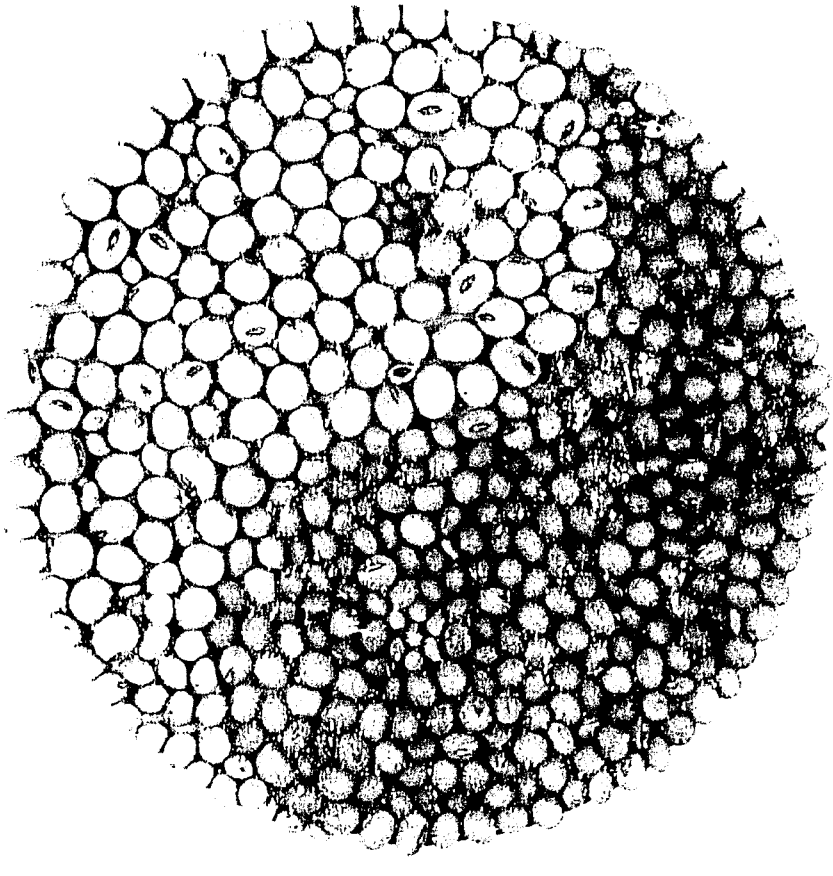
Soybean Varietal Improvement



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Tropical Vegetable Information Service

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Soybean Varietal Improvement

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Scientific Editor
S. Shanmugasundaram
Plant Breeder, AVRDC

Publication Editors
P. Lastimosa and N. Llemit
Assistant Information Specialists, AVRDC

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Foreword

This publication contains papers presented at the Asian Soybean Improvement Workshop held in Jakarta, Indonesia on 21 and 22 July 1984. The workshop itself is unique in several ways. First, it was held in conjunction with the monitoring tour of the International Rice Research Institute's Asian Farming System Network. Second, it was intended to bring together various international, regional, and national institutions working on a specific crop to focus on priority areas in order that they could individually and jointly attack specific problems to make improvements. Third, it established an Asian Soybean Improvement Network (ASIN).

The reports presented in this publication review the progress of soybean research in seven Asian countries and four International Agricultural Research Centers (IARCs). The major problem areas and difficulties involved in solving them are also presented by the authors. The four Centers (AVRDC, IITA, INTSOY, and IRRI) describe their expertise and major areas of responsibility.

The summaries of the two working group meetings defined the need to strengthen the national programs, provide autonomy, and respect the interests of individual countries. Appropriate emphasis was placed on supporting the national programs with germplasm and screening techniques. Such support should come through the collaborative studies with the IARCs. The need to jointly coordinate the regional testing program by different international and national agricultural research institutions was approved. The necessity to evolve a system of inter-regional cooperation to take advantage of the expertise available was reiterated.

I understand that the preliminary proposal to establish ASIN was critically reviewed by all the participating IARCs and the national program scientists, and a consensus was obtained. ASIN encompasses a number of different priority areas, recognizes the concerns of various countries and institutions, gives due attention to connecting institutions or

countries for specific collaborative research, and presents a priority basis for needed action. The proposal should be attractive to any prospective donor looking for an action-oriented proposal aimed at minimizing problems and maximizing production of soybean in the developing Asian countries. The proposal depicts a clear example of how international, regional, and national programs are willing to pool their expertise to establish a network system to achieve a common goal.

AVRDC is pleased to acknowledge the initiative of its former Director General, Dr. G. W. Selleck; Dr. M. S. Swaminathan, Director General of IRRI; Dr. E. H. Hartmans, former Director General of IITA; Dr. H. E. Kauffman, Director of INTSOY; and the late Dr. B. H. Siwi, Director of the Central Research Institute for Food Crops, Indonesia for making this workshop possible.

The publication of these proceedings was made possible by the diligent work of Dr. S. Shanmugasundaram, Ms. Pura J. Lastimosa, and Ms. Norma V. Llemit who have carefully edited the papers presented at the workshop by the scientists from different countries. We hope that the donor community will appreciate the proceedings and favorably consider the Asian Soybean Improvement Network proposal for funding and execution.

George A. Marlowe

GEORGE A. MARLOWE, JR.
Director General

August 1987

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Opening Remarks

B. H. Siwi
Director
Central Research Institute for Food Crops
Bogor, Indonesia

Distinguished Participants, Ladies and Gentlemen:

It is a pleasure to welcome you to Indonesia for this Soybean Varietal Improvement Workshop. During the last 12 days most of you have participated in the upland crops monitoring tour in Nepal and here in Indonesia. You have seen the diverse conditions under which soybean is grown in these countries. This will no doubt assist you in the discussions over the next two days.

Indonesian farmers have been planting soybean since the eighteenth century, but progress in their production techniques has been relatively slow. The harvested area has remained constant during the last two decades, at around 700,000 to 800,000 ha annually. Yields have risen only slightly from 0.7 t/ha in the 1960s to 0.9 t/ha in 1983. Demand for soybean, on the other hand, has been increasing so fast that national production cannot keep pace; and so Indonesia has been importing a substantial amount of soybean each year. In 1980 we imported around 100,000 t and in 1983 imports had reached more than 400,000 t. It is, therefore, very important for us to raise our soybean production to meet local demands.

The intensification program for rice in Indonesia has proved highly successful in raising national rice production. The Ministry of Agriculture has recently launched a similar production program for soybean covering about 70% of the total soybean area over the next five years. Under this program, farmers receive technical guidance and credit for seeds, insecticides, fertilizers, and other inputs. We hope to increase our national average yields from 0.9 t/ha to around 1.2 t/ha through this program.

Most of Indonesia's soybean is grown in Java; and relatively little is planted in the outer islands of Sumatra, Kalimantan, Sulawesi, and others. We are opening up new areas for soybean cropping outside Java. A 100-ha pilot project on newly-cleared land in Jambi, in Eastern Sumatra, has produced yield as high as 2 t/ha with the use of improved production techniques. This shows that the prospects for increasing soybean production on such lands are great.

However, many problems remain to be solved. Most farmers grow local, unimproved cultivars that do not respond to modern cropping techniques, and thus, provide only low yields. We are trying to develop soybean cultivars suited to low pH and other stresses. Seed viability is a major problem when farmers attempt to use seeds from their previous crop. Pests and diseases threaten the crop and cause fluctuations in production and yield.

Indonesia's research program has been systematically tackling these production constraints. We have released four new cultivars in the last five years, and two more are being proposed for distribution. Our new cultivars are suited to planting after wetland rice, and yield an average of 1.6 t/ha with good management. We are working on the poor seed-viability problem through breeding, postharvest handling, and by developing a system of seed flow, in which farmers in one area plant the newly-harvested seeds produced by farmers in another area.

We are researching on the effectiveness of various rhizobium strains, liming, micro- and macro-nutrient fertilizers, and integrated pest and disease management. Our socio-economists are trying to identify the constraints to production, consumption, and marketing and will find measures to alleviate these constraints. We place great emphasis on developing improved cultivars to suit the various soils, climates, and cropping systems.

We greatly value the collaboration among national programs and between national institutes and IARCs represented in this workshop. I trust that this workshop will be beneficial to all concerned in formulating strategies for soybean improvement in this region, and I wish you fruitful deliberations in the workshop and a pleasant stay in Jakarta.

I take great pleasure in declaring this workshop open.

Thank you.

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Intensifying Soybean Research in Asia

H. E. Kauffman
Director
International Soybean Program (INTSOY)
University of Illinois
113 Mumford Hall, 1301 West Gregory Drive
Urbana, Illinois 61801, U.S.A.

Introduction

It is my privilege to present this keynote address to this distinguished group of soybean scientists from various Asian countries. This meeting provides opportunity for us to draw on our collective experiences in soybean research and development and increase our cooperative activities to strengthen soybean production, marketing, processing, and utilization in the region.

Most of my professional career has been spent working with rice in the region. I therefore believe we can draw on some of the successful experiences gained from doubling rice yields and production during the past two decades. If soybean is to become a major crop in tropical and subtropical Asia, we must work closely with rice scientists and government policy makers to make it a more profitable crop to grow in a rice-based farming system.

Objectives of the Meeting

I believe it is important from the outset to clearly define the objectives of this meeting. I would interpret them as being:

1. Develop a long-term strategy to elevate soybean from a 'secondary crop' to a major crop in the region, so soybeans can help meet rapidly expanding edible oil and protein needs.

2. Identify present constraints limiting soybean industries in the region, and discuss ways research and development activities can overcome these constraints to accelerate production and utilization.

3. Develop a definitive plan of action to initiate collaborative work through a regional 'network' approach.

Historical Perspective on Soybean Development

The importance of soybeans can only be understood if one looks at the historical development of the crop on a global basis. You are all aware of the origin of soybeans in China and the domestication of the crop as far back as 5,000 years ago. During the evolution of soybeans they spread into both the temperate regions of Asia, as well as the tropical regions of Southeast Asia. Soybeans also spread from China to the Himalayan region of India, Pakistan, Nepal, and Burma but did become widely used in the plains of the Asian subcontinent. Soybeans have primarily been used for human food in Asia.

Traders took soybeans to Europe from whence they reached the United States. In the United States it took a number of years of research and industrial activity to convert soybeans from a forage crop to an oilseed/protein meal crop. Soybeans began to be grown widely in the midwestern U.S.A. in the early 1920s after processors guaranteed the purchase of soybeans from the farmers. Since that time, there has been phenomenal growth in the U.S. soybean industry.

Research, extension, and education at U.S. universities, the United States Department of Agriculture (USDA), and private industry developed cultivars, mechanized production practices,

produced effective inoculants, organized effective marketing and processing activities, resulting in a range of products to meet consumers' needs. Farmers, processors, and agri-business invested heavily in the U.S. soybean industry and benefitted significantly because of the high demand and low risk involved.

This technology was transferred to the temperate regions of South America, especially Brazil, in the late 1950s and early 1960s. Due to similar growing conditions and appropriate technical input, soybeans spread very rapidly in Brazil and are now their largest export commodity. Soybeans have recently spread through several other South American countries, especially Argentina, Paraguay, and Uruguay, which also have ideal growing conditions and have been able to benefit from a good global soybean market.

During the past decade, soybeans from the Western Hemisphere have been reintroduced into tropical Asian countries especially in South Asia. Cultivars from the Western Hemisphere yield well but do not have proper maturity, disease or insect resistance, or good seed viability for these regions. Therefore, low yields still persist in most Asian countries, as soybeans are forced to be grown in a less than favorable environment due to intensive cereal based cropping systems. Low-yielding cultivars, poor agronomic practices, low seed availability, lack of marketing and processing facilities, and the ever-present threat of cheap foreign imports make soybeans a high-risk crop for many Asian farmers.

This group must recommend research and development activities to give improved technology to Asian soybean industries so they can become competitive and profitable in the future.

Research and Development Thrusts in Asia

There are a number of short-term and long-term activities which should be initiated to accelerate soybean development. In the short-term, 'input responsive' soybean production, technology should be more widely tested and refined to increase yields. Much technology is already available, but it must be more finely tuned to meet local needs and government policy adjusted to make production profitable to incorporate.

In the long-term, input-neutral technology should be developed. This includes varietal development efforts to incorporate disease and pest resistance and tolerance to problem soils and moisture stress. Genetic improvement must be combined with improved cultural practices to lead ultimately to significant gains in soybean yields in farmers' fields.

National programs must be strengthened through collaborative research, training, and education.

Discussions of this workshop should identify the roles of the international, regional, and national organizations in strengthening national programs and developing new technology.

Organizational Cooperation

There are a number of organizations doing soybean research in the region. International organizations such as AVRDC, IITA, IRRI, INTSOY, and FAO have had various types of programs. Advanced national soybean programs in countries, such as Australia and Japan, have developed technology which is relevant to a number of areas in the region.

National programs in the region have been strengthened in recent years. China has a vast number of soybean scientists and expertise from centuries of growing, processing, and consuming soybeans. Therefore, the Chinese must be involved in developing soybean technology in the region. Indonesia, likewise, has a long association with soybeans. More recently countries like India and Sri Lanka have established programs which might serve as models for other countries.

The most effective way to use scarce individual resources is to establish an 'Asian Soybean Improvement Network'. A network can stimulate and, where appropriate, coordinate soybean research activity in the region. It can serve as a focal point for donors to contribute additional

funds to support component activities with the ultimate goal of strengthening national programs. Each country in the region can benefit from participation in such a network.

Conclusion

In conclusion, the success of rice in the region during the past decade and a half gives many leads as to the type of approach we must follow to make soybeans successful in tropical and subtropical Asia. There must be strong national programs linked to regional activities by a network so that a 'critical mass' of scientific effort is established. Relevant elements of the large soybean research effort in the Western Hemisphere must also be made available in Asia.

It is my hope that this meeting will lay the foundation for a strong and concerted soybean research network which will lead to significant production and utilization increases in the region during the next decade.

Progress of Soybean Research

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Soybean Breeding for Indonesian Cropping Systems

Sumarno
Soybean Breeder
Bogor Research Institute for Food Crops
Bogor, Indonesia

Introduction

The important role of soybean in the Indonesian food supply is indicated by the sharp increases in soybean imports in the last five years. Domestic production has been relatively constant at around 0.6 million t annually, while imports have risen from 0.1 million in 1975 to 0.5 million t in 1983. The annual harvested area has remained constant during the last 10 years at around 0.8 million ha, while the yield level has increased slightly from 0.73 t/ha in 1973 to 0.89 t/ha in 1983 (Table 1).

Table 1. Harvested area, average yield, total production, and imports of soybean in Indonesia, 1973-1983.[a]

Year	Harvested Area (000 ha)	Yield (t/ha)	Production (000 t)	Imports (000 t)
1973	742	0.73	541	-
1974	768	0.77	589	-
1975	752	0.79	590	-
1976	646	0.81	522	-
1977	646	0.81	523	-
1978	733	0.84	617	82
1979	784	0.87	680	177
1980	732	0.89	653	101
1981	810	0.86	704	361
1982	606	0.85	514	361
1983	803	0.89	735	503

[a] Source: Central Bureau of Statistics and Department of Agriculture, Indonesia.

Potential Soybean Areas

Among the soybean areas, 80% is in Java; and the remaining 20% is divided between Sumatra, Bali, Nusa Tenggara, Kalimantan, Sulawesi, and West Irian. Some reasons why soybean is not widely planted outside Java are.

1. Soybean is not part of the local diet.
2. Farmers are unwilling to grow soybean because it is a new crop and requires intensive crop management.
3. Soils are too acid for growing soybean.
4. Local markets have not been established.

However, farmers from Java have initiated the expansion of soybean, especially in Sumatra and Sulawesi. Of the 650,000 ha of soybean-planted area in Java, 60% is wetland after rice and 40% is dryland. In contrast, 80% of 161,000 ha of soybean planted outside Java is planted in dryland, and only 20% in wetland areas.

The potential for expanding the soybean area is great, both on wetland and dryland. There are around 6 million ha of wetland and about 9 million ha of dryland used for food crops. The

Department of Agriculture has launched a program to increase soybean production by increasing the harvested area from 0.63 million ha in 1983 to 1.12 million ha in 1988, and by increasing yield levels from 0.89 t/ha in 1983 to 1.17 t/ha in 1988. The increase in area will be on drylands outside Java, where farmers from Java have settled under the transmigration program.

Problems in Soybean Production

Factors contributing to low yields of soybean in Indonesia are: 1) low yielding local cultivars, 2) poor seed quality, 3) inadequate land preparation, 4) inadequate weed control, 5) pest and disease infestation, 6) water logging during the vegetative stage and/or drought stress during the generative stage, 7) planting on marginal land, 8) planting under mixed cropping, and 9) minimum inputs.

Soybean is considered secondary to such main crops as rice, corn, or tuber crops. Consequently, it is often grown during unfavorable weather when the main crop cannot be grown. Inputs for soybean are kept as low as possible. No land preparation, no minimum weed control, and minimum pest protection are common. The introduction of improved technology packages to the farmers has often met with difficulties.

Breeding Objectives

Breeding for high yields alone is not sufficient for soybean in the tropics. Other aspects which contribute to yield stability are equally important. These include:

- **Adaptability to minimum or no tillage, and weeding.** Soybean grown after wetland rice is usually not preceded by land cultivation. The seedbed is generally compact and has poor drainage. Farmers' cultivars are adapted to this environment because of their small seed size (7 to 9 g/100 seeds), indeterminate or semi determinate plant type, and branching habits. The yield potential of these cultivars is low, however, and they mature late. Improved cultivars should possess the above characteristics in order to adapt to the existing environment. Selection should be conducted under conditions which represent the actual environment for crop production.

- **Earliness.** A soybean crop occupies a very short period in the rotation scheme, which in some cases coincides with a period of water shortage. In certain areas, farmers require cultivars which mature in 75 days with reasonable yield (e.g. 1 t/ha). Earliness is also useful to avoid drought during the generative stage.

- **Seed viability.** In the tropics soybean seed deteriorates quite rapidly when stored under regular room conditions. Breeding for good seed viability is important. Research needs include screening techniques and breeding methods.

- **Season specificity.** The environment of a wet-season soybean crop encounters excessive rainfall and low sunshine due to cloud or rain. Adequate land preparation and weeding are done and soybean is frequently intercropped with other crops. The dry-season crop planted on wetland after rice experiences compact soil structure, poor drainage/waterlogging during early growth, drought during the generative stage, high temperatures, longer sunshine duration due to clear skies, and weed competition. Research needs include screening techniques, breeding methodology, and selection criteria.

- **Low pH tolerance.** The priority areas for expanding soybean cropping are the newly opened lands outside Java. Unfortunately, most of these have acidic soil, with a pH ranging

from 4.5 to 5.0. Liming is expensive, and so soybean cultivars adapted to low pH are required. Research should therefore focus on developing varieties tolerant to low pH and on incorporating such tolerance with high yield.

- **Shade tolerance.** Soybean grown on dryland is generally intercropped with other crops. Shading may reduce soybean yield by up to 60%. Soybean cultivars which are shade-tolerant are required in order to obtain high yields. Therefore, the method of screening and selection for shade tolerance need to be devised so that high-yielding, shade-tolerant cultivars can be developed.

- **Pest resistance.** Soybean in the tropics may be attacked by numerous insect pests. The most important of these are the armyworm (*Spodoptera litura*), cabbage looper (*Plusia chalcites*), green stink bug (*Nezara viridula*), pod borer (*Etiella zinckenella*), beanfly (*Agromyza phaseoli*), and leaf beetle (*Phaedonia inclusa*). Although it is very difficult to combine all resistant genes into a single cultivar, it is useful to breed cultivars with resistance to one or two pests. Research should attempt to identify resistant sources, develop suitable screening techniques, and selection procedures.

- **Disease resistance.** Soybean rust (*Phakopsora pachyrhizi*) is an important disease. Yield losses due to rust can reach up to 75%. However, rust is not a serious problem when crop rotation involving nonlegume crops is practised. Tolerant cultivars, such as Orba and Wilis, have been developed in Indonesia. Virus diseases, including yellow mosaic, soybean stunt, soybean dwarf, and bud blight, have become more important in the past five years. Yield reduction due to viruses can reach up to 100%. Breeding for virus resistance is urgently required. To accomplish this, sources of resistance to rust and viruses need to be identified, and practical screening techniques developed.

- **Breeding methodology.** Many alternative methods are available for selecting and developing superior lines. The choice of selection procedure depends on the objectives of the breeding program, the availability of resources (manpower, equipment, budget), and the preferences of the breeder. Discussions on the breeding methodology for cultivar development would be useful to formulate the most efficient method, based on the experiences of breeders.

- **Regional yield evaluation.** Soybean has a limited area of adaptation due to photoperiod sensitivity. However, some cultivars such as Improved Pelican, Orba, and Clark 63 show wide adaptation. Regional yield tests using the best lines derived from breeders in the same region should be organized to identify lines which are suitable to the region.

Research Findings

During the last 10 years, five improved soybean cultivars developed by the Central Research Institute for Food Crops have been released, and two lines are proposed for release (Table 2). The advantages of these cultivars include high yield, earliness, and tolerance to some fungal diseases. Improved soybean cultivars are presently grown on approximately 30% of the total area (Djauhari, et al. 1984). We have identified several lines which yield above 2 t/ha, with maturity ranging from 80 to 90 days (Table 3). We have also selected more than 150 promising F_4 lines derived from several crosses, which mature in 72 to 75 days (Sumarno 1984a).

Interspecific crosses between *G. max* and *soja* were made and three backcrosses have been completed. The objectives of these crosses are to broaden the germplasm background of our soybean cultivars and to transfer some genes for possible pest resistance derived from *G. soja*. Each year we make 20 to 30 cross combinations using various parents, to create genetic recombination for possible selection to develop new cultivars. Stratified bulk selection is conducted from F_2 up to F_4, then followed by single-plant selections to create pure lines (Fig. 1).

Table 2. Improved soybean cultivars released in indonesia, 1974-1984.

Cultivar	Year Released	Maturity (days)[a]	Average Yield (t/ha)
Orba	1974	85	1.5
Galunggung	1981	85	1.5
Lokon	1982	75	1.2
Guntur	1982	75	1.2
Wilis	1983	88	1.6
Amerikana (DEMPO)	1984	90	1.6
B-3035 (Kerinchi)	1985	89	1.7

[a] After planting

Table 3. Selected soybean lines with high yield potential, Bogor, 1982-1983.

Lines	Yield (t/ha)	Maturity (days)
1312/1667-1-2	2.3	85
1399/945-2-1	2.5	86
1667/1682-10-2	2.4	89
1667/1682-11-3	2.2	89
1399/1682-6-1	2.4	86
1667/7985-19-2	2.1	86
1399/945-2-3	2.4	86
1667/1682-8-5	2.4	89
1400B/1399//1682-10-3	2.2	87
Orba	1.6	84

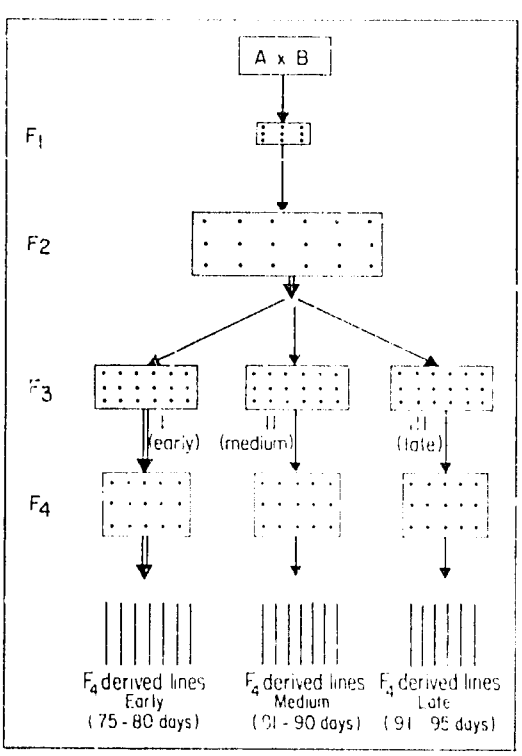

Fig. 1.
Selection procedure to develop early-maturing, high-yielding soybean lines.

Table 4. Introduced soybean cultivars with high yields, Bogor, dry season 1982 and 1983[a].

Cultivar	Source	Yield (t/ha)	Maturity (days)
UPL-SY-2	IRRI	1.1	89
GC 50106-4-7	AVRDC/IRRI	1.4	95
GC 30050-2-17	AVRDC/IRRI	1.2	90
7207-1	AVRDC/IRRI	1.3	94
SJ-5	Thailand/IRRI	1.5	90
AGS-8	AVRDC/INTSOY	1.2	85
Wilis	CRIFC Bogor	1.4	88

[a] Sumarno 1984b

Phosphate and lime are found to be the keys for successful soybean production on red-yellow podzolic soils. In some areas where aluminum toxicity exists, liming is not necessary, since phosphate alone can correct the problem.

Research Collaboration

Collaborative research in soybean breeding involves the INTSOY (USA), the IRRI's Cropping Systems Network, and AVRDC (Taiwan). Several cultivars have been identified for their high yield potential, good seed quality, and earliness (Table 4). These have been crossed with local cultivars to combine better adaptation (Sumarno 1984b).

The International Development Research Center (IDRC), Canada, is providing funds for strengthening the breeding program to develop legume cultivars adapted to wetland after rice and tolerant to acid soils. Other collaborative research is needed, especially in the following areas: screening for virus resistance (mosaic virus, and bean yellow mosaic virus), screening for insect resistance (leaf-feeding insects, pod borer, pod sucker) and screening for Al toxicity.

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AVRDC Soybeans for the Tropical World

S. Shanmugasundaram
Leader, Legume Program
Asian Vegetable Research and Development Center
P.O. Box 42, Shanhua, Tainan 74199
Taiwan, China

Introduction

In 1972 the Asian Vegetable Research and Development Center (AVRDC) was established as an International Agricultural Research Center (IARC) with the objective of improving the agronomic potential and nutritive value of legumes and vegetables in the tropics. Recognizing the importance of soybean as a protein and energy source and since no other IARC was working on soybeans for the tropics at that time, soybean was included as a major crop for research in 1973. In the east soybean is a major grain legume crop in China, Indonesia, Japan, Korea, Taiwan and Thailand while Argentina, Brazil, Canada, Paraguay, U.S.A., and Uruguay are the major soybean producers in the west. Recently, India and Sri Lanka have been increasing their soybean production.

The average yield of soybean in the tropics is around 1 t/ha compared to nearly 2 t/ha in the temperate countries. The low average yield of soybean in the tropics is due to lack of improved cultivars for specific purposes, sensitivity to short photoperiods and high temperature, susceptibility to diseases and insects, lack of good quality seeds, unavailability of effective Rhizobium inoculum, and nonadoption of appropriate management practices.

The AVRDC Soybean

The goal of the AVRDC soybean program is to develop stable tropical and subtropical cultivars with wide adaptability, high yield, disease and pest resistance, and good seed quality. The objectives of the program are to:

1. Collect, document, utilize, maintain, and distribute germplasm.
2. Develop stable higher-yielding selections.
3. Develop cultivars with good seed quality and resistance to weathering.
4. Develop cultivars with wide adaptability to different photoperiods and high temperature.
5. Control diseases principally through resistance/tolerance or by cultural and chemical control. The priority diseases will be soybean rust, bacterial diseases, viruses, downy mildew, anthracnose, and seed diseases.
6. Control of insect pests mainly through resistance/tolerance and possibly through cultural and chemical control. The priority pests will be beanflies, pod borers, stink bugs, and defoliators.
7. Develop appropriate management techniques for maximum economic yield.
8. Develop soybeans for use as green vegetables and bean sprouts.
9. Develop soybeans suitable for intercropping or mixed cropping.
10. Study Rhizobium and the ecology of vesicular arbuscular mycorrhizae and their potential to increase yield.
11. Expand improved techniques through training, communication, and bilateral projects.

Research Achievements

Germplasm collection and varietal improvement

By the end of 1983, AVRDC's soybean germplasm collection totalled 10,523 accessions, one of the largest collections in the world. AVRDC has screened the majority of the germplasm, and has identified resistance or tolerance to soybean rust and beanflies and insensitivity to photoperiod (Chiang and Talekar 1980, Shanmugasundaram 1981, Tschanz et al. 1985). Thus far, the Center's hybridization program has made 3,554 crosses to combine desirable characteristics from new selections and local cultivars.

Soybean can be planted at AVRDC (23°07'N latitude and 120°17'E longitude) three times a year: in January-February (spring season), June-July (summer season), and September (autumn season). Because photoperiod and temperature conditions vary according to season and locations "disruptive seasonal selection" is used to identify breeding lines adapted to diverse agroclimatic conditions. Photoperiods and temperature during the three seasons simulate tropical and subtropical environments and, therefore, selections adapted to all the three seasons can be moved across the latitudes regardless of location and season. In addition, selections adapted to specific seasons were also identified for use in specific locations.

Soybean rust (*Phakopsora pachyrhizi* Sydow) and downy mildew (*Peronospora manshurica* (Naum.) Syd. ex Gäum.) are serious in the spring and autumn, while bacterial diseases, such as bacterial pustule (*Xanthomonas campestris* pv. *phaseoli* (Smith) Dye) are severe in the rainy summer season at AVRDC. Similarly, beanflies (*Melanagromyza* spp.) are an important pest in the autumn, while defoliators are a problem in the spring and summer in Taiwan. The seasonal diversity of these pests allows AVRDC scientists to effectively screen for resistance and tolerance.

Selected breeding lines undergo replicated preliminary yield trials (PYT) across all three seasons during a single year. Selections from the PYT's undergo another year of three-season intermediate replicated yield trials (IYT). Promising entries from the IYT's are coded as AVRDC *Glycine* selections (AGS), and are tested for an additional year in advanced yield trials. The photoperiodic response of AGS entries are evaluated in pot culture studies using artificial and natural lighting and dark rooms. Selections with high yield potential across all three seasons have been identified, some of which yield up to 10 t/ha each year from three crops (Table 1). Some high-yielding AGS entries combine resistance or tolerance to diseases and reduced sensitivity to photoperiod (Table 2).

Table 1. AVRDC *Glycine* selections (AGS) with high yield potential and adaptability to three seasons in 1980 and 1981 at AVRDC.

AGS No.	Yield (kg/ha) Sowing Date		
	February	July	September
AGS 129	4,000	3,400	2,600
AGS 130	3,800	3,000	2,500
AGS 135	3,800	3,000	2,500
AGS 144	4,300	3,000	2,200
AGS 146	3,400	2,100	2,800
AGS 154	2,400	2,400	2,700

In beanfly, *Melanagromyza sojae* Gehnter, resistance has been identified in Korean *G. soja* accessions G 3089, G 3091, G 3104, and G 3122. Efforts are currently underway to transfer this resistance to cultivated soybean; however, each of the Korean cultivars is susceptible to another beanfly species, *Ophiomyia phaseoli* Tryon (Chiang and Talekar 1980). Work on tolerance to beanfly is also in progress.

Table 2. AGS entries with high yield potential, resistance/tolerance to one or more diseases and/or reduced photoperiod sensitivity.

AGS No.	Disease Reaction				Photoperiod Sensitivity Score[d]		Yield Potential (kg/ha)
	soybean rust[a]	downy mildew[b]	bacterial pustule[b]	SMV[c]	DF	DM	
AGS 129	ST	MR	MS	I	9	9	4,300
AGS 130	MR	MS	HR	S	9	9	3,800
AGS 154	MR	MR	HR	S	8	2	2,700
AGS 48	MR	HR	MS	S	0	2	2,500
AGS 9	MS	HR	HR	I	5	8	3,700
AGS 12	MR	HR	MS	S	9	2	2,900
AGS 19	MR	HR	HR	I	7	7	3,200
AGS 162	MS	HR	MR	S	7	8	3,200
AGS 182	HT	HR	MR	S	6	7	2,300
AGS 183	HT	HR	MR	S	6	7	2,400

[a] Soybean rust rating was based on the rating system of the International Working Group of Soybean Rust (IWGSR): HT = highly tolerant; ST = slightly tolerant; MS = moderately susceptible; MR = moderately resistant.
[b] Downy mildew and bacterial pustule ratings were based on a 0 to 3 scale: 0 = highly resistant (HR); 1 = moderately resistant (MR); 2 = moderately susceptible (MS); and 3 = highly susceptible (HS).
[c] SMV = soybean mosaic virus strain-1 rating: I = immune, S = susceptible.
[d] DF = days to flowering; DM = days to maturity; 0 = insensitive; and 9 = most sensitive.

The epidemiology of soybean rust has also been studied. Yield losses due to rust can reach 90%. Vertical resistant genes available in the soybean germplasm are being incorporated into improved breeding lines. Rate-reducing resistance has also been identified at AVRDC. However, the concept of tolerance to soybean rust (defined as relative yielding ability under severe soybean rust epidemics) appears to have more promise than vertical resistance, which tends to break down because of the pathogen's multiplicity of races (Tschanz et al. 1986).

Vegetable soybeans are an excellent source of protein and their popularity is increasing (Shurtleff 1984; Liu and Shanmugasundaram 1984). AVRDC vegetable soybean cultivars suited to tropical and subtropical environments are currently being evaluated and distributed to national programs.

Soybean Management Technology

Soybeans are planted continuously on the same piece of land in countries such as Indonesia. Results from two years of continuous cropping of two AGS entries (three times a year) on the same piece of land showed no obvious adverse effects. Both entries yielded 8 t/ha/each year from three crops (Fig. 1).

The results of a three-year study of genotypes continuously planted with either maximum or minimum management inputs in different seasons, revealed that the yield gap between minimum-input treatments varied according to season (Fig. 2). Genotypic differences were also observed (Shanmugasundaram et al. 1982). The same study also showed that high yielding cultivars in maximum management input trials in the spring season were also high yielding in the autumn season (r=0.70)**. Furthermore, genotypes with optimum yield potential that are indifferent to inputs in specific seasons may also be selected (Shanmugasundaram et al. 1982; Shanmugasundaram and Toung 1986).

Mulching or plowing combined with nitrogen top-dressing was found to increase soybean yields. Deep plowing and compost application significantly increased both nodule formation and yield (AVRDC 1984). Traditionally, soybeans are planted by broadcasting seeds with or

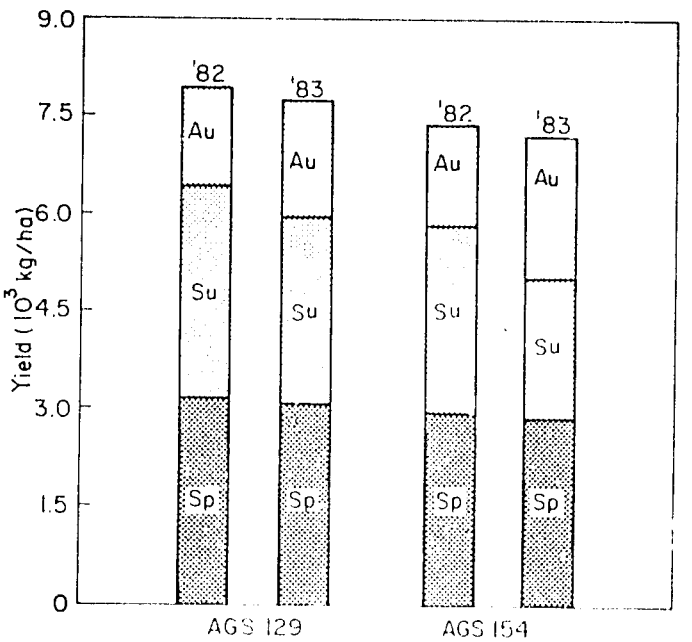

Fig. 1. Yield of two soybean selections continually cropped for three seasons, 1982 and 1983.

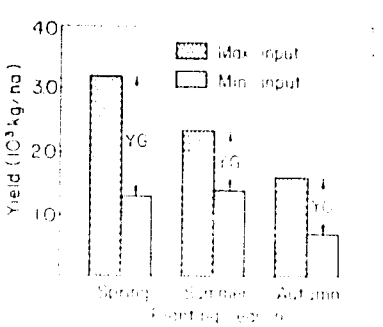

Fig. 2.
Yield gap (YG) between maximum and minimum inputs over three seasons and three years, 1980 to 1982. Maximum input includes herbicide application, irrigation, and insecticide and fungicide applications, while minimum input consists of planting and harvesting.

without tillage followed by rice straw mulching to cover the seeds. An experiment comparing the broadcast method with row planting and space planting in different seasons showed that, under certain conditions, the broadcast method might be successful. However, there is considerable risk in using this technique (Shanmugasundaram 1982).

The number of days to maturity are less in the tropics and subtropics than in the temperate zone because of shorter photoperiods. Early maturity is desirable in the tropics because soybean is frequently used in multiple-cropping systems. However, to obtain higher yields in a shorter growing period, it is necessary to have higher plant population densities. For example, in a plant-population-density experiment on AGS genotypes with narrow and broad leaflets planted in three consecutive seasons, yields varied according to genotype, season, plant population density, and planting configuration. The results suggest, however, that plant population density and spacings within and between the rows are cultivar- and season-specific. Nevertheless, a range of 400,000 to 600,000 plants/ha appears to be the optimum number required for maximum yield under AVRDC conditions (AVRDC 1981).

International Cooperation and Training

AVRDC has distributed 15,500 accessions and 15,800 breeding lines to 164 scientists in 56 countries. In 1980 the AVRDC Soybean Evaluation Trial (ASET) network was established for the tropics and subtropics. As a result of ASET and the crossing of AVRDC germplasm with local cultivars, six countries have released seven improved soybean cultivars (Table 3).

Table 3. New soybean cultivars released to farmers from AVRDC breeding materials.

Country	Cultivar Name	Year Released	Remarks
India	KM-1	1980	Adapted to rice-fallows
Indonesia	Taiwan G 2120	1980	High yield and adapted to crude cultivation
	Wilis[a]	1983	High yield, earlier maturing than Taiwan G 2120
Honduras	Darco-1	1980	High-yielding, early-maturing, and resistant to alternaria leaf spot
U.S.A.	Dowling[b]	1978	AVRDC assisted in screening for soybean rust resistance
Malaysia	T 30050	1982	Higher-yielding
Taiwan	Kaohsiung No. 9	1982	Adapted to the spring and summer seasons

[a] One of the parent was AVRDC G 2120 variety developed by Dr. Sumarno.
[b] This cultivar was not developed from AVRDC breeding materials.

AVRDC selections are currently being tested in the International Soybean Program's (INTSOY) International Variety Experiment (ISVEX) trials, and by the International Rice Research Institute's (IRRI) farming systems network. AVRDC also cooperates with the International Institute for Tropical Agriculture (IITA) and the International Board for Plant Genetic Resources (IBPGR).

To date, AVRDC has co-sponsored three symposia on soybean: Expanding the Use of Soybean in Asia and Oceania (1977), in cooperation with INTSOY and the Kingdom of Thailand); Soybean Rust (1977), in cooperation with INTSOY and the Philippine Council for Agriculture and Resources Research and Development; Soybean in Tropical and Subtropical Cropping Systems (1983), in cooperation with the Tropical Agricultural Research Center of Japan.

Since 1977 assistance has also been rendered to the Korean government's national soybean program in a generation-advance project during the Korean winter season. Thus far, the project has resulted in the release of four improved soybean cultivars. Similarly, AVRDC serves as an off-season nursery for the Land O'Lakes and Dairyland Seed companies in the USA.

In 1983, the AVRDC Vegetable Soybean Evaluation Trial (AVSET) network was established in Taiwan. AVSET will be extended to cooperators overseas in 1985.

AVRDC was one of the key organizers of the International Working Group on Soybean Rust (IWGSR), and has published the Group's *Soybean Rust Newsletter* since 1977.

To date, AVRDC has trained 102 specialists from ten countries in soybean production, research, and extension.

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The Changing Role of INTSOY in International Soybean Research and Development

H. E. Kauffman
Director
International Soybean Program (INTSOY)
113 Mumford Hall, University of Illinois
Urbana, Illinois 61801, U.S.A

Introduction

The past decade has been an active one in soybean research and development. Successful soybean productions in countries as divergent as tropical Brazil in Latin America, India and Sri Lanka in Asia, and Zambia and Zimbabwe in Africa illustrate the gains made in soybean technology development and application in tropical environments. In these and other countries soybeans have begun to find their niche within local farming systems.

Donor agencies have finally begun to realize the important role soybeans can play in improving the protein and oil supply of less developed countries, and at the same time help the economic well-being of small farmers. A number of soybean programs are now being strengthened to refine, develop, and extend appropriate technology.

Soybean scientists in Asia will play a key role in accelerating soybean development activity during the next decade. Asia is the most important region in the world because of its rich soybean genetic resources and its long history of soybean use for human food. Therefore, the success we have in strengthening regional cooperation at this meeting will influence soybean development in the rest of the world.

My presentation will highlight past INTSOY activities and touch briefly on way INTSOY plans to use its unique, but limited resources, to link up with regional soybean research activities, such as those in Asia.

Historical Perspective

Past

Most of you are acquainted with the development of INTSOY as an outgrowth of the University of Illinois' involvement in agricultural research and development activities in India in the early 1960s. The USAID has provided most of the modest funding for INTSOY. A major INTSOY focus has been varietal development work with the International Soybean Varietal Experiment (ISVEX) as the main component. The ISVEX trials have been conducted in 131 countries since their inception in 1973. Soybean cultivars from these trials have been released as commercial cultivars in approximately 25 countries. Numerous entries have been used as building blocks for their national soybean breeding programs. Whereas the initial trials consisted of cultivars primarily from the United States, in recent years soybean cultivars nominated by scientists from various tropical countries have provided the majority of the test entries.

INTSOY entomologists and pathologists have worked collaboratively with scientists in a number of tropical countries on component technology in the development of integrated pest management practices. Insect problems in the tropics have been minimized in a number of countries as a result of research and development activities. Major diseases have been characterized, and in some cases, strains, such as soybean mosaic virus, have been identified. A range of research from the applied screening activities for disease and insect resistance to more basic research on DNA activities in viruses has been undertaken. Research on the distribution and survival of Rhizobium in different types of soil, as well as studies on the enhancement of

nodulation, has significant implications for establishing a highly productive soybean technology for various cropping systems.

A number of INTSOY conferences and workshops have provided forums for scientists from over 50 countries to contribute important knowledge relating to soybean production and utilization practices. The Soybean Insect Research Information Center (SIRIC) maintains computerized files on the scientific literature of soybean arthropods and supplies bibliographic listings and copies of documents. The *INTSOY Newsletter* contains information on current INTSOY activities and research, and features news items of interest to soybean workers around the world. The INTSOY training course in technical aspects of soybean production has been host to 101 participants. The soybean processing for food use course has been host to 79 trainees from 36 countries. In addition, regional short courses have been held in Colombia.

Present

During the last two years INTSOY has been undergoing the following changes with the purpose of laying a foundation for future activities.

- In recognition of the need to strengthen national and regional soybean programs, INTSOY has phased out its activities in Puerto Rico and transferred its plant breeder to Colombia to work in the Latin American Network with CIAT and the Colombian National Program (ICA). The microbiologist has been relocated at AVRDC to work more closely with Asian soybean scientists.

- INTSOY has increased cooperation with AVRDC, IITA, and IRRI to work towards the establishment of regional soybean networks.

- An observational trial (modified ISVEX) has been initiated to provide more diverse germplasm to cooperators.

- A focus on marketing, processing, and utilization has been initiated to help develop balanced national soybean programs.

- Discussions have been held with national and international organizations about ways to improve communications among soybean scientists.

Future

INTSOY has recently received assurances of a modest long-term funding from USAID. With these limited funds INTSOY plans to focus its activities in areas where it has unique expertise or a comparative advantage. These areas will be determined in consultation with scientists from national, regional, and international programs. We envision these areas to be as follows:

- **Soybean processing and utilization.** Emphasis of the USAID funding will be placed on simple techniques to produce soymilk and whole soybean extruded products and to extract soybean oil. A modest research program will be undertaken at the University of Illinois with strong extension and training linkages to scientists in Asia, Africa, and Latin America through the regional networks which are being established.

- **Germplasm preservation, evaluation, and enhancement.** INTSOY will work with IBPGR to help national programs collect, evaluate, and preserve soybean germplasm. It will also publish jointly with IBPGR a directory of soybean germplasm. INTSOY will support where appropriate, regional testing programs.

Depending on the availability of funds, INTSOY scientists will concentrate research in areas with a broad application, such as on integrated pest management, and link up with those of several

international centers and national programs to work on location-specific problems.

- **Education and communication.** INTSOY will continue to co-sponsor conferences and workshops and conduct training programs which will focus more on regional needs and, therefore, an increasing number will be held in collaboration with national and other international organizations. A greater effort will be placed on the degree training of soybean scientists who will give leadership to soybean industries being established in an increasing number of countries.

Strengthening of the International Research Network

This meeting of Asian soybean scientists is a step towards the realization of a stronger international soybean research network. INTSOY is committed to the strengthening of this network through joint program planning and the establishment of collaborative research and development activities.

This process will be helped further in early November as the CGIAR has agreed to schedule a session on soybeans at the Center's Week Meeting in Washington, D.C. Interested country delegates, representatives of institutions, and donors will participate. It is hoped that this discussion will be a further step towards the establishment of a strong international soybean research network.

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Selection and Testing of Soybean for Rice-Based Cropping Systems

V. R. Carangal
Head, Rice Farming Systems Program
International Rice Research Institute
Los Baños, Laguna, Philippines

Introduction

Soybean is one of the upland crops that is grown after rice in developing countries in Asia. China, Taiwan, Indonesia, Thailand, and India grow large areas of soybean after one or two rice crops. In dryland areas, rice is generally grown during the wet season followed by soybean and other upland crops during the dry season either as monocrop or as an intercrop with taller crops, especially corn. It is also grown in a rice-upland crop-upland crop cropping pattern in some countries. In rainfed rice areas where water is limited, soybean is grown after one rice crop especially in Indonesia and Sri Lanka.

Most of the available soybean cultivars are developed under upland conditions with good management. Yield levels are generally high. When these cultivars are grown after rice, yield levels are generally lower because of adverse conditions, such as excessive moisture at the early stage and drought at the later stage. There are also problems of establishment in previously puddled soil and water management. One of the most important problems identified by the participants of the Cropping Systems Conference in 1980 is the development of upland crop cultivars (including soybean) that fit the rice-based system.

Asian Rice-Farming Systems Network

There are two major components of cropping system research in IRRI. One is research conducted by the interdisciplinary team at the IRRI farm and the other is research conducted in farmers' fields. Research at IRRI farm concentrates on component technologies that are major problems in crop intensification of rainfed, irrigated, and dryland rice areas. Potential cropping systems are also studied in the station. On-farm research focuses on developing and refining the farming-systems research methodology. Our on-farm research involves the farmers in the research process and considers them as members of the research team.

The present methodology now used in the Asian Rice Farming Systems Network involves several steps. It includes selection of target areas, selection of a farming system site representative of the target area, description of the farming system site, design of cropping patterns, testing of designed cropping patterns, multilocation testing, pilot production program, and production program. In carrying out the research process a research team composed of an agronomist, economist, and crop protection specialist is assigned to the farming systems site. The team lives near or in the site.

A network of farming system sites was established in collaboration with national programs in Asia. This collaboration is a scheme for IRRI and national programs to work together to generate farming systems technology for different rice environments in Asia. Our work focuses on rice plus upland crops that can be grown before and after rice. The upland crops are soybean, corn, peanut, mungbean, cowpea, sweet potato, and sorghum. In 1984, 188 operational farming system sites in 10 countries in Asia were involved in the Network (Table 1).

The methodology used in the site is the same as the methodology mentioned above. The work in the sites is concentrated on design and testing of cropping patterns in rainfed wetland, partially irrigated, rainfed dryland, irrigated, and deep-water rice. The sites represent a broad

Table 1. Number of cropping/farming systems research sites in the Asian national programs, 1984.

Country	No. of Sites	Rainfed Wetland	Partially Irrigated	Irrigated	Rainfed Dryland	Deep Water
Bangladesh	24	14	2	9	1	2
Burma	11	5	2	2	1	-
China	6	-	-	6	-	-
Indonesia	30	9	-	-	23	1
Korea	6	-	-	6	-	-
Nepal	6	5	6	1	-	-
Philippines	85	75	11	13	20	-
Sri Lanka	7	3	1	1	-	-
Taiwan, China	5	-	-	5	-	-
Thailand	8	7	-	1	-	-
Total	188	118	22	44	45	3

range of climatic zones, soil type, soil texture, and socioeconomic conditions in Asia. Philippines, Sri Lanka, Indonesia, and Nepal are implementing the multilocation and pilot production phases of the methodology. The Philippines is also implementing a provincial cropping-systems production in Iloilo and in Nepal at a district level (six districts).

In addition to the cropping pattern testing mentioned above, there are several other collaborations on major problems in crop diversification. These are varietal testing of upland crops, farm implements for intensive cropping, rice-wheat cropping systems, long term cropping pattern, fertilizer studies, and crop-livestock research. Testing of upland crops before and after rice has resulted in: 1) the identification of several cultivars of mungbean, soybean, cowpea, corn, peanut, and sorghum that are better than local checks, 2) breeding for upland crops that fit rice systems in national programs, and 3) evaluation of upland crop cultivars at the time they fit the system.

The rolling injection planter designed at IITA was evaluated in establishing upland crops after rice. It works in light and medium textured soils but not on heavy ones. A long term trial was initiated in 1982 to determine the effects of continuous cropping on soil fertility and crop productivity. Seven countries are involved in this project. The rice wheat trial is a collaboration between CIMMYT, IRRI, and national programs to identify the best rice wheat combinations. There are 13 countries involved. Crop livestock research is a new project to be implemented in 1984 in five sites, one each in the Philippines, Thailand, Indonesia, Nepal, and Sri Lanka. The main thrust is on ruminant animals.

Varietal Characteristics of Soybean

During the monitoring tour last year, the group identified the varietal characteristics of soybean for rice-based cropping systems. The group is composed of legume breeders from collaborating countries. The desirable characteristics of soybean are (See Table 2):

- High stable yield
- Early to medium maturity
- Good seedling vigor
- Water-logging tolerance
- Resistance to beanfly and pod borer
- Small- to medium-sized seeds
- Photoperiod insensitivity
- Uniform maturity
- Drought tolerance
- Resistance to virus and rust
- Nonshattering

Table 2. Desirable soybean varietal characteristics for rice-based cropping systems in different countries involved in the Network.

Characters	Burma	Malaysia	Nepal	Thailand	Indonesia	Bangladesh	Philippines	Sri Lanka
High stable yield	x	x	x	x	x	x	x	x
Photoperiod-insensitivity	x	x	x	x		x	x	x
Early maturing	x		x (80-90)	x (80 or less)	x (75-85)	x	x	x
Mid-Maturity	x	x (110-125)	x (90 or less)		x			x
Resistance to virus	x	x	x		x	x		
Resistance to rust		x	x	x	x	x	x	x
Uniform maturity	x	x		x		x	x	x
Good seedling vigor	x	x	x	x	x	x	x	x
Resistance to water logging	x	x	x	x	x	x	x	x
Resistance to beanfly	x	x			x	x	x	
Resistance to pod borer		x	x		x	x	x	
Nonshattering	x	x	x			x		x
Drought tolerance	x	x		x	x	x	x	x
Small to medium seed size	x		x	x	x		x	x
Shade tolerance			x		x			
Large-seeded								x
Tolerant to low pH				x	x			

Collaboration with the University of the Philippines

One of the subprograms in the IRRI farming systems program is 'Selection and Testing Cultivars for Rice Based Cropping Pattern' (805). Since IRRI has no mandate to develop upland cultivars for rice-based farming systems, we work with other research institutes to be able to do so. We are collaborating with the Institute of Plant Breeding at the University of the Philippines at Los Baños on soybean, mungbean, peanut and cowpea; with IITA on soybean; with CIMMYT on wheat and corn, and with ICRISAT on pigeon pea and sorghum.

The project with UPLB started 1 January 1982 with the following objectives: 1) to collect advanced generation lines and promising cultivars of soybean, mungbean, and peanut from the international institutes, centers, and national breeding programs for evaluation of adaptability to rice-based cropping systems; 2) to develop cultivars of the three legume crops for intensified production systems for rainfed wetland and partially irrigated rice areas; 3) to evaluate the most promising lines and cultivars in several environments at research stations and farmers' fields in Asia through the Asian Cropping Systems Network; and 4) to cooperate with and make available to national programs promising experimental lines or cultivars for use in their own production programs. Funding is provided by IDRC through IRRI.

The Institute of Plant Breeding is responsible for the breeding component which includes collection of cultivars and advanced lines from international and regional centers and national programs; screening of introduced materials before and after rice; and hybridization, selection, and preliminary evaluation of promising lines and cultivars. Soybean lines and cultivars used in breeding and screening came from INTSOY, AVRDC, Thailand, and Indonesia. Selection and evaluation are done after rice with zero tillage and less amount of fertilizer. The project has two outreach sites: in Santa Maria, Pangasinan, north of Manila and in Iloilo about one hour jet flight south of Manila. The most promising cultivars from the evaluations are forwarded to IRRI for seed increase and distribution to the Asian Rice Farming Systems Network.

The project includes training of breeders for four months in the Institute of Plant Breeding. We already trained two breeders, one each from Indonesia and Thailand. This year we are scheduled to train four breeders from Indonesia, Thailand, Burma, and Sri Lanka. The project also provides training of young scientists who are conducting collaborative trials in the Network. Training is usually for four weeks with focus on field layout, data collection, analysis, and report writing. We already trained 14 young scientists from eight countries and the next training is

tentatively scheduled in early January 1985. We expect to have trainees from the Philippines (2), Nepal (1), China (2), Indonesia (2), Thailand (2), Sri Lanka (1), Vietnam (1), Burma (1), and Bangladesh (2).

Sharing of research information and ideas among scientists in the Network is another important activity of the project. A workshop was organized in 1982 and in early 1985. The monitoring tour in Indonesia and Nepal and soybean workshops are partially funded by this project.

The collaboration of IRRI and IITA on cowpea and soybean will be discussed in more detail by Dr. R. K. Pandey who is an IITA staff assigned to work in IRRI.

Varietal Testing of Upland Crops

One of the collaborative research in the Network is varietal testing of upland crops before and after rice. It includes soybean, corn, sorghum, mungbean, peanut, cowpea, and bush sitao. The most promising entries from the breeding and screening of IPB, IRRI, and national programs are sent to the Rice Farming Systems Program at IRRI for seed increase and distribution in the Network for evaluation. Trials are not uniform. We encourage national programs to put more entries from their own breeding program. Data format which was finalized during workshops and working group meetings is uniform. The number of entries from IRRI varies from 6 to 10. There is no uniform cultural managements. Collaborators use the recommended practices in the site. They are encouraged to analyze and publish their data. A field book is usually sent with the trial and copy of the raw data is returned to IRRI for compilation.

The scheme for varietal testing is shown in Fig. 1. The trials are tested at the time it fits the rice-based cropping systems. It is conducted in an experiment station or cropping-farming systems site. The number of locations depends on the request of the collaborators. The most promising entries are included in their own regular regional testing project until it is recommended for release to the farmers.

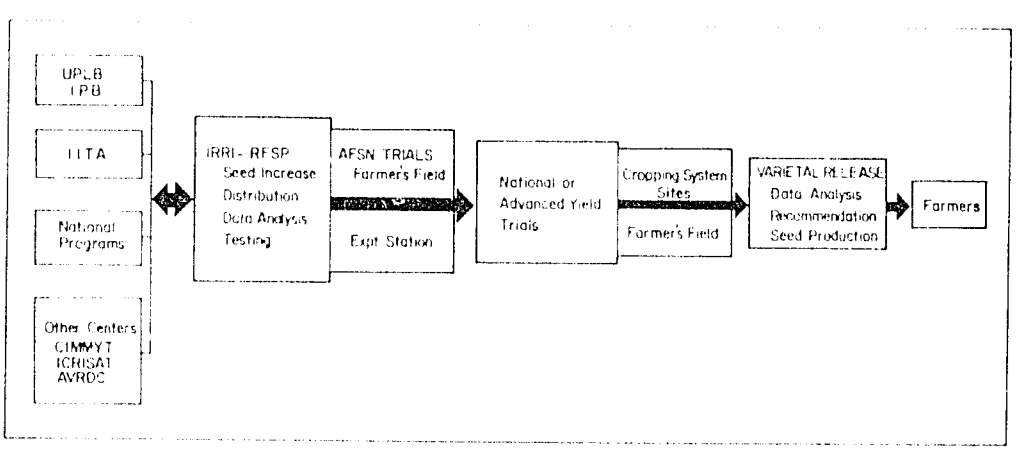

Fig. 1. Scheme for varietal evaluation of upland crops for a rice-based farming system.

Seven soybean trials after rice have been completed and returned to the Asian Farming Systems Network for analysis. The trials came from Nepal, Sri Lanka, the Philippines, and two each from Vietnam and Indonesia. The summarized data for yield alone of all the trials are presented in Table 3.

Results showed that there are several promising cultivars better than the local checks in all the locations, except Sri Lanka (no local check included). The highest-yielding cultivars for each of the country are shown in Table 4.

Table 3. Yield in t/ha of soybean cultivars evaluated after rice in different countries from 1983-84 under Varietal Testing of Upland Crops in Rice Farming System of the Asian Farming Systems Network.

Cultivar	Nepal	Vietnam		Indonesia		Sri Lanka	Philippines
	Parwanipur	Sen Chieu Agric Crop Univ	Hanoi Agric No. 1	Malang	Bogor Pluppalkarna	Maha	IRRI
UPL SY-2	0.41cd	0.94d		0.32f	1.22a	0.95ef	1.66bc
Clark 63	0.22d	1.49a	0.36bc	0.53f	1.27a	1.05cde	1.65bc
7207-1	1.03a	1.53a	-	0.90cde	1.29a	1.56bc	2.43a
30290 11-11	0.47bcd	1.18b	0.29bc	-	-	1.65b	2.49a
30050-2-17	0.45bcd	1.24b	0.35ab	0.47f	1.16ab	1.35bcd	2.07ab
50106-4-7	0.77abc	1.07c	0.37a	1.01cde	1.28a	0.23f	-
11-4	0.69abc	-	0.40a	0.45f	1.24a	2.13a	-
G-2261	0.80abc	-	0.27c	1.06bcde	0.85c	1.31bcd	-
Guntur	0.84abc	-	-	1.17bcd	0.77c	-	1.18cd
Lokon	1.09a	-	-	1.18bc	0.93bc	-	-
Line 1682-1343-1-10	1.17a	-	-	1.58a	1.23a	-	-
SJ-5	0.92ab	-	0.35ab	0.87de	1.45a	-	-
SJ-2	-	-	0.37a	-	-	0.93de	-
1248/1682-IR-14	-	-	-	1.34a	-	-	-
GP 29	-	-	-	0.82e	-	1.32bcd	-
7507-38-4	-	-	-	-	-	-	2.33a
7521-26-2	-	-	-	-	-	-	2.14ab
AGS 144	-	-	-	-	-	-	1.67bc
AGS 129	-	-	-	-	-	-	0.94d
Local Check	0.56bcd	1.17bc	0.24c	1.16bcd	-	-	-
Mean	0.74	1.23	0.33	0.92	1.16	1.22	1.86
CV (%)	33.31	4.42	11.14	17.45	13.16	22.62	18.40
Total Rainfall (mm)		249.50	248.40	496.80	406.40	59.20	88.10

Table 4. Highest-yielding cultivars in five countries conducting trials for the Asian Farming Systems Network.

Country	Source	Cultivar	Yield (t/ha)
Nepal	Indonesia	Line 1682-1343-1-10	1.17
Vietnam	Thailand	7207-1	1.53
Indonesia	Indonesia	Line 1682-1343-1-10	1.58
Sri Lanka	Thailand (AVRDC)	11-4	2.13
Philippines	AVRDC	GC 30290-11-11	2.49

It was observed that Line 1682-1343-1-10, a cultivar from Indonesia was relatively a stable cultivar having ranked first in two countries (Nepal and Indonesia). On the other hand, UPL SY-2, a cultivar recommended by the Philippine Seedboard showed poor performance in almost all locations. It was the lowest yielder in Nepal, Vietnam, and Indonesia. At IRRI, two new entries coming from Thailand (7507-38-4 and 7521-26-2) were found to be promising and have potential for post rice planting. The two cultivars yielded more than 2 t/ha. AVRDC lines GC 30290-11-11 and 11-4 (selected by Thailand breeders) gave more than 2 t/ha in Sri Lanka and the Philippines.

Although the Indonesian sites received the highest total rainfall during the experiment, their yields were relatively low compared to other sites that received low amount of rainfall. The Sri Lankan site received the lowest rainfall of about 59.2 mm, yet its mean yield was relatively high at 1.22 t/ha.

For the 1984-85 cropping pattern we will distribute 156 trials (mungbean- 23, cowpea-23, bush sitao-18, soybean-26, peanut-23, sorghum-20, and corn-23) after rice. There are seven countries involved (Table 5). For crops before rice we will distribute 99 trials (mungbean-24, cowpea-24, bush sitao-18, soybean-7, peanut-9, and corn-17) to six countries (Table 6).

Table 5. Number of trials to be distributed for testing after wetland rice by the Asian Farming Systems Network, 1984-85 cropping pattern.

Country	Crops and Number of Sets						
	Mung-bean	Cowpea	Bush sitao	Soybean	Peanut	Sorghum	Corn
Burma	-	3	-	3	3	3	-
Nepal	1	1	-	1	-	-	1
Thailand	3	4	2	3	3	-	4
Indonesia	2	2	2	2	1	3	2
Bangladesh	3	-	-	3	2	-	2
Sri Lanka	2	2	2	2	2	2	2
Philippines	12	12	12	12	12	12	12
Total	23	24	18	26	23	20	23

Table 6. Number of trials distributed for testing before wetland rice by the Asian Farming Systems Network, 1984-85 cropping pattern.

Country	Crops and Number of Sets					
	Mungbean	Cowpea	Bush sitao	Soybean	Peanut	Corn
Vietnam	2	2	-	-	-	-
Burma	2	-	-	-	2	2
Nepal	3	4	2	2	2	1
Thailand	3	4	4	3	3	-
Indonesia	2	2		2	2	2
Philippines	12	12	12	-	-	12
Total	24	24	18	7	9	17

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7

The Role of IITA Soybean Improvement Program in Tropical Asia

R. K. Pandey
Agronomist Breeder and Coordinator
South and Southeast (Asia) IITA Grain Legume Improvement Program
Rice Farming Systems Program
IRRI, P.O. Box 933, Manila
Philippines

Introduction

Soybean is one of the important grain legume crops in Indonesia, Philippines, Thailand, Burma, India, Sri Lanka, Malaysia, Bangladesh, and Vietnam. In Indonesia and Thailand, soybean is predominantly a part of a rice-based farming system, and to a lesser extent, is grown with other upland crops.

The early research at the International Institute for Tropical Agriculture (IITA) revealed that soybean production in the tropics is constrained by generally poor seed longevity resulting in poor stand establishment and a requirement for specific rhizobial inoculants for effective nitrogen fixation. Physiologists at IITA identified germplasm lines with superior seed longevity and lines which can nodulate effectively with indigenous Rhizobia. IITA recognized the great opportunity to breed for a combination of prolonged seed longevity and 'free nodulation' with high yield potential. No other research institution has addressed itself to these problems which are specific to tropical conditions in Africa.

In 1978, IITA initiated breeding efforts on seed longevity and nitrogen fixation. In the past five years progress has been made on the development of high yielding tropic cultivars that have superior seed longevity and have the ability to nodulate with indigenous rhizobia. Preliminary studies have been initiated on the resistance of soybean to stinkbug. Cultivars with resistance to the prevalent strain of soybean mosaic virus (SMV) and to bacterial pustule have been identified, and resistance to these diseases is being incorporated into elite breeding lines. Germplasms with greater levels of resistance to lodging and to pod shattering were also recently identified.

The major objectives of the IITA Soybean Improvement Program are to develop cultivars with the following traits: 1) tropically adapted and high yielding with different maturity durations; 2) with seed longevity and good field emergence; 3) promiscuous in nodulation; 4) tolerant to drought/excessive moisture; 5) resistant to diseases and insects; and 6) resistant to shattering/lodging.

IITA/IRRI collaborative research in grain legumes will evaluate materials generated at IITA for their adaptation in rice-based farming systems in Asia (Fig. 1).

Tropically Adapted Cultivars

Unlike in the temperate countries where only one soybean crop is grown, in the tropics soybeans can be grown year-round. Since the changes in photoperiod and temperature are dependent on latitude and season, the selection of genotypes should be concentrated on a narrow band of latitude in the specific season. Three international centres, IITA (7°N), IRRI (14°N), and AVRDC (23°N) are uniquely located in almost equally spaced latitudes and can ideally contribute towards the improvement of cultivars adapted in the countries located within the range of their latitudes (Fig. 2). The cultivars selected at these latitudes can also be tested in other areas through collaborative network. The regional trials on soybean should consist of the cultivars

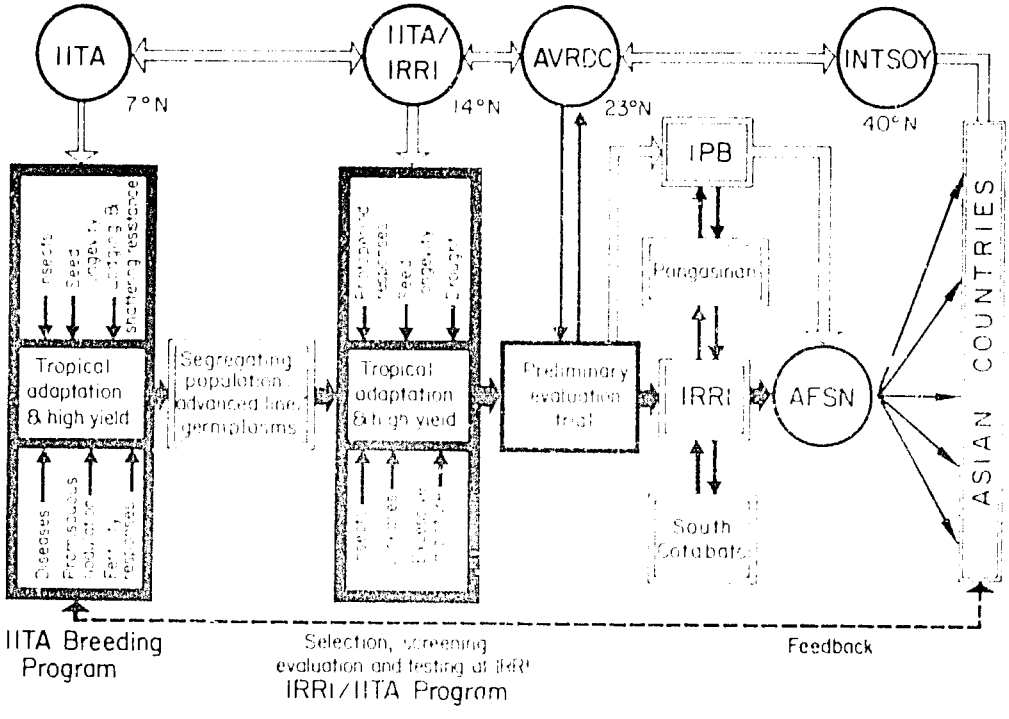

Fig. 1. Soybean collaborative improvement program.

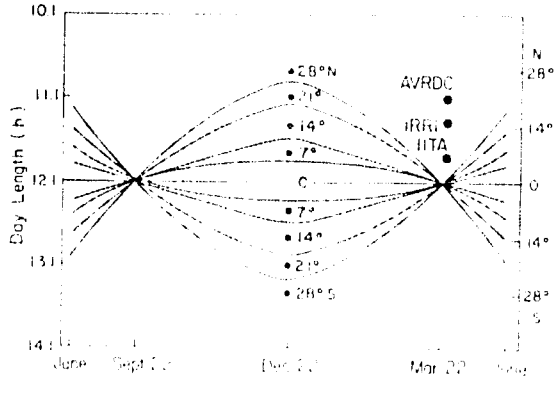

Fig. 2.
Day length (hr) variation at different latitudes.

from these three centers and national programs. IITA has recently diversified its soybean breeding program and is selecting cultivars with different maturity groups to fit into the cropping systems of the tropical world.

Soybeans are grown in the following five situations in tropical Asia: 1) upland conditions: rainfed (July-October), rainfed/partially irrigated (November-February), and irrigated (March-June); 2) lowland conditions: rainfed - after one rice crop (November-February), irrigated - after two rice crops (February-June).

Two distinct situations exist: short-day-planting time on lowland/upland soil and long-day-planting time on upland/lowland soil. Specific cultivars for each situation may be desirable.

Seed Longevity and Establishment

Seed longevity during storage at ambient room temperature and, consequently, good field emergence is the most important factor determining the final stand and yield of soybean. Identification of genotypes with longer storability under room temperature is desirable in Asian countries where small farmers generally store their seed by themselves.

The IITA germplasm was screened and several lines from Indonesia were identified to be genetically resistant to rapid seed deterioration (Wien and Kueneman 1981). The Indonesian lines are agronomically poor (low-yielding, viny, susceptible to shattering and diseases); therefore, crosses were made to incorporate their superior seed longevity into genotypes with desirable agronomic traits. By modifying the accelerated ageing technique (a method used by commercial seedsmen to characterize the seed vigor status among seed lots of a given cultivar), a rapid ageing method was developed at IITA to quickly identify breeding lines that have genetically superior seed longevity (Wien and Kueneman 1981). Collaborators in these regions are encouraged by IITA to make seed quality assessment a routine part of varietal evaluation (Kueneman 1981).

If soybeans mature in the field under humid conditions, considerable loss of seed vigor can occur prior to harvest; this is known as 'field weathering'. A screening method developed in 1981 provides uniform stress for all cultivars regardless of maturity, allowing the breeder to identify resistant progenies (Dassou and Kueneman 1984). At physiological maturity, yellow pods are removed from plants and placed on a plastic grid in an incubator and kept for seven days at 30°C and 95% RH. Seeds are then shelled and planted for emergence evaluation.

The majority of parental lines, identified prior to the development of the 'incubator weathering' technique to have resistance to seed deterioration during storage, were subsequently found to be resistant to field weathering as well. It is, therefore, probable that many breeding lines selected for seed longevity in storage are also resistant to field weathering. This was confirmed in 1983. Inheritance studies on seed deterioration during storage revealed that there is pronounced noncytoplasmic maternal plant influence so that expression of genetic segregation is delayed for one generation (Kueneman 1983).

Seed coat characteristics appear to play a major role in conditioning resistance. Cultivars that imbibe water slowly tend to maintain viability longer than rapid imbibers (Dassou and Kueneman 1984). Many of the lines with exceptionally good seed longevity have black or brown seed coats. West at the University of Florida (personal communication 1981) showed that the seed coats of resistant lines identified at IITA have fewer pores which are plugged with a wax-like material. Parent-offspring regression studies at IITA revealed low heritabilities in the early generations (F_3 seed) and improved heritability in subsequent generations.

The incorporation of superior seed longevity into superior genotypes has been successful. The high-yielding parents in these crosses have large seeds, a character which is associated without exception with relatively poor storability. It should now be relatively easy to move the genes for good storability into other backgrounds, as it will no longer be necessary to cross them with the original seed-quality parents. Breeders at IITA and elsewhere can now use IITA-improved breeding lines as sources of seed quality.

Nitrogen Fixation in Soybeans

Most soybean cultivars require infection from a specific group of bacteria (*Rhizobium japonicum*) for symbiotic nitrogen fixation. In developed countries inoculant industries and distribution systems exist, and consequently, the use of inoculants on soybeans is routine. In developing countries, however, the use of inoculants is problematic, especially for small farmers. Good quality control is often lacking in the production of inoculants, and a good extension system is required to teach farmers how to use it. The inoculant must be able to survive and multiply in environments which may vary considerably.

The microbiology section at IITA is addressing its research efforts to overcoming constraints which may restrict the future use of inoculants in the tropics. Meanwhile, the soybean improvement program at IITA has tackled the problem in a practical way. A few soybean cultivars were observed to nodulate profusely with indigenous Rhizobia in Africa (Pulver et al. 1982). Such soybean cultivars are infected by a very wide range of Rhizobia, primarily of the cowpea inoculant group which is ubiquitous in tropical Africa. Because of the indiscriminate association with local Rhizobia, these cultivars have been termed "promiscuous".

Germplasm was screened at six sites in Nigeria from 1976 to 1978 (Pulver et al. 1983). Several lines which nodulated well at all sites were selected as parents, and crosses were first made in 1978 to incorporate the promiscuous character into high-yielding backgrounds. The frequency of promiscuous progeny in segregating populations was high, suggesting that inheritance of promiscuity is conditioned by relatively few major genes. Early generation selections (F_3, F_4, F_5) were made on nitrogen depleted soils with low fertility in the middle of the savannah belt of Nigeria. Many of these selections made under low fertility were observed to grow too tall on more fertile soils in subsequent generations. New crosses were made to improve stem type and incorporate seed quality into the same promiscuous populations. Several lines that nodulate well without inoculant and have improved seed longevity were found to perform well at several locations in the savannah of Nigeria (Table 1). IITA breeding lines have also been found to nodulate well in the Philippines and Sri Lanka.

Table 1. Yield (kg/ha) and nodulation of three promising soybean breeding lines from IITA with intermediate maturity (110-125 days) grown in an advanced yield trial, 1982.[a]

	Mokwa	Ilorin
TGx 326-034C		
Yield	2553	1606
Nodulation	2.7	3.0
TGx 330-054D		
Yield	1978	2387
Nodulation	3.9	3.3
TGx 454-060C		
Yield	2298	1899
Nodulation	2.5	2.9
Check cultivar Bossier		
Yield	897	1121
Nodulation	1.6	2.2
LSD		
Yield	89	124
Nodulation	0.6	0.1

[a] Entries 29, reps 3, nodulation scores: 1 = poor, 2 = fair, 3 = good, 4 = excellent

Drought and Excessive Moisture

Soybeans encounter excessive moisture in the early vegetative growth and drought during the reproductive phase when grown in the post rice environment. Identification of cultivars tolerant to drought and excessive moisture will increase the prospect of improving seed yield in lowland rice areas. Forty-four breeding lines/cultivars were tested for their tolerance to these conditions with the use of the line source sprinkler system. The cultivars/breeding lines which showed better performance at both ends of the moisture gradient were selected. Lines that performed better were, 7024-2, 7024-3, SJ-5, 7207-1, and PM 78-6-5-13. In another study, we observed that drought tolerance in grain legumes was associated with rooting depth. The measurement of canopy, temperature, and leaf water potential also provided useful criteria for relative drought tolerance of a species or cultivar (Pandey et al. 1984a,b).

Insects and Diseases

IITA soybean improvement program has given attention to pod borers and stinkbugs. Identification of resistant sources, as well as insect population dynamics, is being studied.

The resistant sources are available for soybean mosaic virus (SMV), and the breeding program at IITA has been incorporating resistant genes in agronomically adapted materials. Another disease, bacterial pustule [*Xanthomonas compestris* p. *phaseoli* (Smith)], is severe in the rainy season. The resistant sources are being utilized to transfer the genes to agronomically adapted cultivars.

Evaluation and Conferences

Initial evaluations of advanced breeding lines are carried out in South Cotabato (7°N) and Pangasinan (17°N), apart from IRRI. The most promising lines are then selected for testing in the Asian countries. After initial testing promising materials are then evaluated in Asia through the Rice Farming Systems Network Program (Fig. 3).

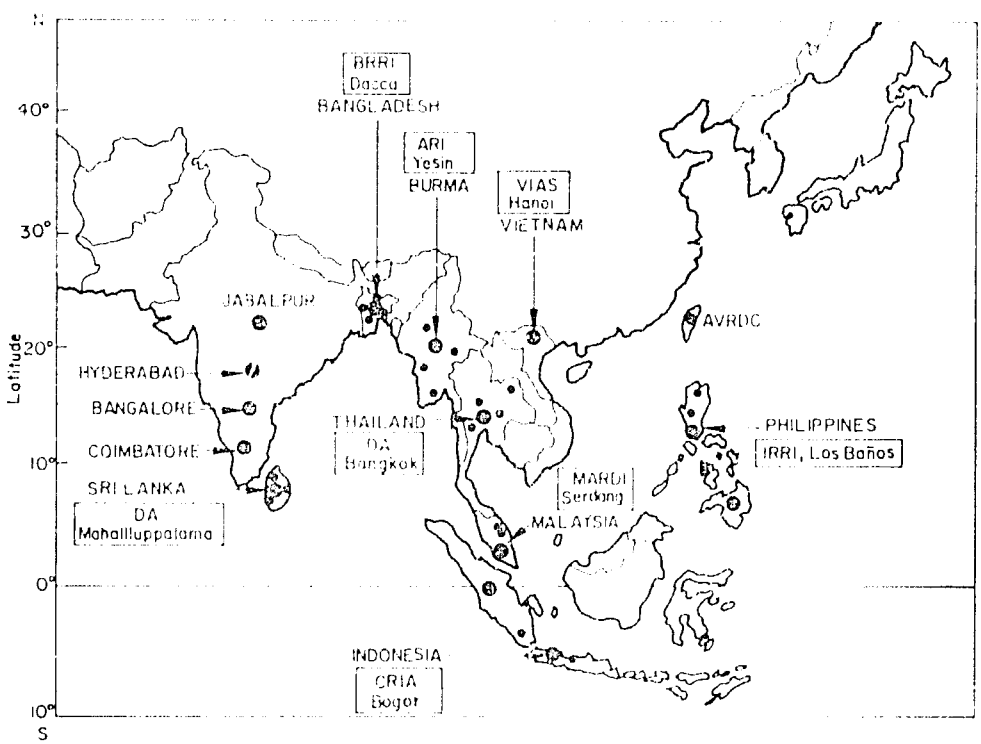

Fig. 3. IRRI's Rice Farming System testing sites where IITA soybeans are evaluated.

IITA has also established strong working relationships with other international institutions involved in soybean research, such as the International Soybean Program (INTSOY) in the USA and the Asian Vegetable Research and Development Center (AVRDC) in Taiwan. IITA will co-sponsor conferences/regional meetings on soybean in collaboration with AVRDC and INTSOY. It will also participate in the training of national scientists at IITA or IRRI or any other centers and will provide expertise in soybean production to national programs in consultation with other international agencies.

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8

Soybean in India: Potential and Research Directions

P. S. Bhatnagar
Project Coordinator
All India Coordinated Research Project on Soybean (ICAR)
G.B. Pant University of Agriculture & Technology
Pantnagar-263145, India

Introduction

A critical review of oilseed production during the last 30 years in India indicates a widely fluctuating growth rate (1.6 to 3.4%). The edible oil requirement in the country is continuously increasing. Today, per capita consumption in India is around 11 g in contrast to the recommended 18 g. The total edible oil requirement by 2000 A.D. would be around 6.2 million t or at least 4.2 million t. At the present level of production, it amounts to more than doubling the production in 16 years at the growth rate of about 5.7% per annum (Kempanna 1984).

The yield of soybean is two to three times higher than that of pulse crops (Singh and Saxena 1975). In addition, soybean has twice as much protein as pulses and yields around 20% high-quality edible oil (Table 1).

Table 1. Average yield, oil and protein contents of soybean and other pulse crops in similar conditions in India.

Crop	Yield[a] (t/ha)	Oil[a] (g/100 g)	Protein[b] (g/100 g)
Soybean (*Glycine max* L.)	2.96	19.5	43.2
Pigeon pea (*Cajanus cajan*)	1.66	1.7	22.3
Black gram (*Phaseolus mungo*)	1.04	1.4	24.0
Cowpea (*Vigna sinesis*)	1.04	1.0	24.1
Green gram (*Vigna radiata*)	0.88	1.2	24.5

[a] Source: Singh and Saxena 1975. [b] Source: Gopalan, Ramasastri, and Balasubramaniam 1971.

Potential for Soybean Production

The earlier convention bound detractions apprehending competition of soybean with groundnut proved to be a fallacy. Soybean if grown only on summer (Kharif) fallows in the States of Uttar Pradesh (UP) and Madhya Pradesh (MP) alone would enable the additional production of 2.5 million t (Williams et al. 1974). The estimated area potentially available for soybean in UP and MP States alone totals to more than 2 million ha (Table 2). Although soybean production has dramatically picked up in these two States, it will not be correct to say that other states in India do not provide the scope for soybean cultivation. Efforts are being made in the states like Rajasthan, Karnataka, Bihar, Himachal Pradesh, and Tamil Nadu, to take up large-scale cultivation of soybean (Anon. 1984). Soybean area increased from 300 ha in 1968 to 1 million ha in 1983 (Table 3). The target for 1984 is 1.81 million ha.

Convinced by the benefits of soybean cultivation, farmers are shifting to soybean from other summer crops like maize, minor millets e.g. *Eleusine coracana*, sawa (*Echinochloa frumentacea*), Ramdana, and even paddy. Due to water scarcity existing in many areas of the country the shift from paddy to soybean is very likely.

Table 2. Estimated area potentially available for soybean in Madhya Pradesh and Uttar Pradesh.[a]

State	10% of Land in		5% of Land for	Total Potential	
	Jowar, small millets, Kharif pulses ('000 ha)	Kharif fallow ('000 ha)	maize, bajra, cotton, upland paddy ('000 ha)	area ('000 ha)	production ('000 t)
Madhya Pradesh	493	494	140	1,127	1,401
Uttar Pradesh	157	538	201	896	1,083
Total	650	1,032	341	2,023	2,484

[a] Source: Williams et al. 1974

Table 3. Targeted and actual area (ha) and production (t) in India.[a]

State	1978-79		1979-80		1980-81		1981-82		1983-84	
	area	prod.	area	prod	area	prod	area	prod	area	prod.
Madhya Pradesh	232.6	232.0	414.3	N.R.	447.6[b]	250.0	647.7	500.0	809.0	600.0
	(200.0)	(211.4)	(40.0)	(51.4)	(480.0)	(375.0)	(600.0)		(1100.0)	(950.0)
Uttar Pradesh	68.7	60.3	75.9	36.1[c]	131.8	84.0	141.2	100.0	102.0	105.0
	(130.0)	(76.4)	(137.5)	(70.4)	(175.0)	(106.4)	(213.0)	-	(275.0)	(150.0)
Karnataka	1.2	0.6	1.3	N.R.	-	-	-	-	-	-
	(3.0)	(2.4)	(3.0)	(2.4)	-	-	-	-		-
Bihar	0.7	0.5	N.R.	N.R.	0.2	0.1	0.1	N.R.	6.0	5.0
	(3.0)	(2.4)	(3.0)	(2.4)	(5.0)	(4.0)	(6.0)	-	(8.0)	(5.0)
Himachal Pradesh	4.0	N.R.	0.2	N.R.	4.0	6.0	N.R.	N.R.	R.A.(0	5.0
	(3.0)	(2.4)	(3.0)	(2.4)	(6.0)	(4.8)	(8.0)	-	(12.0)	(5.0)
Rajasthan	-	-	-	-	12.5	6.3	13.0	12.0	3.0	10.0
		-	-	-	(2.0)	-	(10.0)	-	(15.0)	(5.0)
Gujarat	-	-	-	-	-	-	-	-	R.A.	5.0
	-	-	-	-	-	-	-	-	(6.0)	(5.0)
Total	307.2	293.4	491.7	36.1	596.1	446.4	802.0	512.0	920.0	730.0
	(339.0)	295.0)	(186.5)	129.0)	(668.0)	(490.2)	(837.0)		(1416.0)	(1120.0)

[a] Source: Directorate of Oilseeds Development, Ministry of Agric., Govt. of India; area = in thousand hectares, production = in thousand tons. N.R. = data not received; data for 1982-83 not available. Figures in parenthesis indicate targeted area and production.

[b] However, the State has taken up a coverage of 6000 ha during 1980-81.

[c] Due to drought the yield and total production went down. The production figures are communicated by the Director of Agriculture and the concerned State.

The demand for soybean has been recently increasing in India. This has been due to continuing interest by both public and private sectors in setting up soybean processing plants.

Constraints and Strategies

The Indian Council of Agricultural Research (ICAR) had launched in 1967, an interdisciplinary all-India coordinated research project on soybean. With its headquarters at Pantnagar, the project has 19 main and sub-centers located in different parts of the country to represent different agro-climatic conditions in India. The organizational pattern of the project is given in Annex I.

Some of the major constraints of soybean development are: 1) lack of suitable location-specific cultivars, 2) low yield potential, 3) susceptibility to diseases and insects, 4) poor seed

viability, 5) susceptibility to drought, 6) poor storage life of soy oil, 7) beany flavor, and 8) high linolenic acid content. In addition, poor processing, marketing, and utilization infrastructure are serious constraints.

The objectives of the research on soybean have been the identification/development of cultivars suitable to different agro-climatic zones having varied photoperiods; appropriate production technology for pure as well as companion crops; surveillance of disease and pests and their control; identification of efficient strains of Rhizobium for higher rate of nitrogen fixation, and commercial inoculum production; technology such as product development, marketing, and production economics. Through the project a number of promising cultivars for different zones have been developed (Table 4). A standard production technology has also been suggested for different agro-climatic zones (Table 5) (Anon. 1984). Performance of some of the promising lines is given in Table 6.

Table 4. Improved soybean cultivars for different agro-climatic zones.[a]

Agro-climatic Zones	Recommended Cultivars	Days to Maturity	Yield (t/ha)
Northern hill zone	Bragg	120	2.5-3.0
	Lee	110	2.0-2.5
	Pb-1	110	2.0-2.5
	Shilajeet	105	2.0-2.5
	DS-74-24-2	110	2.0-3.0
Northern plain zone	Bragg	120	2.0-3.0
	Ankur	125	2.0-3.0
	Alankar	120	2.5-3.5
	Shilajeet	105	2.0-3.0
	PK-327	110	2.5-3.5
	PK-271	115	2.5-3.5
	DS-74-24-2	120	2.5-3.5
	DS-73-16	120	2.5-3.5
Central zone	Bragg	115	2.0-3.0
	Ankur	120	2.0-3.0
	JS-2	105	2.0-2.5
	MACS-13	110	2.0-3.0
	JS-72-44	110	2.5-3.5
Southern zone	Improved Pelican	110-120	1.5-2.0
	Hardee	110-120	1.5-2.0
	KHSb-2	110-120	2.0-2.5
	DS-74-40	110-120	2.0-2.5
	PK-74-292	110-120	2.0-2.5

[a] Source: Summary tables of experiments under the All India Coordinated Research Project on Soybean 1982-83

By screening the germplasm sources of resistance to yellow mosaic virus (UPSM-534, *G. formosana*), rust (Ankur), bacterial pustule (Bragg), and *Macrophomina phaseolina* (Jawa-16) have been identified. The use of these sources have resulted in improved disease-resistant cultivars (Bhatnagar and Ram 1981). Efficient *R. japonicum* strains have also been identified, and commercial inoculum production has been established.

Some of the insect pests causing economic damage are girdle beetle (*Oberea brevis*), beanfly (*Melanagromyza sojae*), whitefly (*Bemisia tabaci*), thrips, and Bihar hairy caterpillars (*Diacrisia obliqua*) (Gangrade 1974). The efforts for evolving insect resistant cultivars are continuing. Chemical control of diseases and pests have been standardized and adopted by the growers

Table 5. Recommended cultural practices for different agro-climatic zones in India.[a]

Item	Northern Hill Zone	Northern Plain Zone	Central Zone	Southern Zone
Variety	Bragg, Lee, Shilajeet	Bragg, PK327	JS-2,Gaurav, Durga, PB-1	KHSb-2,Hardee Co-1, Davis
Planting time	1 June to 15 July	23 June to 15 July	15 June to 15 July	15 June to 15 July (Kharif crop)1 Oct. to Nov.(Rabi crop)
Planting distance	Row to row 45 cm, seed to seed 5 cm	45-60 x 5 cm	30-45 x 5 cm	
Mixed cropping	maize, ragi		cotton, sorghum, pigeon pea	sorghum,ragi

[a] Depth of seeding is 3 to 5 cm, basalin 2 liters/8 ml water per hectare, presowing incorporation in soil. A 20:40:40 NPK to inoculum and 75 kg/ha seed rate, Thiram-3 g/kg seed treatment, irrigation at flowering and pod filling, and two to three sprays of 0.1% Thiodan + 0.1% metasystox are common to all locations.

Table 6. Performance of some promising advanced soybean breeding lines developed in India.

Breeding Line	Pedigree	Developed at	Suitable Zone	Days to Maturity	100-Seed Wt. (g)	Yield Potential (t/ha)	Reaction to Diseases[a] YM	BP	RAB
PK-374	M534 x PK-71-39	Pantnagar	Hill zone	120	15.3	2.5-2.8	HT	R	MR
Himso-107	Sel. from PK-74-260	Palampur	Hill zone	125	13.2	2.8-3.0	MR	MR	NA
N-23A		Ranchi	Northern Hill zone	121	13.5	2.0-2.4		T	
Hiraso-352	Bienville	Palampur	Hill zone	124	15.8	2.4-2.9		M	
PK-429	(M-534 x S-38) Bragg x Bragg	Pantnagar	Hill zone	120	12.8	2.6-3.0	T	R	MR
PK-416	(534 x S-38)	Pantnagar	Plain zone	115	12.5	3.0-3.5	R	R	S
PK-486	(GF x Bragg) x Bragg	Pantnagar	Plain zone	115	11.2	2.8-3.0	R	R	S
DS-76-1-37-1	Bragg x Jawa 16	Delhi	Plain zone	120	11.3	2.8-3.2	S	R	MR
DS-76-1-29	Bragg x Jawa 16	Delhi	Plain zone	116	10.6	2.1-2.7	S	S	
PK-308	L-31 x Hardee	Pantnagar	Plain zone	115	12.5	2.5-2.6	T	R	MR
JS-76-259		Jabalpur	Central zone	108	14.4	2.2-2.8		T	
PK-472	Hardee x Pb-1	Pantnagar	Central zone	109	14.9	2.9-3.0	R	R	NA
N-19		Ranchi	Central zone	101	14.2	2.4-2.8			
DS-74-62	Semmes x S-3	Delhi	Southern	95	13.6	2.5-3.0	MR	R	NA
JS-72-185		Jabalpur	Southern	94	14.3	2.6-3.3		T	

[a] YM = yellow mosaic, BP = bacterial pustule, RAB = rhizoctonia aerial blight, HT = highly tolerant, T = tolerant, R = resistant, MR = moderately resistant, S = susceptible, NA = not available.

Spray of Thiodan and Metasystox mixture in the ratio of 1:1 (0.1%) at 25 day intervals has been found to be effective against most of the insect pests. By controlling thrips and aphids, diseases like yellow mosaic and soybean mosaic can be minimized (Nene 1972). Use of Thimet-10 granules at 10 kg/ha and seed treatment with Thiram at 3 g/kg of seed are effective against beanfly and seedling rot respectively (Nene et al. 1972).

Production economics have revealed that in UP State the return per dollar investment has been 1.73 for soybean, 1.08 for paddy and 0.79 for maize (Prasad 1983). In Madhya Pradesh,

per dollar return from yellow soybean had been 2.3; from black soybean, 1.6; from groundnut, 1.5; and from jowar, 1.2 (Tripathi 1983). Soybean is primarily used for its oil in India, and soybean meal is currently exported. Efforts are underway to make use of the defatted soy flour domestically as human food.

Future Research

Future research directions should focus on the following areas:

1. Develop cultivars with high yield, resistance to disease and pests, seed storability, low linolenic acid and high lecithin, earliness, tolerance to moisture stress and promiscuous nodulation
2. Develop crop-management practices for hills and marginal soils for pure and mixed crops
3. Control diseases and insect pests particularly girdle beetle
4. Increase the shelf life of soy oil and defatted soya flour
5. Evolve reasonable and practical standards for soybean products
6. Develop low cost, small scale processing plants to use soybean and soy flour
7. Develop processes to produce low priced product using defatted soy flour

International Collaboration

Recently, a project on soybean processing and utilization in collaboration with USAID and ICAR under Project No. 380-0470 has been approved. The project located at Central Institute of Agricultural Engineering, Bhopal and G.B. Pant University of Agriculture and Technology (GBPUA & T), Pantnagar, is to be implemented soon. The research outcome of the project along with the contributions of the approved National Centre of Soybean Research would help overcome the constraints of large-scale development and utilization of soybean in India.

Acknowledgment

The information in this paper has been compiled from the research and development contributions of various soybean workers of the project in India, and they are gratefully acknowledged.

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Annex I

Organizational pattern of the All India Coordinated Research Project on Soybean

Indian Council of Agricultural Research, New Delhi

Dr. N. S. Randhawa
Director General

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

Dr. C. Kempanna
Asst. Director General (CC)

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

Dr. P. S. Bhatnagar
Project Coordinator

Special Centre

1. G.B. Pant Univ. of Agric. & Tech., Pantnagar, (U.P.)
2. J.N.K.V.V., Sehore (M.P.)

Main Centre

1. Univ. of Agril. Sci., Bangalore (Karnataka)
2. I.A.R.I., New Delhi
3. M.A.U., Parbhani (Maharashtra)

Sub-Centre

1. H.P.K.V.V., Palampur (Himachal Pradesh)
2. P.A.U., Ludhiana (Punjab)
3. R.R.S., Majhera (U.P.)
4. G.A.U., Junagadh (Gujrat)
5. Univ. of Agril. Sci., Dharwar (Karnataka)
6. M.A.C.S., Pune (Maharashtra)
7. T.N.A.U., Coimbatore (Tamil Nadu)
8. A.R. Center, Koraput (Orissa
9. B.A.U.,Kanke, Ranchi (Bihar)
10. A.A.U., Jorhat (Assam)
11. N.B.P.G.R. Regional Res. Station, Akola (Maharashtra)
12. B.C.K.V.V., Kalyani (W. Bengal)
13. S.K. Agril. Univ., Srinagar (J & K)

Voluntary Centre

1. H.A.U., Hissar (Haryana)
2. C.S.A.U. & T., (Kanpur)
3. College of Agril., Dryland Res. Proj., Indore (M.P.)
4. Agril. Exp. Inst., Kudumiamalai (Tamil Nadu)
5. Pulses Oilseeds Res. Station., Berhampur (W.B.)
6. ICAR Res. Complex of NEH Region, Shillong (Assam)

9

Soybean Research in Nepal

Rajman P. Chaudhary
Agronomist and Leader
Grain Legume Improvement Program
Agronomy Division
Khumaltar, Nepal

Introduction

Soybean, an ancient crop of Nepal, is grown only in altitudes between 915 and 1525 m until a few years ago. Recently soybean cultivation is moving to other parts of the country as well. Although soybean is a minor crop, it plays an important role in human and animal nutrition, soil fertility, and cropping systems in Nepal. The soybean area and production in 1972 and 1977 were 18,040 and 18,530 ha with 10,824 and 12,044 t, respectively. The average yield was 600 kg/ha in 1972 and 650 kg/ha in 1977.

Soybean is usually not a sole crop, but is commonly mixed with corn, pigeon pea, and upland rice. It is also planted on the hill terraces and on rice field bunds after rice transplanting. In some areas, soybean is planted (relayed) in the corn field after two months.

Problems of Soybean Production and Research

1. The major problem is finding suitable cultivars for each area and for intercropping with corn.
2. Manpower for research work is inadequate.
3. Farmers and policymakers appear to be unaware of soybean as a source of protein and oil and its use in agro-industries.
4. Seeds produced at the government farms and stations are insufficient to meet the demand.
5. Systematic marketing system is unavailable in Nepal.

Research Directions

With the objective of evaluating and identifying suitable indigenous and exotic soybean lines/cultivars for high yield, good seed quality, early maturity, and suitability for intercropping, the following activities have been conducted in the last decade:

1. Collection and screening of soybean germplasm. There is a need to systematically collect the local soybean germplasm in Nepal. However, the Grain Legume Improvement Program has 205 soybean germplasm (29 local).

2. International screening nurseries. Several international soybean nurseries from INTSOY, AVRDC, and IRRI are received and tested to identify superior cultivars and those carrying resistance to major diseases and pests. Promising lines are again tested in the Initial Evaluation Trial (IET).

3. Initial evaluation trial. Promising lines from international nurseries and germplasm banks are promoted to IET. It is a replicated trial conducted in Terai and hill locations.

4. Coordinated varietal trial (CVT). Promising cultivars from IET are promoted to coordinated varietal trials. Three types of coordinated varietal trials are conducted in Nepal. They are CVT's for plains, mid-hills (3000 to 5000 ft) and high hills (above 5000 ft). CVT's for mid-hills and high hills are tested in an intercrop environment. Promising cultivars in CVT are tested in farmer's fields and through the minikit program.

5. Farmer field trial (FFT) and minikit. Most promising lines are tested in the farmer's fields with farmer's management. The best local check is included in this trial. Promising cultivars are distributed in the form of minikits (500 to 1000 g/packet). The cultivars becoming popular among the farmers are forwarded to the variety release committee for release and general cultivation.

6. Improvement of cultural practices.

a. Weed control trial. Basalin at 0.5 liters/ha to 2.5 liters/ha were directly applied, but the results were inconclusive. The work is continuing.

b. Fertilizer and Rhizobium inoculation trial. No response to nitrogen was observed in Nepal. However, N:P:K at 20:60:30 kg/ha are being used for experiments. Up to 60% increase in soybean yield has been observed with 800 g/ha rhizobium inoculation. The division of Soil Science and Chemistry has the facilities to produce 1000 packets (each 200 gr) of inoculants every year. They are distributed to research stations as well as to the farmers.

7. Pathological studies. There are several major diseases of soybean observed in Nepal. They are:

a. Cercosporella leaf spot (*Cercosporella* sp.). a disease new to the world, observed only in Nepal. Varietal screening for *Cercosporella* sp. was conducted in Kakani, but none of the cultivars were found resistant to this disease.

b. Frog-eye leaf spot (*Cercospora sojina*). Seed treatment trial, fungicidal trial and varietal screening were conducted at Khumaltar. Seed treatment with Thiram is effective. In fungicides, difolatan and Dithane M-45 (mancb) are effective. Also some cultivars (Hardee, Davis, Dare, Comet, Clark, CNS, Dorman, Kent, Palmetto, Scot, Tanner and Volstate) were found resistant to this disease.

c. Bacterial pustule (*Xanthomonas campestris* pv. *phaseoli*). Varietal screening for bacterial pustule resistance was conducted in Khumaltar and Sarlahi. Sixty eight cultivars were found resistant to this disease (Manandhar 1980).

d. Soybean mosaic (Soybean mosaic virus). Varietal screening for soybean mosaic virus resistance was conducted in Khumaltar. Some of the varieties (GC 20170-0-18, GC 40095-0-9, Capital, Cutler 71, Dare, D-49-2491, Hermon-41, K-162, KS-419, KKS 525, Lincoln, Lumle Local, Markhu Seto Thulo, Nuwakot Kanchhi, Nuwakot Mahili, P_3, P_3, Paripatle small white, Ross, Teradthum white) were heavily infected with this disease (Joshi 1984).

e. Pod and stem blight. This disease occurs in the early vegetative growth stage. No work has been done so far against this disease.

f. Soybean rust (*Phakopsora pachyrhizi*). This disease was observed for the first time in 1981. This disease usually occurs in Nepal at the time of maturity (early to mid-September). Up to 77% leaf area is affected by rust. No significant yield loss was observed due to its late occurrence in a rust screening nursery in Khumaltar (Joshi 1984).

8. Insect problems. Several insects are found in Nepal, and some of them are serious.

a. Hairy caterpillar (*Spilarctia casignata*). It is one of the major insect problems of soybean in Nepal. The presence of trichomes are useful in the reduction of the damage caused by the larvae (Gyawali 1984a). Among the CVT for hill zones (Table 1), the percentage of damage on the cultivars Hill and Ransom was less than the others, whereas in CVT for Terai (Table 2), the percentage of damage on cultivars P-44, Bossier, F-76-88, Acc. G 2120, TK-5, Improved Pelican, and Davis was significantly less than the others.

Insecticides such as Decis, Sumicidin, Thiodan, and Metacid were tested on fourth-instar larvae of the soybean hairy caterpillar. Thiodan performed well over Metacid, similarly Decis was better than Sumicidin (Gyawali 1984b).

Table 1. Cultivars used in soybean CVT for mid-hills.

Cultivars	
1982	1983
Ransom	KS 419 x KS 525
GC 30229 (Shih-Shih x SRF 400)	Shih Shih x SRF 400 (GC 30229-18)
KS 419 x KS 525	CES 16-103
Sathiya	PK 7394
Desoto	Gasoy-17
CES 16-103	Ransom
Celeste	Clark 63
Clark 63	Hill
Gasoy-17	Sathiya
PK 7394	Celeste
Hill	Kent
11-4	Essex

Table 2. Cultivars used in soybean CVT for Terai.

Cultivars	
1982	1983
Hardee	Hardee
PK 7394	PK 7394
Cobb	Cobb
ACC. G 2120	Pickett
Improved Pelican	F-76-8817
UPL-SY 2	P-28
Pickett-71	Bossier
Bossier	Bragg
Celeste	GC 30290-11-11
Bragg	Celeste
F-76-8827	UPL-SY 2
P-28	Crawford
GC 30290-11-11	Sparks
Clark 63	Kent
Centennial	11-4
Davis	Essex

b. Chinch bug (*Chaetiops fallax*) - This bug caused serious damage at Bonch Agriculture Farm in 1983 (Gyawali 1984a).

c. Stinkbug (*Viridula antenata*) - This insect was serious at Kabhre Agriculture Farm during the reproductive stage in 1983 (Gyawali 1984a).

Research Findings

Cultivar Hill and Hardee were introduced to Nepal from U.S.A. in 1968. Hill was released for general cultivation in the mid-hill region. It matures in 125 days and yields 2 to 2.5 t/ha as a monocrop and 1 t/ha when intercropped with corn. Hardee was released in Inner Terai and Terai regions. It matures in 125 days and yields 2 to 3 t/ha in sole cropping.

A seed rate of 60 kg/ha is recommended to obtain 400,000 plants/ha. A spacing of 50 x 5 cm was found best to obtain 400,000 plants/ha. Optimum date of plantings are 15 June to 5 July, 20 May to 15 June and 1 to 15 May for Terai, mid-hills and high hills, respectively.

International Cooperation

The Grain Legume Improvement Program is receiving several international nurseries of soybean from INTSOY and AVRDC. These international nurseries are the source of genotypes for superior agronomic traits and resistance to major diseases and pests.

Nepal would like to collaborate with other organizations, such as All India Coordinated Research Project on Soybean in India and Soybean Development Program in Sri Lanka.

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10

Soybean in Malaysia: Potential and Research Directions

Ramli bin Mohd Noor
Senior Research Officer
Miscellaneous Crop Division
Malaysian Agricultural Research and Development Institute (MARDI),
Kuala Lumpur, Malaysia

Introduction

Soybean at present is not widely grown in Malaysia and its acreage is still insignificant. In 1980, the area under soybean was only 24 ha in terms of total sole-crop equivalent. However, Malaysians consume a substantial amount of soybeans and soybean products annually, and virtually all of these are imported. In 1980 alone, the total import of soybeans and soybean products into Malaysia amounted to nearly US$ 59 millions. Of this amount, approximately 95% was in the form of seeds and soybean cakes. The seeds are used in making soybean products for human consumption, while the soybean cakes are used for animal feed.

Potential for Soybean Production

In 1980, it is estimated that Malaysia utilized 317,871 million t of soybean. To produce it locally, it requires about 215,000 ha. However, it could be quite difficult to identify suitable lands to meet the acreage. The objective, therefore, is to identify potential areas where soybean can be profitably produced partially to meet the domestic requirement at least.

The lands/areas with potential for soybean production can be grouped into two categories:

1. Lands/areas which are suitable but already utilized.

   a. Lands already planted to oil palm, rubber, cocoa, coconut, and orchards could still grow soybean during replanting at least during the first three years;
   b. Double cropped rice areas which do not have sufficient water during the off-season may be planted with soybean as an alternative crop;
   c. Riverbank areas presently grown to fresh cob maize, groundnut, and vegetables may also be planted to soybean.

2. Lands/areas which are suitable and can be utilized.

   a. Single-cropped rainfed rice areas estimated to be about 34,000 ha suitable for soybean production (also for other upland crops) in the off season;
   b. Abandoned upland and rice lands which are idle;
   c. Forest lands, such as those found in Pahang (about 13,200 ha) and in Perak (about 28,200 ha).

It is fully recognized that lands suitable for soybean production are also suitable for other upland crops. In this context, it is envisaged that soybean will have to be grown either as an intercrop or in rotation with other crops.

Production Constraints

The constraints to soybean production in Malaysia are many and interrelated. However, the foremost problems are cheap import price, lack of marketing facilities/infrastructures, low-yielding cultivars, high cost of production, and unavailability of suitable lands.

1. **Cheaper import price.** The present import price of soybean in Malaysia (ex-factory) is about US$ 485/t while the cost to produce one ton of soybean locally is estimated about US$ 500/t. Therefore, locally produced soybeans are more expensive than the imported ones.

2. **Lack of marketing facilities/infrastructures.** Since at present imported soybean is cheaper than locally produced soybeans, the feed millers and other soybean users prefer to import them. As a result, the marketing facilities/infrastructures for soybeans in the country are not yet developed. In fact, marketing of locally produced soybeans is such a serious problem that several entrepreneurs in the past have difficulty disposing their soybeans.

3. **Low-yielding cultivars.** The lack of suitable high yielding cultivars could be considered the basic constraint that leads to the unpopularity of the crop in Malaysia. The presently available cultivars can produce only about 1.5 t/ha. Although this yield is comparable to those in neighboring countries, it is still uneconomical to farmers.

4. **High cost of production.** The cost of production for soybean is very high in Malaysia. This is because it is based mainly on manual operations. The present cost is about US$ 800/ha, out of which US$ 450 is for manual labor. The cost of production, however, can be reduced through mechanization.

5. **Unavailability of suitable lands.** Since soybean is an unprofitable crop at present, it cannot compete against other crops for suitable lands which are being utilized for the more lucrative crops such as rubber, oil palm, cocoa, tobacco, vegetables, groundnuts, etc. Thus, to a certain extent there is a need to utilize marginal lands for soybean cultivation.

Of the five production constraints, low yielding cultivars, high production cost and unavailability of lands may be overcome by research. The low import price and lack of marketing facilities/infrastructures could only be solved by positive government policies.

Directions in Soybean Research

Soybean research in the future needs to focus on the development of stable and high-yielding cultivars, the reduction in cost of production, and improvement of marginal lands for soybean production. Breeding should aim for cultivars with a yield potential of 2 t/ha or more which will be attractive to the Malaysian farmers. At the same time, the new cultivars should also possess tolerance to moisture stress and water logging, resistance to important insect pests and diseases, and good seed quality.

Research to further reduce production cost will be mainly on mechanization and biological nitrogen fixation. Mechanization research will work on the modification and adaptation of existing soybean machinery and implements available in the soybean-producing countries. The focus on nitrogen fixation will be the identification of effective and efficient rhizobium strains and the development of suitable production and application techniques for local environments. To improve marginal lands, research must be conducted on method of land preparation, method and time of planting, irrigation techniques, and drainage systems.

Research Highlights

The research highlights include the following:

1. Three introduced soybean cultivars have been identified to yield relatively higher than others and have been recommended. They are Palmetto, Jupiter, and CES 434 with a yield of about 1.5 t/ha.
2. Several potential soybean breeding lines have been developed from MARDI's breeding program.
3. In the West Coast areas, the best time to plant soybean is in March-April and September/October; in the East Coast, January, March and June.
4. A planting distance of 50 cm x 5 cm with one seed per point is found to be the optimum for the presently recommended cultivars.
5. A fertilizer rate of 34-56-56 kg/ha has been found to be optimum for most soils and is recommended for the presently recommended cultivars.
6. Beanfly and pod borer have been recognized as the most serious pests in soybean. Spraying dimethoate two to three times at weekly intervals starting 10 days after planting controlled beanfly effectively. To control pod borer, spraying with systemic insecticides during flowering and early pod development is recommended.
7. Bacterial pustule has been found to be the most common although not a serious disease. Some cultivars resistant to the disease have been identified (Bossier, Jupiter, William, and Clark 63).

Collaboration with IARCs and Other Regional Centers

Soybean research in Malaysia has received assistance from the International Agricultural Research Centers (IARCs). In the past ten years, MARDI has collaborated with SEARCA, INTSOY, AVRDC, and IRRI mainly on varietal evaluation and selection. In the future, MARDI hopes to collaborate with IITA through its South East Asian representative located at IRRI. In this collaborative work, MARDI is usually supplied with selected soybean cultivars/strains/lines for research and in return is requested to send back research results for compilation and analysis. Hopefully, MARDI will try to explore other forms of collaboration with the IARCs in the future.

Conclusion

Presently soybean is not an important crop in Malaysia. However, there is potential to grow the crop in the future, at least to satisfy partially the large annual import. High-yielding cultivars and low production cost will assure economic returns and encourage farmers to grow soybean. To this end, there is a need to focus research on breeding and selection and to a certain extent on rhizobiology, mechanization, and water management.

11

Soybean Research in Sri Lanka

V. Arulnandhy
Soybean Breeder
Agricultural Research Station
Maha Illuppallama, Sri Lanka

Introduction

Soybean is one of the five major grain legumes cultivated in Sri Lanka; the others being cowpea, mungbean, black gram, and groundnut. Soybean is recognized as a potential source of protein and oil in Sri Lanka. Recent surveys have indicated that the diet of the average person in the country is deficient in proteins which soybeans can alleviate

Soybeans were first introduced to Sri Lanka in 1947. However, the importance of this crop was realized only in 1973 and a project was initiated to popularize its cultivation. Varietal introduction, multilocational testing, and agronomic investigations provided useful technology to the farmer. Both the cultivated area and production increased since the start of the project. Soybean area increased from a few hectares in 1973 to 6,000 ha in 1979 and to about 10,000 ha in 1983. Utilization patterns and processing technology are now geared to expanded production.

Cropping Patterns

The bulk of the area under soybeans is presently confined to the north central part in the dry zone (Table 1), where soybeans are grown during the rainy season (November through February) as well as during the dry season (May through August). This part of the country has successfully adopted this crop. Soybean is grown on the highlands purely under rainfed conditions using simple but effective cultivation techniques. Minimum tillage and the use of the hoe on weeds just prior to the onset of the northeast monsoon are the only practices the farmers follow before seeding. During the dry season, soybeans are mainly grown with irrigation in paddy fields and usually after rice. This appears to be the best rotation for the larger tracts of irrigated land in the dry zone, where water availability is inadequate to raise a second crop of rice during this season. Under irrigated conditions in previously puddled rice fields, it has been estimated that about 70 cm of water is required for a crop of soybeans during the dry season, when the evapotranspiration rates are as high as 6 to 9 mm a day. In most instances, soybean seeds are sown with little land preparation after rice is harvested. Attempts are also made to grow soybeans on undisturbed rice lands with an initial weeding soon after the rice is harvested to utilize the residual moisture.

Table 1. Targets in area and production of soybeans in 1982/83.

Place of Production	Season	Total Area (ha)	Total Production (t)
North central region	wet	8,250	12,250
	dry	4,500	6,750
Entire country	wet	10,322	14,037
	dry	5,806	8,360

There is tremendous potential for intercropping in coconut plantations. The area under coconut in Sri Lanka is 450,000 ha. At full bearing age (25 to 30 years) coconut plants utilize only 25 to 30% of land and about 40 to 50% of sunlight. The greatest potential for intercropping with soybeans under partial shade exists in the intermediate zone, especially in the drier areas

in both wet and dry seasons. The performance of some soybean cultivars under coconuts are shown in Table 2.

Table 2. Mean yield of soybean cultivars grown in pure stand and under coconuts in the intermediate zone.

Cultivar	Grain Yield (kg/ha)	
	Pure stand	Under coconut
Improved Pelican	3,554	808
Bossier	2,304	484
P-b	2,148	607

Constraints

One of the major soybean production problems in Sri Lanka is poor seedling emergence. Emergence and establishment of seedling is erratic and frequently poor. Nonuniform seedling emergence may be due to: 1) crusting of soil surface making it difficult for cotyledons to penetrate through the surface; 2) high soil temperature, especially during the dry season, inhibiting hypocotyl elongation; and 3) infection by pathogenic fungi of unemerged seedlings.

Rapid loss in viability of stored seeds under humid tropical conditions prevailing in Sri Lanka is another constraint. In general, soybean seeds can be kept under farmer's conditions for about three months without appreciable loss in viability. However, viability of the seeds of promising high-yielding cultivars like Bossier, Davis, and Hardee from U.S.A. drops tremendously in less than three months. Production of poor quality seed occurs when adverse weather conditions exist during the post-maturation and preharvest periods.

Currently, there are no serious pests or diseases that threaten soybean cultivation in Sri Lanka. With increase in soybean area, however, yellow mosaic virus may be a potential threat in the future. The incidence of this virus and other diseases and insect pests is low when the crop is planted at the appropriate time. The incidence of attack increases with the delay in planting. Weeds are a problem in some soybean fields. Although, pre-emergence weedicide Lasso is recommended, the farmers cannot afford to use it because of high cost. Weeding is done manually between two and four weeks after planting.

Objectives

The primary objective of the Sri Lanka soybean program is to develop production, marketing, processing, and utilization simultaneously. The main objectives of soybean research are as follows: 1) to identify and develop suitable cultivars adaptable for different agroclimatic zones of Sri Lanka; 2) to identify cultivars resistant to yellow mosaic virus and *Macrophomina*; 3) to identify and develop short-duration cultivars for intercropping with chilli, maize, sorghum, etc.; 4) to identify and develop cultivars for long storability, without losing their seed viability; 5) to improve indigenous cultivars, like Nuwera Eliya local, for yield and other important agronomic characteristics; 6) to identify and develop cultivars that will nodulate freely under local conditions; 7) to develop cultural methods to improve seedling emergence under adverse conditions; 8) to develop a Rhizobium culture with longer shelf life under farm conditions, wider adaptability, and greater efficiency; 9) to increase the shelf life of soybean seeds under farm conditions; and 10) to develop soya-based products for efficient home as well as commercial use.

Research Highlights

Varietal Improvement

Varietal improvement began in 1973 with the introduction of advanced breeding lines and cultivars from INTSOY. A local breeding program was initiated in 1978 using the promising introductions and local cultivars. Some of the U.S. cultivars yielded about 4000 kg/ha with irrigation (Table 3); however, they were poor in seed storability under humid tropical conditions of Sri Lanka. The U.S. cultivars Bossier, Improved Pelican, and Davis, and a cultivar Pb-1 from India have been recommended for general cultivation.

Table 3. Performance of soybean cultivars at the Agricultural Research Station, Maha Illuppallama, Sri Lanka

Cultivar	Country of Origin	Grain Yield (kg/ha)
Hardee	U.S.A.	4,877
Bossier	U.S.A.	4,627
Pb-1	India	3,606

Two advanced breeding lines evolved from crosses of exotic cultivars with indigenous cultivar, Nuwera Eliya local, produced 11 to 16% higher yields than Pb-1 in multilocational trials (Table 4) and had superior storability and germination traits from the indigenous cultivar.

Three advanced short duration breeding lines from AVRDC in Taiwan were identified from the screening program (Table 5). These lines would have great potential in areas where short-duration cultivars are in demand. They would be more suitable to grow with irrigation during the dry season and would also be suitable for intercropping with maize and chilli.

Table 4. Some characteristics of improved soybean lines developed in Sri Lanka.

Cultivar/line	Grain yield (kg/ha)	Days to Maturity	100-seed Wt. (g)	Storage Period in months
PM-78-6-5-13	3,264[b]	90	12	6
PM-78-2-5-25	3,095	100	9	8
Pb-1	2,816	90	13	3
Nuwera Eliya local	2,000	110	8	9

[a] Period during which 80% viability was maintained
[b] Mean of five locations

Table 5. Grain yield and some agronomic characteristics of short-duration advanced breeding lines from AVRDC, Taiwan.

Breeding Line	Days to Maturity	Plant Height at Maturity (cm)	100-Seed Wt (g)	Grain Yield (kg/ha)
GC 50106-26-8-6	75	51	13	2,607
GC 50226-2-7-6-6	75	62	14	2,253
GC 60058-18-1-8-7-6	78	55	12	2,089

Production Technology

Studies have demonstrated that a successful crop of soybean can be grown with a relatively low fertilizer level (N:P:K = 20:60:40 kg/ha), provided the seeds are treated with Rhizobium.

A plant population of 0.5 million/ha is suitable for both dry- and wet-season planting.

Fungicide thiram increased the seedling emergence by 21% over the untreated control, without affecting nodulation (Table 6). Five metric tons of straw mulch per hectare applied after planting the seeds provided good weed control and grain yield 2.5 times that of the unweeded, unmulched control and 38% higher than that of a recommended hand weeding practice three weeks after planting (Table 7).

Table 6. Effect of fungicidal seed treatment on seedling emergence and nodulation in soybeans.

Fungicide	Emergence (%)	Fresh Wt. of Nodulation per 5 plants (g)
Thiram	62	6.0
Captan	59	5.7
Benomyl	51	6.7
Untreated (control)	50	5.8

Table 7. Effect of straw mulch on weed control and grain yield in soybeans.

Treatment	Weed Count[a] (% of check)	Grain Yield (kg/ha)
5 mt of straw/ha	3.86	2,138
4 mt of straw/ha	13.81	1,750
Handweeding at 3 weeks after planting	29.28	1,549
3 mt of straw/ha	44.19	1,239
No straw and no weeding (control)	100.00	868

[a] Weed counts were taken at 8 weeks after planting.

Studies demonstrated that it is better to store well-dried soybean seeds in moisture proof polyethylene bags than in moisture permeable gunny bags under ambient humid tropical conditions (Table 8). Gunny bags were as good as polyethylene bags for storage of soybean seeds under controlled conditions with low humidity and temperature. It was clearly shown that well dried seeds of most soybean cultivars could be stored with good viability for three months under any conditions of storage in Sri Lanka. Cultivar differences for storability was observed.

Inoculum production in Sri Lanka is still in the initial stage. Commercial inoculum production using imported isolates of *Rhizobium japonicum* and local carriers has been undertaken recently.

Table 8. Mean percent germination of soybean seeds under different conditions of storage after 0, 3, and 6 months.

Months in Storage	Storage Condition	Storage Container: Gunny bag	Storage Container: Polyethylene bag
0	Ambient storage	90[a]	90
	Cold storage	90	90
3	Ambient storage	80	81
	Cold storage	88	80
6	Ambient storage	2	70
	Cold storage	79	86

[a] Values are means of 12 soybean cultivars.

Processing and Utilization

Considerable progress has been made in product development and pilot plant demonstration of various prototypes since the establishment of the Soybean Food Research Center in Sri Lanka. Liquid and dried soymilk, full fat soy flour, soy-fortified bakery and other products, low-cost weaning food, tofu, tempeh, and soy dhal have been made available in Sri Lanka by this Center.

Collaboration with Other Institutions

Arrangements have been made to receive breeding materials from soybean breeding programs in Puerto Rico (INTSOY), U.S.A. (University of Illinois), Taiwan (AVRDC), India (G.B. Pant University), Australia (University of Queensland), Africa (IITA), and the Philippines (IRRI). INTSOY publications have been obtained regularly from the University of Illinois at Urbana-Champaign. Research and extension staff have received training from INTSOY and the University of Illinois.

Collaboration with these institutions will be further intensified. We also collaborate with leading regional agricultural research centers as well, in the exchange of seed materials and publications, and participation in conferences, monitoring tours, and workshops.

Acknowledgment

The information contained in this paper is based on research carried out at different research centers by various soybean workers; their efforts are gratefully acknowledged.

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Soybean Research in Thailand

Nark Potan
Oilseed Crops Branch
Field Crops Research Institute
Department of Agriculture
Bangkhen, Bangkok 10900, Thailand

Introduction

Soybean is widely used in Thailand as animal feed and human food in the form of oil, soy milk, bean sprout, bean curd, and various sauces. A campaign to encourage people to produce beef, and some desserts from soybean and eat fresh steam-cooked pods has been done intensively. At present, Thailand produces 130,000 to 150,000 t of soybean from 122,000 ha but the domestic demand is about 350,000 to 400,000 t/year. About 62% of the soybean produced in Thailand is used for oil extraction and the rest are used for seeds and human consumption. The local demand for soybean cake amounts to 300,000 t/year, but only a total of 205,751 t of soybean cake valued at US$ 66.4 million was imported in 1982.

Area, Planting Season, and Productivity

The soybean area in Thailand is relatively limited and confined mostly to the fertile soil which will give profitable return. Soybeans are usually planted in both dry (from mid-December to mid-January) and rainy (from May to August) seasons. In the early rainy season, soybean is mostly planted in May followed by sorghum and black gram. In some areas it is also planted after maize and mungbean in the late rainy season, and also after rice in the dry season. The area planted to soybean in the rainy and dry seasons and the yield per hectare are shown in Table 1.

Table 1. Area planted and grain yield of soybean grown in dry and rainy seasons.[a]

Area Planted (ha)	Total Area (ha)[b]		Yield (kg/ha)[c]	
	rainy season	dry season	rainy season	dry season
Small-scale (148-815)	2,023		1,030	
(150-789)		1,554		890
Medium-scale (1,005-3,183)	9,105		966	
(1,306-3,537)		10,988		933
Large-scale (4,454-41,039)	55,752		892	
(7,314-20,947)		28,261		904
Total	66,880	40,803	963	909
Total (throughout the country)	77,438	44,257	913	906

[a] Source: Office of Agricultural Economics, Center for Agricultural Statistics.
[b] Area average from 1979-1983. [c] Yield (kg/ha) average from 1980-1983.

The soybean area in the rainy season is nearly double that of the dry season. The policy to increase soybean production in Thailand includes the following:

1. Yield per hectare should be gradually increased from 913 to 1,500 kg/ha in the next five years.
2. Planting method and soybean cultivars grown in the corn-based cropping system need to be improved effectively.
3. The ideal soybean cultivars required for the above cropping pattern should have short maturity and carry moderate tolerance to drought.
4. Soybean production in the dry season normally provides quality seeds and, therefore, should be extended to some other potential unutilized irrigated areas.

At present, the average production cost of both seasons in 1982-1983 is about US$ 0.29/kg, while the selling price is about US$ 0.30 to US$ 0.38.

Problems in Soybean Production

The major problems of soybean production in Thailand can be divided into three categories as follows:

1. Traditional factors. Most farmers are generally conservative and are hesitant to adopt new technology and provide inputs. Since the risk involved in growing a single crop is great, small farmers usually diversify their agriculture. For instance, soybean in the early rainy season is normally followed by black gram, sorghum, or mungbean. In the dry season, farmers usually grow many crops, like soybean, tobacco, and vegetables in different areas.

2. Inadequate supply of quality seeds. At present, the total soybean seed requirement for farmers is about 7,000 t, but the official agencies can produce only 980 t or about 14% of the requirement. The price of official seed is about US$ 0.65/kg in cash as compared with US$ 0.35/kg on credit from the local market. Although the local market seeds are poor in quality and are a mixed lot, the poor farmers prefer to buy them because they are available on credit. Government agencies now try hard to encourage and support the private sector to produce enough quality seeds and teach the farmers to produce good seeds of their own. The Department of Agricultural Extension has set up a seed-exchange project since 1983. The farmers who want good seeds can exchange them for rice and soybean seeds or other grains at the ratio of 1:1 on the weight basis. The project is now vigorously being implemented in soybean-production areas.

3. Limited area for soybean. Successful soybean cultivation requires proper crop management. In the dry season, if irrigation is available, farmers prefer to grow rice rather than soybean. Rice is the easiest crop to grow and needs very little attention. Consequently, extending the production area for soybean is relatively difficult. Because of its potential economic importance and the need to increase production, the government has, however, included soybean in the fifth five-year plan (1983 to 1988) of Thailand's national, social, and economic development program and set up the goal to produce about 400,000 t in 1988.

The problems in research work at the Department of Agriculture are lack of research personnel and disease-resistant cultivars.

The Department of Agriculture is currently being reorganized. To improve the system and the staff, researchers are being sent abroad for advanced training. As a result the Department is understaffed. Disease is the main limiting factor in soybean production. The cultivars recommended are moderately tolerant to rust but susceptible to anthracnose which is likely to become a serious threat to soybean production in Thailand.

Research Directions

The Department of Agriculture organized a seminar and workshop for soybean researchers in 1983 at the Northern Office of Agriculture and Cooperative in Chiengmai Province. The

participants in the workshop decided to set up the following research guidelines:

1. Develop improved disease- and insect-resistant cultivars. Diseases and insect pests in the order of their importance are:

a. Anthracnose became an important disease since 1978. The late-maturing cultivars appear to be moderately resistant. Therefore, breeding for varietal resistance was undertaken and is now in progress.
b. Bacterial pustule is presently not a serious disease. Bossier, PI 230970, and CES 16-23 were found to be resistant and are being used in the breeding program.
c. Soybean rust is currently not a serious problem. Recommended cultivars SJ 4 and SJ 5 carry some level of field resistance to this disease. Research to obtain high levels of resistance and high yield appear promising.
d. Beanflies (*Ophiomyia phaseoli* and *Melanagromyza sojae*) are serious pests in some locations. At present, the cultivars resistant to beanflies are not available, and so their control is solely dependent on insecticides.

2. Development of improved cultivars with wide adaptability. The ideal cultivars should be insensitive to photoperiod and should possess characteristics and maturity suited to the following conditions:

a. Monocropped rainfed areas: late-maturing cultivars (140-150 days), resistant to water-logging, and seed-weathering.
b. Dry and rainy seasons: cultivars of medium maturity (90-100 days).
c. For the early rainy-season cropping systems: early-maturing cultivars (70-80 days).

3. Development of cultivars resistant to environmental stresses. The characteristics required for stress environments are:

a. Drought resistance for rainfed cultivation.
b. Cold tolerance for dry-season cultivation.
c. Acid and saline tolerance for specific locations.

4. Development of cultivars suitable for vegetable soybean. This cultivar should have big seeds and high protein content.
5. Other desirable characters include good nodulation, good seed quality and vigor, and seed longevity.
6. Development and improvement of small-scale equipment. Small-scale equipment suitable for planting, weeding, harvesting, threshing, and drying should be developed to serve the farm requirements and to reduce production cost.

Research Highlights

Four cultivars SJ 1, SJ 2, SJ 4, and SJ 5 were released and recommended to the farmers. Other promising lines are in the regional yield trials and have high yields. The promising lines Nos. 7508-50-10 and 7608-25-4 obtained from crosses involving multiple parents in 1975 and 1976, respectively, appear to be highly tolerant to rust and moderately tolerant to anthracnose and bacterial pustule. Selection 7608-25-4 has gray hilum. A comparison of the new selections against that of SJ 4 and SJ 5 are shown in Table 2.

The soybean cultivar O.C.B. 81 (oilseed crop branch 81) introduced from Vietnam in 1980 has been tested in two seasons at Chiang Mai Field Crops Research Center and then evaluated at Taklee and Phitsanulok. It has high yield, early maturity, and desirable characters for planting after corn in August in the central plains (Table 3).

Table 2. Yield of promising selections compared with SJ 4 and SJ 5.

Cultivar/Selection	Dry Season[a] Mean from three locations (1981-1983)(t/ha)	Rainy Season[b] Mean from six locations (1980-1983)(t/ha)
7508-50-10	1.89	2.06
7608-25-4	2.19	1.98
SJ 4	1.88	2.00
SJ 5	1.88	1.94

[a] Dry season: December to April (Maejo, Phitsanulok and Chainat Field Crops Experiment Station).

[b] Rainy season: May to October (Maejo, Sisaketrong, Taklee, Praputtabaht, Loei, and Sakolnakorn Field Crops Experiment Station)

Table 3. Mean yield from two rainy seasons in 1982-1983 and other characters of O.C.B. 81 compared with SJ 4 and SJ 5.

Cultivar	Yield (t/ha) Taklee	Yield (t/ha) Phitsanulok	100-Seed Wt (g)	Plant Height (cm)	Maturity (days)
O.C.B. 81	2.4	2.8	19.7	54	74
SJ 4	1.7	1.8	14.4	93	100
SJ 5	1.9	2.2	14.1	83	92

Collaboration with Other Agencies

Soybean researchers in Thailand have collaborated with several foreign agencies involved in many research aspects, especially in varietal exchanges and testing. Some of the activities are:

1. Selecting and testing AVRDC's early- and late-generation breeding lines.
2. Five ISVEX trials from INTSOY.
3. IRRI varietal testing for rice-based cropping system.
4. Technical cooperation with ACIAR for training, study tour, and evaluating trials from 1984.
5. Soybean research for 1975-1980 at Khon Kaen University with financial support from IDRC.

Soybean Research in Pakistan

Akhtar Beg
National Coordinator (Oilseeds)
Pakistan Agricultural Research Council
P.O. Box 1031
Islamabad, Pakistan

Introduction

There is an acute shortage of edible oil in Pakistan. The present edible oil production is reported as 220,000 t against the total requirements of 915,000 t. Moreover, the consumption of edible oil is increasing at a rate of 55,000 per annum. To meet the demand, 695,000 t of oil was imported in 1983-84 at the cost of about US$ 3 million (Rs 4,200 million = US$ 3 million). The consumption of edible oil during the last six years is given in Table 1. The major sources of vegetable oil are cotton seed (57%), rape seed and mustard (28%) and other oilseed crops (15%). The yield of various oilseed crops in Pakistan at present are low because of unadapted cultivars and poor management (Table 2).

Table 1. Production, consumption, and import of edible oils in Pakistan.[a]

Year	Production ('000 t)	Consumption ('000 t)	Imports ('000 t)	Import as % of Consumption	Value of Imports in U.S.$ (million)
1977-78	229	514	285	55	1.11
1978-79	210	571	361	63	2.11
1979-80	243	632	389	62	1.64
1980-81	228	673	445	66	1.80
1981-82	253	750	491	65	2.46
1982-83	220	860	640	74	2.62
1983-84	220	915	695	76	3.00

[a] Source: Strategy for oilseeds, Government of Pakistan, Ministry of Food, Agriculture and Cooperatives, 1982.

Table 2. Actual and potential yields of oilseed crops in Pakistan.[a]

Crop	Area ('000 ha)	Yield (kg/ha)	Potential Yield (kg/ha)
Rapeseed and mustard	433	572	2,765
Sunflower	16	946	1,800
Safflower	5	800	1,800
Soybean	4	423	2,500

[a] Source: Annual reports of coordinated program on oilseed crops (1977-1983).

History of Soybean Research in Pakistan

Commercial soybean cultivation in Pakistan commenced in the early 1970s. Research on soybean started at Tandojam in Sind in 1960 under a scheme of the Agricultural Research Council. A number of promising cultivars were selected. Some local black- and chocolate-colored soybean cultivars are being grown in the hills of northern Pakistan i.e., Hazara, Azad Kashmir, Swat, Dir, and Kurram agency. To improve these cultivars and to introduce better cultivars, a scheme

under the auspices of the Agricultural Research Council was started in 1965 in the Peshawar region with headquarters at Mansehra (Hazara). The trials were conducted at Tarnab and D.I. Khan. Cultivars Bragg and Lee were found promising and were approved by the National Action Committee for commercial cultivation in Pakistan in 1968-69.

Since the establishment of the oilseed coordinated program at PARC in 1975, extensive varietal evaluation work has been in progress at all the research institutes. The cultivars and germplasm for these trials were received from INTSOY and AVRDC.

In Pakistan, upland (60,300 ha) and lowland rice (1.92 million ha) is grown on an area of about 2.02 million ha. It is estimated that about 30% of the rice area remains fallow, while the rest is planted to wheat, legumes, and fodder in winter. Until now none of the fallow area is being utilized, although there is potential to grow these to soybean in the spring season. Suitable cultivars and appropriate management practices are being developed to grow soybeans in the fallow lands. Soybean is also being evaluated as an alternate crop to rice and other summer crops for the summer season. Soybean is also very suitable for planting on summer fallow land occurring in rainfed areas which have abundant moisture due to monsoon rains.

Problems of Soybean Production and Research

So far no commercial area is available on which soybean can be regularly planted on rotation without disturbing the main food, fibre, or feed crop which is the mainstay of agriculture in Pakistan. Some of the reasons for this are

1. The potential of soybean as a crop on conventional rotation has not been demonstrated.
2. Farmers are unaware of the production technology of soybean.
3. Specific duration bound (long, short, medium) cultivars, for which area is available have not been selected.
4. Rhizobium production and effective inoculation have not been demonstrated.
5. Quality seed is not available.
6. Harvesting and threshing procedures have not been studied.
7. The economics of soybean production is not understood.

Different area categories remain fallow at different times of the year (Table 3). To utilize these areas for soybean production, research objectives have been formulated.

Table 3. Estimated area for nontraditional oilseed crops.[a]

Land Description	Area ('000 ha)	Area Available for Oilseeds (%)	Total Area Available ('000 ha)
Dobari	1,900	30	570
Cotton-fallow	2,210	30	663
Rainfed	6,000	25	1,500
Riverine	4,500	75	3,375
Intercropping with sugarcane	946	25	236
Total	15,556		6,344

[a] Source: USDA/OICD estimates.

Research Objectives and Development Activities

1. Introduce and select high-yielding soybean cultivars for fallow areas lying idle in winter in the rice and cotton zone of Pakistan in Punjab and Sind from December to May; for rainfed

areas remaining fallow in summer from May to November; for Katcha lands (riverine lands) remaining fallow from October to July and flooded rest of the year; and for mixed inter- and relay-cropping in the main rabi and Kharif crops.

2. Develop appropriate agronomic practices including planting date, plant spacing, fertilizer requirements, inoculum requirements, plant population density, and irrigation needs for different areas mentioned in No. 1.

3. Select cultivars resistant to major diseases, such as soybean mosaic virus and purple seed-stain disease.

4. Initiate a small breeding program.

5. Develop a no tillage stubble planting of soybean in wheat, rice, and cotton.

Future Soybean Research

1. **Evaluation of soybean cultivars for different areas.** Germplasm will first be increased at Swat in Northwestern Frontier Province (NWFP) and at the National Agricultural Research Center (NARC). The rice remains fallow from November to end of May, while the cotton area may become fallow from end of November to end of February. Evaluation of soybean cultivars and lines will be done on rice fallows in Sind and cotton fallows in Punjab as a spring crop for planting in the first week of February. Since the winter is mild in Sind, soybean can be evaluated as a winter crop as well.

It will be tested as a summer (May–October) crop on areas where land remains fallow in summer when rice, cotton, or maize are not planted and on land where maize, sorghum, and millet give marginal yield. The Barani fallow areas during summer, when abundant moisture is available from July to September, will also be used. The Kacha areas which remain flooded from July to October also need to be evaluated for soybean cultivation during winter in the south and spring in the north.

2. **Evaluation of soybean as a companion crop.** Soybean may be evaluated as a mixed crop, intercrop, and relay crop of cotton, maize, tobacco, sugarcane, groundnut in summer and as a relay crop with wheat, rapeseed, and mustard in winter. The beneficial effects of soybean as a companion crop and its effect on rice, cotton, or other crops need to be evaluated.

3. **Soybean seed production.** Since soybean matures in May to October when the temperature is high, the seeds lose viability resulting in poor stand. Therefore, for seed production a separate area in the cooler foothills such as Hazara, Swat, and Parachinar is required. Alternatively, the autumn raised seed, which is planted in late July, can be used.

4. **Inoculum production.** In areas where soybean has not been planted previously, nodulation is poor and consequently yield is poor. Inoculum production and testing trials will be conducted to determine optimum inoculum production and application techniques. Initially, soil from soybean producing areas in the country may be used as a starter inoculum, and inoculum needs may be assessed for different soils after first soybean planting.

5. **Minimum tillage.** Since rice soil is difficult to cultivate and land vacated late by cotton may not leave much time for soil preparation for soybean, trials will be conducted on minimum tillage for soybean production. Research will also be conducted to assess whether soybean can be grown between wheat and summer maize which is planted in July.

Research Findings

Insect pests and diseases. The following insects attack soybean in Pakistan: stem borer (*Zygrita* sp.), white fly (*Bemisia tabaci*), green stinkbug (*Nezara viridula*) and lepidopterous

larvae (*Heliothis* sp.). To effectively control the above insect pests Dimecron, Malathion, Gusathion are sprayed on soybean plants.

A list of major soybean diseases observed at NARC, their causal organism, nature of injury, and yield losses are given in Table 4. Fungal diseases can be controlled by spraying with Dithane, Captan, and Benlate. Soybean cultivars resistant to diseases are being selected from the germplasm. Cvs. Celeste and Centennial have been found to be resistant to charcoal rot with less than 10% plants affected at NARC. Cvs. Ware, Bay, Desoto, and Gail were found to be resistant to yellow mosaic virus with less than 1% of the plants infected.

Table 4. Major soybean diseases observed at NARC.[a]

Disease	Causal Organism	Nature of Injury	Yield Losses
Charcoal rot	*Macrophomina phaseolina*	Root & stem rot	Up to 50%
Pod & stem blight	*Diaporthe phaseolorum*	Pod & stem blight, shrivelled pods	
Anthracnose	*Colletotrichum truncatum*	Brown spots on stem, pods & leaves	20%
Fusarium blight	*Fusarium oxysporum*	Root rot, seedling blight	Up to 50%
Purple stain	*Cercospora kikuchii*	Purple blotching of seed	Lower marketing value and germination
Bacterial blight	*Pseudomonas* sp.	Brown angular leaf spots	10-15% loss in susceptible cultivars
Bacterial pustule	*Xanthomonas* sp.	Leaf pustules	
Yellow mosaic	Bean yellow mosaic virus	Yellow mottling of leaves	Yield loss 21 to 61%

[a] Source: Annual reports of coordinated program on oilseeds, NARC, Islamabad.

Yield trials. Yield trials were conducted in different agroecological zones in Pakistan on introduced cultivars from all maturity groups. The highest yielder in each maturity group is given in Table 5. The yield data are the averages of different tests. The average performance of other cultivars tested so far is given in Table 6. The yield data of cultivars from AVRDC is given in Tables 7 and 8 for the year 1982 and 1983. In both years, AGS 62 topped the list followed by AGS 66.

Table 5. Highest-yielding soybean cultivars.

Maturity Group	Cultivars	No. of Trials	Yield (kg/ha)
00	Altona	4	918
0	Evan	1	601
I	Hark	5	1,279
II	Horsoy 63	1	1,702
III	Elf	2	1,846
	Adelphia	2	1,800
IV	Union	2	2,387
V	Dare	2	3,096
VI	Lee 69	6	2,987
VII	Gasoy 17	5	1,471
	Bragg	23	1,412
	Semmes	10	1,406
VIII	Hutton	2	2,337
	Hampton 266	1	1,959
IX	Jupiter	9	1,176

Table 6. Performance of soybean cultivars from 1973 to 1981 in Pakistan.

Maturity Group	Cultivar Name	No. of Trials	Yield (kg/ha)	Maturity Group	Cultivar Name	No. of Trials	Yield (kg/ha)
00	Altona	4	918	V	Dare	2	3,096
0	Evans	1	601		Bay	3	1,433
	Swift	3	535		Gill	13	1,425
	Hark	5	1,280		Forrest	25	1,176
I	Steele	4	1,129		Celeste	3	1,144
	Hodgson	5	987		Essex	7	928
II	Horsoy 63	1	1,702	VI	Lee 68	6	2,987
	Harcor	2	1,391		Pickett 71	6	1,877
	Amsoy 71	3	1,191		Davis	25	1,493
	Corsoy	5	1,000		Tracy	11	1,293
	Wells	6	888		Gail	3	1,269
	Beeson	6	832		PK 7394	2	1,150
III	Elf	2	1,845		Centennial	3	1,118
	Adelphia	2	1,800		Rillito	5	1,069
	William	32	1,371	VII	Gasoy 17	5	1,471
	Calland	25	1,208		Bragg	23	1,412
	Woodworth	13	1,119		Semmes	10	1,405
	William 79	1	1,095		Ransom	9	1,379
	Ford	5	316		Bossier	21	1,318
IV	Union	2	2,387		Braxton	2	667
	Clark 63	20	1,471	VIII	Hutton	2	1,233
	Cutler 71	14	1,317		Hampton 266	1	1,959
	Columbus	11	1,250		Hampton 266 A	17	1,452
	Franklin	7	1,207		Foster	1	1,375
	Bonus	8	1,195		Cobb	9	1,352
	Desoto	3	1,157		Hardee	11	1,310
	Mitchel	7	1,069		Improved Pelican	21	984
	James	5	1,043		Acc G 2120	3	939
	Crawford	4	967		UFV-1	1	922
	Cutler	1	750	IX	Jupiter	9	1,176
	Ware	3	602		Alamo	2	991

Table 7. Performance of soybean cultivars from AVRDC during 1982 at NARC, Islamabad, Pakistan.

Cultivar	Days to Flowering	No. of Pods Per Plant	100 Seed Wt. (g)	Yield kg/ha)
AGS 66	44	35	10.9	1,167
AGS 62	38	35	14.8	1,550
AGS 2	61	31	6.3	700
AGS 17	54	26	12.8	811
G 9946	50	30	15.3	667
G 9645	51	20	14.6	1,133
Bragg (loca.)	56	34	10.0	933
AGS 129	55	25	14.9	850
G 9946	53	28	17.6	700
AGS 130	54	26	14.2	633
AGS 135	55	23	10.1	917
G 2261	51	34	12.6	700
G 9925	55	23	10.5	967

Planting of soybean in the first week of June to mid-July gave optimum yield in the Kharif season in the plains for cultivars from maturity group V to VIII. Early sowing significantly

Table 8. Performance of soybean cultivars from AVRDC during 1983 at NARC, Islamabad, Pakistan.

Cultivar	Days to Flowering	No. of Pods Per Plant	100-Seed Wt.(g)	Yield (kg/ha)
AGS 66	44	29	11	1,175
AGS 62	39	32	15	1,556
AGS 2	60	20	8	804
AGS 17	53	25	13	825
G 9645	51	24	15	1,140
G 9946 (Emry-II)	51	18	16	712
AGS 129	55	35	15	931
AGS 130	55	16	15	709
AGS 135	53	23	11	1,016
G 2261	54	36	13	1,041
G 9925	54	24	11	1,109
G 9946	51	27	18	912
Bragg (local)	54	27	10	1,051

increased yields for cvs. Amsoy-71, William, and Bragg. Bragg matured 28 days later than William.

Seed rate of 75 kg/ha with a 30 cm row spacing resulted in high yield at Ayub Agricultural Research Institute, Faisalabad. In the Tandojam area the early sown crop (February 14) gave significantly higher yield than the late sown crop. Among the four cultivars (Loppa, Columbus, Bragg, and T-15), Columbus gave the highest yield (Table 9).

In a Rhizobium inoculation trial with 12 strains, strains S-140 and S-571 gave a yield of 4,046 and 4,642 kg/ha, respectively; the control gave only 2,994 kg/ha.

In an inoculation cum-fertilizer trial at two locations in Punjab, it was found that there were no significant differences between treatments (Table 10). In a seed and soil inoculation trial at two locations the results indicated that seed inoculation was effective (Table 11). In a soybean-cotton intercropping trial there were indications that additional income can be obtained by intercropping soybean, provided an adapted cultivar is planted (Table 12).

Table 9. Sowing dates and yield of cultivars during spring 1979 at Tandojam, Pakistan.

Cultivar	Yield (kg/ha)			
	Feb. 14	Feb. 27	March 12	Mean
Loppa	1,163	563	554	760
Columbus	1,000	954	658	870
Bragg	917	871	237	675
T-15	904	492	379	591
Mean	996	720	457	

Cropping systems. The following cropping systems were suggested suitable for different ecological zones:

For irrigated areas-

Cotton (June-Dec.)	-	Soybean (Feb.-May)	-	Cotton (June-Dec.)
Rice (June-Oct.)		Soybean (Feb.-May)		Rice (June-Oct.)

Table 10. Inoculation-cum-fertilizer trial conducted during autumn 1979 and spring 1980 at Faisalabad and Khanpur, Pakistan.

Treatment (N:P:K)	Yield (kg/ha)		
	Autumn 1979 Faisalabad	Khanpur	Spring 1980 Faisalabad
Inoculation + 100:75:50	1,071	1,231	1,002
Inoculation + 75:75:50	1,307	1,223	1,069
Inoculation + 50:75:50	913	1,060	1,162
Inoculation + 225:75:50	655	880	1,162
Inoculation	1,071	1,166	1,018
Control	919	1,265	1,228
Cultivar	Bragg	Bragg	Williams
Sowing date	26/07/79	12/08/79	20/2/80
Harvesting date	28/10/79	30/11/79	12/6/80

Table 11. Inoculation trial on soybean during autumn 1979 and spring 1980 at Faisalabad and Khanpur, Pakistan.

Treatment	Yield (kg/ha)		
	Autumn 1979 Faisalabad	Khanpur	Spring 1980 Faisalabad
Seed inoculation	1,102	682	1,283
Soil inoculation	932	519	1,155
Seed + soil inoculation	995	457	1,256
Control	1,089	346	1,071
Cultivar	Bragg	Bragg	Williams
Sowing date	26/07/79	12/08/79	20/02/80
Harvesting date	28/10/79	20/11/79	12/06/80

Table 12. Intercropping soybean in cotton at Sukrand, Tandojam, Pakistan.[a]

Treatment	Yield (kg/ha)		Harvesting Date
	cotton	soybean	
Cotton alone	1964		
Cotton + Hampton 266-A	1976	175	30/09/79
Cotton + Sue Hasine	1961	138	15/10/79
Cotton + Loppa	1774	740	13/10/79

[a] Planting date 17/6/79

For the Barani areas:

Wheat (Nov.-April) Soybean (July-Oct.) Wheat (Nov.-April)

Groundnut (May-Nov.) Wheat (Dec.-May) Soybean (July-Oct.) Fallow Groundnut (May-Dec.)

Groundnut (May-Nov.) Soybean (Feb.-May) Groundnut (May-Nov.)

Intercropping of soybean under shade. Northwestern Frontier Province (NWFP) is considered to be the best area for tobacco cultivation, and has 20,000 ha of Virginia flue cured tobacco. Tobacco remains in the field from February to June; from the end of May and beginning of June picking of the leaves starts. Trials were conducted to intercrop soybean with tobacco after two pickings. So far, the practice has not been adopted by the farmers because the yield of intercropped soybean is low because of shading by tobacco. Extra labor is also involved for sowing soybean when the farmer needs the labor for tobacco picking, tying, curing, etc.

Similarly, intercropping with maize is frequently suggested but no practical guidelines have been given to the farmers. Trials on intercropping soybean with sugarcane have also been conducted. Intercropping soybean with apple, pear, peaches, and plum orchards is very common in Swat.

Varietal trials. The INTSOY's ISVEX trial is tested at Islamabad, Swat, Lahore, and Faisalabad (Fig. 1). The results of each location are reported in Tables 13 to 16. At Islamabad, cv. Bragg gave consistently higher yields, followed by cvs. Cobb and Williams. Yield varied from year to year (Table 13). The yield per hectare was the highest at Swat because of low temperature and availability of sufficient moisture throughout the year (Table 14). The promising cultivars are Lee-68, Davis, Bragg, and Williams.

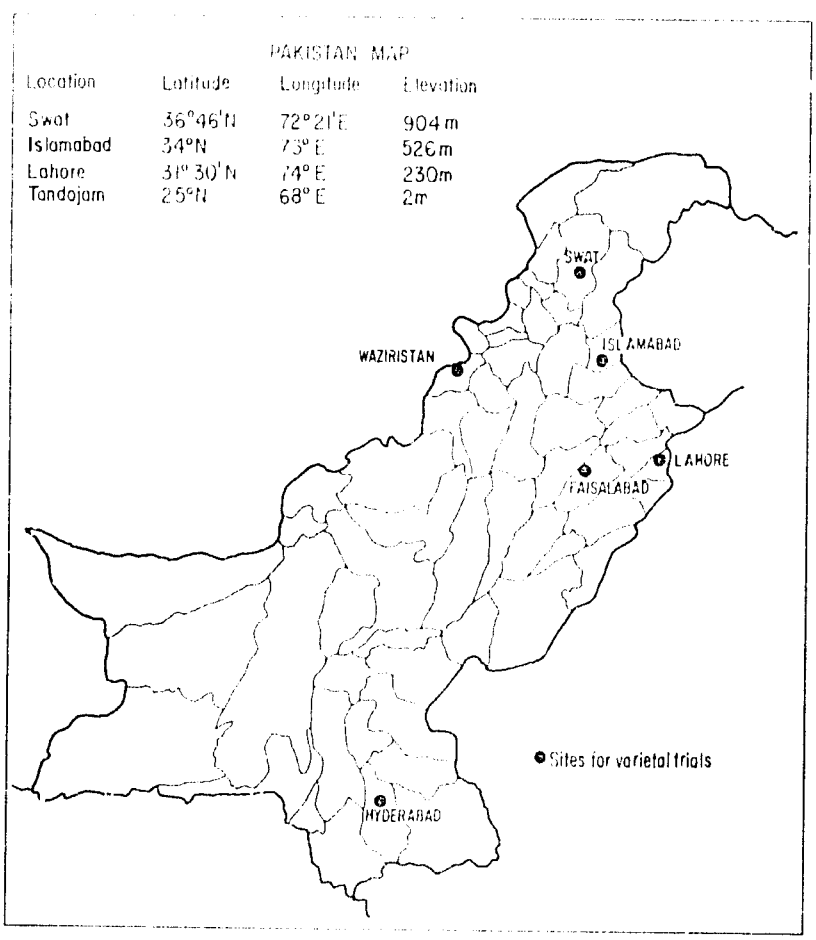

Fig. 1. Locations in Pakistan where soybean varietal trials are conducted.

Table 13. Performance of soybean cultivars at NARC, Islamabad, Pakistan.

Cultivar	Yield (kg/ha)				
	1975	1976	1978	1979	Average
Cobb	364	-	2,386	923	1,225
Williams	363	1,019	1,910	1,251	1,138
Bossier	275	1,125	1,585	1,088	1,019
Improved Pelican	224	-	1,268	446	646
Forrest	206	983	1,478	917	896
Calland	172	866	1,058	1,154	813
Davis	165	1,097	1,941	1,017	1,055
Bragg	-	1,129	2,094	1,071	1,431
Cutler	-	1,097	1,231	1,154	1,161
Ransom	-	929	1,409	1,171	1,170
Gasoy	-	-	1,941	1,000	1,471
Mitchel	-	-	927	1,092	1,009
Franklin	-	-	871	1,309	1,090

Table 14. Performance of soybean varieties at Swat, Pakistan.

Cultivar	Yield (kg/ha)				
	1973	1974	1975	1976	Average
Williams	3,026	493	3,579	2,168	3,316
Bragg	3,593	1,181	-	3,025	3,602
Davis	4,123	4,347	3,378	3,261	3,776
Clark 63	2,269	3,874	3,473	1,276	2,723
Hill	3,215	3,709	-	378	2,434
Hampton 266-A	1,714	1,216	2,268	-	1,733
Pickett 71	3,782	-	-	2,836	3,309
Lee 68	4,826	4,358	3,508	-	4,231
Cutler 71	3,404	-	-	2,097	2,751
Improved Pelican	3,215	2,091	1,512	-	2,272
Tracy	-	2,888	2,953	-	2,920
Forrest	-	3,236	2,173	1,453	2,288
Woodworth	-	-	3,307	1,994	2,651
LSD 5%	340	378	357	323	-

Table 15. Performance of soybean cultivars from 1975 to 1979 at Lahore, Pakistan.

Cultivar	Yield (kg/ha)					
	1975	1976	1977	1978	1979	Average
Williams	540	119	2,063	1,430	960	1,022
Columbus	524	65	1,930	-	1,171	923
Calland	496	88	1,794	288	1,606	854
Forrest	379	71	757	301	-	377
Davis	289	73	-	323	-	288
Cutler 71	-	51	2,136	884	829	975
Hodgson	-	-	1,467	1,381	835	1,228
Steel	-	-	1,393	1,732	446	1,190
Corsoy	-	-	1,135	1,816	810	1,254
Elf	-	-	-	2,419	1,272	1,846
Mitchel	-	-	-	1,167	1,125	1,146
Franklin	-	-	-	1,149	1,560	1,355

At Lahore and Faisalabad, the yield in general was low because of high temperature at seed-filling, although at both locations irrigation water was available. The results show that cv. Elf is high-yielding, followed by cvs. Franklin and Hodgson at Lahore (Table 15). At Faisalabad cvs. Wayne and Loppa were the highest-yielding among the seven cultivars evaluated but the yields obtained were generally low and uneconomical (Table 16).

Table 16. Performance of soybean cultivars from 1975 to 1983 at Faisalabad, Pakistan.

Cultivar	Yield (kg/ha)						
	1975	1978	1979	1980	1982	1983	Average
Davis	514	-	-	-	517	-	515
Williams	435	395	703	819	277	418	508
Wayne	-	347	1,053	-	-	-	703
Loppa	-	342	957	-	-	-	649
Ford	-	189	916	593	386	305	478
Sueshine	-	120	1,093	-	565	-	593
S.B.L.	-	309	618	624	582	359	498

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Soybean Varietal Testing Program in Burma

Pe Maung Thein
Deputy General Manager
Food Legumes Division
Agricultural Research Institute
Pyinmana, Burma

Introduction

The Food Legumes Division at the Agricultural Research Institute (ARI) is mandated to develop dryland legume crops for both nonrice and rice-based cropping systems. However, it cannot handle all the different legume crop species within the country. Priority has to be given according to the State's interest. So far, eight crops were chosen for improvement with soybean at the last in this priority list. However, the recent deficit in edible oil has emphasized the importance of soybean for research and development.

Varietal improvement is a major activity which is expected to increase cropping intensity and yield. Since soybean is grown mostly as an upland, nonirrigated crop, it has to withstand drought as well as water-logging to fit to the prevailing rainfall patterns in different regions. The development of early-maturing and photoperiod-insensitive cultivars which are resistant to pests and diseases is desirable. Cultivars responsive to minimum tillage and limited use of fertilizers should also be identified.

Results of Varietal Testing

Two soybean varietal tests were conducted in 1983-84. One was for a non-rice cropping and the other, for a rice-based system. The former trial was planted in mid-August, which coincided with the typical planting season of food legume crops following sesame, sorghum, etc. Soybean was planted after rice in the latter pattern.

Nine local soybean cultivars were tested under upland conditions, with Williams 82, an exotic cultivar, as the check. Grain yield and other agronomic characters are presented in Table 1. Local cultivar Shwemyaing Pale got the highest yield (1.57 t/ha). However, it was not significantly better than Williams 82. Local cultivars are taller (except Shwe-ywah-lon-thay) than the check and showed a tendency to lodge. Some local cultivars had larger seed size than Williams 82.

Eighteen exotic soybean cultivars were tested under upland conditions, against two local cultivars as checks. Grain yield and other agronomic characters are presented in Table 2. Jupiter produced the highest yield (2.28 t/ha) which was significantly better than the remaining cultivars.

In collaboration with IRRI, adaptability trials at Wakema (lower Burma) and Patheingyi (upper Burma) were conducted after the rice crop. Grain yield and other agronomic characters are presented in Tables 3 and 4. Genotype x environment interaction was observed. Plant height and days to maturity were greatly affected by environmental factors. Multi-locational tests should be conducted to further establish adaptability.

Future Directions

The Food Legumes Division in ARI mainly depends on IRRI, AVRDC, and INTSOY for soybean cultivars that can be used in intensive nonrice and rice-based cropping patterns. This will continue for many more years because of limited manpower and resources in the Division. Evaluation tests and adaptability trials will be mainly conducted for varietal improvement. The

Table 1. Yield and agronomic characters of local soybean cultivars evaluated under upland conditions at ARI, Yezin, Burma, 1983-84.

Yield Rank	Cultivar	Yield (t/ha)	Plant Height (cm)	No. of Branches/ Plant	No. of Pods/ Plant	No. of Seeds/ Pod	100 Seed Wt. (g)
1	Shwemying Pale	1.57	83	6.7	69	2.2	10.1
2	Williams 82 (check)	1.39	43	1.9	24	2.0	15.4
3	Lashio-1	0.99	48	2.9	15	1.4	18.5
4	Lashio-2	0.91	54	3.8	22	1.7	12.4
5	Lashio-3	0.81	58	3.4	17	1.6	14.7
6	Shansein	0.72	58	3.7	17	1.9	13.4
7	Lashio-4	0.69	47	2.8	18	1.5	18.8
8	Lashio-5	0.66	48	3.7	13	1.4	13.8
9	Shwe-wah-lon-thay	0.62	42	3.0	18	1.7	9.3
10	Ahsein-thay	0.59	53	4.4	21	1.7	9.5
	Mean	0.84	53	3.6	24	1.7	13.6
	CV (%)	22.41	13	20.0	19	17.0	10.2
	Significant (* = 5%, ** = 1%)	**	**	**	**	*	**
	LSD 0.05	0.29	10	1.1	7	0.4	2.0

Table 2. Yield and agronomic characters of exotic soybean cultivars evaluated under upland conditions at ARI, Yezin, Burma, 1983-84.

Yield Rank	Cultivar	Yield (t/ha)	Plant Height (cm)	No. of Branches Plant	No. of Pods/ Plant	No. of Seeds/ Pod	100-Seed Wt. (g)
1	Jupiter	2.28	64	4.9	41	2.2	16.1
2	Ecuador	1.69	47	3.5	39	2.0	17.3
3	Shwemyaing Pale (check)	1.68	82	6.9	98	2.1	9.3
4	AGS 129	1[illegible]	49	2.6	25	2.3	17.6
5	G 9645		40	3.4	34	2.0	15.3
6	Improved Pelican	1.3[illegible]	69	3.9	47	2.1	14.6
7	G 9946	1.35	42	3.2	35	2.2	18.6
8	AGS 2	1.32	62	2.9	40	2.1	5.9
9	AGS 12	1.17	44	3.7	22	1.9	13.6
10	G 9646	1.09	41	4.7	49	2.1	12.6
11	G 9925	1.08	51	3.4	50	2.0	14.1
12	AGS 135	1.06	47	3.0	30	1.9	12.1
13	AGS 130	1.01	44	2.8	23	1.7	15.3
14	AGS 58	0.94	47	4.1	30	1.9	16.3
15	Williams 82	0.92	46	2.2	26	2.2	14.7
16	AGS 66	0.88	33	3.2	27	2.0	11.2
17	G 2261	0.79	40	3.5	21	1.6	12.8
18	AGS 62	0.76	36	2.0	21	2.2	13.4
19	AGS 17	0.75	39	2.5	19	1.6	12.1
20	Lashio (check)	0.40	42	3.6	16	1.6	13.9
	Mean	1.17	48.2	3.5	35	2.0	13.8
	CV (%)	23.40	15.9	32.0	32	9.5	18.3
	Significant (* = 5%, ** = 1%)	**	**	**	**	**	**
	LSD 0.05	0.40	11.0	1.6	16	0.3	3.6

evaluation studies will be handled by the institutional programs, and the adaptability tests will be conducted in collaboration with the Applied Research Division (ARD) in the research stations. Some adaptability tests and most of the superimposed trials will be conducted in farmers' fields

by the Cropping Systems Division. The seeds for multilocational trials, breeders, and foundation seed stocks will be provided by the Food Legumes Division.

Table 3. Yield and agronomic characters of soybean cultivars evaluated after rice at Wakema, Burma, 1983-84.

Yield Rank	Cultivar	Yield (t/ha)	Days to Maturity	Plant Height (cm)	100-Seed Wt. (g)
1	GC 30290-11-11	0.45	85	18	12.4
2	Clark 63	0.41	83	19	11.2
3	Shan Sein (check)	0.20	81	22	10.0
4	GC 30050-2-17	0.19	85	18	12.3
5	UPL-SY-2	0.18	83	19	12.2
6	11-4	0.17	85	18	13.6
7	G 2261	0.16	83	21	12.0
8	Guntur	0.13	81	21	8.9
9	SJ 5	0.13	85	27	12.0
10	Line 1682/1343-1-10	0.11	85	25	8.2
11	Lokon	0.09	85	24	8.1
12	7207-1	0.08	85	24	10.6
13	GC 50106-4-7	0.07	85	19	6.4
	CV (%)	20.22	2.52	12.4	6.8
	LSD 0.05	0.06	NS[a]	4.3	1.2

Table 4. Yield and agronomic characters of soybean cultivars evaluated after rice at Patheingyi, Burma, 1983-84.

Yield Rank	Cultivar	Yield (t/ha)	Days to Maturity	Plant Height (cm)	100-Seed Wt. (g)
1	11-4	0.74	105	64	14.2
2	Line 1682/1343-1-10	0.73	105	38	8.4
3	7207-1	0.72	106	65	12.8
4	SJ 5	0.72	104	58	13.3
5	Guntur	0.72	98	45	8.5
6	Lokon	0.63	108	63	9.4
7	Shan Sein (check)	0.56	97	46	9.4
8	GC 50106-4-7	0.50	105	61	9.2
9	UPL-SY-2	0.48	91	61	13.7
10	G 2261	0.48	97	43	13.3
11	Clark 63	0.25	92	58	13.8
12	GC 30050-2-17	0.24	104	57	11.6
	CV (%)	0.14	10	8	4.9
	LSD 0.05	0.09	NS[a]	7	0.9

[a] NS = Not significant.

Working Group Discussions

Group I: Improvement, Productivity, and Adaptation of Soybean

S. Shanmugasundaram
Leader, Legume Program
Asian Vegetable Research and Development Center
P.O. Box 42, Shanhua, Tainan 74199
Taiwan, China

It was reiterated by the group that the adaptation and productivity of soybean in Asia needed to be improved. Currently, IARCs (AVRDC, IITA, and INTSOY) and a number of national programs have soybean varietal improvement programs. IRRI is also deriving such improved materials for use in rice-based cropping systems. The group agreed to the importance of considering the specific problems stated by the national programs.

In attaining the objectives there is a basic need to generate fundamental information on the problem, the extent of yield loss due to the problem, and the best means to attack the problem, so that it can be minimized or eliminated. A multidisciplinary-team approach should be used to define the problem. The solution may be through genetic means or through environmental manipulation or a combination of both.

We need to determine what needs to be centralized in research and what needs to be devolved. Whether it is national or international, it should be fostered, developed, and strengthened. The proposed Asian Soybean Improvement Network (ASIN) will primarily be a service-oriented coordinating unit with funds to foster national and international cooperation. The capabilities and competence of each of the IARCs and national programs need to be determined so that they can be strengthened.

Objectives of the National Program

The objectives of the national program are as follows:

1. Stable, high yield: with early maturity (70-80 days) about 1 t/ha; higher maturity days yield should be more than 1.5 t/ha.
2. Resistance

   Diseases: Viruses, YMV, SMV, Rust, Bacterial pustule, Bacterial blight, Arthracnose, Charcoal rot, Fusarium blight, Macrophomina blight, Pod and stem blight, and Frog eye leaf spot.

   Insects: Beanfly, Pod borer, Stink bug, Girdle beetle, Defoliators, and Whitefly.
3. Good seed quality
4. Wide adaptability, specific adaptability, photoperiod- and temperature-insensitivity
5. Tolerance to moisture stress and water-logging
6. Promiscuous nodulation and biological nitrogen fixation
7. Adaptation to inter- and mixed-cropping and shade tolerance
8. Tolerance to acidic and alkaline soils
9. Adaptation to minimum input, no-tillage, and responsive to inputs
10. Vegetable soybeans
11. Cold tolerance

Information Exchange

Information exchange among the ASIN members and Centers is essential. National programs which have specific objectives, breeding programs, and methods of attacking a common problem may be grouped and urged to join hands in solving pressing problems, so that progress can be made rapidly. Results from such programs can be beneficial to other countries with similar problems.

Countries which lack personnel and require assistance in hybridization and obtaining early generation breeding materials may seek help through ASIN which can make the necessary arrangements with international or national programs. However, both donor and recipient should exercise extreme caution to avoid the inadvertent introduction of potentially dangerous diseases and/or insects through distribution of segregating populations.

In screening for diseases, insect pests, and stress resistance/tolerance, there is a need to understand phenology, population dynamics, insect behavior, and yield loss. International centers and national programs can develop the methodology so that the latter can take up the work. It may be wise to bring consultants to generate such information within the country.

Based on long term data on the plant pest relationship, a useful model can be developed in pest management which may be applicable to other locations. Meanwhile, national programs should keep the pest under economic threshold level. Basic information and screening techniques for the control of insect pests, diseases, weeds, and stresses need to be developed and disseminated to national programs and centers. It is the responsibility of national programs to determine the biology and other data on pests. The information has to be generated where it can be best developed. An interim management package is required which can be improved upon as additional data are obtained.

International programs shall cooperate with national programs on areas that require collaboration. Whenever national programs desire to take the leadership, the IARC's shall give support and collaboration to the best of their ability. For example, AVRDC can cooperate on soybean rust, beanfly or other areas of expertise with Indonesia and Thailand. Australia may help on wet-soil culture. Collaboration among national programs may also be established.

Production training is offered at IITA beginning January for 8 to 10 weeks. Contact person is R. K. Pandey. AVRDC is offering regular five-month training and specialized courses. IDRC is a potential donor for specific areas of training. The contact persons are D. V. Castro, C. Y. Yang, and S. Shanmugasundaram. Graduate training may be arranged in any U.S., Australian, or other universities and the research may be carried out in one of the IARC's in the tropics. Other locations for training are India, Australia, Philippines, Nigeria, Taiwan, and Thailand. Efforts should be made to develop and foster in country training through ASIN.

It is recommended that ASIN explore how best FAO's TCDC project and ASIN can get together, to work and utilize the funds for common goals.

There is a need to exploit the local cultivars. It is suggested that countries desiring to collect, evaluate, and multiply the local germplasm can develop a project proposal and may submit to IBPGR for consideration.

Information exchange and communication between members is an essential component of the project.

Members of Group I

1. Sumarno - Indonesia
2. V. Arulnandhy - Sri Lanka
3. Rudy Navarro - Philippines
4. S. R. Singh - Nigeria
5. Ramli bin Mohd Noor - Malaysia
6. N. S. Talekar - Taiwan
7. Akhtar Beg - Pakistan
8. Mike Erwin - U.S.A.
9. Don Byth - Australia
10. Francois Dauphin - Indonesia (ESCAP, CGPRT)
11. J. S. Siemonsma - Indonesia (Malang, Dutch Project)
12. S. Shanmugasundaram (Chairman) - Taiwan (AVRDC)

Group II: Soybean Testing

H. E. Kauffman
Director
International Soybean Program (INTSOY)
University of Illinois
113 Mumford Hall, 1301 West Gregory Drive
Urbana, Illinois 61801, U.S.A.

The group focused its deliberations on ways cooperative soybean-testing activities in the region can strengthen national soybean research programs and raise the productivity of soybeans on farmers' fields.

The following activities were recommended:

I. Soybean testing for the region

1. Screening nurseries (for hot spots)

   a. Disease - rust screening nursery (AVRDC)
   b. Insect - pod borer screening nursery (AVRDC, MARIF)

2. Regional yield trials (ASIN trials)

   a. Tropical lowland - IRRI/IITA
   b. Tropical upland - IITA/IRRI
   c. Subtropical lowland - AVRDC
   d. Subtropical upland - AVRDC

II. Collaborative research

1. Reference yield trial (Philippines/Indonesia/Taiwan)

   The purpose of the trial is to determine the yield potential of soybeans and to help identify constraints limiting yield.

2. Virus diseases (INTSOY/Australia/AVRDC/Netherlands/Japan)

   The purpose of the research is to identify the virus complexes severely affecting soybeans in tropical testing and develop guidelines for practical control measures.

3. Integrated pest management (IPM) (INTSOY)

   The purpose is to review and apply IPM practices in production situations.

4. Utilization (INTSOY/CGPRT)

   The purpose is to promote processing and utilization of soybean products in home and village situations.

5. Socio-economics (CGPRT/AVRDC)

   The purpose is to conduct a benchmark study on soybean production, processing, and utilization in the region.

Members of Group II

1. Nark Potan - Thailand
2. R. K. Pandey - Philippines
3. Ruben Villareal - Philippines
4. R. M. Abiley - Philippines
5. Rajman P. Chaudhary - Nepal
6. Virgilio Carangal - Philippines
7. Omar Hidayat - Indonesia
8. Jerry McIntosh - Indonesia
9. Libertito Feliciano - Philippines
10. Isidro Domingo - Philippines
11. Ramon Bonifacio - Philippines
12. J. A. Jackobs - U.S.A.
13. Shiro Okabe - Indonesia
14. P. A. Batugal- Philippines
15. Rasiden Azwar - Indonesia

Proposal

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Asian Soybean Improvement Network

S. Shanmugasundaram
Leader, Legume Program
Asian Vegetable Research and Development Center
P.O. Box 42, Shanhua, Tainan 74199
Taiwan

Introduction

Soybean is the most important protein and oil crop in Asia. Yet during the past decade, soybean production in Asia has been stagnant, whereas the demand for soy products has increased dramatically (Table 1). The average yield of soybean in the Asian countries in 1983 was 1.1 t/ha as against 1.6 t/ha for the world. Therefore, there is considerable room for improving the average yield in Asia.

Table 1. Changes in soybean production and trade in Asia between 1962 and 1982.[a]

Production	1961-65	1972	1982
Area (1000 ha)	14,877	15,888	10,778
Production (1000 t)	11,825	12,790	11,246
Yield/ha (kg)	795	805	1,043
Trade	1962	1972	1982
1. Soybeans net imports (t)	1,674,300	3,827,200	7,384,700
2. Soybean oil net imports (t)	45,600	114,000	1,406,400

Changes in the last 20 years

Area: Overall reduction of 28%
Production remained at the same level in 1982 as in 1961-65; yield increased by 31%.
Net imports of beans and oil increased 3.4 and 30 times, respectively.

[a] Source: FAO monthly bulletin of statistics, Vol. 13, April 1964, Vol. 23, April 1974, and Vol. 7, January 1984.

Until recently almost all the Asian countries have concentrated their research efforts on cereal crops. As a result, priority for research personnel and research funds was directed towards cereal crop improvement. The demand for grain legumes (pulses) and oilseed crops in developing countries has increased more rapidly than population growth. However, in most countries the production of legumes and oilseeds has either been static or has declined due to lack of improved cultivars and nonadoption of appropriate production technology. Unfortunately, the 'Green Revolution' in cereal production has adversely affected grain legume and oilseed production in some countries, since the high-yielding cereal crops have replaced less competitive traditional legume and oilseed crop hectarage. Prices of edible oil and legumes have unduly increased in many countries, putting an especially heavy burden on middle- and low-income families.

Role of Soybean in Asia

The need for increasing food supply and improving food quality, especially in developing countries in Asia, has focused attention on soybean as a major world crop which has an important

role to play in meeting the expanding demands for protein, edible oil, and calories. Soybean can be used in many forms: fresh, frozen or canned green soybean, dry beans, soybean sprouts, soybean milk, soybean mash or pulp, soybean curd, and soybean sauce. Soybean is also a valuable source of oil, flour, and grits. Soy protein concentrate, protein isolate, and textured protein have found their way into the multifarious commercial food industry. Due to its good-quality protein, soybean is used as a substitute for meat and, combined with meat, as an extender. Soybean is also used as livestock and poultry feed.

In spite of all the above desirable characteristics, research and development efforts on soybean in Asia have been inadequate. Lack of sufficiently trained personnel in different disciplines and inadequate financial resources to make a concerted research effort are but a few of the problems. Therefore, the national and international soybean research and development programs in Asia need to be strengthened.

Strategies for Soybean Improvement in Asia

To improve soybean production in developing Asian countries, it is necessary to consolidate national and international research efforts. It is also essential to understand the location-specific problems limiting soybean production in various countries. To accomplish the above goal a cooperative effort for planning, executing, and monitoring soybean improvement needs to be developed. Such an effort is expected to complement the already ongoing research efforts, sharpen the focus of specific countries, and pool the international and national resources to mount an effective research thrust. At the Soybean Varietal Improvement Workshop organized by INTSOY, IRRI, AVRDC, and the Government of Indonesia in Jakarta, Indonesia on July 22, 1984, the participants from various national programs discussed the Asian Soybean Improvement Network (ASIN) and agreed on the ASIN proposal which is expected to bring available expertise from national and international programs into focus and improve research coordination.

Rationale for the Asian Soybean Improvement Network

The international activities of the University of Illinois initiated soybean research for production, processing, and utilization in India in 1966. After establishing the International Soybean Program (INTSOY) in 1973 the adaptability of U.S. cultivars was evaluated around the world through the International Soybean Variety Experiment (ISVEX) trials. The results of the trials demonstrated the high yield potential of a number of U.S. cultivars. INTSOY has recently diversified its international testing by including cultivars from soybean breeders around the world. They have also grouped the cultivars as tropical, subtropical, and temperate. Furthermore, different levels of testing were initiated in the ISVEX.

The Asian Vegetable Research and Development Center (AVRDC) included soybean as a mandate crop for research and development in the tropics. By making use of the useful germplasm available from the temperate regions, AVRDC has improved the tropical cultivars by incorporating desirable characteristics such as photoperiod-insensitivity, resistance to diseases and insects, and adaptability to different situations posed by various types of cropping systems. AVRDC provides advanced selections and cultivars from breeders in different regions through the AVRDC Soybean Evaluation Trials (ASET). Recently the AVRDC Vegetable Soybean Evaluation Trial (AVSET) has also been initiated. AVRDC also provides national programs with valuable germplasm having specific characteristics and segregating populations for selection under their conditions. Research and production training programs at AVRDC are geared to meet the local conditions in Asia. An international working group on soybean rust has also been established which publishes an annual newsletter.

The International Institute for Tropical Agriculture (IITA) initiated research on soybean for the tropics in Africa with major emphasis on seed longevity and promiscuous nodulation.

With the addition of an agronomist/breeder at IRRI, IITA is planning to collaborate with AVRDC, IRRI, and national programs to test the improved soybeans from IITA in tropical Asia.

IRRI's Asian Rice Farming Systems Network (ARFSN) was involved in the testing of improved soybeans in lowland rice area either as a pre- or as a post rice crop.

Other international organizations such as the United Nation's Food and Agricultural Organization (FAO), the United Nation's Development Program (UNDP), the United Nation's Economic and Social Council for Asia and Pacific's Course Grain, Pulses, Root and Rubber Crop Center (ESCAP CGPRT), European Cooperative Soybean Network, International Atomic Energy Agency (IAEA), and the Australian Center for International Agricultural Research (ACIAR), and others have been actively supporting the national programs for soybean research and development.

The participants from national programs in Bangladesh, Burma, Indonesia, India, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, and Thailand have soybean programs to solve or minimize specific problems so that soybean production can be improved. Although soybean was only recently introduced in several of them, production and utilization are making rapid progress. Recognizing the importance of soybean as a crop and commodity, participants from all of these countries expressed the need to increase productivity and promote utilization. To assist in their research efforts the international research and funding agencies provide various levels of support. In some cases such assistance overlap each other.

The national programs recognize some of the problem areas; however, the priorities have not been well established. Research is ongoing in some of the national programs, but better defined objectives can make them more efficient. The participants indicated that the international programs should assist them by organizing ASIN and undertaking the coordination and articulation of research and development directions. The participants also suggested that ASIN should include monitoring tours, workshops, training, and information service components.

Organizational Set-up and Objectives of ASIN

The objectives of the ASIN are to:

1. Provide a mechanism for cooperative research and planning by Asian national programs and international programs operating in Asia;
2. Organize working-group meetings to promote the exchange of information and plan cooperative research and monitoring tours to study problems and progress;
3. Assist in developing and identifying improved cultivars for the soybean-growing areas of the tropics;
4. Assist in developing appropriate management technology for specific locations;
5. Assist national programs in the transfer of suitable methodologies and appropriate technologies from international centers and among national programs; and
6. Promote long-term upgrading of national soybean programs.

The ASIN Working Group is composed of program leaders from each collaborating country and representatives from IRRI, AVRDC, IITA, INTSOY, CGPRT Center, ACIAR, and Japan (Table 2). Soybean scientists from other parts of the world may be invited during the working-group meeting. The Chairmanship of the Working Group will be rotated among the IRRI, AVRDC, ACIAR, or Japanese representatives. An advisory committee will be formed consisting of the regional and country coordinators of the UNDP/FAO-funded project, TCDC, for research and development of food legumes and coarse grains in the tropics in Asia; and selected representatives from other countries will provide overall guidelines and formulate policies.

The Secretariat of ASIN will be co-located at AVRDC and IRRI. The secretariat of ASIN will have two joint coordinators (and support staff), one from AVRDC and the other from the IRRI/IITA legume project. The coordinators will formulate and coordinate the activities with

Table 2. Potential composition of the Asian Soybean Improvement Network Working Group.

Asian Vegetable Research and Development Center (AVRDC)[a] (Joint Secretariat)
Australian Center for International Agricultural Research[a]
Australia[a]
Bangladesh
Bhutan
Burma
China
CGPRT Center[a]
India
Indonesia[a]
International Institute for Tropical Agriculture/IRRI[a]
International Soybean Program[a]
International Rice Research Institute[a] (Joint Secretariat)
Japan
Korea
Laos
Malaysia[a]
Nepal[a]
NiFTAL[a]
Pakistan[a]
Philippines[a]
Sri Lanka[a]
Thailand[a]
Vietnam

[a]Countries or institutions that participated in the Soybean Varietal Improvement Workshop in Jakarta, Indonesia on July 21-22, 1984.

the national programs. The joint coordinators, in consultation with the chairman and the advisory committee, will organize monitoring tours, workshops, and training. The secretariat at AVRDC requires a budget for the salary of an agronomist/plant breeder and travel expenses for the joint coordinator. Funds will also be required for monitoring tours, workshops, training, and special collaborative research projects. The working group will formulate policies and strategies for soybean improvement and provide guidance to collaborators on various aspects of soybean improvement and production.

Collaborative Research Activities

Since soybean flowering and pod-setting are sensitive to photoperiod and temperature, adaptation of cultivars may be dependent on latitude and altitude. However, with the use of photoperiod- and temperature-insensitive germplasm and by following disruptive seasonal selection, both specific season adapted cultivars and those with fairly wide adaptability may be selected.

AVRDC intends to continue incorporation of desirable characters into tropical cultivars, to develop cultivars with wide adaptability for the tropics with a range of maturity duration, and to improve levels of pest and disease resistance and/or tolerance. Selections will also be made for adaptation to various cropping systems, including rice. IITA is expected to make further progress in incorporating good seed quality and promiscuous nodulation in tropical soybean.

INTSOY will make available a collection of newly released cultivars and promising breeding lines from national soybean breeders around the world, as well as material from the INTSOY and Latin American breeding programs. The national programs in India, Indonesia, Pakistan,

Philippines, Sri Lanka, Taiwan, and Thailand are developing cultivars with desirable characteristics for adaptation in the tropics either in a crop rotation with rice or on upland situations.

The primary focus on varietal improvement and testing is clearly justified; however, there is a need to strengthen the contribution by other disciplines. Several pests, diseases, and management constraints are yet to be identified; the damages due to pests and diseases need to be evaluated further and adequate control measures developed. Appropriate, economical, maximum-yield management practices need to be identified. The proposed ASIN, in addition to focussing on varietal improvement and testing, will also be involved in the following four research areas preferably to be conducted in participating countries:

1. Development and testing of genetic materials for specific traits through national and international programs;
2. Collaborative research on yield constraints and reference yields and the development of an integrated pest and disease management;
3. Ways and means of soybean processing and utilization at the village level; and
4. Socio-economic studies.

The following is a work plan for the collaborative research to be coordinated through the ASIN:

1. Varietal development and testing. A consolidated regional varietal program will be established. The testing program will consist of the following two levels of testing:

a. ASIN initial evaluation trial. This observational trial will evaluate large numbers of breeding lines/cultivars from the region and the world. Selected test locations are given in Table 3.

Table 3. ASIN initial evaluation trial sites.

Country	Location or Site	Latitude	Remarks
Korea	Suweon	35°N	One season[a]
Malaysia	Serdang	4°N	Two seasons[b]
Philippines	Los Banos	14°N	Two seasons[c]
Philippines	Mindanao	7°N	Two seasons
Philippines	Central Luzon	17°N	Two seasons[d]
Taiwan	Shanhua	23°N	Three seasons[e] (four trials)
Thailand	Kamphaensan	15°N	Two seasons[f]
Thailand	Chiang Mai and Chainat	18°N	Two seasons[g]
Indonesia	Bogor/Malang	7°S	Two seasons[h]

[a] Entries will be screened primarily for virus disease reaction.
[b] Malaysia will coonerate with AVRDC in conducting the trial.
[c] Entries will be evaluated under pre- and post-rice situations.
[d] Entries will be evaluated under lowland conditions.
[e] Trials will be conducted in spring, summer, autumn, and under no-tillage rice-stubble culture in autumn.
[f] Entries will be evaluated under upland conditions by the Thailand outreach program of AVRDC.
[g] One trial will be conducted in Chiang Mai under higher elevation in the cool season and another will be at Chainat in the hot lowland in the dry season.
[h] Entries from AVRDC, IITA, INTSOY, and other programs.

b. ASIN yield trials. Several yield trials will be composed of entries from the national evaluation trials. The number and types of trials will be determined by the Working

Group. The materials for all ASIN trials will be distributed by the joint coordinators. The trial data will be returned to the joint coordinators whose responsibility is to process it and prepare the report for review at the annual workshop at which a decision on selection of entries for future trials can be made.

2. Collaborative research activities

   a. Reference yield trial and yield constraint analysis. To understand constraints to high yield and to realize the full potential for soybean after rice, several institutions will conduct maximum yield trials and share the information and results.
   b. Wet-soil culture of soybean. The Australian wet-soil culture will be tested in several countries with ACIAR coordinating the activities.
   c. Integrated disease and pest management. Activities will include identification and classification of soybean viruses (ACIAP, INTSOY, and AVRDC will provide leadership); soybean pod borer screening nursery (AVRDC will provide leadership); integrated pest management workshop and monitoring tour (IRRI, INTSOY, AVRDC, and IITA will organize activities); soybean rust research and rust screening nursery (AVRDC will provide leadership); integrated disease management (Indonesia, Thailand, India, AVRDC, INTSOY, ACIAR).

3. Village level and small commercial soybean processing and utilization. INTSOY in collaboration with CGPRT and AVRDC will provide leadership.
4. In socio-economic studies and economic analysis, CGPRT Centre will lead in cooperatin with AVRDC and INTSOY.
5. Seed quality and seed production research. INTSOY, IITA, AVRDC, and the Mississippi State University team in Bangkok will jointly collaborate in organizing the activities according to national program needs.

As the soybean network becomes effective and more problems are identified, new collaborative programs will be initiated.

Varietal Monitoring Tour/Workshop

The ASIN Working Group will coordinate activities with IRRI ARFSN and organize annual workshops on soybean improvement. Past activities will be evaluated and future research and trials planned at the annual workshops.

Communication

Members of ASIN will present their results at workshops and through a number of existing communication channels such as IRRI's Rice Research Newsletter, AVRDC's Tropical Vegetable Information Service Newsletter, Soybean Rust Newsletter, IITA's Grain Legume Bulletin, or ACIAR's Grain Legume Newsletter. The processed data from the ASIN trial, as well as workshop proceedings, will be published annually.

In addition, the national program scientists will coordinate closely with the international programs, so that methodologies and concepts can be transferred to the national programs.

Training

To improve and strengthen the national program's capabilities, research personnel will be trained at AVRDC, IITA, INTSOY, and IRRI on various aspects of soybean improvement

research. The governments are urged to take advantage of these programs by training a number of subject matter specialists to assist in the efficient implementation of the program. The following short-term training programs are available: 1) AVRDC – five-month soybean production or research internship (for specific subject matter specialists), 2) IITA – three-month soybean production training, 3) INTSOY – three-month soybean production training, 4) IRRI – upland crop (soybean) varietal testing training, and IPB–IRRI varietal improvement training. Apart from this, training for advanced degrees should be available at all of these centres.

List of Participants

Participants at the Soybean Varietal Improvement Workshop held in Jakarta, Indonesia on July 21-22, 1984.

Name/Institution	Country
1. R. M. Abiley	Philippines
2. V. Arulnandhy	Sri Lanka
3. Rasiden Azwar	Indonesia
4. P.A. Batugal (PCARRD)	Philippines
5. Akhtar Beg	Pakistan
6. P.S. Bhatnagar (ICAR)	India
7. Ramon Bonifacio	Philippines
8. Don Byth (ACIAR)	Australia
9. Virgilio Carangal (IRRI)	Philippines
10. Rajman P. Chaudhary	Nepal
11. Francois Dauphin (CGPRT Centre)	Indonesia
12. Isidro Domingo	Philippines
13. Mike Erwin (INTSOY)	U.S.A.
14. Libertito Feliciano	Philippines
15. Omar Hidayat (SUBIF)	Indonesia
16. J. A. Jackobs (INTSOY)	U.S.A.
17. H. K. Kauffman (INTSOY)	U.S.A.
18. Jerry McIntosh (RMI)	Indonesia
19. Rudy Navarro (UPLB)	Philippines
20. Ramli bin Mohd Noor (MARDI)	Malaysia
21. Shiro Okabe (CGPRT Centre)	Indonesia
22. R. K. Pandey (IITA/IRRI)	Philippines
23. Nark Potan	Thailand
24. S. Shanmugasundaram (AVRDC)	Taiwan, China
25. J. S. Siemonsma (Dutch Team)	Indonesia
26. S. R. Singh (IITA)	Nigeria
27. Sumarno (BORIF)	Indonesia
28. N. S. Talekar (AVRDC)	Taiwan, China
29. Ruben Villareal (UPLB)	Philippines