–
Yala	–	–	–
Narathiwat	9	5,092	0.58
Total	160,761 (1,004,757 rai)	188,323,386	1.17 (187.43 kg/rai)

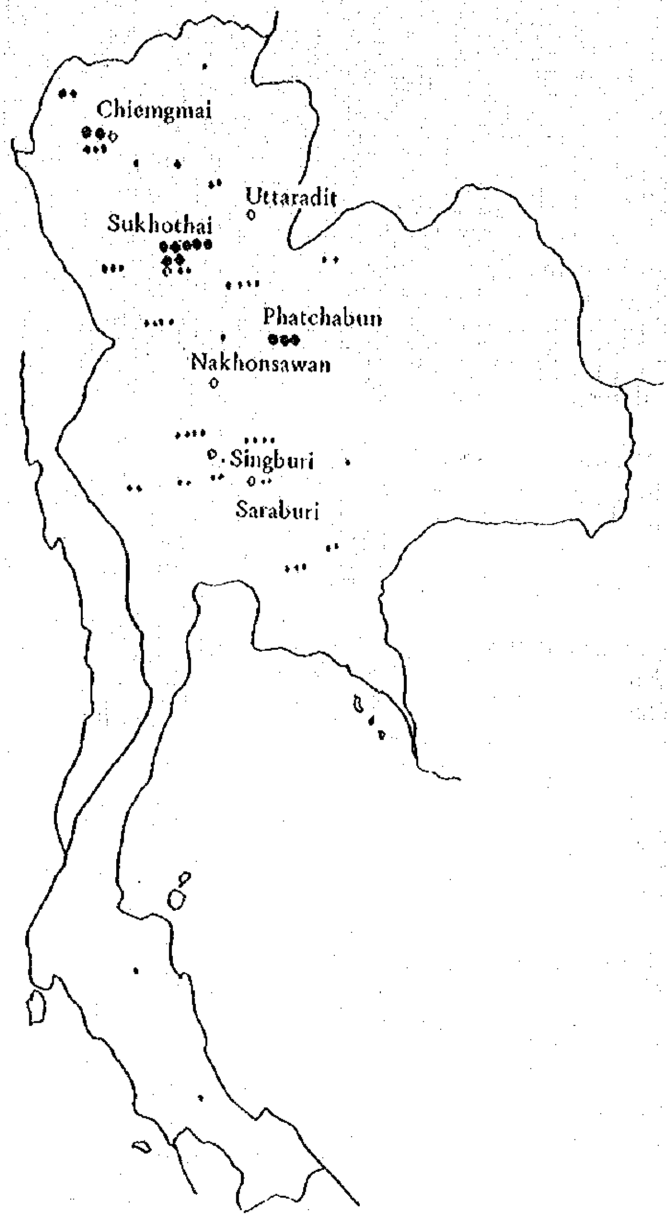


Fig. VI-1. Main soybean producing area in Thailand (1974)

• : 10,000 t
o : 5,000 t
• : 1,000 t

Photo 1. Ceremony for the delivery of machinery with the presence of the Thai Minister of Agriculture and the Japanese Ambassador. Bangkok, June 29, 1970.

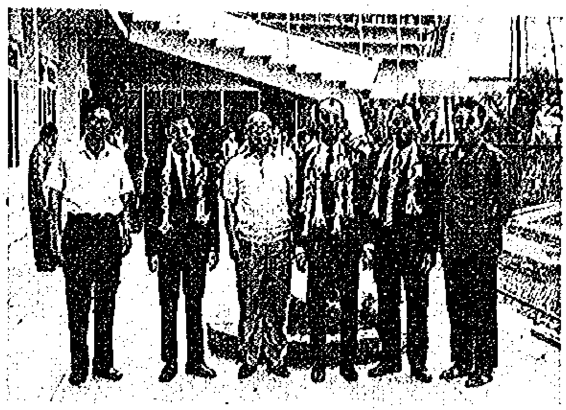


Photo 2. The first group of Thai trainees with dispatched Japanese experts. June, 1971.

Photo 3. Rainy season soybeans in Sukhothai. Swankalok, June, 1971.

Photo 4. Rainy season soybeans and the making of rows for cotton intercropping in Sukhothai. Swankalok, July, 1973.

Photo 5. Harvesting of rainy season soybeans in Sukhothai. Intercropped cotton is visible. Swankalok, August, 1971.

Photo 6. Effects of fertilizer application to soybeans at a farmer's field, Khon Kaen, May, 1971.

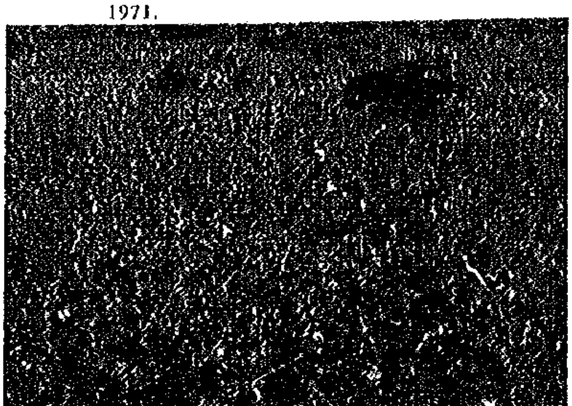


Photo 7. Rainy season soybeans in the maturity in Chiengmai. Mae Fak, September, 1973.

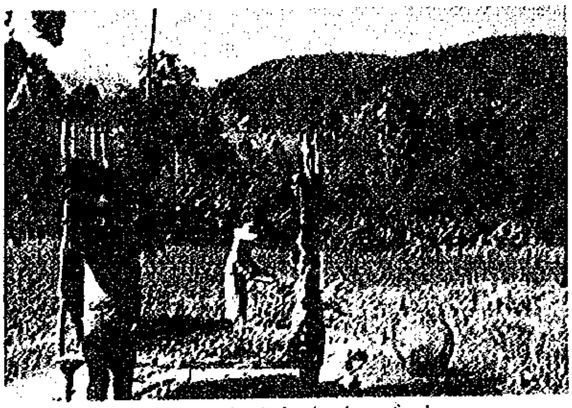


Photo 8. Threshing and wind selection of rainy season soybeans in Chiengmai. Mae Fak, September, 1973.

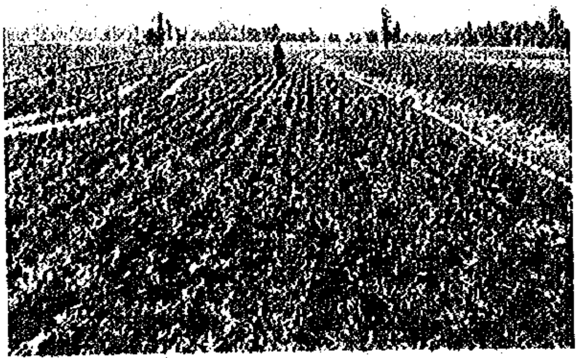


Photo 9. Dry season soybeans in Cheingmai. Sanpatong, January, 1976.

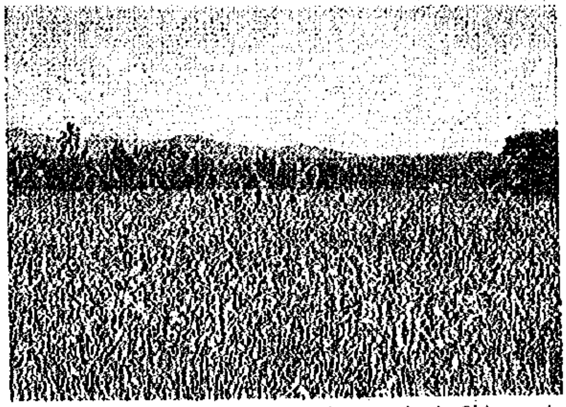


Photo 10. Dry season soybeans in the maturity in Chiengmai. Mae Rim, April, 1970.

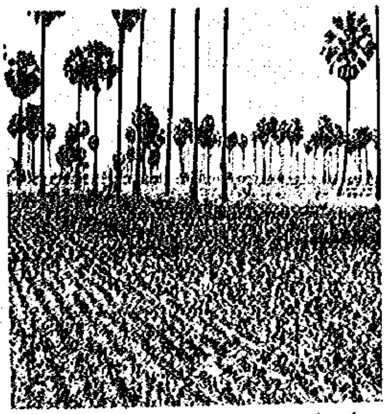


Photo 11. Dry season soybeans in Chainat for the production of green soybeans. January, 1976.

Photo 12. Mae Jo Agricultural Experiment Station where dispatched Japanese experts stationed. Chiengmai, San Sai, Mae Jo, March, 1976.

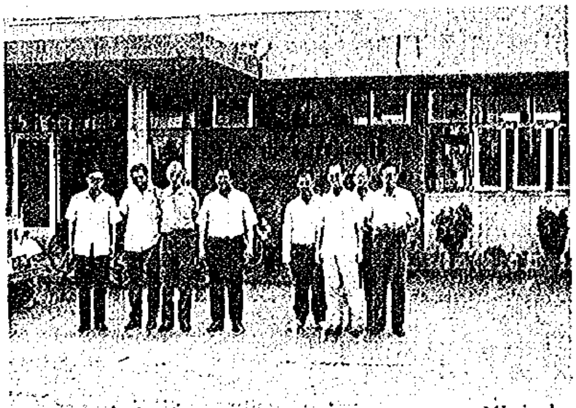


Photo 13. The first Circuit Guidance and Survey Mission's visit to the Mae Jo Agricultural Experiment Station. August, 1971.

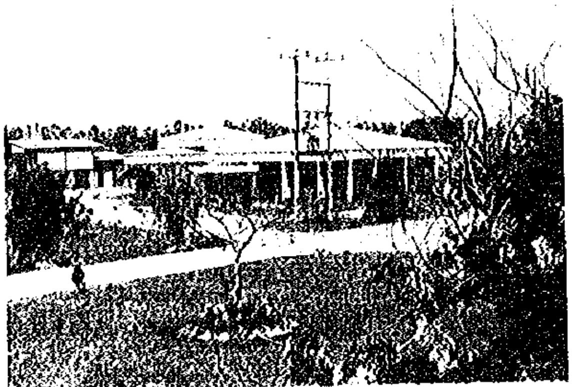


Photo 14. Soybean Laboratory in the Mae Jo Agricultural Experiment Station. March, 1976.

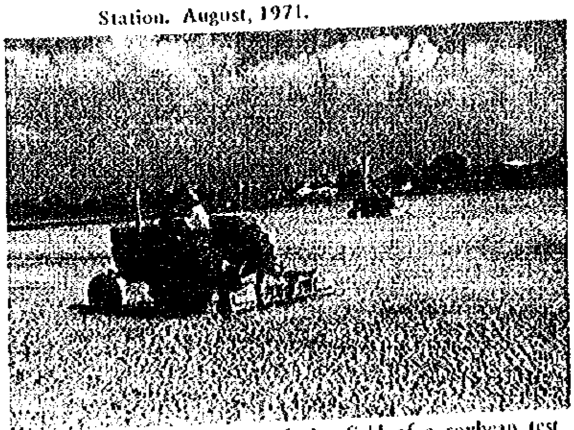


Photo 15. Soil preparation of the field of a soybean test ground with a tractor supplied from Japan. Mae Jo, January, 1976.

Photo 16. Ridging at a test field. Mae Jo, January, 1976.

Photo 17. Planting of soybeans at a test field, Srisamrong, June, 1973.

Photo 18. Planting at a test field. Srisamrong, June, 1973.

Photo 19. Fertilizer application and hilling at a test field. January, 1976.

Photo 20. Irrigation to a test field. January, 1976.

Photo 21. A review of the tests with the Circuit Guidance and Survey Mission (3rd). Mae Jo, March, 1975.

Photo 22. A review of the tests. Mae Jo, January, 1976.

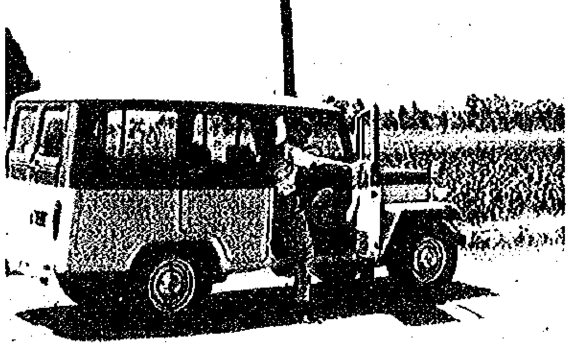


Photo 23. Jeep offered from Japan and a soybean test field. Mae Jo, February, 1976.

Photo 24. Crossing of soybeans. Mae Jo, September, 1973.

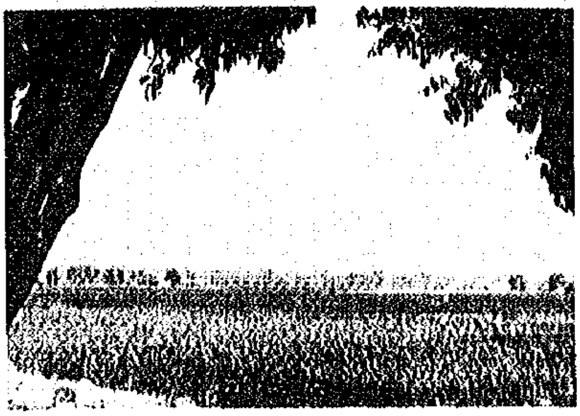


Photo 25. Dry season soybean test field. Mae Jo, March, 1976.

Photo 26. Selection scene. Mae Jo, March, 1976.

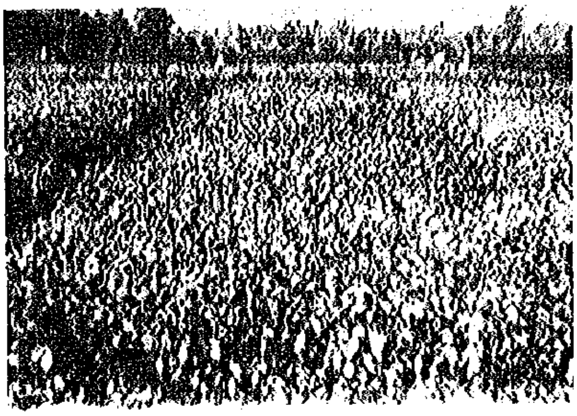


Photo 27. Regional Yield Trial. Mae Jo, March, 1976.

Photo 28. Candidate for new variety '7019 - P_2 - 49 - P_4 - 3 ... ' 'SJ-4' in growth. Mae Jo, March, 1976.

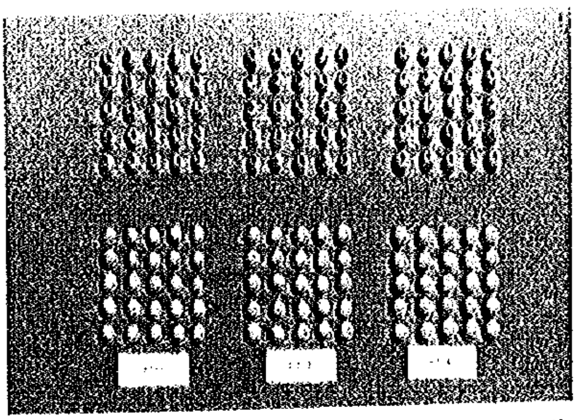


Photo 29. Grain type of the candidate for new variety 'SJ-4' and comparison with recommended varieties. From left to right: 'SJ-1', 'SJ-2' and 'SJ-4'. Mae Jo, April, 1976.

Photo 30. Plant of the candidate for new variety 'SJ-4' and comparison with recommended varieties. From left to right: 'SJ-1', 'SJ-2' and 'SJ-4'. Mae Jo, April, 1976.