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INTERNATIONAL SYMPOSIUM ON SOYBEAN IN THE TROPICS AND SUBTROPICS

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Jointly held by the Tropical Agriculture Research Center and the Asian Vegetable Research and Development Center

Proceedings of a Symposium on Tropical Agriculture Research
Tsukuba, September 26～October 1, 1983
March 1984

TROPICAL AGRICULTURE RESEARCH CENTER
MINISTRY OF AGRICULTURE, FORESTRY AND FISHERIES

Yatabe, Tsukuba, Ibaraki
305 JAPAN

Note

The International Symposium on Soybean consisted of two parts. The first part which was sponsored by the Tropical Agriculture Research Center dealt with the soybean situation in the tropics and subtropics. The second part which was organized by the Asian Vegetable Research and Development Center was centered on the cropping systems aspects of soybean.

The Proceedings published by the Tropical Agriculture Research Center cover exclusively the first part of the symposium.

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Inaugural Address

S. NAKAGAWA
Director
Tropical Agriculture Research Center

Distinguished Guests and Participants,

On behalf of the Symposium Organizing Committee of the Tropical Agriculture Research Center, I have the honor and privilege to open the International Symposium on Soybean under the cosponsorship of the Tropical Agriculture Research Center, Ministry of Agriculture, Forestry and Fisheries, Japan (TARC) and the Asian Vegetable Research and Development Center (AVRDC).

Above all, I would like to extend my cordial welcome to all the participants, in particular to those who have come over to Japan from abroad.

The Tropical Agriculture Research Center was established in 1970 with the objective of contributing to the development of agricultural technology in the tropical areas in undertaking research programs in a spirit of international collaboration. The basic principle of our research activities is to work together with overseas scientists on a partnership basis to solve technical obstacles which hamper the agricultural development of the tropical countries. The activities of the Center cover a fairly wide range of research fields such as crop production, soil fertility, plant protection, forestry, agricultural engineering, etc.

One of the major activities of the Center is to send research scientists from Japan to overseas research institutions located in the tropical countries to conduct cooperative research work in agricultural fields. About 40 staff members of the Center with long-term assignments are engaged each year in such cooperative activities in many parts of the world, mainly in the Asian countries and partly in the Latin American countries.

An other important activity of the Center is to hold international symposia for exchanging information and views among different countries and among scientists concerned. Since 1967 the symposia have been held every year, covering such subjects as crop diseases, animal production, methods of crop breeding, optimization of fertilizer effect, water management in paddy fields, silvicultural technologies, etc.

The present symposium, the seventeenth of its kind will give the opportunity to consider various aspects relating to the cultivation of soybeans. Undoubtedly, there is a growing awareness of the importance of soybean due to the remarkable versatility in the use of the crop. Indeed, soybeans with their well-balanced composition in protein, carbohydrate and lipid are processed to supply a variety of nutritious food products in several countries of Asia. Also, soybeans are a major source of edible vegetable oil for human consumption and of protein meals in animal feeds in numerous countries. Although soybeans are consumed on a large scale worldwide, it appears that in most of the countries located in the tropical zone the soybean area and production are not keeping pace with the growing demand. Since in these regions soybeans have a considerable potential as a low-cost source of protein for human needs, efforts should be made to remove some of the main constraints to their cultivation which are chiefly related to the insufficient development of suitable cultivars, high incidence of pests and diseases limiting yields and inadequate marketing structure.

I am convinced that the discussions in the present symposium will further contribute to the enhancement of research in these fields.

I sincerely hope that the symposium will be successful and that through our joint effort friendship and cooperation will be strengthened.

Thank you.

Keynote Address

G. W. SELLECK
Director General
Asian Vegetable Research and Development Center

Director General Sekiya, Director Nakagawa, Dr. Kauffman, Distinguished Participants:

It is a privilege for me to welcome you to this international symposium on soybean. My colleagues and I at the Asian Vegetable Research and Development Center appreciate your presence here and look forward to your presentations. We are also most grateful for the support of the various donors and for these excellent facilities provided by the Tropical Agriculture Research Center.

The Green Revolution, which greatly increased cereal crop production through the use of new high-yielding cultivars appears to have averted a pending world food crisis. Increased production in Asia has created a rice surplus for the first time in memory. Paradoxically, this occurs at a time of famine in several African countries.

Twenty years ago, nearly 30% of the world's population suffered from nutritional diseases (Aykroyd and Doughty, 1980). Today, despite the apparent adequacy of staple food production in the world, protein and calorie malnutrition are widespread (FAO, 1981). Even though several developing countries are now exporting staple crops, the percentage of the world's population suffering from nutritional diseases has not decreased, and this year an estimated 40 million people will die of starvation or nutrition-related diseases. In developing countries, nearly half of all children exhibit symptoms of malnutrition. The silent crisis of protein and calorie malnutrition may be denying a billion human beings of the opportunity to realize their physiological and intellectual potential (Brown, 1974).

The need for soybean is amply demonstrated by tremendous increases in world demand. Production more than doubled between 1970 and 1979, from 46.7 million tons to 94 million tons. By the year 2000 demand is expected to reach 275 million tons (Shanmugasundaram and Selleck, 1982).

It is unlikely that greater amounts of animal protein will be available to the world's poor in the near future, mainly because of high cost. In India vegetable protein sells for about US$ 0.25/kg compared with US$ 4-5/kg for mutton, chicken, and eggs (Shanmugasundaram and Selleck, 1982). Soybean can play a major role in alleviating nutrition-related diseases. In terms of its biological value and net protein utilization, soy protein is superior to corn, wheat, or rice (Table 1). Current

Table 1 Biological value of protein from selected commodities

Source	Biological value	Protein score	New protein utilization
Egg	96	100	100
Soybean	72	70	56
Corn	54	45	55
Wheat flour	53	50	52
Rice (milled)	61	—	59

world average yields of soybean are about 1.7 ton/ha. Of this amount, approximately 38% is protein, which translates into about 0.65 ton/ha. This compares with 0.27 and 0.46 ton/ha for wheat and corn, respectively (Table 2) and translates into high protein productivity in terms of kg/ha/day.

Soybean has been an important food crop in Asia for 5000 years (Ma and Zhang, 1983). This crop has made an important contribution in supplying protein and other nutrients to human diets. Aside from its uses as animal feed and as a source of oil, soybean can be consumed as texturized protein (tofu), as a whole soybean food, and as a vegetable (seeds and sprouts).

Table 2 Energy input and output relationship for selected crops per hectare in the USA

Crop	Crop yield ton/ha	Crop yield in protein ton/ha	Crop yield in food energy 10^6K cal	Fossil energy input for production 10^6K cal	Labor (man-hours)	K cal fossil energy input/ K cal protein output
Soybean	1.9	0.65	7.6	5.3	15	2.1
Corn	5.1	0.46	17.9	6.6	22	3.6
Wheat	2.3	0.27	7.5	3.8	7	3.4

Table 3 Protein productivity of major cereals and grain legumes

Crop	Estimated yield ton/ha (1)	Crop yield in food energy 10^6K cal	Protein content %	Crop duration days	Protein productivity kg/ha/day[a]
Legumes					
Soybean	1.7[c]	6.9	38	95	6.8
Lima bean	3.2	—[b]	25	115	7.0
Cowpea	1.8	—	25	80	5.6
Peanut	1.6	—	26	120	3.5
Winged bean	1.4	—	31	112	3.9
Chickpea	2.5	2.3	20	125	4.0
Mungbean	0.9	2.9	24	75	2.9
Cereals					
Rice	5.0	18.1	7.5	140	2.7
Wheat	2.3	7.6	11.9	100	2.7
Maize	4.0	14.0	9.5	120	3.2
Sorghum	3.5	11.7	10.1	110	3.2

[a] $\frac{1\times 2}{3}=4$

[b] Not available

[c] World average for 1979

The establishment of international soybean research programs marks a turning point in the history of soybean in the tropics and subtropics. At AVRDC, new cultivars with improved adaptability to tropical environments have been developed and released to farmers in India, Indonesia, Malaysia, Honduras, Sri Lanka, and Taiwan (AVRDC, 1983). During the past 10 to 15 years, breeding efforts by national programs in the tropics, i.e. Thailand, Indonesia, Brazil, and Korea, have also made significant contributions to soybean production.

The introduction of photoperiod- and temperature-insensitive, narrow-leaflet types with increased photosynthetic efficiency and improved resistance to diseases and insects further enhances production potential of soybean in the tropics (Shanmugasundaram and Selleck, 1982). Soybean yields of 2 ton/ha are attainable on farmers fields through the use of improved varieties and management practices presently available. In the future, yields of 4 ton/ha may be attainable (Shanmugasundaram *et al*., 1980).

Unlike in the temperate countries, soybean can be grown the year around in the tropics and subtropics. Furthermore, the crop can be introduced without jeopardizing the production of other staple crops. Soybean fits well into multiple cropping systems and can be intercropped with staple or plantation crops (Shanmugasundaram, 1976).

Vegetable soybean seeds and sprouts can be grown successfully even during hot, humid conditions when other vegetables are in short supply. Unlike grain soybean, vegetable soybean can be harvested during wet weather with little or no adverse effect on yield or quality.

The ability of soybean to fix atmospheric nitrogen through its symbiotic relationship with *Rhizobium* is a major advantage (Hardy *et al*., 1980). Nearly 90% of the crop's N requirement is provided through biological nitrogen fixation. In developing countries alone, nitrogen fixation resulted in savings of US$ 1.5 billion in producing the 1979 soybean crop which was valued at US$ 4.66 billion (Shanmugasundaram and Selleck, 1982).

This symposium is unique in that the discussion of production in tropical and subtropical environments will focus on cropping systems. To be successful, soybean production must be considered as a component in integrated cropping systems, modified appropriately for changing environments. INTSOY, IRRI, IITA, and AVRDC, along with various national institutions have done considerable work in this area. It is now time to review this research. What are the areas of achievement? What problems have developed? Which strategies can resolve, circumvent, or minimize these problems? Do present researcher philosophies coincide with farmers' requirements? To progress, national programs and international Centers must identify priorities for research, generate improved high-yielding varieties and appropriate economical management technologies, improve consumer products that are nutritious and acceptable in local diets, and most important, efficiently transfer new technology to farmers. If your efforts can increase average yields by only 0. 1 ton/ha, total annual production in Asia will increase by one million tons.

I therefore hope that this symposium will identify soybean production and utilization problems in the tropics and help to integrate the research generated in the more than 25 countries represented here today. I expect that special efforts will be made to identify where and how research and extension can increase soybean production, development, and utilization. I trust that in future national programs will commit resources to the transfer of technology without jeopardizing the welfare of the farmer in the process.

Obviously, the potential for soybean in the tropics is great, the challenges are many, and the responsibilities are awesome. The well-being of a billion people may well depend upon the success of your plans and programs for the future. I wish you every success in your deliberations.

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Welcome Address

H. E. KAUFFMAN
Director of INTSOY

Distinguished Guests and Participants,

On behalf of the International Soybean Program (INTSOY) at the University of Illinois, I would like to welcome all participants in this important symposium.

I would like to compliment the Tropical Agriculture Research Center (TARC) and the Asian Vegetable Research and Development Center (AVRDC) for organizing this International Symposium on Soybean in Tropical and Subtropical Cropping Systems. It is a privilege for INTSOY to be a cosponsor of this symposium.

It is appropriate that this symposium is being held in the Orient where soybeans originated. It is encouraging that 100 participants from 25 different countries are presenting their research results and participating in discussions about their past accomplishments and future plans for soybeans in their countries.

It must be noted that during the 20th century soybeans have made phenomenal gains in production in the Americas, whereas area has not expanded greatly in Asia. Although major gains in soybean production have occurred in temperate regions, recently substantial gains are being made in the tropical and subtropical regions.

Therefore as we look to the last two decades of this century and into the 20th century we must develop the best technology which will accelerate soybean production in the tropics and subtropics. The challenge is for the distinguished scientists at this symposium to contribute to this worthy goal.

Thank you.

Welcome Address

K. YANAGI
Director-General
Economic Cooperation Bureau
Ministry of Foreign Affairs

Mr. Chairman, Distinguished Participants,

On the occasion of the opening of the First International Symposium on Soybean in Tropical and Subtropical Cropping Systems hosted by the Asian Vegetable Research Development Center and the Tropical Agriculture Research Center, I wish to express my sincere welcome to all of you who are gathered here in Tsukuba today.

This symposium aims at coordinating future directions of research for tropical soybean production, while concentrating on the study of existing cropping systems of soybean in the tropics and subtropics. Soybean is one of the crops on which the Japanese people have long lived. And it may be said historically that soybean protein has been an important source of nutrition for the Japanese people. In this connection too, I believe, it is very meaningful to hold this symposium in Japan.

The food problem in developing countries and regions is one of the most serious issues in the world which require urgent solution. The role that is played by development in agricultural fields is extremely important in overall economic development of developing countries and regions, and this importance, which was stressed by the "World Development Report of the World Bank of 1982", has been well known to us. In this respect, the Government of Japan, though faced with severe financial constraints, has extended through various means active economic cooperation in the field of food and agriculture, bearing in mind that this field constitutes one of the most important areas in its economic cooperation with developing countries and regions.

Since its establishment in 1971 as the organization to conduct research on the improvement of varieties and others which is essential for bettering health conditions of the people in Asian regions, the AVRDC has developed its activities steadily. In the case of economic cooperation for food increase, its effect could be visible in short terms. In the case of such research activities as the AVRDC has been carrying out or economic cooperation for such activities, on the contrary, long-term and steady efforts are required before those efforts actually produce effects. As part of its assistance in the field of food and agriculture, Japan has extended cooperation to the AVRDC in such forms as financial support and dispatch of experts.

Fortunately, Japan has been able to provide the developing countries and regions with accumulated expertise in response to their actual needs and Japan, I believe, is thus contributing to the development of agriculture in the world. As I have been personally involved in Japan's economic cooperation, I have many occasions to talk with Japanese experts who have had experiences in development. I hear of their stories and, through them, know of so many problems that confront us and of the necessity of further extension of cooperation in this field.

I understand that there has been remarkable progress in biochemistry recently and that in the field of the improvement of varieties in agriculture, significant progress has been made. Those who succeed in improving genetic resources can contribute to better controlling food production in the world. Whereas agricultural research is thus being linked with the world food strategy, I am sometimes told that information which can have significant meanings for the improvement in the world food situation has not been fully transferred to developing countries and regions. Therefore, such a symposium as the one we hold here is important, where researchers in the world are gathered, focus attention on specific areas and gain common understanding about future food problems. As you are aware, the AVRDC takes generous "Open-Door-Policy" on its research outcome, promoting exchanges of germplasm and utilization of its genetic resources. This represents sincere attitudes on the part of the AVRDC vis a vis the improvement of world food situation. I believe that this symposium is held based on the same spirit. It further provides us with an important means for transfer of technology.

I wish to conclude my statement by expressing my hope that all the participants in this symposium will gain benefits from intensive exchange of views during the coming 6-day sessions and will fully utilize them for the benefit of the people of the regions concerned.

Thank you for your kind attention.

Welcome Address

S. SEKIYA
Director-General
Secretariat of Agriculture, Forestry
and Fisheries Research Council

Distinguished Guests and Participants,

On behalf of the Agriculture, Forestry and Fisheries Research Council of the Ministry of Agriculture, Forestry and Fisheries of Japan, it is with great pleasure that I extend my most sincere greetings and best wishes to all the participants in the International Symposium on Soybean, which is being held under the cosponsorship of the Tropical Agriculture Research Center, Ministry of Agriculture, Forestry and Fisheries and the Asian Vegetable Research and Development Center.

The first symposium which was held under the auspices of the Tropical Agriculture Research Program of the Council took place in 1967. Since that time, the Council has devoted its efforts to promote international cooperation with the tropical countries in agricultural research fields. With a view to meeting the world and national requirements in promoting technologies pertaining to tropical agriculture, the Japanese Government established a new research institute in 1970, the "Tropical Agriculture Research Center" which is exclusively responsible for international coöperation dealing with agricultural programs in the tropical and subtropical countries. I am very much pleased to learn that the present symposium is the seventeenth of its kind and that for the last sixteen years a large number of research scientists from Japan and abroad have enjoyed their participation in the symposia which have been convened by the Tropical Agriculture Research Center.

The present symposium has been organized since the problems relating to the cultivation of soybeans in the various growing countries particularly in those located in the tropical zone are assuming an increasing importance worldwide.

I am convinced that fruitful ideas and information on techniques developed in each country will be exchanged throughout the discussions which will take place during the symposium so as to further promote research and investigations.

I do hope that the symposium will be successful.

I again wish to express my cordial welcome to all the distinguished delegates and participants.

Thank you.

INTERNATIONAL SYMPOSIUM ON SOYBEAN
TARC • AVRDC Sept. 26th–Oct. 1, 1983, Tsukuba, Japan

Contents

COUNTRY REPORTS

SOYBEAN SITUATION IN BRAZIL

M.A.C. de MIRANDA. E.A. BULISANI and H.A.A. MASCARENHAS*

Abstract

In this paper are discussed some aspects relating to the present and the future expansion areas of soybean cultivation in Brazil, soybean production and utilization, climatic conditions, soil acidity, liming and fertilizer application, utilization of soybean cultivars, cultural practices, weed control, the principal insects and diseases of soybean and their control.

Soybeans in the world

According to available statistics the United States is the major soybean producer in the world, accounting for an average of 64% of the world production in 1977/78. Brazil has also the largest soybean area under cultivation with alnost 52% of the land under this legume. On the other hand, Argentina shows the highest yield compared with other important producers. Only four countries were responsible for about 94% of the world soybean production in the 1977/78 period. These countries are the United States, Brazil, China and Argentina.

The world production of soybeans in 1980 was estimated at 83.5 million tons, showing a decrease of 8.7% over 1979. This decrease was mostly due to losses in the United States production which were not compensated by increases in the Brazilian production.

Soybean grain export in the 1977/80 period reached an average of 24.1 million tons, with a value of US$ 6,302.2 million. The United States is the main exporter, followed by Argentina and Brazil. These countries were responsible for 82.5% of the international trade in soybeans. China, in spite of being the third world producer does not participate in grain export. As grain importer Japan occupies the first place. This country followed by Germany, the Netherlands, Spain, Italy, China, URSS, the United Kingdom and France imported almost 82% of the available soybeans.

Soybean production in Brazil

Soybean was introduced in Brazil as experimental crop in 1882 in the State of Bahia by Gustavo D'utra, however this attempt was unsuccessful. In the State of Sao Paulo the crop was cultivated for the first time in 1892 by Daffert at Instituto Agronomico de Campinas. The highest yields were obtained by Japanese immigrants in 1908. These yields were further improved with the introduction of 50 North Anerican lines and cultivars in 1933. During the following years, soybeans were cultivated in small areas, mainly for home consumption.

In the State of Rio Grande do Sul, Craig started the soybean cultivation in 1914. This crop was here to stay as it was being utilized as hog feed which caused a rapid expansion in acreage and Rio Grande Sul the first State to export soybeans in 1949 (18,000 tons) . On the other hand, the State of Parana where soybean cultivation was initiated in 1954, is today (1983) the major state producer. Soybean production experienced a sharp increase during the period 1960/70, mainly due to the introduction of the double cropping system, wheat-soybean. The Brazilian soybean participation increased from 0.5% in 1954 to 16% in 1976 on a world basis. This increase was due to the high prices of soybeans (International) , availability of cultivars and production technology stemming from research work carried out mainly at governmental institutions. Consequently, the farmers were

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*Research Agronomists, Seção de Leguminosas, Instituto Agroômico de Campinas, Caixa Postal 28, CEP. 13. 100 Campinas, SP. Brazil.

able to obtain high average yields, similar to those in the United States.

In 1980 the total area planted to soybeans represented 5% of the area of the country. During the period 1960/80 there was a great change in the areas planted to different crops. In the periods 1960/1964 and 1976/1980 the total areas under cultivation increased from 28.5 to 47.2 million hectares which represents an annual increase of 3.2%. The area under soybeans from 1960 to 1980 in Brazil increased at the rate of 26% annually. On the other hand the average annual increase of wheat was 9.2%, corn 2.7%, rice 3.2%, dry bean 2.9% and other crops only 0.3%. Soybeans represented 1% of the area under cultivation during the period 1960/64, and this figure increased to 16.2% during the 1976/80 period.

The Brazilian production of soybean in 1981/82 was around 13 million tons according to the latest available data. This total represented 23.3% in relation to the estimate for that season, and it was due mainly to the drought that affected the Southern States (Rio Grande do Sul, Sante Catarina, Parana and Mato Grosso do Sul) together with the restriction in the use of fertilizers, herbicides, insecticides, etc. caused by the unavailability of financial loans in relation to harvesting of crops in previous years. Subsequently there was a reduction of 3 % in the total area under soybeans during this year (1980/81).

Table 1 Production of soybeans in the states of Brazil in the 1969/70-1981/87 period

	Period							
	1969/70	1971/72	1973/74	1975/76	1977/78	1979/80	1980/81	1981/82*
States	1,000 ton							
Rio Grande do Sul (RS)	976.8	2,173.6	3,870.0	5,035.0	4,567.8	5,737.2	6,088.3	4,200.0
Parana (PR)	368.0	688.2	2,588.9	4,500.0	3,150.1	5,400.2	4,950.0	4,500.0
Mato Grosso do Sul (MS)	—	—	—	—	—	1,322.1	1,346.0	1,400.0
São Paulo (SP)	90.1	175.3	522.0	765.0	745.5	1,099.1	1,032.0	1,100.0
Santa Catarina (SC)	53.0	98.9	431.5	435.0	354.7	718.8	648.2	600.0
Goias (GO)	9.8	49.9	99.0	46.7	100.4	455.8	382.6	—
Mato Grosso (MT)**	9.0	27.9	307.0	209.4	479.1	117.2	224.9	—
Minas Gerais (MG)	1.8	8.9	57.6	165.5	137.1	289.5	279.4	—
Others	—	—	—	81.0	—	16.0	26.6	1,200.0
Total	1,508.5	3,222.7	7,876.0	11,237.6	9,534.7	15,155.9	14,978.0	13,000.0

* Estimate ; Source-IEA,IBGE.

** Includes Mato Grosso do Sul for the period 1969/70 to 1977/78.

As shown in Table l, the southernmost state (Rio Grande do Sul) contributed in 1980/81 to 40.7% of the total production but, in 1981/82 there was a reduction to 32.7%. On the other hand, Parana showed an increase from 33.2% to 34.6%, Santa Catarina from 4% to 4.6%, Mato Grosso do Sul from 8.7% to 10.8%, and in the State of Sao Paulo there was practically no difference in the level of production. The data show no substantial increase in the expansion of soybean production which is due mainly to the unavailability of loans.

Brazilian consumption of soybean meal in 1981 was 2.29 million tons, 15.2% lower than that of 1980, indicating that poultry and hogs suffered from this decrease. Soybean oil consumption in Brazil has amounted to 1.36 million tons approximately, corresponding to about 80% of available edible vegetable oil.

In previous years Brazil was a major soybean grain exporter but, today, it exports not only grains but also soybean meal and oil. Among the exports of soybean grain and its products the sale of soybean meal brought in more dollars than the others. On the other hand the export of grain declined in spite of increases in the average prices.

Crop characterization

Figure 1 shows an approximate outline of soybean production in Brazil:

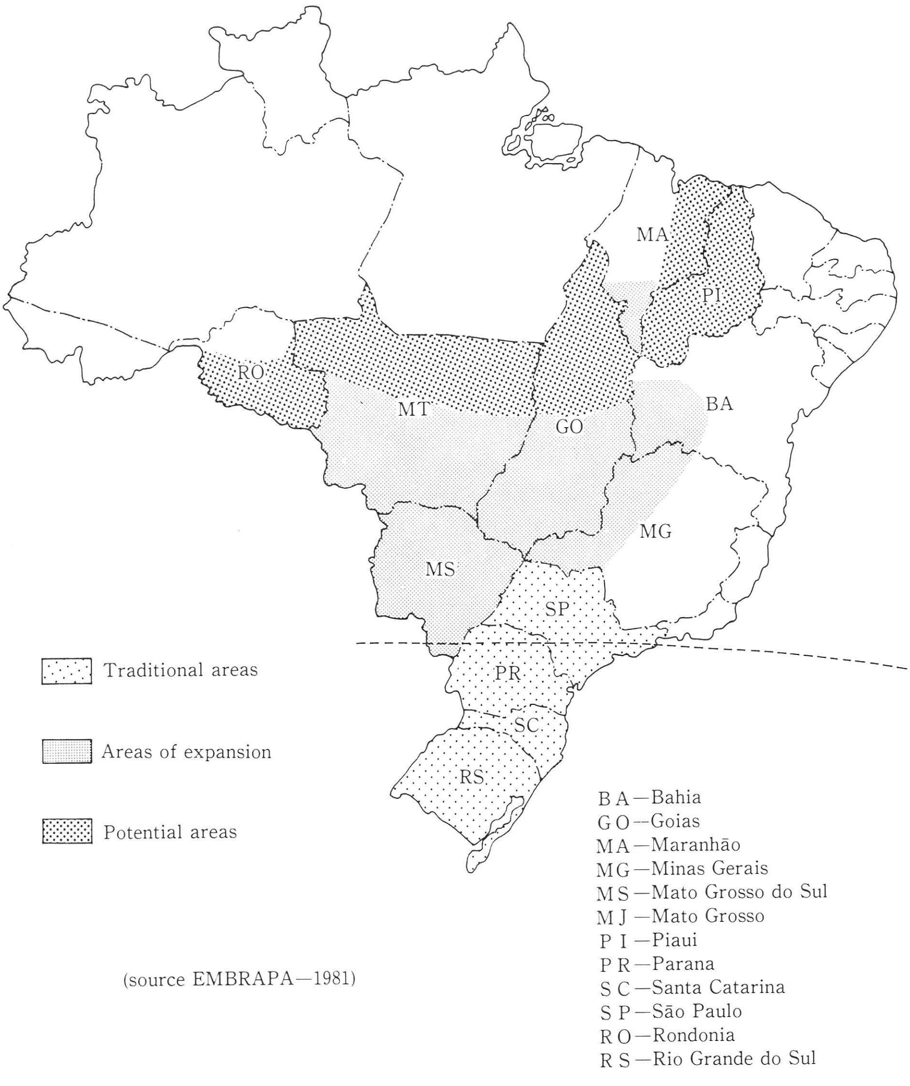


Fig. 1 Areas under soybeans and future expansion areas.

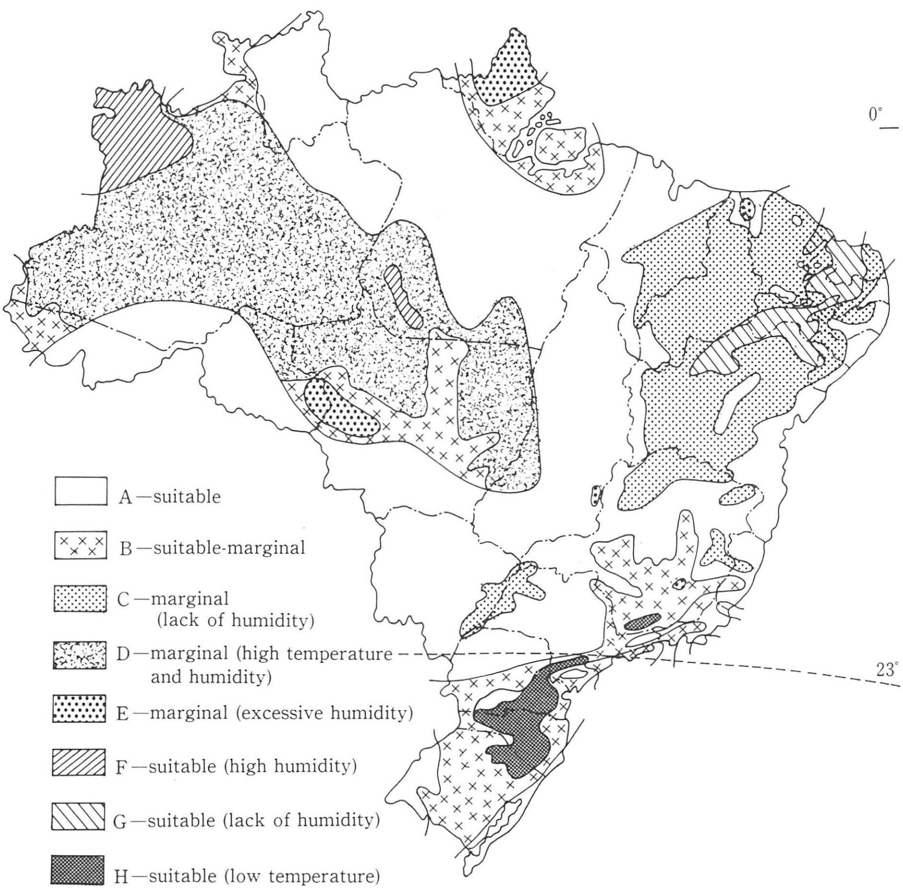
a) Traditional area; includes the southern States of Rio Grande do Sul, Santa Catarina, Parana and Sao Paulo, which produce approximately 89% of the Brazilian soybeans. With the advanced technology available presently the crop is completely mechanized from planting to harvesting. Improved varieties, are being utilized along with the control of weeds, diseases and insects and yields average 1.880 kg/ha.

b) Expansion area: includes the States of Mato Grosso do Sul, southern part of Mato Grosso, Goias and Maranhao, besides the western part of Minas Gerais and Bahia. Most of this area is characterized by acid soils, under "cerrado" vegetation. In several regions of this area soybean cropping is quite recent and the technology used has been exclusively developed in Brazil, mostly in Sao Paulo where a great part of the soybean area was cultivated on "cerrado" soils. In the area of soybean expansion in the States already mentioned the average yields are approximately 1.500 kg/ha.

c) Potential area: includes the northern part of Mato Grosso and Goias, southern part of Rondonia, northeastern part of Maranhao and Piaui. Field trials are being carried out to evaluate the possibility of planting soybeans.

Climatic conditions

Based on climatic parameters such as average annual temperature (Ta) =17°C and (Ta) =24°C, and annual rainfall indexes (lm) =-40 (lm) =0, (lm) =100 associated with cultivar requirements and behavior of commercial soybean planting, an ecological zoning for soybeans in Brazil was established including eight climate zones: A - suitable, B - suitable to marginal, C - moisture restriction, D - marginal, high temperature and humidity, E - marginal, excessive humidity, F - unsuitable, suitable, low temperature (Fig. 2) .



(source Climatology-IAC-SP—1976)

Fig. 2 Climatic zones.

Another aspect linked with the climate and related to the soybean expansion was the ecological survey showing that wheat could be planted from the southern border of Brazil to latitude 23°S. With government loans readily available, the farmers were able to buy equipment to mechanize wheat cultivation from planting to harvesting . With the same machinery they could plant soybeans. The possibility of double cropping (wheat and soybean) during the same cropping year, using the same fixed investment (land and machinery) was responsible for the increase of the area under soybean cultivation.

At latitudes lower than 23° S, soybeans are being planted in soils under "cerrado" vegetation, during the wet season. In the winter, the cultivation of new soybean cultivars with irrigation has become possible.

Soils

Initially, soybeans were planted in Brazil on a small scale where the slope of the land was not an important factor, because planting and harvesting were performed manually. Today with the expansion of the area, flat lands are preferred, as soybeans can be mechanized from planting to harvesting. The use of flat lands has an advantage in that the chances of erosion are minimum and there are better facilities for the transport of limestone, fertilizers, pesticides and grains. Land with slopes over 12% are not recommended for soybean cultivation in Brazil.

Soil acidity and liming

It is well known that soil acidity is a limiting factor in soybean production. As a rule, the increase in the soil pH by liming increases soybean yields from 30% to 100%. Liming increases the availability of phosphorus and molybdenum in the soils, reduces the toxic effect of aluminum and manganese and is a source of calcium and magnesium as nutrients for plant growth . It also promotes the establishment of *Rhizobium japonicum*, that fixes nitrogen symbiotically. The quantity of lime required to reduce the toxic effect of manganese is greater than that for aluminum.

Fertilization

Soils in which soybeans are presently cultivated originally have a low amount of phosphorus, with considerable variations in the level of potassium. Although as a rule, soil analyses are a good indicator of the soil fertility status, for soybean it is also important to take into account the behavior of the previous crops planted and the fertilizers used. Soybean plants are scavengers and when used in rotation with other crops they are able to utilize effectively residual fertilizers.

When soybeans are cultivated for the first time in acid soils, frequently nitrogen deficiency is observed, which is caused mainly by the lack of nodulation. Under these circumstances, nitrogen fertilization increases soybean yield. It has also been demonstrated that the nitrogen applied does not increase soybean yields in limed soil, or in soils where the availability of calcium, magnesium, phosphorus, sulfur and molybdenum is adequate, because efficient nitrogen fixation can take place.

In relation to phosphorus, the critical level in the soil for good production is 0.07 meq or 7 ppm (extraction with $H_2SO_4$0.05 N) . Only below this level is phosphorus fertilization recommended. In spite of the low initial phosphorus availability, it seems that fertilization over long periods of time (five or nore years) reduces the need for application to a low minimum for achieving high yields. Highest soybean yields are obtained when the soil potassium availability is equal to or higher than 0.12 meq or 48 ppm. Although there are only a few reports describing the yield response to potassium, 30 to 50 kg/ha of K_2O are recommended for restoring the soil supply and as measure to control pod mold (*Diaporthe phaseolorum* var. *sojae*)

Cultivars

In relation to daylength, since soybean is a short day plant, the response to photoperiod is the most important factor for the adaptation of a given cultivar. Daylength is closely related to the latitude, and this is well illustrated by the fact that cultivars developed for the South of the USA can become perfectly adapted to the conditions prevailing in Rio Grande do Sul. In this regard, when there were no cultivars developed by Brazilian breeders, in Rio Grande do Sul most of the growers utilized cultivars introduced from the USA, such as Hill, Hood, Major, Bragg, Davis, Jew 45, Hampton, Harde and Bienville. However, it must be mentioned that the cultivar Santa Rosa and Industrial which were originally developed by the Instituto Agronomico in Sao Paulo, contributed significantly to soybean developnent. Santa Rosa and IAC-2 cultivars were very important for the expansion of soybean cultivation. Both cultivars have a broad adaptability and Santa Rosa accounted for approximately 60% of the overall area cultivated with soybean in Brazil during the period 1973/78.

As there were no cultivars adapted to latitudes lower than 23°S, there was a need for the introduction of new germplasm, as no commercial soybean cultivars were adapted to the conditions prevailing in areas near the equator. The American cultivars at this latitude (23°S and lower) , show early flowering and the plant height does not allow mechanized harvesting. The best materials for late flowering, were the lines from the cross Hill × Pl 240,664 which were also efficient. These lines crossed again with American cultivars (Hill, Bragg, Davis Hampton, Tracy, and Lee) produced cultivars such as IAC-6, IAC-7, IAC-8, IAC-9, IAC-11, Tropical, Doko and Numbaira. Thereafter it was verified that some of these materials such as IAC-8, had a juvenile period, with a broader adaptation to planting date and latitudes compared with other materials. An important part of this feature is that when the materials are planted in November, soybean cultivars requiring 230 days or more to mature are likely to experience a lack of moisture at the pod filling stage, resulting in low yields. However the planting of IAC-8 in October was associated with comparatively stable yields when high moisture and rainfall periods coincided with the vegetative and reproductive cycle of the plant. Today IAC-8 is being successfully planted in Sao Paulo, Minas Gerais, Mato Grosso, Mato Grosso do Sul and Goias, and even at latitudes as low as 10°N (Ivory Coast) .

Other materials with late flowering were also identified, some of them being derived from mutations in commercial cultivars. Recently germplasm from Delta Experiment Branch Station (Mississipi) with a juvenile period has been introduced in the State of Sao Paulo. Cultivars derived from it show a performance similar to that of cultivar IAC-8.

Tillage practices

Three main systems of soil preparation are adopted in Brazil to plant soybeans:

1 Conventional : this system consists of deep plowing (almost 20 cm) followed by two or more diskings. The first disking aims at breaking down clods and reducing the quantity of weeds. The second disking is performed near the planting date in order to apply herbicides before planting if necessary. With the double cropping system (wheat and soybean) there is always a delay in the planting of one of the crops because of the lack of time to prepare the soil.

2 Minimum tillage : this system leads to less soil disturbance when compared with the conventional method especially in a double cropping system. Normally the operations consist of disking with a heavy implement followed by one or more diskings with a light implement. Unfortunately this practice in clayey soils causes compaction of the soil which restricts root development, reduces water penetration and promotes erosion.

3 No tillage : this practice consists of planting soybeans without seed bed preparation using a special machine that cuts the remaining of vegetation and leads to soil fragmentation. Thereafter seeds and fertilizers are being introduced. This system makes compulsory the use of dry herbicides. Experimental data show that yields are almost similar in any of the soil preparation systems.

However direct planting (no tillage) consumes less oil than others. Indirect benefits also have to be taken into consideration as in this system there is better erosion control and soil improvement.

Weed control

Weeds may depress soybean yield by 30% to 50%. High infestation of *Brachiaria plantaginea* may cause losses of up to 80%. Besides the direct injury caused by competition, weeds may host insects, pathogenic nicroorganisms and nematodes. The following are the nost common weed in soybeans :

1 Dicotyledons : *Acanthospermum australe, Acanthospermum hispidum, Amaranthus hibridus, Bidens pilosa, Commelina* sp. , *Euphorbia heterophila, Ipomea* sp. , *Portulaca oleracea* and *Sida* sp.

2 Monocotyledons : *Brachiaria plantaginea, Digitaria sanguinalis, Cenchrus echinatus, Sorghum halapense, Eleusine indica* and *Cyperus rotundus*.

Several measures are utilized for weed control, each of them being selected for specific requirements. Prevention of the introduction of new weeds starts with the careful selection of the seed lot. The infestation on a large scale of small bean (*Vigna* sp.) which has the same seed size as soybean may occur under such conditions. Machinery cleaning is an other important preventive measure to avoid the dissemination of vegetatively propagated weeds.

Cultural practices are undertaken to promote rapid vegetative development of soybean and to restrict weed growth. Crop rotation is another measure to alter the pattern of weed population to promote crop development.

Manual control through hoeing is impractical due to low efficiency. However, mechanical cultivation is widely utilized, because such a method in addition to controlling weeds also breaks the soil surface, facilitating water and air penetration. In spite of the high cost (about 10 to 20% of the total cost) and the hazards to the environment, herbicide application is the most common practice for weed control in soybeans. One of the most important reasons for the use of herbicides is the initial control of weeds during the early development of soybean plant, when competition is detrimental.

Pest control

Soybeans are attacked by a large number of insects, which may cause damage, depending on the level of infestation, growth stage, and pest control measures.

For several years, soybean growers have been applying large amounts of pesticides based on a systematic schedule, without checking if the insect was present or determining the level of infestation. This resulted in high production cost, environmental disruption, the surge of secondary pests and insect resistance to pesticides.

Nowadays, integrated control does not allow insect population to reach a hazardous level. Due to the availability of knowledge on the geographical distribution, biology, attack period, damage level, measures of control are considered adequate. The potential of biological control, pesticide selectivity and plant resistance to insects have contributed largely to the establishment of integrated control. Breeding programs are releasing cultivars with resistance to the most common insects pests, which should contribute to further promote the efficiency of current pest management.

Soybean caterpillar, *Anticarsia gemmatalis*, is the most common larva feeding on soybean leaves. The second nost important insect is the soybean looper, *Pseudoplusia includens*. For a long time it was considered that only one *Plusia* species attacked soybean. Now it is recognized that there are various *Plusia* sp. attacking soybean and they are known as the *Plusiinae* complex, with *Pseudoplusia includens* being the most prevalent species.

Amidst the lepidopterous larvae *Epinotia aporema*, bores the tip of the plant. The attack of this insect on soybean results in the increase of branching while the plant stature is reduced and the yield decreases due to damage of the racemes.

Stink bugs are by far the most important pests of soybean. These insects show a preference for the reproductive parts (pods) causing pod drop and seed injury. Besides this direct effect greening of the plants (abnormal maturation) also takes place. The most common species involved are *Nezara viridula, Piezodorus guildinii* and *Euschistus heros*. Control measures are only undertaken after evaluation of the pest population through entomological surveys conducted during the plant cycle.

Diseases

It is estimated that about twenty diseases are of economic importance for soybeans in Brazil among more than one hundred that may affect this plant. Among the bacterial diseases it seems that under the Brazilian conditions bacterial blight caused by *Pseudomonas syringae* pv. *glycinea* does not affect soybean yield, while the incidence of *Xanthomonas campestris* pv. *phaseoli* var. *sojensis* and *Pseudomonas syringae* pv. *tabaci*, when associated, may depress yields by 15% in susceptible cultivars.

Two virus diseases are of major importance, one caused by soybean mosaic virus (SMV) and bud blight caused by tobacco streak virus (TSV) . The soybean mosaic virus has several hosts and is transmitted by a large number of aphid species. The SMV causes darkening of the hilum which spreads to the seed coat. In certain seasons this symptom causes rejection of seed lots as foundation seeds for planting.

Bud blight is potentially a hazardous disease due to the considerable yield reduction associated with the disease. However two facts make bud blight a disease of low economic importamce. Firstly there are few host plants, and the vectors, *Frankliniella schultzei* and *Frankliniella rodeos* are not too common under the Brazilian conditions.

The control of SMV is being performed by introducing resistance into commercial cultivars in breeding programs. The source of tolerance to bud blight was obtained recently. The use of tolerant cultivars will probably allow soybean production to be stabilized in the regions affected by bud blight.

Frog eye caused by *Cercospora sojina* is by far the most important and common fungus disease, which occurs from Rio Grande do Sul to Goias and Mato Grosso. The fungus attacks the leaves, pods, seeds and branches causing severe yield reduction, depending on the climatic conditions and susceptibility of the cultivar. Cultivar resistance is the most practical way of overcoming this disease. Downy mildew caused by *Peronospora manshurica*, brown spot by *Septoria glycines* and target spot by *Corynespora cassiicola*, are of common occurrence. However the economic damage caused by these fungi has still to be evaluated, but does not appear to be important.

Soybean rust, *Phakopsora pachyrhizi*, is a foliar disease of soybean which has been identified in Minas Gerais, São Paulo and Parana. The soybean plant shows three typical changes in response to rust fungus infection : tan changes - characterized by light brown lesions with heavy sporulation; reddish brown changes - characterized by reddish brown lesions with light sporulation, and 0 (zero) changes - when there is no evidence of lesion formation.

Brazilian and Puerto Rican isolates have induced changes of the reddish brown type in soybean but the tan type has not been detected. The incidence of soybean rust has not caused significant damage since the attack mostly occurs at the final stages of the plant cycle. The possibility of changes in the genetic constitution of the fungus which could become more pathogenic even with the formation of tan type changes should not be overlooked. This could pose a serious problem for soybean production in Brazil.

Among the soil-borne fungi *Rhizoctonia solani* is the most important as it lowers plant population and wilting generally occurs during the flowering stage. This disease has been cited as occurring in areas of Rio Grande do Sul, Santa Catarina, Parana, Minas Gerais and Mato Grosso. The only practical way of controlling the disease is to promote crop rotation with Gramineae, deep plowing soon after harvest and the use of systemic fungicides which may lower the inoculum potency, since cultivars tolerant to this disease are not available.

The fungi that decrease seed quality are *Colletotrichum dematium* var. *truncata* and *Phomopsis sojae* (*Diaporthe phaseolorum* var. *sojae*), which occur where soybeans are planted. They cause seed rot in periods of high moisture during plant maturation and when harvest is delayed.

Nematodes

In a nematode survey, thirteen nematode genera were detected in association with soybean plants. The most harmful species are the root knot nematodes *Meloidogyne javanica* and *Meloidogyne incognita*. According to observations, the latter predominates in areas in which soybeans have been cultivated for many years, while *Meloidogyne javanica* is prevalent in newly cultivated areas mainly "cerrado soils" and in areas where soybean is cultivated in rotation with pastures and sugarcane.

If the nematode attack is associated with water stress, losses are high. It is very important that nematodes be controlled because soybean is an important economic rotation crop and this crop could be planted, especially late cultivars that do not require fertilization, in rotation with other crops to which fertilizers had been previously applied. Planting corn, sugarcane, and rice after soybeans can reduce significantly the amount of nitrogen applied, hence decreasing the cost of production. Nematodes have been controlled on a small scale in the State of Sao Paulo by rotation with *Stizolobium atterrimum*. Screening cultivars for resistance to the two species has already been undertaken and a breeding program has already been initiated in some states.

Cultural practices

1 Spacing and plant density : Soybean is seeded at a depth of 5 to 6 cm in sandy soils and 3 cm in clayey soils where there is a risk of crust formation. Plant population is maintained at approximately 350,000 plants/ha with a row spacing of 60 cm and plant density of about 20 plants/meter. Under special conditions such as early plantings for double cropping, the row spacing is reduced to 40-50 cm in order to increase the plant height.

2 Seeding period : The planting period is the most important parameter for successful cultivation of soybeans. The planting period depends mostly on the soil temperature for seed germination, environment temperature during the life cycle of the plants, daylength for flowering, moisture chiefly for pod filling and dry period for maturity and harvest.

In latitudes lower than 23°S if planting is performed in the second fortnight of November, plants will show good vegetative growth. Even early cultivars (110 days) will develop adequate plant height for harvesting because the temperature, daylength and moisture are favorable for plant growth and production. However, cultivars of medium and late cycle (130-140 days) , in spite of a good vegetative growth may be subjected to drought during the pod filling stage in February. Therefore growers tend to choose early cultivars, and are encouraged by the prospect of double cropping during the same year.

To reduce the risk of potential high losses in large areas the utilization of soybeans with at least three different cycles is recommended. Both field trials and large scale planting have shown that the best planting date for late and medium cycle soybeans (130-140 days) with a juvenile period is October. In the Southern States planting time extends from October to December. The late cultivars are planted in October and December whereas the early cultivars are planted in November because of the favorable climatic conditions.

Perspectives

A reasonable amount of information on the major components of soybean production in the traditional areas has already been obtained. To maintain the present yield level, emphasis is being placed on crop rotation, soil conservation and measures to increase soil organic matter by research and extension workers as well as growers. The efficient use of lime, fertilizers and pesticides associated with cultivars with a higher level of resistance to diseases and pests, drought and acid subsoils will allow soybean producers to continue to plant this crop economically.

In the expansion area (central Brazil) , in soils under "cerrado" vegetation, there is a possibility of cultivating soybeans over an area greater than that planted to other crops in Brazil today (Fig. 1)

The "cerrado" area has been easily converted into regular cultivated land due to the expertise already gained in Sao Paulo State where during the period of 1965/75 almost all the "cerrado" land was converted into cultivated land. Presently such soils are extremely fertile. The expansion of soybean cultivation in central Brazil depends on the availability of financial loans.

If the northward trend of soybean production were to continue in the near future, it can be anticipated that the central part of Brazil may become the major soybean-producing area in Brazil.

Discussion

Dutt, A. K. (India) : What is the soil pH and the exchangeable aluminum content in the soybean expansion area in Brazil?

Answer: The exchangeable aluminum content is 1. 2 meq/100 gr.

Sadikin, S. (Indonesia) : Are there liming programs?

Answer: Yes.

Wang, J. L. (China) : What is the proposed cropping system for the newly opened area of soybean as well as methods of soybean management?

Answer: The methodology proposed for soybean cultivation in the newly opened areas is as follows: 1. In the first year, lime application (2-3 ton/ha) after clearing the land. 2. Fertilization with phosphorus and potassium (0-20-10) at the rate of 0.2-0.3 ton/ha and inoculation with *Rhizobium japonicum*. 3. Utilization of new cultivars (IAC-6, IAC-7, IAC-8, Numbaira, Doko and Tropical) which show a broad adaptation in relation to planting date and latitude. 4. Chemical control of weed and insect pests if needed. 5. Mechanization from planting to harvesting. The cropping system adopted is sole cropping during the wet season (September-April) for 3-5 years and thereafter rotation with corn and other grain crops.

SOYBEAN IN INDIA
— RETROSPECTIVE AND PERSPECTIVE —

P. S. BHATNAGAR*

Abstract

Unless suitable measures are taken in time, rapid increase in population could further increase the gravity of the global problem of food and oil shortage. Soybean, often designated as miracle crop with over 40% protein and 20% oil, has now been recognized all over the world as a potential supplementary source of edible oil and nutritious food. In a society predominantly vegetarian as that of India, the importance of soybean is even more conspicuous.

Soybean is not new for India: black soybean has been cultivated for ages in hills and in some scattered pockets of Central India. However strangely enough, the crop has not so far become popular in the Indian sub-continent and other tropical countries.

The importance of soybean in India as a crop to narrow the oil and protein gap has now been generally appreciated and ambitious plans have been drawn-up. Compared to pulse crops grown in India, soybean produces about 2.5 times more yield with twice as much protein and 20% edible oil. Area under soybean has increased from 300 hectares in 1968 to 900,000 hectares in 1982.

Recognizing the potential of soybean to augment production of vegetable oil and protein-rich food, the Indian Council of Agricultural Research, launched the multi-locational inter-disciplinary All India Coordinated Research Project on Soybean. There are 19 centers involved in the project which represent different agro-climatic regions of the country. In addition, research is also undertaken elsewhere in the country. The headquarters of the project are located at G. B. Pant University of Agriculture and Technology, Pantnagar, India. Research during the period has sequentially led to the identification/development of suitable varieties for different agro-climatic zones of the country and standardization production technology for high yield of soybean. Utilization of soybean is envisaged for oil extraction and use of defatted soybean as well as whole soybean for food and feed. Out of more than 120 solvent extraction plants established in the country, several have started processing soybean for oil extraction. Extrusion products based on defatted soya flour have also come in the market. Recipes, using various percentages of soybean for dishes similar to those being conventionally used in different parts of the country have been published. More recently, "soy milk " and "tofu" are being popularized in some parts of the country.

Lack of appropriate agencies to ensure market to soybean growers and raw material to processors, want of consumers' awareness of the benefits of soy products and need for low cost product process development, have been some of the reasons for slow development. Creation of a center to undertake operational research on product, process and market development studies will go a long way in achieving the target of soybean production and utilization in India.

Introduction

Notwithstanding the fact that due to the combined efforts of agricultural scientists and the ingenuity of Indian farmers significant strides have been made in increasing the food production, the rate of population growth has, to some extent neutralized the impact of increased food productivity. The race between the food supply and population increase has in fact become the

*Project Coordinator, All India Coordinated Research Project on Soybean, Indian Council of Agricultural Research, G. B. Pant University of Agriculture and Technology, Pantnagar 263145, U. P., India.

greatest challenge to man. The population of India has doubled to 684 million in the last 34 years. Thus, 15.53% of the total world population lives in our country. In other words every one of six people in the world is an Indian.

Although, hunger and pooı nutrition are the problem of developing and under-developed countries, they are not unknown even in developed countries. A national conference on nutrition held early in 1982 at New Delhi concluded with the observation that 30 million children in India alone are suffering from hunger and malnutrition. On a global level not less than 15 million people die each year due to starvation and diseases caused by malnutrition and 75% of these deaths affect children, resulting in 41,000 deaths each day and over 1,700 each hour. During the 30 minutes of this presentation more than 856 people will have died of starvation and malnutrtion caused by diseases. An estimate of the survey conducted by the FAO and the World Bank, independently, indicates that 450 to 1,000 million people i. e. 11 - 25% of the world population in developing countries do not receive sufficient food (Shurtleff, 1976) .

On the oil front the situation is even more uncomfortable. To narrow the gap between the domestic production and the requirement of edible oil in India, import of soybean oil and soybean grain has been ranging from 3,509 tons to 350,617 tons during 1970 to 1980 (Table 1) . The requirement in India would further increase with increasing per capita consumption of edible oil from the present 11 g/day to the recommended 30 g/day which is likely to occur with the development and rise in living standards of the people, in India.

Table 1 Import of soybean and soy oil (1970-71-1979-80)

Year	Beans (ton)	Oil (ton)
1970-71	—	78,956
1971-72	—	101,506
1972-73	—	50,257
1973-74	—	60,387
1974-75	—	14,874
1975-76	—	3,509
1976-77	—	87,949
1977-78	5	345,795
1978-79	516	350,617
1979-80	—	58,179

Source : Chief Controller of export and import (Statistics Division) "Monthly Statistics of Foreign Trade in India. Vol. 1."

The severity and duration of the world food and oil problem lead only to the conclusion that massive long range, innovative efforts, unprecedented in the human history are necessary to avert the inevitable food crisis. Among the various means to increase the supply of nutritious food and oil for people, agricultural research will continue to play an important role. It has been reiterated that both conventional and unconventional sources of food and oil must be tapped to meet the challenge. Nevertheless, the plain fact that has been emerging is that the yield/unit for many conventional crops has perhaps come to a plateau. This has necessitated the search for unconventional sources of food, nutritious feed and edible oil supply. The potential of soybean in this context has now been generally recognized in India, too.

For over 2 million years in China and 1000 years in Japan, the importance of soybean has been realized. Soybean has been priced for its remarkable ability to produce over 33% more protein from an acre of land than any other known crop and 20 times as much usable protein as would be raised from an acre given over to grazing beef cattle for growing their fodders (Shurtleff and Aoyagi, 1981). The world production of soybean has increased seven fold from 13,169,000 tons in 1939 to 94,375, 000 tons in1979. The production during the first half of this period doubled while during the second half, it has trebled (USDA Agricultural Statistics, 1980) . This points to the fact that with growth and development of society, the importance of soybean has been increasingly recognized.

Soybean in India

Soybean is not new to India: black soybean has been cultivated for ages in the low hills of the Kumaon and Garhwal regions of UP as well as on the foothills of the Himalayas and in some scattered pockets of Central India. However, strangely enough, the crop has not so far become popular in the Indian sub-continent and other tropical countries. While the importance of soybean as number one in world oil production and as a cheap source of protein for food and feed has been recognized by developed countries, it is ironical that the tropical and sub-tropical under-developed or developing countries are still debating whether soybean is good or bad for their people. Surprisingly, this indifference towards soybean prevails in spite of the fact that in general, these tropical or sub-tropical countries depend for their dietary requirement of protein on less productive and less nutritive pulse crops. It has, however, been realized thad even with concerted efforts, productivity of pulse crops in general could not show a marked increase. Soybean yields are two to three times higher than those of the pulse crops which are the major source of dietary protein requirement in India (Singh *et al.* , 1975) . Soybean also contains twice the quantity of protein and yields 20% edible oil (Gopalan *et al.* , 1971) (Table 2) , and is much cheaper than any pulse crop in India. Besides, soya protein is known for its high lysine, methionine and cystine content.

The importance of soybean in Indian agriculture as a crop to narrow the oil and protein gap has now been generally appreciated and ambitious plans to achieve a target of around 20 lakh hectares under soybean during the Sixth Plan were drawn up.

Many nutritionists indeed expect pulse crops (edible legumes) to play an increasing role in meeting food and protein need at a time of widespread food shortage and malnutrition. The role of soybean in providing a cheap source of protein is undisputed. Fortification of wheat flour with protein-rich defatted soy meal alone would result in 10 - 15% increase in the availability of food, on the one hand and increase of protein content of wheat flour on the other. In addition, several other low-cost products can go a long way in providing protein-rich food to the weaker sections of the society.

Table 2 Average yield, oil and protein content of soybean and other pulse crops in similar conditions in India

Crops	Yield (q/ha)	Oil* g/100g	Protein** g/100g
Soybean (*Glycine max* L.)	29.60	19.5	43.2
Pigeon pea (*Cajanus cajan*)	16.60	1.7	22.3
Black gram (*Phaseolus mungo*)	10.40	1.4	24.0
Cowpea (*Vigna sinensis*)	10.40	1.0	24.1
Green gram (*Vigna radiata*)	8.80	1.2	24.5

Source : *Singh *et al.*, 1975.

**Gopalan, Ramasastri and Babsubramaniam, 1971.

A fallacy

Some sections of society apprehend that soybean in India will compete with groundnut. This however, is not correct. Soil and climatic requirements of the two crops being different, replacement of groundnut by soybean is not likely. In fact, soybean would complement groundnut to meet the national needs of edible vegetable oil. In addition, high protein food will be provided as by-product. Nevertheless, comparative potential of these crops in oil production in India can be well appreciated from the fact that, while a wide gap between the national and world average of soybean productivity for oil (132 kg/ha v/s 216 kg/ha) does exist, in groundnut the national and world average of groundnut oil production per hectare (246kg v/s 258 kg) is almost the same. This highlights the prospects of increasing the national average of soybean yield while increase in groundnut yield could not be expected in the near future.

Time and again the question has been asked whether soybean will displace any crop of importance to disturb the commodity balance in the country. In fact, soybean will not have any adverse effect on other important crops. This is mainly because several hundred thousand hectares of land lying fallow during summer could be utilized for growing soybean (Table 3, William *et al.*, 1974) . This could result in an additional production of 24,84,000 tons of soybean to provide a stable supply of oil in the country.

Table 3 Estimated area potentially available for soybean in Madhya Pradesh and Uttar Pradesh

State	10% of land in		5% of land in	Total potential	
	jowar, small millets, kharif pulses (ha)	kharif fallow (ha)	maize, bajra, cotton, upland paddy (ha)	area (ha)	production (ton)
M. P.	493,000	494,000	140,000	1,127,000	1,401,000
U. P.	157,000	538,000	201,000	896,000	1,083,000
Total	650,000	1,032,000	341,000	2,023,000	2,484,000

Source : Williams *et al.*, 1974.

Soybean development

The increase in area of soybean from 300 hectares in 1968 to about 900,000 hectares during 1981-82 in India speaks for itself and shows that in spite of numerous detractions, the importance of soybean in India has been ultimately recognized. The pace has however been slow (Table 4) .

To promote the soybean development in the country the government of India has launched a centrally sponsored scheme in many States. In addition, Rs. 15,55,55,000.00 have been allocated for soybean development during the VI Plan period in the State of Madhya Pradesh.

Research in India

There is a general consensus in the world that the rate of technological advancement in agriculture must increase to keep pace with our growing requirement of food, timber and fibre. As in the case of other crops, in soybean too, research and educational programs are the key to exploiting its full potential as a cheap source of protein and high quality edible oil.

Recognizing the potential of soybean in meeting the present and future needs of the country for vegetable oil and protein-rich food, the Indian Council of Agricultural Research—an apex national

Table 4 Targetted and actual cultivation (ha) as well as production (ton) in India under the centrally sponsored scheme for soybean development

State	1978—79		1979—80		1980—81		1981—82	
	Acreage	Production	Acreage	Production	Acreage	Production	Acreage	Production
Madhya Pradesh	232,562 (200,000)	232,000 (211,400)	414,341 (40,000)	N. R. (51,400)	447,606* (480,000)	350,000 (375,000)	647,711 (600,000)	500,000
Uttar Pradesh	68,689 (130,000)	60,326 (76,400)	75,866 (137,500)	36,121** (70,400)	131,745 (175,000)	84,002 (106,400)	141,196 (213,000)	100,000
Karnataka	1,181 (3,000)	588 (2,400)	1,296 (3,000)	NGR. (2,400)	— —	— —	— —	— —
Bihar	665 (3,000)	500 (2,400)	N. R. (3,000)	N. R. (2,400)	157 (5,000)	77 (4,000)	111 (6,000)	N. R.
Himachal Pradesh	4,000 (3,000)	N. R. (2,400)	244 (3,000)	N. R. (2,400)	4,000 (6,000)	6,000 (4,800)	N. R. (8,000)	N. R.
Rajasthan	—	—	—	—	12,500 (2,000)	6,250	13,000 (10,000)	11,975
Total	307,087 (339,000)	293,414 (395,000)	491,747 (556,500)	36,121 (139,000)	596,008 (668,000)	446,329 (490,200)	802,018 (837,000)	611,975

Figures in parenthesis indicate targetted acreage and production.
* However, the State has taken-up a coverage of 6,000 hectares during 1980—81.
** Due to drought the yield and total production have decreased.
The production figures are communicated by the Director of Agriculture and the concerned States.
N. R. = Not received.
Source : Directorate of Oilseeds Development, Ministry of Agriculture, Government of India.

body for agricultural research—launched the multi-locational inter-disciplinary All India Coordinated Research Project on Soybean in 1967 (Fig. 1) . There are 19 centers involved in the project which represent different agro-climatic regions of the country. In addition, research on specific aspects is being independently undertaken at some other institutes/universities in the country. The headquarters of the project are located at G. B. Pant University of Agriculture and Technology Pantnagar, India (Fig. 2). The total outlay of the project is Rs. 86,26,997.00 (US$ 8, 62,699.7) (Bhatnagar, 1981c) . Eighty one scientists are engaged in soya research. Under an international cooperation program with the USA, a project on Post-Harvest Technology of Soybean has also been approved. Moreover it has been decided to set up a National Soybean Research Center in India.

Some of the main objectives of the All India Coordinated Research Project on Soybean have consisted of the identification and development of varieties suited to the various Indian conditions; standardization of production technology for high yield of quality soybean as pure or companion crop; isolation and standardization of techniques for commercial production of the most efficient strains of *Rhizobium* for soybean plant; surveillance of diseases and their control with economic threshold; post-harvest technology; product development, marketing and economics.

The research efforts devoted so far in India sequentially led to an understanding of the genotype environment interaction, identification/development of suitable varieties and standardization of production technology for remunerative yield.

Screening of 4,000 germplasm collected from all over the world has resulted in the identification of resistance of yellow mosaic (UPSM-534, *G. formosana*) , rust (Ankur) , bacterial pustule (Bragg) and *Macrophomina*. These sources of resistance are being used for evolving disease-resistant varieties of soybean (Singh *et al.* , 1974) .

Varietal improvement program attaining high priority has resulted in the identification/ development of suitable exotic and indigenous varieties for different agro-climatic zones (Table 5). Some varieties in pipeline incorporating, resistance to yellow mosaic and other diseases, have widened the scope of soybean cultivation in India (Bhatnagar, 1982) .

Dr. O. P. Gautam
Director General

Dr. M. V. Rao
Deputy Director General (CS)

Dr. C. Kempanna
Assistant Director General (CS)

Coordinating Unit
G. B. P. U. A. and T., Pantnagar

Dr. P. S. Bhatnagar
Project Coordinator

Special Center	*Main Center*	*Sub-Center*	*Voluntary Center*
1 G. B. P and University of Agriculture and Technology Pantnagar, U. P. A	1 University of Agricultural Sciences Bangalore (Karnataka)	1 H. P. K. V. U., Palampur (Himachal Pradesh)	1 H. A. U., Hissar
2 J. N. K. V. V., Jabalpur (M. P.)	2 I. A. R. I., New Delhi	2 P. A. U., Ludhiana	2 C. S. A. U. and T., Kanpur
	3 M. A. U., Parghani (Maharashtra)	3 R. R. S., Majhera	3 College of Agriculture, Dryland Research Project Indore
		4 G. A. U., Junagadh	4 Agricultural Experiment Institute, Kudumiamalai
		5 University of Sciences, Dharvar	5 Pulses Oilseeds Research Station, Berhampur (W. B.)
		6 M. A. C. C., Pune	6 ICAR Research Complex of N. E. H. Region, Shillong
		7 T. N. A. U., Coimbatore	
		8 A. R. Center, Korapur	
		9 B. A. U., Kanke, Ranchi	
		10 A. A. U., Jorhat	
		11 N. B. P. G. R. Regional Research Station, Akola	
		12 B. C. K. V. V., Kalyani	
		13 S. K. Agricultural University Srinagar (J and K)	

Fig. 1 Organizational pattern of All India Coordinated Research Project on Soybean, Indian Council of Agricultural Research, New Delhi.

Studies on fundamental aspects relating to ideal plant type, path coefficient analysis, mutation research and inter-relationship of various morphological, anatomical and quality characters are in progress to accrue useful information for adaptive research.

Seed production

Suitable areas with mild temperature and low humidity have been identified and cultural practices for production of seed of high quality have been standardized. Locations in foothills of UP (Kumaon and Garhwal) and Himchal Pradesh provide bright prospects for high quality seed production of soybean. Harvesting of the crop when all the leaves are shed and the moisture content in the seed comes down to 14% or less, has given the best results. Post-harvest weathering and seed handling are also of prime importance in tropical countries like India. To avoid any possible seed damage during threshing, low cylinder speed (500 rpm) at a moisture content of 13 - 14% is recommended. Soybean seed being hygroscopic must be stored in moisture-proof bags/godowns.

Production technology

Research conducted on various aspects of crop management and input demand has led to the standardization of production technology for remunerative yield of soybean. It has been indicated

ALL INDIA COORDINATED RESEARCH PROJECT
ON SOYBEAN
(Indian Council of Agricultural Research)

Fig. 2 **Centers of research under All-India Coordinated Soybean Research Project.**

Table 5 Improved varieties of soybean for different agro-climatic zones*

Agro-climatic zones	Variety recommended	Days to mature	Yield (q/ha)
Northern Hill Zone	Bragg	120	25—30
	Lee	110	20—25
	Pb—1	110	20—25
	Shilajeet	105	20—25
	DS—74—24—2	110	20—30
Northern Plain Zone	Bragg	120	20—30
	Ankur	125	20—30
	Alankar	120	25—35
	Shilajeet	105	20—30
	Pk—327	110	25—35
	PK—271	115	25—35
	DS—74—24—2	120	25—35
	DS—73—16	120	25—35
Central Zone	Bragg	115	20—30
	Ankur	120	20—30
	JS—2	105	20—25
	MACS—13	110	20—30
	JS—72—44	110	25—35
Southern Zone	Improved Pelicon	110—120	15—20
	Hardee	110—120	15—20
	KHSb—2	110—120	20—25
	DS—74—40	110—120	20—25
	PK—74—292	110—120	20—25

* Summary Tables of experiments under All India Coordinated Research Project on Soybean 1982—83.

that a good crop of soybean can be raised with comparatively low fertilizer doses (NPK 20:60:40 kg/ha) . The application of nitrogen can be often avoided if the soil is richly inoculated with *Rhizobium japonicum* strain by cultivating soybean during previous years. However, the starting dose of nitrogen (15 kg/ha) has been found to be useful for good yield (Singh and Saxena, 1972) .

Row spacing of 45 -70 cm to maintain a plant population of 0.4 million per hectare has been found to be ideal for high yield. The depth of planting is reported to be an important factor for maintaining optimum plant stand. Optimum depth of planting has been found to be 3 cm. Required moisture in the field should be ensured by giving one pre-sowing irrigation, if necessary. Subsequent irrigation may not be necessary for rainy season crop, however, in case of early withdrawal of monsoon, one or two irrigations during the pod filling stage have given good response (Saxena, 1977) . The field should be maintained free of weeds during the early stages by hand weeding or by using chemical herbicides like Lasso and Basalin. Cropping systems studies have indicated that cultivation of soybean with crops like maize, cotton, millets has as potential to increase the returns per unit area.

Microbiology

Identification of efficient strains of *Rhizobium japonicum* for maximum nodulation and nitrogen fixation in soybean has been continuing. Indigenous commercial production of bacterial inoculum has resulted in the decrease in foreign dependence on *Rhizobium* culture. The studies have indicated that to achieve the best results there should be a small gap between the seed treatment (@ 1 kg soil medium or 1/2 kg in peat medium with bacterial culture, fungicide) and planting.

Plant protection

Surveillance studies have indicated the possibility of economic damage by some diseases like soybean mosaic, yellow mosaic virus, bacterial pustule, anthracnose (pod blight) and *Rhizoctonia* aerial blight (Fig. 3) .

Insect pests of significance to soybean cultivation in India, have been reported to be pea stem fly, white fly, thrips, Bihar hairy caterpillar and girdle beetle. Overall survey of the pest occurrence and damage is presented in Fig. 4 (Gangrade, 1974) .

Efforts to incorporate genetic resistance to diseases as best control measure, are being attempted with encouraging results. Nevertheless, effective spray schedule of fungicides and insecticides, has been standardized for efficient control of diseases and pests.

Spraying of 0.1% Thiodon and 0.1% Metasistox in combination, starting from 20th - 25th day

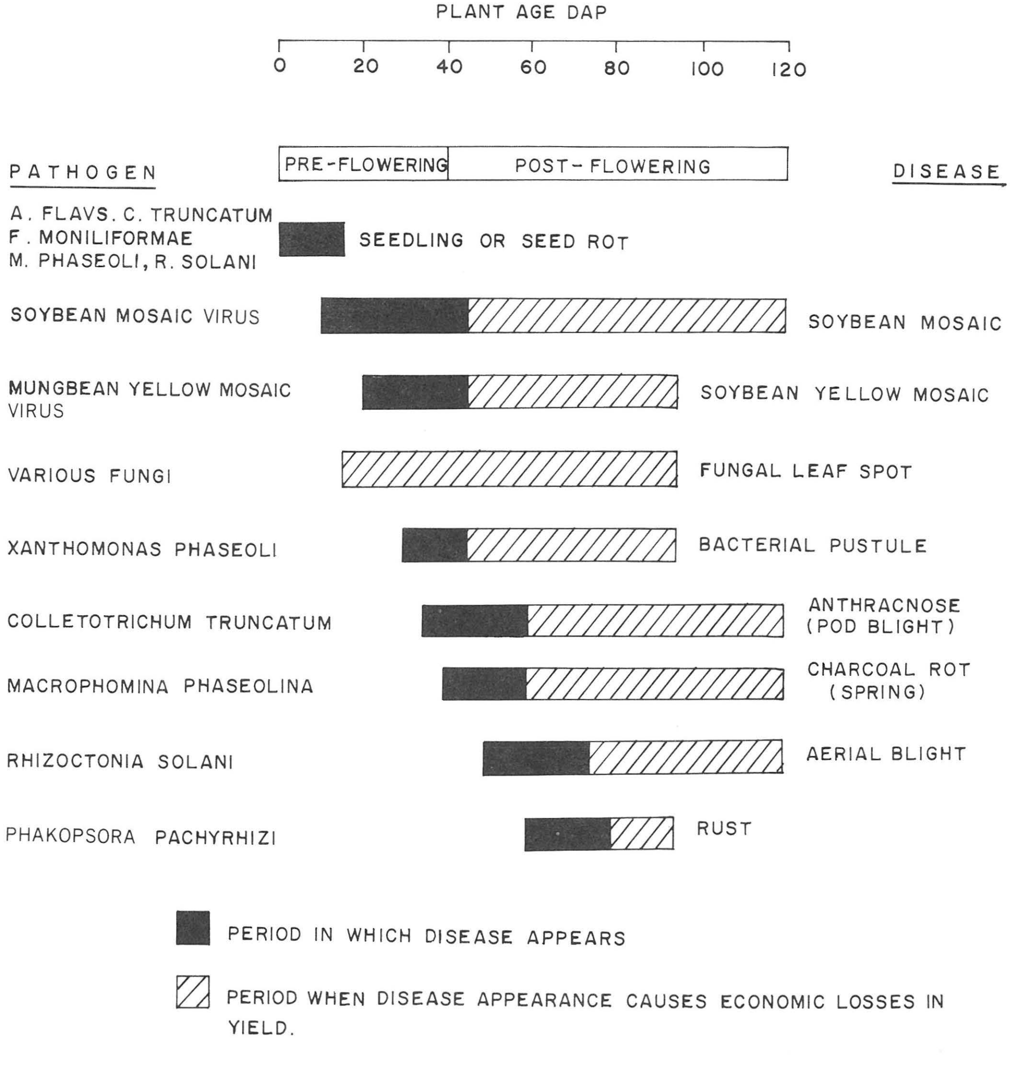


Fig. 3 Soybean disease complex.

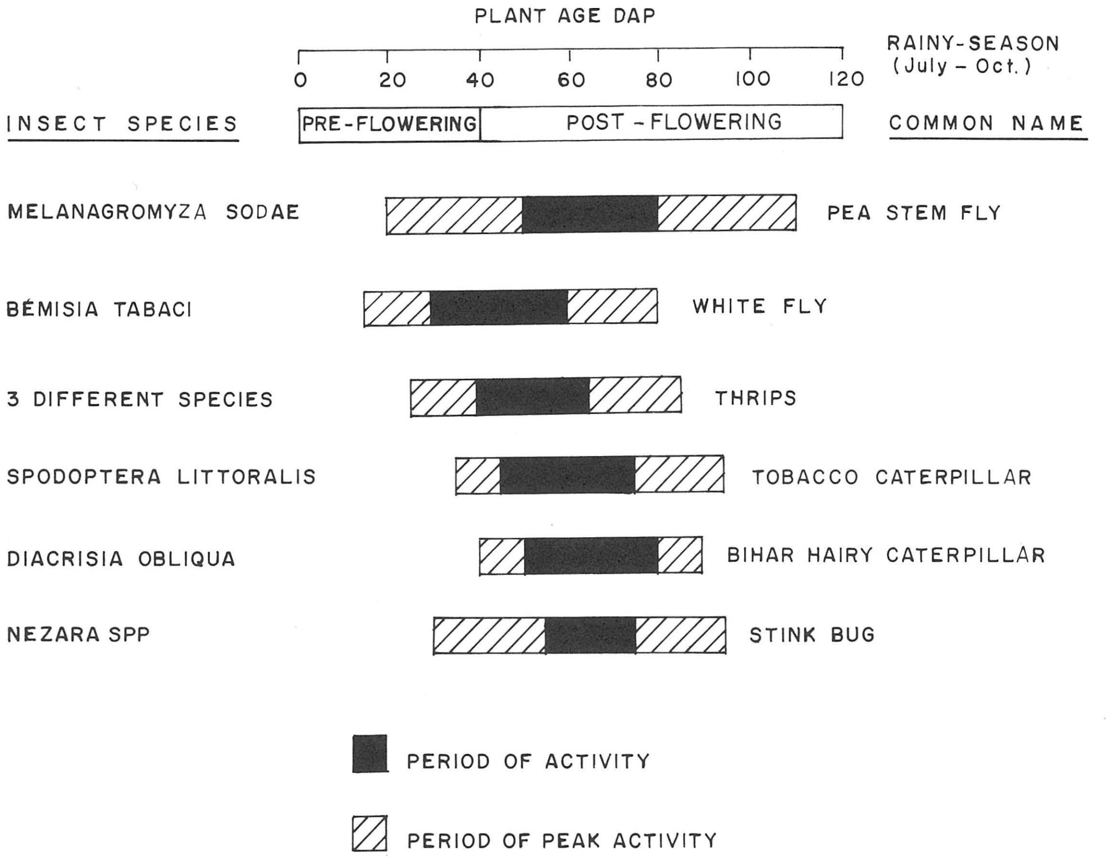


Fig. 4 **Soybean insect pest complex.**

of planting with an interval of 10 days till pod filling controls white fly (*Bemisia tabaci*), preventing the occurrence of yellow mosaic disease and most of the leaf-eating insects (Nene, 1972). Stem borer can be effectively controlled by Thimet-10 granules @ 10 kg/ha. To ensure effective plant stand, seed treatment with Thiram @ 3 - 4.5 g/kg, has been found to be very effective.

Product development, utilization and production economics

In India, both the American and Japanese pattern of utilization of soybean has bright scope. Out of 112 solvent extraction plants established in the country, several have started processing soybean for oil extraction. Recently, some commercial plants for extrusion products have also come into production and texturized soy food is available in the market.

Studies on product development aspects undertaken at Pantnagar, Jabalpur, Bangalore and elsewhere, have led to the standardization of recipes, using various percentages of soybean for dishes similar to conventional dishes in different parts of the country and publication of soy cookbooks (Singh, 1970; Kanthamani, 1970a, 1970b, Lingaiah *et al.*, 1975; Krishnamurthy and Shivshankar, 1975 and Mohta, 1975). More recently, production of tofu, is gaining popularity in some parts of the country.

Studies have indicated that the defatted soy flour can be used for fortification of wheat or other cereal flour up to 15% without any detectable difference from the viewpoint of the taste or appearance but considerably increased nutritional quality. Use of soy flour for production of low cost products like soya sattu has also been demonstrated.

Development of processes for soy milk, curd, soy ice cream, nuts and weaving food has resulted in the commercial production of soy milk, soy curd and weaving food in some cities.

Although whole soybean is still fed to livestock, defatted soy flour has not yet become popular as feed due to comparative economic factors.

Investigations on production economics, based on farm survey results, conducted at Pantnagar, have revealed that the cost of soybean production was Rs.199.00/g (US$ 19.9/g) with an input/output ratio of 1: 1. 32 (Arora and Gupta, 1981) .

Constraints to rapid expansion of soybean

Although by and large the importance of soybean has been recognized in India as well, and efforts at national, state and institutional levels are being made to expand the cultivation of soybean, however, the pace of progress has been rather slow. Some of the reasons for the slow growth have been- 1) lack of appropriate agencies establishing linkage between growers and processors; 2) lack of appropriate marketing facilities; 3) convention-bound detraction and want of efforts for creating consumer's awareness of the benefit of soya products, and 4) need for low cost product and process development having consumer preferences.

Perhaps, setting up of a center for product, processing and market development would go a long way in overcoming many constraints. The center would *inter-alia* undertake in depth studies and action research with respect to consumer preferences, comparative price structure and nutritional value of competing products; the scope for product diversification based on soybean processing and problems of storage, packaging as well as marketing to provide much needed information for wider development of soybean in India.

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Discussion

Summerfield R. J. (United Kingdom) : In the regional evaluation of germplasm do you: 1. Rely on nodulation with indigenous strains of *Rhizobia*? or 2. Distribute a standard inoculum with the seeds? or 3. Use imported or locally-produced inoculum subject to standard quality control? or a combination of 1. and 3. ?
control? or a combination of 1. and 3. ?

Answer : 1. In the new areas we inoculate and get a response from inoculation.
However, if soybean is cultivated in the same field for a long period of time, there is no response to inoculation. 2. With seed the *Rhizobium* inoculum locally produced is distributed by the seed-producing agency. 3. Presently we are not importing the inoculum. The indigenously-produced inoculum is to observe the standards identified by the India Standard Institute.

Trikha, R. N. (India) : Comment: Nodulation in soybeans is still a problem in the new areas with low organic carbon content and sandy soils. However if soybean is continuously grown for 2-3 years nodulation takes place.

Okabe, S. (ESCAP) : It appears from your presentation that in India large amounts of soybean inported from other countries are presently used for oil production. I would like to know what is the market for the residual soybean cakes in India?

Answer : It is indeed true that the expansion of the area planted to soybean is mostly related to the large demand for edible oil. Approximately 90% of defatted soybean cakes are exported, which represents a drain of protein in India. There is a need for promoting the development of low cost products of soybean as a a source of protein for the people.

Yang, C. Y. (AVRDC): What is the current area planted to soybean in India, as well as total production and average yield/ha?

Answer : Current planted area: 802,018 hectares (1981-1982) , 900,000 hectares (1983-1984) . Total production: 802,000 tons (1981-1982) and little over 900,000 tons (1983) . National average yield: 1 ton/ha.

DEVELOPMENT OF SOYBEAN CULTURE IN INDONESIA

Sadikin SOMAATMADJA*

Abstract

Since the initiation of the PELITA Plan the production of soybean has generally increased, primarily due to the expansion of the area planted.

At the same time the demand for soybean, especially in the last six years, has also been increasing. As the production could not meet the increasing demand, importation of large quantities of soybean has taken place. This situation necessitates the promotion and development of soybean cultivation.

Since 1974 an intensification program has been initiated. To date the government has recommended technological packages for boosting soybean production. These packages will be applied in the intensification and areal expansion programs as well.

Multilocational trials followed by demonstrations and seed production are the main activities supporting the technological packages. These trials are conducted by Research Institutes and the Directorate of Production, in farmers' fields.

Soybean cultivation is associated with a large number of constraints hampering production. The use of important components, as specified in the intensification program, and of suitable varieties is essential.

With the government support and policies followed by the action program, soybean cultivation appears to have a good prospect for further development.

Area and production

Share in national food production

Food legumes occupy the fourth place among the food crops cultivated in the country. Among the food legumes soybean gets first priority in farm operation.

The latest data from 1981 recorded a harvested area of 811 thousand, 519 thousand and 273 thousand hectares for soybean, groundnut and mungbean, respectively. Data of the same year indicated that rice accounted for 9,376 million, corn for 3,013 million, cassava for 1,395 million and sweet potatoes for 265 thousand hectares of agricultural land.

National soybean production

Soybean production tends to increase in every PELITA Plan (Five-year development plan) implemented in the country. The increase of production was 19.7%, 38.2% and 54.7% in PELITA I, PELITA II and PELITA III, 1977-1982, respectively, as compared to that of the five-year average before PELITA that covered the period 1964-1968. The average relative increase per PELITA Plan was 15.7% (Table 1) .

During the period 1977-1981 (Table 2) , in spite of fluctuations, the production generally increased. The increase of production was primarily due the increase of the harvested area. The increase of yield per hectare was too small to be considered as having made a significant contribution to the national production. In 1982 the production decreased, because of a long period of dry weather (Table 2) .

*Central Research Institute of Food Crops, JL. Merdeka 99, Bogor, Indonesia.

Table 1 Annual average of soybean production during and before PELITA

Years	Harvested area 1,000 ha	Harvested area Relative increase %	Yield ton/ha	Yield Relative Increase %	Production 1,000 ton	Production Relative increase %
1964—68*	605 (100)	—	0.68 (100)	—	411 (100)	
1969—73	674 (111.4)	11.4	0.73 (107.2)	7.2	492 (119.7)	19.7
1974—78	709 (117.2)	5.2	0.81 (118.9)	11.0	568 (138.2)	15.4
1979—81 (4 years)	733 (121.2)	3.4	0.87 (127.5)	7.2	636 (154.7)	12.0
Average		6.7		8.5		15.7

Source: Directorate General of Food Crops.
* Five years before PELITA ( ) percentage.

Table 2 Soybean production in the last six years, 1977—1982

Years	Harvested area 1,000 ha	Harvested area Relative increase %	Yield ton/ha	Yield Relative increase %	Production 1,000 ton	Production Relative increase %
1967—71 Average	689	—	0.70	—	478	—
1972—76 Average	721	—	0.77	—	552	—
1977	646	−10.4	0.81	5.6	523	−5.0
1978	733	13.5	0.84	4.0	617	18.0
1979	784	7.0	0.87	3.1	680	10.0
1980	732	−6.6	0.90	2.8	653	−4.0
1981	811	−10.8	0.85	−4.9	687	5.0
1982*	604	−25.5	0.87	2.2	523	−23.7

Source: Directorate General of Food Crops.
* 1982: Longer drought period.

Producing centers

Soybean has been and is being grown widely throughout Java. On the other islands, except for West Nusa Tenggara and Sumatra, it is only grown to a limited extent. Table 3 lists the six provinces, which during 1977-1981, had more than 20 thousand hectares planted to soybean annually.

In addition to these centers, Aceh, Bali, North and South Sulawesi also contribute to soybean production besides Java (Table 4) . Aceh tends to show a steady increase in soybean culture. Aceh,

Table 3 Soybean production in six provinces*, 1977—1981

Year	Province	Harvested area (1,000 ha)	Production (1,000 ton)	Province	Harvested area (1,000 ha)	Production (1,000 ton)
	East Java			Central Java		
1977		334	275		132	104
1978		350	343		174	119
1979		374	361		171	136
1980		373	372		136	100
1981		393	363		171	139
	Yogyakarta			Nusa Tenggara Barat (NTB)		
1977		31	25		42	34
1978		39	25		48	38
1979		49	31		49	43
1980		48	37		38	30
1981		55	40		35	29
	Lampung			West Java		
1977		31	27		21	15
1978		32	24		31	21
1979		38	31		25	17
1980		29	24		29	19
1981		47	36		31	20

Source : Directorate General of Food Crops.
* as producing centers.

Table 4 Soybean production in four additional centers, 1977—1981

Year	Province	Harvested area (1,000 ha)	Production (1,000 ton)	Province	Harvested area (1,000 ha)	Production (1,000 ton)
	D. I. Aceh			Bali		
1977		6.50	4.90		9.80	8.30
1978		8.40	6.10		10.00	8.70
1979		1.70	1.40		10.60	9.40
1980		17.90	13.80		9.30	9.30
1981		22.20	16.80		10.40	7.60
	N. Sulawesi			S. Sulawesi		
1977		6.20	4.50		11.70	8.10
1978		1.80	1.40		14.90	10.40
1979		2.10	1.40		21.30	13.70
1980		9.30	6.10		17.20	13.90
1981		7.60	5.50		12.20	9.00

Source : Directorate General of Food Crops.

North and South Sulawesi are new soybean-producing regions. Although in North Sulawesi the area planted to soybean is smaller as compared to the other regions, it has a potential for expansion. In this province, Bolang Mangandow has three crops of soybean annually on the same land.

Soybean area

Lowland rice (sawah) fields and dry land fields (tegalan) are used for soybean production.

Sawah fields account for the largest soybean production area in the country. The sawah fields give an average yield which is always higher than that of the dry fields.

Data from 1979-1981 indicated that approximately 59% of soybean was produced in the sawah fields. On Java appoximately 60% of the soybean area is on sawah fields, whereas outside Java it amounts to only 20% (Table 5) .

Table 5 Soybean production in sawah and tegalan, 1979—1981

Year	Harvested area 1,000 ha			Yield t/ha			Production 1,000 ton		
Province	Sawah	Tegalan	Total	Sawah	Tegalan	Average	Sawah	Tegalan	Total
1979									
Java	371	248	619	0.98	0.73	0.88	364	181	545
	(60)	(40)					(67)	(33)	
Os Java	32	132	164	0.89	0.79	0.82	29	106	135
	(20)	(80)					(21)	(79)	
Indonesia	403	380	783	0.97	0.75	0.87	393	287	680
	(51)	(49)					(58)	(42)	
1980									
Java	350	236	586	1,01	0.74	0.90	355	174	529
	(62)	(38)					(67)	(33)	
Os Java	28	118	146	0.90	0.84	0.85	25	99	124
	(19)	(81)					(20)	(80)	
Indonesia	378	354	732	1.00	0.77	0.89	380	273	653
	(52)	(48)					(58)	(42)	
1981									
Java	390	260	650	0.99	0.68	0.86	386	176	562
	(60)	(40)					(69)	(31)	
Os Java	32	129	161	0.87	0.75	0.78	28	97	125
	(20)	(80)					(22)	(78)	
Indonesia	422	389	811	0.98	0.70	0.85	414	273	687
	(52)	(48)					(61)	(39)	

Source : Directorate.

( ) = Percentage ; Sw = Sawah, rice field, Tg = Tegalan, dry land.

Supply and demand situation

Export and import

The demand for soybean in the country has been on the increase, especially in the last six years. National production of this crop is far from being sufficient to meet the demand. This situation has resulted in the importation of the product. It is worth noting that before 1978 Indonesia was able to export soybean, though the quantity was small. In 1969 the exports amounted to 750 tons. Up to 1973 the exports had tended to increase and in 1973 they amounted to 36 thousand tons. Since then there has been a decreasing trend, and finally in 1977, the quantity of soybean exported was too small to be considered significant (Table 6) .

The imports of soybean before 1978 fluctuated annually. The largest quantities of imported soybean during the period 1969-1977, were recorded in 1976, amounting to 172 thousand tons. In 1977 the imports decreased to 89 thousand tons. In addition to the import of soybean as grain, a small amount of soybean oil had also been imported (Table 6) .

Table 6 Export and import of soybean, 1969—1982

Year	Export (1,000 ton)	Import (1,000 ton)
1969	0.75	
1970	3.95	
1971	0.73	0.28
1972	3.06	0.18
1973	36,00	0.10(0.03)
1974	4.15	0.15(0.04)
1975	0.03	17.8 (0.01)
1976	0.60	171.75 —
1977	0.01	89.10(0.02)
1978	0	130.45
1979	0	137.35
1980	0	248.25
1981	0	308.08
1982	0	476.00

Source : Central Bureau of Statistics.
( ) = Soybean oil

Since 1978 the situation has changed completely. To date Indonesia is no more in position to export. The increasing demand for soybean has compelled the country to import a large amount of this commodity. Since 1978 the imports have been steadily increasing. In 1978 the imports of soybean amounted to approximately 130 thousand tons or 20.0% of the demand. The imports increased up to 476 thousand tons or 43.0% of the demand in 1982. Figure 1 illustrates the demand, production and imports of soybean during the period 1978-1982.

Future demand and production

The prevailing situation in which the national production cannot meet the demand and the imports are increasing, is a cause for concern. In this connection the government determined the "targets" of production directed toward self-sufficiency for this crop within a rather short time.

The target of production for 1983 is one million tons with a harvested area of 985 thousand hectares. For 1988, which corresponds to the end of PELITA IV the target of production will be 2,098 million tons with a harvested area of 1,596 million hectares. The demand for soybean in 1983 was estimated to be as high as 1,112 million tons, and in 1988 it will amount to 1,661 million tons. Table 7 shows that the demand for soybean should be met in 1984 by the latest.

In order to reach the target of production, the development of soybean culture will be directed especially to the dry land area. Therefore soybean cultivation on dry land will expand. In 1988 soybean area on dry land will involve 897 thousand hectares, whereas that on sawah fields 699 thousand hectares (Figure 2) .

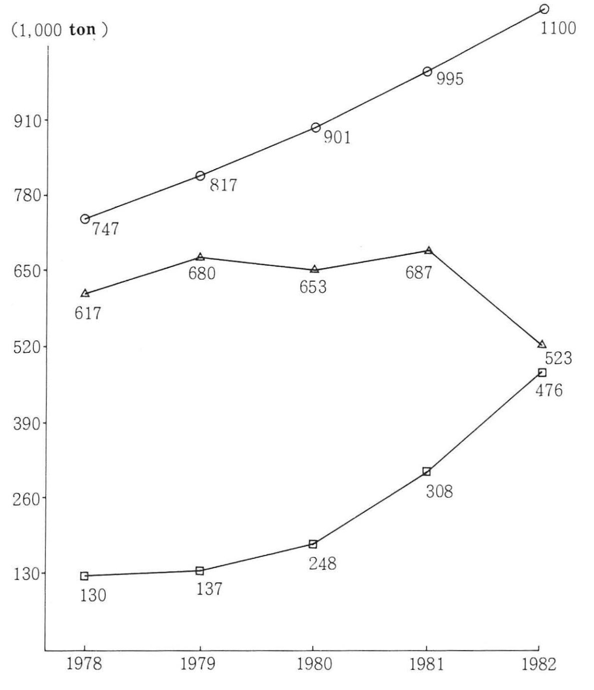

Fig. 1 **Demand, production and import of soybean, 1978—1982.**
○=Demand : △=Production ; □=Import

Table 7 The estimated demand for soybean and production target, 1983—1988

Year	Demand	Production	Harvested area	Yield
	1,000 ton	1,000 ton	1,000 ha	ton/ha
1983	1,112	1,011	985	1.03
1984	1,223	1,231	1,127	1.10
1985	1,305	1,496	1,263	1.20
1986	1,413	1,764	1,381	1.25
1987	1,530	1,943	1,491	1.30
1988	1,661	2,098	1,596	1.30

Source : Directorate General of Food Crops.

Utilization

Soybean may be used as side-dish with rice, as beverage, as vegetable or as cooking oil. Recently synthetic meat made from soybean is beginning to draw the attention of the people. In addition, soybean is also utilized for animal feed. More specific uses of soybean for food in the country are:

1 Side-dish with rice: Tempe (fermented soybean cake) , tahu (soybean cake) , tauco (soybean paste) , tauge (soybean sprout) , kecap (soy sauce) and goreng kedelai (fried soybeans) . Of these, tempe and tahu are very important in the diet of the people.

2 Snacks: Roasted soybeans, kerupuk tahu (tahu chips) , boiled young soybean pods.

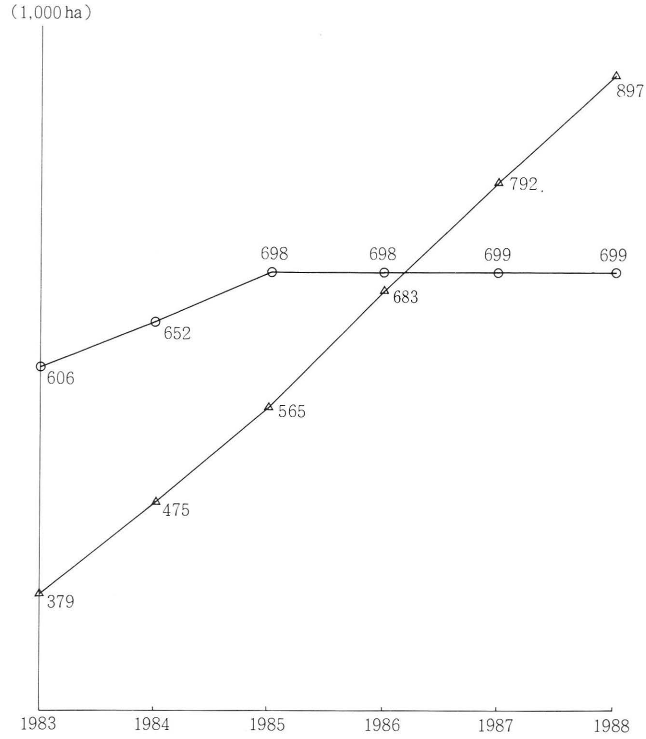

Fig. 2 **Target of soybean area, 1983—1988.**
○ = Sawah fields ; △ = Tegalan fields

Methods of cultivation

Cropping system

Soybean may be grown alone or in mixed condition with other upland crops in the local cropping systems. The cropping systems may differ from region to region. Area of production such as sawah and tegalan also determines the pattern of the system. Whereas in the sawah fields the cropping system is rice-based, in tegalan the cropping may be soybean-based or based on other crops depending on the importance of the crop. It is worth noting that in some districts such as Dumoga in North Sulawesi and Langsa in East Aceh, soybean is grown three times a year on the same tegalan land.

Cultivation

In the sawah fields soybean is cultivated in three different ways: a) simple, b) semi-intensified and c) intensified method of cultivation, (Somaatmadja, 1972) . In tegalan a semi-intensified or an intensified method of cultivation can be applied.

Most farmers apply the simple method of cultivation, which is performed without soil tillage. The seeds are either broadcast or dibbled in the fields after rice is harvested. In some occasions seeds may also be sown before rice is harvested.

The semi-intensified method of cultivation is performed with light soil tillage and the seeds are dibbled at regular intervals with 2 or 3 seeds/hill. The intensified method of cultivation is carried out with soil tillage (plowing and harrowing) , in dibbling the seeds at regular intervals along with weeding, applying irrigation and pest control. Fertilizers are usually not used in soybean cultivation, particularly when soybean is grown in the sawah fields.

Pests, diseases and other problems

During the growth period soybean is subject to insect attacks and diseases which may cause serious damage to the crop and lower the yield. Iman *et al.* (1972) , divided the most important insects that attack soybean into those attacking the vegetative and reproductive parts respectively (Table 8) .

Table 8 The important insects of soybean

On vegetative parts	On reproductive parts
Phaedonea inclusa	*Etiella zinckenella*
Prodenia litura	*Phaedonea inclusa*
Plusia chalcites	*Nezara viridula*
Longitarsus suturellinus	*Riptortis linearis*
Lamprosema indicata	
Agromyza phaseoli	
Agromyza dolichostigma	
Agromyza sojae	
Stomopteryx subseccivella	

Soybean diseases have also become important in the country. In addition to rust diseases caused by *Phakopsora pachyrhizi,* some virus direases seem to affect soybean cultivation (Iwaki *et al.* , 1975) . Other diseases commonly found, but still of minor importance are bacterial wilt, bacterial diseases on leaves, sclerotial blight, anthracnose, powdery mildew and purple seed stain.

In addition to pests and diseases, a serious problem encountered in soybean cultivation is the seed supply. Good quality seeds with high germinability are difficult to obtain. Therefore the stands of soybean crop in the farmers' fields are generally poor. This is one of the reasons for low yield which also influences the national production. The quantity of seed also can not meet the demand, especially for the intensification program and expansion of the soybean area.

Selection of cropping system, method of cultivation and use of products are important factors determining the use of varieties. In addition soybean also differs in its adaptability to the various areas of production. Therefore a specific variety recommended as well as local may thrive in a certain region, surpassing the other varieties.

The reason why early-maturing varieties (70 -80 days) are generally more acceptable, is related with the locally prevailing cropping system. Seed size is also an important factor for the farmers' soybean cultivation. This is especially related with product's utilization. The most prominent local varieties are Genjah Slawi and Petek in Central Java; Pressi and Sinyonya in East Java; Klungkung in Bali and Kipas in North Sumatra. The varieties are in mixed condition and need purification.

As the expansion of soybean cultivation is directed to the dry land areas, selection of varieties may become important. Most of the transmigration areas have Al-toxicity problem which needs correction and requires the cultivation of specific varieties. In new areas soybean cultivation is a new agricultural activity with which the local farmers are not familiar. For that reason most of the good soybean crops in the transmigration areas are usually those cultivated by Java and Bali transmigrants. In addition, soybean cultivation in the new areas requires the supply of *Rhizobium* inoculant for successful cultivation. Failure of the first crop may discourage the farmers from growing soybean henceforth.

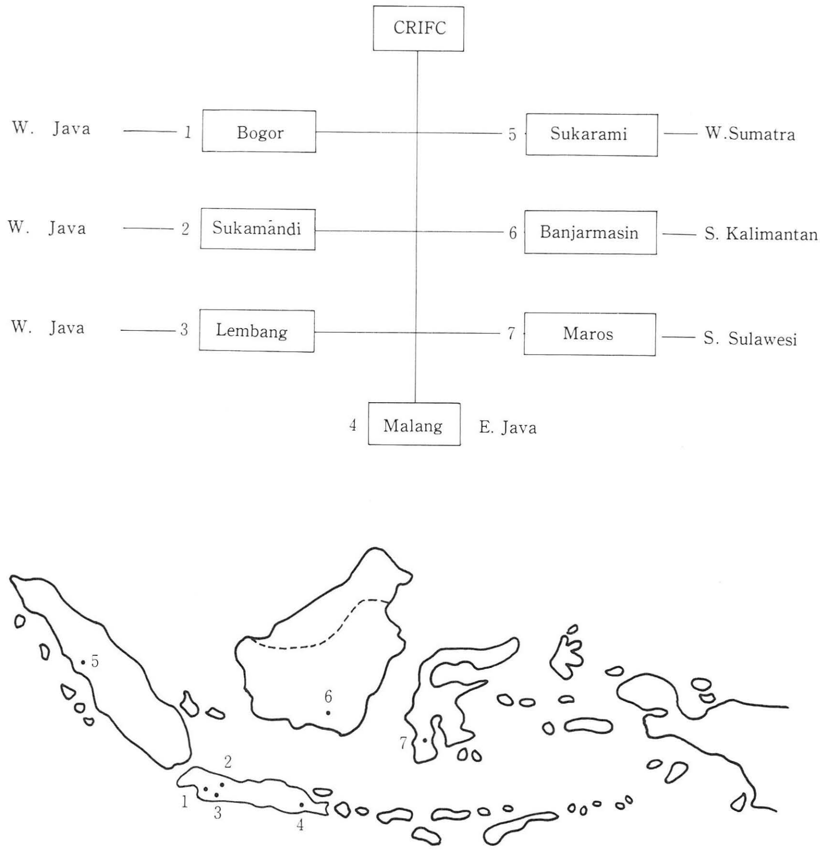

Fig. 3 **Research Institutes under Central Research Institute for Food Crops (CRIFC).***

* Taken from 5 years AARD, 1976—1980.

Research

The Central Research Institute for Food Crops (CRIFC) is responsible for soybean research in the country. The universities such as Bogor Agricultural Institute, Padjadjaran University, Gajah Mada University and Brawijaya University are also engaged in soybean research. These universities are conducting fundamental research, and to some extent also applied research in cooperation with the institute.

CRIFC has seven Regional Research Institutes (Figure 3) . Bogor and Sukamandi research institutes are conducting most of the soybean research activities, whereas other institutes also carry research to a limited extent.

The Agency of Agriculture Research and Development (AARD) has designated Malang in East Java as the main center for soybean research. The choice of Malang as the main center appears to be a good decision, because East Java is the main center of soybean cultivation. This institute however still needs improved staff training.

Research program and activities

Soybean research program has two broad objectives: varietal development and crop management. Research activities are problem-and production-oriented. These are related to areal expansion, cropping systems and cultural practices applied by farmers. In this way the experiments conducted will be significant for identifying the main constraints and for promoting the transfer of technology to increase production and farmer's income. The activities of research disciplines are as follows:

RESEARCH ACTIVITIES

A. BREEDING

1. Germplasm collection	: assemblage, maintenance, evaluation.
2. Varietal development	: hybridization, induced mutation, selection, preliminary yield trials, advance yield trials, multi-locational trials.
3. Multiplication	: promising lines, breeder seed

B. AGRONOMY

1. Cultural practices	: tillage practices, planting methods, population dynamics, crop rotation.
2. Fertility aspects	: fertilizer application/liming (macro-micro-elements) , method of placement and time of fertilizer application.
3. Weed control	: mechanical, chemical, culture techniques

C. PESTS AND DISEASES

1. Resistance	: screening for resistance to important pests, screening for resistance to important diseases.
2. Chemicals	: pesticide screening, fungicide screening.
3. Pest and disease control	: use of insecticides, use of fungicides.

4. Eco-biological study of important pests and diseases.
5. Study of losses caused by insects.
6. Control of pests and diseases in storage

D. PHYSIOLOGY

1. Adaptation	: screening for adaptation to acid soils, screening for drought tolerance, screening for tolerance to low light intensity, screening for adaptation to "problem soil" .
2. Seed quality	: methods and time of harvest, seed processing, seed storage.
3. *Rhizobium*	: inventory, collection, identification, utilization.

E. POST-HARVEST

1. Product quality	: method and duration of storage, processing.

F. CROPPING SYSTEMS

1. The use of soybean in agricultural systems: cropping pattern, inter-cropping, mixed cropping,

catch cropping
2. Cropping system model : improvement of cropping systems, introduction of new cropping systems.
3. Production practices following the result of cropping system model.

The progress of research is only manifest if the research institute releases new varieties. After the establishment of the Sukamandi research institute, the release of new varieties became accelerated compared with the time when only Bogor was doing most of the research activities. It is therefore expected that with the designation of Malang as main center of research and the assistance of other institutes, soybean research will make further progress. Table 9 shows the soybean varieties released by the institute, CRIFC.

Table 9 Improved soybean varieties

Variety	Flower color	Seed color	Kernel weight (1,000 seed)	Maturity (days)	Origin
No. 16	purple	black	70—80	90—100	Introduction
No. 27	purple	black	70—80	100—110	Selection
No. 29	purple	yellow (nasty colored)	60—70	100—110	id
No. 317 (Ringgit)	purple	yellow	70—80	85—90	Hybridization
No. 452 (Sumbing)	purple	yellow	70—75	80—85	id
No. 520 (Merapi)	white	black	70—80	80—85	Selection
No. 945 (Shakti)	purple	yellow	120—160	80—85	Introduction/ Selection*
No. 1248	white	yellow	120—160	80—90	Selection
No. 1291 TK 5	purple	yellow	120—160	80—85	Introduction
No. 1343 (ORBA)	purple	yellow	120—140	80—85	Hybridization
No. 1667 (Galunggung)	white	yellow	130—140	80—90	Hybridization
Gm 1293 Si (Lokon)	white	yellow	100—110	72—78	Hybridization
Gm 1300 Si (Guntur)	purple	yellow	100—110	75—80	Hybridization

* In Garut named Metro, selected from Wakashima.

In cooperation with the Directorate of Production, the Research Institute conducts multilocational trials. These may include varietal, fertilizer or other agronomic trials. These trials are then followed by demonstrations, such as demonstration plots (Demplot) or demonstration areas (Demarea) . Demplot and Demarea may eventually contribute to the promotion of seed production.

Support for soybean production

The government shows a keen interest in soybean production. Since 1974 an intensification program has been initiated in connection with BIMAS (mass guidance) and INMAS (mass intensification) programs. The program aimed at boosting the production. The important components of the intensification program are the use of good quality seed, insecticides and fertilizers. In the BIMAS program the government provides credit for these components. To encourage the cultivation and promote the marketing of soybean, since 1979, the government has fixed the floor price of soybean.

The increasing demand for soybean which results in increasing importation makes the government aware of the need to speed up the increase of production. In this context the government has recommended packages of technologies which will be applied in the intensification and the areal expansion programs as well (Table 10) .

Table 10 Packages of technology in the intensification and areal expansion programs

Components	Package I *	Package II	Package III
Varieties	Local	Released varieties (Lokon, Guntur, Galunggung, ORBA).	Released varieties (Lokon, Guntur, Galunggung, ORBA).
Seed quality	Improved	Improved	Improved.
Seed rate	70 kg/ha		
Cultural practices	Improved	Improved	Improved
Inoculum	*Rhizobium* (Legin) 150 gr/ha	*Rhizobium* 150 kg/ha	Rhizobium *150 g/ha*
Weed control	Weeding operations Herbicides Mulch	Weeding operations Herbicides Mulch	Weeding operations Herbicides Mulch
Pest control	Pesticides 4—6 l/ha	Pesticides 4—6 l/ha	Pesticides 4—6 l/ha
Fertilizers	Especially P_2O_5 ; K_2O	Especially P_2O_5 ; K_2O	Especially P_2O_5 ; K_2O
Soil tillage	No	Especially in tegalan	Especially in tegalan
Area	Sawah	Sawah, tegalan	Sawah, tegalan
Liming	—	—	a. 4,000 kg/ha, then b. 500 kg/ha every year after the fifth year

Source : * Must be readily practiced.

Further prospects and main constraints

The increasing demand and import of soybean necessitate the increase of the production of this commodity. Government support and encouragement in the intensification and areal expansion programs are likely to accelerate the development of soybean cultivation which in turn should lead to an increase in the production. Recent survey indicates greater possibility for areal expansion and increase of productivity.

There are however several constraints hampering soybean production, such as seed supply, problem soils, pests and diseases, capital and variety. The government however is taking the necessary steps to overcome these difficulties, directly or gradually. In this connection the action program which is being and will be implemented appears to be a good solution for speeding up soybean production.

Soybean is still considered as a secondary crop. This fact therefore accounts for the poor management practices resulting in lower productivity. A fairly high loss in plant population and insect infestation depress the yield and the inherent yield potential of the varieties cannot develop.

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Discussion

Bhatnagar, P. S. (India) : What is the main use of soybean in Indonesia?
Answer: In Indonesia, soybean is mainly used for human food in preparations such as tempe, tofu, soy sauce, etc. It is also used as feed for poultry along with various industrial uses. In Indonesia, most of the proteins consumed by the people originate from soybean.
Dutt, A. K. (India) : What is the cropping pattern adopted in the highlands with acid soils affected by aluminum toxicity?
Answer: The cropping patterns are as follows: rice-corn-soybean, rice-soybean-corn and corn-soybean-peanut. It is also recommended to apply lime every 5 years.
Yap, T. C. (Malaysia) : I understand that your country wishes to increase soybean yield from the present 0.9 ton/ha to about 1.3 ton/ha within a very short period of time (from 1983 to 1985) . Could you outline the measures to be taken to achieve this objective?
Answer: The three packages of technology recommended by the government are as follows: 1. Use of local varieties with good seed quality for the rice fields, 2. Use of improved varieties on dry land as well as rice fields 3. Lime application (4 ton/ha) in problem soils and use of legume inoculant in problem soils, dry land and rice fields for the improved varieties. The objective is to increase the yield within a short period of time as in the case of the BIMAS program for rice.
Palaniyappan, K. (India) : In India we obtain reasonable results with a seed rate of 30-35 kg/ha. I noticed that in Indonesia you recommend a seed rate of to kg/ha.
What is the reason for adopting such a high seed rate? I would also like to know which is the population size you recommend.
Answer: The seed rate is high due to low viability of seed. The population is 500,000 plants /ha.
Yang, C. Y. (AVRDC) : In the areas where you have 3 crops of soybean in the same piece of land, what is the time interval between the crops. What are the soybean varieties used in this cropping system?
Answer: We are using early-maturing varieties (85-90 days) . The time interval between the crops is about one month. In this region the farmers are using Orba. In other regions, they are using 75-day varieties such as Genjah Slawi and Petek. We have also developed Lokon and Guntur which mature within 75 days for the northern part of West Java.

SOYBEAN PRODUCTION IN THAILAND

Arwooth Na LAMPANG*

Abstract

Soybean production is largely based on soybean' s role as a minor component of cropping systems. In irrigated areas it is grown in paddy fields in the cool season. In upland areas it is planted in the early rainy season and intercropped with cotton. In the late rainy season it is intercropped with corn or more commonly grown after corn harvest. The day-neutral cultivars grown can be planted in any of the three seasons. Minimum inputs are used in soybean cultivation, and yields average 1 ton/ha. Production in these systems has provided a sufficient quantity to meet the national needs in soybeans which are largely used for food in traditional ways. Recently, production has not kept pace with the expanding demand for soybeans, especially as a protein supplement in animal feeds. Production packages available could double the present average yields. Economic incentives, efficient marketing and more effective technology transfer are needed to encourage farmers to adopt new technology. Mungbean is a major competitor in cropping systems.

Soybean production in Thailand

Speculation has been made that the Chinese immigrants brought soybean into Thailand during the past three to four centuries. After periods of association with the crop, Thai people adopted soybean as an additional food and began to cultivate the crop for household consumption. The first record of soybean promotion in the Kingdom appeared in 1930 when soybean was introduced into the Northern Valley to be grown after the main rice crop in the paddy fields where traditional irrigation was available.

During the Second World War, there was a strong demand for cotton for domestic use. Soybean was found to be a suitable crop to be sown in the early part of the monsoon season in upland areas where it could be followed by an intercrop of cotton planted in the middle of the rainy season. This cropping pattern has been practiced in the Upper Central Plain area where about two-thirds of the national soybean grains are produced. Since the crop matured and was harvested during the rainy season, grain quality was inferior due to lack of proper drying and storage.

In the Lower Central Plain, corn is planted in the early rainy season, i. e. May to June, and harvested in August to September. Following harvest of corn, soybean can be grown as a second crop to utilize the remaining period of some two months before the rainy season closes in October. Since the termination of the rainy season varies considerably soybean yields are unstable and often very low. Thus, the planted area is rather limited.

With these cropping patterns, Thailand produces about 50,000 tons of soybean annually which covers the requirements for domestic consumption.

The Thai people utilize soybean in traditional Chinese methods, i. e. making various beancurds, pastes and sauces. Only small amounts are exported to neighboring countries, usually following good crop years.

During the past few decades, modern soybean industries have been established for processing of vegetable oils, animal feeds and human food. Domestic bean production has not kept pace with the rapid expansion of agro-industries. Increasing amounts of grain and cake have been imported to meet the growing demand.

*Field Crop Research Institute, Department of Agriculture, Bangkhen, Bangkok 10900, Thailand.

Statistics for soybean production in Thailand are given in Table 1. It should be noted that there were trends of expansion in both production and area during the period covered. Export and import data are shown in Table 2. Prices of soybean at different locations are presented in Table 3. International or Chicago prices have had some effect on soybean trade in Thailand.

Table 1 Soybean acreage, yield and production in Thailand (1971—81)

Year	Average (1,000 ha)	Yield (kg/ha)	Production (1,000 ton)
1971	57.4	944	54.3
1972	84.5	863	72.4
1973	122.6	850	104.2
1974	131.7	837	110.4
1975	118.1	963	113.9
1976	101.6	1,119	113.6
1977	153.1	631	96.3
1978	161.6	981	158.9
1979	108.6	938	102.1
1980	126.1	994	100.0
1981	127.5	1,031	131.5
Rates/Year	+5.5	+0.27	+5.81

Source : Office of Agricultural Statistics, 1981.

Table 2 Balance of soybean export and importation during 1976—1930

Year	Exportation (grains)		Importation			
			Grains		Cakes	
	1,000 ton	US$1,000	1,000 ton	US$1,000	1,000 ton	US$1,000
1976	8.1	2.1	0.05	0.03	9.8	2.3
1977	11.5	3.6	4.0	1.1	53.6	11.0
1978	8.1	2.3	10.8	2.6	82.4	16.9
1979	9.7	3.0	0.005	0.002	58.6	14.6
1980	3.4	1.2	15.3	4.4	154.8	42.8

Sources : Office of Agricultural Statistics, 1981.

Table 3 Soybean prices at different locations (US g/kg) (1977—1981)

Year	Farmgate	Bangkok		Government guarantee	Export	Import	Chicago
		lst grade	2nd grade				
1977	20	28	26	—	31	25	25.7
1978	23	24	23	24	27	25	23.9
1979	21	27	26	27	30	30	25.9
1980	24	38	29	29	36	28	25.5
1981	26	33	31	32	38	30	27.4

Source : Office of Agricultural Statistics, 1981.

Cropping patterns and practices

Historically, Thailand has been mainly a rice-producing country. Soybean and other grain legumes were treated as marginal or minor crops to be grown when extra-land and labor were available. These crops were cultivated with very minimal inputs. Little attention or management was directed to them between sowing and harvest. The farmer was content to harvest whatever he found in the field when harvest labor was available.

A recent trend in soybean cultivation has involved a shift from subsistence to semi-commercial practices. Farmers are paying more attention to management of this crop. More frequent use is made of inputs such as good seed of improved varieties, inoculum, weeding and insecticides. However, the pace of yield improvement is very slow. Increased production has been mainly from expanded area or cropping frequency.

In upland fields for early season plantings, land preparation may be done either with animals or with hired tractors. One, or rarely two, plowings are practiced with one harrowing. When heavy rains come early in the season, and thoroughly soak the soils, seeds are sown and covered immediately. Heavy seeding rates, generally twice the recommended rate, are used to assure adequate stands because of the poor quality of seed which is available. Where cotton is to be intercropped, row spacing is set at one meter to allow proper spacing for the cotton. For late rainy season and dry season plantings, row width is reduced to 50 cm. In paddy fields, seeds are directly dibbled into the rice stubbles followed by an irrigation to provide moisture for germination. Hand weeding is practiced in the rainy season, but seldom in the dry season. Seed inoculation has not become popular and is employed by only a few farmers. Only a few growers apply fertilizer directly to soybean, mostly when soybean is the first crop in a sequence. In the dry season plantings, the crop typically receives two or three furrow irrigations during the season.

Experimental results have indicated that the optimum plant population is about 200,000 per hectare. This can be obtained in 50 cm rows with 20 cm between hills and 2 plants per hill. If plantings are made into furrows rather than in hills, there should be 10 plants per linear meter of row. For such a population, with recommended varieties, 50 kg of good quality seed per hectare should be sufficient. Proper inoculation increases yield by about 15%. Adding $P_2 O_5$ at a rate of 50 kg/ha during land preparation could double total grain yield in general, but the majority of farmers do not apply it for a variety of reasons. Fertilizer costs are quite high in comparison to the price received for soybean. Credit may be difficult to obtain, and interest rates may be very high. Under upland conditions, rainfall patterns are quite erratic and the risk of yields being restricted by moisture stress may discourage farmers from making a fertilizer investment. Soil analyses revealed that on most soils where soybean is grown application of potassium is unnecessary. Where weed populations are high, weed control during the first six weeks could raise yields up to two or three times in comparison to uncontrolled plots.

The results of these studies are urgently needed by farmers. Lack of efficient communication and demonstration of results has limited farmers capabilities of obtaining higher yields. Recently, extension units have been expanded to village levels. It is hoped that improvement will be achieved in the future.

Varietal adaptation and improvement

Variations among those varieties introduced by Chinese immigrants opened choices for Thai farmers in the past to make their own selections. The first requirement was to sort out plants that matured early enough (100 days) to fit their existing cropping patterns. Photoperiod insensitivity was considered essential to enable them to use one variety for all plantings during the year (cropping systems involve three distinct planting seasons) . The use of a single variety also facilitated seed propagation. Seeds produced in one season could be used in the next, thus avoiding the necessity of storing seed from one year to the next.

In the present breeding program undertaken by the Department of Agriculture, these two phenological traits of early maturity and photoperiod insensitivity are maintained as prime objectives. Other desirable characteristics to be added to varieties for improved consistency of performance at higher levels include: resistance to shattering and lodging and drought tolerance. Resistance to major diseases such as rust, downy mildew, bacterial pustule and mosaic has been achieved. Programs for adding resistance to anthracnose and pod and stem blight are in progress. The newly recommended varieties, SJ4 and SJ5, are of about 100 day duration and daylength neutral with high and stable yielding ability. They are well accepted by farmers. However, additional work on varietal improvement is considered necessary in order to obtain more widely adapted and more productive cultivars. Other objectives in the breeding program are to obtain varieties of different growth duration to fit specific locational constraints and for different cropping systems. For certain areas tolerance to edaphic conditions such as salinity and high acidity is required. Multiple sources of resistance to major diseases and insect pests are desirable to protect against the eventuality of breakdown of present sources of resistance and introduction or evolution of biotypes of pathogenic organisms and insect pests which could attack the resistant commercial cultivars.

Pest management

In the hot and humid tropical countries, wide ranges of diseases and insect pests capable of attacking soybean prevail the year round. More than 100 species of plant pathogens have been recorded as attacking soybean crops. Twenty-five of these cause yield reductions to various degrees. However, only six diseases are considered of economic importance. They are:

Diseases	Causal agents
Soybean rust	*Phakopsora pachyrhizi* Sydow.
Anthracnose	*Colletotrichum dematium* (Pers. ex Fr) Grove var. *truncata*. (Schw) Arx.
Pod and stem blight	*Diaporthe phaseolorum* var. *sojae*
Bacterial pustule	*Xanthomonas phaseoli* (Smith) Dawson
Damping off	*Pythium* spp. , *Rhizoctonia* spp. , *Fusarium* spp.
Soybean mosaic	Virus

Cultivars with satisfactory resistance to rust, bacterial pustule and mosaic have been developed while resistance to anthracnose and pod and stem blight is being incorporated in the breeding program. Management practices including sanitation and crop rotation help to reduce damage from these diseases. Chemical treatments are relatively ineffective and uneconomic at present.

Ten serious insect species have been identified and control measures have been developed for recommendation to farmers. Two miners which universally attack legume crops at the seedling stage and cause severe growth reduction constitute a first group. These are the stem miner (*Melanagromyza sojae* Zehn.) and root miner (*M. phaseoli* Try.) . Systemic insecticides are required for spraying at about ten days after emergence in order to eradicate the pests and prevent seedling damage. Aphids (*Aphis glycines* Mat.), leaf hopper (*Empoasca* spp.), leaf rollers (*Lamprosema* spp. and *Archips micaceana* Wkr.), leaf miner (*Stomopteryx subsecivella* Zell.) and white fly (*Bemisia tabaci* Genn.) constitute a second group that often damages soybean heavily in the dry season and during drought periods. In addtion to direct destruction of plant tissues some of them serve as vectors in transmission of viral diseases.

The third group of important insect pests includes the pod borer (*Heliothis armigera* Hubn.) and cut worms (*Prodenia litura* Fab. and *Agrotis ypsilon* Rott.) . They have been found abundantly during the rainy season and especially in the pod developing stage. Heavy infestations result in great reductions in growth, yield and seed quality. Seed beetle (*Callosobruchus chinensis*) is a commonly observed storage pest. It can cause extensive damage if left unattended.

In general, farmers seldom apply chemicals although commercial insecticides and recommendations for their use are available. Yield losses due to insects have been observed in all soybean-growing locations. Spraying is done only when pests threaten to destroy the whole crop. Strong programs of pest management are needed to improve production.

Certain vertebrates including birds, rodents and rabbits are sporadically observed to cause minor damages in a few localities.

Harvest and storage

When the soybean crop has reached maturity, plants are cut by hand and left in the field for a few days until the leaves have dropped from the stems. Plants are then piled together and tied into bundles of 30 to 50 cm in diameter. The bunches are then stored under a shed during rainy periods, otherwise they are spread on a hard surface to sun-dry until ready for threshing. The time required for proper drying varies depending upon atmospheric conditions. Drying usually takes longer for soybeans harvested from early plantings, i. e. when intercropped with cotton.

After plants have cured and dried properly, threshing is commonly done by beating with a bamboo stick which forces pods to split and the beans to fall out. In some cases, the bundles are spread on a hard flat surface and a tractor or pickup truck is driven repeatedly over them.

Within the past few years tractor-powered threshers have been developed in being operated to provide custom services. These machines have proven to be very efficient. They save time, reduce losses and make it possible to preserve grain quality. Although the number of units presently available is limited it is increasing and the use of the machines is gaining in popularity. It is hoped that this development will replace the tedious manual threshing practices. The cost of labor is increasing, and it is becoming difficult to get workers, especially when soybean threshing coincides with peak labor periods for other crops.

With the traditional threshing method, after the threshing has been completed the grains are sorted from the stems and pods by hand. Cleaning is accomplished by placing the beans, and any included plant and soil residues, onto a loosely woven bamboo sieve which is shaken by hand. The beans are then redried in the sun until moisture has been reduced to a level safe for storage. After the grains have been dried adequately they are mostly placed in gunny bags, although some are stored in metal containers. The bags are then stored temporarily under a protective roof.

Post-harvest studies confirmed that multiple handling during harvesting, threshing and drying caused considerable losses of grains—up to 50%. Effective means to overcome these constraints are urgently needed. In addition to large losses in quantity, inferior grain quality also resulted from poor handling and storage. Quality is a major issue in price setting by the local merchant who purchases the product from the farmer. Processing factories are very cautious about accepting sub-standard lots.

Marketing

The majority of the farmers sell their soybean crop immediately after it is dried to local merchants or "middlemen" who come to the village. Some prefer to take their grain to a market town and negotiate a sale there. Because of the sharp competition, few farmers trade their beans with the local Farmers Association or Cooperative.

Middlemen transport the soybean grain from the up-country market towns to large warehouses in Bangkok after price negotiations with the Bangkok purchasers. From these warehouses they are then distributed te processors. Farmgate prices tend to be depressed because of the several transaction steps involved in the present marketing system.

Consumption and utilization

Thai people consume soybean in various ways. Soybean sprouts have their place in most local markets and are included in restaurant menus. Because of their beany flavor, sprouts are not as popular as those from mungbean. Fully developed pods before reaching maturity are picked and boiled, with a small amount of salt, to make market vegetable soybeans which have become very popular snacks.

The traditional methods of processing of dry grain are those adapted from Chinese ways of preparation mentioned earlier. Local food processors, by employing new technology, have developed modified processing methods which are more economical and yield a more standardized and hygienic output. Numerous products that have recently been developed in the western countries are also locally manufactured on a commercial scale and are distributed throughout the country. Government programs to promote improved nutrition have substantially influenced the people' s diet. This, in turn, has increased the demand for soybean and other grain legumes.

Soybean, along with rice bran, cotton and kapok seeds, is used as a raw material in the oil extracting industry. Vegetable oils are widely used in cooking. Recently, importation of palm oil to blend with other cooking oils has partially relieved the shortage of the local supply.

Bean cakes or meals are important sources of protein for use in animal feed. The rapid growth of animal industries, especially poultry, has created great shortages of this raw material. Increasingly larger amounts of cake have had to be brought into the country to meet the growing demand. Re-exportation of animal feeds as well as export of animal products is also taking place. These activities are occurring in response to the availability of local materials and labor for processing.

Prospects and constraints

In the promotion of soybean production, the Thai government has set the target first for self-sufficiency and then for exportation. Production tripled from about 50,000 tons in 1971/72 to over 150,000 tons in 1978/79. Thereafter, the expansion of production has slowed. Close analysis shows keen competition with mungbean. These two legumes compete with each other in many aspects of production, including land use and labor. Mungbean is a tropical crop, well adapted to the Thai climate and soils. Soybean requires approximately 100 days to complete the cropping cycle and yields about one ton per hectare. Mungbean, on the other hand, takes only 65 days to produce about 0.75 ton per hectare, and it can be grown anytime of the year when moisture is available. The price of mungbean currently is about US$ 0.45/kg while that of soybean is only US$ 0.30/kg. In addition, Thailand is a major exporter of mungbean and the international market for mungbean is not yet saturated. In the case of soybean, domestic price is about at or somewhat above Chicago price. Farmers tend to grow soybean only when they can not grow mungbean because of rainfall or temperature patterns or price outlook of mungbean does not appear to be favorable.

From an agro-ecological standpoint, soybean is regarded as a crop with considerable potential in Thailand's agriculture. Soybean yields now being obtained by farmers could be doubled by application of present knowledge and technology as has been shown in demonstration plots. There is still ample land involved in cropping systems in which soybean could be included if socio-economic problems can be solved. There are several steps which can be taken to promote soybean production. These include a stronger government effort in transfer of technology, some subsidy on necessary inputs, increased farmer access to credit, and increased efficiency of the marketing system.

Acknowledgement

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Discussion

Hidayat, O. O. (Indonesia) : In view of the very low viability of soybean seed in the tropics, how do the farmers in Thailand store soybean seed as well as how long do they store the seeds before planting?

Answer: The use of seed produced in the wet season for the dry season and *vice versa* was found to be one way to solve the problem of low viability and germinability of seed.

Summerfield, R. J. (United Kingdom): We must be careful in the use of terminology and in particular I refer to your use of the term "adaptability" . On the basis of your data mungbean and soybean produce 11 kg seed/day/ha and can be said to be equally well adapted. Should we think in terms of protein and oil production/ha/day to make valid comparisons? Adaptability can be defined as the exploitation of space and time or output of a particular product per unit of agricultural resource (such as water, fertilizer, land, etc.) . A crop which is poorly adapted and produces small yields could command a large market, price, while another well-adapted crop, giving high yields only a small price. Economics does not reflect "adaptability of crops to agro-climates" .

Answer: In my presentation the term "adaptability" is used since mungbean can tolerate adverse conditions such as soil acidity, drought, heat, infestations with pests much better than soybean under tropical conditions. From the evolution standpoint, mungbean originated in the tropics whereas soybean was introduced to the tropics from the temperate zone, hence mungbean is very well adapted to tropical conditions. In addition the higher price of mungbean is another incentive for the Thai farmers to grow mungbean whenever time, land and labour are available.

Palaniyappan, K. (India) : Is there any advantage in modifying the level of fertilization you recommended so as to increase production?

Answer: I would like to mention that there are indigenous populations of *Rhizobium* in the soils of Thailand. Also inoculants are produced in Thailand and recommended rather than nitrogen. In the soils of Thailand the available potassium level is 100 ppm.

Okabe, S. (ESCAP) : I noticed that Thailand imports large amounts of soybean cakes for use as feed. Is the price of soybean competitive enough in Thailand compared with that of other feeds such as rice bran, maize, etc. ?

Answer: The feed industry which is expanding rapidly requires large amounts of protein sources which are only represented by fish meal and soybean cake. Rice bran, maize and other products cannot be used as substitutes. Soybean cake even imported is cheaper than fish meal.

SOYBEAN PRODUCTION AND RESEARCH IN TAIWAN

Hsiung WAN*

Abstract

Soybean is a crop of economic value in Taiwan. There are three crops each year, spring crop planted in mid-February to mid-March; summer crop in June to July; and fall crop in late September to mid-October. Of these crops, the fall crop is planted mainly in the Kaohsiung-Pingtung area. Generally two cultural practices, conventional method and stubble planting, are used in soybean production. The stubble planting is predominantly for the fall crop.

In 1982, the acreage and value of soybean were only 0.85% and 0.24% of the total national crop land and value, respectively. In contrast to the pre-war years, the soybean production significantly increased from 3,500 tons on 6,100 hectares (average 600 kg/ha) in 1936-1945 to 63,000-67,000 tons on 40,000-50,000 hectares (average 1,500-1,700 kg/ha) in 1964-1973.

This increase resulted from the extensive effort mady by research institutions in the improvement of variety, physiology, cultural practices, nutrition, and pest management. However, further increase in production is expected to be difficult due to the constraints in 1) competition from the low-priced, imported soybean and from other crops; 2) high labor cost; and 3) unfavorable weather conditions. Nevertheless, the government is striving toward the increase of soybean production through the conversion of paddy land for soybean along with price supporting program, cost reduction and research.

Soybean is a crop of economic value in Taiwan. Although the production had once increased tremendously since the end of World War II, a large part of the supply still relies on imports every year to meet the demand for oil and feedstuffs. Great efforts have been made by the government to increase the soybean production in order to reduce imports as much as possible. This goal, however, has never been fulfilled because of the government policy for rice self-sufficiency. Due to the excessive supply of rice in recent years, more farmland is being allocated to the planting of soybean and other feed grain crops. Thus soybean production is expected to increase hereafter.

Production

Soybean production, as viewed by the national crop production, is of relatively minor importance in Taiwan. Its largest acreage averaged about 6% of the total cropland in the period of 1959-1968 and dropped to 0.85% in 1982, accounting for 1.7% and 0.24% of the national crop value respectively.

Soybean production has fluctuated tremendously over the last three decades. The period of peak output ran from 1964 to 1973 with 63,000-67,000 tons produced on nearly 40,000-50,000 hectares. These figures contrast strikingly with those in 1936-1945, when an average of only 3,500 tons was harvested from 6,100 hectares annually (Table 1) . This significant rise in soybean production was made possible largely by the expansion of acreage; also important was the significant increase in yield per hectare, from less than 600 kg/ha in 1936-1945 to 1,500-1,700 kg/ha after 1964, through varietal and cultural improvements as well as disease and pest control. However, yield began to decline in the last decade, with only 50,000 tons produced on 30,000 hectares in 1977. A continuous decline in both acreage and production was so prominent that there were only 12,043 tons harvested from 7,782 hectares in 1982.

Soybeans can be grown in any part of the island, especially in the southern Kaohsiung-Pingtung

*Taiwan Agricultural Research Institute, Wufeng, Taichung, Taiwan.

Table 1 Soybean production in Taiwan

Year	Planted area (1,000 ha)	Yield (ton/ha)	Production (1,000 ton)	%	Import (1,000 ton)	%
1936—1945	6.1	0.568	3.5			
1959—1963	56.5	0.913	51.3	29.1	124.9	70.9
1964—1968	51.5	1.303	67.0	21.2	248.8	78.8
1969—1973	40.2	1.572	62.8	9.6	590.6	90.4
1977	30.1	1.717	51.7	7.3	655.1	92.7
1978	24.5	1.668	40.8	4.3	959.4	95.7
1979	19.3	1.644	31.8	2.8	1,103.8	97.2
1980	15.3	1.692	25.9	2.7	939.0	97.3
1981	10.3	1.543	15.9	1.4	1,113.4	98.6
1982	7.8	1.549	12.1	1.0	1,150.4	99.0

From Taiwan Agriculture Yearbook.

area which accounts for 70%-80% of the total acreage and 75-85% of the total production (Table 2). Soybeans are mainly grown as a fall crop in this area (Table 3), with the yield per hectare being 5-10% higher than the national average. The recent decline in soybean production is naturally more drastic in the Kaohsiung-Pingtung area.

Supply and demand

The supply and demand of soybeans vary significantly from year to year. The total supply consists of local produce and imports. In 1959-1963, it was only 176.2 thousand tons, of which the local produce accounted for 29.1% (Table 1). The amount of imports has increased enormously since 1969; it reached 1.15 million tons in 1982, leaving the local produce to only 1% of the total supply. The marked increase of soybean imports is due to the lifting of import control in 1966 as

Table 2 Soybean production in Kaohsiung-Pingtung area, Taiwan

Year	Planted area (1,000 ha)	Yield per ha (ton/ha)	Production (1,000 ton)
1936—1945	—	—	—
1959—1963	33.0(58.4)	0.954(104.5)	31.4(61.2)
1964—1968	38.3(74.4)	1.405(107.8)	53.8(80.3)
1969—1973	32.6(63.3)	1.668(106.1)	54.3(86.5)
1977	24.3(80.5)	1.585(106.5)	58.2(85.2)
1978	17.1(69.7)	1.809(105.4)	43.9(84.9)
1979	13.7(70.7)	1.845(109.3)	31.5(77.2)
1980	10.8(70.5)	1.782(108.4)	24.4(76.7)
1981	6.3(61.1)	1.814(107.2)	19.6(75.7)
1982	4.2(55.0)	1.663(107.8)	10.5(66.0)

Note :Figures in parentheses are % of the corresponding national total in that year or of the average in that period.

Table 3 Soybean production in different planting seasons in Taiwan

Year	Crop	Planted area (1,000 ha)	Yield/ha (ton/ha)	Production (1,000 ton)
1967—1971		46.0	1.488	68.3
	Spring	6.1	1.221	7.5
	Summer	5.1	1.224	6.2
	Fall	34.8	1.570	54.6
1977		30.1	1.717	51.7
	Spring	4.1	1.447	6.1
	Summer	3.3	1.324	4.3
	Fall	22.6	1.825	41.3
1978		24.5	1.668	40.8
	Spring	5.3	1.326	7.1
	Summer	3.3	1.320	4.4
	Fall	15.8	1.857	29.4
1979		19.3	1.644	31.8
	Spring	3.6	1.324	4.8
	Summer	2.4	1.290	3.1
	Fall	13.3	1.794	23.9
1980		15.3	1.692	25.9
	Spring	2.7	1.462	3.9
	Summer	2.2	1.332	2.9
	Fall	10.4	1.827	19.1
1981		10.3	1.543	15.9
	Spring	2.8	1.452	4.1
	Summer	1.5	1.199	1.7
	Fall	6.0	1.669	10.0
1982		7.8	1.549	12.0
	Spring	2.2	1.440	3.2
	Summer	1.5	1.372	2.1
	Fall	4.1	1.675	6.7

From Taiwan Agriculture Yearbook.

well as the increase of local demand for oil and feedstuffs (oil meal) .

The use of soybeans is multiple. A survey in 1977-1978 (Chiang, 1979) showed that 90.18% of soybeans were processed into oils, 9.23% into beancurd and milk, 0.5% into soy sauce and 0.09% into fermented food; only a negligible amount was for direct uses, i. e. beansprouts and cooked beans.

The projected demand for soybeans in 1982 in the same report was 1.08 million tons, which agreed closely with the actual supply of 1.16 million tons. It must be pointed out, however, that the total supply shown in Table 2 does not reflect the actual consumption of that year. The actual consumption includes reserved stocks, and the total amount of local produce and imports is also partly reserved as stoks.

Methods of culture

Planting time

Because of the subtropical climate in Taiwan, soybeans can be grown all the year round. Generally, there are three crops: spring crop planted in mid-February through mid-March, summer crop in June through July, and fall crop in late September through mid-October. The fall crop is the major and predominant crop in southern Taiwan, while the spring and summer crops are planted in other parts of Taiwan because of the difference in cropping systems and relatively low temperatures in the winter (Table 3) .

Varieties used

Soybean varieties released and adopted for commercial production by the farmers are Shih-Shih, Palmetto, Wakashima, Tainung 4 , Kaohsiung 3 and 8 , and Tainung 15. Their major characteristics and planting areas are listed in Table 4 (Cheng and Chan, 1968; Chan, 1981; Thseng and Chan, 1980) .

Planting methods and field management

1 Conventional method Land preparation and spacing: The conventional method is generally applied to spring and summer crops. The land is plowed twice, compost and basic fertilizers are applied at the second plowing and followed by harrowing and levelling. For better drainage, a plant bed 1.0-1.2 m wide is usually prepared. Spacings vary with planting seasons and varieties used. The row spacing is usually 40-50 cm with plants 10-20 cm apart. Spring crop is spaced wider than the summer crop because of a longer vegetative growth. The row spacing for the fall crop is 40 × 10 cm. Drilling is the general practice with a seeding rate of 50-70 kg/ha.

Fertilization: Fertilization of soybeans is practiced as early as possible. As basic fertilizers, all of phosphorus and potassium and half of nitrogen are applied during land preparation: the remaining nitrogen is applied 2 weeks after germination by topdressing. Liming is not a common practice in the southern and western parts of Taiwan because of the presence of alkaline soils. In other acid soils 1.5-3.0 ton/ha of $Ca(OH)_2$ or 2.0-5.0 ton/ha of $CaCO_3$ are used, depending on the acidity of the soil.

The amount of fertilizer recommended to the farmers is N 10-30 kg/ha, P_2O_5 40-90 kg/ha, K_2O 30-75 kg/ha, and compost 10-20 ton/ha.

The fertilizers used in the different crops are more or less the same except that more nitrogen is applied for the fall crop.

Weed control: Hand-weeding is mainly practiced because farms are small. The first cultivation is made two weeks after seed germination when soybean plants are 15-20 cm tall. Topdressing of nitrogen is completed at the same time. A small ridge is formed after cultivation. The second cultivation is performed 15-20 days after the first one.

Chemical control of weeds is not common. Linuron, Stomp and Lasso are used for pre-emergence and Kusagard for post-emergence applications.

Irrigation and drainage: Soybeans are irrigated when soils are dry. No irrigation is performed right after seeding because poor germination may result from seed decay. The first irrigation is generally made 10-15 days after seedling emergence or after the first cultivation. Irrigations at the flowering and pod-setting stages are most important to increase the yield significantly. Drainage may be needed if soybeans are grown in paddy fields, particularly for the soybean crops grown in spring and summer which are rainy seasons.

2 Rice-stubble planting method Rice-stubble planting is a special cultural method for soybeans in Taiwan and of particular significance because it is commonly performed for the fall crop in the Kaohsiung-Pingtung area which is the producing center.

Soybeans are planted immediately after the harvest of the second rice crop without land preparation. A small opening is dug right beside each rice stubble with a small spade. Three to four seeds are dropped into the opening and then the spade is removed. No soil cover is needed. The seeding rate is about 100-120 kg/ha. As the soybeans are planted at each rice stubble, the spacing is naturally the same as for rice which is 22.5 cm × 22.5 cm or 27 cm × 13.5 cm. However, every tenth row should be left unplanted to facilitate field operations thereafter.

After the sowing of soybeans, rice straw is spread over the paddy field to prevent the loss of soil moisture and to control the weeds as well. Some farmers burn the rice straw right after its spread.

This practice is said to promote seed germination, but there is no scientific evidence for it.

No tillage is practiced. Irrigation is applied two weeks after the sowing of soybeans and at the flowering and pod-setting stages.

Fertilizers are applied two weeks after germination in the amounts of N 10-20 kg/ha and P_2O_5 30-40 kg/ha without K_2O.

Harvesting

Soybeans are harvested by uprooting the whole plant by hand or cutting the plant near the ground with a sickle and then treshed by a power tresher. Soybean seeds are dried under natural sunshine for 3-4 days until the moisture content is reduced to about 13%. In case of rainy days, soybean seeds may be dried by dryers for 1.0-1.5 days.

The harvesting time varies with the planting seasons, from May to July for the spring crop, September to November for the summer crop, and January to early February for the fall crop.

Disease and pest control

Due to the hot and humid weather in Taiwan, soybean diseases and insects are prevalent and sometimes cause severe damage to the crop. The major ones and the chemicals for their control are listed below:

Diseases and insect pests	*Chemicals for control*
Rust (*Phakopsora pachyrhizi* Sydow)	Dithane M-45, Bayleton
Bacterial blight (*Pseudomonas glycineum*)	——
Bacterial pustule (*Xanthomonas phaseoli*)	——
Purple speck (*Cercospora kikuchii*)	Maneb
Virus	——
Root miner (*Melanagromyza dolichostigma*)	Disyston, PSP204, Thimet
Stem miner (*M. sojae*)	ditto
Leaf miner (*Phytomyza atricornis*)	ditto
Black cut worm (*Agrotis ypsilon*)	ditto
Blister beetle (*Epicauta hiriconis*)	ditto

Soybean research and extension systems

Research institutions

A number of institutions are engaged in soybean research, such as the National Taiwan University (NTU) , National Chung Hsing University (NCHU) , Pingtung and Chiayi Institutes of Agriculture, Taiwan Agricultural Research Institute (TARI) , and Kaohsiung, Hualien and Tainan District Agricultural Improvement Stations (DAIS) . Their geographical locations are shown in Figure 1.

NTU had cooperated with Kaohsiung DAIS in breeding research to develop high-yielding and daylength-insensitive varieties, and also worked on genetics, physiology and cultural practices. However, it has not implemented any active research program in recent years except for some studies on soybean seed physiology.

NCHU is interested in soybean breeding and genetics research, particularly in interspecific hybridization, quantitative genetics, yield components analysis, and some physiological studies.

TARI and Kaohsiung DAIS are responsible for breeding such soybean varieties that are high-yielding, resistant to rust and daylength-insensitive. TARI is recently engaged in research on the nitrogen fixation of soybean nodule bacteria and on the physiological aspects of low yield. Other DAISs do the breeding work in cooperation with TARI and Kaohsiung DAIS.

Besides, the Pingtung and Chiayi Institutes of Agriculture also conduct soybean research in the fields of breeding and genetics, photoperiod, nutrition, and cultural practices. Their interests are not

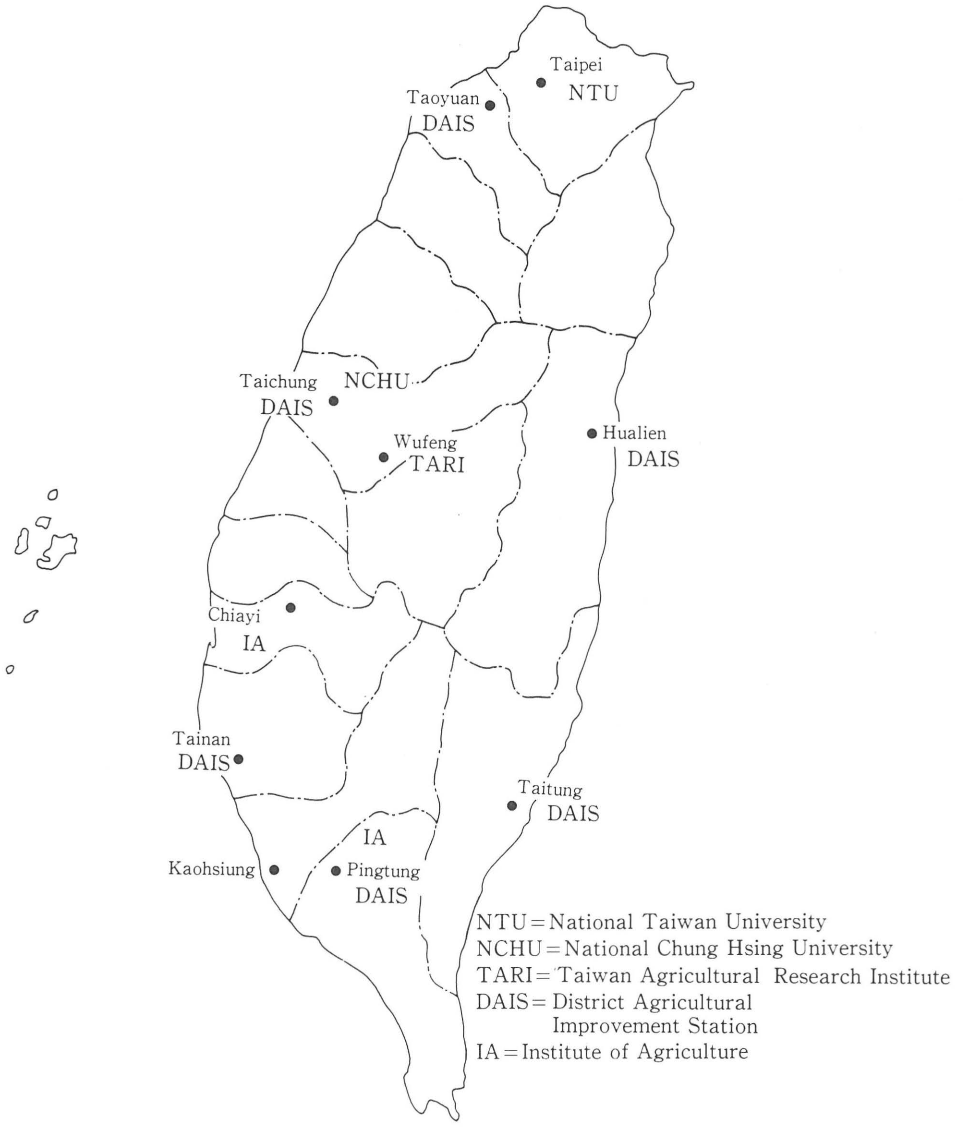

Fig. 1 Location of soybean research and extension institutions.

consistent, depending largely on the grants available.

The Asian Vegetable Research and Development Center (AVRDC) , an international organization, is very active in soybean research in the fields of breeding, pathology, physiology, nutrition, etc. to solve production problems not only for Taiwan but also for other Asian countries.

Other organizations contributing a great deal to soybean production are: 1) the Council for Agricultural Planning and Development (CAPD) which, at the national level, maps out overall plans for soybean production and makes funds available to various research institutions, and 2) the Provincial Department of Agriculture and Forestry (PDAF) which handles research and extension programs.

Table 4 Soybean varieties released in Taiwan and their characteristics

Variety	Year released	Days to maturity (days)	Plant height (cm)	Flower color	Pod color	Pubescence color	Seedcoat color	Hilum color	Yield (ton/ha)	Disease resistance (reaction)	Adapted area and season	Other
San-Kuo	1956	86—124	46—10	P	Tan	Tawny	Dark yellow	Brown	1.4—3.0	Resistant to PS and DM	Northern, Summer	Sensitive to daylength
Shih-shih	1957	80—95	25—40	P	Tan	Gray	Yellow	Brown	1.6—2.0	Resistant to PS, DM and SMV	Any season	Insensitive to daylength and temperature
Palmetto	1957	83—127	55—100	P	Tan	Light brown	Brown	Black	1.3—2.5	Resistant to PS and DM	Summer and Fall	Sensitive to daylength and temperature
Wakashima	1960	91—120	50—80	P	Tan	Tawny	Light brown	Brown	1.5—3.0	Virus susceptible	Fall	Sensitive to temperature
Talientto	1949	80—95	50—70	W	Tan	Tawny	Brown	Dark brown	2.1—3.0	Resistant to PS	Fall	Sensitive to temperature
Acadian	1960	90—95	30—35	P	Dark brown	Tawny	Brown	Brown	1.4—2.0	—	Fall	Sensitive to daylength
Nungyuan 1	1958	92—100	35—40	W	Brown	Light brown	Yellow	Black	1.2—2.0	—	Fall	
Chunghsing 1	1964	107—122	36—58	P	Brown	Gray	Yellow	Dark brown	2.5—4.5	Resistant to rust	Eastern, Fall	Insensitive to daylength and temperature
〃 2	1964	107—113	35—95	W	Tan	Light brown	Yellow	Brown	2.9—3.7	ditto	ditto	ditto
〃 3	1967	84—96	47—51	P	Dark brown	Tawny	Yellow	Brown	2.2—2.6	ditto	Spring and Summer	ditto
NTU-KS 5	1963	85—100	35—50	W	Tan	Tawny	Yellow	Brown	1.5—2.5	Rust susceptible	Fall	Vigorous growth
Kaohsiung 1	1959	80—90	40—60	P	Dark brown	Tawny	Yellow	Dark brown	1.0—1.8	Rust and DM susceptible	Spring and Fall	Drought tolerant
〃 2	1959	90—105	60—80	P	Brown	Tawny	Brown	Dark brown	1.6—2.7	Resistant to rust	Fall	Sensitive to daylength
〃 3	1971	90—115	30—60	W	Dark brown	Tawny	Yellow	Brown	1.2—3.0	Resistant to rust	Any season	Large-seeded
〃 8	1980	87—110	38—65	W	Dark brown	Tawny	Yellow	Brown	1.6—3.5	ditto	ditto	Insensitive to daylength and temperature
〃 S—9	1982	97—120	40—60	W	Brown	Tawny	Yellow	Brown	1.0—3.2	Resistant to rust and DM	Spring and Fall	Vigorous growth
Tainung 1(R)	1963	110—120	60—80	P	Tan	Tawny	Yellow	Brown	1.5—2.9	Resistant to rust	Northern, Summer	Lodging resistant
〃 2(R)	1963	110—120	55—82	P	Tan	Tawny	Yellow	Brown	1.5—3.0	ditto	ditto	—
〃 3	1967	85—113	30—54	P	Brown	Light brown	Yellow	Brown	1.8—2.8	Resistant to rust and SMV	Spring and Fall	—
〃 4	1970	93—112	25—54	P	Brown	Tawny	Yellow	Brown	1.2—2.3	Resistant to rust	ditto	—
〃 15	1980	88—102	33—58	P	Brown	Gray	Yellow	Brown	1.3—1.7	Rust susceptible	Southern, Summer	Salt tolerant
Hualien 1	1980	100—115	35—60	P	Brown	Tawny	Yellow	Brown	1.5—3.2	—	Eastern, Summer	Lodging resistant

W = White, P = Purple, PS = Purple Speck, DM = Downy Mildew, SMV = Soybean Mosaic Virus

Extension service

Responsible for agricultural extension are the District Agricultural Improvement Stations (DAISs) . There are six such DAISs located respectively in Taoyuan, Taichung, Tainan, Kaohsiung, Hualien and Taitung. They operate under the PDAF but technically work in close cooperation with TARI. Any findings by research institutions are transferred to DAISs for local evaluation and the results thereof are disseminated to farmers.

DAISs are also responsible for seed multiplication. The breeder's seeds of a new variety are provided by the research institutions to the DAISs for multiplication of foundation seeds. Then, the registered seeds are produced by reliable farmers selected and guided by the DAISs. Some foundation seeds may also be multiplied by the Taiwan Seed and Seedling Improvement Station.

Major research programs completed

Variety improvement

A total of 22 soybean varieties have been developed in the last two decades by NTU, NCHU, TARI, and Kaohsiung and Hualien DAISs. Six of them are introductions, and the remaining are selections from hybridization (Table 4) . All varieties are daylength-insensitive and mature early. Days to maturity are generally less than one hundred so that they can be fitted into the rice-rice-soybean cropping system in the major soybean-producing areas. Rust resistance is essential for newly developed varieties. For exampe, Tainung 3 and 4 and Kaohsiung 2, 3 and S-9 are all moderately resistant to rust. The sources of resistance are mainly from PI200492, PI230970 and PI230971.

Breeding and genetics research

Breeding and genetics are the major fields of soybean research in Taiwan. An extensive review has been made by Thseng and Chan (1980) . Breeding scheme, heritability, yield components analysis, correlation between agronomic characters, and heterosis are the major subjects.

1 Selection scheme: Soybeans are very sensitive to daylength and temperature so that the selection scheme is extremely important in developing varieties best suited to the cropping system. There are controversies about this matter. According to Yu *et al.* (1965) , most characters of the lines selected from F_2 populations grown in different seasons showed different coefficients of variability and the genetic differences were expressed more evidently in the spring crop. They suspected that the disruptive selection scheme might not be the best approach. Other scientists agreed with them by obtaining larger genetic variances and higher heritability for most characters in the spring crop, but indicated that some lines selected by disruptive selection produced high yields in both spring and summer crops, and were stable in different years (Lu *et al.* ,1967) . By using the same scheme, Tsai *et al.* (1967, 1970) also obtained lines adapted to both spring and fall crops. Hence, they strongly suggested that the use of disruptive seasonal selection was advantageous. The same results were obtained by Thseng and Ling (1977a, 1977b) who indicated that the disruptive selection scheme might have three advantages: (1) shorten the breeding period; (2) make selected lines more flexible to the environment; and (3) reduce the seed storage problem. They suggested that selection be made in the spring or summer and propagation in the fall. Continued research is required if the time of soybean production is to be shifted to spring and summer seasons.

2 Heritability: The estimates of heritability vary so greatly that care must be taken in the use of it. The h^2 estimates obtained by various workers are under entirely different environmental conditions, such as year, location, experimental design, spacing, single plant or plot basis, etc. Some of them are expounded in broad sense, while others in narrow sense. In general, the h^2 estimates of plant height, 100-seed weight, days to flowering and days to maturity (Thseng and Ling, 1977b; Yu, 1964) , unit seed weight, number of nodes on main stem (Tai, 1964) are high, while the seed yield estimates are generally low. The h^2 estimates are higher from the crosses of determinate ×

indeterminate types than from the crosses between the same growth types (Thseng, 1980) .

3 Yield components analysis and correlation between characters: Yield components analysis and correlation studies may facilitate the selection of high-yielding varieties. The results, however, vary greatly because the materials and planting seasons are different. Most results show that genotypic correlations are higher than phenotypic correlations which in turn are higher than environmental correlations for most agronomic characters (Tang, 1963; Tai, 1964; Yu *et al.* , 1965; Tsai *et al.* , 1970; Thseng and Ling, 1977a, 1977b) . One group of characters (number of branches, number of seeds per pod, number of pods per node) is negatively correlated with another group of characters (unit seed weight, number of nodes on main stem, number of nodes per branch) . However, characters within one group are positively correlated (Tai, 1964) . Other negative correlations are found between 100-seed weight and days to flowering, plant height, plant weight, number of branches, number of pods, days to flowering and pod-setting duration (Yu *et al.* , 1965), days to maturity as well as days to flowering with characters such as plant height, number of branches, number of pods, number of seeds and plant weight (Tsai *et al.* , 1967) . Other correlations between characters are generally positive.

With respect to yield components, the most significant ones are the number of branches, number of nodes, number of pods, 100-seed weight (Tang, 1963; Yu *et al.* , 1965; Tsai *et al.* , 1967, 1970) , plant height and plant weight (Tsai *et al.* , 1967, 1970) . Thseng and Ling (1977b) found that the vegetative growth was negatively correlated to the yield in the spring crop, but not in the fall crop, because of an over-vegetative growth resulting from long day, high temperature and abundant rainfall.

In progenies of determinate $\times$ indeterminate types, only the correlations between yield components are significant. However, in crosses between the same growth types, the correlations are significant not only between yield components but also between agronomic characters (Thseng, 1980) .

4 Growth type: The growth type of soybeans may be classified into determinate, indeterminate and semi-determinate. However, Thseng and Hosokawa (1972) classified it into determinate, semi-indeterminate and indeterminate based on the degree of growth habits (DGH) expressed in terms of the increase in node number after the first flowering. Thseng and his colleagues in Taiwan suggested that for developing high-yielding soybean varieties, the use of the semi-indeterminate type would be advantageous because of its longer flowering and podding time as well as the flexibility in yield potential against adverse growing conditions in the main soybean crop (fall crop) season(Thseng and Lee, 1976) .

5 Heterosis: The use of heterosis to increase the yield of soybeans is of interest. Most of the F_1 hybrids exhibit heterosis in plant weight, number of branches, leaf area, leaf weight, number of leaves, and thickness of leaf (Thseng, 1978) , total dry weight, seed weight, number of pods and seeds per plant (Chan and Tsuar, 1982) . However, in most cases, 100-seed weight shows negative heterosis.

In the use of genetic male sterility in hybrid seed production, Chan (1975) found that the percentage of pod setting was 63% if manual pollination was made by removing the corolla of male sterile flowers. It was only 6.2% to 15.5% if pollination was made without the removal of the corolla. Bees are not suitable for increasing the natural crossing rate (1.4%) . Thus, genetic male sterility is useful only in making manual crosses for breeding purposes and not for producing commercial hybrid seeds.

6 Cytology: Efforts in soybean cytological and taxonomic research have been limited. Further progress in soybean production is expected to be more difficult. Wild species may be of value. The morphology and cytology of 12 different soybean species and interspecific crosses between *G. max* and *G. gracilis* and between *G. usseriensis* and *G. formosana* have been studied in Taiwan (Cheng, 1962a, 1962b, 1963a, 1963b, 1963c; Lu, 1966; Lu and Thseng, 1968; Tang and Chen, 1959; Tang and Li, 1963; Tang and Tai, 1962) . Attempts to overcome the barrier of other interspecific crosses have not been successful (Chan, 1969) .

Physiology, nutrition and cultural practices

1 Photoperiod and temperature sensitivity: In Taiwan, 9-12 hr is the critical photoperiod for normal plant growth (Cheng, 1963; Lu and Yen, 1975) . Different varieties respond differently to daylength, ranging from 4-14.5 hr, and temperature (Shee, 1966b) . Most of the varieties from high latitude are daylength-insensitive, and those from lower latitude are sensitive. Sensitive varieties mature too late in the spring crop while insensitive varieties are generally temperature-sensitive and mature too early in the summer with resulting low yields (Lu, 1957; Lu and Tsai, 1964) . The days to flowering are prolonged due to low temperature on the one hand and high temperature with longer daylength on the other. However, the effect of high temperature on maturity is not very significant under short daylength but will delay maturity under longer daylength (Lu and Yen, 1975) . Shee (1964) found that the longer the daylength the smaller the seed size. This explains why soybean seeds produced in the spring crop are relatively smaller.

In a series of studies, Shee (1970a) indicated that the substance produced by photoperiod treatment for inducing flowers did not translocate itself. One branch of a sensitive soybean plant subjected to longer photoperiod did not flower while another branch of the same plant left untreated flowered, or *vice versa*. Another interesting result is that when the branch of the sensitive variety, Palmetto was grafted onto that of the intensitive variety, Shih-Shih and was grown simultaneously with the branch of Shih-Shih on the same plant under 16 hr photoperiod, the daylength sensitivity was not altered (Shee, 1970b) .

The daylength sensitivity of some soybean varieties has been identified (Lu, 1954, 1969; Shee, 1966a) as shown in Table 4.

When soybeans were grown under low temperature, Wu (1977, 1978, 1980) found that the pollen development was retarded and plant height, number of branches, number and size of pods, leaf area, leaf dry weight, chlorophyll content were all reduced. The root system was also severely affected.

2 Physiology of different leaf-types: There are three different types of soybean leaf, i. e. , broad, intermediate and narrow. Attempts to use the narrow leaf type and to understand its physiology have been made. Chan (1967) found that the narrow leaf type had smaller stomata, larger aperture and lower transpiration so as to be more tolerant to drought. Lu and Muh (1979) indicated that the physiological characters differed significantly among different leaf types, e. g. , AGR : intermediate > broad > narrow ; CGR : intermediate and narrow leaf types were the largest in the spring and summer crops respectively; LAI: the intermediate type was the largest while the narrow leaf was the smallest. The canopy of different leaf type varieties affected the growth and yield of soybeans (Su *et al.* , 1971) .

Seeds, deteriorated under high temperature (42^0 C) and humidity (100%) , show no change in protein content but a slight reduction in oil content. Deteriorated seeds germinate poorly, plant growth is retarded, and all agronomic characters are reduced. The adverse effects of seed deterioration on yield components result in lower yields (Wu, 1977) .

The relationship between O_2 uptake, C_2H_2 reduction and H_2 evolution as affected by water stress has been evaluated in soybean nodule. The relative efficiency of nitrogen fixation in soybean nodule is not affected, the absolute rates of C_2H_2 reduction and H_2 evolution decrease with increasing water stress. The water stress also increases the respiratory cost in soybean nodule (Sung, 1982) .

3 Nutrition: Soybean nutrition studies were mostly conducted in the 1960s.

Lin *et al.* (1960, 1962) found that there was no significant response to NPK if soybeans were planted in paddy fields because of the residual effect of fertilizers applied to rice, and suggested as optimum fertilizer levels N: P_2O_5: K_2O =5: 20: 20 kg/ha. Potassium might increase the number of soybean branches (Fong, 1964; Yu and Hsu, 1962) and urea could be used as foliar application at the concentration of 1/600 - 1/850. In acid soils, the application of Mo or liming increased soybean yields because of the increase of nitrogen fixation by nodule bacteria. However, it did not affect the absorption of P, K and Ca. If both Mo and lime were applied, the effect of Mo would greatly diminish as soil pH became higher after liming (Lee *et al.* , 1967) .

There would be a higher dry matter production if the growth rate of soybeans at the vegetative stage could be increased. The dry matter production is positively related to the yield. The response of soybeans to fertilizers, particularly nitrogen, generally takes place at the early growth stages (Liu, 1982) .

4 Cultural practices: Most researches on soybean culture are conducted at DAISs and TARI. Spacings and seeding rates for various crops are the common topics. In conventional cultural practices, the spacing of 40 × 20 cm or 40 × 10 cm is the best for both spring and summer crops (Hualien DAIS, 1960; Chan and Cheng, 1971) . However, Tang (1970) indicated that soybeans would yield better if closer spacing (20 × 10 cm) was used. For the fall crop, the adequate spacing is 30 × 10 cm (Tainan DAIS, 1971) .

Stubble-planting is used for the fall crop. Soybeans are planted at the same spacing as rice. The spacing of 27.0 × 13.5 cm is better than 22.5 × 22.5 cm, with two plants per hill (Chen and Hung, 1968; Chen and Li, 1969) .

Weed control in soybean fields is very limited. Preforan 30 and Prometryne are as effective as Lasso and TOK-25 (Cheng, 1973) . Additional weeding is necessay for maintaining the normal growth and yield of soybeans in continuous cropping with repeated application of the same herbicides (Wang *et al.* , 1975) .

Diseases

More than 40 soybean diseases caused by fungi, bacteria, nematodes and/or viruses have been recorded in Taiwan (Tsai *et al.* , 1979) . Among them rust is the most important (Han, 1959a; Chu and Chuang, 1961; Yang, 1977) . Downy mildew, purple seed stain, and bacterial pustule are commonly observed in soybean fields, but they are not as prevalent as rust (Han, 1959a; Chu and Chuang, 1961) .

1 Disease control: Soybean rust (*P. pachyrhizi*) is one of the factors limiting the yield (Chan, 1977) . It is especially destructive in the spring and fall crops and also prevalent in the summer crop (Liu, 1966; Yang, 1977) . Complete defoliation may occur in case of heavy infection. Yield losses of 23-50% are recorded in the field (Chan, 1977; Chan and Tsuar, 1975; Liu, 1966) and 90% in the nursery (Yang, 1977; Yeh and Yang, 1975) . No highly resistant cultivar is currently available (Liv, 1966; Yang, 1977) . The spraying of fungicides such as Bayleton, Maneb, Zineb, Mancozeb, Plantvax, Saprol and Sicarol gives satisfactory control (Chan and Tsuar, 1975; Hu *et al.* , 1975; Hung and Liu, 1961; Jan and Wu, 1971; Liu, 1966; Yang, 1977; Yen and Yang, 1975; Wang, 1961) .

The vegetable soybean cultivars in southern Taiwan are very susceptible to downy mildew (*Peronospora manshurica*) (Chu and Chuang, 1961; Han, 1959a) . However, no fungicide has yet been officially recommended to the farmers to control this disease. They usually use Dithane M-45 to prevent its spread.

Purple seed stain (*Cercospora kikuchii*) occurs islandwide, and is serious in the spring crop in central Taiwan (Han, 1959b) as rainfall is abundant before harvest. Heavily infected seeds decrease the germination ability. Differences in resistance are observed among soybean varieties. The disease is controlled by spraying the fungicide Mancozeb (400 ×) at 10-day intervals once symptoms appear. Seed treatment with fungicides has also been reported as effective. The use of high quality or clean seeds will prevent seedling infection and reduce primary inocula. Bacterial blight (*Pseudomonas syringae* pv. *glycinea*) is severe under cool and humid conditions. Chu and Chen (1968) reported that the varieties Sanko and TK5 were less susceptible than Tainung 2 and 64-91.

Other diseases such as soybean mosaic virus disease, witches' broom (MLO) and those caused by root-knot nematodes (*Meloidogyne javanica, M. incognita*) have also been recorded but not yet become a problem (Tsai *et al.* , 1979) .

2 Studies on pathogens: Few studies on pathogens have been reported. The uredospores of soybean rust germinate well at 21° C in free water. The germinability decreases drastically within three weeks at room temperature. However, cold storage at 5° C prolongs the germinability up to

46 days. Light is necessary for the formation of infection pegs to penetrate host epidermis (Hsu and Wu, 1968) . Lin (1966) found that collections of the soybean rust organism varied in pathogenicity and virulence among non soybean hosts. Based on the lesion types of five soybean differentials, three races of *P. pachyrhizi* have been identified at TARI (Yeh, 1983) .

Insects

Fifty-seven species of soybean insects have been recorded in Taiwan. Stem and root miners, green stink bugs, scarab beetle and Kanzawa spider mites are the most important.

1 Bionomic studies: Bionomic studies on the stem miner (*Melanagromyza sojae*) (Wang, 1979, 1980) , root miner (*Ophiomya centrosematis*) (Lee, 1958, 1976; Lee and Wang, 1968) , bean root miner (*O. phaseoli*) (Lin *et al.* , 1977) , bean leaf roller (*Hedylepta indicata*) (Anonymous, 1981) , green stink bug (*Negara viridula*) have been reported. Information contained therein can be used for the study of control measures.

2 Chemical control: The use of chlorinated hydrocarbon compounds such as BHC, Endrin, Dieldrin and Heptachlor is banned due to their residue problems. The application of granular insecticides upon seeding or the spraying of insecticides on plants to control miners, aphids and spider mites has been the major control measure since 1968. Monocrotophos, Demathoate, and Chlorinate give satisfactory control when sprayed at one-week intervals starting 7 days after germination (Chang, 1971; Chen, 1953; Lee, 1962) . Disyston, Thimet, Furadon, Temik, Folimat and PSP are commonly used by the farmers at present.

3 Biological control: Biological control of soybean pests has been studied at TARI since 1970. However, efforts are concentrated on the survey of the species of parasitoids of bean leaf rollers and stem and root miners. The parasitoids reported are: six species for the stem miner, four species for the root miner, and four species for the bean leaf roller (Chiu and Chou 1977; Chou *et al.* , 1981) . Three species of parasitoids for the green stink bug (*Trissolus* sp. , *Telenomus* sp. and *Gymnosonia* sp.) and two species for the mantid have also been recorded (Wang, 1979, 1980) .

There are 24 species of natural enemies of Tranuchoideae found in Taiwan for Kanzawa spider mites. Among them, two predatory bugs (*Stethorus loi* and *Oligota oviformis*) , gall midge (*Arthrocnodax* sp.) and two predatory mites (*Amblyseius longispinosus* and *A. ovalis*) are important with regard to their potential to reduce the population of pest mites (Chiu and Chou 1977; Chou *et al.* , 1981) .

4 Pheromone : The use of a synthetic sex pheromone of the tobacco cutworm (*Spodoptera litura*) to trap male moths in the fields has been attempted. However, its effectiveness is reduced under cool and wet conditions (Chiu and Chien, 1979) .

5 Variety resistance : Screening of soybean germplasm for resistance to beanflies or miners shows that no variety is highly resistant (Chan *et al.* , 1973) . However, differences among varieties are observed. Lo *et al.* (1981) reported that 24 varieties/lines were resistant to Kanzawa spider mites and that the length, intensity and growth angle of leaf hairs were highly correlated to the population density of spider mites on the plant.

Major constraints in soybean production

The supply of soybeans in Taiwan depends solely on imports.

The major constraints attributable to the downhill trend of soybean production have been discussed in detail (Cheng, 1971; Thseng and Chan, 1980; Wan and Cheng, 1969) .

Import of low-priced soybeans

Soybean production in Taiwan has never been sufficient to meet local needs in the past three decades. The shortage is mainly due to the import of low-priced soybeans. This greatly affects the marketing price of locally-produced soybeans and thus makes the soybean-growing non profitable.

Competitive crop in soybean-producing center

Another factor responsible for the decline of soybean production is the marked increase of adzuki bean production as a substitute for soybeans in Pingtung County — the soybean-producing center.

Although 90% of the adzuki beans were originally produced in this area, a constant balance between the acreages of soybeans and adzuki beans had been maintained before 1976 at the ratio of 9: 1. However, the acreage of adzuki beans increased from 5,855 hectares in 1976 to 17,354 hectares in 1981, particularly in Pingtung County (Table 5) . The shift is due to higher profits from growing adzuki beans (Huang, 1980) , which are produced for export to Japan under contract.

Table 5 Acreages of soybean and adzuki bean

Year	Taiwan province				Pingtung County			
	Soybean (ha)	Adzuki bean (ha)	Total (ha)	% adzuki bean	Soybean (ha)	Adzuki bean (ha)	Total (ha)	% adzuki bean
1970	42,749	1,986	44,735	4.4	28,390	1,420	29,810	4.8
1971	40,151	2,655	41,806	6.2	27,422	2,218	29,640	7.5
1972	36,123	5,475	41,598	13.2	24,658	4,229	23,387	20.2
1973	36,491	6,878	43,369	15.6	23,422	6,362	29,784	21.4
1974	44,454	4,714	49,168	9.6	28,872	4,242	33,115	12.8
1975	41,446	5,021	46,467	10.8	29,074	4,601	33,675	13.7
1976	35,548	5,855	41,403	14.4	26,635	5,469	32,104	17.0
1977	30,117	10,975	41,092	26.7	20,503	10,415	30,918	33.7
1978	24,473	19,692	44,165	44.6	13,729	18,423	32,152	57.3
1979	19,333	18,254	37,587	48.6	10,806	16,764	27,570	60.8
1980	15,329	16,369	31,698	51.6	8,386	14,700	23,086	63.7
1981	10,312	17,354	27,666	62.7	4,476	15,293	19,769	77.4

From Chiang, 1979 and Taiwan Agriculture Yearbook.

Unfavorable growing conditions in the tropics

Soybeans are grown mainly as a winter crop after the harvest of the second rice crop in Taiwan. The winter time is dry, short in daylength and low in temperature, which is not favorable for soybean growth. Nor are spring and summer suitable for soybean plantings because of abundant rainfall, high temperature and pest problems. These environmental stresses render soybean production in the tropics low-yielding and difficult.

High cost of production

The average yield of soybeans in Taiwan is 1,500-1,600 kg/ha, which is not very low in comparison with that in other Asian countries. However, the high labor cost, small farm size, low input in soybeans as a side-crop and unfavorable weather conditions have resulted in an ever-higher cost of production, making soybeans difficult to compete with other crops.

Measures for promotion of soybean production

The local soybean output accounted for only 1% of the total demand in Taiwan for the year 1982. It is far from the projected national goal for soybean production. The government made its utmost efforts both from the economic and technological angles to increase the production in order to reduce imports.

Price support

For the purposes of stimulating the farmer's interest in growing soybeans and offsetting the adverse effect of soybean imports, the government set up a Grain and Feed Development Foundation in 1972. An amount of NT$40 was surcharged on each metric ton of imported grains. The funds thus raised were partly used to establish a guaranteed price program for soybeans. However, the program was not very effective because the support price was too low to be attractive and the scope of its applicability was rather limited. Since 1982, the government has raised the support price to NT$25 per kg and made the program applicable to any soybean-growing area. The program is expected to become more attractive to soybean growers and thereby make the soybean more competitive with other crops provided that the funds for the program are available.

Expansion of acreage

For decades, the major area for soybean production has been limited to the southern part of Taiwan as a fall crop. Expansion of its acreage in that area is rather difficult. In 1982, a landuse readjustment program was announced by the government to cope with the over-production of rice. The shift of paddy cultivation to that of soybean and other feed-grain crops has since been emphasized. In other words, the soybean is no longer limited to the winter cropping; it can be planted in paddy fields to replace rice as spring and summer crops. On the other hand, various incentives such as NT$10,000 per hectare subsidies and low-interest loans are provided to encourage farmers to grow grain crops other than rice. This policy will undoubtedly serve to expand the acreage of soybeans.

Change in the aim of variety improvement

To match the readjustment of farmland uses, the aim of soybean variety improvement must also undergo a change. This calls for the development of such varieties that are adapted specifically to spring and summer seasons in order to fit the new cropping pattern. Attention will still have to be paid to the daylength-and temperature-insensitive varieties.

Soyban rust poses a risk in soybean production. The presently available sources of resistance are not entirely adequate for protecting the crop against the disease. Continued search for adequate sources of rust resistance is encouraged.

Reduction of production cost

The labor cost accounts for 41.5% of the total production cost (Thseng and Chan, 1980) . Under such a pressure, emphasis is being placed on the development of farm machinery for feed grain crops and on the study of labor-saving cultural practices. On the other hand, an integrated cultivation method, including the use of improved varieties, new cultural techniques, proper pest control, and adequate fertilization and irrigation, should be stressed in order to increase the yield and reduce the cost.

Prospects

In 1978, the highest target of soybean production was set at 170,000 tons to be harvested from 85,000 hectares, but actually only 40,824 tons were produced on 24,473 hectares. This downward trend of soybean production may continue for some time.

Great strides have been made by the government in its efforts to reduce rice production and allocate more paddy land for the planting of soybeans and other feed grains. Thus, there will be much more room for soybean acreage expansion in the spring and summer seasons if incentives are attractive enough and readily available to farmers. A reasonable 100,000 tons of soybeans with quality preferred by local consumers can be produced.

In this context, the variety improvement program should be aimed at developing such varieties as can be fitted to the spring and summer seasons and have a higher protein content and other specific qualities to meet the need of making soybean milk and beancurd for domestic markets. Researches on labor-saving cultural practices, pest control, mechanization and other related fundamental studies should also be strengthened to reduce the production cost and make soybeans more competitive against other crops.

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Discussion

Bhatnagar, P. S. (India) : 1. In your presentation you mentioned that 90% of the soybean produced was utilized for oil. Is the defatted soybean flour used only for cattle feed or also for human food? 2. Could you give the reasons why you changed your breeding objectives in order to increase the acreage planted to soybean ?

Answer : 1. Defatted soybean meal is chiefly used as pig feed and not for human food, except a small amount which is used for the manufacture of soy sauce. 2. Emphasis is placed on the breeding of varieties that are tolerant to high temperature and high rainfall in order to plant them in the summer and spring which coincide with a period of the year when the temperature and precipitation are high.

Dutt, A. K. (India) **Comment** : In Taiwan there are three planting periods, February, June-July and September. Moreover the cultivation of soybean is restricted to the southern part of the country and soybean is not grown in the highlands. In India, soybean can be grown in June to September all over the country provided that the land is well drained and there is no waterlogging. In the southern part of the country and in the Sunderbans soybean can be grown as a winter crop even at tropical latitudes provided suitable cultivars are available.

Carangal, V. R. (IRRI) : 1. You described stubble-planting. Since labor is expensive what is the potential of machine planting as a substitute for stubble-planting?
2. You indicated that the government is now encouraging the cultivation of soybean instead of rice. Are you going to replace the first or the second rice crop in the rice-rice-soybean system since the breeding objectives would be different ?

Answer : 1. Indeed labor cost is high in the case of stubble-planting and the use of machines for planting is increasing. Strictly speaking, the practice described is not exactly stubble-planting but some type of labor-saving cultivation because the machine-planted soybeans are not necessarily at or near the rice stubble. On the other hand some hand-operated planter is also used but not popular. 2. Under the land use readjustment program, the farmers are encouraged to plant soybeans in paddy fields to replace the first or second rice crop. Since the yields of the second rice crop are lower than those of the first crop, farmers are likely to grow soybeans in the summer to replace the second rice crop. Thus the breeding objectives for soybean will be good adaptability to high temperature and heavy rainfall while the requirements for the spring crop of soybean would be tolerance to high temperature and daylength-insensitivity.

SITUATION OF SOYBEAN PRODUCTION AND RESEARCH IN CHINA

JIAN YU YU*

Abstract

Soybeans are distributed throughout China, but their cultivation is mainly concentrated in eight provinces. The soybean production area in China is generally divided into three cultivation regions : Northern Spring Sowing Region, Huanghe and Huaihe Valley Summer Sowing Region, Southern Multiple Cropping Region. In 1981, the total area covered approximately 8 million hectares with a total yield of 9,245 million tons.

Soybean research has been carried out for over 30 years. The objective of research focusses on increasing yield and improving the quality of soybeans. In this report, the organization of soybean research at different levels, the situation of studies on breeding, genetics, germplasm conservation, physiology, ecology, regionalization of production, cultivation techniques for achieving high yields and control methods of soybean diseases, insects and weeds are described.

Soybean, a native plant of China, has been cultivated for more than 5000 years. Soybeans are distributed throughout China, from Heihe, Huma (Heilongjiang province) to Taiwan, Hainan ; from Altay, Tachang (Xinjiang province) to Zayu, Bomi (Xizang) (Fig. 1). But, they are cultivated mainly in eight provinces : Heilongjiang, Jilin, Liaoning, Hebei Henan, Shandong, Jiangsu and Anhui. In 1981, the area under soybeans in the eight provinces accounted for 76.5% of the total area under soybeans and 80.4% of the total production in China.

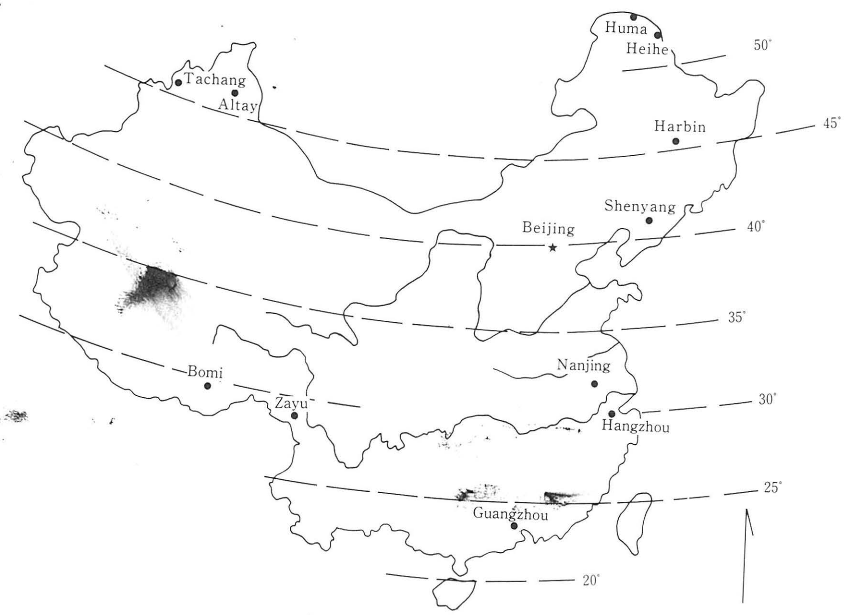

Fig. 1 Soybean production regions in China.

*Soybean Institute, Jilin Academy of Agricultural Science, Gongzhulinh, Jilin Province, China.

Depending on the annual rainfall, mean temperature during the growth season, duration of frost-free days, photoperiodic response and crop rotation system, the soybean production area in China is generally divided into three cultivation regions (Fig. 2) :

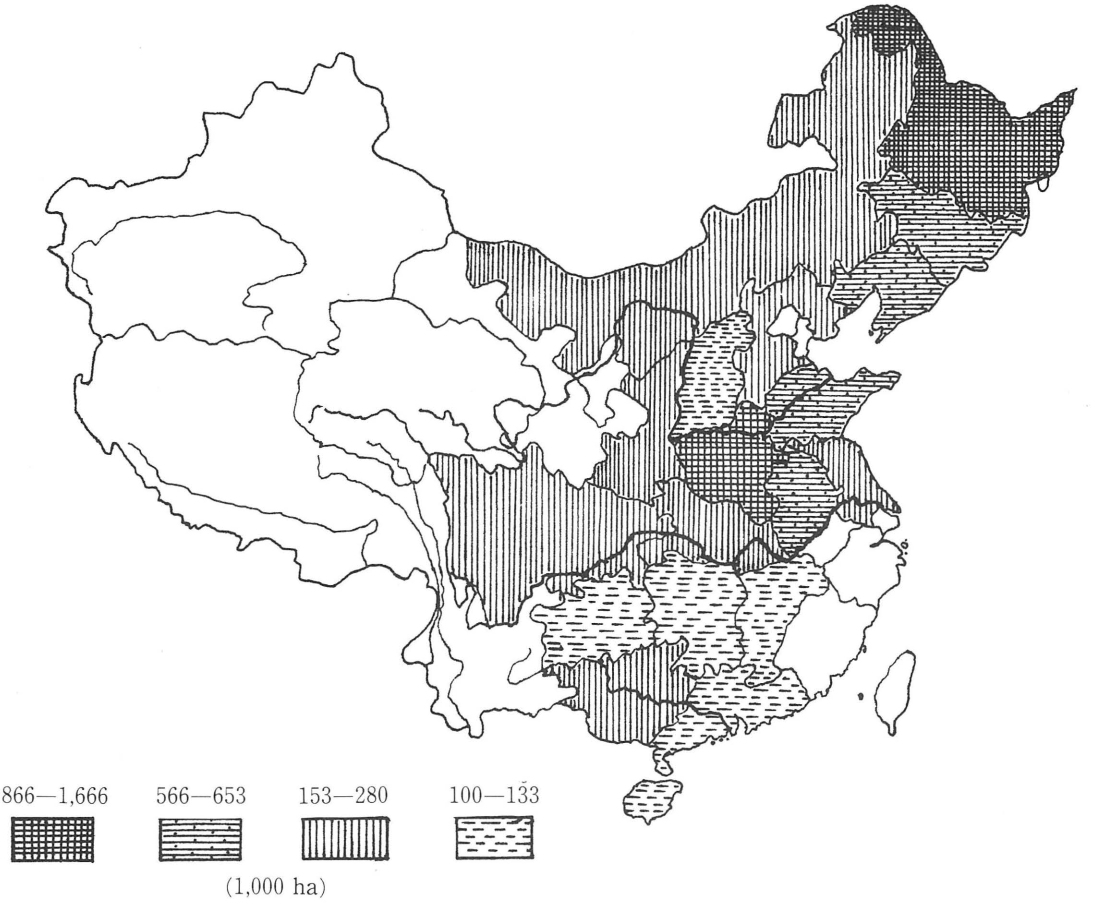

Fig. 2 Soybean distribution in China (1979).

1 Northern Spring-Sown Soybean Region

It is one of the major soybean production areas in China. This region includes the three northeastern provinces, Inner Mongolia, Ningxia, Xinjiang and the northern parts of Hebei, Shanxi, Shaanxi and Gansu provinces. It is mainly concentrated in the Songhuajiang and Liahe plains. This region has one crop a year, the soybean is sown from late April up to mid-May and harvested in September, the growing period being about 105-155 days. The main rotation system includes corn-soybean-millet or kaoliang, or soybean-spring wheat-corn. In 1977, the area of this region covered 3.060 million hectares with a total yield of 3.101 million tons acccounting for 43. 9% of the total soybean area and 40.5% of the total production. Most of the varieties have yellow seed, good quality with high oil content.

2 Huanghe and Huaihe Valley Summer-Sown Soybean Region

It is another major soybean production area in China. It includes Shandong, Henan and the northern parts of Jiangsu and Anhui, the central and southern parts of Hebei, Shanxi and Shaanxi provinces. The rotation system of two crops a year usually includes winter wheat-soybean. Soybeans are sown from mid-or late June and harvested in mid-or late September or early October, the growing period being 95-110 days. The area of this region covers 2.306 million hectares with a total yield of 2.750 million tons accounting for 33.1% of the total soybean area and 36% of the total production.

3 Southern Multiple Cropping Soybean Region

This region is located along the lower Yangtze and includes the southern provinces of China. The cropping system consists of two or three crops in one year, three crops in two years or five crops in three years. Soybean can be sown in spring, summer or autumn ; in Guangdong and Guangxi, soybean can be sown in winter. Spring soybeans are planted after March, or intercropped with winter wheat or barley, harvested in July or August, and followed by rice. Summer soybeans are planted in monoculture or intercropped with corn in June after winter wheat, barley or rapeseed, and harvested in October. Autumn soybeans are planted in late July after rice is harvested in October or November. The area of this region covers 1.800 million hectares with a total yield of 1.800 million tons accounting for 23% of the total soybean area and 23.4% of the total production.

Before 1949, the average annual soybean production in China was about 7-9 million tons. In 1949 the total yield of soybean dropped to 5.08 million tons. In 1957, the yield reached 9.1 million tons. In 1981, the total area under soybeans was approximately 8 million hectares with a yield of 9.325 million tons. The yield per hectare is 1.16 tons (Tables 1 and 2).

Table 1 The soybean acreage and production of the provinces in 1981

Province	Planted area (1,000 ha)	Production (1,000 ton)
Heilongjiang	1,800.0	2,015
Henan	1,194.0	1,540
Anhui	737.3	905
Shandong	719.3	830
Jilin	605.3	790
Liaoning	461.3	625
Jiangtsu	326.7	480
Hebei	323.3	340
China	8,015.3	9,310

Table 2 The acreage and production of soybean in China

Year	Planted area (1,000 ha)	Yield per ha (ton/ha)	Production (1,000 ton)
1977	6,844	1.05	7,250
1978	7,143	1.05	7,565
1979	7,246	1.02	7,460
1980	7,187	1.09	7,880
1981	8,024	1.16	9,325
1982	8,414	1.07	9,030

Since the foundation of the People's Republic of China, soybean research work has been conducted by public institutions. The Ministry of Agriculture, Animal Husbandry and Fishery includes a Bureau of Science and Technology and a Bureau of Education. The research organizations under the Bureau of Science and Technology are : National Chinese Academy of Agricultural Science, provincial Agricultural Academies and Institutes, and district Agricultural Institutes. There are also county Agricultural Institutes, county extension services, and county seed multiplication farms. The Bureau of Education coordinates two levels of agricultural colleges and universities : regional and provincial agricultural colleges. In Heilongjiang and Jilin, the Soybean Institute has been set up under the guidance of the academy of agricultural science of the respective provinces. Soybean research laboratories were established at the Crop Breeding Institute and the Oil Crop Institute under the guidance of the National Chinese Academy of Agricultural Science, and also there are soybean research sections in Shandong, Henan, Anhui and Jiangsu provinces. Besides, there are soybean research laboratories and sections in agricultural colleges and universities, such as Nanjing Agricultural College. Now China has more than 400-500 researchers working on soybean (Fig. 3).

Ministry of Agriculture, Animal Husbandry and Fishery

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[Bureau of Science and Technology] [Bureau of Education]

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National Chinese Academy of Agricultural Science — Regional and Provincial Agricultural Colleges

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Provincial Agricultural Academy and Institutes

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District Agricultural Institutes

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County Agricultural Institutes
County Extension Services
County Seed Multiplication Farms

Fig. 3 The organization of research.

Soybean breeding work in China primarily involves the use of conventional techniques. Soybean is a self-pollinated crop and since inbred pure lines are used in breeding, the selection methods include pedigree, bulk population and various modifications of pure line method, such as single seed descent, early generation testing and recurrent selection which are used by different soybean breeders. Another modification of the pure line method that has been used extensively is backcrossing. The method uses good varieties with the breeding objectives of selecting lines, i.e. for high yield, good quality (high oil and protein content), wide adaptability, resistance to diseases, insects and lodging and adaptation to mechanized harvest. Since the establishment of the People's Republic of China, we have developed more than 250 new soybean cultivars which are used in production. For example : Heihe No 3, Dongnong No 4, Fengshou No 10, Heinong No 26, Hefeng No 6, Jingshanpu, Jilin No 3, Jilin No 8, Jiunong No 9, Qunxuan No 1, Tiefeng No 18, Wenfeng No 5, Qihuang No 1, Yuechin No 4, Xudou No 1, Nannong 493-1, Taixingheidou, E dou No 2, Most of those varieties cover more than 66,000 hectares or 200-300,000 hectares.

In the meantime, we have adopted some special techniques such as the induction of mutation by radiation and chemicals, induction of haploids by pollen, studies on cell modification, somatic hybridization and genetic engineering for plant improvement, to produce the desired genetic changes in our soybean breeding research program and preliminary results have been achieved. Research on soybean genetics has been carried out in the laboratories of agricultural colleges, institutes of provincial academies, including heterosis and inbreeding depression, the quantitative inheritance of economic characters, and the theory and methods of selection.

Research work on soybean germplasm has been carried out throughout the country, and at present China has more than 8,000 *Glycine max* and almost 5,000 *Glycine soja* materials being maintained. Systematic research consists of the following aspects : geographic distribution of ecotypes, production, classification, identification of pest-resistant varieties, analysis of seed composition. The "Checklist and Catalog of Chinese Soybean Varieties" was published, in which over 6,000 varieties have been recorded, to describe in terms of a series morphological and physiological characters. At present some germplasm with high-yielding characters, strong adaptability and multiple resistance has been selected and used as parent materials in our breeding program. Cultivated, wild and semi-wild species of soybean have been collected both at home and abroad. The wild and semi-wild soybean materials have been sorted out and identified.

Furthermore, research has been done on soybean physiology, ecology and cultivation techniques to achieve high yields, i.e. studies on ideotypes and physiology of high photosynthetic rate, nutrient requirements (nitrogen, phosphorus, potassium, micro-nutrients) of soybean, photoperiodic response and regionalization of soybean production, and irrigation techniques. In the soybean-producing area of the northeastern provinces, an integrated soil cultivation system consisting of mechanized deep plowing, loosening and harrowing has been established.

A preliminary survey of the major diseases and insects of soybeans has been carried out, and research work on the pattern of outbreak of diseases and insects, as well as their control methods, has been initiated. Soybean mosaic virus is the most widespread disease on soybean in China. Six races have been identified and some highly resistant cultivars have been developed. Soybean rust is widespread in the southern region of China and resistant cultivars such as Jiu-yue-huang have been planted. Soybean pod borer is one of the important insects of soybean in the northeastern region and some insect-resistant cultivars such as Jilin No 3, Jilin No 16, Heihe No 3, have been developed by soybean breeders. The control methods of *Aphis glycines* Matsumura, *Etiella zinckenella* Treitschke, *Clanis bilineata* Walker, *Melanagromyza sojae* (Zehnter) have been studied. Research has also been conducted on the control of weeds by application of chemical at the time of cultivation.

To further develop soybean production, we shall continue to intensify our scientific research work, coordinate research and establish soybean research centers in many soybean-producing areas. We will study culture techniques and rotation systems, and develop comprehensive culture practices to achieve high yields, collect soybean germplasm extensively and systematically and identify, study and utilize these genetic resources. We will speed up selection breeding and multiplication of seeds and use of new certified soybean cultivars ; we will study the pattern of outbreaks of soybean diseases, insects and weeds, and their control methods, and carry out forecasting work. It is necessary to promote soybean science and technology in order to increase rapidly the per unit yield of soybean.

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Discussion

Sumarno (Indonesia) : 1. Have your experiments on somatic hybridization been successful ? 2. What part of the plant do you use for culture ?

Answer : 1. Somatic hybridization of soybean is in its early stage and is not particularly successful. 2. We use cell suspensions of root as well as cotyledon. Cell fusion with materials from other crops such as tobacco, pea and corn has also been attempted.

Dutt, A. K. (India) : What are the major uses of soybean in China ?

Answer : Soybean is mostly used for oil. Defatted soybean meal is used as animal feed and as fertilizer. Soybeans are also processed for food products such as tofu, soy sauce, soy milk, etc. or consumed directly as vegetables.

Trikha, R. N. (India) : 1. What is the percentage of the varieties released that are popular with the farmers ? 2. How do you procure seed ?

Answer : 1. Approximately 50%. 2. Seeds are made available through seed multiplication farms.

Galal, S. Jr. (Egypt) : Has any of the germplasm collected in China been evaluated for shade tolerance ? Indeed we are looking for such material for intercropping corn with soybean in Egypt.

Answer : We have some varieties that are shade-tolerant such as Jilin No 3. They are suitable for intercropping with corn, particularly in northeastern China. These varieties are also resistant to lodging.

SOYBEAN CROPPING SYSTEMS IN SOUTH CHINA

GAI Jun Yi*

Abstract

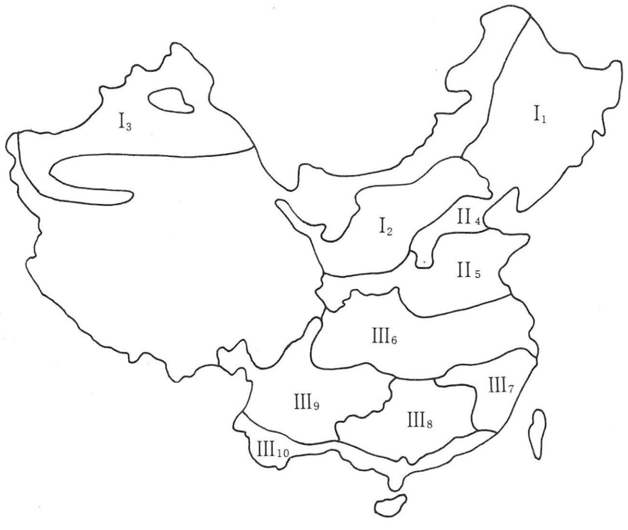
The regionalization, including three regions and ten sub-regions, with respect to cropping systems of soybeans is presented. The cropping systems and related soybean cultivars of the Chang-Jian Valley, Southeastern, Mid-southern, Southwestern, and Tropical sub-regions in the Southern Multiple Cropping, Multiple Planting Region are described. Among them, the Chang-Jian Valley Sub-region is the most important area for soybeans in the Southern Region. There is a potential to raise the soybean production in this region since it is possible to increase both the acreage and unit acreage yield. The approaches are discussed.

Regional distribution of soybeans in China

The cultivated soybean *(Glycine max* (L) Merrill) is believed to have originated in China (Probst and Judd, 1973), although there are conflicting views as to which part of China is the primitive center of origin for the cultivated soybean (Wang and Gai, 1981 ; Hymowitz, 1970). The long history of production and adaptation of soybeans resulted in the widespread distribution of soybeans in China, from Heilongjiang in the north to Hainan island in the south, from Taiwan in the east to Xinjiang and Xizang in the west, and from the plains to the plateaus below 2000 m in elevation. A variety of cropping systems and a large number of land cultivars fitted to the various environments have evolved throughout the years.

Wang (1943, 1958) divided the soybean area in China into five regions : (1) the Spring Planting Soybean Region, (2) the Summer Planting Soybean, Winter Fallow Region, (3) the Summer Planting Soybean Region, (4) the Fall Planting Soybean Region, and (5) the Double Soybean Region. During the past three decades, the position of the crop in China has changed greatly, with the acreage of rice increasing gradually and the soybean acreage decreasing correspondingly. There has been a tendency to increase the cropping index throughout the country, in order to increase the total output of food to meet the requirements of self-sufficiency for the growing population of the country. The intercropping of soybeans with other crops, mainly corn, was recommended in northern China, and the practice of double cropping and triple cropping with soybeans expanded northwards in central and southern China. To make full use of solar energy and the growing season, multiple cropping was adopted when the temperature in early spring was suitable for the spring planting of soybeans and the temperature in late fall or early winter allowed a normal ripening of the fall planting. Since the cropping system changed considerably and there were spring, summer, and fall plantings in southern China, Wang and Gai (1981) combined the latter three regions of Wang's regionalization into one. Therefore, they divided the soybean area into three regions : (1) Northern Spring Region, (2) Northern Summer Region, (3) Southern Region (Fehr and Gai, 1980). Lu *et al*. (1981) further divided the above three regions into ten sub-regions. Pu and Pan (1982) modified Lu's sub-region classification in changing both the boundaries and terminology. The three regions and ten sub-regions of Pu and Pan, in a modified and reduced form, are as follows (Fig. 1) :

*Professor, Department of Agronomy, and Deputy Director, Soybean Research Laboratory, Nanjing Agricultural College, Nanjing, China.



I Northern Single Cropping, Spring Planting Region
- I_1 Northeastern Sub-region
- I_2 Northern Plateau Sub-region
- I_3 Northwestern Sub-region

II Northern Double Cropping, Summer Planting Region
- II_4 Hai Valley Sub-region
- II_5 Huang and Huai Valley Sub-region

III Southern Multiple Cropping, Multiple Planting Region
- III_6 Chang-Jiang Sub-region
- III_7 Southeastern Sub-region
- III_8 Mid-southern Sub-region
- III_9 Southwestern Plateau Sub-region
- III_{10} Tropical Sub-region

Fig. 1 Regions of soybeans in China.

Cropping systems of soybeans in southern China

The acreage and production of soybeans in the Southern Region are indicated in Table 1. Both accounted for about 23% of the whole country. The average yield in 1977 was 1.12 ton/ha. Within this region, both acreage and production of soybeans in the Chang-Jiang Valley Sub-region were superior to the total of the other four sub-regions, and the average yield (1.34 ton/ha) was also higher than in the other sub-regions.

Obviously, from 1955 to 1977, the soybean acreage in the Southern Region was reduced by one-third, while the total production remained at the same level. There was some restoration of soybean acreage afterwards. However, the trend to expansion has not been limited to the Southern Region but has also involved other regions at various periods of the year so as to maximize the use of the growing season through the expansion of multiple cropping systems, especially through the expansion of the spring and fall plantings of soybeans. This is chiefly because, as mentioned above, soybeans had already spread all over the country.

The major cropping systems of soybeans in the sub-regions of the Southern Region are listed in Table 2, and the dates of developmental stages in Table 3.

Table 1 The acreage and production of soybeans in southern China[a]

Sub-region	Year	Soybean acreage			Soybean production	
		(1,000 ha)	% CA[b]	% TCA[c]	(1,000 ton)	% TSP[d]
Chang-Jiang	1955	1,561.1	7.1	13.7	1,312.0	14.4
	1977	859.6	4.5	12.3	1,154.5	15.1
Southeastern	1955	241.9	7.1	2.1	150.0	1.6
	1977	142.7	4.6	2.1	163.5	2.1
Mid-southern	1955	386.0	6.3	3.4	140.5	1.6
	1977	241.3	4.1	3.4	167.5	2.2
Southwestern	1955	278.8	4.3	2.5	167.0	1.8
	1977	226.4	4.3	3.2	223.0	2.9
Tropical	1955	114.3	3.3	1.0	53.5	0.6
	1977	130.2	4.1	1.9	83.0	1.1
Total	1955	2,582.1	6.3	22.7	1,823.0	20.2
	1977	1,600.1	4.4	23.0	1,791.5	23.4

a. Abbreviated from Pu and Pan (1982).
b. Percentage of soybean acreage accounting for the cultivated acreage in the sub-region.
c. Percentage of soybean acreage accounting for the soybean acreage in the whole country.
d. Percentage of soybean production accounting for the soybean production in the whole country.

The Chang-Jiang Valley Sub-region, including parts of the province along the river, has three planting types of soybeans, i.e. summer, spring and fall, in the decreasing order of relative importance. Triple cropping applies to spring and fall soybeans and double cropping to the summer planting (Table 2). Formally, there were only the summer and spring plantings and the fall one was newly developed during the 1970s.

The summer soybean crop is usually cultivated in upland fields with or without corn intercropping. The spring one is usually planted while a winter crop, such as wheat or barley is still present. The fall one may follow either pattern, in paddy fields, or upland fields and may be planted with early corn.

The cultivars of Maturity Group 0 (such as Taixing-heidou) and Group II (such as Aijiao zao) are used for the spring planting with an average yield of 1.2-1.5 ton/ha. Group V (such as 1138-2, Houzimao, and Suidaohuang) and Group VI (such as Nannong 493-1, 4-1, 19-15) are for both the summer and fall plantings, with an average yield of 1.8-2.0 ton/ha and 1.2-1.5 ton/ha, respectively.

The Southeastern Sub-region, including southern Zhejiang, northeastern Jiangxi, most part of Fujian and the whole Taiwan, has fall, spring and summer plantings in the decreasing order of relative importance, in contrast with the situation in the Chang-Jiang Valley Sub-region where the fall planting is the most important. Both spring and fall soybeans are usually found in paddy fields, and only a small acreage of summer soybean is in upland fields. The spring crop is usually planted while a winter crop is still present.

Cultivars of Group III (such as Shangyu-kanshanbai, Jinjiang-zhuzidou, and Jinxian-liuyueba) are used for the spring planting, with an average yield of 1.1-1.4 ton/ha, Group VIII (such as Shangrao-daqingsi, Lanxi-daqingdou, and Liancheng-baihuadou) and Group VII for fall and summer plantings, with an average yield of 1.1-1.4, and 1.6-1.8 ton/ha, respectively.

Table 2 The major cropping systems of soybeans in southern China

Sub-region	Planting	RI[a]	Crops in a year	Notes
Chang-Jiang	Spring	2	Winter wheat (barley)-spring soybean-late rice	Relay cropping
	Summer	1	Winter wheat (rape seed)-summer soybean	Intercropping or not
	Fall	3	Winter crop-early rice or corn-fall soybean	Relay cropping (corn)
South-eastern	Spring	2	Winter crop-spring soybean-late rice	Relay cropping or not
	Summer	3	Winter crop-summer soybean	
	Fall	1	Winter crop-early rice-fall soybean	
Mid-southern	Spring	1	Winter crop-spring soybean-hybrid rice or sweet potato	Relay cropping or not, Intercropping with corn or not
	Summer	3	Winter crop-summer soybean	
	Fall	2	Winter crop-early rice-fall soybean	
South-eastern	Spring	1	Rape seed-spring soybean	Intercropping with corn
	Summer	2	Winter wheat-summer soybean	Intercropping with corn
Tropical	Spring	1	Winter crop or rice seedling bed-spring soybean late rice	
	Summer	3	Early rice-summer soybean-late rice or sweet potato	
	Fall	4	Winter crop-early rice or rice seedling bed-fall soybean	Intercropping with sweet potato or not
	Winter	2	Winter soybean-early rice or rice seedling bed-late rice	

a. RI-relative importance. "1", "2", "3", and "4" indicate the relative importance in the decreasing order.

Table 3 The dates of developmental stages of various planting types of soybeans in southern China

Sub-region	Planting type	Planting[a]	Flowering	Maturity
Chang-Jiang	Spring	3L-4E	5L-6M	7L-8M
	Summer	5L-6E	7L-8M	9L-10M
	Fall	7L-8E	8L-9E	10L-11E
Southeastern	Spring	3L-4E	5M-6E	7M-7L
	Summer	5L-6E	7L-8M	9L-10M
	Fall	7L-8E	8L-9M	11E-11M
Mid-southern	Spring	3M-4E	5M-5L	7E-7M
	Summer	5L-6E	7M-8E	10E-10M
	Fall	7M-8E	9E-9M	11E-11M
Southwestern	Spring	4E-4M	7E-7M	8M-9E
	Summer	5E-5M	7M-7L	8L-9L
Tropical	Spring	3E-3M	4M-4L	6E-6M
	Summer	5L-6E	7M-7L	8M-9E
	Fall	7M-8E	8L-9E	10M-10L
	Winter	12L-1E	2L-3E	4M-5E

a. The number indicates the month, and the letter the dates in which E represents the first ten days, M the second ones, and L the last ones in a month.

The Mid-southern Sub-region, including most part of Hunan, Guangdong, and Guangxi provinces, and the southwestern Jiangxi province, also has spring, fall, and summer types of soybeans with a different order of relative importance from the Southeastern Sub-region.

Both spring and fall soybeans are mainly found in paddy fields with or without relay cropping for the spring one. If the spring soybean is found in upland fields, intercropping with corn sometimes is practiced. The summer type is basically in upland fields, intercropped or not with sweet potato or corn.

Cultivars of Group III (such as Xiangdou No 3) and Group IV (such as Yishan-liuyuehuang) are used for the spring planting, with an average yield of 1.0-1.2 ton/ha. Group VIII (Qiudou No 1, Guangxi-dawudou, and Bayueqing) and VII (Ruijin-xiohuangdou) are used for the fall and summer plantings, with an average yield of 1.0-1.2, and 1.4-1.6 ton/ha, respectively.

The Southwestern Sub-region, including most parts of Guizhou and Yumnan provinces, and western Guangxi, Sichuan, and Hunan provinces, is mainly located on the plateau Yun-Gui with a relatively cool summer in contrast with the situation in the other sub-regions. Only spring planting and to a lesser extent summer planting can be found in this region. Since basically, the soybeans are cultivated in upland fields and intercropped with corn, the yield per unit acreage (0.75-1.00 ton/ha) is comparatively low.

The cultivars consist essentially of Group IV, such as Beishuedou, and Liuyuehuang.

The Tropical Sub-region, including the tropical part of Guangdong, Guangxi, and Yunan, has spring, summer, fall, and winter plantings. The spring and winter plantings with an average yield of 1.0-1.2 ton/ha, have more potential than the summer and fall ones with a yield of 1.4-1.6 ton/ha, because farmers can make use of the fallow season, especially in winter.

Both paddy and upland fields are used for soybeans. In the case of upland fields, intercropping with sweet potato is practiced for the summer and fall plantings.

The cultivars used for the spring and winter plantings consist of Group III (such as Heibiqing), IV (such as Beihuadou), and V (such as Yangchun-qingdou). It is interesting to note that the same set of cultivars can be used for the summer and fall plantings. Some summer cultivars such as Suidaohuang (Group V), from the Chang-Jiang Valley, performed very well in the spring, summer, and fall plantings in this sub-region.

In fact, a certain amount of the soybeans produced has not been included in the statistics of total soybean acreage and production, especially in the Chang-Jiang Valley, Southeastern, and Mid-southern Sub-regions. They are planted on ridges along paddy fields, with one planting (spring) or two plantings (spring and fall). The soybeans harvested are essentially for farmers' self-consumption.

Approaches to increase soybean production in southern China

During the recent years, the soybean acreage in southern China has somewhat recovered for the following reasons : (1) requirement of protein for the people, (2) soil improvement through nitrogen-fixation by *Rhizobium* and rotation between paddy crops and upland crops, (3) effective utilization of solar energy and land by soybeans, a short-season crop on fallow land, and (4) effective utilization of land through intercropping and relay cropping.

There is a potential to raise the soybean production in southern China since it is possible to increase both the acreage and unit acreage yield.

Some of the acreage for rice double cropping, for the cropping system winter crop-early rice-late rice, can be diverted into the cropping system winter crop-spring soybean-late rice to obtain a good harvest of late rice and an adequate income along with a reduction in cost and labor. Some of the acreage mentioned above can also be diverted into the cropping system winter crop-early rice-fall soybean with the same advantage. This is especially true in the Chang-Jiang Valley Sub-region, as well as Southeastern, and Mid-southern Sub-regions. In these areas, rice is cultivated on the hills and slopes where irrigation systems have not been established very well yet. Summer type of soybean is suited to such kind of land. In the latter two sub-regions, the red-soil problem (aluminum toxicity and very low fertility) must be taken into account. Soybean cultivation would be more suitable than the cultivation of rice or other crops for the improvement of the soil and increase of income.

Some amount of corn acreage (monocropping) in the Southwestern Sub-region can be converted into intercropping with soybeans. Also some acreage of winter fallow land can be used for winter soybean in the Tropical Sub-region.

There is no official estimate on how much land could be planted to soybeans in southern China since soybeans are not a major crop, especially in the latter four sub-regions. However, scientists believe that there should be and will be some increase of soybean acreage for all-round and long-term increase of total food production.

The increase of unit acreage yield is especially promising. The yield of soybeans in the Southern Region was relatively low due to the following reasons : (1) Soybeans were usually cultivated on very poor land and management was less satisfactory than for rice. (2) There was less emphasis on soybean cultivation than on corn cultivation due to the intercropping system. (3) The land cultivars were still broadly used because cultivar improvement lagged behind the requirements, especially in the latter four sub-regions. Accordingly, there is a potential to raise the unit acreage yield of soybeans.

Among the five sub-regions, the Chang-Jiang Valley Sub-region is more important than the others for the increase of soybean production. Multiple cropping systems have received much attention (Lin and Gai, 1978). There are several breeding programs in Nanjing and Wuhan to meet the requirements for various planting types of soybeans. The fall planting has been developed and expanded recently. It is more difficult to cultivate soybeans in this area compared with the other sub-regions because of the limitation of the growing season and high temperature at planting time. The most important aspect is to select the preceding crop not too late, then to plant soybeans as early as possible after the harvesting, as well as to obtain good stands with a planting density of 450-600 thousand seedlings per hectare by preparing a fine soil and using irrigation. Fertilizer application including nitrogen, phosphorus and potassium is also essential for increasing yield. However, the weed problem for the fall soybean is not as serious as for other planting types.

In the other sub-regions, the natural environment such as temperature, solar energy and, therefore, the growing season are better than in the Chang-Jiang Valley, except for the soil conditions. The prospect for the increase of soybean yield can be also be considered since several programs on cultivar development and cultivation techniques have been established in each provincial institution.

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Discussion

Navarro, R.S. (The Philippines) : In the rice-soybean cropping pattern, do you prepare land for soybeans ?

Answer : It depends on the type of crop. For the spring type, there is no land preparation and soybeans are planted immediately before wheat is harvested while rice is still persent. For the summer type, the fields are plowed or no tillage is preformed after harvesting of wheat. In the fall cropping there is no land preparation and soybeans are planted approximately 5 days before corn harvesting. In the case of stubble planting, soybean is planted beside rice.

Yap, T.C. (Malaysia) : You have mentioned that you had more than 200 varieties of soybean in China. Could you indicate how a variety is released for commercial production in China ? Are there regional trials ?

Answer : There is a system of regional testing before releasing a variety. Sometimes several regions are involved. There is a soybean cultivar board composed of several experts in each soybean-producing province to decide whether a cultivar can be released. If a new cultivar is expected to be used in several provinces, the breeder can apply for the release to the national soybean cultivar board after the cultivar has been evaluated in an interprovincial regional test. The provincial regional tests are carried out for two or more years at a certain number of locations.

PRODUCTION AND USE OF AND RESEARCH ON SOYBEANS IN KOREA

E. H. HONG, S. D. KIM and Y. H. HWANG*

Abstract

In Korea, soybeans rank third both in the area planted and production after rice and barley among all food grain crops and soybean products such as soy paste, soy sauce, beancurd and beansprouts are the primary side dishes in conventional daily Korean meals.

But the area planted to soybeans showed a decreasing trend from about 300,000 hectares of the 1967-1971 average to 183,000 hectares in 1982. The reduction was mainly due to the low income derived from soybeans compared to other competing summer crops such as red-pepper, sesame, potato, and garlic, etc. National demand also increased drastically from 319,000 tons in 1973 to 769,000 tons in 1982, mainly due to the rapid increase in the population and in the amount of animal feeds.

Compared to the major soybean-producing countries, national soybean yields are very low because two-thirds of the soybeans are planted as second crop after barley harvest and many farmers do not make any investment for inputs such as fertilizers and protectants as they believe that soybeans do not require such inputs and that soybeans are not cash crops.

To cope with the rapid increase of national demand, the Korean goverment in 1983 asked the Agricultural Cooperatives to organize Soybean Production Increase Units throughout the country. The Soybean Production Increase Units are supported by the government in many ways including subsidies and prizes. At the same time, national soybean research is focussed on the development of soybeans which can be utilized for various purposes such as soy paste and soy sauce, cooking with rice, beancurd, and beansprouts, etc. and on the mechanization of soybean cultivation in anticipation of labor shortage in the future.

Trends in soybean production

Importance of soybeans

The relative importance of soybeans among all food grains in Korea is well shown in Table 1. Soybeans rank third both for the area planted and production after rice and barley, based on the 1977-1981 data. Among all food grains, the area planted to soybeans and soybean production in the same period were 11.0 and 3.5%, respectively.

Area planted, yield, production and import

The area planted to soybeans showed a general decreasing trend from about 300,000 hectares of the 1967-1971 average to 183,000 hectares in 1982 (Table 2). In spite of the decrease in the area planted, soybean production showed nearly the same level during this period, presumably due to the fact that the yield levels of soybeans per unit area have increased considerably. However, soybean yield in the country is generally low compared to that of other major soybean-producing countries, in taking into account the fact that nearly two-thirds of all soybeans are cultivated as a second crop after barley or wheat harvest on low fertile upland fields.

*Crop Experiment Station, Office of Rural Development, Suweon 170, Republic of Korea.

Table 1 Area planted and production of major food crops in Korea

Crop	Area planted (1,000 ha)	Ratio (%)	Production (1,000 ton)	Ratio (%)
Rice	1,229.9	61.0	5,617.5	74.0
Barley + Wheat	468.9	23.0	1,512.4	20.0
Italian millet	6.0	0.3	7.1	0.1
Sorghum	4.7	0.2	4.6	0.1
Corn	32.4	1.8	126.2	1.7
Buckwheat	10.4	0.5	8.7	0.1
Soybean	219.0	11.0	268.4	3.5
Adzuki bean	33.1	1.9	31.5	0.4
Mungbean	6.7	0.3	5.7	0.1
Total	2,011.1	100.0	7,582.1	100.0

Source : KMAF, 1982.

Table 2 Production, yield and import of soybeans by year in Korea

Year	Area planted (1,000 ha)	Yield (ton/ha)	Production (1,000 ton)	Import (1,000 ton)	Export (1,000 ton)
1967—1971 Average	299.9	0.76	227.4	33	—
1977	250.6	1.27	318.7	151	—
1978	246.9	1.19	292.8	223	—
1979	207.3	1.24	257.1	422	—
1980	188.4	1.15	216.3	417	—
1981	201.4	1.27	256.9	529	—
1982	183.0	1.27	233.0	536	—

Source : KMAF, 1982.

Regional distribution

The typical feature of soybean production in the country is that it is not much concentrated in any specific region although there are some regional differences (Table 3).

Trends in supply and consumption

Demand and supply

The trend in total demand and consumption of soybeans in Korea from 1973 to 1982 is shown in Table 4. During this period, the total demand increased from about 319,000 tons in 1973 to 769, 000 tons in 1982 while the national production remained at nearly the same level or even slightly decreased. The great increase in the demand is mainly due to the rapid increase in the population and in the amount of animal feeds. To meet the national demand, 536,000 tons of soybeans were imported in 1982.

Utilization

Utilization of soybeans by year in Korea is shown in Table 5. From the early 1970s to 1981, the increase from 27,000 tons in 1971 to 388,000 tons in 1981, mostly involved animal feeds with the ratio of annual mean increase being 30.5% while that of non-animal feeds was only 3.2%. Among the non-animal feeds, soybeans for industrial use (soy oil and soy milk, etc.) showed the greatest increase while that for foods (soy paste, soy sauce, beancurd, and beansprouts, etc.) remained at the same level. No further detailed data for each item are available.

Table 3 Regional distribution of soybean production in Korea

	For soybean			Production	
	Area planted (1,000 ha)	Rate of all upland areas (%)	Yield (ton/ha)	Amount (ton)	Ratio (%)
Kyunggi	20.0	19.3	1.17	23.4	9.1
Kangweon	14.6	16.2	1.33	19.4	7.6
Chungbuk	14.9	17.1	1.41	21.0	8.2
Chungnam	28.4	28.3	1.15	32.8	12.8
Jeonbuk	15.7	21.4	1.21	18.9	7.4
Jeonnam	45.4	32.9	1.29	58.4	22.7
Kyungbuk	35.6	24.0	1.44	51.3	20.1
Kyungnam	18.4	22.1	1.40	25.8	10.0
Total (average)*	201.7	22.9	1.27	256.9	100.0

* Total (average) includes data for Seoul, Busan, and Jeju.
Source: KMAF, 1982.

Table 4 Demand and supply of soybeans in Korea

Year	Demand (1,000 ton)	Production (1,000 ton)	Import (1,000 ton)	Ratio of self-sufficiency (%)
1973	318.8	245.8	73.0	77.1
1974	367.9	318.4	49.5	86.5
1975	367.2	310.6	56.6	85.6
1976	442.8	294.9	147.9	66.6
1977	451.8	318.7	133.1	70.5
1978	531.8	292.8	238.6	55.1
1979	679.1	257.1	422.0	37.9
1980	633.3	216.3	417.0	34.1
1981	786.1	256.9	529.2	32.7
1982	769.0	233.0	536.0	30.3

Source: KMAF, 1982.

Table 5 Utilization of soybean in Korea

Unit : 1,000 ton

Year	Animal feeds	Non-animal feeds				Losses	Total
		Foods	Industrial use	Seeds	Subtotal		
1971	27 (9.6)	110 (39.1)	111 (39.5)	19 (6.8)	240 (85.4)	14 (5.0)	281 (100)
1975	46 (12.4)	109 (29.3)	176 (47.3)	21 (5.6)	306 (82.2)	20 (5.4)	372 (100)
1981	388 (53.4)	100 (13.8)	219 (30.1)	10 (1.4)	329 (45.3)	10 (1.3)	727 (100)
Mean ratio of annual increase 1971—1981	30.5				3.2	10.0	

( ) indicate indices of values to total.

Methods of cultivation currently applied

Cultural practices

Planting time Soybean croppings in Korea can be largely classified into three different groups according to the planting time and growth duration : summer-type, full-season type (monoculture), and after-barley crop. The planting time varies which the cropping. The summer-type crop which does not account for a large area is generally planted from mid-to late April and harvested in early August. Thereafter autumn vegetables are usually cultivated. The full-season soybean, which is more common in the north-central and the southern mountainous areas where there are few days without frost compared to the rest of country, is planted in the middle of May. The after-barley soybean which accounts for the largest area planted to soybean, (about 56 % of the total area) is planted from mid-to late June. Sometimes the planting is delayed and takes place in early July due to labor competition for barley harvest and rice transplanting (Table 6).

Land preparation and planting For land preparation, a small cultivator (Korean made, 8 H.P.) is generally used. Soybean fields are thoroughly plowed and harrowed except in the lowlands where two or four plowed ridge hill plantings are more common. No-tillage and broadcasting of barley stubbles by hand or no-tillage and drilling by seed-planter are common practices for saving labor in after-barley plantings. There are two kinds of soybean planters which are very popular with the soybean growers. One is a planter which can be attached to the cultivator (Korean made, 8 H. P.) and the other is a hand-planter.

Table 6 Regional distribution of soybean planting times in Korea

Region	No of farmhouses	Early to late April (%)	May (%)	June (%)	Early July (%)
Total	450	3	50	41	6
Northern	108	—	92	8	—
Central	162	6	46	39	9
Southern	180	1	28	64	7

Source : ORD-TDB,1982.

Planting density of 222, 222 plants per hectare, with an interval of 60 cm between rows, 15 cm between hills, 2 plants per hill, for the summer-type and full-season cropping and 333, 333 plants per ha, 10 cm between hills with the same distance between rows and number of plants per hill, for after-barley croppings are recommended, respectively.

Fertilizer application In most cases, compound fertilizer is applied as basal dressing. About 40 kg of N, 70 kg of P_2O_5, 60 kg of K_2O are applied per hectare. Fertilizer particularly suitable for soybeans which contains 2 kg of N, 3.5 kg of P_2O_5, and 3 kg of K_2O with a net weight of 25 kg is sold at markets for soybean growers. Along with the above fertilizer, 1.5-2.0 tons of limestone and 10 tons of compost are additionally applied.

Management Inter-tillage and hilling up are performed twice or three times before flowering for weeding and prevention of lodging. A cultivator, or more often cattle power, is used for that purpose.

Herbicides are commonly applied at the early stages of soybean growth to control weeds, especially in the southern area after barley cropping compared to the northern and central areas, as shown in Table 7. Granule type herbicides are preferred by farmers to powder or hydrated ones.

Table 7 Results of sample investigation for the application of herbicides on soybean in Korea

Region	No of farmhouses investigated	No of farmhouses applying herbicides	Ratio (%)
Northern	108	35	32
Central	162	46	28
Southern	180	105	58

Source : ORD-TDB, 1982.

Although several fungal diseases such as purple seed stain (*Cercospora kikuchii*), pod and stem blight (*Diaporthe phaseolorum*), and black root rot (*Clandrocladium crotalariae*), etc. impair considerably seed quality and yields, the amount of fungicides sprayed on soybeans is comparatively small except in cases of severe infestation. In contrast, insecticides are often sprayed, if necessary.

Because nearly all the soybean fields are located on mountain slopes, it is practically impossible to irrigate soybean fields though soybean crops often experience severe drought conditions.

Harvesting and processing Harvesting time of soybeans differs with the type of cropping mentioned before. Summer-type soybean is harvested in early August while full-season (monoculture) soybean is harvested from late September to early October. After-barley soybean is generally harvested from early to late October.

Hitherto no harvesting machines for soybeans have been developed in the country and in the farms soybeans are harvested by uprooting the whole plant or cutting the stalks with a sickle.

Harvested soybeans are generally tied up in bundles and dried in the sun.

Marketing and procurement No reliable investigations on the commercialization ratio of soybeans in recent years are available. However the ratio reached 64.1 % in 1975. Marketing channels for soybean in Korea are illustrated in Fig. 1. There are two main buyers of soybeans : the peddler and the agricultural cooperative. There are no significant differences between farmgate and wholesale prices. Soybean prices are actually regulated by the government's purchasing prices which are announced annually and determined in taking into account related price levels.

Cropping patterns Cropping patterns of soybeans have markedly changed in recent years from the very simple pattern of barley (or wheat) - soybean which accounted for nearly 70 to 80 % of all upland cropping patterns in the 1960s-1970s to the very complicated ones which include high economic cash crops such as red-pepper, sesame, garlic, etc. as partner crops (Table 8).

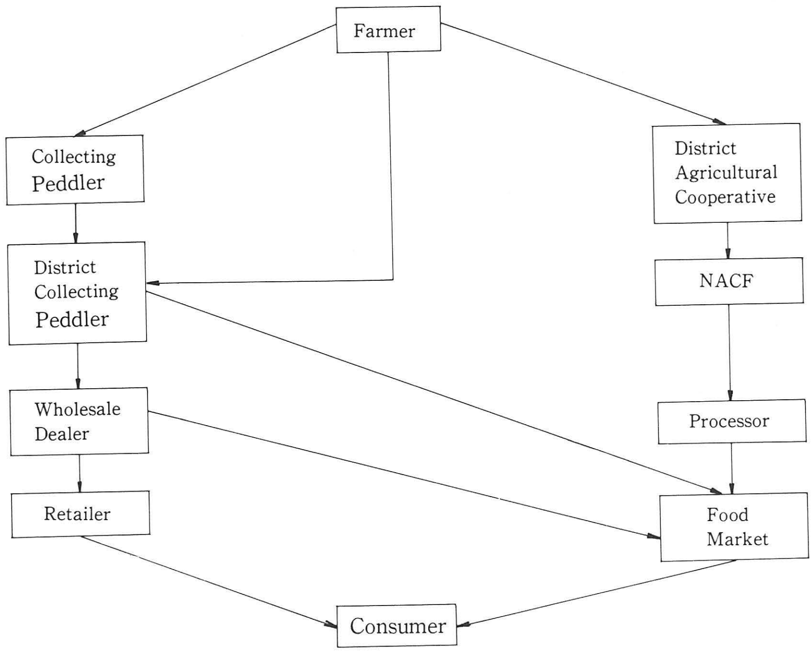

Fig. 1 Marketing channels for soybean in Korea.

Table 8 Change of cropping systems in the central part of Korea

Location	1960s		1980s	
	Cropping system	Percentage planted	Cropping system	Percentage planted
Cheongyang	Barley-Soybean	80	Chinese matrimoney vine	60
			Tobacco	10
Gonju	Barley-Soybean	70	Red-pepper	70
			Water melon-Vegetables	20
			Barley-Soybean	10
Seosan	Barley-Soybean	80	Garlic-Soybean, Radish	40
			Tobacco-Radish, Cabbage	15
			Potato-Vegetables	10
			Ginseng	5
Dangjin	Barley-Soybean	90	Radish-Sesame	40
			Radish-Garlic	10
			Lettuce-Cabbage	10
			Carrot-Garlic	25
			Onion	15

Source : ORD-FMO, 1982.

Competitive power Competitive power of soybean is indicated in Table 9. The farm income derived from soybean ranges only between half to one tenth of that of major summer crops (Table 9). This is the main reason for the rapid reduction in the area planted to soybeans.

Table 9 Farm income derived from major summer crops in Korea

Crop	Farm income (US $/ha)	Index (%)
Soybean	982	100
Potato	2,764	281
Corn	2,363	241
Radish	4,432	451
Chinese cabbage	6,422	654
Red-pepper	10,587	1,078
Water melon	6,439	655
Tobacco	5,590	569

Source: ORD-FMO, 1980.

Varieties and their distribution

Some of the characteristics and geographical distribution of the main soybean varieties which are currently recommended to the farmers are shown in Table 10. Ten soybean varieties are presently recommended to the farmers. On the basis of after-barley cropping, the days to maturity for the varieties range from 113 to 130 days. Compared to other soybean-producing countries, most of the soybean varieties except those for beansprout purposes have heavier seed weight (over 20 gram). Seed weight of less than 16 gram is preferred for beansprout purposes. Soybean varieties with large seeds are cultivated in the northern area while those with small seeds are cultivated in the southern part of Korea.

Except for the soybean varieties shown in Table 10, many local varieties of beansprout and vegetable-type are cultivated throughout the country.

Table 10 Characteristics of main soybean varieties currently recommended and their geographical distribution in Korea

Variety	Year of release	Maturity* (days)	100 seed* weight(g)	Province recommended
Hill	1967	130	14.5	Jeju
Kwangkyo	1969	120	20.2	Entire country except Kangweon and Jeju
Bongeui	1970	125	22.2	Kangweon
Kanglim	1974	127	24.5	Jeonnam and Kyungnam
Dongbuktae	1974	113	23.0	Chungbuk and Chungnam
Backcheon	1977	130	16.0	Jeju
Danyeobkong	1978	130	15.0	Jeonnam, Jeonbuk, Kyungbuk, Kyungnam
Jangyeobkong	1978	115	25.0	Kyunggi, Kangweon, Chungbuk, Chungnam
Hwangkeumkong	1980	116	24.0	〃
Jangbaegkong	1982	126	16.0	Entire country except Jeju

* Data from crops after barley.

Major diseases and pests

There are numerous diseases and pests which impair the growth, quality and yield of soybeans in Korea. Among all the soybean diseases the most destructive ones are those caused by viruses, mainly soybean mosaic virus (SMV) and necrotic soybean mosaic virus (SMV-N). Mosaic virus caused the most destructive soybean disease before the new soybean varieties developed by artificial crosses were released. But most of the newly developed varieties are nearly immune to soybean mosaic virus because utmost efforts were made to breed varieties resistant to this disease. SMV-N which is not endemic to Korea but often becomes epidemic in the country severely impairs soybean production, especially in the northern part of Korea. This disease reduces soybean yield up to 100 % when soybean plants are infected at the early stage of growth. No seed-burn has been reported in this disease but it is considered that the disease is transmitted by aphids sucking soybean plants infected with common soybean mosaic virus. Soybean varieties susceptible to SMV are never infected with SMV-N while those resistant to SMV are generally susceptible to SMV-N. A few soybean varieties have been found to be resistant to both SMV and SMV-N.

Black root rot caused by *Clandrocladium crotalariae* also impairs soybean production, especially in wet years. A yield loss of 21 % was reported at the Crop Experiment Station in 1980 (ORD-CES 1980). No resistant varieties to this disease have been identified hitherto.

Purple seed stain caused by *Cercospora kikuchii* is also a serious soybean disease in Korea. It does not reduce the yield *per se* but impairs the seed quality of soybeans especially that of the summer-type soybeans harvested in the summer season.

The major pests are the pod borer (*Leguminivora glyconovorella*), beanfly (*Melanagromyzae sojae*), and cyst nematode (*Heterodera glycines*), etc. but the yield losses caused by these pests have not been accurately documented so far.

Problems in farm cultivation

Due to the low income derived from the soybean crop, the farmers do not pay much attention to any inputs which might increase soybean yields up to the levels that compensate for all their investments. An ORD investigation (ORD-TDB 1982) on soybean farming in Korea well illustrates this fact. According to the investigation, the ratio of soybean growers using fertilizers and protectants was only 58 and 51 %, respectively. Another problem was the planting density of soybean. Only 46 % of the farmers followed the government recommendation that the planting density should be 333, 333 and 222, 222 plants per hectare for the full-season and after-barley croppings, respectively. The rest of the farmers planted soybeans with a low density of less than 100, 000 plants per hectare. Although two to three plants per hill were recommended, more than 4 plants per hill were planted by 29 % of the farmers.

Soybean research and extension service

A diagram illustrating the research and extension activities on soybeans in Korea is shown in Figure 2.

The Crop Experiment Station (CES), Office of Rural Development which is located in Suweon is the central research institute for soybean in Korea. Two more CES, Youngnam Crop Experiment Station and Mokpo Sub-Crop Experiment Station, also conduct some research on soybean for the southern part of Korea. Research on varietal development is conducted at the three CESs mentioned above. Each province has its own Provincial Office of Rural Development and one or two research workers are carrying out research mainly for the improvement of cultural practices. Except for the researchers under ORD, several researchers at universities and a semi-government agency, the Korean Atomic Energy Institute, are carrying out some research on soybeans. The name of the related institutions, location and number of researchers are shown in Table 11.

Extension services are better organized in Korea. Under the Extension Bureau of the Office of Rural Development, there are 9 PORDs extension bureaus, 300 county extension offices and 3,000

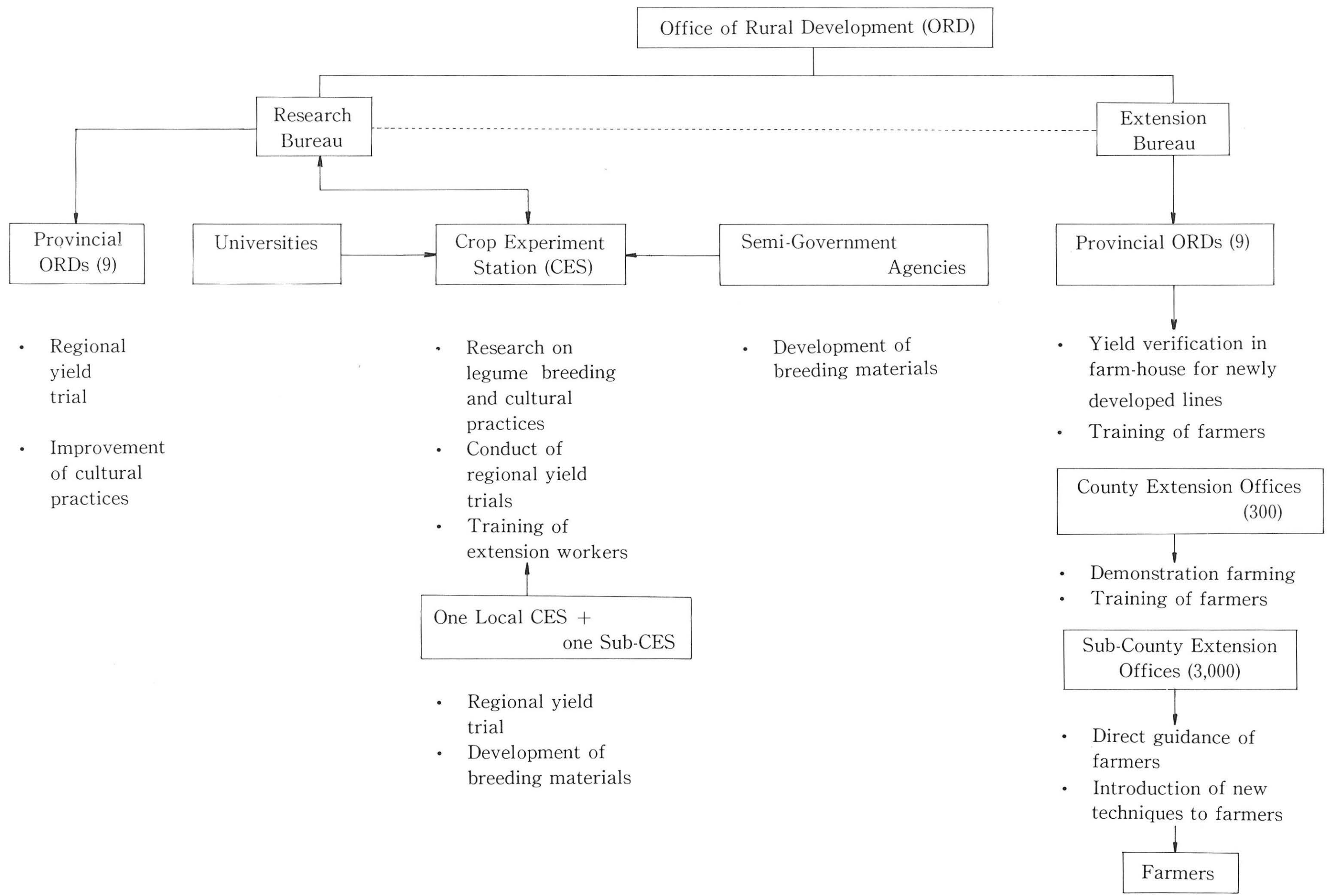

Fig. 2 **Flow chart of soybean research and extension services in Korea.**

Table 11 Research institutions, location and number of researchers related to soybeans in Korea

Institution	Location	No of researchers
Crop Experiment Station (CES) Office of Rural Development	Suweon	5
Youngnam CES, ORD	Milyang, Kyungnam	2
Mokpo Sub-CES, ORD	Mu-ahn, Jeonnam	2
Provincial Office of Rural Development(9)	One for each province	9
Korean Atomic Energy Institute	Seoul	5
Universities (12)	Three in Seoul, one for each province	12

sub-county extension offices in the country. Each extension office has one or two well-trained officers not only for soybeans but also for most of the upland crops.

The relative importance of soybean research or research programs among all agricultural research projects in Korea can not be easily defined but the share of the research programs on a certain crop generally corresponds to the importance of the crop in the country. In taking into account the fact that soybean is the third most important staple food crop after rice and barley in Korea, the priority given to soybean research or research programs is considered to be commensurate to the importance of the crop.

Soybean research trends in Korea can easily be estimated from the present main breeding objectives. The main breeding objectives are as follows : 1) Adaptability to late (after-barley) planting, 2) Varieties for specific use such as soy paste, beansprout, cooking with rice, and vegetable type, 3) Resistance to major agronomic disasters such as diseases, insects, drought, excessive humidity and cold damage, etc., 4) Adaptability to mechanization and cropping systems (shattering and lodging). Along with the above breeding objectives, emphasis is placed on the improvement of cultural practices such as the use of seed planter and no-tillage for after-barley planting, cropping systems related to high income cash crops, and effective weed control by herbicides, etc.

According to the 1983 plan for seed production and distribution of soybeans in Korea, 1,275 tons of certified soybean seeds will be supplied to the farmers to cover a cultivated surface of 33, 000 hectares or 13 % of the total soybean acreage. Four classes of soybean seeds are produced in Korea. *Breeder seeds* are produced at both CES and Youngnam CES. *Foundation seeds* are grown

Table 12 Amounts, area planted, and production for every class of soybean seeds in Korea in 1982

Class	Production office	Amount of seeds aimed (ton)	Area planted (ha)	Amount of seeds planted (ton)
Breeder seeds	Crop Experiment Station, Youngnam CES	0.3	0.9	—
Foundation seeds	Provincial Office of Rural Development(9)	10	12.7	0.4
Registered seeds	Office of Seed Production and Distribution	78	86.2	3.9
Certified seeds	Agricultural Cooperative	1,275	1,275	63.8

Source : 1983 Plan for Seed Production and Distribution in Main Crops, KMAF, 1983.

at 9 PORDs. Each PORD grows the foundation seeds of the soybean varieties which are recommended in the province. *Registered seeds* are grown by the Office of Seed Production and Distribution (OSPD) which is a government office affiliated to the Ministry of Agriculture and Fisheries.Soybean seeds multiplied by OSPD are grown as *Certified seeds* by Agricultural Cooperatives. Certified seeds are distributed to the farmers each year. Government's plan for soybean seed supply follows the system of once-in-6 years. The amounts, area planted, and production for every class of soybean seeds are indicated in Table 12.

Government participation in and support for soybean production

Since the ratio for the national self-sufficiency in soybeans dropped below 30 % in 1982 and in view of the considerable increase in domestic demand, the Korean government set up a plan to promote the increase of soybean production in 1983. The government asked the Agricultural Cooperatives to organize 2,000 Production Increase Units (PIU) throughout the country. Each unit is in charge of 10 hectares of soybean fields. The number of farmers in a unit varies from unit to unit depending on the size of the cultivated area by the members of the unit. Each unit receives compound soybean-fertilizer (N-P_2O_5-K_2O=8-14-12), 30 % free and 70 % free of interest. Soybean seeds of good quality (1,000 tons in 1983) will also be supplied in parts. The government plans to purchase 20,000 tons out of the 30,000 tons which are expected to be produced by all the PIUs. The government will give a prize to 3, 27, and 500 top yielders in the country, county, and sub-county respectively. At the same time, 3, 9, and 40 best units in the country, county, and sub-county, respectively will also receive a prize from the government. The government plans to set up an additional number of PIUs and to subsidize the farmers next year to further promote the national soybean production.

Undoubtedly, the most effective way to promote national production increase is to raise the soybean prices. Actually national soybean prices have always been much higher than those of imported soybeans, as shown in Table 13. Imported soybean price was only one third of the government purchasing price for domestic soybeans in 1982. This wide gap in prices between imported and national soybeans forces the government to import cheaper foreign soybeans. Considering the fact that the ratio of commercialization for domestic soybeans is over 60 %, the amount of soybeans purchased by the government, i.e. 0.9 % of the total production in 1982 (Table 13), was too small. This could be one of the reasons for the relatively low price of soybeans compared to that of other main food crops.

Table 13 The amount and purchasing prices of soybean by the government and the prices of imported soybeans by year in Korea

	1975	1976	1977	1978	1979	1980	1981	1982
Amount purchased by government (1,000 ton)	6.4	1.7	1.6	2.2	4.9	0.04	0.4	2.0
Ratio of total production (%)	2.0	0.6	0.5	0.7	1.9	0.01	0.1	0.9
Prices for soybeans purchased by government (US $/ton : A)	451	541	672	778	889	885	1,017	1,091
Prices for imported soybeans (US $/ton : B)	240	269	291	270	312	296	347	—
A/B (%)	188	201	231	288	285	299	293	—

Source : KMAF, 1982.

Future prospects of soybean production and main constraints

According to a preliminary estimate of the long-term demand and supply of soybeans in Korea made by the Korean Rural Economic Institute in 1982, the annual consumption of soybeans per capita will increase from 8.0 to 9.1 kg in 1991. During the same period, the national production is expected to increase from 216,000 tons to 250,000 tons while the imports should increase from 536, 000 tons in 1982 to 1,240,000-1,540,000 tons. Accordingly the ratio of national self-sufficiency is expected to drop from 30 % in 1982 to below 15 % in 1991. The projected soybean yield is 1.68 or 1.92 tons per hectare based on a conservative or optimistic estimate, respectively. The government's main targets for soybean production are not the complete national self-sufficiency but reduction in foreign dependence.

In order to achieve these targets, the government has set up a long-term plan to encourage national soybean production. Some of the aspects are as follows :

(a) Gradual increase of area planted - The increase in soybean area will be realized by converting hillside paddy fields which are often damaged by drought and hillside forests into upland field.

(b) Political support for soybean growers by transferring the import-margin into production increase of national soybeans.

(c) Harmonization of high yields through the creation of additional production increase units.

(d) Large scale dissemination of new high-yielding varieties and cultivation techniques to achieve high yields.

(e) Timely planting by controlling drought.

(f) Guarantee for both amounts and price of government purchase - Government will purchase as much soybean as the farmers wish to sell and propose a purchasing price to enable the farmers to grow soybeans in being assured that their product will be purchased.

(g) Continued incentive awards to farmers who achieve high yields and adopt excellent cultivation practices.

(h) Development of labor-saving cultivation techniques through mechanization.

The main constraints to the increase of soybean production are as follows ;

(a) Insufficient varietal development and delay in the dissemination of new varieties. A great deal of yield losses is due to SMV-N and many of the varieties that have been developed are susceptible to this disease. No full-season varieties have been developed yet, although the increase in the area planted to full-season soybeans has increased in recent years.

(b) Many of the farmers do not make any investment for inputs such as fertilizers and protectants as they believe that soybeans do not require such inputs.

(c) Soybean is a low-income crop compared to other competing summer crops such as sesame, red-pepper, garlic, potato, and several vegetables, etc.

(d) Soybean planting especially after-barley cropping, is often delayed to early July due to labor competition for harvest of barley and transplanting of rice, which results in a considerable yield reduction. Control of drought is practically impossible because most of the soybean fields are located on mountain slopes although soybeans are often damaged by insufficient rainfall.

(e) There is no government guarantee for the amounts and prices of the soybeans produced.

Discussion

Pookpakdi, A. (Thailand) : It appears that soybeans in Korea respond to a longer photoperiod during growth that those grown in the humid tropics. Also the days to maturity are long. Since you use a very high population density such as 300,000 plants/ha, have you experienced any lodging problem ?

Answer : A population density of 300,000 plants/ha is recommended for the after-barley crop of soybeans. Lodging has been observed in case of heavy rains. However lodging is infrequently observed since most of the soybeans are cultivated·on hillsides or mountains with marginal soils where other crops cannot grow well. On these soils, the growth of soybeans is very poor, hence lodging is seldom recorded.

Yang, C.A. (AVRDC) : You mentioned that the use of soybeans for industrial purposes was increasing in Korea. Could you define what you consider as industrial use ?

Answer : The term industrial use refers to any product manufactured through industrial processes. Thus soy oil is included in this category along with by-products such as soap, paint, etc. Soy paste, soy sauce, beancurd which are made in factories fall into the category of "industrial use".

SOYBEAN PRODUCTION IN JAPAN

S. KONNO*

Abstract

In Japan soybean is an important crop next to rice and wheat since it is one of the sources of traditional Japanese foods and an important crop in cropping systems, even though it accounts for only 2.5% of the total cultivated area.

Recently, the importance of soybean cultivation in Japan has increased because in 1978 the government decided to restrict the cultivation of rice and to promote the cultivation of wheat, forage crops as well as soybeans.

In 1982 the area planted to soybeans covered 147.1 thousand hectares, of which 68% was cultivated in converted paddy fields and production amounted to 226.3 thousand tons with an average yield of 1.54 ton/ha. The rate of self-sufficiency was only 5%. About 800 thousand tons were consumed for foods.

Since the increase in soybean cultivation is being promoted by allocation of government subsidies, it is essential to develop a new technology of cultivation enabling to achieve high yields at a low cost in order to firmly establish soybean cultivation before the discontinuance of the subsidies. Therefore, comprehensive research and field trials are being promoted at various institutes as well as national and prefectural agricultural experiment stations throughout the country.

According to the government projections, by the year 1990, it is anticipated that 210 thousand hectares will be planted to soybeans and that the production will amount to 420 thousand tons will an average yield of 2.2 ton/ha.

To achieve this objective efforts on extension aspects should be made to enlarge the scale of farm operations through farmers' cooperation so as to increase yields by the adoption of advanced technology ; save labor by promoting mechanization ; enhance and unify the quality of the products; etc.

The following aspects of research are particularly needed : breeding varieties adaptable to late planting after wheat cultivation, resistant to pod shattering for mechanization, having wide adaptability to produce uniform seed quality ; control of fusarium blight-like disease and seed coat breaking which tend to occur when soybeans are cultivated in converted paddy fields ; identifying ideal growth patterns to achieve high yields ; etc.

Trend in soybean production

In Japan the area planted to soybeans accounts for only 2.5% of the total cultivation area which amounts to 5.6 million hectares. However soybean is an important crop in Japan next to rice and wheat since it is one of the traditional sources of protein for the Japanese people and due to the beneficial role it plays in cropping systems as a legume.

The cultivation of soybeans gradually decreased since the liberalization of soybean trade which took place in 1956 led to the increase in the importation of soybeans whose cost was lower than that of the domestically produced soybeans and also due to the fact that soybean cultivation was deemed less profitable than that of other crops. As a result, in 1977, the area planted to soybeans totalled only 79,000 hectares. However in 1978 the government decided to restrict the cultivation of rice and to promote the cultivation of wheat, forage crops as well as soybeans by allocating subsidies. From then on the area planted to soybeans increased steadily. In 1982, from the 147.1

*Tropical Agriculture Research Center, Yatabe, Tsukuba, Ibaraki, 305 Japan.

thousand hectares planted to soybeans, the production totalled 226.3 thousand tons with an average yield of 1.54 ton/ha (Table 1).

Table 1 Production and trade of soybeans in Japan

Year	Planted area (1,000 ha)	Yield per ha (ton/ha)	Production (1,000 ton)	Import (1,000 ton)	Export (1,000 ton)
1950—1954	419.3	1.07	449.6	328	—
1967—1971	112.5	1.32	148.4	2,727	—
1977	79.3	1.40	110.8	3,602	—
1978	127.0	1.50	189.9	4,260	—
1979	130.3	1.47	191.7	4,132	20
1980	142.2	1.22	173.9	4,401	30
1981	148.8	1.42	211.7	1,197	40
1982	147.1	1.54	226.3	4,344	13

Statistical yearbook of Ministry of Agriculture, Forestry and Fisheries in Japan,
Data about soybeans, MAFF, 1983, Division Upland Farming Improvement, Agricultural Production Bureau.

In addition to Hokkaido and Tohoku which are the leading producing regions, recently, soybeans are being increasingly cultivated in the converted paddy fields of the southern and central parts of Japan and a large area planted to soybeans is found in Kyushu. Presently Hokkaido, Tohoku and Kyushu account for 13, 27 and 16% of the total area under soybean cultivation in Japan, respectively (Fig.1).

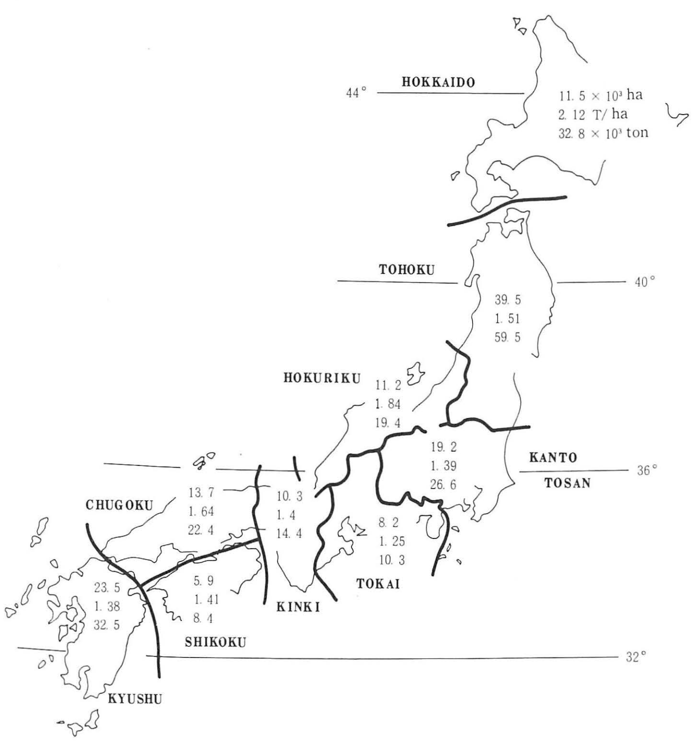

Fig. 1 Soybean production by region in Japan (1983).

Trends in supply and consumption of soybeans

The demand for soybeans is likely to continue to increase in Japan. In 1982 the importation totalled 4,344 million tons while the rate of self-sufficiency was only 5%. Among the imported soybeans, 83% is for the extraction of edible oil while the by-products are used as animal feeds. The consumption of soybean foods including tofu, natto, miso,etc. amounts to 800 thousand tons. Besides, about 50 thousand tons of soybeans are kept by farmers for their own use (Table 2).

The increase in consumption of soybeans is due mainly to the strong demand for soybean cakes as animal feeds as well as edible oil. Also the consumption of tofu, natto and soybean milk is increasing.

Table 2 Soybean consumption in Japan

(1,000 ton)

Year	Oil	Feed	Tofu	Frozen tofu	Natto	Miso	Shoyu	Soybean milk	Boiled beans and others	Sub - Total	Total
1975	2,620	30	414.3	30	68	186.1	11	—	16	725.4	3,375.4
76	2,701	30	416.5	29	69	190.5	10	—	16	731	3,462
77	2,878	30	427	30	70	185	8.5	—	16	736.5	3,644.5
78	3,297	40	445	29.8	71	182	6	—	16	749.8	4,086.8
79	3,401	55	452	29	73	181	7	1	16	759	4,215
80	3,453	55	460.3	28	75	185	6.6	2	16	772.9	4,280.9
81	3,495	55	470	28	77	183	6.5	5	15	784.5	4,334.5
82	3,591	55	480	28	80	180	6.5	12	13	799.5	4,445.5

Statistical yearbook of Ministry of Agriculture, Forestry and Fisheries in Japan.
Data about soybeans, Division Upland Farming Improvement, Agricultural Production Bureau, MAFF,1983.

Methods of cultivation currently applied in Japan

The growing season of soybeans in Japan starts earlier in the northern part of the country than in the southern part. In Hokkaido and in the northern Tohoku region soybeans are sown in late May and harvested in October. In the central and western parts of Japan they are sown in June and harvested in October and November while in the southern part of Japan or in the Shikoku and Kyushu regions they are sown in June and harvested in November. In Shikoku and Kyushu, farmers grow also a very early-maturing variety as short-season crop which is sown in April to May and harvested in July to August (Fig.2).

For soybean growing, plowing is performed mostly by tractors. However, in smaller fields, power tillers are being used. Then the fields are harrowed once or twice to improve the soil.

About 10 ton/ha of compost and 1 to 2 ton/ha of dolomite or limestone are plowed in the soil. In most cases compound fertilizer is used. About 30 kg of N, 100 kg of P_2O_5, and 100 kg of K_2O are applied per hectare under the row at the time of sowing.

Seeds are placed in hills (2 to 3 seeds/hill) on the rows. The spacing between rows is 50 to 75 cm. The seeding rate ranges between 50 and 70 kg/ha or 100 to 200 thousand plants/ha. Recently mechanization of seeding and fertilizer application are making steady progress and about 1/3 of the soybean area is planted by powered machines.

Herbicides are applied immediately after sowing. Intertillage and hilling up are performed two to three times at 20 to 40 days after sowing and 10 to 14 days thereafter with the use of a cultivator, so as to control weeds at the same time.

Soybean pod borers (*Leguminivora glycinovorella*), soybean pod gall midges (*Asphondyla* sp.), bugs, viruses and purple seed stain (*Cercospora kikuchii*) are important insect pests and diseases which severely limit grain yield and adversely affect quality.

Soybeans are harvested by uprooting the whole plant or cutting the stalks with a sickle in the fields on a small scale while machines are used for harvesting in operations on a large scale. At

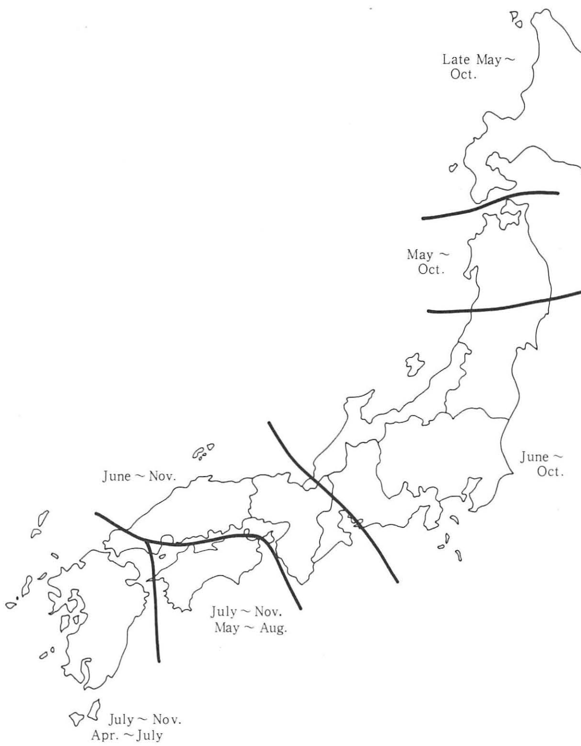

Fig. 2 Planting and harvesting time of soybeans in Japan.

present, soybeans that are harvested with the use of a mechanical bean harvester account for about half of the soybean area.

Harvested soybeans are mostly dried in the fields before threshing. Moreover, some are dried in the sun after threshing and others are dried at a low temperature with the use of a mechanical drier.

After threshing, usually soybeans are grouped by seed size and also imperfect grains are removed with the use of a grain sorter. Thereafter they are sold to users through agricultural cooperatives or local brokers.

Most of the seeds sown by the farmers are those collected from preceding year's harvest. Most of the prefectures have seed multiplication farms and supply certified seeds of suitable varieties, by which farmers rejuvenate their seed stocks at several year intervals.

Since the Japanese islands stretch over a long distance from north to south, in some areas there is only one cropping season during the year and in others a 4- to 5-crop rotation for a 2-year period. In Hokkaido the 4- to 5-year crop rotation consists of soybeans-maize-kidney bean-wheat-potato. In other regions soybeans are grown in combination with tobacco, potato, wheat, vegetables, etc. In addition, in converted paddy fields, soybeans are mostly grown under the following cropping pattern : rice-soybeans-wheat-soybeans-wheat-rice.

Generally, the crops grown in the same season as soybeans such as adzuki bean, kidney bean, beet, wheat, tobacco, vegetables, maize, forage crops, etc. are of the same or of a higher economic importance and compete with soybeans.

Several varieties of soybeans have been recommended for commercial production to farmers by the authorities of each prefecture. At present about 80 soybean varieties in total are recommended in Japan. Among them, Enrei, Akiyoshi, Shirosennari, Tamahomare, Kitamusume, and Toyosuzu varieties are widely distributed in the country. Kitamusume and Toyosuzu are the leading varieties in the Hokkaido region and the latter variety is moderately resistant to the cyst nematode (*Heterodera glycines*). Shirosennari which is a variety adapted to the Tohoku region is resistant to lodging as well as to purple seed stain and fusarium blight-like disease. Enrei variety is planted over a wide area from the Kanto to the Chugoku regions and is covering the largest area in the entire country. This variety is high-yielding and has a good quality even in the case of late sowing. Tamahomare which is a variety suited to the Kinki and Chugoku regions is moderately resistant to purple seed stain (*Cercospora kikuchii*). Akiyoshi which is a high-yielding variety in the Kyushu region accounts for the second largest area planted to soybeans in the country.

Among the soybean diseases the most destructive ones are those caused by viruses, mainly soybean mosaic, cucumber mosaic (soybean stunt), and soybean dwarf viruses. Purple seed stain (*Cercospora kikuchii*) and fusarium blight (*Fusarium oxyporum*)-like disease are likely to occur where soil contains a high moisture level such as in the case of converted paddy fields.

Insect pests that attack the soybean crop are numerous and cause serious damage, particularly in the warm areas. Soybean cyst nematode (*Heterodera glycines*), soybean pod borer (*Leguminivora glyconovorella*), soybean pod gall midge (*Asphondylia* sp.), lima bean pod borer (*Etiella zinckenella*) and bugs (bean bug (*Riptortus clavatus*), green stink bug (*Nezara antennata*), one-banded stink bug(*Piezodorus hybneri*))are the major harmful insect pests that limit grain yield.

The farmers who are growing soybeans on a small scale only for their own use do not usually proceed to weeding, intertillage, hilling up, and pest control after sowing up to the harvesting period because they cultivate other crops more important than soybeans. Thus soybean yield in those fields remains at a very low level, which reduces the average yield in the country.

Although, growing of soybeans after wheat is a desirable cropping pattern, soybean seeds must be sown later than the normal time which results in low soybean yields. Moreover, the farmers in some regions are confronted with the difficulty of sowing the soybean seeds in their fields due to continuous rainfall and unfavorable field conditions since the time coincides with the rainy season (bai-u) in Japan.

Seed coat breaking in mature grain is frequently observed when soybeans are cultivated in converted paddy fields and the quality of these grains is low when estimated by standard inspection.

Soybean research and extension

In Japan, soybean breeding is conducted at the Hokkaido Tokachi Agricultural Experiment Station, Hokkaido Central Agricultural Experiment Station, National Tohoku Agricultural Experiment Station, Nagano Prefectural Chushin Agricultural Experiment Station and National Kyushu Agricultural Experiment Station (Fig.3).

The major breeding objective in these stations is focussed on varieties whose maturity is adapted to the respective areas so as to achieve high yields and good seed quality.

In addition each station pursues specific objectives. The Hokkaido Tokachi Agricultural Experiment Station places emphasis on the breeding of varieties that are resistant to cool weather damage and soybean cyst nematode and are highly adaptable to mechanized cultivation ; at the Hokkaido Central Agricultural Experiment Station, breeding of varieties with large grain that are resistant to soybean dwarf virus is given priority ; at the National Tohoku Agricultural Experiment Station emphasis is placed on the breeding of varieties resistant to soybean cyst nematode, viruses and purple seed stain and with a high protein content ; at the Nagano Prefectural Chushin Agricultural Experiment Station priority is given to breeding for resistance to soybean cyst nematode and fusarium blight-like disease as well as lodging and adaptability to late planting ; at the National Kyushu Agricultural Experiment Station emphasis is placed on the breeding for resistance to diseases, insects (soybean stem miner and bugs) and lodging. Also mutation breeding is carried out at the Institute of Radiation Breeding which is affiliated to the National Institute of Agricultural Sciences.

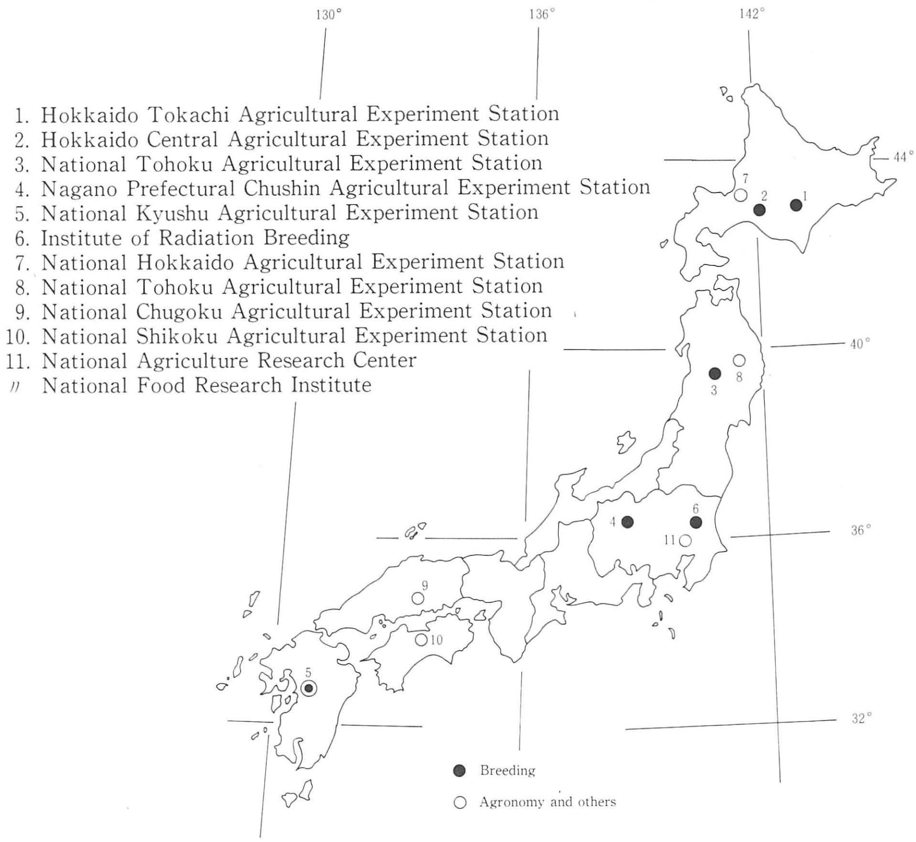

Fig. 3 Centers for breeding and research on soybeans affiliated to the Ministry of Agriculture, Forestry and Fisheries in Japan.

The progenies bred at these stations are tested for their resistance to the following pests and diseases in six locations : soybean pod borer (Hokkaido Central Agricultural Experiment Station) ; sphaceloma scab (Iwate) ; viruses (Yamagata and Ehime) ; purple seed stain (Aizu, Fukushima) ; soybean cyst nematode (Kuroiso, Tochigi) ; and root knot nematode (Oosumi, Kagoshima).

During the last decade 18 varieties were released and registered by the Ministry of Agriculture, Forestry and Fisheries (Table 3). Among these varieties, Tamahomare is a high-yielding variety with good seed quality and wide regional adaptability. It is thus being grown in 15 prefectures from the central to the western part of Japan and covers more than 10 thousand hectares of soybean area.

Suzuyutaka is a variety resistant to soybean cyst nematode, viruses and to lodging. It is grown in Tohoku and in the northern part of the Kanto region as a stable and high-yielding variety.

Miyagioojiro and Yuuhime are large-seeded varieties (about 40 g/100 seed) grown in Tohoku and the northern Kanto region, and in Hokkaido, respectively.

Komamusume and Fukuyutaka are highly adaptable varieties which can be grown in the converted paddy fields of Hokkaido, and the Kyushu and Shikoku regions, respectively.

Suzuhime is a small-seeded variety (13-15 g/100 seed) suited to natto making and cultivated in Hokkaido.

Dewamusume is a resistant variety to most races of soybean mosaic and cucumber mosaic viruses as well as to cyst nematode.

Table 3 Varieties registered during the last decade

Year of release	Variety and station where released	
1976	Himeyutaka (Tokachi)	
1977	Nanbushirome (Tohoku)	Dewamusume (Tohoku)
1978	Kitakomachi (Tokachi)	Tanrei (Chushin, Nagano)
	Nakasennari (Chushin)	Miyagioojiro (Chushin)
1979	Yuuhime (Hokkaido Central)	Akishirome (Kyushu)
1980	Kitahomare (Tokachi)	Suzuhime (Tokachi)
	Tamahomare (Chushin)	Fukuyutaka (Kyushu)
	Fukunagaha (Hokkaido Central)	
1982	Komamusume (Hokkaido Central)	Suzuyutaka (Tohoku)
1983	Tachikogane (Tohoku)	Wasesuzunari (Tohoku)

Research on soybean physiology, ecology, cultural methods, protection, mechanized cultivation and processing is carried out at the National Agriculture Research Center, National Institute of Agricultural Sciences, and at the National Agricultural Experiment Stations in Hokkaido, Tohoku, Chugoku, Shikoku and Kyushu, at the National Food Research Institute and Institute of Agricultural Machinery.

At present two kinds of national research programs involving soybeans have been conducted since 1978 and 1979. One is related to basic research on nitrogen fixation under the comprehensive research program on the "Effective Utilization of Natural Energy Resources". The other is a research project for "Promoting Upland Crop Cultivation in Converted Paddy Fields". These programs which will cover 10 years are carried out by teams of researchers from the above mentioned research institutes/experiment stations and some universities.

Experiments on the selection of varieties, cultivation practices and extension are being conducted at each prefectural agricultural experiment station in the country.

Each prefecture has organized extension services through local agricultural extension offices which are located in several districts grouped according to ecological conditions.

Along the lines of the government policy aiming at the improvement of soybean production, extension services concerned with the guidance on soybean cultivation have recently been strengthened. Also efforts have been made to establish demonstration plots, seed multiplication trials to promote more intensive cultivation with a view to raising the yield level in farmers' fields.

Government participation in and support of soybean production

As mentioned before, since soybean is an important crop as a source of traditional Japanese foods and as a significant component in cropping systems, the Japanese government is intent on promoting soybean production. Moreover, as a result of export limitations imposed by the soybean-producing countries in 1972-1973 followed by the "Oil-Shock" of 1973, the government was forced to reconsider the policy of easy-going dependence of food imports. Thus, in recognizing the importance to increase the level of food self-sufficiency the government is making efforts to promote the production of soybeans.

With a view to alleviating the possible effects of low cost imports on local prices of indigenous soybeans, the government has since 1961 determined the floor price for soybeans (i.e. ¥17,200, US$70.20/60 kg for 1982 crop). When the average sale price is lower than the floor price, the difference is paid to the producers by the government.

Financial assistance is also provided for the establishment of demonstration plots as well as for promoting planting of soybeans in converted paddy fields. Also the government subsidizes the cost of the activities of farmers' groups to improve soybean production, such as holding of meetings and seminars, purchase of machinery and equipment or construction of facilities.

Since the recent increase in soybean cultivation is being promoted mainly by the allocation of government subsidies, it is essential to develop a new technology of cultivation enabling to achieve high yields at a low cost in order to firmly establish soybean cultivation before the discontinuance of the subsidies. Therefore, comprehensive research and field trials are being promoted at various institutes as well as national and prefectural agricultural experiment stations throughout the country.

In order to encourage the farmers to cultivate soybeans, national contests have been held since 1972. The prizes are awarded by the minister of Agriculture, Forestry and Fisheries and directors of National Federation of Agricultural Cooperative Associations and several organizations to individual farmers and farmers' groups who have achieved a high level of technology for soybean cultivation.

Future prospects of soybean production and main constraints

It is anticipated that the demand for soybeans in 1990 will reach 5,200-5,430 thousand tons of which only 420 thousand tons will be produced in Japan. The objective is to increase indigenous production to satisfy at least 61% of the soybean requirements for processed foods (excluding oil extraction) by 1990. The projected area to be planted to soybeans for 1990 is 210 thousand hectares and the projected average yield is 2.02 ton/ha.

To achieve these objectives efforts on extension aspects should be made to enlarge the scale of farm operations through farmers' cooperation so as to increase yields by the adoption of advanced technology ; save labor by promoting mechanization ; enhance and unify the quality of the products; etc.

The following aspects of research are particularly needed : breeding of varieties adaptable to late planting after wheat cultivation, resistant to pod shattering for mechanization, having wide adaptability to produce uniform seed quality ; control of fusarium blight-like disease and seed coat breaking which tend to occur when soybeans are cultivated in converted paddy fields ; identifying ideal growth patterns to achieve high yields ; etc.

Discussion

Wang, J.L. (China) : What are the requirements for the quality of soybeans used for food in Japan ?
Answer : Soybeans are classified into three grades by standard inspection. A lot that contains more than 35% of damaged grains, foreign materials or grains affected with purple seed stain or with seed coat breaking is not accepted.
Bhatnagar, P.S. (India) : A considerable amount of soybean is being consumed as human food in Japan. Are there any apprehensions regarding inhibition of iron absorption or adverse effect on the digestion ?
Answer : There are no apprehensions since little soybean is consumed directly and most of it is processed.

THE CHALLENGES OF STRENGTHENING SOYBEAN RESEARCH AND DEVELOPMENT ACTIVITIES IN THE TROPICS AND SUBTROPICS

H. E. KAUFFMAN,* J. A. JACKOBS,** and Shashi KOLIVALLI***

Abstract

The International Soybean Program (INTSOY) of the University of Illinois is seeking to improve human nutrition and economic conditions through the use of soybeans. INTSOY works collaboratively with like-minded national, regional, and international organizations in a) germplasm enhancement and testing; b) developing effective production practices for a range of cropping systems and different agro-climatic conditions; and c) the developing of locally accepted soy products. Funding for most INTSOY activities comes from the US Agency for International Development.

INTSOY collaborates with scientists in 80 different countries who participate in the global soybean testing program. Trials for three target environments are organized: tropical, subtropical, and temperate regions. Most cultivars originated from the USA when the testing program began but now a majority of the cultivars tested originate from other countries. Results of the past 10 years of trials show conclusively that soybeans are adapted to a wide range of environments and cropping system conditions. A number of countries have made direct use of the test cultivars for commercial production and a larger number have used the cultivars in their local breeding program.

Although the soybean genetic potential has been demonstrated to be high, expanded breeding efforts are needed to develop improved cultivars for many of the adverse conditions which soybeans are exposed to if they are to become widely used in tropical and subtropical cropping systems. INTSOY is, therefore working with other organizations to develop strong national and regional efforts to develop improved soybean germplasm. INTSOY is working with a number of organizations to develop an International Soybean Consortium/Network which can help developing countries meet their rapidly increasing needs for edible oil and protein.

Introduction

The purpose of the International Soybean Program (INTSOY) is to assist developing countries exploit the inherent potential of the soybean as an efficient source of high quality protein and edible oil. Major attention has been given to countries in the tropics and subtropics who in the past have not shared widely in the benefits from soybeans. In the effort to develop a strong global research, education, and service network, INTSOY has cooperated with many national, regional, and international organizations.

This paper will briefly review some INTSOY activities which relate to cropping systems, discuss results of a recent survey of cooperators in the INTSOY varietal testing program, and outline ways we feel the international effort in soybean research and development for tropical and subtropical countries can be strengthened.

History of INTSOY

INTSOY was formally organized in 1973 as a collaborative effort of the University of Illinois at Urbana-Champaign and the University of Puerto Rico, Mayaguez, as a variant of the highly successful food crop oriented International Agriculture Centers (IARCs) supported by the Consultative Group for International Agriculture Research (CGIAR).

Domestically, its antecedents date to the late 1800s when the University of Illinois pioneered

*Director and** Agronomist respectively, INTSOY, 113 Mumford Hall University of Illinois, Urbana, Illinois, USA, and *** Graduate Student, Department of Agriculture Economics, University of Illinois, Urbana, IL.

soybean research in the USA, and internationally, to the mid-1960s when the University of Illinois development team initiated soybean work in India. The United States Agency for International Development (AID) has provided the basic program support for INTSOY augmented by support from the Rockefeller Foundation, United Nations Development Program (UNDP), Food and Agriculture Organization of the United Nations (FAO), United Nations International Children's Fund (UNICEF), and Cooperative for American Relief, Inc. (CARE). INTSOY programs have focussed on germplasm improvement, plant protection, nitrogen fixation, and soy food utilization. Research, training and information exchanges are avenues followed to meet INTSOY program objectives.

INTSOY activities contributing to cropping system research

INTSOY's research activities in germplasm evaluation and improvement, plant protection and microbiology have been directed toward identifying appropriate technology for soybean production in various cropping systems.

INTSOY's three interrelated variety testing programs - The Soybean Initial Evaluation Variety Experiment (SIEVE), the Soybean Preliminary Observation Trial (SPOT), and the International Soybean Variety Experiment (ISVEX) compose the major germplasm activity. Trials have been conducted in 115 countries since 1973. More than 200 scientists, representing some 100 different research institutions and organizations from 80 different countries, annually participate in this collaborative effort (Table 1). These global trials and the modest tropical breeding program in Puerto Rico complement regional and national efforts in breeding and testing. The trials have stimulated breeding programs in various countries which now contribute more than half of the entries evaluated. The publication of trial results has recently been brought up-to-date with the publication of 1981 trial results.

Table 1 Number of countries conducting ISVEX trials

	Africa	Asia	Americas	Europe	Other	Total
Total since 1973	42	26	27	10	10	115
1982	26	23	19	9	9	86

The following general observations made from international trial results during the past decade give some general leads on breeding strategy for tropical and subtropical environments:

- Average yields tend to be comparable in tropical and temperate regions.
- In the tropics, yields tend to be considerably higher from late-maturing cultivars than from early-maturing cultivars.
- Yields are affected more by changes in altitude than by changes in latitude.
- Yields are usually quite high when soybeans are first introduced into a region but frequently face increasing disease and pest problems when grown widely.
- Seed viability is a universal problem in warm climates, but small-seeded varieties have better seed viability than large seed varieties.
- Small seed size does not appear to restrict yield potential.
- The protein and oil content and chemical composition of a cultivar remain stable in different sites and environments.

The trial results indicate that existing soybean cultivars perform reasonably well in many environments in experimental stations. However, to obtain high stable yields in a wide range of cropping systems environments a vastly increased range of soybean varieties will be needed.

In addition to developing or identifying soybean cultivars for various cropping systems, INTSOY entomologists, pathologists, and weed scientists have developed integrated pest management practices collaboratively with scientists in several tropical countries. Pest control practices in various crops in a cropping system are essential to obtain and maintain high yield levels over a long period of time. Since soybeans are being introduced into many new areas in the tropics, scientists have the challenge of preventing the build-up of disease, insects, and weeds.

Equally important are ways to improve inoculants for soybeans. Research on inoculant production, distribution and the survival of *Rhizobium* in different types of soils as well as studies on the enhancement of nodulation has significant implication for establishing highly productive soybean technology for various cropping systems—especially in the tropics where soybeans are frequently grown under less than ideal conditions.

INTSOY conferences and workshops in several countries have provided forums for scientists to contribute important knowledge relating to soybean production and utilization practices. Publications of conference proceedings, research results, and the newsletter have aided in the dissemination of information on a global scale.

In several countries, notably India, Sri Lanka, and Peru, INTSOY has had long-term projects of collaboratively establishing and developing national soybean research and utilization programs. The cooperative efforts have resulted in the development of viable wheat/soybean rotations in India, rice/soybean rotations in Sri Lanka, and maize/soybean and rice/soybean rotations in Peru. In these three countries the soybean crop did not replace other crops. Soybean production was successfully popularized on small farms ranging from 1-4 hectares. The cash income which soybeans have brought to thousands of small farmers has helped them economically. These experiences clearly show that such long-term multi-discipline collaborative efforts can lead to the introduction, establishment, and significant gains in soybean production within existing cropping systems of interested nations in the tropics and subtropics.

Soybean research and development activities in cooperating countries

INTSOY recently sent a survey questionnaire to scientists who cooperate in the international soybean trial network to better understand the current soybean research, production, and utilization activities and their needs in various countries. Cooperators from 54 countries responded to the survey with 47 nations being in the tropics or subtropics. Most respondents worked with Ministries of Agriculture and Agricultural Universities and on the average had slightly more than 5 years of experience working on soybeans. More than half had Masters' or Ph.D. degrees and devoted half-or full-time to work on soybeans.

The research programs of tropical and subtropical countries were less well established and the seed and inoculant industry was not well established to support production programs (Table 2). Diseases and drought rated as a more serious problem in the tropics than in the temperate countries. The crops most frequently rotated with soybeans in the tropics in order of importance were maize, rice, and wheat. There was considerable interest in growing soybeans as a single crop and also to grow in rotation with a number of other minor crops. Twenty-seven percent of the respondents indicated soybean was replacing cotton in the cropping pattern in their country.

When comparing various continents, the Americas and Asia had more advanced soybean research programs than did Africa. For example, more than two-thirds of the nations in Asia and the Americas had active breeding efforts, whereas in Africa, less than one-third of the countries had breeding programs. Inoculant and seed industries in African countries were much less prevalent also and the yields were considerably lover when trials were first introduced into Africa. There are many more problems relating to soybean production in Africa but research capabilities are less to overcome these constraints—clearly indicating that a greater research and development effort will be required to establish viable soybean industries in Africa.

Maize/soybeans was the most popular cropping system in Africa and the Americas, whereas rice/soybeans was the most popular system in Asia. In Asia, maize/soybean and soybean/other

Table 2 Comparisons between tropical/subtropical and temperate areas

	Tropical/Subtropical	Temperate
A. Respondents :		
- Number of countries	47	7
- Location of countries (%)	85	15
B. National Soybean Program		
- Have inoculant industry in country (%)	30	67
- Have seed industry in country (%)	38	67
- Important cropping sequence in countries of respondents (%)		
-Rice/soybean (%)	42	0
-Wheat/soybean	25	92
-Maize/soybean	57	42
-Soybean/other crop	43	17
-Single crop	40	17
-Replacement for cotton	27	8
C. International Soybean Trials		
- Reasons for yield reduction in trials (%)		
-Drought	37	8
-Disease	28	8
-Insects	13	17

crops were next most important, whereas in Africa, soybean/other crops was of second most importance and mono-culture of soybeans third. In the Americas, wheat/soybean was second and soybean mono-culture was third (Table 3).

Most comments on desired cultivar characteristics for each of the three regions appear to reflect the type of cropping systems in which soybean will be grown. For example, in Asia short duration cultivars (80-100 days) were top priority to apparently fit into the rice/soybean cropping systems. In Africa, 100-120 day cultivars were most frequently desired to fit into their maize/soybean cropping sytems. In the Americas, 120-140 day varieties were listed as most desirable, possibly because of higher percentage of mono-culture or more flexibility in their cropping rotation.

Disease resistance and tolerance to water stress were rated as the most important breeding objectives in the three regions. Insect resistance was rated high in Asia and the Americas. Tolerance to acid soils was also rated high in Asia and very important in tropical Africa and the Americas.

In all three regions protein meal was mentioned as the most important use for soybeans, both currently and as having greatest growth potential (Table 4). Soy foods rated as the second most important use of soybeans in Asia with edible oils a close third. Asian respondents perceive soy foods as having the greatest growth potential. In Africa, soy food and edible oil were a distant second and third in current use but both were expected to become very important in the future. In the Americas, edible oil was nearly as important as protein meal but soy foods were perceived as a significant growth area.

These results clearly illustrate the commonality of breeding, production, and research needs within a given region and the differences between regions. To develop appropriate technology for each country, regional cooperation will be essential.

Table 3 Staffing, soybean programs, ISVEX trials: comparisons between Africa, Asia, and the Americas from survey respondents

	Africa(20)*	Asia(14)	Americas(14)	Other	Overall average
A. Educational attainment of respondents(%)					
- Ph.D.	28	33	14	75	30
- M.Sc.	28	38	45	25	35
- B. Sc.	20	21	14	—	16
- Ing. Agr.	16	—	27	—	12
Percentage of staff working 1/2 to full-time	56	38	73	50	54
B. National soybean programs:					
- Have active breeding programs(%)	32	63	77	62	
- Have inoculant industry in country(%)	20	42	40	50	
- Primary cropping sequences in countries of respondents	Maize/Soybean Soybean/Other Soybean	Rice/Soybean Maize/Soybean Soybean/Other	Maize/Soybean Wheat/Soybean Soybean		
- Have soybean seed industry in country (%)	44	29	55	38	
C. ISVEX trials:					
- Average yields at first introduction	2,000 ton/ha	3,000 ton/ha	3,000 ton/ha	2.5ton/ha	
- Reasons cited for yield reduction in ISVEX trials:					
(1) Drought(%)	32	38	36	13	
(2) Disease(%)	20	38	23	13	
(3) Insects(%)	12	16	14	14	
- Countries which have released varieties from ISVEX (%)	40	42	40	50	

*Number of countries in parenthesis.

Table 4 Respondents comments on current and future uses of soybeans in Africa, Asia, and the Americas

	Africa	Asia	Americas
Current Uses*			
- Protein meal	64	75	82
- Edible oil	28	63	73
- Soy foods	36	67	27
Growth Potential for Future Uses*			
- Protein meal	76	79	82
- Edible oil	68	79	45
- Soy foods	56	79	45

*% of respondents saying was of major importance.

Global soybean research and development needs

It is clear that an expanded international effort is required if the nations in the tropics and subtropics are to fulfill their potential as soybean producers and consumers in the near future to enable them to meet their rapidly increasing edible oil and protein needs. The groundwork for such international cooperation has been laid during the past decade but improved coordinated efforts and funding must be made available to accelerate activity in the future.

A number of research areas must be addressed. The respondents in the survey listed improved germplasm and the training of their scientists as their most important needs for their individual countries (Table 5). Next most important were the needs for improved research facilities and production technologies. Respondents from Africa indicated that production techniques were their most important need.

Approximately one-third of the respondents indicated that the marketing and processing facilities and the development of soy products were most important to strengthening their national soybean programs. These needs were much higher in Asia and Africa than in the Americas where the soybean industry is more widely established.

This survey reinforces the views that the following programs must be strengthened through global cooperation in research and development:

Table 5 Perception of future need of respondents (%)

	Africa	Asia	Americas	Other	Overall importance
Improved germplasm	72*	83	72	50	75
Production techniques	76	42	41	13	49
Training of scientist	64	75	68	63	68
Research facilities	60	46	64	25	53
Marketing and processing facilities	32	50	23	25	34
Development of soy products	32	42	18	13	29

*Percentage of respondents indicating this to be important.

(1) Germplasm preservation, evaluation and enhancement: To globally preserve, document, evaluate, and enhance soybean germplasm, a dynamic network of collaborating varietal improvement scientists representing national, regional, and international organizations must be established.

For soybean germplasm preservation various organizations must work closely with the International Board of Plant Genetic Resources (IBPGR) to make a global inventory of soybean germplasm collections. The primary collection of cultivated species, related wild annual species and perennial species in a number of Asian countries must be speeded up. Financial support must be found to improve maintenance facilities for base collection in Australia, China, Japan, and USA and working collections in various countries.

Germplasm enhancement must be greatly expanded in tropical and subtropical environments. Dynamic breeding programs at regional network centers, AVRDC (Asia), IITA (Africa), and INTSOY/CIAT/ICA (Latin America) and in larger national programs such as Brazil, China, India and the USA must be expanded to serve as the collaborative base for regional networks to better exploit genetic diversity in gene pools for the tropics and subtropics.

National programs must be strengthened in the tropics and subtropics through regional network collaboration and training activities.

Existing international and regional and national testing programs should be integrated to effectively increase the number and diversity of germplasm tested. Tests must be expanded to include conditions common to those experiences in various cropping systems. More on-farm testing will be required.

(2) Improved production technology for various cropping systems : The IARCs and national programs must develop appropriate and economical agronomic production practices for a wide range of tropical and subtropical environments. Collaborative activities to develop integrated pest management practices to control diseases, insects, and weeds for various cropping systems environments are essential.

Improved technology must be developed for *Rhizobium japonicum* production and management under tropical conditions. This must be done in collaboration with NifTAL, BNF programs of several IARCs and national programs.

(3) Marketing, processing and utilization : The most urgent overall goal will be to encourage and increase soybean processing and need in most tropical and subtropical countries to establish processing facilities and soy products tailored to each country's needs and conditions.

There is a significant need to increase soybean utilization for human food on a global basis.

Global cooperation

It is clear that global cooperation is essential to exploit the significant potential for soybean production and utilization in the tropics and subtropics.

Strong national research and development programs are the foundation for successful soybean industries. Regional programs in genetic improvement and cropping systems agronomy located at the International Agriculture Research Centers (Asia : AVRDC, IRRI, and ICRISAT), (Africa : IITA), and (Latin America : INTSOY/CIAT/ICA) can support and strengthen production research in various countries. INTSOY can concentrate on utilization and basic research aspects of genetic improvement and evaluation and documentation.

A consortium approach among various international research organizations and selected national programs may provide the coordinating mechanism required to give proper attention to soybean production and utilization in tropical and subtropical countries.

Discussion

Palaniyappan, K. (India) : I would like to know whether INTSOY would help private companies in India in the cooperative research efforts for the promotion of soybean cropping and for establishing processing units ?

Answer : It is certainly important that both government agencies and the private sector be involved in this effort.

Carangal, V.R. (IRRI) : Can you elaborate more on how the international soybean research consortium would be organized and operate ?

Answer : The research consortium concept in soybean dates back to about 10 years. This consortium can be proposed as a mechanism to intensify soybean research for the tropics through improved cooperation of national, regional and international soybean programs. A secretariat could be established and member organizations could discuss and determine research priorities. The secretariat would work to obtain funds from donors to support member individual and joint research. There is a considerable amount of expertise in soybean research in many countries such as Brazil, the USA, India, China. Testing of germplasm should be promoted. It is important to strengthen regional and national breeding programs to generate improved germplasm so as to be able to increase soybean yields, in particular in the tropics.

SPECIAL REPORTS

ISOLATION, CULTURE AND CALLUS FORMATION OF SOYBEAN PROTOPLAST

JIAN YuYu*

Abstract

Protoplasts isolated enzymatically from cotyledons of immature pods can be rapidly obtained in great numbers. Protoplast regenerating a wall and sustaining division can be induced to form a callus. Protoplast division occurred after 2-3 days of culture and compact clusters of cells appeared in the second week of the culture. Transfers of these clusters to the liquid medium resulted in the formation of rapidly growing callus tissues, which turned green after exposure to light.

Isolation

One of the most significant developments in the field of plant tissue culture during recent years has been the isolation, culture and fusion of protoplasts. The techniques are especially important because of their far-reaching implications in studies of plant improvement by cell modification and somatic hybridization. Protoplasts also have the remarkable property of taking up small and large molecules, viruses, bacteria, chloroplasts, DNA and whole nuclei. This suggests a method by which "transformed" plants may be obtained (Bajaj, 1977). Protoplasts have been isolated from numerous different plant species. The recently developed technique of protoplast culture has led to the successful regeneration of whole plants in 30 species. In the last few years, plants have been regenerated from interspecific and intergeneric somatic hybrid cells. Somatic hybridization has become a useful tool for studying genetic engineering of plant and hopefully an experimental system for the uptake of extraneous genetic materials.

Soybean is one of the most important crops in the world market. Tissue culture of soybean has been established for a number of years. In 1975-76, we successfully induced plantlets from the callus culture of the soybean hypocotyl (Research Group of Soybean Tissue Culture, 1976). In 1979, we successfully induced a pollen plantlet from an anther (Jian *et al*., 1980).

Protoplasts have been isolated from cultured root cells (Kao, 1970; Kao *et al.,* 1970; Kao *et al.,* 1971; Millev *et al.,* 1971) root (Xu Z.H., 1982), immature pod tissue (surface below the endocarp) (Zieg and Outka, 1980) and leaves (Schwenk, 1981) of soybean plants. To date pod and root protoplasts have produced callus in culture, but plant regeneration has not been obtained.

The objective is to enlarge the scope of soybean hybridization, to increase the range of variation and to create new cultivars or mutants with high photosynthetic rate, good quality, resistance and high yield by means of somatic hybridization through protoplast fusion and uptake of organelles and extraneous genetic material by protoplasts. In order to establish an experimental system for studying genetic engineering of soybean, first of all, the protoplasts must be obtained in large quantities, secondly, a protoplast may be induced to regenerate into an intact plant.

We have thus used various tissues of soybean, including leaf, stem, pith, root and pod as the materials for protoplast isolation. This report describes the method applied for protoplasts isolated enzymatically from cotyledons of immature pods and rapidly obtained in great numbers, and the conditions for sustained division to produce visible callus. There are no reports of isolation and cultivation in soybean cotyledon.

*Soybean Institute, Jilin Academy of Agricultural Science, Gongzhulinh, Jilin Province, China.

Materials and methods

Sixty-nine varieties were used in an attempt to isolate protoplasts. Soybeans were grown under field conditions, immature pods (less than 1 cm x 4 cm) were surface-sterilized with alcohol, the epidermis and endocarp layer were removed, sterilized cotyledons were cut in vertical sections approximately 1-2 mm in width. These cotyledonary segments (per seed) were incubated in 3 ml of enzyme-protoplast medium mixture (1: 1), placed in a 60x50 mm dish to form a thin layer and the dish was incubated on a rotary shaker (60 rpm) in the dark at room temperature (25°C) for 24 hr. The enzyme solution containing 2% Onozuka R-10 cellulase, 2% Rhozyme hemicellulase, 1% Sigma pectinase, was dissolved in 10 ml of the following solution : 10 mg $CaCl_2$ $2H_2O$, 1 mg NaH_2PO_4 H_2O, 1.26 g glucose and 5.8 mg MES in 10 ml distilled water (pH 5.5). The medium used was Kao's plant protoplast medium (Kao, 1982).

After incubation, the enzyme-protoplast mixture was passed through a stainless steel filter 60 μm in pore size. The filtrate was then centrifuged (1000 rpm, 4-6 min.) to sediment the protoplasts, the supernatant was removed and the protoplasts were washed in 5 ml medium in which they were cultured. After the enzyme was washed away the protoplasts were resuspended in the protoplast medium in a 0.01-0.2 % suspension, 5-12 drops (50 μl) of the protoplast suspension were placed in a 60 x 50 mm Falcon petri dish, the dish was sealed with parafilm and incubated at 25°C in dim light in a plastic box. After protoplasts divided, fresh medium was added for dilution (the medium was made by mixing 1 part of a cell culture medium to 3 parts of the protoplast culture medium) (Kao, 1982).

Results

These experiments were repeated 24 times and 69 varieties were used in an attempt to isolate the protoplasts. Isolation of protoplasts was easier in 15 varieties than in the others. Protoplasts from *Glycine max* were usually isolated more rapidly than the protoplasts from *Glycine soja*. Protoplast release reflected clearly differences of the genotypes of *Glycine max* used. In some varieties protoplasts were easily isolated, unlike in others. Percentages of isolated protoplasts in most of the varieties exceeded 50%, and in some varieties production of 80% of protoplasts could be achieved. After the isolation, in viable protoplasts the cycle of differentiation inside the cell could be observed.

Generally speaking, young cotyledons from rapidly growing pods are the best source of protoplasts and enrichment of a mineral salt medium with proper amounts of organic acids, amino acids and vitamins usually resulted in a much rapid initiation of cell regeneration and division in protoplasts. A newly formed cell wall sometimes could be observed within 24 hr after isolation of the protoplast. First division of protoplast occurred after 2-3 days of culture, second division after 4-5 days, followed by the formation of 5 to 10 cell clusters within 2 weeks. Percentages of divided protoplasts in most of the varieties were more than 30-50%. After 5-8 days of culturing, fresh medium with a slightly lower osmolarity was added. At one month, when the protoplasts formed cells and divided several times, gradual dilution of the culture with fresh medium was necessary to sustain cell division. After dilution with fresh medium, the clusters were incubated in the incubator shaker (100 rpm), and they grew to form visible colonies up to 1-2 mm in size. They were transplanted onto solid medium with agar and subsequently they formed a callus 4-5 mm in diameter. Protoplast-derived tissues grew vigorously when maintained in Kao's medium and became green under diffuse light. Differentiated culture is continued.

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Discussion

Thulasidass, G. (India): Could you achieve any success in the transfer of economic characters like disease resistance from one variety to another through somatic hybridization ?

Answer: No success has been achieved yet.

LIMITED POPULARITY OF SOYBEAN CULTIVATION IN SOUTH AND SOUTHEAST ASIA

S. SHANMUGASUNDARAM*

Abstract

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

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

Soybean, one of the oldest cultivated crops originated in northeastern China (Hymowitz, 1970). World soybean hectarage increased from 29.2 million hectares in 1969-71 to 52.2 million hectares in 1982. During this period, the area planted to soybean in the USA and Brazil increased by 11.66 million and 6.9 million hectares, respectively. Production for all of the Asian countries combined however, only increased by 876,000 hectares (Table 1). World soybean production increased by 52. 6 million tons in the past decade, from 43.5 to 96.1 million tons. The increase was mainly from the USA (60%) and Brazil (22%). Six percent came from the Asian countries.

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

Research emphasis

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

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

*Legume Program Leader and Soybean Breeder, AVRDC, P. O. Box 42, Shanhua, Tainan 741, Taiwan.

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

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

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

Table 2 Soybean exports

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

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

Socio-economic aspects

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

Table 3 Asian soybean imports

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

[1] Refers to soybean oil.

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

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

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

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

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

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

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

On whole plant basis.

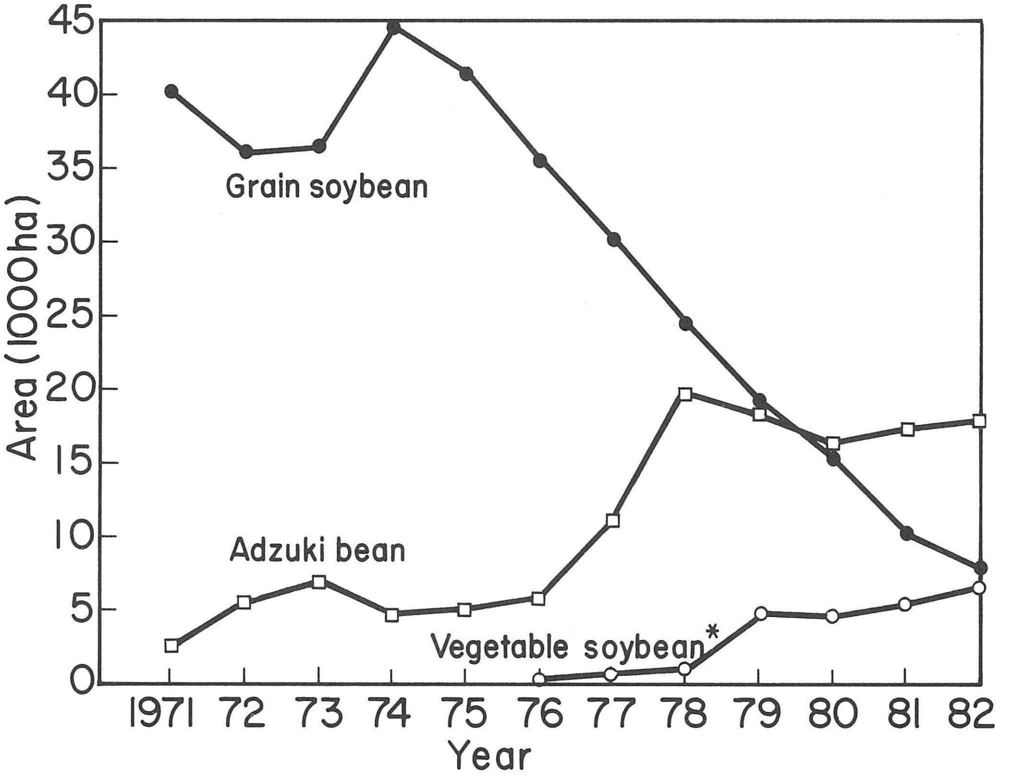

Fig. 1 **Area planted to soybean, adzuki bean and vegetable soybean in Taiwan (*Kaohsiung district only).**

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

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

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

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

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

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

Major causes for low yield and future prospects

Varietal development

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

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

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

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

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

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

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

Source : Personal communications and other sources.

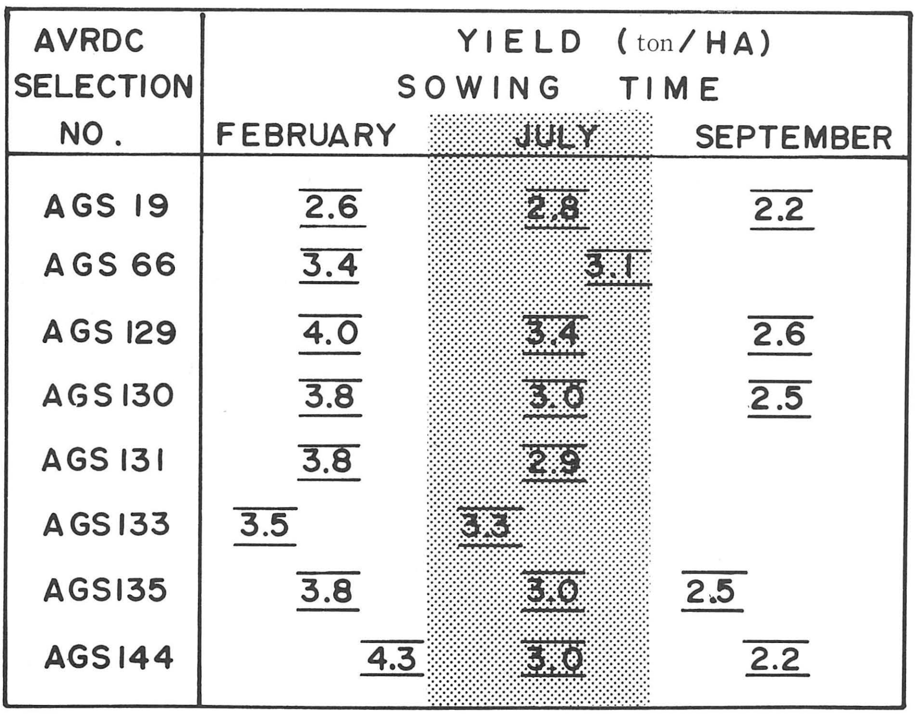

Fig. 2 **AVRDC selections with high yield potential that are adapted to different seasons.**

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

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

Table 9 AVRDC soybean cultivars released by national programs

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

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

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

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

[2] Plants per hectare.

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

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

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

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

Table 12 Cultivars with high yield potential in the tropics.

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

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

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

Agronomic aspects

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

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

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

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

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

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

Disease and insect problems

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

Adaptability to unfavorable environments

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

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

Conclusion

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

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Discussion

Thulasidass, G. (India): There is technical collaboration between India and several countries in the field of industrial production. Could there be a collaboration between India and China for soybeans ? We would like more collaboration between AVRDC and INTSOY on the one hand and India, on the other hand to manufacture soybean products at a lower cost.

Answer: INTSOY and AVRDC will make their utmost efforts to extend their cooperation in this field.

Dutt, A.K. (India): I would like to know how much nitrogen is returned and added to the soil for the next crop after soybeans are cultivated.

Answer: Information about this problem will be provided later on during the symposium.

Bhatnagar, P.S. (India): In reference to the possibility of cooperation with INTSOY, I would like to emphasize that India welcomes this proposal. However, details pertaining to specific aspects should be decided at the government level. Would you like to elaborate how low cost soybean products could fit within a cottage industry concept so as to disseminate the consumption of soybeans ?

Answer: Socio-economic and cultural aspects should be taken into consideration prior to transferring technology for the manufacture of a product from one country to another. Training programs in home economics are most important in promoting the dissemination of soybean products among farmers' households.

Galal, S. (Egypt), **Comment**: Direct use of soybeans in the human diet is a short cut to improve the daily diet in the developing countries. In Egypt we were confronted with the problem of marketing soybean products in the late fifties when I introduced the crop in cropping systems in 1957. Using soybean to enrich corn bread of the rural families resulted in improving the corn bread quality and nutritive value, in addition to solving the early marketing problem. During the 1984 INTSOY

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

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

CONTRIBUTION OF SOYBEANS TO THE AGRICULTURE OF THE USA

R. W. HOWELL*

Abstract

The soybean industry is unique in its rate of growth, which has made soybeans a major factor in world trade and in the agricultural and economic sectors of the United States. Soybeans are now second in value and second or third in production area among crops produced in the United States.

Many factors account for the unprecedented rise in importance of soybeans. These include the shift in agriculture from animal power to mechanization, the development of synthetic fibers, shortage of vegetable oils, and a growing appreciation for the importance of well-balanced protein in human and animal diets.

Soybeans were grown to a small extent for hay in many parts of the United States during the 19th century. Many states and the USDA had soybean production trials by the early 1900s. Breeding research and extension increased gradually. In 1936 a formal agreement for cooperation in research on soybean production and utilization was made between USDA and several state (university) agricultural experiment stations.

Meanwhile, several companies had encouraged farmers to produce soybeans by offering a guaranteed market. This led to the development of the soybean processing industry which now includes many large mills well-distributed over soybean production areas.

Throughout the last several decades there has been close cooperation between research groups, producers, and marketers which has made it possible to develop markets for the ever-increasing soybean production. Soybean interests have been active internationally for many years, including both research and market development.

The present soybean industry is the culmination of the efforts of many people and economic interests. Soybeans provide a vital alternative to farmers because of the strong market demand. Domestically, soybeans are the main source of dietary vegetable oils and of protein meals in animal feeds. Internationally, they are important components in the food and feed systems of many countries, and an important source of foreign currencies.

The growth of the soybean industry in the mid-20th Century is unique. In a remarkably short time soybeans have become a major factor in world trade and in the agricultural and economic sectors of the United States. Introduction or adoption of new crops such as potatoes, corn, tobacco into Europe came soon and steadily after their discovery by explorers of the New World. Cotton, wheat, garden vegetables, and ornamentals came to America with the settlers. Nowhere in the country's past, indeed nowhere in the history of civilization is there another example of a crop that has advanced in importance in a mature agricultural economy as quickly as has the soybean in the United States.

Soybeans are now second in value and second or third in acreage among crops produced in the United States. Only corn production and value consistently exceed soybeans. Soybeans are a major export commodity serving strong and stable markets in Western Europe and Japan, and important markets in Latin America, Bangladesh, and elsewhere.

Soybeans were not one of the major crops brought by the Europeans who settled and developed America. Our great historical crops were maize, wheat, cotton, and tobacco. Those crops provided food and fiber to the early settlers, and were items of commerce that formed the economic foundation of the New World.

Although they did not achieve major status until recently, soybeans had reached the English

*Emeritus Professor, Former Head, Department of Agronomy, University of Illinois, and Former Leader, Soybean Investigations, USDA, USA.

colonies in America by 1765, 11 years before the Declaration of Independence. Samuel Bowen, a recent arrival in Georgia, who as yet had no land, asked Henry Yonge to grow the seed he had brought, and in 1765 Yonge did so. A short time later Bowen obtained an English patent for soy sauce and exported significant quantities. Earlier, Bowen had been a seaman with the East India Company and had reached China, where he was imprisoned for several years. Upon his release he returned to England and then emigrated to Georgia. (The record of Samuel Bowen's introduction of soybeans was recently discovered and described by T. Hymowitz and J. R. Harlan, 1983).

In 1804 Mease, a physician in Pennsylvania and an enthusiastic gardener, reported that the crop did well in his area, nearly a thousand miles north of Georgia.

It is reasonable to assume that Bowen brought his seeds from China. Mease did not identify the source of his seeds. However, in 1769 the American Philosophical Society of Philadelphia reported receiving samples of seed from S. Bowen of Georgia.

In these early references the crop is identified as "Chinese Vetches," or "Pease". The fact that the crop was soybeans is well-documented.

How did the American soybean miracle come about ? How and why was it possible for soybeans to penetrate and dominate agricultural and economic systems that had been stable for centuries ?

The soybean story is an example of the right commodity in the right place at the right time. Many factors came together to create a demand—a market— and a new product which could respond to the demand. Mechanized agriculture was reducing the use of animal power. The number of draft animals was declining, releasing millions of hectares that had been used to produce feed for horses and mules. Synthetic fibers were replacing cotton, creating surpluses of that basic crop. Production of surplus crops was curtailed by government policy. Meanwhile, a national shortage of vegetable oils was becoming more severe as population grew. There was increasing appreciation of the importance of well-balanced protein in human and animal diets. It was known that processing of soybean for oil and meal had been introduced in China.

The situation was favorable for a new crop that would maintain farm income and contribute positively to the national economy. Soybeans were well-suited to satisfy the market demand, and proved to be well-adapted to inclusion in existing farming systems, especially the corn system of the North and the cotton system of the South.

The fact that soybeans yield two products, highly unsaturated oil and protein with amino acid distribution similar to beef, brought ready acceptance by different groups of users and provided stability as markets for oil or for protein meals fluctuated.

During the 1800s there were occasional mentions of soybeans in various parts of the United States. By the end of the century, the crop was known throughout the eastern and central parts of the country. Varieties were originating by selection in North Carolina, Indiana (Purdue), Illinois, Iowa, and Arkansas. Variety development by hybridization was not known until much later.

Perhaps the most important single person in soybean history in the United States was William J. Morse, who was appointed in 1907 to be in charge of soybean research in the US Department of Agriculture. Even earlier, C. V. Piper had initiated USDA work on soybeans. For more than 40 years, Mr. Morse led, inspired, and promoted research, education, production, and marketing of soybeans. He was instrumental in the organization of the American Soybean Association in 1921 and served three times as its president. He traveled widely in the United States, offering seed and persuading farmers to try this new crop. He spent two years (1929-31) in northeast China exploring and collecting soybean seeds. He led the development of the cooperative research program of the USDA and the State Agricultural Experiment Stations until 1949. This cooperation, which Mr. Morse had encouraged for many years, was formalized by an agreement between USDA and several stations in 1936. The cooperative program continues in its essentials, but is vastly expanded at the present time. Mr. Morse died in 1959.

Soybean research began at many universities prior to the 20th Century. The first breeder/geneticist with primary responsibility for soybeans at the University of Illinois was Dr. Clyde

Melvin Woodworth, who joined the faculty in 1920. Dr. Woodworth was a geneticist; he constructed the first chromosome map for soybeans. He developed the varieties "Illini" and "Chief," and made the cross which led to the variety "Lincoln." Lincoln was released jointly by the University of Illinois, USDA, and several other universities in 1943; it was the first variety to be developed from a purposeful hybridization, and was the first to be cooperatively released under the agreement of 1936.

A contemporary and colleague of Dr. Woodworth was Professor Jay Courtland Hackleman, a crops extension specialist at the University of Illinois. Professor Hackman was an ardent promoter of soybeans. He and his extension colleagues in other states appreciated the potential of soybeans and strongly encouraged farmers to try them on their farms.

Along with Woodworth and Hackman, Professor William Leonidas Burlison, Head of the Department of Agronomy at Illinois from 1921 to 1951, was instrumental in establishment of soybeans in the agriculture of Illinois.

These people had counterparts in many states who were equally enthusiastic and effective in encouraging farmers to grow soybeans. Developments in Illinois were paralleled in other universities and states where interest in soybeans was growing.

J. L. Cartter, a graduate student at the University of Wisconsin, was hired by USDA as a soybean agronomist in 1928, stationed at Holgate, Ohio. When the US Regional Soybean Industrial Products Laboratory was established in 1936, Mr. Cartter moved to Illinois to lead the production research at the Laboratory. He continued in that position until he retired in 1965. Plant breeders were employed by USDA and stationed at Iowa State and Purdue Universities, and later at Stoneville, MS, North Carolina State University, and the Universities of Florida, Missouri, and Minnesota, in addition to Illinois.

The cooperative production research program of USDA and the states has had a strong foundation in breeding and genetics. Until recently, virtually all soybean production in the United States involved varieties developed in the cooperative program of USDA and the State stations. Some also originated in Canadian programs with which US researchers have cooperated closely and effectively.

Varieties which have occupied millions of acres and dominated soybean production for many years, such as Hawkeye, Clark, Wayne, Williams, and Lee were originated and developed in the cooperative program. Harosoy is of Canadian origin. The group of pioneering soybean breeders, who deserve much of the credit for the success of soybeans, included R. L. Bernard, E. E. Hartwig, H. W. Johnson, J. W. Lambert, A. H. Probst, C. R. Weber, M. G. Weiss, and L. F. Williams. Hartwig and Bernard are still active soybean breeders.

After the retirement of Morse, Dr. Weiss became the leader of Soybean Investigations in USDA, serving in that position from 1949 to 1953. Under Weiss' leadership the preservation of the germplasm collection was formalized and facilities established at Urbana, IL and Stoneville, MS for preservation and management of the collection. Weiss was followed by Herbert W. Johnson, who next to Mr. Morse probably had the greatest influence on the development of soybean research. Dr. Johnson led Soybean Investigations from 1954 to 1964, a period during which the soybean cyst nematode was found for the first time in the United States, the first disease-resistant varieties were developed, and a significant increase in size and scope of soybean research staffs occurred, including the beginnings of the major increase in research on soybean physiology. Dr. Johnson left USDA in 1964 to become Head of the Department of Agronomy and Plant Genetics, University of Minnesota, a position he still holds.

Prior to 1965 the only company with a soybean variety development program was the Coker's Pedigreed Seed Co., of South Carolina, where Henry Webb was the soybean breeder. In 1965 a group of midwestern seed companies jointly formed the Soybean Research Foundation, Inc., (S.R.F.), and employed A. L. Matson of Missouri as a soybean breeder. During the 1970s many companies established soybean variety development groups following enactment by Congress of the Plant Variety Protection Act of 1970. Consequently, the number of varieties available to farmers has increased manyfold. In 1983, it is estimated that at least 300 different varieties were offered for sale in Illinois alone. It is probable that company-developed varieties will occupy much more of the market in the future. In addition to conventional plant breeding, the Plant Variety Protection Act has stimulated interest in new techniques such as genetic engineering.

A few years after establishment of the cooperative program with breeders in 1936, plant pathologists were added. W. B. Allington joined the USDA group during World War II and was joined by a second pathologist, D. W. Chamberlain, in 1947. Earlier, Benjamin Koehler, a contemporary of Woodworth at Illinois, was among the first pathologists to become interested in soybean diseases. Pathologists have worked closely with soybean breeders as breeding for disease resistance has proved to be a powerful means of controlling soybean diseases. Soybeans so far have been spared the ravages of a major pestilence, due at least in part to vigilance of soybean workers and some brilliant research to deal with emerging problems. Phytophthora rot was devastating in fields in parts of Ohio and Indiana and was beginning to appear elsewhere about 30 years ago. Prompt response, notably by pathologist A. F. Schmitthenner of Ohio State University and breeder R. L. Bernard (USDA) and pathologist M. J. Kaufmann of Illinois led to discovery of genetic resistance which was incorporated by backcrossing to produce resistant varieties of good agronomic quality. The first such varieties were released in 1963. Additional races of *Phytophthora* have appeared, but the disease has been adequately controlled.

An even more dramatic response to a disease threat involved the soybean cyst nematode, first identified in the United States in North Carolina in 1954 and soon found also in Tennessee, Missouri, Arkansas, and Mississippi. The cyst nematode is now known to be widely distributed in soybean production areas from the Gulf of Mexico almost to the Canadian border. Resistance to races 1 and 3 of the cyst nematode was discovered in the variety "Peking," which had been introduced into the United States in 1906. Resistance, however, involved a complex of several genes, one of which was closely linked to the gene for black seed coat, a trait which is unacceptable in modern soybean varieties. However, intensive research by C. A. Brim and J. P. Ross in North Carolina, L. F. Williams and A. L. Matson in Missouri, E. E. Hartwig and J. M. Epps in Mississippi and Tennessee, and others resulted in the first commercially acceptable resistant variety in 1967. Other resistant varieties have followed. Varieties with resistance or a satisfactory level of tolerance are available in maturity groups for which the cyst nematode can be a problem. Meanwhile, additional races of the nematode have been identified.

Research on weed and insect control in soybeans was much slower to develop. Many manufacturers initiated pesticide development research related to soybeans. Close cooperation was established between companies, USDA, and the Universities, coordinated by W. C. Shaw of USDA. In the early 1960s a significant increase in weed research began with weed scientists C. G. McWhorter in Mississippi, L. M. Wax, and E. W. Stoller in Illinois. During the following decades, improved weed control methods probably contributed more than any other single factor to improvement in soybean yields. Increased emphasis on insect control research is very recent, reflecting awareness of the seriousness of insect losses, especially in the southern states, and the opportunities for effective and safer insect control through integrated pest management.

Plant physiologists have worked with soybeans for many decades. The pioneering work of Garner and Allard on photoperiodism in the second decade of this century included soybeans as one of the three crops studied. Their work and later studies on the details of photoperiodism by Borthwick, Parker and Hendricks provided the basis for the maturity group system which has been in use by soybean breeders for more than 40 years.

Since about 1960 the number of physiologists and the scope of physiological research have expanded rapidly. The first photosynthesis research group with orientation toward crop production was established in soybeans. W. L. Ogren and his associates have made major contributions to the understanding of photosynthesis, especially photorespiration, a process occurring in noncereals and some cereals that drains the plant of some of the product of photosynthesis. The existence of photorespiration is a major biochemical difference between soybeans and corn, effectively limiting soybean production potential to something less than that of corn. D. B. Peters has designed equipment for continuous non destructive measurement of photosynthesis in the field.

Meanwhile, research on uses of soybeans expanded at the Northern Regional Research Center, Peoria, IL, in the universities, and in industrial laboratories. At Peoria, where USDA soybean utilization research has been based since 1942, a strong research group developed, under the leadership for many years of J. C. Cowan. Others who have made significant contributions included A. K. Smith, H. J. Dutton, J. J. Rackis, and W. J. Wolfe. At the University of Illinois, research on food uses began in 1930. Similar studies were undertaken elsewhere. The great development of soybeans in the United States has been based on extraction of the oil, followed by uses of oil and the oil meal. Soybean oil is used mostly in food products; oil meal, high in well-balanced protein, is used mainly in poultry and livestock feeds. Only 3% of the meal is used to manufacture industrial or human food products. In recent years soy protein has been used to create a number of products which simulate well-known foods in texture, appearance and other qualities.

Soybeans have been an important part of the United States' efforts to improve nutrition at home and abroad and to assist developing countries to strengthen their economies. Meat extenders in school lunch programs illustrate the use of soy food products to improve the nutritional status of children. Simple ("Village") methods of preparing foods using soybeans have been developed at Peoria and the University of Illinois.

US soybean researchers have been involved since the end of World War II in international assistance programs. The spectacular growth of the soybean industry in Brazil was possible in part because of training provided to Brazilians in the United States, and more directly because of the assistance provided by US scientists on long-and short-term assignments in Brazil. These included T. Hymowitz of Illinois, K. L. Athow of Purdue, H. C. Minor and Roger Hansen of Missouri, D. F. Weber of USDA, and many others.

The University of Illinois and other universities have had international programs for many years. In the mid-1960s, soybeans were chosen as the means of demonstrating in India the concept of coordinated resident instruction-research-extension, which is the basis of American agricultural education. The University of Illinois International Soybean Program, INTSOY, evolved directly from the soybean work in India. Reflecting the experience obtained in India and elsewhere, INTSOY programs include production and utilization research and outreach, with emphasis on rural or village uses that involve a minimum of processing. INTSOY has successfully completed projects in Sri Lanka, where C. N. Hittle, now in Nepal, headed the program, and in Peru, and recently began a new one in Zambia. INTSOY, from its inception, has been a joint effort of the University of Illinois and the University of Puerto Rico.

For many years there has been interest in soy foods such as soy curds, whey, cheese, and meat analogues, especially in international programs and for vegetarians. Recently, in part reflecting the University's interests in improving nutrition in less developed countries, a number of soy "milk" products have been developed by a team including A. I. Nelson, M. P. Steinberg, and L. S. Wei. Flavor and aroma factors are concerns in both industrial and university laboratories. Interest in soy foods seems to be increasing. A number of small companies and individuals who are interested in soybean food use have formed the Soycrafters Association. They are currently active in dissemination of information on use of soybeans as a human food, including traditional oriental foods as well as western dishes.

A key element in the continued expansion of soybeans has been the parallel development of uses, markets, and products, plus storage and transportation. Although in the beginning, soybeans were grown as a hay crop, the first production of soybean oil and meal in the United States occurred in 1911, in Seattle, WA. The soybeans had been imported from Northeast China. The earliest record of processing of American-grown soybeans for oil and meal was at Elizabeth City, NC in 1915. Since 1941, soybean production has been primarily for processing and export. Production for hay is now less than 1% of total production.

Farmers need assurance of a market if they are to become very interested in producing a new crop. In the early days of commercial soybean production, this assurance was given by a few pioneering processors. In 1922 A. E. Staley, founder of the company which today has oil and meat extraction facilities in many locations, announced that he would begin processing soybeans that year. He guaranteed that he would buy all the soybeans that farmers would grow. Not long after, Eugene Funk, of Funk's Seeds in Bloomington, Illinois, offered a guaranteed price. Another pioneer was Dale McMillen of Fort Wayne, Indiana, founder of Central Soya, a major processor of soybeans.

The decisions of these and other business leaders to commit themselves and their organizations to soybeans, and especially their assurances to farmers started soybeans on the tremendous expansion of the last 60 years. But the processors, in turn, need markets for their products. A market that developed early was the New York milkshed-feed for dairy cows. In subsequent years, swine and poultry feeds have used a major fraction of soybean meal production. It is unlikely that the vast expansion of the US poultry industry would have occurred without feeds based on soybeans.

From the small beginnings of soybean processing in Seattle and Elizabeth City, a strong and extensive system of soybean mills developed. The mills have become larger and somewhat fewer in number. There are now about 115 mills listed in "Soya Bluebook," published by the American Soybean Association. Modern mills can process as much as 3,000 tons of soybeans per day, and thus each mill requires the production of several hundred thousand hectares annually. Median capacity is 1,385 tons per day. Although soybean processing is still referred to as "crushing," the transition from extraction by hydraulic presses to solvent extraction, was complete by 1970. Parallel to development of the milling industry was development of facilities for transportation, storage, and future markets.

The American Soybean Association, an organization of soybean producers, was established in 1921. The secretary of the association from 1940 until 1967 and the founder of the Soybean Digest in 1940, was George M. Strayer of Hudson, Iowa. He was very instrumental in guiding the soybean industry into foreign markets. In 1949 he and J. L. Cartter were the first people to be sent to Europe to explore possible markets for US soybeans. In 1955 Strayer came to Japan in behalf of American soybeans, following which the Japanese-American Soybean Institute was formed in 1956.

The National Soybean Processors Association was formed in 1928 and is now a powerful organization representing the interests of the processors. The NSPA, like the growers' organization, the ASA, has been a strong supporter of research and education programs. The two associations have long cooperated in market development activities abroad. Since 1948 the NSPA has sponsored the National Soybean Crop Improvement Council with an advisory board of University and USDA research administrators, as a means of promoting communication between the soybean industry and soybean researchers. J. W. Calland was the first managing director of NSCIC; R. W. Judd has been managing director since 1961. Calland and Judd have contributed immeasurably to growth of the soybean industry by promoting interchange of information and by effective presentation of research needs to legislative bodies.

Support and management of soybean activities is very broadly based. Farmers themselves control much of the planning and financing of research and market promotion through a system of "check-offs," that is, a levy collected on soybeans at the first point of sale. Funds thus obtained amount to many millions of dollars-about $1.5 million annually in Illinois alone. Boards or committees of farmers at the state and national levels determine how these funds will be used. There are now such check-off programs in 21 states, collecting 1/2 cent to 2 cents per bushel.

The culmination of a few decades of research, production and marketing effort with soybeans is a "new" commodity of great importance in agriculture, commerce, and nutrition. The crop is widely grown in the north central and southern parts of the United States. As we have already seen, soybeans rank second and third in value and production area of US crops. Soybeans overwhelm other oilseeds in the American market. The manager of the largest vegetable oil refining plant in the United States said recently that soybean oil makes up more than 90% of his company's raw materials.

The story is similar on a worldwide basis. Soybeans are a major crop in Brazil, China, Argentina, and Canada. Soybean oil is the principal vegetable oil worldwide. Others such as palm oil and sunflower oil have recently increased in importance, but soybean oil continues to be the dominant product.

It can hardly be emphasized too much that the great strength of soybeans in the market is due to two excellent products—oil and meal. In the United States, where diets are high in meat, soybean meal is even more dominant in its market than is soybean oil. The value and advantage of soybean protein is certainly not peculiar to livestock feeds and is probably even more important in environments where dietary intake of protein should be improved. Recognition of the nutritional value is the basis for the importance of soybeans in international trade.

For 20 or more years there has been a major effort to expand use of soybeans in improving world diets. This has involved vigorous marketing programs, but significantly has included export of technology to assist other countries in evaluating soybean and adapting them to their own economies. Soybeans have been successfully introduced and attained significant status in Brazil, Argentina, and elsewhere. The vigor of soybean production internationally is reflected in the highly competitive market that now exists. But apparently abundant supplies only reflect inability to buy.

Soybean history in the United States is a story of many people in industry, on the farm, in government and the universities who recognized a need and opportunity. For most of this century they have worked together well to bring about the soybean miracle. There are still hundreds of millions whose diets are inadequate. Soybeans will continue to grow in importance.

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HISTORICAL REVIEW OF SOYBEAN CULTIVATION IN JAPAN

K. GOTOH*

Abstract

Soybean which was introduced from China to Japan in olden times had been grown on a small scale in the farm as a crop for protein source in Japan. In the initial stage of cultivation soybean was grown in dikes of paddy fields or marginal areas of upland fields mainly on an individual plant basis.

Various kinds of cultivars were identified and developed, in taking account of the diet of the Japanese people and special environmental conditions. Transplanting, topping, ridging and intercropping were generally and traditionally performed for regulating growth, for effective use of nutrients and water and for repeated land use.

After World War II, research has been undertaken actively to learn more about soybeans. Cultivars with cool weather tolerance, cyst nematode resistance, and resistance to several diseases have been developed. However, in this period the differences between record yields and actual average yields were considerably wide.

Since 1978 soybeans have been grown mainly in converted paddy fields, and yields have recorded a conspicuous increase. Cultivars should be endowed with such characters, as lodging resistance, as well as shattering resistance for mechanized culture and modified further to become adapted to grow on a canopy community basis in the near future.

Before Meiji era (-1866)

1 Dissemination

The time when soybean was introduced from the northern part of China to Japan is not precisely known. The earliest reference to soybean appeared in the Kojiki (completed in 712 AD) and Nihonsyoki (in 720 AD). They referred also to rice, barley, Italian millet (*Setaria italica* Beauv.), Japanese millet (*Echinochloa frumentacea* Link), and adzuki beans (*Vigna angularis* (Willd.) Ohwi and Ohashi). Thus, it appears that soybeans were grown as one of the important crops in olden times.

Nagata (1959) discussed the origin of soybeans and the routes of soybean introduction to Japan. According to his report, soybeans were first introduced from North China to Korea, and subsequently they were disseminated to North Japan through Korea. These soybeans were the full season type or the type with a long growing period. The other type had a short growing period, and it was introduced through two possible routes, namely Formosa and Okinawa and directly from Central China to South Japan, especially to Kyushu. These soybeans are designated as Natsu-daizu (summer type), since they are sown in spring and show early maturity and occasionally very high protein content. On the other hand, the former type is called Aki-daizu (autumn type) which belongs, more or less, to the short-day type.

Nagata's assumption that soybean may have been introduced to the northern part of Japan seems plausible. In 1932 and 1933 at the Komoriyama ruins located in Senhata, Akita Prefecture, which date back to the Jyōmon era carbonized soybeans and hulled rice were found in an old house. The dating of this specimen of soybean was not performed since radio-carbon was not available at that time. As will be mentioned later, a large number of land races have been found in Tohoku, as a result of extensive surveys conducted in the early 1950s. Apart from the Nagata's hypothesis it is probable that soybeans may have been first introduced as an important medicinal herb and later as a food crop into the ports along the Japan Sea.

*Faculty of Agriculture, Hokkaido University, Nishi 9, Kita 9, Kita-ku, Sapporo, Japan.

2 Instructions to farmers

Engishiki (completed in 927 AD) which described in detail the regulations on crop products (for example, exchange rates of soybeans with bundles of rice and barley for yearly tribute), stated that the Kinki, Chugoku, and Shikoku districts were the main soybean production areas, as shown in Fig. 1 (regions or prefectures cited in this report are shown together).

Fig. 1 Regions or prefectures cited in the report.

Seiryōki (published around 1560) which is the oldest Japanese book of agronomy, identified two types of soybeans, namely, summer and autumn types. Aizu-nōsyo (1684) and Hyakusyō-denki (around 1688) described in detail the characteristics of many cultivars, various cultivation practices, namely, ridging and intercropping with barley. Nōgaku-zensyo (1697) outlined the principles and practices of management already widely applied and mention was made of vegetable beans (Edamame). Kōka-shunjȳu (1707) described special types of soybeans, such as boiled soybeans (Nimame). This book also described how to grow soybeans on dikes or levees between paddy fields. Seikei-zusetsu (1804) outlined the methods of soybean production as recent practices.

Traditional cultivation (1867-1945)

1 Characteristics of this period

When the Meiji era started in 1867, acreage of cultivated soybean was approximately 400,000 ha with grain yields of 0.5 ton/ha on the average. In 1908 the acreage became the largest during the history of soybean production in Japan, namely, 487,700 ha, and the highest production was recorded in 1920, namely, 547,800 tons.

Since the beginning of the Syowa era in 1926, imports of soybeans have increased. Imports accounted for 60% of annual consumption in 1928 and 70% in 1938. Thus, acreage of soybeans decreased gradually, especially in the Kanto and Tosan areas, in contrast with the increase of production in Hokkaido.

As for the cultivars, Iwate No 2 and Ōu No 13 were released in 1920 and 1929 in Tohoku. They were bred through artificial crossing. Norin No 1 and No 2 were released from the Ibaraki Agricultural Experiment Station in 1939 and 1940 in Kanto. Dairyu-hodaka and Nagaha-hadaka derived from crossing were released in 1936 and 1939 in Hokkaido. Thus before the time of release of these cultivars, land races and strains derived from pure line selection were grown in Japan.

Determinate type of cultivars was mainly grown. Dewamusume was the first indeterminate cultivar recommended in Honshu and it was released in 1977 from the Tohoku Agricultural Experiment Station. The reason why the indeterminate type was not grown remains unknown. It can be inferred that the slightly larger variation of grain size in the indeterminate type than in the determinate type may not be favorable for marketing. One of the interesting characteristics of soybeans in Japan is the size of grains which are large. Furthermore, there are many kinds of grains with varying size and seed coat color which have been produced for special usages.

Fertilizers used consisted of ashes, barnyard manure, rice bran, and dried fish (sardines), when available. In 1904 superphosphate was applied. In this report, however, problems relating to the fertilization of soybeans will not be taken up.

So far the scale of soybean cultivation per farm had been rather small. In the areas where upland crops were grown, soybeans were produced under marginal and poor conditions, and in the areas where paddy rice was grown soybeans were grown on dikes for farmer's own consumption. According to the results of a survey conducted in 1961, ratio of amounts of commercial use to total products was 49% on the average throughout Japan. The scale was such that only Hokkaido and Iwate Prefecture produced more than 200 kg per farm.

2 Special methods of cultivation

In the cultivation of soybeans on the dikes of paddy fields damage due to dry conditions and various pests (diseases and insects) is limited. Due to the presence of sparse stands, sunshine and wind easily pass through the canopy and fairly high yields of grains with high quality could be obtained. However, there were some disadvantages. For instance, the decrease of rice yields was somehow inevitable and weeding was rather laborious.

Transplanting of seedlings was practiced extensively. Planting date was earlier (for instance 10 days) than the usual date, and seedlings 15 to 30 days of age after planting were used. Transplanting caused growth depression, and thus plant height was reduced. Flowering was delayed, but maturity was hastened. Number of branches and flowers increased and abscission was reduced, hence the number of pods increased. However, tap roots were cut by transplanting, and since the lateral roots became predominant, the root system was formed within a rather shallow depth.

Topping has been widely applied. It also depresses the growth. When topping is performed in the early stages of growth, secondary branches are increased, and flower and pod numbers are also considerably increased. Flowering and maturity are delayed slightly. In this treatment deep root system may be obtained. Cultivars adopted for topping treatment should have many branches. They must be sown earlier than the usual date. Since topping reduces growth remarkably, it must be applied under fertile soil conditions.

Recently, Torigoe *et al*. (1982) have reported on the cultivation of Tanbakuro-daizu (cultivar having large grains with a black coat). According to these authors, a special method of cultivation combining transplanting and topping has been applied for this cultivar both in Kyoto and Hyogo Prefectures. The cultivar is sown on 10 June, transplanted on 17-27 June, 2-3 plants per m^2, and topped in the primary leaf stage or in the 7th to 8th leaf stages depending on the environmental conditions, and harvested on 18-20 November.

Ridging is generally practiced in soybean cultivation as well as weeding, and lodging may be prevented to some extent. Fukui *et al.* (1978) who recognized the effectiveness of ridging (applied 3 times, each 5cm, 20, 35, and 50 days after sowing) concluded that new roots developed after the treatment absorbed water and nutrients, and that the abscission of flowers and pods was reduced, hence the increase of grain yields.

During this period intercropping systems were occasionally adopted, with soybeans being grown mainly with cereals (barley and common millet (*Panicum miliaceum* L.)) and cotton.

Scientific approaches (1946-1977)

1 Characteristics of this period

Extensive research works on soybean breeding and cultivation started after World War II. Nagata (1955) wrote a book on soybeans in a comprehensive manner, based on domestic and foreign information. It may be said that Nagata's publication was the first well written Japanese book on soybeans.

The progress of research works was compiled by Saito (1972) (breeding), by Kaizuma and Fukui (1972) (quality breeding), by Konno (1972) (physiology) and by Matsumoto and Ohba (production techniques) in the Proceedings of the Symposium on Food Legumes held at the Tropical Agriculture Research Center in 1972.

In the early stage of this period, production of soybeans for oil was attempted. However, since the quantity of soybeans imported from the USA increased, especially after 1961 when the Japanese market was opened for soybean importation, production became restricted to protein use or food.

During this period the constraints on soybean production were analysed in each area in Japan. It was recognized that cool weather in Hokkaido, cyst nematode in the northern part of the country, especially, Tohoku and Hokkaido, virus diseases in particular in Tohoku, various insects in the southern part of the country, such as Kyushu, excessive growth and lodging in the south-western part of Japan, and drought conditions during the 6 weeks following the topmost leaf-expanding stage in Tosan are the major factors preventing healthy growth of soybeans (Mikoshiba *et al.*, 1975). The authors compared the growth pattern of soybeans at various locations, and related them with temperature, precipitation and solar radiation.

Thus, breeding for overcoming these hazards was undertaken and cultivars showing cool weather tolerance, cyst nematode resistance, virus disease resistance, resistance to several important diseases, and lodging resistance were released in each location.

One of the important objectives of breeding was to obtain cultivars with white hilum of grains which was requested from the processing industry, especially for miso production. Thus, 30 of a total of 43 cultivars released from 1961 to 1977 had white hilum. As mentioned previously, large grain size was preferred for consumption, and the cultivars with large grain size became predominant. However, several cultivars with small grain were maintained for natto production.

2 Genetic resources

During the period 1952-1954 surveys on land races of soybeans were conducted and the data were summarized in 1957. According to the results, Tohoku had abundant genetic resources. Almost all of the land races were grown in dikes surrounding paddy fields and some were used for soiling under alluvial and diluvial soil conditions and for the cultivation of vegetable beans.

It was well known that the wild soybean (*Glycine soja* Sieb. *et* Zucc.) is native to Japan, except for Hokkaido. However, in 1973 this variety was observed along the river Saru in the Hidaka area of Hokkaido and thereafter along several rivers there. Recently, Fukui *et al.* (1978) reported on the earliness of wild soybean strains collected from wide geographical areas.

3 Cultivation practices recommended

Several research workers attempted to introduce modern technology for the management of soybeans. Nishiiri (1976) worked on the mechanization of soybean production in Tohoku and reported the following results. Early cultivars, for instance, Tokachi-nagaha should be planted on 10-25 May under a population density of 200,000 plants/ha with uniform stands. Then yields of 3.0-3.5 tons can be obtained. The converted paddy fields were more productive than the upland fields.

Ohkubo *et al.* (1978) evaluated the possibility of late planting of soybeans after harvesting winter cereals in the upland fields of Kanto. According to their results, soybean planted in mid-June under deep plowing with heavy application of fused phosphate and manure could yield 3.7 tons. Irrigation at the critical stage, if available, is effective in increasing yields.

At the present time in Kyushu the autumn type of soybeans is grown predominantly. However, from after World War II until 1965, 70-80% of the soybeans that were cultivated belonged to the summer type, generally to the maturity group IIa, which will be mentioned in the next section. Matsumoto and Asahi (1977) studied the summer type and classified the growing season into 4 specific periods. By means of gravel culture, growth was controlled by fertilizers. Thus, suitable growth in each period was determined so as to increase yield. Thereafter, soybeans were cultivated in the field under dense planting with deep placement of fertilizers, and high yields of 3.5 tons could be achieved.

4 Physiological studies

Fukui and Arai (1951) classified cultivars, based on the length of growth from germination to flowering and flowering to maturity. This classification which does not correspond with the maturity groups of the USA is widely used in Japan. Groups Ia, Ib, and IIa belong to the so-called summer type, IIb, IIc, IIIb, and IIIc to the intermediate type, and IVc and Vc to the autumn type, respectively.

As is well known, abscission of flowers and pods of soybeans occurs with high frequency. Kato (1964) studied this phenomenon from the viewpoint of water and nutrient competition during the flowering and pod formation stages.

Kawashima *et al.* (1962) developed the grain-stem ratio for the determination of the equilibrium between vegetative and grain filling processes. This ratio is still widely used as a physiological and ecological criterion for the analysis of soybean growth and yields.

Kumura (1969) studied the photosynthesis and canopy structure of soybeans and related them to dry matter production.

Ojima (1972) compiled the results obtained in a series of experiments on photosynthesis, showing that photosynthetic ability varies among cultivars.

5 Planting density

Although progress has been made in the understanding of soybean characteristics as a crop, the cultivation of soybean in practice is still based on sparse planting on an individual plant basis. This concept may be due to the fact that under the hot and humid conditions prevailing in Japan luxuriant growth and severe lodging are likely to be associated. Thus plant growth must be inhibited and the number of branches must be increased for increasing the number of nodes which in turn results in the increase in the number of pods. Consequently, cultivars bred before 1960 were generally adapted to such growing conditions. However, several cultivars bred after 1961 had a stiff stem and seemed to be adapted to dense planting. These findings suggest that the plant type has been changing from the branching type to the main stem type in which a larger proportion of pods occurs on the main stem, and lodging resistance becomes far more important.

6 Differences between record yields and average yields

During this period record yields were obtained in several Agricultural Experiment Stations and in some yield contests as outlined in the paper of Gotoh (1982). However, the average yield of soybeans was low as usual, namely, less than 1.5 tons.

Except in some fertile soils where high yields have been obtained continuously, record yields were observed occasionally only.

It may be concluded that the main emphasis of soybean production was placed on the improvement of grain quality, still based on conventional management. Although information on soybeans was widely available, there was no remarkable progress in yield increase during this period.

Recent situation (1978-)

1 Take-off in yields

Soybeans have been grown mainly under upland conditions. In 1971, 71% of the soybean fields were upland fields. However, in 1978 the ratio of converted paddy fields and upland fields was 51 and 49, respectively. Although in Hokkaido soybean growing in converted paddy fields accounted for 24% in 1978, it rose to 49% in 1981. Presently soybeans are being cultivated not only in dikes, but also in converted fields directly. Since then, soybean yield has been increasing. Recently, high yields have been obtained repeatedly at the Mogami Branch Station of Yamagata Agricultural Experiment Station in Shinjo. In 1978 the weather conditions were unusually favorable for the cultivation of soybeans in Hokkaido, and average yields in Hokkaido and Tokachi area were 2.77 tons and 3.05 tons respectively, as mentioned in Gotoh's paper (1981). The year 1982 was especially favorable in the Ishikari area of Hokkaido and an average yield of 3.01 tons was obtained. In this season high yields were also recorded in Toyama Prefecture, 2.23 tons, in Yamaguchi, 1.99 tons and in Yamagata, 1.96 tons, respectively.

This situation may be associated with weather conditions and also with the combined effects of various techniques. The release of the following three high-yielding cultivars in 1980 has contributed significantly to the improvement of yields. The cultivar Kitahomare in Hokkaido has a stiff stem, slighly larger grains and longer growing period compared with the old check cultivar used there. The cultivar Tamahomare in the south-western part of Japan showed a remarkable performance in the yield contest in 1982, and contributed effectively to the increase of average yields in such areas. According to the data of the contest, average yield in 4 lots in Mie, Wakayama, Kyoto and Yamaguchi Prefectures was 4.47 tons. The cultivar Fukuyutaka in Kyushu performed well at the Fukuoka Agricultural Experiment Station in 1979. It was cultivated in newly developed fields, 2 plants per hill at a distance of 50 cm x 18 cm and a yield of 6.43 tons was recorded. The new cultivar, Suzuyutaka was released in 1982 in Tohoku. It is a high-yielding cultivar showing a high resistance to almost all the races of mosaic and stunt viruses, and to lodging. Thus, the contribution of these cultivars that are adapted to dense planting is likely to be significant in future. Hashimoto (1978) described the recent techniques of cultivation in converted paddy fields. Ōnuma *et al*. (1975, 1981) analyzed record yields (average of 7 years, 5.57 tons) obtained in converted paddy fields at the Mogami Branch Station. If the drainage of paddy fields is adequate, its environment is suitable for soybeans with regard to nitrogen and water supply. Consequently, in the second and third years after the conversion of paddy fields extremely high yields have occasionally been obtained.

2 Problems in the near future

Combine harvesting of soybeans is still limited. However, for mechanized harvesting cultivars should be resistant to shattering and lodging. In Hokkaido a few old cultivars, such as Wasekogane and Koganejiro possess these characters, and they are already used for combine harvesting.

Gotoh (1981) pointed out the occurrence of a new race of cyst nematode in Tokachi, Hokkaido. Further breeding works should be continued to develop cultivars resistant to such pest.

Ohba *et al*. (1982) observed varietal differences in the resistance to bean bugs. Cultivars PI 229358 and Himeshirazu were highly resistant to the bean bug (*Riptortus clavatus* Tunberg), the lima bean pod borer (*Etiella zinckenella* Treitshcke), and some other insects. Introduction of this kind of resistance to new cultivars is very important in the south-western part of Japan.

The use of cultivars endowed with the above-mentioned resistance, proper fertilization and timely protection of pests should be combined for further raising the yield level.

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SOYBEAN PROCESSING FOR FOOD USE IN TAIWAN

W. L. CHEN*

Abstract

Processing methods and eating habit of some of the Chinese soybean foods are described in this paper. The soybean foods so depicted include soy milk, instant soy milk powder, tofu, soybean pudding, hard beancurd, beancurd thread, spiced and dried hard beancurd, protein-lipid film and its products, sufu, chou tofu and dehulled soybean powder.

Taiwan, imported 1,150,433 tons of soybeans from the United States in 1982. In the same year, the domestic production of soybeans reached 11,942 tons. Eighty percent of soybeans are used to be processed into soybean oil. Defatted soybeans are mixed with imported corn or fish flour for feed. Defatted soybeans are also the major raw material for the manufacture of soy sauce. The other twenty percent of soybeans are processed to versatile soybean foods. They are directly consumed by our people every day. The processing technologies of these foods evolved more than two thousand years ago. In this report, the methods used currently are described.

Soy milk

In the morning, there are many shops selling sweetened or salted soy milk. The soy milk so sold is produced by the shops themselves by a traditional method consisting of soaking the beans, grinding them in water, filtering to remove the sediment and then heating the extract (Fig. 1). Soy

Soybean
↓ ← cold water
soak
↓
drain
↓ ← cold water
grind
↓
filter → residue
↓
boil
↓
Soy milk

Fig. 1 Flow sheet of soy milk production by traditional method.

*Food Technologist, Food Industry Research and Development Institute (FIRDI), P. O. Box 246 Hsinchu, Taiwan 300.

milk is heated to keep hot when it is being sold. In summer, cold soy milk is also sold. Sweetened soy milk is prepared by the addition of sugar only. Salted soy milk is prepared by the addition of soy sauce, vinegar, crumbs of deep fried dough, dehydrated radish, fresh scallion and sesame oil just before eating. In the food stores or supermarkets, soy milk packaged in glass bottles or tetra pack is being sold. Bottle-packaged soy milk is produced in the plants of local farmers' associations or small private factories. Tetra pack soy milk is produced in modern factories. The packaged soy milk may be produced by the traditional method or the modification of the Cornell method (Wilkens *et al.*, 1967) and the Illinois process (Nelson *et al.*, 1976). Soy milk prepared by the traditional method has a strong beany flavor, but it is bland when prepared by the new method. Bland soy milk is flavored with strawberry, chocolate, vanilla and peanut.

The difference between the traditional method and the modern methods lies in the heating procedure. In the Cornell method, an acceptable bland milk is produced by grinding unsoaked, dehulled soybeans with water at temperatures ranging between 80 and 100°C and maintaining the temperature for 10 min to completely inactivate the lipoxidase enzyme (Fig. 2). In the Illinois

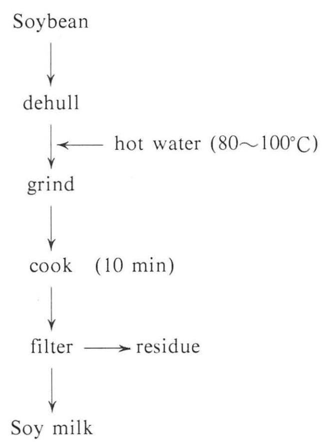

Fig. 2 Flow sheet of soy milk production by Cornell method.

process, preparation includes soaking and then blanching the whole soybeans in 0.5% sodium bicarbonate, grinding with water in a hammermill, heating the slurry to 93°C, homogenizing, neutralizing, dilution, addition of sugar and flavor, pasteurizing and re-homogenizing (Fig. 3). Enzyme inactivation by blanching prior to grinding of soaked beans is found to completely prevent the formation of painty (oxidized) flavor and results in a bland and flavored product. Liao (1980) uses deoxygenized water and steam to grind soybeans or a mixture of soybeans and peanuts. The soy milk obtained has a peanut flavor and taste, and lacks the beany flavor.

Instant soy milk powder

Last year two new brands of instant soy milk powder appeared on the market in Taiwan. One of them is produced by the traditional method to prepare soy milk, followed by spray-drying and agglomeration (Chen and Chen, 1972; Hsu, 1983) (Fig. 4). The other brand is produced by a different method; its preparation includes drying, cracking, dehulling, grinding to a very fine powder (300 mesh), mixing with water, sterilization and spray-drying (Chen, R.F., 1982) (Fig. 5). The instant soy milk powder can be flavored with cocoa (Wang *et al.*, 1976). By the separation of indigestible oligosaccharides and enrichment with vitamins and minerals, the instant soy milk powder can be used for infants (Chen *et al.*, 1979). The instant soy milk powder can also be used to prepare tofu (Chen, 1970).

Tofu

More than 1,400 small tofu plants are located almost everywhere in Taiwan (Chiang and Huang, 1979). They produce and sell their products on the same day. Only two big modern tofu plants produce packaged and refrigerated tofu. Chinese prefer the traditional tofu which is coagulated by calcium sulfate and pressed in a cheese cloth. Many delicious Chinese foods are prepared from this kind of tofu. The soft tofu coagulated by gluconodeltalactone (GDL) or a mixture of calcium sulfate and GDL is mostly consumed in the Japanese restaurants.

Soybean
↓
soak — in 0.5% $NaHCO_3$ solution
↓
drain
↓
blanch — in 0.5% $NaHCO_3$ solution for 30min
↓
drain
↓ ← cold water
grind
↓
heat — to 93°C
↓
homogenize
↓
neutralize
↓
formulate
↓
heat — to 82°C
↓
homogenize
↓
bottle
↓
cool

Fig. 3 Flow sheet of soy milk production by Illinois process.

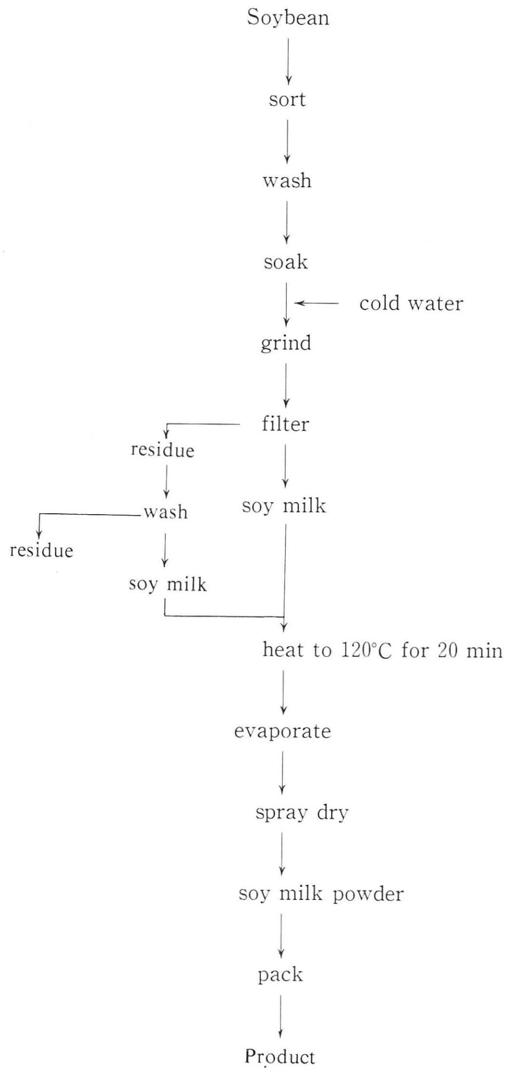

Fig. 4 **Flow sheet of instant soy milk powder production (I).**

Soybean pudding

This is a very soft beancurd prepared by pouring hot soy milk suddenly into a container in which there is a suspension of calcium sulfate and starch. After setting for 10 min the pudding is formed (Chen, 1979) (Fig. 6). This product is usually put in a ginger syrup with well cooked peanuts and consumed hot in winter and cold in summer. Other coagulants, such as agar-agar and carrageen, are also used for the manufacture of soybean pudding. The products have different flavors.

Soybean
↓
dry
↓
dehull
↓
grind
↓
soybean powder (300 mesh)
↓ ← water
cook
↓
formulate
↓
spray dry
↓
soy milk powder
↓
pack
↓
Product

Fig. 5 Flow sheet of instant soy milk powder production (II).

Hard beancurd

This product is processed by the same method as that for tofu, but with a higher pressure and during a longer period of time. To obtain a smooth and shiny appearance, the hard beancurd is cooked in an alkaline solution for a short period of time, then colored yellow or brown with pigments. Usually, this product is cooked in meat gravy or soy sauce and sliced before consumption.

Hard beancurd thread

This product is processed by the same method as that for tofu, but only a small amount of beancurd is put in each cheese cloth to form a thin (1.5 mm) sheet of hard beancurd. The sheet in cut to threads through a cutter. This product usually is sauteed with meat and vegetables.

Spiced and dried hard beancurd

This is a snack soybean food. The hard beancurd is cut into different shapes and cooked with soy sauce, sugar, salt, spices and water. Some products are directly dried in a kettle; some are dried in a continuous hot air dryer (Fig. 7). To obtain a special chewing texture, some products are deep-fried in fat before being cooked with seasoning. The shelf life of this product is 2 to 3 months. Our

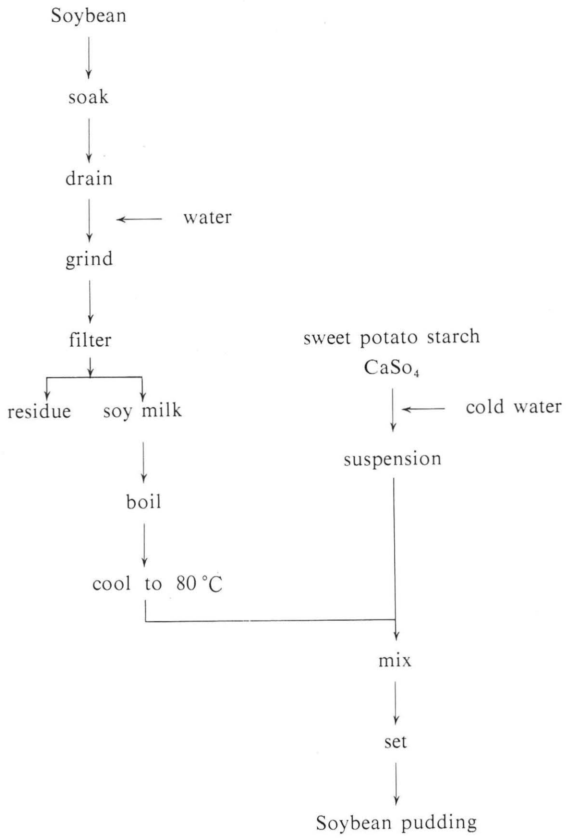

Fig. 6 Flow sheet of soybean pudding production.

Institute (FIRDI) has carried out studies and succeeded in prolonging the shelf life to 6 months (Lee *et al*., 1983; Chen *et al*., 1983).

Soy protein-lipid film and its products

Traditional methods of film formation consist of heating soy milk in shallow pans and periodically removing the films manually when their strength so warrants. Films are hung in the air for drying into sheets or rolls. Manufacture of vegetable-textured ham is performed with rehydrated and flavored films. The sheets are soaked in appropriate flavoring solutions such as soy or meat broths. After layering several sheets, rolling them tightly, wrapping them firmly in cloths, and tying them to retain internal pressure, the rolls are then steamed for about 1 hr and consumed as a main dish. A continuous film-forming method was developed by FIRDI (Li *et al*., 1977) (Fig. 8). This method has been adopted by two plants already. In this method, soy milk is concentrated by isoelectric isolation. Another method to obtain soy milk at a high concentration is to grind beans with little water (bean: water = 1 : 3) (Chen and Lin, 1981).

Sufu (Chinese cheese)

The various processes used for the preparation of Chinese cheese by fermentation of soybean

Soybean
↓
soak
↓
grind
↓
boil
↓
filter ⇢ residue
↓
soy milk
↓ ← $CaSO_4$
coagulate
↓
press
↓
hard beancurd
↓
cut
↓
season
↓
dry
↓
cool
↓
pack
↓
Product

Fig. 7 Flow sheet of spiced and dried hard beancurd production.

curd with mucor and other fungi were evaluated by Wai (1969). In general, sufu-making process consists of three major steps: preparation of tofu, molding process and brining process (Fig. 9). The molds belonging to the genus of *Mucor* or *Actinomucor* are usually used. The standard brining solution consists of salted-fermented rice mash, soy sauce, moromi mash, fermented soy paste, red koji or 5% NaCl solution containing rice wine having about 10% ethyl alcohol. The time of aging ranges from one to twelve months depending upon the types of brining solution. Sufu is used as a seasoning in Chinese food.

Soybean
↓
soak
↓
grind
↓
boil
↓
filter
↓
soy milk
↓ ← acid
coagulate
↓
press → whey
↓ ← alkali
neutralize
↓
homogenize
↓
drum dry
↓
Soy protein lipid film

Fig. 8 **Flow sheet of soy protein lipid film by drum drying.**

Chou tofu (fetid tofu)

Chou tofu is also a fermented tofu. After deep frying in fat, it has a special odor and a spongy structure. Tofu used for chou tofu should be more rigid than the usual tofu. It is steepened in a fermentation liquor for 6 hr at room temperature. The fermentation liquor consists of a brining solution of pickles, dried shrimps and salted egg (Lai, 1977; Su, 1980). Chou tofu is usually eaten immediately after deep frying in fat and with pickled vegetables, chili paste and soy sauce.

Dehulled soybean powder

This product is also called active soybean powder, the enzymes being still active. Soybeans are dried under mild conditions and cracked in a mill and the hulls are removed by air separation. Finally, the dehulled soybeans are ground to a very fine powder. This product is used to prepare soy milk or soybean pudding in factories, schools and families.

Soybean
↓
soak
↓
grind
↓
boil
↓
filter
↓
soy milk
↓ ← $CaSO_4$
beancurd
↓
press
↓
tofu
↓
dry
↓ ← *Mucor or Rhizopus*
fermentation
↓
pehtze
↓
salt
↓ ← dressing mixture
ripening
↓
Sufu

Fig. 9 Flow sheet of sufu production.

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DIETARY PATTERN AND SOYBEAN PROCESSING IN JAPAN TODAY

K. SAIO*

Abstract

Low intake of animal protein as a whole, high intake of marine products compared to livestock, high intake of edible oil as a whole and strong influence of traditional taste preference, characterize the present food consumption pattern in Japan. These characteristics are considered to be rational and ideal from the nutritional point of view. The demand for soybeans has increased for the past decade in spite of a noticeable dependence upon imported soybeans. In Japan soybeans are processed to supply a wide variety of sophisticated foods, both traditional and modern.

Consumption of soybeans in Japan

Tables 1 to 4 show statistical data on the Japanese food situation presently. Food consumption patterns which changed in the 1960s during the rapid economic growth experienced by the country have resulted in the increase of calorie, protein and fat intake with a corresponding decrease in carbohydrate consumption and such pattern has been maintained since 1970 up to now. The characteristics of the present food consumption patterns in Japan are:
1) low intake of animal protein and high intake of vegetable protein,
2) high ratio of intake of marine products compared to livestock,
3) high intake of edible oil in total fat,
4) strong influence of traditional taste preference.

The intake of animal protein in Japan is comparatively low, in proportion to the relationship between the gross domestic product (GDP) and the intake of animal protein in other countries of the world. The ratio of intake of animal to vegetable protein in Japan is less than 50% (Tables 2 and 4). The high consumption of marine products is partly due to the high price of meat but mainly attributable to the Japanese traditional taste. The ratio of intake of marine products to that of livestock is almost 50% (Table 2). Marine products are consumed fresh but are also processed into many kinds of sophisticated food products. The Japanese have developed a habit of eating a variety of marine vegetables, which is unusual in the world. The Japanese taste preference is highly oriented toward bean foods. The Japanese consume daily 5.4g of soybeans, 2.2g of other legumes and 4.6g of soybeans as miso and soy sauce. Such a consumption pattern corresponds to that of the populations living in Southeast Asia, Central and South America and Africa who also consume a large amount of legumes.

As emphasized by WHO, protein, carbohydrate and fat should account for 11 to 12%, 63 to 67% and 20 to 22% of the total calorie intake, respectively. Thus the Japanese PCF pattern with protein, carbohydrate and fat accounting for 12.5%, 67.3% and 20.2% of the calorie intake, respectively is very near the ideal one. Moreover the quality of fat derived from marine products or vegetable sources helps prevent the occurrence of adult diseases because of their high content in unsaturated fatty acids.

The demand for soybeans has been on the increase, especially for the production of edible oil (Table 5). Also defatted soybean meals are mainly used for feeds and are processed into vegetable protein products. The use of whole soybeans in many traditional food products is still prevalent in Japan (Table 6). I personally find it regrettable that Japan is not self-sufficient in the production

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*National Food Research Institute, Yatabe, Tsukuba, Ibaraki, 305 Japan.

Table 1 Intake of Kcal/day/person

Kcal

Year	Cereals	Rice	Total CHD	Beans	Vegeta-bles	Fruits	Meats	Eggs	Dairy products	Marine products	Sugars	Lipids	Others	Total
1960	1,439	1,106	1,580	104	84	29	28	27	36	87	157	105	53	2,290
			(69)	(4.5)	(3.7)	(1.2)	(1.2)	(1.2)	(1.6)	(3.8)	(6.9)	(4.6)	(2.3)	
1965	1,398	1,076	1,528	98	89	39	54	49	61	90	196	161	47	2,411
1970	1,238	914	1,351	104	93	53	83	64	81	91	283	229	45	2,478
			(50)	(4.2)	(3.8)	(2.2)	(3.3)	(2.6)	(3.3)	(3.7)	(11.4)	(9.2)	(1.8)	
1973	1,197	873	1,308	103	88	60	108	62	85	98	295	270	45	2,522
1975	1,175	844	1,283	99	87	58	112	60	86	103	263	277	40	2.466
			(52)	(4)	(3.5)	(2.4)	(4.5)	(2.4)	(3.5)	(4.2)	(10.7)	(11.2)	(1.6)	
1976	1,164	829	1,285	94	88	55	117	61	88	105	265	283	41	2,483
1977	1,137	802	1,264	90	91	57	127	62	92	103	280	289	40	2,494
1978	1,120	785	1,250	89	90	56	134	64	96	105	266	311	39	2,500
1979	1,101	765	1,232	91	91	56	143	63	100	101	271	321	39	2,507
1980	1,101	759	1,249	90	92	54	144	63	101	102	245	336	38	2,514
			(50)	(3.6)	(3.7)	(2.1)	(5.7)	(2.5)	(4.0)	(4.1)	(9.7)	(13.4)	(1.5)	
1981	1,083	748	1,242	90	92	53	144	63	105	105	235	356	38	2,520

Figures in parentheses indicate percentage.

Table 2 Intake of protein/day/person

g

	Animal protein						Vegetable protein				Total
	Livestock				Marine products	Sub-total	cereals	beans	others	Sub-total	
	meats	eggs	dairy products	total							
1960	1.7	2.2	1.7	5.6	15.6	21.2	28.8	8.0	11.5	48.3	69.5
	(2.5)	(3.2)	(2.4)	(8.1)	(22.4)	(30.5)	(41.1)	(11.5)	(16.6)	(69.5)	
1965	3.5	4.0	3.0	10.5	16.4	26.9	28.4	7.3	11.2	46.9	73.8
1970	6.0	5.2	4.0	15.2	16.6	31.8	25.8	7.8	11.1	44.7	76.5
	(7.9)	(6.8)	(5.2)	(19.2)	(21.7)	(41.6)	(33.7)	(10.2)	(14.5)	(58.4)	
1973	8.0	5.0	4.2	17.2	17.7	34.9	25.0	7.8	11.5	44.3	79.2
1975	8.5	4.9	4.3	17.6	18.1	35.7	24.7	7.6	11.1	43.4	79.1
1976	9.1	5.0	4.5	18.4	18.2	36.6	24.6	7.2	11.3	43.1	79.7
1977	9.9	5.2	4.7	19.4	17.9	37.3	24.1	6.9	11.4	42.4	79.7
1978	10.6	5.1	4.9	20.5	18.1	38.6	23.8	6.9	11.3	42.0	80.6
1979	11.2	5.1	4.9	21.2	17.7	38.9	23.4	6.9	11.4	41.8	80.6
1980	11.3	5.1	4.9	21.3	17.8	39.1	23.6	6.9	11.1	41.6	80.7
	(14.0)	(6.3)	(6.1)	(26.4)	(22.1)	(48.5)	(29.2)	(8.5)	(13.8)	(51.5)	
1981	11.4	5.1	5.1	21.6	18.1	39.7	23.1	6.9	11.0	41.0	80.7

Figures in parentheses indicate percentage.

of the raw materials of such important food products and remains heavily dependent on imported soybeans.

Table 3 Intake of fat/day/person

g

	Vegetable fat	Animal fat	Total	Meats	Eggs	Dairy products	Cereals	Others	Total	Total
1960	8.8 (30.2)	3.1 (10.7)	11.9 (40.9)	1.7	1.9	2.0	3.6	8.0	17.2 (59.1)	29.1
1965	13.7	4.6	18.3	3.7	3.5	3.4	3.5	8.1	22.2	40.5
1970	19.9 (37.9)	5.9 (11.2)	25.8	5.9	4.6	4.5	3.2	8.5	26.7 (50.9)	52.5
1973	23.8	6.6	30.4	7.8	4.4	4.8	3.1	8.9	29.0	59.4
1975	25.2	6.0	31.2	8.0	4.3	4.8	3.0	9.1	29.2	60.4
1976	26.3	5.6	31.9	8.5	4.4	5.0	3.0	8.9	28.8	61.7
1977	27.2	5.4	32.6	9.1	4.4	5.2	2.9	8.7	30.3	62.9
1978	28.6	6.4	35.0	9.6	4.6	5.4	3.0	8.7	31.3	66.3
1979	29.4	6.7	36.1	10.4	4.5	5.6	2.9	8.8	32.2	68.3
1980	30.8 (44.0)	7.1 (10.1)	37.9	10.4	4.5	5.6	3.0	8.6	32.1 (45.9)	70.0
1981	33.2	6.9	40.1	10.4	4.5	5.9	2.9	8.7	32.4	72.5

Figures in parentheses indicate percentage.

Varieties and processing of soybean foods

Figures 1 to 4 show the processing methods of the main traditional soybean foods which have already acquired a reputation worldwide. Apart from the products listed, a new soybean product such as soy milk is becoming increasingly popular in the market. The production of soy milk which totalled less than 5,000 tons in 1975 increased 10 times and amounted to 50,000 tons in 1982. The growing interest of the consumers in health foods is no doubt responsible for this considerable increase. It should also be emphasized that modern food technology has contributed to such success in making soy milk acceptable to the public by removing the unpleasant beany flavor and sterilizing it for wider and safer distribution (Figure 5). The vegetable protein products listed in Figure 6, are presently being used by 73% of the food processors and have already been accepted as food ingredients due to their functionalities. The Japanese Agricultural Standards (JAS) for vegetable protein products were established in 1976 and those for soy milk in 1981, respectively.

Traditional technology for modern products and emerging technology applied to traditional foods

Flow sheets shown in Figures 1 to 4 include several improved aspects for the standardization, mechanization and/or mass-production of soybean derivatives. Herein, tofu and miso can be produced with slightly different processing methods. On the ohter hand, foods of more local nature are still produced on a small scale, such as yuba: surface-induced film on soybean milk, rokujotofu: salted and dried tofu, shimitofu: classical products of kori tofu obtained by natural freezing, tofukan: hard tofu conditioned with soy sauce, hoshiaburage: deep-fried tofu largely expanded, confectionery, etc. Recently food industries have reevaluated traditional soybean food technology. On the other hand, vegetable protein products are being introduced in traditional foods (for example delicacies for home use).

We are happy to observe that traditional and modern technologies are applied to modern and traditional foods in keeping a dynamic interaction between them.

Table 4 Comparison of intake of nutrients among various nations

	Calorie		Protein			Lipids		
	Kcal	ratio J=100	g	ratio J=100	animal protein / total protein (%)	g	ratio J=100	edible oil / total lipid (%)
Sweden	2,871	114	96	119	73	133	183	26
West Germany	3,397	135	98	122	68	178	246	30
France	3,340	133	112	139	68	168	231	30
Netherlands	3,421	136	97	120	67	184	254	45
England	3,150	125	89	110	62	140	193	33
USA	3,393	135	106	132	70	166	230	38
Canada	3,138	125	98	122	67	151	208	35
Denmark	3,369	134	97	120	71	179	247	36
Switzerland	3,358	133	103	128	66	163	225	26
Italy	3,363	133	109	135	50	137	189	44
New Zealand	3,121	124	111	138	70	145	201	13
Japan	2,520	100	81	100	49	73	100	55
Argentina	3,110	123	109	136	64	115	159	38
Brazil	2,514	100	62	77	37	49	68	42
China	2,343	93	62	77	18	39	54	28
Korea	2,615	104	72	89	19	27	37	23
Pakistan	2,281	91	63	78	25	42	57	53
India	1,919	76	47	59	10	30	41	51
Indonesia	2,112	84	43	54	12	33	45	42

Kcal, g of protein or lipid/day/person.
From OECD: Food consumption statistics and FAO: Food balance sheets.

Table 5 Supply and demand of whole soybeans in Japan

1,000ton

Year		1970	1974	1975	1976	1977	1978	1979	1980	1981
Supply		3,477	3,705	3,614	3,801	3,954	4,617	4,754	4,984	4,978
	edible oil	2,505	2,729	2,620	2,701	2,878	3,297	3,401	3,453	3,495
	fermented	187	206	190	193	193	188	205	208	
Demand	foods									785
	foods	522	520	526	537	552	565	572	578	
	feeds	10	30	30	30	30	40	55	55	55
	export							20	30	40

Table 6 Detailed use of whole soybeans supplied for food

1,000ton

Year	1975	1976	1977	1978	1979	1980	1981	(1982)*
For tofu analogues								
IOM	350	365	380	393	389	390	400	410
Howkeye and Beeson	27	23	22	21	20	22	25	25
Canada	6	6	8	10	3	3	5	5
Brazil	1	3	2	2	0.5	0.3	—	—
China	20	10	5	5	10	10	10	10
Domestic	10	10	10	15	30	35	30	30
Total	414	417	427	445	452	460	470	480
For kori tofu								
IOM	25	26	28	29	26	25	28	28
China	5	3	2	1	3	3	—	—
Total	30	29	30	30	29	28	28	28
For natto								
China	61	37	15	15	40	27	30	25
IOM and others	3	24	45	46	8	20	27	35
Domestic	4	8	10	10	25	28	20	20
Total	68	69	70	71	73	75	77	80
For miso								
China	160	90	60	55	120	94	89	60
Domestic	11	11	10	7	17	22	15	20
variety	10	27	50	30	25	40	50	60
IOM	5	63	65	90	20	30	30	40
Total	186	191	185	182	181	185	183	180
For shoyu								
IOM	11	10	9	6	7	7	7	6
For other foods								
	16	16	16	16	17	18	20	23
Total	725	731	737	750	759	773	785	797

* Projected values.

water → immersion; water → heating

SOYBEAN —— washing —— immersion —— grinding —— heating —— filtering

filtering → RESIDUE

coagulant → coagulation

SOY MILK —— coagulation —— removing whey —— molding ——

removing whey → WHEY

pressing —— cooling —— cutting —— MOMEN TOFU

Fig. 1 Flow sheet of Momen Tofu preparation.

water → immersion; water → heating

SOYBEAN —— washing —— immersion —— grinding —— heating —— filtering

SOYBEAN → coagulant

filtering → RESIDUE

SOY MILK —— coagulation —— TOFU —— cooling —— cutting —— freezing

WHEY → coagulation

aging —— thawing —— dehydrating —— drying —— softener addition

packing —— KORI TOFU

Fig. 2 Flow sheet of Kori Tofu preparation.

DEFATTED SOYBEAN MEAL —— watering — steaming

WHEAT —— toasting grinding

steaming, grinding —— mixing —— SHOYU KOJI ——

koji starter → SHOYU KOJI

water, salt

SHOYU MOROMI —— mixing —— fermentation —— airing —— pressing ——

pressing → RESIDUE

FRESH SHOYU —— sterilization —— bottling —— SHOYU

Fig. 3 Flow sheet of Shoyu (soy sauce) preparation.

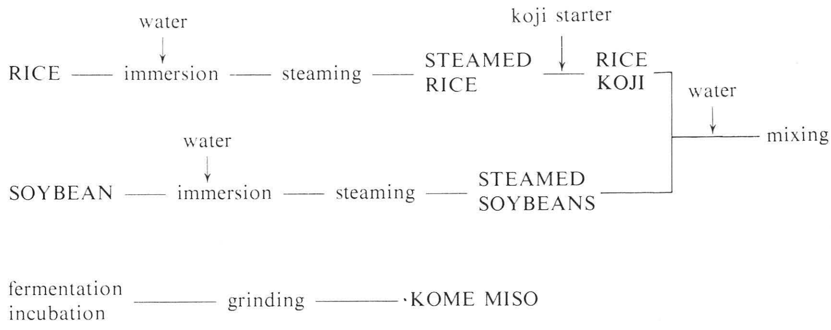

Fig. 4 Flow sheet of Kome Miso preparation.

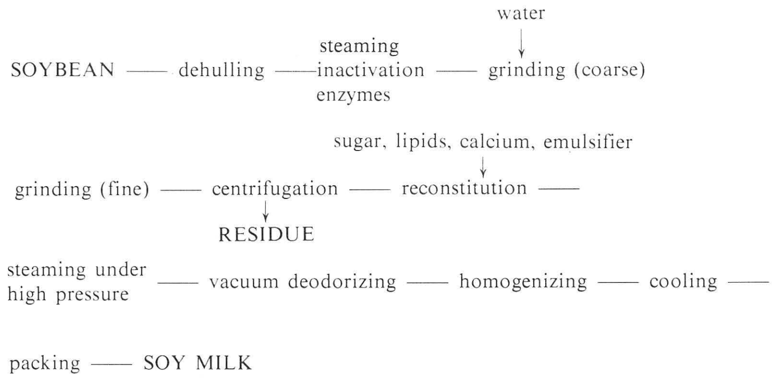

Fig. 5 Flow sheet of soy milk preparation.

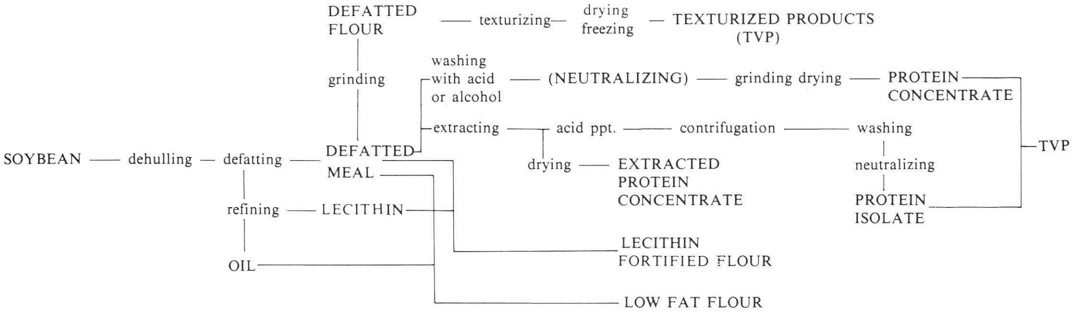

Fig.6 Manufacture of vegetable protein products.

Reference

1) Japanese Food Consumption Yearbook, 1981, Ministry of Agriculture, Forestry and Fisheries.

Discussion

Palaniyappan, K. (India): 1. What are the products that you add for the reconstitution of soy milk ? 2. What is the shelf life of soy milk ? 3. We would like to have more information about the soya products which are being marketed in Japan so as to introduce them to the Indian public. Could you assist us in this regard ?

Answer: 1. The chemical composition of reconstituted soy milk is very similar to that of cow milk. We therefore add sugar, honey, dextran, malt, vegetable oil and Ca in the colloidal state to avoid the precipitation of proteins. 2. Since the conditions of sterilization of soy milk are very strict, soy milk can be preserved at room temperature for more than 3 months. 3. This information will be supplied to you on the occasion of your visit of the National Food Research Institute after the symposium.

Bhatnagar, P.S. (India): 1. Is it possible to prepare tofu from defatted soy flour or soy meal ? 2. We have observed that when we boil the slurry from soy meal, it often sticks at the bottom of the pan and chars in spite of frequent stirring. Could you indicate us how to avoid this problem ?

Answer: 1. It is possible to prepare tofu or soy milk from defatted soy flour. However the taste of tofu or soy milk is not as good as when these products are prepared from whole beans. In Japan, most of tofu and soy milk is prepared from whole beans. 2. You may overcome the difficulty you described in preparing soy milk from soy meal. After heating, tofu can be obtained.

GENERAL DISCUSSION

General Discussion

Chairman: Kauffman, H.E. (INTSOY): The purpose of the general discussion is to review and bring out some of the highlights of the presentations and to give the the opportunity to the participants to ask questions and consider in more detail particular aspects of the problems outlined in the reports. It appears that the group is primarily represented by scientists working in production. However some of the speakers presented data on the processing and utilization of soybean products. I believe that this area is extremely important. Indeed production and utilization are closely related and soybean scientists must understand the total aspect of the soybean industry so as to be able to make pertinent recommendations to the authorities concerned in the respective governments to establish, implement or expand programs.

The discussion on the reports presented by the delegates of several countries and international organizations is now open. Emphasis will be placed on defining more precisely the future trends and policies of the respective countries with regard to soybean production.

I would like to ask Mr. Miranda what are the projections on future trends of soybean production in Brazil.

de Miranda, M.A.C. (Brazil): In Brazil plans are being made to further develop soybean cultivation in the tropical areas, in particular in the area presently under "cerrado" vegetation in making the best use of the technology available.

Galal, S. Jr. (Egypt): I would like to know how and where the 275 million metric tons of soybeans needed for the international market in the year 2000 will be produced in considering the current level of production which stands at 94 million metric tons. Also I wonder if it is wise for some countries to reduce the area under production in favor of more profitable crops.

Kiihl, R. (Brazil): It appears as if the technology required to double the world soybean production is available. The use of the Brazilian "cerrado" soil would probably be the easiest solution. Indeed the "cerrado" area covers approximately 150 million hectares, of which 50 million hectares can be used presently and the total world soybean production could be doubled in a few years. However to bring the "cerrado" soil under production, lime and phosphorus application is necessary. I believe that the economical aspects will determine the future development of soybean production in the world. A new economic organization will be necessary because the cost of production is increasing and the price of the product must increase too. It appears as if the people who need food, in particular protein, cannot afford it and that the countries which have land and resources do not have the money to produce.

Bhatnagar, P.S. (India): In India there is a deficit of 2 million tons in the production of edible oil. The demand which is likely to increase further cannot be met by other crops but soybeans whose production should therefore increase. Ten years ago the area cultivated to soybeans covered less than 1,000 hectares while now it amounts to 200,000 hectares. The expansion of the area planted is likely to take place in the southern states such as Tamil Nadu.

Wang, J.L. (China): Brazil has a high potential to increase the production of soybeans because large areas still remain uncultivated. The main problem is related to the price of soybean in the world market. The cost of production of soybeans is fairly high in Brazil because of the high input of lime, phosphorus fertilizer and herbicides. The price of soybeans should be high enough to enable the Brazilian farmers to derive a profit from soybean cultivation. The soil erosion problem is also very important in the Brazilian soybean production and a stable cropping system will have to be developed.

As far as China is concerned, the increase in the area of soybean is limited. China has some potential for the increase of soybean production by increasing the yield per unit area.

Sumarno (Indonesia): It is interesting to note that the acreage of soybean in the tropics has tended to remain constant or has even decreased for the last 10 years, in spite of the attempts made to expand the production of soybean. What are the possible reasons ? Agronomic or economic ? I would also like to ask Dr. Kauffman whether any cultivars have been released or recommended by the countries participating in the programs since INTSOY was organized in 1973.

Chairman: Kauffman, H.E. (INTSOY): A large number of breeding materials have been released in the countries where they have been tested. About 40 countries have released or have grown under a certain scale of production materials from these trials. Moreover the materials have also been used as parents in breeding programs.

With regard to the first question of Dr. Sumarno, some of the reasons for the lack of increase or even for the decrease in soybean production observed in the tropics and subtropics may be related to agronomic or economic factors, as emphasized by Dr. Shanmugasundaram. Would any of the participants comment on these aspects ?

Trikha, R.N. (India): The area under soybean is definitely decreasing. Such a situation could be compensated by an increase in yield. However there is a wide gap between the potential yield and the actual yield. For example, in the experimental stations the yields are in the range of 3-4 ton/ha while in the farmers' fields they are less than 1 ton/ha. In India also we are facing the same situation. Therefore there is an need for a integrated approach. Scientists should establish a better working relationship with extension workers.

Chairman: Sadikin, S. (Indonesia): The lack of increase of the area under soybeans is often related to agronomic reasons. For example, the varieties are not well adapted to the tropical conditions. Also seed provision is difficult to realize in tropical countries. In Indonesia in farmers' fields, yield is hardly reaching 1 ton/ha. The seed rate should definitely be increased.

Rahman, L. (Bangladesh): It appears clearly that in some countries like Taiwan, Korea and Japan the acreage of soybean has considerably decreased with the increase in consumption. As a result these countries have increased imports from the USA where the price policy is in fact a controlling mechanism of this price. In many of these countries due to changes in the trend of labor, the cost of production has increased. Since the price is low in the world market each country favours imports and the farmers have no incentive to grow soybeans. However the yield needs to be increased but not at a high cost. Therefore the breeders should tackle this problem in developing high-yielding varieties (competitive with other crops) which tolerate low management practices. There should be a coordinated regional approach to share available technologies relating to variety development, germplasm exchange, promotion of training, expert assistance and development of an integrated system for utilization of techniques and methods.

Galal, S. Jr. (Egypt): Would it be possible to have a steady increase in production of about 11%/year until the year 2000 to be able to produce the needed amount of 275 million tons ? Also should soybean production depend only on a few countries and is it wise for other countries to increase production so as to cushion this dependence ?

Al Jibouri, H.A. (FAO): I believe that there is a great potential to increase the yield per unit area through plant breeding and genetic manipulation as in the case of rice or maize. In tropical Africa soybean is not a traditional crop and the technology has to be developed and adapted to introduce it into the African cropping systems. The fact that some countries such as Cuba, Mozambique, Zambia, Zaire, Sri Lanka and India are promoting soybean cultivation and are expanding the production of this commodity both horizontally and vertically is certainly a major achievement.

Yap, T.C. (Malaysia): I would suggest that soybean be produced as a source of protein for food rather than as an oil crop. Indeed compared with oil palm in which one hectare produces 3 tons of cooking oil, the yield of soybean is comparatively low.

Garside, A.L. (Australia): It appears to me that the real problem related to the decrease in soybean production is economic. In the countries with declining production, such as Korea and Taiwan alternative crops are more profitable to grow. If the demand is to increase, as has been suggested, the price will also increase and therefore encourage more production.

Chairman: Kauffman, H.E. (INTSOY): would like to ask each of the delegates who presented a country report to outline the projections for soybean production in the respective countries.

Bhatnagar, P.S. (India): The increasing demand and decreasing trend of soybean production in the world points to the conclusion that there is a need for more concerted efforts and active involvement of international organizations such as FAO, World Bank, etc. for reducing the gap between experimental yields and farm yields and to increase both productivity and output of soybeans. The international organizations could help in undertaking in-depth studies and active research on development of disease resistant and high-yielding varieties, production technology and cropping pattern, consumer preference and comparative price structure of soybean products, marketing strategies based on the judicious mix of media and approaches.

As I mentioned before, in India there is a vast potential to increase the production of soybeans. It is anticipated that in the years 1983-1984, 1.4 million hectares will be planted to soybeans and in the years 1984-1985, 1.8 million hectares should be devoted to soybeans. Although the use of soybeans will mostly be for oil production, emphasis should be placed on the utilization of defatted soy flour for food and feed.

Chairman: Sadikin, S. (Indonesia): In Indonesia there are short-term and long-term programs relating to soybean production. For the short-term measures, there are three packages of techniques aiming at area expansion and intensification. The long-term programs will involve more research. The main constraints to increased production are seed provision, pests and diseases and adaptability of varieties. There is a need for the development of varieties with short maturity to meet the requirements of the cropping systems adopted in Indonesia.

Arwooth Na Lampang (Thailand): As mentioned previously by Dr. Shanmugasundaram, the farmers are usually motivated by income consideration when they grow a crop. Therefore, in Thailand farmers grow soybeans when they cannot grow mungbeans which fetch a higher price. In the early rainy season, when frequent rainfall will promote the sprouting of mungbean seed at the time of maturity, soybeans are being grown. Likewise in the winter when the temperature is too low for mungbean to germinate and causes injury to the plant, soybean will be grown.

Howell, R.W. (USA): The trend of soybean production will essentially be governed by economic factors. Production area will likely remain rather constant with year to year variations largely reflecting relative prices of corn and soybeans at planting time. Average yield increases of 1/2 to 2/3 bushel per acre will continue but year to year variations due to weather may obscure the increase trend in a single year.

Gai, J.Y. (China): Soybean acreage is likely to increase in the southern part of China. However the most important objective is to raise the unit acreage yield and the soybean breeders are now facing the challenge of matching the progress made in the breeding of other crops such as rice, wheat and corn. The target set presently is to achieve a yield of 3-4 ton/ha.

Chairman: Kauffman, H.E. (INTSOY): Since China has large collections of soybean germplasm, do you consider that some of the materials could be used to develop high-yielding varieties ?

Gai, J.Y. (China): It is unlikely since the germplasm consists of local cultivars and the potential is not promising unless genetic engineering is performed.

Wang, J.L. (China): Soil fertility is the most important problem to solve in China, particularly with regard to phosphorus availability and organic matter preservation.

Shanmugasundaram, S. (AVRDC): At IRRI a comparison was made of the yield and return per hectare and per kg between soybean and mungbean which are grown after rice during the 65- to 70-day interval between the two crops of rice in the rotation. It was observed that the yield of mungbean after 70-day cultivation was 1.2 ton/ha while that of soybean exceeded 2 ton/ha after 72-day cultivation. Since the unit price for mungbean is twice that for soybean, farmers are naturally motivated to grow mungbean rather than soybean.

Konno, S. (Japan): In Japan soybean production can increase only by enlarging the scale of operation or reducing the production cost.

Chairman: Kauffman, H.E. (INTSOY): Does any of the participants wish to make any comment on aspects pertaining to the application of biotechnology to promote soybean production ? Indeed it may be important to evaluate the potential of biotechnology for achieving higher soybean yields which has already been realized in other crops through standard breeding techniques.

Galal, S. Jr. (Egypt): I would like to propose that a tissue culture program for soybean breeding, particularly for the development of cultivars resistant to pests and diseases be financed. I have great hopes in the potential of tissue culture since I visited Dr. Zapata's tissue culture laboratory at IRRI. I have seen there new cultivars produced from anther culture of rice which were resistant to the brown planthopper in the breeding plots. These results could be obtained in a six-month period compared with at least ten years with the conventional breeding methods.

Chairman: Kauffman, H.E. (INTSOY): I would like to add that in China very successful programs for anther culture of rice have been developed. Tissue culture of soybean appears to be more difficult but should draw a great deal of attention in future. Topics relating to soybean processing, food uses, dietary pattern could now be discussed.

I was very much impressed with the variety of soy foods that are being marketed in the Orient but have yet to be recognized in other parts of the world. There is a need for popularizing these products so as to promote their use worldwide.

Dutt, A.K. (India): The potential of soybean in West Bengal is quite high in rice fallows where soil moisture is adequate for the maturation of early-maturing varieties of soybean, especially in the coastal area and in the Sunderbans. Active programs of demonstration and preparation of soybean foods have promoted the consumption of soybean grains whose demand markedly increased in the cities and rural areas. Such programs are particularly important so as to motivate farmers to grow soybeans, as a source of protein for the people with low income.

Chairman: Kauffman, H.E. (INTSOY): I would like to ask Dr. Gotoh if he wishes to make a few comments about the symposium.

Chairman: Gotoh, K. (Japan): I would like to emphasize the three following points: 1. I believe that the local strains or land races which are well adapted to the conditions of a given area are important and should be preserved. 2. To increase the potential of the existing cultivars with regard to yield, a suitable system for supplying and increasing the seed samples should be developed. 3. Multi-line varieties should be developed and various kinds of seed samples should be mixed before they are allowed to grow under specific conditions. Types resistant to diseases, pests, etc. should be prepared prior to releasing them to the farmers.

Chairman: Sadikin, S. (Indonesia): In Indonesia, emphasis should be placed on the development of a stable system of seed provision, such as the seed flow system.

Chairman: Kauffman, H.E. (INTSOY): We have now reached the end of Session I which was focussed on the present situation of soybean production and the role of soybeans in tropical and subtropical agriculture.

Closing Remarks

M. OJIMA
Chief of the First Crop Division
National Agriculture Research Center

Ladies and Gentlemen, Distinguished Guests and Participants,

At the end of the International Symposium on Soybean, I would like to express my deep gratitude to all the participants for contributing so significantly to the success of the symposium, in particular to those who came from overseas.

Indeed only the close cooperation between AVRDC and TARC along with the assistance extended by the Agriculture, Forestry and Fisheries Research Council as well as by various research organizations made it possible for such a large number of researchers from all over the world to gather here in Tsukuba to present the latest information on various aspects of soybean production. I would like to take this opportunity for thanking all of those who were so helpful in the organization of the symposium.

During the symposium, the delegates of several countries presented a report outlining the situation of soybean production and research in their respective countries. I believe that we were extremely fortunate to have among us the delegate from China where soybean cultivation actually originated. The valuable experience acquired in the cultivation of soybeans in the southern part of China, in particular in the Chang-Jiang Valley, as well as the attempt to introduce soybeans in the subtropical and tropical zone of Brazil is certainly highly relevant to other countries located in the tropics and subtropics. In addition the delegates from all the countries, without exception, outlined the numerous technical and socio-economic constraints that still hamper the increase in soybean production which is of paramount importance for these countries. They also indicated the measures that are being taken to promote research and improve extension services so as to overcome these difficulties.

On the other hand, due to the remarkable changes in the meteorological conditions which are being recorded worldwide, the information on the trend of soybean production in the USA and Brazil, the leading soybean-producing countries, should be highly appreciated by the delegates of the countries that import soybeans or are concerned about the increase in the production of this commodity. In this regard, the emphasis placed by the USA on the need for establishing a close cooperation among the groups involved in soybean research, production and commercialization so as to increase production, along with the reports from Taiwan and Japan on the long history of soybean processing to a variety of food products should give valuable suggestions for further expanding soybean production in many countries.

Also, we all know that it is essential to stabilize food production to keep pace with the increase in the world population, particularly in the tropical and sub-tropical countries. To achieve this objective, the establishment of cropping systems that include soybeans, a short-duration crop, should be promoted since soybeans represent an important source of protein and edible oil and exert a beneficial effect on the other crops in the rotation, with respect to nitrogen supply. In this regard, the diversity of the cropping systems outlined in the reports presented at the symposium reflected well the weather conditions peculiar to each country, including the temperature and amount of precipitation and solar radiation as well as the spectrum of diseases and pests, the soil conditions and the socio-economic characteristics prevailing in the respective countries. Moreover the concept underlying the breeding strategies and the methods for the application of fertilizers, for enhancing nitrogen fixation through *Rhizobium* association and controlling pests and diseases in soybeans along with data on basic research were presented during the symposium.

In addition, the difficulty to reconcile recommendations based on experimental results with farmers' practices, which is shared by most of the soybean-growing countries was discussed. The need for overcoming these constraints in order to consolidate and increase soybean production was stressed, in taking into account the various technical, social, economic and psychological factors involved.

I am convinced that the symposium was successful although it is obvious that a great deal of problems still remain to be solved in future.

As you may already know, tomorrow you will have the opportunity of visiting the National Agriculture Research Center, including the experimental soybean fields. Meanwhile, I do hope that you will enjoy your stay in Japan.

Once more, I should like to thank all the participants for their interesting presentations and for their active role in the discussions which took place during the symposium.

Thank you.

LIST OF PARTICIPANTS

Australia	DICKSON, Trevor	Dept. of Primary Industries, P. O. Box 23, Kingaroy Q. 4610
	GARSIDE, L. Alan	Dept. of Primary Production, P. O. Box 4160 Darwin, T. T.
	LAWN, John Robert	Division of Tropical Crops and Pastures, CSIRO, The Cunningham Laboratory, 306 Carmody Road, St. Lucia, Queensland 4067
	TREDSON, J. Robert	Dept. of Agriculture, University of Queensland, St. Lucia, Q. 4067
Bangladesh	AHMED, Md. Seleh	Japan International Cooperation Agency, 3-6, Koyadai, Yatabe, Tsukuba, Ibaraki, Japan
	RAHMAN, Lutfur	Dept. of Genetics and Plant Breeding, Bangladesh Agriculture University, Mymensign
	ROY, B. L.	Japan International Cooperation Agency, 3-6, Koyadai, Yatabe, Tsukuba, Ibaraki, Japan
	SHAHIDUZZAMAN, A. N. M.	Japan International Cooperation Agency, 3-6, Koyadai, Yatabe, Tsukuba, Ibaraki, Japan
Brazil	KIIHL, Romeu Alfonso Souza	Embrapa-CNPSo - Caixa Postal 1061, 86.100 - Londrina - PR.
	MASCARENHAS, Hipolito A.A.	Secao de Leguminosas, Instituto Agronomico de Campinas, Ave. Barao de Itapura 1481, Caixa Postal 28, 13.100 Campinas, Sao Paulo
	MARTINEZ, Eugenio	Fundacao Rockefeller Caixa Postal 511, 40000 Bakia
	De MIRANDA, Manoel Albino Coelho	Secao de Leguminosas, Instituto Agronomico de Campinas, Ave. Barao de Itapura 1481, Caixa Postal 28, 13.100 Campinas, Sao Paulo
	SASAKI, Jose Luis Susumu	Japan International Cooperation Agency, 3-6 Koyadai, Yatabe, Tsukuba, Ibaraki, Japan
Burma	AUNG, Shwe	National Agriculture Research Center, Yatabe, Tsukuba, Ibaraki, 305, Japan
Canada	CAMPBELL, Marilyn	IDRC, P.O. Box 8500, Ottawa
	RENNIE, Robert J.	Research Station, Agriculture Canada, Lethbridge, Alberta, TlJ 4Bl

China	CHUNG, Yong Kyu	The Food and Fertilizer Technology Center for the Asian and Pacific Region, 5th Fl., 14 Wenchow Street, Taipei
	GAI, Jun Yi	Dept. of Agronomy, Nanjing Agricultural College, Nanjing
	HSIEH, Ko-Chang	Science Division, Association of East Asian Relations Tokyo Office, Mesoniku 39 Mori Bldg., 2-4-5, Azabu-dai, Minato-ku, Tokyo
	JIAN, Yu Yu	Soybean Institute, Jilin Academy of Agricultural Science, Gongzhulinh, Jilin Province
	JIANG, Zhong Ren	Japan International Cooperation Agency, 3-6, Koyadai, Yatabe, Tsukuba, Ibaraki, Japan
	LIN, Liang Ping	Department of Agricultural Chemistry, National Taiwan University, Taipei
	THSENG, Fu-sheng	National Chung Hsing University 250, Kuokuang Rd., Taichung
	TU, Hsun	Council for Agricultural Planning and Development, 37, Naikai Road, Taipei
	WAN, Hsiung	189 Chung-cheng Road, Wufeng, Taichung
	WANG, Jin Lin	North East Agricultural College Harbin, Heilongjiang
	WANG, Lian Zheng	Heilongjiang Academy of Agriculture Sciences, Harbin, Heilongjiang
	YEH, Chung-Chnan	Taiwan Agricultural Research Institute, Wufeng, Taichung 431
Cote d' Ivoire	ROGER, Diallo	Projet Soja, Bureau D' Etudes Techniques des Projets Agricoles, 04 B. P. 716, Abidjan 04
Egypt	El TAWEEL, Moustafa Kamal	Mallawi Agricultural Research Center, Mallawi
	GALAL, Sayed Jr.	Post Office Box 943, Cairo
	KHALID, Mohamed Ahmed	Japan International Cooperation Agency, 3-6, Koyadai, Yatabe, Tsukuba, Ibaraki, Japan
	MEHANY, Badry Mohamed	Sids Agricultural Research Station, Beni Suef
	NASSIB, Abdullah M.	Food Legume Research, Field Crops Institute, Agricultural Research Center, Giza

France	PICASSO, Christian Georges	IRHO 11 Square Petrarque, 75016, Paris
Guinea	DIALLO, Mody S.	Japan International Cooperation Agency, 3-6, Koyadai, Yatabe, Tsukuba, Ibaraki, Japan
India	BHATNAGAR, Prem Swaroop	G.B. Pant University of Agriculture and Technology, Pantnagar-263145, U.P.
	CHOUDHARI, V. B.	Japan International Cooperation Agency, 3-6, Koyadai, Yatabe, Tsukuba, Ibaraki, Japan
	DUTT, Arabinda Kumar	Farming, Plantation and Agrochemicals-Formulation Consultants, P-16, Darga Road, Calcutta-700 017
	PALANIYAPPAN, K.	Sakthi Sugars Limited, Head Office 73-A, Race Course Road, Post Box No. 3775, Coimbatore-641018
	REDDY, M. S.	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) ICRISAT Patancheru, P.O. 502324, AP
	SHANMUGASUNDARAM, Thiru A.	Sakthi Sugars Limited, Head Office 73-A, Race Course Road, Post Box No. 3775, Coimbatore-641018
	THULASIDASS, Gopala-pillai	National Pulses Research Centre, Pudukkottai 622 001, Tamil Nadu
	TRIKHA, Ravendra Nath	G.B. Pant University of Agriculture and Technology, I/237 Phool Bagh. Pantnagar, Distt. Nainital (UP) 263145
Indonesia	ADINATA, Asep	Japan International Cooperation Agency, 3-6, Koyadai, Yatabe, Tsukuba, Ibaraki, Japan
	ADISARWANTO, Titis	Malang Research Institute for Food Crops, P.O. Box 66 Malang, East Java
	ARIFIN, Sultoni	Social Economic Dept., Bogor Research Institute for Food Crops, Jalan Cimanggu Kecil 2, Bogor
	BARADSANEGARA, Abdul Aziz	National Institute of Genetics, Mishima, Shizuoka-ken, 411
	HIDAYAT, Omar O.	Sukamandi Research Institute for Food Crops, Sukamandi, Subang, West Java
	SOMAATMADJA, Sadikin	Bogor Research Institute for Food Crops, Jl. Cimanggu Kecil No. 2, Bogor Kotak Pos 368/Boo
	SUMARNO	Bogor Research Institute for Food Crops, Cimanggu Kecil No. 2, Bogor
	TAMPUBOLON, Leonard	PT. Perkebunan IV, Gunung Pamela, Tebingtinggi Deli, Sumatera Utara

Italy	Al-JIBOURI, Hazim A.	Plant Production and Protection Division, Food and Agricultural Organization (FAO) of the U.N. Via delle Terme di Caracalla, 00100 Rome
Japan	MUTAI, S.	Ministry of Foreign Affairs
	KURITA, T.	Secretariat of the Agriculture, Forestry and Fisheries Research Council
	KANEDA, C.	〃
	TAKATA, Y	〃
	TANAKA, N.	〃
	TARUMOTO, I.	〃
	YAMAKAWA, O.	〃
	KISHI, K.	National Agriculture Research Center
	HOJOH, Y.	〃
	OJIMA, M.	〃
	WATANABE, I.	〃
	WATANABE, Y.	〃
	YOSHIDA, T.	〃
	KOYANAGI, A.	〃
	SEKIMOTO, M.	〃
	HAMAGUCHI, H.	〃
	ODA, S.	〃
	KIKUCHI, M.	〃
	SAKAI, K.	National Institute of Agricultural Sciences
	FUJII, K.	〃
	HARADA, H.	〃
	KONNO, T.	〃
	KAWAKAMI, J.	〃
	KIRITANI, K.	〃
	KISHINO, K.	〃
	KOBAYASHI, H.	〃
	NISHIZAWA, T.	〃
	NODA, T.	〃
	OHTA, Y.	〃
	OHNO, K.	〃
	SHIMURA, E.	〃
	SUGIHARA, S.	〃
	SUZUKI, S.	〃
	TANABE, I.	〃
	YAZAWA, F.	〃
	TSUMURA, S.	National Food Research Institute
	HORII, M.	〃
	KATOH, K.	〃
	SAIO, K.	〃
	TAIRA, H.	〃
	YAMAMOTO, M.	〃
	TORIYAMA, K.	Institute for Plant Virus Research
	IWAKI, M.	〃

HASHIMOTO, K.	National Tohoku Agricultural Experiment Station
KOKUBU, K.	〃
MOCHIDA, H.	〃
OHBA, T.	National Kyushu Agricultural Experiment Station
OKABE, S.	ESCAP, CGPRT Centre, Jalan Merdeka 99, Bogor
GOTOH, K.	Hokkaido University
ISHIZUKA, Y.	〃
TANAKA, A.	〃
KISHIMOTO, O.	Utsunomiya University
KIKUCHI, F.	University of Tsukuba
KOBAYASHI, N.	〃
NAMAI, H.	〃
WATANABE, Y.	〃
YOSHIDA, T.	〃
ONO, Y.	Ibaraki University
FUKAI, S.	University of Tokyo
INANAGA, S.	〃
NIWA, M.	〃
HIRATA, M.	University of Agriculture and Technology
KONDO, N.	Tokyo University of Agriculture
YAMAMOTO, M.	〃
YAMAMOTO, I.	〃
INOUE, J.	Kyushu University
MATSUMOTO, S.	〃
YAMADA, Y.	〃
KUMAZUKA, S.	Nagoya University
YOSHIDA, K.	〃
BANBA, H.	Hokkaido Agricultural Experiment Station
KUBO, Y	Toyama Agricultural Experiment Station
ISHIDA, N.	Ehime Agricultural Experiment Station
IYAMA, S.	National Institute of Genetics
OKA, H.	〃
HASEGAWA, M.	Potassium Research Association
NAKATA, M.	Nippon University
SHINOHARA, S.	4-7-7, Nishiooi, Shinagawa, Tokyo
NAKAMURA, M.	Ciba-Geigy Co.
EGUCHI, Y.	Japan International Cooperation Agency
KANO, Y.	〃
NAGAI, K.	〃
YAMANAKA, K	〃
YAZAWA, S.	〃
HARADA, J.	J O C V
SAKAI, A.	〃
INOUE, S.	Monsanto Japan Co.
FUJIYAMA, M.	〃
TAKAHASHI, N.	Nagano Agricultural Experiment Station
IHARA, Y.	Japan Plant Protection Association
FUJIWARA, T.	〃

Korea	HONG, Eun-Hi	Crop Experiment Station, Office of Rural Development, Suweon 170
	HWANG, Young-Hyun	Crop Experiment Station, Office of Rural Development, Suweon 170
	LEE, Joo Yeul	Chung Nam Provincial Ord, Sang Dae Dong, Jung Gu, Dae Jeon
Malaysia	MAK, Chai	Dept. of Genetics and Cellular Biology, University of Malaya, Kuala Lumpur
	YAP, Thoo Chai	Dept. of Agronomy, Faculty of Agriculture, Universiti Pertanian Malaysia, Serdang, Selangor
	YUSOF, Mohamed B. G.	Japan International Cooperation Agency, 3-6, Koyadai, Yatabe, Tsukuba, Ibaraki, Japan
Nepal	DAHAL, Peelamber	Japan International Cooperation Agency, 3-6, Koyadai, Yatabe, Tsukuba, Ibaraki, Japan
Netherlands	Van HINTUM, Theodorus Johannus Leonardus	National Institute of Genetics, Mishima, Shizuoka-ken 411
Nigeria	DASHIELL, Kenton	IITA, PMB 5320, Ibadan
The Philippines	CARANGAL, Virgilio R.	The International Rice Research Institute (IRRI) P.O. Box 933, Manila
	NAVARRO, Rudy S.	IPB, University of the Philippines at Los Banos, College, Laguna
	PRICE, Edwin C.	The International Rice Research Institute (IRRI) P.O. Box 933, Manila
	VIRTUCIO, Roberto H.	Ministry of Agriculture, Bureau of Plant Industry, Los Banos, Laguna
Sri Lanka	ABEYWARDENA, Percy O. S.	Department of Agriculture, Paradeniya
	CAFFOOR, Ziard	Soyabean Project, Peradeniya
	DHARMASENA, Cecil D.	Soybean Project, Gannoruwa, Peradeniya
	HERATH, Edward H. M.	Soybean Project, Division of Farms and Horticulture, Department of Agriculture, Peradeniya
	NILIWEERA, Dixon	Ministry of Agriculture Development and Research, 73/1 Galle Road, Colombo 3

	RATNAYAKE, W.	Agriculture Extension Office, New Town, Anuradhapura
	VIGNARAJAH, Nadarajah	Regional Agricultural Research Centre, Makanchura, Gonawila (NWP)
Thailand	BENJASIL, Vichitr	Field Crops Research Institute, Department of Agriculture, Bangkhen, Bangkok
	CHONGPRADITNUN, Praphasri	University of Tsukuba, Sakura, Ibaraki, Japan
	KERDCHOECHUEN, Orapin	6 Moo 3 Bangmod, Bangkuntien, Bangkok, 10150
	LIAMSOMBAT, Seenseri	Japan International Cooperation Agency, 3-6, Koyadai, Yatabe, Tsukuba, Ibaraki, Japan
	Na LAMPANG, Arwooth	Field Crops Research Institute, Department of Agriculture, Bangkhen, Bangkok, 10900
	NATTRIBHEP, Sawing	Chiang Mai Field Crop Research Center, Chiang Mai
	POOKPAKDI, Aphiphan	Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkhen, Bangkok 10900
	SAETANG, Chuliporn	
	SINGH, Gajendra	Division of Agriculture and Food Engineering, A.I.T., G.P.O. Box 2754, Bangkok 10501
	TONGDEE, Amnuay	Tak-Fa Field Crops Research Center, Tak-Fa, Nakornsawan Province
	YANG, Charles Y.	TOP/AVRDC
Tanzania	DOTO, Andrew	Faculty of Agriculture and Forestry, University of Dar es Salaam, Box 643, Morogoro
United Kingdom	SUMMERFIELD, Rodny J.	University of Reading, Plant Environment Laboratory, Department of Agriculture and Horticulture, Shinfield Grange, Cutbush Lane, Shinfield, Reading RG2 9AD, Berkshire
USA	BURTON, Joe C.	College of Tropical Agriculture and Human Resources, University of Hawaii, 4930 N. Elkhart Av., Milwaukee, Wi, 53217
	DAILEY, Nancy A.	National Geographic Magazine, R.R.I. Eaton, Indiana 47338

	FREDERICK, Lloyd R.	Agency for International Development ST/AGR, Rm 420 SA-18, Washington D.C. 20523
	HOWELL, Robert W.	University of Illinois, 2012 S. Cottage Grove, Urbana, Illinois 61801
	JACKOBS, Joseph A.	University of Illinois at Urbana-Champaign, 113 Munford Hall, 1301 West, Gregory Drive, Urbana, Illinois 61801
	KAUFFMAN, Harold E.	International Soybean Program, College of Agriculture, University of Illinois at Urbana-Champaign, 113 Munford Hall, 1301 West, Gregory Drive, Urbana, Illinois 61801
	MINOR, Harry C.	1418 Bradford Drive, Columbia, Missouri, 65201
	PRASKIN, Alan	Plenty Agriculture Project, 156 Drakes Lane, Summertown, Tennessee 38483
	SINCLAIR, James B.	Department of Plant Pathology, University of Illinois, 1102 S. Goodwin Ave., Urbana, Illinois 61801
	SINGLETON, Paul W.	College of Tropical Agriculture and Human Resources, University of Hawaii, P.O. Box O, Paia, Hawaii 96779
	WHIGHAM, David K.	Iowa State University, 119 Curtiss Hall, Ames, Iowa 50011
AVRDC	SELLECK, George W.	AVRDC, P. O. Box 42, Shanhua, Tainan 741
	SHANMUGASUNDARAM, Subramaian	〃
	IMAI, Hideo	〃
	SAJJAPONGSE, Adisak	〃
	SULZBERGER, Edward W.	〃
	TALEKAR, N. S.	〃
	TSCHANZ, Arnold T.	〃
TARC	NAKAGAWA, Sho-ichiro	Tropical Agriculture Research Center Yatabe, Tsukuba, Ibaraki, 305 Japan
	HAYASHI, K.	〃
	KONNO, S.	〃
	TAKAHASHI, T.	〃
	KITSUTAKA, A.	〃
	HATTA, S.	〃
	ARITA, H.	〃

MIYAKE, M.	〃
ABE, N.	〃
HORIBATA, S.	〃
UCHIYAMA, Y.	〃
OMORI, T.	〃
MIKOSHIBA, H.	〃
FUJIMURA, T.	〃
ARAI, K.	〃
IWATA, F.	〃
UMEMURA, Y.	〃
UEMATSU, T.	〃
MOROOKA, Y.	〃
YAJIMA, M.	〃
ARIHARA, J.	〃
TAKITA, T.	〃
TAKADA, H.	〃
OKA, M.	〃
YAMAGUCHI, T.	〃
KIMIGAFUKURO, T.	〃
KANEKO, T.	〃
MACHIMURA, T.	〃
MOCHIDA, O.	(I R R I)

Organizing Committee

Chairman

Ojima, M.	Director, Department of Summer Crop Science, National Agriculture Research Center, Yatabe, Tsukuba, Ibaraki, Japan

Members

Hashimoto, K.	Chief, 3rd Laboratory of Crop Research, 2nd Agronomy Division, Tohoku National Agricultural Experiment Station, 4 Akahira, Shimo-kuriyagawa, Morioka, Iwate, Japan
Harada, H.	Chief, Statistical Research Laboratory, Division of Statistical Research, Department of Physics and Statistics, National Institute of Agricultural Sciences (NIAS)
Ishizuka, J.	Chief, 3rd Laboratory of Plant Nutrition, Division of Plant Nutrition, Department of Soils and Fertilizers, National Institute of Agricultural Sciences (NIAS)
Iwaki, M.	Senior Researcher, 2nd Research Division, Institute for Plant Virus Research
Kaizuma, N.	Professor, Faculty of Agriculture, University of Iwate, 3-18-8, Ueda, Morioka, Iwate, Japan
Kobayashi, T.	Chief, Upland Crop Insect Pest Laboratory, Department of Plant Protection, National Agriculture Research Center
Konno, S.	Director, Research Division, Tropical Agriculture Research Center, Yatabe, Tsukuba, Ibaraki, Japan
Matsumoto, S.	Professor, Faculty of Agriculture, Kyushu University, Hakozaki, Higashi-ku, Fukuoka, Japan
Takata, Y.	Research Coordinator (International Cooperation), Agriculture, Forestry and Fisheries Research Council Secretariat, MAFF, Kasumigaseki, Chiyoda-ku, Tokyo, Japan

Watanabe, I.	Chief, Legume Physiology Laboratory, Department of Summer Crop Science, National Agriculture Research Center
Yamakawa, O.	Associate Research Coordinator, Agriculture, Forestry and Fisheries Research Council Secretariat, MAFF,
Yoshida, T.	Chief, Legume Production Laboratory, Department of Summer Crop Science, National Agriculture Research Center

Secretariat

Hayashi, K.	Director, Planning and Coordination Division, Tropical Agriculture Research Center, Yatabe, Tsukuba, Ibaraki, Japan
Iwata, F.	Senior Researcher, Research Division I, Tropical Agriculture Research Center
Mikoshiba, H.	Senior Researcher, Research Division I, Tropical Agriculture Research Center
Yamaguchi, T.	Head, Planning Section, Planning and Coordination Division, Tropical Agriculture Research Center

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