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INDUCED MUTATIONS FOR THE IMPROVEMENT OF GRAIN LEGUMES IN SOUTH EAST ASIA (1975)

PROCEEDINGS OF A SOUTH EAST ASIA REGIONAL SEMINAR
ORGANIZED BY THE
JOINT FAO/IAEA DIVISION OF ATOMIC ENERGY
IN FOOD AND AGRICULTURE
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FOREWORD

Following the advice of a panel of international experts held in Vienna in 1974, a research programme on the use of induced mutations in the improvement of grain legumes production in South East Asia, to be co-ordinated by the Joint FAO/IAEA Division, was proposed. As a preliminary to the initiation of this regional programme representatives from various countries and institutes were invited to participate in a seminar to discuss the improvement of grain legumes in South East Asia. This volume contains the reports presented by delegates at this seminar, held in Colombo, Sri Lanka from 8 - 13 December 1975, as well as the conclusions and recommendations adopted by its participants.

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IAEA REGIONAL SEMINAR ON GRAIN LEGUMES IMPROVEMENT

Opening address by the Hon. Minister of Agriculture and Lands
Mr. H.S.R.B. Kobbekaduwa, Sri Lanka

At the very outset, let me thank the Chairman, Atomic Energy Authority, in Sri Lanka and the organizers for having invited me to address this Regional Seminar. I am indeed happy to state that Sri Lanka has chosen to host this Seminar at a very appropriate time.

It is well known that grain legumes have been an important component of the diets of the people of the different countries in the Asian Region since very early history.

It is also recognized that according to the different environmental conditions prevalent in these different countries, a large variety of grain legumes have been developed over long periods of time. While a grain legume like soya bean had reached a very high state of development in some of the far-eastern countries, other grain legumes such as black gram, green gram, cowpea, pigeon pea and chick pea have also been developed to varying stages in the South Asian and neighbouring countries.

It is also observed that the component of grain legumes in the traditional diets have differed from country to country. This has naturally been due to the differences in the soil and climatic environments found in the different areas of the Asian Region.

One could broadly infer, that within the framework of the subsistence type of agriculture that was common to most of the Asian countries, there was little or no opportunity afforded for any radical improvements in the well established traditional varieties of grain legume crops that had been accepted by the various farming communities.

Despite this, the last few decades have however, seen the development of improved strains of better adopted varieties of grain legumes in the

different environments. Some countries have been able to evolve strikingly superior strains of some grain legumes crops in the more recent decade.

In the transformation that is taking place over most of the Asian agricultural landscape from subsistence to more productive forms of agriculture, new opportunities are now being afforded for the acceptance of more selective and higher yielding varieties of grain legumes.

It is in this context that I see the significance of today's regional seminar which will examine both the breeding and agronomic aspects of increasing grain legume productivity in the South East Asian region.

It appears to me that the stage is now set in most of the South East Asian region for a rapid breakthrough in several fronts of food production. It is therefore logical at this stage for scientists to strive to attain a proper balance in our food materials that have hitherto been disproportionately weighted in favour of carbohydrates and thereby deficient in some of the more essential protein components.

The scientific techniques that are now available to plant breeders enable them to breed and evolve varieties that are adaptable to a very wide range of soil and climatic conditions. It also enables the development of strains that could stand up to a wide range of hazards that are associated with pests and diseases. I am aware of the substantial contributions that have already been made on these lines of scientific research in some of the agricultural research centres in the South East Asian region.

The nuclear techniques that will be discussed at today's Regional Seminar is yet another useful tool in the hand of the agricultural scientist. The opportunities that such techniques offer in terms of shortening the time scale within which it would be possible to tailor different strains and varieties to different agricultural conditions are indeed very considerable.

Recent interest in some of the less popular legumes, for example the creeper types like (Dambala local) is also of special significance to

Sri Lanka, because these types are well adapted to the wetter regions of our own country, as well as to some areas of the South East Asian region. These types are also observed to perform better in the wet climatic regions than the better known grain legumes that are more adapted to the drier climatic regions. I also understand that the yam or tuber of this creeper type (Dambala) has a higher protein content than the conventional yams and tubers. This is yet another example of a new frontier of agricultural research that offers an exciting challenge to the agricultural scientist, and a breakthrough in an area like this is bound to be of great significance to the farmers in the wetter areas of the South East Asian region.

Another area which awaits the impact of scientific research is that of the yield level of the more common grain legume crops. As is well known, plant breeding and agronomic research has been able to push up the yield level of the more popular cereals such as rice, wheat, and maize to appreciably high levels. Grain legumes on the other hand have yet to benefit from the full impact of scientific research in respect of pushing up the yield levels that could make them economically attractive to farmers. At the same time it would be possible through appropriate changes in the policy framework to ensure price levels that would make it attractive for farmers to grow larger extents of grain legumes. In fact our own fiscal as well as import and export policies over the last few years have made the production of grain legumes quite attractive to our farmers.

The question of storage and processing of grain legumes which have now assumed important proportion also await the skills of the scientists. I am certain that the problems that are presently encountered in this area would be successfully resolved in the near future.

The issues I have raised, though of a general nature, are in my opinion, extremely vital to the production programmes launched by us in our country. There may be equally important view points that the delegates present here would like to bring to the notice of this seminar which are relevant to the Food Production Programmes of their respective countries.

Therefore, it seems to me, and I am sure that delegates present here would agree, that the role of this Regional Seminar should be to evolve a path by collectively addressing the minds of all scientists present here, for the solution of problems encountered in the field of grain legumes improvement within the policy framework of the individual countries.

Thank you.

THE PROPOSAL FOR A REGIONAL COOPERATIVE AGREEMENT FOR IMPROVING GRAIN LEGUME PRODUCTION IN SOUTH EAST ASIA

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Background

Grain legumes (pulses) have traditionally afforded a considerable portion of the protein nutrition for the people of South East Asia and do provide a means for improving significantly the level of this essential dietary component in the future.

The grain legumes offer major advantages as food materials in the fact that they are very rich in protein, i.e., commonly contain 25% or more protein in contrast with cereals which rarely reach half that level. Furthermore, the protein is higher in its content of the essential amino acid lysine, human dietary needs which are not met by most cereal grains. Because of these facts, the legumes have been most valuable supplements to the normal staple of cereals at the S.E. Asian table. In fact the presence of legumes in the diet in combination with cereals increased the nutritive value of the cereals.

The advent of the energy crisis with resulting shortages and soaring prices for nitrogen fertilizer has accepted a further benefit of legume production. These plants, with proper soil and crop management, are capable of fixing much, if not all, of their nitrogen requirement through microbial symbiosis, thereby minimizing the need for the costly nitrogen input, as cropping is more equitably shared between the higher yielding cereals and the grain legumes. The great success of the Green Revolution during the past decade, with its heavy dependence on fertilizer nitrogen, had actually caused a diversion of land from legume to cereal production in many countries. I view of the high N fertilizer required for increased yields to be obtained with cereals, circumstances of the present dictate

the need for some reversal of that trend.

Much remains to be done through research for improving the productivity of legumes in the S.E. Asia region. The intervention of nuclear techniques can expedite the solution of these problems. The soil and crop management for legume production needs intensive study to maximize the yield of these crops. For example, the inter relationship between plant and micro-organisms of the symbiotic nitrogen fixation association needs more study in order to optimize the nitrogen supply to the legume. In addition the various other factors influencing grain yield such as rate of seeding, plant spacing, requirements for non-nitrogen plant nutrients and a host of other considerations also need attention. Some of the predominant genotypes presently employed in the region are very late maturing, have a low harvest index and suffer from a variety of other disadvantages. Much improvement through breeding is required in order to achieve higher efficiency of crops and consequently better yields.

Programme Objective:

The work of this programme is to be directed towards increasing the productivity of grain legumes for human nutrition in S.E. Asia. The different facets of enhancing grain legume production through improved management practices as well as enhancement of crops through breeding will be emphasized.

To define one specific set of objectives which would lead to the improved production of grain legumes is difficult. Firstly, there are clear-cut agronomic practices, which, if followed, would boost production immediately. These would include the use of high quality seed and active Rhizobium inocula for insuring a high level of nitrogen fixation during the growth of the crop. Other possible, and definitely worthwhile, topics for investigation falling into the agronomic category include the prospects of utilizing phosphatic and other fertilizers, or even nitrogen at the early stages of development. These important concerns cannot be covered in their entirety in a programme of the magnitude as that being proposed, however, some of these will definitely be probed.

The second aspect and the one to which a part of this research will be aimed concerns the genetic improvement of legumes of importance to the South East Asia region. Even in this context, the problems are manifold and large. One need only refer, as we have, to three attempts at defining the problems of grain legume improvement in principle. These are, the UN PAG "Nutritional Improvement of Food Legumes by Breeding", the CGIAR-TAC Report of the TAC Working Group on the Biology Yield of Grain Legumes and the CIAT "Potentials of Field Beans and other Food Legumes in Latin America". There are other studies as well.

A. Crop Management: There are many facets to the management of grain legumes. Some of these are involved with how to plant, the application of fertilizers and still others with biological interactions such as symbiotic nitrogen fixation.

1. Fertilizer Studies. The grain legumes such as bean, ground nut, soya bean, chick pea, pigeon pea, etc., are known to give economic yield responses to the application of phosphorus fertilizers (50 to 80 kg P_2O_5/ha) and starter doses of nitrogen fertilizers (10 to 30 kg N/ha) on many soils. Sometimes, economic yield responses are obtained by heavier application of nitrogen, e.g. in the acid soils of the humid tropics, in areas newly planted to legume crops, and in some areas where they are grown in rotation with non-leguminous crops. It is known that in the absence of adequate soil or fertilizer nitrogen inoculation with effective nitrogen fixing strains of Rhizobium is often necessary for satisfactory grain legume production. But this is not always practised. When conditions ideal for Rhizobium survival and nitrogen fixation are not present, legume crops must depend on fertilizer nitrogen for maximizing production.

Inadequate information is available on how and when fertilizers should be applied for maximum efficiency of utilization by grain legume crops. Isotope techniques offer the best means of studying this problem. The programme will be directed towards studying; (1) various factors

influencing the efficiency of fertilizer utilization with particular reference to nitrogen and phosphate fertilizers, and (ii) the impact of fertilizer application on nitrogen fixation. The crops to be included in the programme and countries participating will be determined by the economic importance of the crops to the respective countries.

The objective of this study is to see how fertilizers should best be applied to grain legume crops when this is necessary, without losing the benefits of their nitrogen fixing capacity. For example, experiments will be designed to obtain answer to the following questions:

a) What is the influence of method, time and source of fertilizer application on the efficiency of fertilizer utilization?

b) What is the influence of other cultural practices such as irrigation and the liming of acid soils on fertilizer efficiency?

c) What is the impact of fertilizer application and liming on Rhizobium activity, nodulation and nitrogen fixation?

These investigations would be complementary to a current Joint Division Research Programme on the subject.

2. Cultural Practices. In conjunction with the fertilizer application studies and those dealing with the genetic improvement of grain legumes there should be partly tracer-aided investigations dealing with ways of optimizing yield of legumes by planting procedures. This kind of investigation would involve studies on plant spacing, land preparation and other manipulations. Clearly, as the genotypes used are changed there may be significance interactions with different soils as well as new relationships presented in regard to insects and pathogens. Problems involving pest and pathogen damage may sometimes be averted by altering farming practices. These possibilities need exploration.

3. Nitrogen Fixation by Symbiosis. With very high agricultural fertilizer prices prevailing, it is incumbent to make do with only as much as

is essential and take advantage wherever possible of other resources. Biological nitrogen fixation is an obvious alternative. Yet in many developing countries there is only limited information available on which to base recommendations for maximizing the fixation by legumes. Thus in order to fill this information gap research on nitrogen fixation is proposed. Such work would aim at identifying the strains of Rhizobium organisms which are best adapted to the particular legumes and to the soils of specific locales. Also it is important to have some ideas as to soil conditions which might inactivate the Rhizobium organisms used for the inoculum and measures for correction. The use of ^{15}N would prove invaluable in this work.

B. Plant Breeding. While the cereals have received most of the attention of plant breeders, there is now recognition that work on the improvement of legumes has been neglected. Thus large programmes are now active for legume improvement at IITA in Africa, at CIAT in Latin America and most recently at ICRISAT in Asia. While the efforts at these institutes are aimed at developing widely adapted varieties of legumes, there will always be the need to further improve such materials or to develop new genotypes where available germ plasm is inadequate to meet local conditions. This is where the independent local plant breeder using both conventional and mutation breeding techniques is crucial.

Previous studies on grain legume improvement such as the PAG study, the CIAT study and others suggest the following considerations:

1. The genetics of grain legume improvement is a highly complex endeavor in which the factors involved are plant architecture, disease and insect resistance, physiological responses to environmental parameters such as photoperiod and mineral nutrients, biological responses as related to nitrogen fixation, nutritional quality including the presence of anti-nutritional factors and of course consumer acceptance.

2. The strategy so successfully in use with the cereals like wheat and rice is probably of more limited applicability. In those crops, the

objective is to develop genotypes with wide adaptability. In the legumes, the growing conditions are quite variable as are the pests and pathogens, to say nothing of the consumer taste differences. Thus, there will probably have to be appreciably more genetic modification done at the local level.

3. Because the tropical grain legumes have not been intensively studied and bred it is necessary to clearly define breeding goals and criteria for maximal production under the conditions in which they are grown.

In the latter context, there have been views expressed that some of the tropical legumes have been bred principally as survival plants. As such they have been grown under decidedly sub-optimal conditions of moisture and nutrition. There have not been many advances towards genetically modifying these same crops for cultivation under conditions of sufficiency. Thus, there appears to be reason to believe that major genetic changes may be and can be made in adjusting these species for cropping systems which could provide much higher yields.

When one speaks of genetic modification, inevitably there is the question of genetic potential or germ plasm resources. At the moment, these are in the process of being collected, classified and evaluated at a number of international and national centers. This material will be the foundation for most of the gentic improvement of the future. However, as an adjunct to these collections, the use of induced mutations can be highly beneficial. Already there is evidence that induced mutations may be recovered in these tropical grain legumes. Some of these include changes for plant stature (dwarf, tall compact and other plant types). In addition, early maturing types of plants have also been isolated. Such characters as these could undoubtedly be useful in breeding programmes. Additionally there is evidence from other crops that photoperiod insensitivity and resistance to certain diseases are characters which are inducible as mutations. The fact that these genetic characters may be incorporated into specific genetic backgrounds within a few generations offers a significant advantage to a breeder.

Nothing of what has been said above should be interpreted to mean that mutation breeding is the panacea for solving the problems of legume breeding; it is a technique, when used intelligently in conjunction with other breeding techniques, which can strengthen the breeder's ability to solve problems.

It is hoped that the participants at this seminar will at the end of their deliberations come up with conclusions and recommendations on the potential value of induced mutations for improving grain legumes in South East Asia. These recommendations would serve as a basis for the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture to judiciously formulate cooperative projects, utilizing induced mutations, for specific problems. It is anticipated that the proposed projects would be complementary to, and cooperative with, existing breeding programmes already being undertaken by national and international institutes.

THE ROLE OF FAO IN IMPROVING PRODUCTIVITY OF FOOD LEGUMES IN THE ASIAN REGION

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Food legumes supply a major part of the vegetable protein and oil for the human diet in many countries of the Asia and Far Eastern region. The importance of food legumes to this region, however, lies not only in the Food value for human beings, but also supplies a proteinacious component for livestock feed and inland fish production. This group of crops is of value to agriculture in maintaining soil fertility through nitrogen fixation.

More than 55 million hectares of food legumes, including the leguminous oil seeds soybean and groundnuts, are grown in Asia and the Far East countries, with a total annual production of 35,000,000 tons. India, the People's Republic of China and Pakistan account for most of the cultivated acreage production in the region.

Over 30 food legume species (Table 1) are grown in this region. Some of the legumes are temperate, some sub-tropical and many are tropical species. The predominant food legume species grown in the Asia and the Far East region are chickpeas, pigeon peas, groundnuts, soybeans, dry beans, peas, mung beans, lentils and other minor species. Many species are grown under rain fed conditions and in the dry season without irrigation, using residual soil moisture (i.e., chickpea in India). Substantial acreage is interplanted with other crops such as maize, sorghum, millet, sesame, barley, linseed, mustard, cotton and other tall plants, where farmers make use of plant height.

Yields in the Asian and Far East region vary from one country to another, and in general are low. The following (Table 2) illustrates the yield levels of some species in five tropical countries.

Table 1. PREDOMINANT FOOD LEGUME SPECIES GROWN IN THE ASIA AND FAR EAST REGION

Species	Common Name
Arachis hypogaea	Groundnut/peanut
Cajanus Indicus or cajanus cajan	Pigeon pea
Cicer arietinum	Chickpea/Bengal gram/Garbanzo bean
Cyamopsis psoralipider	Guar/cluster bean
Dolichos biflorus	Horse gram
Dolichos bulbosus	Yam bean
Dolichos lablab	Country bean/Garden bean/Hyacinth bean
Glycine max	Soybean
Lens esculenta	Lentil
Lathyrus sativus	Grasspea/Vetchling
Morninga oleifera	Horse radish tree
Pachyrrhizua erosus	Yam bean
Phaseolus acomitifolium	Moth bean
Phaseolus angularis	Azuki bean or Small red bean
Phaseolus aureus	Mung bean
Phaseolus calcaratus	Red bean or Rice bean
Phaseolus lunatus	Lima bean
Phaseolus mungo	Urdbean/Black gram
Phaseolus trilobus	Phillipesara
Phaseolus radiatus	Green gram/Green mung
Phaseolus vulgaris	Kidney bean
Pisum arvense	Field pea
Pisum sativum	Garden pea
Psophocarpus tetragonolobus	Manila bean/Goa bean
Sesbania grandiflora	Sesbania
Tetragonolobus purpureus	Winged pea/winged bean
Vicia faba	Broad bean

Species	Common Name
Vigna sesquipedalis	Yard-long bean
Vigna sinensis	Cowpea
Voandzeia subterranea	Bambarra groundnut/Madagascar peamut/ Earth pea/Juga bean

N.B. Taxonomists are still uncertain about the classification of some of the above Phaseolus species. e.g. Mung bean (Phaseolus aureus) is classified by some as Vigna radiata.

Table 2. AVERAGE YIELDS OF THREE LEGUME CROPS IN FIVE TROPICAL ASIAN COUNTRIES

Country	Crop		
	Groundnut	Mungbean	Soybean
	kg/ha		
Indonesia	750	505	560
Laos	1,050	800	850
Philippines	500	420	825
Thailand	1,200	1,100	1,000
Vietnam	1,100	710	900

Low productivity and yields may be attributed to the following major constraints and problems:

1. Farmers and policy makers may not be fully aware of the importance of food legumes as a source of protein, oil and use in agro-allied industries.

2. They are cultivated as subsistence crops, in lands of marginal productivity, in small holdings and often grown only for home consumption. Land tenure and low labour efficiency are other problems.

3. Food legumes face a very strong competition from main crops like rice, wheat, jute, cotton, sugar cane and others which have much higher economic return than that obtained from this group of crops. In fact, in some countries, such competition has resulted in food legumes being replaced slowly by highly remunerative crops. As a result, food legumes are given lower priority.

4. A lack of appreciation of the importance of harnessing the available natural resources to the food requirements of the population.

5. Many countries lack effective research programme to deal with problems related to variety development, cultural practices, inoculation, fertilizers, water use, plant protection methods, nutrition, and post harvest technology.

6. Lack of experienced researchers. Very few well qualified and experienced researchers are engaged in food legumes improvement. Most of the technicians join other research discipliens or have to work in other fields such as teaching and business.

7. There has been little work done on varietal collection, evaluation and preservation of germ plasm in many species. In fact, many countries are unaware of the diversity of varieties and species available.

8. Very little attempt has been made to introduce exotic germ plasm.

9. Many countries lack an effective seed industry development programme whereby quality seeds are made available to the farmers, in quantity and on time.

10. The technology of production of food legumes has not yet been fully worked out for many countries. Little information reaches the farmer regarding the agronomic improvement of his crop.

11. Work on the development of simple mechanical tools and power driven harvesters, shellers, and cleaners for small farm use has made little progress. Many farm operations are still done manually.

The role of FAO

To improve food legume production quantitatively and qualitatively. FAO assistance may be made in the following direction:

(a) Direct assistance. Through its Regular Programme, FAO staff both at Headquarters and in the Regional Office in Bangkok where a Plant Production Officer, Plant Protection Officer and a Senior Agronomist are located are delighted to assist member countries through direct visits for the purpose of providing technical advice and guidance on policies and programmes aimed at improving productivity of food legumes.

(b) FAO, through multilateral and lateral aid giving agencies could assist in the identification, preparation and implementation of small and large scale field projects related to various aspects of food legume production and improvement, in particular in the fields of breeding and agronomy.

Two FAO assisted soybean projects, one in Pakistan and the other in Vietnam have been completed. Other FAO assisted projects include a "Soybean Development" in Sri Lanka and "Grain Legumes Development" in Burma; both are in operation. A project for Burma on "Soybean Production" has already been prepared.

(c) Establishment of inter-country cooperative research and development networks for improvement of food legumes. FAO is in correspondence with the UNDP on the development of a regional project proposal for food legumes in the humid tropics of Asia. The emphasis in the design of the project would be on introduction and testing of promising varieties, mainly using the existing national institutes by strengthening as required and coordination of their work with a view to ensuring inter-country technical cooperation in increasing the productivity of this group of crops.

(d) Organizing training programmes, meetings and seminars in food legume improvement and production. FAO is planning to hold an Ad hoc Expert Consultation on improvement of productivity and minimizing post harvest losses of food legumes in Asia and the Far East early in 1976.

(e) Exchange and dissemination of information and establishment of linkages between research workers and institutes working with food legumes. FAO presently is placing two publications in print, one titled "Soybean

Production in the Tropics", and the other "Distribution, Adaptability and the Biology of Yield in Food Legumes". A revised "World List of Plant Breeders" is under preparation.

(f) Plant introduction, collection and evaluation and conservation of food legumes genetic resources and the establishment of regional and sub-regional germ plasm centres.

BACKGROUND TO NATIONAL REPORTS ON GRAIN LEGUMES

Prior to the regional seminar, participants were requested to supply answers to the following questions:

1. What are the principal grain legume crops produced in your country?

2. How are legumes used in the diet of the people? What foods are used in combination with grain legumes? How available are grain legumes to that part of the population most vulnerable to dietary insufficiency? What is the average diet of the children? What is the cost per kilo of various legumes and cereals?

3. What is the area under production of each grain legume crop?

4. When are these grown? Please indicate the months of sowing and harvesting.

5. How are legumes grown in your country? Are they grown as monoculture or as intercropped plantings with cereals or other crops?

6. Does the plant type (architecture) of grain legumes grown in your country appear to be inefficient? Would alteration of the crop duration and maturing time of grain legumes grown in your country facilitate the planting of another crop during the year?

7. Are any fertilizers used in growing grain legumes in your country? If so, on which crops, how much and what kinds of fertilizers? Do you have any evidence for fertilizer responses in the grain legumes grown in your country? If so, to which fertilizers?

8. Are the varieties used in commercial production derived from indigenous germ plasm or from introductions? If so, from where?

9. What are the yields during the various seasons in which these crops are grown? Please give the average farmer's yield and the best yields which are obtainable under experiment station conditions.

10. What are the factors which you consider to be principal obstacles to increased production of specific legumes in your country? If these include diseases or insect pests, please indicate which pathogen and which crop.

11. How much has been done in studying nitrogen fixation in legume crops? Is this a deterrent to higher production of grain legumes and if so, on what basis?

12. Has there been any mutation breeding carried out on grain legumes in your country? If so, which crops, by whom and what specific characters have been sought? What were the results?

13. How much overall breeding activity is carried on in your country in regard to grain legumes? Which institutions are involved?

The subsequent national reports were presented by delegates in response to the above questions.

GRAIN LEGUMES IN PAKISTAN

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ABSTRACT

The principal grain legumes grown in Pakistan are: chickpea, lentils, peas, green gram, black gram, cowpea and pigeon pea. Chickpea which is covering an area of 1,143,00 hectares, is the absolute dominating legume.

Grain legumes are grown in two main seasons: the summer (rainy season) June - October and the winter (dry season) November - April.

Most grain legumes are grown as monoculture but intercropping is also practised. Very little breeding has been done with these grain legumes and yields are low. The needs for improvement are described and both convential breeding and mutation breeding play an important role in obtaining increased yields and production of these legumes which are important protein sources for a large part of the population.

1. Principal grain legumes

a) Chickpea or Bengal gram (*Cicer arietinum*)
b) Lentil (*Lens esculenta*)
c) Peas (*Pisum sativum*)
d) Mung or green gram (*Phaseolus aureus*)
e) Urd, or Mash or black gram (*Phaseolus mungo*)
f) Cowpea (*Vigna sinensis*)
g) Pigeon pea (*Cajanus cajan*)

2. Uses of grain legumes

a) The whole grains of chickpea, peas and cowpeas are eaten green or dried for use as boiled dishes at a later date. Lentils, Mung, Urd and Pigeon peas are dried for later boiling.

b) The most common form of usage is in the production of 'Dhal' after removal of the seed coat, the grains are split and the coyledons separated and are then either parched, fried or boiled. 'Dhal' forms an essential proteinaceous food complementing a basically starch (rice) diet in many of the lower income groups.

c) Often ground and made into flour.

d) Chickpeas are often eaten as salted parched grains, like peanuts and chickpea flour is used in the preparation of many Pakistani deserts.

e) The growing tips ("Pali") of chickpeas are plucked mid-season and cooked as a green vegetable - rather like spinach.

Studies undertaken at the University of Lyallpur indicate that grain legumes may be the only major source for protein and energy available to the low income groups; their consumption is inversely proportionate to incomes. viz: -

	Monthly income in Rupees					
	0-99	100-199	200-399	400-599	600-999	1000-3000
Proportion of Cereals and Pulses in Diet	34.7%	26.0%	23.3%	19.5%	16.8%	15.1%

The costs of the major foods in Pakistan are:

	Rupees per Kg
Chickpea	1.80
Mung	2.70
Mash	3.60
Lentil	1.80
Maize	1.08
Rice (fine)	2.70
Rice (course)	1.35
Wheat	1.00
Meat	10.80

3. Areas under Production

Area and Production of Grain Legumes in Pakistan

Source: Ministry of Agriculture and Works: 1974/75

Crop	Hectares	Tons
Chickpea	1,143,000	555,000
Lentil	71,000	25,000
Peas	227,000	92,000
Mung	70,000	30,000
Urd/Mash	39,000	18,000
Pigeon Pea	Not available	1,000
Cowpea	Not available	Not available

4. Time of Sowing and Harvest

Crop	Time of Sowing	Time of Harvest
Chickpea	15 Oct - 15 Nov	15 April - 30 April
Lentil	15 Oct - 15 Nov	1 April - 15 April
Peas (green pod)	1 Oct - 15 Oct	20 Dec - 20 Jan
Peas (for seed)	1 Nov - 15 Nov	28 Feb - 10 March
Mung/Mash/Cowpeas (Spring)	15 Feb - 10 March	15 June - 30 June
Mung/Mash/Cowpeas (Summer)	15 July - 30 July	1 Nov - 15 Nov
Pigeon Pea (for seed)	1 July - 16 July	15 Dec - 30 Dec
Pigeon Pea (intercropped with sugarcane)	15 March - 30 March	15 Dec - 30 Dec

There are two main seasons in Pakistan: the summer, rainy season, called "Kharif" from June to October and the winter, dry season, called "Rabi", from November to April.

5. Most of the grain legumes are grown as monoculture but intercropping is sometimes practiced as a security against crop loss (chickpeas and wheat or chickpeas and barley) or to reduce disease incidence (cotton/green/black gram). In the extreme north of the country i.e. Chitral and Gilgit, a number of grain legumes and cereals may be grown and harvested together.

6. (a) Architecture

Many of the present day varieties of grain legumes grown in Pakistan are characterized by poor harvest index, low pod setting, indeterminate plant habit and tall bushy growth. It is generally assumed that these characteristics are responsible for low yields, but so little is known about the physiological basis of yield in grain legumes that it is difficult to state catergorically the architectural structure which would be best suited for producing maximum yields in any one species. As many of the varieties now grown are still land-race types, their architectural structure may well have been selected by nature and for man as the best homeostatic mechanism for ensuring survival and for stability of yield. Due care must be exercised in any breeding programme therefore to retain plant characteristics ensuring survival and stability.

(b) Cropping Season

In many instances short-term varieties could be useful and would fit into the normal seasons, e.g. if there were only arly maturing varieties of cowpeas, mung, or urd, it would be possible to grown two crops of these plus one crop of wheat per season.

The season for chickpeas in the north of the country is a long one and the present day varieties are adpated to this. Short term varieties would be useful however when plantings are of necessity late due to an extended rainy season. A short term variety of chickpeas is at present being sought for Sind Province to produce a crop after two harvests of rice.

7. Fertilizers

Grain legumes are usually grown on light soils and farmers do not generally apply fertilizers to the crop. Chickpeas are generally presumed to the unresponsive to fertilizers though under experimental conditions Mung and cowpeas have given significant responses to phosphate viz: -

	Yield in Lbs/acre	
Rate	Mung	Cowpea
100 lbs. P_2O_5/acre	848	490
50 lbs. P_2O_5/acre	536	394
Nil	481	331

Nitrogen applications induce excessive early growth which appears in some cases, possibly where soil moisture is limiting, to result in reduced yield.

8. Most of the varieties grown by farmers, of grain legumes, have been grown for some time. In the case of chickpea the varieties grown are mostly land-races of ancient origin, though new varieties have been produced by research stations. The chickpea cultivars which have been produced in Pakistan are mostly derivations of crosses between exotic and indigenous varieties. Some exotic varieties used in the breeding programme were Pois chiches No. 4F, 32, 199 and 281 obtained from the Bureau of Plant Industry, Washington, D.C. (U.S.A.). Varieties were also obtained from the Pulses Improvement Centre, Teheran and more recently from the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) based in Hyderabad, India. Some new promising lines of chickpea (Nos. 6227, 6550 and 6560) have been produced from irradiated material at Lyallpur.

9. Average Yields

The average yields from farmers fields in Pakistan are:

Chickpea	540	Lbs per acre
Lentil	398	"
Peas	468	"
Mung	495	"
Mash	495	"
Pigeon Pea	450	"

10. Obstacles to Increased Production

a) No great effort is excerted by farmers to increase grain legume

yields. They are usually grown on lands of marginal productivity. Improved cultural practices would undoubtedly improve yields, but no such "package of practices" has been scientifically worked out to suit the specific requirements of a grain legume crop.

b) Fertilizers are not applied because the varieties currently being grown do not give economic responses. Breeding varieties responsive to fertilizers may be an essential prerequisite to increasing yields.

c) Chickpea is naturally adapted to growing on residual moisture, though one or two irrigations may sometimes increase yields in very dry seasons. Other grain legumes would respond to irrigation, but irrigation water can rarely be spared for them. Lack of water may therefore be an obstacle to increased production and varieties with increased adaptability to dry conditions would undoubtedly increase yields.

d) Introduced genotypes have mostly been unadopted and can only be used as germ plasm for breeding. "Kabuli" types (white grain and large seed) are adapted to Western Asia and summer plantings and do not give high yields in Pakistan though the seed type is prefered to the local "Desi" and fetches higher prices.

e) Diseases

Ascochyta rabiei (Blight)can be devastating to chickpeas in Pakistan in certain years. Introduced germ plasm has so far been highly susceptible whereas the local land races may have enough field resistance to mitigate the severity of attack. This can be a serious problem and resistance breeding is urgently required, but there are, to date, no known sources of genetic resistance. Wilt disease caused by Fusarium oxysporum and Fusarium solani can be serious and breeding for resistance is required. Other diseases of chickpea which may be of future importance are Rhizoctonia solani and Sclerotium bataticola and there is some indication of nematodes (Pratylenchus sp.) causing damage.

Yellow Mosaic Virus (YMV) transmitted by the white fly (Bemisia tabaci) can be particularly serious on Mung and Urd. Colletotrichum sp. can damage cowpeas.

f) Insect Pests

The pod borer (Heliothis armigera) can badly attack chickpeas and lentil. No insecticides are used by farmers and resistance varieties are needed.

The cutworm (Agrotis spp.) can be an important pest in the early stages of plant growth of chickpeas and may considerably reduce the plant stand. Bruchids also cause much damage to grain in seed stores.

11. Nitrogen fixation

Very little work has been done to date on nitrogen fixation of grain legumes in Pakistan, though it is known that nodule formation, on various grain legumes grown in vast areas of canal irrigation tracts, has decreased over the years. This may be linked with increased salinity in these areas.

Investigations on nitrogen fixation would be useful and studies have recently been initiated in the Microbiology Department of the University of Agriculture, Lyallpur.

12. Mutation Breeding

Dr. M. Abdullah Khan initiated a mutation breeding programme on chickpea in 1963 and on Mung in 1971.

In chickpeas, types with varying plant habits, leaf types, pod size, number of peduncles per node and seed size were selected from irradiated populations. Most of the mutants behaved as monogenic recessives, some mutant lines with simple-tiny-compound leaves were hybridized with lines bearing 2 pods per peduncle - selections selected from these crosses were disappointing in that while flowering was profuse the seed set was low. However, one mutant line with an erect habit was crossed with a double podded mutant and some lines selected from this cross are now outyielding some of the commercial varieties. One of these lines has a proportion to produce 3-pods per peduncle.

Mutation breeding has recently been started at the Nuclear Institute for Agriculture and Biology Lyallpur. The M_4 generation derived from mutagenic treatment of local varieties of green gram is now being tested. Some lines

look promising in that they mature in about 70 days as compared with commercial varieties which mature in 85 days.

Preliminary observations regarding plant yield and other agronomic characters are also encouraging; they will be tested in regular yield trials next season.

13. Breeding Activity

Prior to 1962 grain legume research was carried out in the Cereal Research Section of the old Punjab Agricultural College, Lyallpur.

The University of Agriculture, Lyallpur came into being in 1962 and the grain legume research was carried on by it. In 1971, a PL-480 project was sanctioned and the grain legume programme expanded with Dr. M. Abdullah Khan as Senior Research Officer. A wider range of exotic germ plasm was introduced of chickpea, lentil, mung, mash and pigeon pea and these introductions tested at various sites in Pakistan.

Research on grain legumes is now being undertaken by the following institutes:

1. University of Agriculture, Lyallpur
2. Punjab Agricultural Research Institute, Lyallpur
3. Nuclear Institute of Agriculture and Biology, Lyallpur
4. Tarnarb Research Station, Peshawar, NWFP
5. Agric. Research Institute, Dokri, Sind
6. Agricultural Research Station, Tandojam, Sind

A national Agricultural Research Council has now been formed, based in Islamabad. It is anticipated that the ARC will in future coordinate research throughout the country.

GRAIN LEGUMES IN INDIA

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ABSTRACT

The most important grain legumes grown in India are chickpea, pigeon pea, mungbean, horse gram, Khesari (Lathyrus sativus), field peans and lentils.

Chickpea accounts for more than one third of the total area and almost half the total production. Pigeon pea is the second important grain legume. The various species are grown all over the country from North to South.

Pulses are used extensively for human consumption, mainly as dhal. Some of the pulses are alse used as animal feed.

Yields of grain legumes are low particularly on farmer's fields as compared with yield potentials shown in well performed trials. Many factors have influenced the low production, i.e. drought, poor soils, weeds, insect pests and diseases and little use of fertilizers.

Very little breeding has been done with these pulses, but the Indian Council of Agricultural Research is now sponsoring an All Indian Coordinated Project for the Improvement of Pulses, where 15 centres spread all over the country are involved. All plant breeding methods will be used for obtaining improved varieties of these important crops.

Grain legumes, called pulses in India, have formed an important component of the agricultural pattern in India from time immemorial. They have played extremely important roles in the nutrition of the people and in enabling the land to give fairly reasonable yields inspite of the low inputs received. Pulses are grown on around 22 million ha. annually, the production ranging from 10-11 million tonnes. The area under pulse crops in different states of India is given in Table 1a while the extent of cultivation of some of the more important pulses is given in Table 1b. It should be noted that the statistics available may not be precise or fully reflective of the real position. For, pulses are very often cultivated as mixed crops - chickpea

with wheat, barley or linseed/mustard and pigeon pea with sorghum, pearl millet or cotton or on the borders of sugarcane/turmeric fields etc. Estimation of areas and production is often imprecise.

Principal grain legumes grown in India

A brief account of the principal pulse crops grown in India is given below:

A. Chickpea (Cicer arietinum, Bengal gram, chana) is the premier pulse crop in India. The main producing areas are in the North and include Uttar Pradesh, Punjab, Bihar, Rajasthan, Madhya Pradesh and to some extent, Maharashtra. It is considered to be a native of Asia Minor, having originated in a tract lying between the Cacusus and the western arm of the Himalayas, from where it has spread far and wide. Archaeological findings suggest that bengal gram had reached India in pre-Aryan times since charred grains have been recovered from sites dated earlier than the coming of the Aryans.

Chickpea in India is grown in winter (October 15 - March 15) and the limits of the crop and relatively cool winters coincide. The growing period of the crop and its productivity are progressively reduced from the North to the South of India. A similar cline can also be seen from West to East along the Gangetic plain. The area and production of chickpea are presented in table 2a,b.

B. Pigeon Pea (Cajanus cajan, tur, red gram, Arhar) is the second most widely cultivated pulse in India. It is mainly consumed in the form of split pulse (dhal). The outer integuments, removed while milling, together with the powdered and fractured kernels is valued as food for milk cattle and poultry. Pigeon pea is considered to have originated in Africa and must have been introduced into India in very early times. It does not appear to occur in India in a truly wild state. An annual shrub with a tendency to become perennial, pigeon pea is cultivated throughout India as a monsoon season pulse crop. Numerous cultivated types based on morphological and agro-ecological criteria have been recognized. The area and production of pigeon pea in different States of India can be seen from table 3a, b.

The milling of the grain to produce dhal is done either in power mills or hand mills. The seeds are milled by a dry or a wet process. In dry process, seeds are smeared with oil and dried in the sun before milling. Often this process has to be repeated 3-4 times. The recovery of dhal by this method is around 65%. This method of processing is common in North

India as well as parts of Maharashtra and Gujarat. The dhal obtained by this method is plump, takes somewhat lesser time to cook and is said to give good flavour. Wet milling prevelant in South India gives a greater return of dahl (80%). In this process the seeds are soaked in water mixed with red earth and heaped up overnight. The seeds are then spread out in the sun to dry before being split. The dhal prepared by this process is less plump and is considered to need longer cookin .

C. Mung, urd and moth(Phaseolus spp.). The major pulses belonging to the phaseolus group cultivated in India are mung (green gram, Phaseolus aureus), urd (black gram, Phaseolus mungo) and moth (Phaseolus aconitifolius). Recent taxonomical studies have suggested that these asiatic Phaseolus spp. differ considerably from the New World Phaseolus spp. and the former should be transferred to the genus Vigna. However, there is still some disagreement regarding this placing. The three spp. of Phaseolus widely grown in India are generally considered to be natives of India having been in cultivation from very ancient times.

This group of pulses is usually grown in the monsoon season (July-November), though in the southern states with very mild winters, they can be grown in the winter also. In these States, as well as in Bengal, mung and urd are often taken as catch crops after the paddy harvest. In North India mung can also be taken as a catch crop after the harvest of wheat in April and before the sowing of the succeeding monsoon crop. These crops are grown on all types of soil; however, urd prefers heavier soils with greater moisture retentivity. Moth is the most drought resistant amongst this group of pulses and is mainly grown in arid to semi-arid regions, especially Rajasthan which accounts for 4/5 of the area and 3/4 of the production.

D. Horse Gram (Kulthi, Dolichos biflorus). Another extensively grown hardy, drought resistant grain legume, horse gram has been in cultivation since ancient times in India and Burma. It has been reported to be growing wild in Queensland. It is cultivated in Sri Lanka, Malaya, Mauritius, Transvaal and West Indies to some extent. The total acreage under this pulse in India is about 1.5 million hectares, the production being approximately 0.86 million tonnes. It is most extensively grown in Andhra Pradesh, Uttar Pradesh, Karnataka, Tamil Nadu and Mahrashtra but is also cultivated to some extent in Orissa, Bihar and Madhya Pradesh. It is a very hardy crop and cultivated invariably under rainfed conditions, with the rainfall not exceeding 60-75 cm. It is grown on soils where no other crop could be grown.

The optimum time for sowing is during the first fortnight of September but can continue up to the end of September. It usually follows an early crop of millet or any oilseed crop. Sometimes, the crop is drilled in standing crops such as castor after inter-cultivation is finished. More generally, horse gram is grown as a single crop of the year in rotation with cereals. Horse gram is the poor man's pulse and is eaten both boiled and fried. In contrast with other pulses horse gram is not converted into dhal but used whole. It is more largely used as a feed for cattle and horses. Working animals invariably receive horse gram as a part of their ration.

E. Lathyrus sativus (Khesari). This is also an indigenous legume cultivated mainly in north India in the cool season. Khesari is mainly grown in Paddy fallows being broadcast in the standing crop just before maturity. It is a very hardy crop and is not affected by excess of water in the field at sowing or water stress during the growing season. Even when the soil hardens almost to the consistency of stone, if can survive and produce a crop. Khesari is also sown as a mixed crop with chickpea, barley or linseed. The chaff is used as a cattle feed. Two types, one with large seed (lakh) and the other with smaller seeds (Lakhori) are usually recognized in Madhya Pradesh, the state with the largest lentil acreage. The consumption of khesari has been shown to cause lathyrism, a paralysis of the lower limbs. This has been traced to the presence of a free amino acid, BOAA, in the seed and indeed in all parts of the plant. However, consumption of khesari results in paralysis only when it forms an appreciable part of the diet.

F. Field peas (Pisum sativum, matar). Another cold season pulse extensively grown in Uttar Pradesh and adjoining areas of Bihar and Madhya Pradesh. Field pea is considered to be a native of Europe introdued into India by the Aryans. Pea is a crop of world-wide importance, China possibly being the leading producer of this legume.

G. Lentil (Lens esculentus, masur). Lentil is also a cold season, winter pulse crop grown in the same area as chickpea and field pea. This is also a crop introduced into India by the Aryans from Europe. Lentil is preferred for its flavour and easy cookability. It is particularly preferred in Sri Lanka for use as dhal and considerable quantities of lentil are exported from Sri Lanka to India.

Availability and utilization of pulses

The reported area and production of pulses have been presented in Table 1. Chickpea accounts for more than a third of the total area and a little less than ½ of the production. Pigeon pea comes next with 1/10 of the acreage and 1/6 of the total production. Between them, these two pulses occupy a little less than ½ of the area under pulses to account for slightly more than 60% of the production. The most important States are Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Bihar, Andhra Pradesh, Mysore and Haryana with over a million hectares each under pulses. Other States where there is substantial pulse acreage are Orissa, West Bengal, Tamil Nadu and Gujarat. Chickpea is confined to areas with cool dry winters; Uttar Pradesh, Rajasthan, Madhya Pradesh and Haryana account for more than 50%. Madhya Pradesh, Maharashtra, Uttar Pradesh, Mysore and Andhra Pradesh account for nearly 3/4 of the area under pigeon pea.

Table 4 presents the net availability from 1951-71 of pulses as well as per captia availability per year and per day. The net availability has been calculated as 87.5% of gross availability to allow for spoilage, provision for feed and seed, losses in milling etc. In the case of chickpea only 77.9% of the gross product has been taken to be available. While there has been some fluctuation in the net availability, by and large this has remained at the same level. Per capita availability has been steadily declining over the years. In the period from 1951-61 per capita availability in general remained above 60 g. per day. Later, however, there has been a steady decline in availability per capita, the lowest figure (39 g per day) being reached in 1967.

Pulses are used extensively in a variety of forms for human consumption. The most common form in which they are used is as dhal, where after removal of seed coat the grain is split to separate the cotyledons and usually boiled, parched or fried. In some cases as the chickpea, mung and urd, the whole grain may be boiled for use. Often, the pulses are soaked and allowed to germinate before they are consumed as such or ground or fried. The cooked pulse is often consumed with unleavened wheat/barley bread (chappati) or boiled rice and vegetables. Some popular fermented foods of India such as iddli and dosa are made from mixtures of rice and pulses (mung, urd) ground together. The fermented batter is steam cooked or fried in a small amount

of oil. A variety of fried foods are also common in the average Indian diet (such as bhajias or pakoras vadas, from a paste of chickpea or other pulse flour mixed with species and ingredients such as potato slices, onion slices, small pieces of vegetables and then deep fried). Powdered or ground pulses are also used in the preparation of sweets.

Some of the pulses constitute fodder for draught and milk animals. Guar (Cyamopsis tetragonoloba) usually grown in mixture with fodder millet, is especially valued as a feed for draught animals. Peas and Lathyrus are common green fodders. After the pods are picked the vegetative parts of mung and urd are often grazed in situ or cut and fed to cattle. Horse gram is a popular fodder legume in the southern parts.

The grain of pulses is also used as concentrates for animal feeding. Guar grain is especially preferred for draught animals while chickpea is esteemed for feeding milk, cattle and horses.

The by-products obtained where pulses, particularly pigeon pea and chickpea, are milled are considered to be valuable animal feed; in addition to the seed coat, these usually contain broken pieces of the cotyledon and scourings. In the case of pigeon pea the sticks are valued as fuel.

Yield levels in farm practice and in experimental plots

Productivity varies from State to State. The difference is particularly apparent in the case of chickpea, which accounts for nearly half of the grain legume production in India. In general, the productivity is much higher (0.8 t/ha) in northern states of Punjab and Haryana, Rajasthan and U.P. where there is a longer cold season with considerable dew fall. But as we go south, the growing season gets shorter, moisture stress becomes more marked and the soils poorer. Correspondingly, the productivity is reduced. A somewhat similar pattern is seen also in the case of pigeon pea, where relatively higher yields are recorded in U.P and M.P. but the yields in the southern states are lower.

In crops such as soybean, groundnut and pigeon pea good technological advice on agronomic practices have been given to farmers: as a result very

high yields under farmers conditions have been recorded. High yields could presumably been achieved with other grain legumes if such advice were available to, and followed, by farmers.

The yields obtained in experimental plots have been much higher than those realized in farm practice. Table 5 presents data on the highest reported yields from research plots of some grain legumes. It is clear from these figures that yields in the range of 2.5 - 3.5 t/ha can be realized from most of the grain legumes. These must be considered fairly good yields, though they may still be below the highest yields realized in certain crops such as maize, wheat and rice. Some short duration grain legumes such as Phaseolus aureus and Phaseolus mungo have a somewhat lower yield potential (1.5 - 2 t/ha) but these occupy the land for only 60-70 days or so.

Factors responsible for the variation observed between yields under farm practice and in experimental plots

The major factors responsible for the lower yields obtained by farmers can be said to be the conditions under which these crops are grown by the farmers. Traditionally, grain legumes are grown on lands and under conditions where other crops cannot be raised. Once the crop is sown, little attention in the way of weed control and plant protection is given to these crops. Such lack of inputs and management understandably results in low production.

Attempts are often made to rationalize such neglect of grain legumes by stating that these crops would not respond to inputs in terms of grain yield but will only put on excessive vegetative growth. Experiments carried out under the All India Coordinated Research Project for the Improvement of Pulses (grain legumes) show, however, that judicious irrigation and phosphatic fertilization can increase grain yields.

One of the major constraints under which pulse crops are normally grown is that of moisture stress. Such moisture stress affects not only the growth of the grain legume but has been shown to seriously interfere with the nitrogen fixation by the nodules. If severe water stress is encountered the nodules are shed and the resulting nitrogen starvation results in serious yield losses.

The effect of irrigation at different stages of plant growth on the yield of chickpea can be seen from Table 6 where the response (over countrol yield) to one irrigation at 45 days, 75 days or early pod filling (90-100 days) and two irrigations at 45+75 days of seedling at a numb r of locations is summarized. As can be seen there is a consistent trend towards an increase of 3-5 q/ha in yield as a result of such treatment, even where the control yield is at a fairly high level. The nearly 10-fold increase obtained at Hissar where the control yield is very low, is probably to be attributed to the protective effect of irrigation against frost damage. The productivity of the grain legumes especially those grown in the relatively arid cool season is, therefore, likely to be influenced by the nature of precipitation and the supplemental irrigation.

Fertilizers are seldom given to grain legume crops in India. Legumes are efficient mobilizers of resudual soil fertility, but they also respond to direct fertilization. Even though they may be capable of fixing atmospheric nitrogen for their own use, a starter dose of 10-15 kg. N/ha may be beneficial. In some crops such as mung bean and cowpea, symptoms of nitrogen deficiency are visible before the establishment and functioning of the nitrogen fixing mechanism. Experiments carried out under the All India Coordinated Project have shown that grain legumes respond to phosphatic fertilization upto 60-70 kg of P_2O_5 per hectare. Other experiments have shown that increases of around 2 quintals per hectare (25% over control) and slightly over 3 q/ha (35% over control) can be obtained with 30/50 kg. P_2O_5 per hectare. The response to N application is much less at 0.5 q/ha with 7.7 kg N/ha and 0.7 q/ha with a higher dose (15.4 kg N/ha). In some cases, responses as high as 65% over control have been obtained at the higher level of P_2O_5 employed.

Weed competition is also responsible for the low yields obtained with grain legumes. During the initial stages, these crops have very slow growth rates and consequently the impact of the competition from weeds on grain yields is considerable. The first few weeks are most crucial from the point of view of weed competition. Sometimes, especially in monsoon grown crops, the competition is so severe that the legumes almost completely fail. The

data in Table 7 show the reduction in yield caused by weed competition. A single mechanical weeding after 4 weeks of sowing can result in almost a doubling of the yield. Pre-emergence application of some herbicides could also be equally effective.

A number of insect pests considerably depress the yield of grain legumes. Mung, urd and pigeon pea are severely damaged by a galerucid beetle and a species of jassid, particularly when the plants are young. Stemfly (Agromyza) also causes serious loss of seedlings and young plants of these crops. Black aphid and hairy caterpillar are sporadic pests which can also cause considerable depredation. White fly is yet another important insect pest which besides causing direct damage acts as a vector of yellow mosaic virus disease in mung and urd. As a result of insecticidal trials, it has been observed that a single application of systemic insecticide viz., aldicarb, phorate or disulfoton, at 1-1.5 kg of actual insecticide/ha at the time of sowing followed by a foliar spray of 0.07% endosulfan, or 0.1% lindane or 0.04% monocrotophos emulsion at 500 litres/ha, when the plants are 4-6 weeks old, protect crops of mung and urd from the pest complex. Pigeon pea which is sown during the summer and harvested during the winter months, is attacked by pests of the monsoon season as well as by pod borers during winter; these insects cause severe damage to early and medium maturing varieties. Spraying with 0.07% endosulfan emulsion at 1000 litres/ha has proved effective in controlling the pod borers.

Bengal gram is chiefly damaged by cut-worms and aphids when the plants are young and later on by pod borers at the time of pod formation. For controlling the pod borers, spraying with 0.07% endosulfan emulsion at 500 litres/ha has proved effective. The same treatment proves effective in controlling the infestation of aphids during the earlier growth stage of the crop.

Pea is severely damaged by leaf miner, aphids and pod borers. Three applications of 0.1% lindane emulsion at 500 litres/ha 6 and 8 weeks after sowing and again at the commencement of pod formation keep the crops sufficiently

safe from various insect pests.

Insecticides are important in affording sufficient control of important pests and achieving good yields in various pulses. The pest control technology should be adopted by the development and extension agencies to increase the yield in various pulses.

Wilt and blight are the most destructive diseases of chickpea. Detailed field surveys showed that wilt of gram is caused by a complex of organisms. Fusarium solani and F. oxysporum were isolated in 25% and 16% of wilted samples collected in Delhi, Haryana and Ludhiana. Rhizocotonia solani and Opercullela padwickii were the other pathogens, these being fairly frequent in Haryana. Isolates from wilted plants at Kanpur were almost all F. oxysporum. Some varieties (C235, H 208) appeared to be tolerant to wilt. C235 was earlier reported to be resistant to blight but its resistance has broken down probably due to the appearance of new races of Ascochyta rabiei. Promising germ plasm lines have been screened for resistance to blight (A. rabiei) under artificial epiphytotic conditions. One black, bold seeded introduction (1528-1-1) from Morocco was found to be immune to both races of A. rabiei. Resistance from this source has already been incorporated into new breeding lines which are being tested for yield.

Pigeon pea wilt caused by Fusarium udum has been a problem in many areas. The varieties C-11, C-36, NPWR (15), KWR-1, 15-3-3, DT 236-6, Bori 192-15-1-2, Bori 192-15-2-2-11-49 have been found to be quite tolerant to wild. A new disease, stem blight of pigeon pea caused by Phytophthora drechsleri var. cajani, has been found to be destructive on short duration varieties in U.P., M.P., and the Delhi areas. Source of genetic resistance to this disease has been located in the variety. Sel.3 which is the Phaseolus group of crops, virus diseases (mosaic, yellow vein mosaic, leaf crinkle etc.) are important. In mung, the early maturing selection 293-1-1 from the crops PLM 1066 x Pusa Baisakhi and ML-6 showed field tolerance to yellow mosaic. Similarly, black gram selection 4-5-2 from the cross IC 11613 x T9 was field resistant. UPU-2 a mosaic resistant urd and Phaseolus sublobatus, a wild relative, are being used as sources of yellow mosaic resistance.

In mung and cowpea leaf spots caused by Cercospora spp. and dry root rot caused by Macrophomina phaseoli are two other major diseases. Seed treatment of these two crops with Captanthiram at 2.5 grams/kg of seed not only improves germination but also controls seed borne infection by the above mentioned pathogens. The cost of treatment will be less than Rs. 2/ha.

Powdery mildew (Erysiphe polygon_) is widespread on peas in India. Spraying with wettable sulphur for 4 times with 3 kg/ha/spray at 7 day intervals gives effective control and can double the yields.

Some recent advances in breeding pulse crops

In vew of the important role played by pulses in the nutritional pattern of the country and their decreasing per capita availability, the Indian Council of Agricultural Research sponsored an All India Coordinated Project for the Improvement of pulses. The philosophy of the coordinated project is to encourage a multidisciplinary appraoch to the problem of increasing pulse production in the country. Some 15 centres located in different parts of the country undertook a coordinated programme of investigation of the factors constraining pulse production in the country. The major thrusts in the research for the improvement of pulses has been (a) evaluation of available as well as newly developed strains in all parts of the country; (b) development of package of practices aimed at realising in full the potentialities inherent in these strains, (c) evaluation of the possibility of fitting pulses into available new niches in areas where necessary inputs can be made available, such as in off seasons or as intercrops and (d) developments of methods of avoiding the losses caused by pests and diseases in the field and during storage.

One of the major approaches has been to identify genotypes which can be useful in respect of (c) above. Some interesting results have been obtained in the case of pigeon pea.

The factor which is likely to have a great role in increasing the production of pigeon pea is the identification of shorter duration, dwarf types with compact plant habit. Varieties have been identified which occupy the

land for only 4-4½ months or 5-5½ months, respectively. The short duration of these varieties means that, sown in July, they would be off the field latest by the second or third week of November unlike the old varieties which continued well beyond December/January. The early varieties will thus escape frost and can help to extend the area of cultivations further northward. They also make possible a wheat-pigeon pea-wheat or pigeon pea-sugarcane rotation. Studies conducted under the project have clearly demonstrated the technical feasibility of such rotations and their economic superiority over traditional millet-wheat or sorghum-wheat rotations, especially where irrigations facilities are limited.

Identification of photoinsensitive, short duration varieties with erect, monspreading habit or without the tendency to become viny and climbing in mung bean, urd bean and cowpea have also opened up several interesting possibilities. With the availability of such types, it has been possible to fit pulses into gaps available in the intensive rotation practical on well endowed lands. Substantial scope for such off season crops is available in the form of 2-2½ months long wheat and rice fallows in different parts of the country. A Spring/Summer crop of mung bean taken after potato/wheat has already become popular to some extent in the northern plains. These short duration, non-cropping with row-sown crops like cotton, sugarcane, jute ect. so that an additional crop can be taken without affecting the productivity of the main crop.

Induced mutation studies on grain legumes have been limited to date. An attempt was made to isolate mutants in Lathyrus with low content of BOAA and to increase the variability for methionine content in mung and chickpea protein. It is perhaps understandable that in the early stages of a breeding programme comparatively little use has been made of induced variability and that the major attention has been concentrated on exploiting the available natural variability. Lack of a clear concept of the plant type which can lead to increased productivity of pulse crops may also be responsible for such a restricted exploitation of mutagenesis.

Table 1a

STATEWISE AREA AND PRODUCTION OF PULSES IN INDIA

1971 - 1974

States	1971 - 72		1972 - 73		1973 - 74	
	Area '000 ha.	Prod. '000 Tons.	Area '000 ha.	Prod. '000 Tons	Area '000 ha.	Prod. '000 Tons
Andhra Pradesh	1342.6	379.6	1344.3	299.4	1359.5	380.8
Assam	86.3	30.9	98.1	48.0	95.0	44.7
Bihar	1544.3	889.3	1474.6	656.0	1519.1	673.1
Gujarat	429.4	161.3	379.2	112.0	420.4	165.2
Haryana	1208.4	684.3	1065.9	589.8	1093.5	489.5
Himachal Pradesh	68.5	29.1	68.9	28.2	77.6	29.5
J & K	49.9	29.1	46.8	28.8	51.1	29.8
Karnataka	1359.2	466.1	1056.5	238.9	1206.3	497.4
Kerala	37.5	13.1	37.6	13.3	37.4	13.7
Madhya Pradesh	4328.3	2352.1	4361.1	2255.6	4493.2	1935.7
Maharashtra	2079.7	642.9	1826.8	451.0	2763.5	986.5
Orissa	860.9	390.2	939.8	488.8	922.2	484.5
Punjab	384.9	305.2	380.3	294.0	418.9	342.7
Rajasthan	3703.7	1317.7	3140.2	994.9	3581.5	1291.5
Tamil Nadu	525.1	153.7	621.7	192.0	707.5	190.0
Uttar Pradesh	3524.7	2919.9	3509.2	2923.0	3476.7	1849.8
West Bengal	597.1	317.0	545.6	284.8	635.0	340.1
Other States	49.9	29.1	46.8	28.8	51.1	29.8
T O T A L	22150.6	11093.4	20915.2	9906.7	22881.5	9753.7

Table 1b

CROPWISE AREA AND PRODUCTION OF PULSES FROM 1971 - 1974

Area = '000 ha.
Prod = '000 Tons

Crop	1971 - 72		1972 - 73		1973 - 74	
	Area	Prod.	Area	Prod.	Area	Prod.
Chickpea	7912.4	4080.7	6967.5	4536.8	7690.8	4005.8
Pea	928.1	546.0	808.3	463.9	763.6	390.3
Lentil	765.6	413.4	843.6	372.5	897.4	395.4
Lathyrus	1705.1	882.8	1491.1	561.3	1645.7	680.9
Pigeon Pea	2345.5	1683.6	2423.1	1927.6	2576.1	1364.1
Moong	2029.7	625.4	2063.8	548.1	2378.3	808.6
Urd	1888.8	539.5	1982.4	603.5	2301.8	710.2
Moth	1745.6	315.4	1606.7	111.2	1751.8	441.7
Horse Gram	1838.6	532.1	1846.2	496.4	1956.4	614.3
Others	982.6	321.2	889.4	301.2	907.1	322.1
T O T A L	22150.6	11093.4	20915.2	9906.7	22881.5	9753.1

Table 2a.

AREA (in thousand hectares) UNDER CHICKPEA

States	1971-72	1970-71	1969-70	1968-69	1967-68
Andhra Pradesh		77.3	77.6	75.6	82.6
Assam		1.7	1.8	1.6	1.7
Bihar		236.9	237.7	237.6	331.1
Gujarat		52.9	44.5	36.6	41.0
Haryana		1,046.0	1,059.0	800.0	1,160.0
Himachal Pradesh		15.3	11.2	-	-
Jammu & Kashmir		2.5	2.5	2.5	1.7
Madhya Pradesh		1,576.9	1,538.9	1,573.0	1,669.9
Maharashtra		368.6	369.8	391.2	392.8
Mysore		159.7	212.7	210.2	204.3
Orissa		21.8	23.4	24.7	19.9
Punjab		353.0	450.0	317.0	560.0
Rajasthan		1,602.1	1,285.1	994.2	1,322.6
Tamil Nadu		2.8	4.1	3.1	3.8
Uttar Pradesh		2,116.2	2.261.5	2,244.9	2,263.3
West Bengal		165.8	165.8	165.8	167.5
Delhi		9.9	·5.7	10.0	18.5
Others		0.2	0.2	-	-
All India		7,809.6	7,751.5	7,105.5	8,256.7

Table 2b.

PRODUCTION (in thousand tonnes) OF CHICKPEA

States	1971-72	1970-71	1969-70	1968-69	1967-68
Andhra Pradesh		21.6	20.6	18.2	20.7
Bihar		163.8	156.8	158.8	247.0
Gujarat		43.9	20.0	17.7	22.1
Haryana		774.0	1,143.0	600.0	1,267.0
Himachal Pradesh		9.2	5.8	7.8	8.8
Jammu & Kashmir		-	-	-	-
Madhya Pradesh		844.4	893.2	756.6	906.1
Maharashtra		98.5	101.9	129.0	108.4
Mysore		62.1	90.7	98.6	90.1
Orissa		12.6	13.3	15.5	11.5
Punjab		285.0	400.0	216.0	472.0
Rajasthan		1,184.2	782.6	600.0	1,049.1
Tamil Nadu		1.5	2.2	1.6	2.0
Uttar Pradesh		1,605.3	1,775.9	1,544.6	1,650.9
West Bengal		133.7	133.7	165.8	167.5
Delhi		5.7	4.4	10.0	19.1
Others		1.1	1.1		
All India		5,247.1	5,545.6	4,309.5	5,971.5

Table 3a.

AREA (in thousand hectares) UNDER PIGEON PEA

States	1070-71	1969-70	1968-69	1967-68
Andhra Pradesh	196.3	175.3	175.3	170.4
Assam	4.1	3.8	3.7	3.2
Bihar	161.0	173.3	173.3	186.2
Gujarat	26.0	90.8	94.1	92.3
Haryana	2.9	9.8	8.4	6.9
Himachal Pradesh	0.2	0.2	0.2	0.2
Jammu & Kashmir	0.3	0.3	-	0.1
Kerala	5.0	7.5	7.5	7.5
Madhya Pradesh	483.9	500.8	487.0	503.7
Maharashtra	639.6	686.2	576.4	590.5
Mysore	309.1	297.5	249.5	299.3
Orissa	51.3	32.6	35.5	38.9
Punjab	1.0	1.0	1.0	1.7
Rajasthan	25.3	24.1	24.5	21.4
Tamil Nadu	52.3	52.2	50.4	55.5
Uttar Pradesh	588.6	579.1	608.0	636.9
West Bengal	32.4	32.4	32.4	40.4
Delhi	0.3	-	-	-
All India	2,647.7	2,668.7	2,528.9	2,669.7

Table 3b.

PRODUCTION (in thousand tonnes) OF PIGEON PEA

States	1970-71	1969-70	1968-69	1967-68
Andhra Pradesh	63.1	85.7	85.7	84.7
Assam	2.9	2.6	2.6	2.3
Bihar	145.0	145.4	145.4	157.2
Gujarat	40.8	34.5	42.8	44.0
Haryana	4.2	4.5	3.1	6.5
Jammu & Kashmir	0.2	0.2	-	0.1
Kerala	0.9	3.5	3.5	3.6
Madhya Pradesh	377.0	318.3	309.2	342.2
Maharashtra	304.5	321.4	334.8	300.8
Mysore	152.6	124.2	125.0	106.2
Orissa	28.6	18.6	22.4	20.9
Punjab	1.0	1.0	1.0	1.5
Rajasthan	13.3	8.8	6.9	8.8
Tamil Nadu	19.5	24.1	18.1	20.2
Uttar Pradesh	663.0	716.1	691.1	609.1
Others	0.9	0.8	0.8	0.9
All India	1841.0	1842.2	1815.8	1741.1

Table 4.

AVAILABILITY OF PULSES FOR HUMAN CONSUMPTION

(87.5% of GP, 77.9% of GP for Chickpea)

Year	Net availability (million tonnes)	Per capita kgs./year	availability gm./day
1951	8.07	22.2	60.9
1952	8.01	21.1	59.2
1953	8.63	22.9	62.9
1954	9.76	25.5	69.9
1955	10.22	26.0	71.2
1956	10.27	25.8	70.5
1957	10.66	26.2	72.0
1958	8.87	21.4	58.6
1959	11.59	27.4	75.0
1960	10.38	24.0	65.5
1961	11.16	25.2	69.1
1962	10.32	22.8	62.5
1963	10.10	21.8	59.8
1964	8.82	18.7	51.0
1965	10.86	22.5	61.9
1966	8.70	17.6	48.2
1967	7.30	14.5	39.1
1968	10.57	20.5	56.1
1969	9.09	17.3	47.3
1970	10.20	18.9	51.9
1971	10.11	18.4	50.3

Table 5.

HIGHEST REPORTED YIELDS FROM RESEARCH EXPERIMENTS IN SOME GRAIN LEGUMES

Crop		Tons ha^{-1}
Phaseolus vulgaris		3.33 (Brazil)
Soyabean		4.40 (U.S.A.)
		3.00 (Nigeria)
Pigeon peas (Cajanus cajan)		3.50 (India)
		5.00 (India)
		4.50 (Nigeria)
	green pods	8.00 (Trinidud)
Groundnut		4.20 (U.S.A.)
		3.06 (India)
Cowpeas		2.62 (Nigeria) (Senegal)
		3.66 (India)
Chickpea		4.40 (India)
Green gram		4.00 (India)
Lentils		2.93 (Europe)
Peas		2.55 (India)

Table 6.

RESPONSE OF CHICKPEA VARIETIES TO IRRIGATION

Location	Control yield (q./ha.)	Yield difference over control in q./ha. with irrigation at			
		45 days	75 days	45 + 75 days	Early pod filling
Badnapur (Maharashtra)	14.00	+2.87	+0.72	+6.75	-
Jabalpur (M.P.)	19.42	+2.29	+2.31	+0.34	-
Sehore (M.P.)	6.42	+2.47	+3.52	+4.82	-
Gaya (Bihar)	22.10	+2.97	+2.82	+4.30	-
Ludhiana (Punjab)	10.74	-0.2	+0.6	+2.65	+3.90
Delhi	3.50	+2.6	+2.9	+3.1	-
Hissar (Haryana)	2.40	+23.2	+19.7	+23.9	+10.4
Rajendranagar (A.P.)	3.86	+4.33	+0.3	+0.1	+2.13
Pantnagar (U.P.)	15.31	+2.97	+3.13	+8.12	+5.14

Table 7.

EFFECT OF WEED CONTROL ON CHICKPEA YIELD

		Grain (q/ha)	Weet dry Wt. (q/ha)
1.	No weeding	19.99	32.5
2.	Weed free	33.33	-
3.	Handweeding (30 days after sowing)	28.44	9.12
4.	Handweeding (45 days after sowing)	32.55	8.17
5.	Handweeding (60 days after sowing)	32.55	8.88
6.	Handweeding (60 days after sowing)	36.66	8.41
7.	Nitrogen at 1.0 kg/ha	21.44	17.14
8.	Nitrogen at 1.5 kg/ha	23.33	28.25
9.	Alachlor at 1.0 kg/ha	22.88	30.39
10.	Alachlor at 1.5 kg/ha	24.77	17.93
11.	Prometryne at 0.25 kg/ha	28.88	17.14
12.	Prometryne at 0.50 kg/ha	20.32	31.19
	CD at 5%	4.65	

GRAIN LEGUME PRODUCTION AND RESEARCH IN SRI LANKA

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ABSTRACT

Green gram, cowpea, black gram, pigeon pea, groundnut and soybeans are the principal grain legumes grown in Sri Lanka.

Green gram and copea are the most popular of the grain legumes. The grain legumes are important protein sources for the human populations so increased production is planned in order to reduce or avoid import of these commodities. The majority of the grain legumes are grown in the dry zone and most in monoculture.

The present varieties give low yields, and the present crop improvement programmes emphasize the improvement of agronomic traits with the ultimate objective of obtaining higher yields. So far, conventional breeding methods have been used but in the future mutation breeding techniques will also be considered in the breeding work.

Introduction

Green gram (*Phaseolus aureus*), Cowpea (*Vigna sinensis*), Black gram (*Phaseolus mungo*), Pigeon pea (*Cajanus cajan*), Groundnut (*Arachis hypogaea*) and Soybean (*Glycine max*) are the principal Grain Legumes cultivated in Sri Lanka.

Poverty, low levels of income and prohibitive costs of animal protein food make Grain Legumes the chief source of protein in the diets of most sections of the people. Yet, the cost of Grain Legumes itself is high (see Table 1), especially in relation to the per capita income of Rs. 1,122.40 per annum (for 1973, based on G.N.P. at 1963 constant prices).

Today, while the Government provides two pounds of rice per individual per week at a subsidised price of Rp. 1.00 per pound (non income tax payers get a further benefit of obtaining the first pound free of charge), the practice of providing any grain legume on ration (ensuring equal distribution even in small quantities) at a controlled price has been discontinued. Thus, it is evident that grain legumes will not be easily available to sections of the population who are most vulnerable to dietary insufficiency.

It must also be noted that Sri Lanka is a small country and seasonal changes in production and changes in imports have an immediate impact on the market prices of food commodities, thus causing considerable fluctuations in market prices within short periods of time.

Green gram and Cowpea are the most popular of the Grain Legumes, and are used in making a curry to be eaten with rice, and also used for breakfast preparations and making sweet-meats. Black gram is mostly used in making certain breakfast preparations and short eats in combination with rice flour. Pigeon pea is mainly used to make a curry to be eaten with rice. Groundnuts are mostly consumed in the roasted form. Soybeans have only recently been introduced to Sri Lanka and have so far gained only limited popularity as a substitute for Black gram in some common food preparations.

Restrictions in the import of food items, in general, over the last ten years, and on the import of grain legumes during the last five years culminating in the present discontinuation of imports of all grain legumes, both on account of foreign exchange difficulties and increasing world market prices (see Table 2), have given a boost to the cultivation of grain legume crops in Sri Lanka.

Acreages and Production

Areas under the major Grain Legumes and yields obtained are given in Table 3 in respect of the years 1968/69 and 1973/74. The targets set for cultivation and production for the year 1975/76 is also included. The figures for these years would reflect acreages and production before and after import restrictions and current trends.

A progressively sharp increase in the acreages and production is evident in respect of each crop except Pigeon pea.

Potential Areas for Production and their Agro-climate

Several agro-ecological zones could be identified in Sri Lanka, and these agro-ecological zones could be grouped into three main agroclimatic zones, namely, (a) Wet Zone, (b) Intermediate Zone and (c) Dry Zone.

Such a classification has been based on rainfall, vegetation, soils, and present land use (4). While the emphasis in the Wet and Intermediate Zones is mostly for the cultivation of Plantation (perennial) crops and rice, the land area available and the agro-climatic of the Dry Zone places it as an ideal area for the cultivation of annual crops including grain legumes and rice.

Out of Sri Lanka's total land area of 16.2 million acres, 11.6 million acres are in the Dry Zone. This 11.6 million acres consists of a resource base of 1.6 million acres of already developed land (approximately half of which is under major and minor irrigation schemes) and 4.3 million acres of new land available, land not available for agriculture accounting for 5.7 million acres. The 4.3 million acres of new land available consists of a proposed irrigated extent of 0.9 million acres and 3.4 million acres of proposed rainfed cultivation (3).

The Alfisols constitute the main soil order in most parts of the Dry Zone (4).

The bi-modal rainfall pattern experienced in the Dry Zone bestows two well defined rainy seasons, namely, (a) Maha - the major cultivation season lasting from early October to late January and (b) Yala - the minor cultivation season lasting from late March to May. Interposed between these two cultivation seasons are two marked dry seasons, one during February and March which is short and moderate, and the other during June to September which is long and protracted (1,2).

It is now clearly recognized that the soil, climate and other environmental characteristics of the Dry Zone are such that it is both physically possible and economically feasible to grow a wide variety of grain legume crops during both seasons under rainfed conditions. The acreages and production of grain legumes in the Dry Zone is comparison to that in the other two zones (see Table 3) is an index of the validity of this conviction.

Research on Grain Legumes

Research work on Grain Legumes is centred at the Agricultural Research Station, Maha Illuppallama. The location of this research station could be considered to represent the modal situation of the agro-climatology of the Dry Zone.

At present, grain legumes are grown as monoculture. However, research is being stepped-up to study the possibilities and advantages of inter-cropping grain legumes with cereals and other crops, and also to fit grain

legumes into viable cropping systems that embrace several crops.

Several varieties of grain legume crops have been released from the Agricultural Research Station, Maha Illuppallama. A brief description of these varieties are given in Table 4.

The yields obtained in Research plots as compared to those in Farmers' fields are given in Table 5. The esearch plot yields have been obtained under very good levels of management and cannot be equalled under practical farming conditions. However, the Research plot yields reflect the potentialities for higher yields obtainable with Grain Legumes.

The present crop improvement programmes and related investigations include breeding for better agronomic traits (using conventional breeding methods) with the ultimate objective of obtaining higher yields. Considerable work has to be done to identify genotypes possessing resistance to major pests (outlined in the following section). Investigations in this direction have just been initiated and, subsequently, any genotypes possessing resistance to minor pests will be used in the breeding programmes. In the wake of increasing acreages under grain legumes and intensification of management practices, it will not be possible to escape a situation where new pests, and new races of pathogens and biotypes of insect pests will occur. In fact, the pests of economic importance existing today, with the exception of the Pigeon pea pod borers, were not known to devastate the crops about a decade ago.

Though the present strategy is to identify resistant genotypes and resort to conventional breeding practices, the use of mutants to obtain resistance donors as well as selections that could be released directly should not be ruled out.

Farmers are advised to use the three main forms of fertilizers - nitrogen, phosphate and potash. But their use is very limited. Most farmers grown grain legumes without any fertilizers. However, investigations on the response of grain legumes to fertilizers have not been conducted and constitute an immediate research need.

The need for investigations on the use of different strains of inoculum, nodulation and nitrogen fixation has been realized and some preliminary investigations in this respect are under way.

The potential response to irrigation and water consumption are two other important aspects being investigated by our Scientists.

Factors limiting Production

The principal constraints limiting production are Virus on Green gram, Rust on Groundnut (Uromyces sp.) and Pod borers on Pigeon pea. Several pod borers infest Pigeon pea. The main species of Pod borers devastating Pigeon pea are Maruca testalabis and Heliothis armigera. The nature, and ecological, epidemiological, and entomological aspects of Virus on Green gram have yet to be determined. Virus on Green gram and Pod borers on Pigeon pea are indeed severely restricting yields in these crops and sources of resistance do not seem to be readily available.

The Cowpea are very susceptible to stored grain pests, mainly Callosobruchus sp. The susceptibility of Cowpea to storage pests coupled with poor marketing facilities discourage farmers from expanding their Cowpea acreages.

The hard seed coat of Pigeon pea renders it very difficult to split. It is essential that this legume be split before cooking. At present, it is ground in a domestic grinding stone. If production is to increase, it is inevitable that a suitable grinder be designed.

Among institutional factors, marketing of Grain Legumes should receive immediate priority.

Objectives of Crop Improvement Programmes

The objectives of the crop improvement programmes could be briefly stated as follows:

1. Improvement of the yield components so as to increase the overall grain yield.
2. Incorporation of resistance or tolerance to diseases and pests of economic importance.
3. Consolidation of agronomic, physiological and morphological traits that would bestow wider adaptability under practical farming conditions.
4. Selection of varieties that would respond to better levels of management.
5. Selection of varieties with improved nutrient content, and with acceptable palatability and cooking qualities.
6. Collection of local varieties from all parts of Sri Lanka, evaluating and preserving them. Likewise, introductions from elsewhere will be obtained and evaluated. Useful genotypes from such a collection will be used in the breeding programmes or even released as varieties if they are found to be better than existing varieties.
7. Selecting varieties to fit the age class of such varieties into the rainfall probability patterns obtained during the two cultivation seasons in the Dry Zone.

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Table 1.

MARKET/1 PRICES OF GRAIN LEGUMES AND RICE

Commodity	Price per lb. (Rs.)/2
1. Green gram	4.50
2. Cowpea	3.25
3. Black gram	6.00
4. Pigeon pea	3.25
5. Groundnut	2.00
6. Soybean	3.75
7. Rice	1.75

/1 Retail Store prices

/2 1 US$ = Rs. 7.35

These figures are approximations (of average prices) made by the author.

Table 2.

TOTAL IMPORTS OF PULSES

Year	Quantity (cwts)	Value(Rs.)/1	Price per cwt(Rs.)/1
1966	1,699,292	60,394,205	36
1967	1,389, 256	51,055,749	37
1968	1,217,212	56,378,479	46
1969	1,550,322	78,121,914	50
1970	990,830	45,340,399	46
1971	607,921	28,412,307	47
1972	1,821,849	97,637,497	54
1973	739,700	42,358,762	57

/1 1 US$ = Rs. 7.35

Source: Customs Department

The figures for 1974 are not available yet, but it is expected that the imports for that year was the least. It is not anticipated to import Grain Legumes in 1975.

Table 3. TOTAL PRODUCTION OF GRAIN LEGUMES IN SELECTED YEARS[1]

Year[1]	Agroclimatic Zone	Season[2]	GREEN GRAM		COWPEA		BLACK GRAM		PIGEON PEA		GROUNDNUT		SOYBEAN	
			Area (acres)	Production (cwts)	Area (acres)	Production (cwts)	Area (acres)	Production (cwts)	Area (acres)	Production (cwts)	Area (acres)	Production (cwts)	Area (acres)	Production (cwts)
1968/69	All island	Maha	na	31850	na	30350	-	-	na	20	na	69700	-	-
		Yala	na	16200	na	18150	-	-	na	nil	na	39450	-	-
		TOTAL	na	48050	na	48500	[3]	[3]	na	20	na	109150	[3]	[3]
1973/74	Dry Zone	Maha	18473	76782	4124	26938	2648	9620	2663	30061	16071	116002	1148	6734
		Yala	5209	27396	2034	11764	756	3030	505	1949	2389	25340	1217	5142
		Total	23682	104178	6158	38702	3404	12650	3168	32010	18465	141342	2365	11876
	Wet and	Maha	2206	12390	697	4455	21	103	44	239	363	4344	359	5290
	Intermediate	Yala	529	9223	540	3970	14	81	62	477	250	1959	505	3763
	Zones	Total	2735	21613	1201	8425	35	184	106	716	613	6303	864	9053
	All island	TOTAL	26417	125791	7359	47127	3439	12834	3274	37726	19078	147645	3229	20929
1975/76	Dry Zone	Maha	29064	145594	22247	142856	6324	58037	na	na	21597	165260	2545	22053
		Yala	11041	70937	15344	104286	1483	16620	na	na	5799	47641	1740	16623
		Total	40105	216531	37591	247142	7807	74657	1090	8889	27396	112911	4285	38676
	Wet and	Maha	2671	13363	1919	11871	68	408	na	na	464	3465	396	2798
	Intermediate	Yala	904	4559	1095	6841	26	156	na	na	367	2538	283	2222
	Zones	Total	3575	17922	3014	18712	94	564	255	2322	831	6003	679	5020
	All island	TOTAL	43725	234453	40605	265854	7901	75221	1345	11211	28227	4964	4964	43696

na. Figures not available

[1] 1968/69 to reflect local production before import restrictions. 1973/74 to reflect local production after commencement of import restriction.

1975/76 - Targets set - to reflect current trends.

[2] See description of agroclimatic zones and seasons in text under 'Potential Areas for Production and their Agroclimate'.

Source: Department of Agriculture and Ministry of Agriculture and Lands, Sri Lanka.
The statistics available are only in respect of administrative districts. The author has grouped figures pertaining to districts (on a rought approximation) to obtain figures for the respective agroclimatic zones.
Statistics for 1968/69 are not available on a district basis.

[3] Figures not collected - probably nil or negligible.

Table 4. VARIETIES OF GRAIN LEGUMES PRESENTLY CULTIVATED

Crop	Variety	Parentage	Important characteristics /1
Green gram	1. MI 1	Selection from the variety Gualior, an introduction from India.	3 months, determinate, medium height, large seed.
	2. S 16 (MI 3)	Introduction from India.	3 months, determinate, tall, small seed.
	3. Type 51	Introduction from India	2 months, determinate, short, small seed.
	4. MI 4	MI 1 X Type 51	2½ months, determinate, medium height, large seed.
Cowpea	1. Bombay Cowpea	Local variety-probably an old introduction from India.	3 months, indeterminate, medium height, favoured by consumers.
	2. Arlington	Introduction from USA.	3 months, indeterminate, medium height, relatively less popular among consumers.
	3. MI 35 (Lanka Parippu)	Arlington X Floricream.	2½ months, relatively determinate, short, favoured by consumers especially for its cream coloured small round seeds.
Black gram	1. MI 1	Selection from a local variety.	3 months, relatively determinate, medium height.
	2. Type 9	Introduction from India.	2½ months, determinate, medium height.
Pigeon pea	1. MI 10	T 64 X Trinidad.	4 months, determinate, dwarf.
Groundnut/2	1. Uganda Erect	Introduction from Uganda	3½ months, determinate, short, three seeded pods, red seed.
	2. Red Spanish	Introduction from New Guinea	3½ months, determinate, short, two seeded pods, red seed.
	3. A 92	Introduction from Zaire	3½ months, determinate, short, two-seeded pods, brown seed.
	4. A 20	Introduction from Zaire	3½ months, determinate, short, two-seeded pods, brown seed.
	5. MI 1	Selection from local variety	3½ months, determinate, short, two-seeded pods, brown seed.

/1 Seedling emergence to maturity duration is given in months. Relative plant height is indicated as short, medium or tall.

/2 The five varieties of Groundnuts are cultivated in very limited extents. The local varieties which are tall and indeterminate are still popular among farmers.

Table 5. YIELDS OBTAINED UNDER RAINFED CONDITIONS BY FARMERS AND IN RESEARCH PLOTS

	Crop	Farmers' Yields /1 (lbs per acre)	Research Plot Yields /2 (lbs per acre)
1.	Green gram	550	960
2.	Cowpea	700	1,620
3.	Black gram	800	1,490
4.	Pigeon pea	400	1,540
5.	Groundnut	1,000	2,310

/1 Based on the consensus of opinion of some extension and research workers.

/2 Average yields of popular varieties in Maha Illuppallama yield trials over several seasons.

GRAIN LEGUMES IN BANGLADESH

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ABSTRACT

The main grain legumes grown in Bangladesh are: lentil, mungbean (green gram), chickpea, blackgram, grasspea and pigeon pea.

Grasspea, chickpea and lentil are covering the largest areas in hectares. Most of grain legumes are normally grown as monoculture but occasional mixed croppings are also practiced. There are two main seasons for growing grain legumes. Breeding activiteis with these crops are fairly new. Mutation breeding with lentil, chickpea and grasspea is being carried out at the Institute of Nuclear Agriculture, Nymensingh, Bangladesh.

1. Principal Grain Legume Crops

Quite a good number of grain legume crops are grown in Bangladesh. Some of these are widely cultivated while others are considered minor crops. These are listed here with their local, common and botanical names and their status of production.

Local Name	Common Name(s)	Botanical Name	Status of Production
Masoor	Lentil	*Lens esculental*	Major
Moog	Mungbean/ greengram	*Phaseolus aureus* Roxb.	Major
Chhola	Chickpea/gram/ Bengal gram	*Cicer arietinum* L.	Major
Mashkalai	Urd bean/ Blackgram	*Phaseolus mungo* L.	Major
Khesari	Grasspea/ Vetchling	*Lathyrus sativus* L.	Major
Arahar	Pigeon pea/ Redgram	*Cajanus indicus* Spreng	Major
Mator	Fied pea	*Pisum arvense*	Minor
Veli or Garikalai	Soybean	*Clycine max* (L.) Merill.	Minor

2. Usage of Grain Legumes

Most of the grain legumes have one common use and at the same time some have very special uses. The one single common use of most of these legumes is in the common dish of Bangladesh, called 'Dal'. 'Dal', is prepared by boiling the cotyledons in water after dehusking, salt and species are added and seasonings are practiced in some areas. 'Dal' is cooked singly like this way or is mixed with meat, fish or vegetables. Cooked 'Dal' is mixed with rice in place of meat or fish while consuming rice. The specific uses of different grain legumes, their mode of preparation and combination with other foods are described as follows:

Lentil: The seed is mainly consumed as 'Dal'. The young pod is also used as vegetable, and dry leaves and stalks after threshing are used as fodder. It should be emphasized that it is mainly grown for food. The fodder is just a by-product. The seedcoat is used for animal feeding.

Mung: The mung seed is also mainly used as 'Dal' cooked singly or mixed with fish-heads, animal brains, meat, rice or vegetables. The stalks, leaves, empty pods and also the seedcoats are used for animal feeding.

Chickpea (Gram): Seeds of gram are primarily used as human food and is also used for feeding livestock. 'Dal', 'Bason' (gram flour) used in 'Beguni', a sort of fried dish made out of brinjal and gram flour, 'chhatu' (flour from roasted gram) consumed with sugar and sweets, boiled whole gram, and fried and roasted gram are some of the gram dishes consumed by man. It is one of the basic materials used for most sweet dishes. The stalk, leaves, empty pods and the husks are used as fodder.

Urd bean: The seed of urd bean is entirely used as human food. Besides being used as 'Dal' it is also utilized in the manufacture of large number of food preparations. The plant parts and husks are used in animal feeding.

Pigeon pea: The seed is primarily used as human food and is also used for feeding livestock. It is consumed as 'Dal' and the roasted pea is also eaten by man in small quantities. Sometimes, the whole pea is soaked in water and fed to horses. The husks are fed to cattle. The stalks and branches of the plants are used as fuel in the country side.

Grass pea (Lathyrus): The seed is used as 'Dal' for human consumption and it is also used for cattle feeding. A major part of the grass pea acreage is used as fodder during or prior to pod formation. When it is harvested for

seed production, the plant parts left after threshing and winnowing are used as cattle feed.

Peas: The seed of field pea (P. arvense) is used mainly for 'Dal' and fed to the cattle in a limited scale. The field pea is also used as a green manuring crop and fodder.

Soybean: The seed is mostly used as 'Dal' for human consumption. In a very limited scale it is also used as roasted beans and in some areas indigenous methods are employed to extract oil from it. The oil is consumed by man and the oil-cakes are fed to the cattle. The plant parts remaining after threshing of the crop are used as fuel.

In Bangladesh, grain legumes have not only been available to that part of the population most vulnerable to dietary insufficiency but were the main source of protein over and above fish to all sections of the population until very recently. It was rightly termed as the "poor man's meat". Availability however, has gone down for everybody due to their increase in price during the last 4-5 years. It is difficult to arrive at a figure as to the quantity of grain legumes consumed per day by an individual from a particular age group but the national average figure is 28 grams/day/person (Anonymous 1966) as against the minimum quantity of 45 gms. advocated by the F.A.O. (Anonymous 1964). It is therefore evident here that the part of the population most vulnerable to dietary insufficiency are not getting the bare minimum quantity.

The diet of the children varies in different areas of the country and in different income groups. Breast feeding upto the age of about 1½ years is universal in the countryside and among the vast majority of the town and city dwellers. A small elite of the town provide baby food to their children at the young age and milk, butter and eggs are supplemented with the growth of these children. Children of the well-to-do villagers and upper-middle-class families of the towns are provided with milk and occasionally an egg or two upto the age of 4-5 years. Apart from these fortunate few, the majority of the children are fed with broth made from wheat or rice flour, rice, vegetables and fish. Children of the small farm-family do not get similar diets. The

elder brother may be brought up on the impoverished broth, rice, vegetables and fish diet whereas his younger one may be given milk for about 10 months if a cow of the farm gives birth to a calf in that year.

The cost of a kilo of lentil, mungbean, chickpea, blackgram, grasspea, pigeon pea, field pea and soybean seed at present varies from Taka 7.50 to 10.00 (0.50 - 0.75 cents. US$). The cost of a kilo of rice varies from Taka 5.00 to 7.50 (approx. US$ 0.33 to 0.50 cents) and that of wheat it is Taka 3.00 (US$ 0.20 cents approx.).

3. Areas and Production

The area under cultivation of the various grain legume crops are shown below. The figures are for the year 1971-72:

Crop	Area (hectares)
Lentil	77,569
Mungbean/green gram	18,840
Chickpeas/gram	71,698
Urdbean/Blackgram	52,649
Grasspea/Vetchling	95,866
Pigeon pea/Redgram	2,917
Field pea	15,154
Soybean	1,607

4. Growing Seasons

In Bangladesh the grain legume crops are grown in two seasons, locally called Rabi and Kharif. In the Rabi season, the crops are sown from late summer to early winter and harvested from late winter to early summer, whereas in the Kharif season, sowing starts from summer and harvested in the late summer or early winter. However, the important grain legumes such as lentil, chickpea, grasspea, field pea, etc. are mainly grown in the Rabi season, while grain legumes of relatively minor importance viz. urd bean, pigeon pea etc. are

grown in the Kharif season. A few legume crops such as mung bean, and soybean are grown in both the seasons. Months of sowing and harvesting are indicated here.

Crop	Season	Sowing months	Harvesting months
Lentil	Rabi	October-November	February-March
Chickpeas	Rabi	October-November	February-March
Grasspea	Rabi	October-November	February-March
Mungbean	Rabi	September-October	December-January
Mungbean	Kharif	May-June	August-September
Urdbean	Kharif	August-September	November-December
Field pea	Rabi	October-November	March-April
Soybean	Rabi	December-January	April-May
Soybean	Kharif	August-September	December-January

5. In Bangladesh, most of the grain legumes are normally grown as monoculture but occasional mixed croppings are also practiced. These intercroppings differ according to the crop itself and the season it is grown. Here each crop is dealt with separately.

Lentil: Normally it is grown as a monoculture but sometimes it is also grown as a mixed crop with mustard, barley and wheat. Yield of lentil in a mixed culture is naturally lower than in the monoculture.

Mungbean: The crop is usually grown as a single crop during the Rabi season. In the Kharif however, it is grown mixed with other crops such as sorghum and maize. In a few areas, mung seed is broadcast in the wet lands of jute fields before the harvest of the latter. The germination and primary growth take place in the jute fields. Plant growth accelerates after the harvest of jute as more abundant sunlight and nutrients are then available to the mung seedlings.

Chickpea: It is normally grown as single crop but is also grown as a mixed crop with mustard, barley, wheat and flax.

Urd bean: This is not grown as a mixed crop in this country. But sometimes is broadcast in standing rice fields. Rice is harvested after about one month and the seedlings grow a few inches tall by this time.

Pigeon pea: This crop is grown both as a monoculture and as intercropped plantings. Groundnut, mungbean, grasspea, chickpea and field or garden peas are grown as mixed crops with pigeon pea.

Grasspea: It is mostly grown as a single crop. It is also sometimes grown as a mixed crop with a very tall, erect and herbaceous variety of mustard called "Radi" (pronunciation like Rye) (Brassica juncea) which grows upto 3-5 ft. The mustard is broadcast when the grasspea has germinated and the moisture content of the soil has decreased to some extent. It is also sown in between lines of pigeon pea as a secondary crop.

Field pea: It is normally grown as a mixed crop with the tall mustard variety Brassica juncea. It is also sown mixed with the Rabi cereals such as wheat and barley.

Soybean: This crop is grown as a single crop in Bangladesh.

6. (a) Architecture

The plant architecture of grain legumes does not appear to be inefficient as such but it seems that there are scopes for improvement in this group of crops in various ways. The lentil plant under good growing conditions grows about 25 cm. in height and possesses 2-3 primary branches. A taller plant with more primary branches with commensurate increase in number of pods would be desirable. The chickpea, mungbean and urdbean plants also possess similar deficiencies and may be tailored according to the hypothetical lentil plant described above. The mungbean plant has very non-uniform ripening of pods and the same plant bears ripened and young pods together. Uniformity in pod-ripening may be a good character to improve upon.

The grasspea and field pea plants are creepers and possess less branching habit. Increase of primary branches per plant may be one of the breeding objectives.

Soybean and pigeon pea plants may be shortened in height and more branching may be encouraged for better performance.

(b) Cropping Season

In most parts of Bangladesh already 2 or 3 crops are grown per year and the important grain legumes fit well in the rotation programmes.

Legume - Aman rice Legume - Jute	low-lying areas
Legume - Aus - Aman Legume - Jute - Aman rice	High land areas

It is possible that chickpea cultivation would be extended further south if a high yielding shorter duration type were found.

7. Fertilizers

Fertilizers are not used in growing grain legumes. There is little experimental evidence for fertilizer responses of grain legumes in Bangladesh, but much higher yields in lentil and chickpea were obtained by applying 70-35-35 kg. of urea, T.S.P. and M.P (ref. P.8).

8. Most of the grain legume species were derived from indigenous germ plasm. The pigeon pea might have been introduced from other parts of the Indian Sub-Continent and the soybean varieties are introductions from the Philippines and the U.S.A.

9. Average Yields

Yield/ha in the average farmer's field is given below: Experimental yield data is available for lentil and chickpea only:

Crop	Season	Yield (Kg) per hectare (Farmer's field)	Yield (Kg)/ha in experimental station
Lentil	Rabi	760	1200
Chickpea	Rabi	880	1500
Grasspea	Rabi	870	Not available
Urd bean	Kharif	900	"
Mungbean	Rabi	750	"
Mungbean	Kharif	Not recorded but much lower than in Rabi	"
Field pea	Rabi	800	"
Pigeon pea	Kharif	750	"
Soybean	Rabi	690	"
Soybean	Kharif	Not recorded but much lower than in Rabi	"

10. Obstacles to Increased Production

It is the feeling of the present author that the main obstacle to increased production of grain legumes has been the varieties that are grown. There has not been any work on the collection and comparative studies of the varieties that are cultivated in different parts of the country. It is not even known how many varieties, of which grain legume, are grown at present. On the other hand, very little attempts has been made to introduce new varieties in the memorable past. Moreover, hybridization among local varieties has also not been done. As a result, there has been a complete lack of variation in these crops.

Secondly, the lack of a clear cut outline describing the rules for

growing the grain legume crops successfully. Moreover, whatever little research has been done in these crops, has not reached the farmers. Consequently the farmers are using the age-old methods of cultivation without bothering about any improvement of production. Even the basic information regarding the best agronomic and cultural practices such as, the type of soil, land preparation, time of sowing, seed rate, methods of sowing, kinds and combination of fertilizers to be used, stages of application of each fertilizer, times and methods of harvesting, mixed croppings, rotations, irrigation practices, methods of storing the produce for marketing and for seed, are still lacking.

Another principal obstacle to increased production of grain legumes as a group is their competition with rice. The competition has been quite high in the last one decade or so due to the chronic shortage of food in the country. The competition has become more serious after the introduction of high yielding IRRI varieties. Some of these high yielding varieties are specially grown in Rabi season when most of the food legumes are grown. Because of the much higher economic return from these HYVs, the farmers tend to invest the major part of their efforts and inputs (irrigation, fertilizer etc.) to these rice varieties and the grain legumes are not getting whatever little attention they used to get previously. As a result of this competition, with each passing year, the grain legumes are being replaced slowly in more areas of the country by rice.

As the Rabi season is characterised by dry season, irrigation water seems to be limiting factor in the improvement of grain legume production.

Diseases and insects do not normally pose a threat to increased production of grain legumes during the Rabi season. During the Kharif season, light infection may occur but it has not been a cause for serious damage.

11. Nitrogen Fixation

Little work has been done on the nitrogen fixation of leguminous crops in Bangladesh. Studies related to the effect of inoculation with some native strains of nodule-bacteria upon the nodulation, dry weight and nitrogen contents of host plants were conducted in the Dacca University. The host plants were Arachis hypogea, crotalaria juncea, phaseolus mungo and Vigna sinesis (Cowpea). In all cases the inoculated plants contained more nitrogen than the uninoculated (Chowdhury & Khan 1970). From the scanty available data it is difficult to ascertain whether nitrogen fixation by nodule-forming bacteria is a deterrent to higher production. Inoculation

of leguminous crops with nodule-forming Rhizobial strains is already an established practice in some countries.

12. Mutation Breeding

Mutation breeding on lentil, chickpea and grasspea is being carried out by M.A.Q. Shaikh and co-workers in the Institute of Nuclear Agriculture, Mymensingh. The characters being sought are higher seed yield and/or higher seed protein. A few mutants of chickpeas and lentils have shown promise of higher yields. Most of the mutants of lentils and chickpeas have shown less protein content than the mother variety. A few are still under rigorous scrutiny.

13. Breeding Activity

Breeding activity in legumes was almost nil before 1972. The Bangladesh Agricultural Research Institute (BARI) at Dacca maintained a few varieties of each pulse crop and research was limited to a few agronomic trials which, as mentioned earlier, did not result into specific recommendations. Mutation breeding of a few pulses are started in the Institute of Nuclear Agriculture (INA) 1972. During 1975, the Bangladesh Agricultural Research Council has promised to finance the legume breeding activities of the B.A.R.I. and I.N.A. The mutation breeding programme of I.N.A. is being supported by the International Atomic Energy Agency through its Research Contract No. 1312/GS.

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GRAIN LEGUMES IN BURMA

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ABSTRACT

Several grain legumes are grown in Burma. Chickpea, butter beans, mungbean, pigeon pea, hyacenth bean are the species which cover the largest acreages. Groundnut is also very important but is mainly grown as oilcrop. Both monoculture and intercropping are practised. Generally, the grain legumes are poor yielders in farmer's field where almost no fertilizers are applied. In experimental trails applications of N, P and K, are doubling the yield. Very little breeding work has been done with grain legumes.

In the present FAO/UNDP project, however, a systematic breeding programme on grain legumes has been started. In the IAEA/UNDP project on mutation breeding some work were also done on grain legumes. The selected mutants are under evaluation.

1. Principal grain legume crops in Burma and their area under production

No.	Vernacular Name	Common English Name	Scientific Name	Area/acres (Thousand)	Yield/acres (lbs)
1.	Htaw-but Pe	Butter bean	Phaseolus lunatus	207	426
2.	Sultani	Sultani	"	16	473
3.	Sultapya	Sultapya	"	132	414
4.	Pe-Gya	Pe-Gya	"	15	288
5.	Pe-byu gale	White bean	"	5	413
6.	Mat-pe	Mung bean	P. mungo	184	456
7.	Pe-di-Sein	Green gram	P. mungo radiatus	84	250
8.	Pe-Yin	Rice bean	P. calcaratus	33	250
9.	Bocate pe	Cowpea	Vigna sirensis	42	542
10.	Pe-lun	Cowpea	Vigna catiang	50	540
11.	Pe-boke	Soybean	Glycine max	51	607
12.	Kala-pe	Chickpea	Cicer arietimum	449	382
13.	Pe-Sein-gone	Pigeon Pea	Cajanus indicas	179	500
14.	Sadaw-pe	Pea	Pisum sativum	63	500
15.	Pe-Ya-Za	Lentil	Lens esculenta	9.8	228
16.	Pe-Gyi	Hyacenth bean	Dolichos lab lab	194	379
17.	Pe-nauk	Urd bean	Thaseolus mungo	72	300
18.	Other Pulses			73	
				1858.8	

N.B. Groundnuts are not included but are a most important oilseed crop in Burma.

2. Use

(a) Diet as:

1. Soup - butter bean, lentil, Dolichos, chickpea, Sultani, Sultapya
2. Roasted - Dolichos, chickpea, pea, Pe-boke, Pe-Gya
3. Pastry - Sultani, chickpea, black gram, green gram, Pe-yin
4. Deep fry - Chickpea, Dolichos

5. Bean thread - Chickpea
6. Germinated bean - mung bean, green gram, Dolichos
7. Bean curd - Cow pea, gram
8. Steamed - pea, Sultani, Sultapya
9. Fermented paste and cake - Soybean

(b) Food in combination with:

1. Sticky rice - cowpea, pea
2. Meat as curry - gram
3. Rice and Pea cooked together
4. Rice, bread, parata, - steamed pea with oil and salt

(c) All the grain legumes are taken commonly by population most vulnerable to dietary insufficiency.

(d) Average diet of children:

1. Mothers milk
2. Steamed Pisum
3. Rice
4. Fish
5. Meat
6. Vegetables

Cost per kilo (Approximately)

1. Sultani, Sultapya, Butter beans - 50 cents (US)
2. P. calcaratus, Mung bean
3. Vigna, cajanus, white bean 40 "
4. Rice 30 "
5. Wheat 35 "

3. Area under production (see No. 1)

4. Growing season

Crop	Sown	Harvested	
Cajanus	May, June	Nov - Dec	(Mixed crop (Cotton, Groundnut))
Mung bean	Dec. (After harvesting Rice)	March	broadcasted before Rice harvest.

Soybean	May-June Oct-Nov	Sept-Oct Jan-Feb
Others	Aug-Sept	Jan-Feb

5. How grown

Both as Mono-culture, Intercropped plantings with groundnut, Potato, Soybean etc.

6. Plant type etc.

Generally most of the grain legumes grown are poor yielders. These may be attributed to plant type, variety and chemical fertilization. Alteration of crop duration and maturing time (both early and late) will facilitate double cropping after rice and avoid heavy rainfall period.

7. Fertilizer application

In general no or very little fertilizer is used by farmers. In some cases they use F Y M. (Farm yard manure)

Some experiments have indicated fertilizer responses. All the three (N.P.K.) gave practically same magnitude of response for Sultani, Butter bean, Black gram and Soybean.

8. Source of the varieties

Expect a few, most of the varieties are grown in Burma for a long time and it is not known definitely if they are indigenous or introduced.

Soybean (L.114)	- from the Philippines
Butter bean (Rangoon-Madagascar)	- from Madagascar

9. Yield under different condition

Crop	Farmers Av. (lbs/acre)	Experimental Farm		
		Without fertilizer (lbs/acre)	With fertilizer (lbs/acre)	N P K
Sultani (P. lunatus)	473	497	1190	39,39,36
Butter bean (P. lunatus)	426	600	1037	26,25,33
Black gram (P. mungo)	456	612	1443	40,47,24
Soybean (G. max)	607	709	1116	27,40,37

10. Factors which are principal obstacles to increased production

1. Disease or insect pest - Disease and insect pests are not very important.
2. Others - Plant type, variety and the application of fertilizers.

11. Studies in nitrogen fixation

No work has been done in studying nitrogen fixation of legume crops in Burma. It may be a deterrant to high production. In poor yielding crops very little nodulation has been observed.

12. Mutation Breeding

Yes; Soybean, Mung bean, Sultani, Sultapya, Mokilima by Dr. Myint Thein and U Tin Myint (only Soybean) under the guidance of IAEA Experts. The specific characters sought for improvement are as follows:

Soybean (G. max)	- early maturity
Mung bean (P. mungo)	- Bigger seed, uniform seed size and colour, short and uniform flowering period
Sultani (P. lunatus)	- Seed colour (purple), seed size uniformity
Sultapya (P. lunatus)	- Seed colour (purple), seed size uniformity

Results:

Soybean: - 1 mutant strain (M_7) developed from the variety Shwe Myaing Pale. This mutant is early and indeterminate type. It is under yield trial. 21 early and 21 late maturing mutant (M_2) have been selected from the variety L114. These are grown as single plant progeny rows this season (M_3).

Mung bean: - 291 (15kR) and 146 (30kR) single plants have been selected from M_2 and these are growing as single plant progeny rows (M_3).

Sultapya: - 35 (5kR), 25 (10kR), 35 (20kR) and 30 (30kR) single plants have been selected from M_4 and these are growing as single plant progeny rows (M_5).

Sultani: - 15 (5kR), 25 (10kR), 30 (20kR) and 20 (30kR) single plants have been selected from M_4 and these are growing as single plant progeny rows (M_5).

Mokilima: - 25 (5kR), 2 (10kR) and 7 (15kR) single plants have been selected from M_4 and these are growing as single plant progeny rows (M_5).

13. Legume breeding

Very little breeding work is done. Recently a grain legume breeding specialist (FAO Project) has arrived and it is expected that a systematic breeding programme will be taken up.

The Agricultural Research Institute (A.R.I.) Yezin in collaboration with Central Farms, carries out the research.

14. Acknowledgement

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GRAIN LEGUMES IN THAILAND

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ABSTRACT

Mungbean, peanut and soybean are the three major legumes cultivated in Thailand. Several other legumes are also important at the village level but are not involved in large scale commerce.

Only the three major crops are discussed in the paper. These crops have a short growing season and 2 to 3 crops or harvests are taken per year. The production of these legumes have drastically increased during recent years especially soybean. The yields at farmer's fields are still fairly low as very little fertilizers are applied.

Both indigenous and introduced varieties have been tried and some breeding work is going on. Mutation breeding has been used in soybean where a non shattering mutant has been selected in an introdced, high yielding Japanese variety.

Legumes or "beans" have been mentioned frequently in the old Thai literature as materials required in certain state and religious ceremonies as well as a favourite example in local proverbs. Consequently, they are often used in preparation of several traditional dishes which are popular among Thai people. Thus, it is reasonable to believe that they have been grown and utilized in Thailand for a long period of time.

Legumes are cultivated for many purposes. However, human consumption ranks first among them. Statistics indicate that mungbean (*Phaseolus aureus*) peanut (*Arachis hypogaea*) and soybean (*Glycine max*) are the three major legumes cultivated in this country. There are also other legumes grown to a lesser extent such as peas (*Vigna spp.*), dry beans (*Phaseolus spp.*), sugar peas (*Pisum spp.*), chickpea (*Cicer arietinum*), pigeon pea (*Cajanus spp.*) and others. This latter group may be important at the village level but are not involved in large scale commerce. Hence, due to availability of reliable information, only mung beans, peanuts and soybeans will be discussed in this paper.

Total acreage, production, crop cost and export value of these three crops over a thirteen year period (1961 - 1973) are given in Table 1. The table indicates that the production has increased more than fivefold for mungbean and six times for soybean during this period. It is expected that the production will continue to increase at a significant rate in the future.

Since these three legumes have a short growing season, they can be grown up to three times a year. The first planting season starts with early rain in April to May and harvesting is finished in August to September. In certain areas, such as Upper Central Plain, the soybean are grown in relatively widely spaced rows which enables intercropping of cotton planted between them in July to August. The second plant season is during late July and August, after the first corn crop has been harvested. Immediate sowings of mungbean and soybean produce a good harvest by the end of the rainy season in late October to November. These two growing seasons are practised in the upland fields under rainfed conditions. The Third planting time is generally conducted in the paddy field following the harvest of rice crops. Direct sowing of soybean and mungbean seed into rice stubble, during December to January, with sufficient irrigation, will give satisfactory yield for April to early May harvest.

The cropping patterns with peanut are different from those for mungbean and soybean due to difficulty in harvesting. Only two crops a year are grown. One is with May or June sowing which will permit crops to be harvested before the end of rainy season. Later planting would cause the farmers to dig the nuts out of dry soils. The other planting time follows rice harvesting in the light textured paddy soils with irrigation as is done with soybean and mungbean.

Legumes were considered to be marginal crops in the past. They were frequently grown when the land and climate did not suit other major crops. In addition to this, two other factors were responsible for further restrictions. Lack of proper technology at the farmer's level contributed to low yields, averaging about 500, 800 and 1,200 kilograms per hectare for mungbean, soybean and peanut respectively. Secondly, lack of a steady local market demand usually resulted in low prices whenever over production occurred. These facts tended to discourage expansion of farm acreage as well as national production.

At present, the overall situation of production of these three grain legumes has significantly changed. Demand for grain legumes, especially soybean, has increased rapidly due to the expansion of domestic feed and oil extracting industries and new markets in neighbouring countries. Consequently,

the Thai government decided to include a soybean acceleration programme in the Third Five - Year Plan (1972 - 1976) and a goal of 300,000 tons of soybean grains for 1976 was set. Also the Third Five - Year Plan stated that mungbean and peanut production are projected to increase at the rate of 5 to 10 percent per annum as there presently is no strong demand for these two crops in local and international markets.

In order to promote the grain legume acceleration programme, the "Oil Crop Project" was set up under the Department of Agriculture in 1970. Mung beans are also included in this programme because of their agronomic similarity to soybean. Research in various disciplines such as varietal improvement, cultural practices, soil fertility, inoculation, pest control and multiple cropping was established. From the beginning, the Government of Japan has provided valuable assistance to the soybean development programme by provision of experts, scientific equipment and materials. The general scope of research works will be briefly discussed.

Two standard varieties of soybean derived from hybridization were released to the farmers since 1967. They have consistently out-yielded several local and introduced varieties during each growing season. They have somewhat compact plant type, being about 60 to 75 centimeters tall with profuse branching, high resistance to lodging and shattering and high oil content (about 20 percent). Their growing periods are about 90 to 100 days which makes them suited to existing cropping patterns of all three growing seasons. Breeding objectives aim to preserve these characters but try to add disease resistance (such as rust), larger seed size and higher yield potential. About 20 to 30 crosses from various genetic stocks have been made each year since 1970. It is expected that new varieties with rust resistance will be released in 1976.

Work on mungbean and peanut varietal improvement has recently started. The native mungbean varieties are considered inferior in several agronomic characters, such as uneven flowering and pod setting and easy shattering. The necessity for several pickings to be done in order to obtain the maximum yield makes them a tedious crop for farmers. Selection of numerous introduced varieties from various origins have yielded certain varieties with more uniform pod setting and maturity. Optimistically, these better adapted varieties will be released for commercial production in the near future. Mungbean hybridization programmes are also conducted under the Department of Agriculture.

Two standard varieties of peanut obtained from evaluation of local collections were released for commercial scale in the last decade. The third variety, Taiwan No. 4, introduced from Republic of China was recently added to the

varietal recommendation list. A breeding programme for peanuts is also undertaken within this Department. Valencia and Bunch Virginia, with medium seed size and growing period of 100 to 120 days apparently would be adapted to existing multiple cropping programmes.

Mutation breeding has been conducted on vegetable soybean. A Japanese vareity "Bominori" having a large seed size and high protein content was introduced to be used as vegetable soybean. However, severe shattering at harvesting time makes them unfavourable for seed production. Gamma irradiations and selection in latter generations provided a non-shattering character with good growth habit. It is hoped that this improved "Bominori" will soon be distributed to farmers after final selection and performance test.

Fertilizer studies indicated that application of lime and phosphate would raise yield. However, relatively few farmers applied fertilizers to the legumes fields. In some cases, fertilizers are given to other crops then legumes are followed in the next season to catch up the nutrient left in soils. A mixed fertilizer of 20 - 60 - 40 kg/ha is generally recommended where it is needed to provide the optimum yield and to maintain soil fertility especially for the Northeast.

Investigation indicates that inoculation is not a serious problem for mungbean and peanut in Thailand. Even in the case of soybean, Rhizobia bacteria occur naturally in the relatively fertile soils represented in the major soybean growing areas. Heavy nodulation usually shows up with or without inoculation, even in the newly cleared land. However, in the infertile soils, especially in the Northeast, proper inoculation is needed to produce nodule formation on the standard varieties. Soil microbiologists have made studies to screen strains of Rhizobia for more effective nodulation and which are adapted for certain locations. It has been proven that a good combination of soybean variety and bacterial race can increase yield substantially. A pilot plant for inoculum production has been built. A plan for further expansion of inoculum production is under consideration.

So far, there has been no indication of serious pest problems. Soybean rust seems to be an important disease during the late rainy season planting. Bacterial pustule, downy mildew and leaf curl virus are occasionally observed in several locations. Powdery mildew and anthracnose also occur in the mungbean field during the heavy rain period. For peanut, root and collar rots have been noticed in poorly drained soils.

Beanfly and leaf and pod cutters are common insects for soybean and mungbean while leaf roller and hoppers are for peanut. Generally, chemical sprayings have given satisfactory control, but insecticidal applications are seldom practised due to prohibitive costs.

The Vegetable Project, also under the Department of Agriculture, is responsible for research and development of vegetable legumes other than the three discussed above. Some works are being conducted on sugar pea, cowpea and string beans.

Dissemination of research results on legumes is mainly conducted by the Department of Agricultural Extension. However, in certain localities, other governmental agencies also take part in encouraging farmers to grow more grain legumes. Coincidently, often shortages of legume grains in local and foreign markets result in growing acreage being expanded considerably.

As in other Southeast Asian countries, rice is the staple food for Thai people. Per capita consumption of rice is about 100 kilograms. Protein in the diet is somewhat lower than the desired standard, and most of it comes from animal sources. Grain legumes rank second as protein supplementary foods of which daily consumption is about 13 grams per person. Several cooking procedures are employed and depend on the kind of legumes. In the case of mungbean, there are three popular methods of cooking. Firstly, the grains are ground, mixed with other ingredients and then cooked as dishes or deserts. Secondly grains are converted to bean noodle and then fixed for foods in certain ways. Bean sprouts are the third method which has gained much popularity compared to other vegetables.

It is estimated that about 50,000 tons of soybean grain per year are processed in traditional Chinese methods in the form of soybean sauces, pastes and curds. For peanut, the nuts are directly consumed as boiled or roasted peanuts. Snacks and confectioneries made from peanut also receive high demand in the domestic markets. The recent establishment of feed and oil extracting factories have placed soybean and peanut seeds in bigh demand which has stimulated the expansion of consumption.

Kasetsart University's Institute of Food Research and Product Development also engages in research on the exploration and utilization of plant protein. These three legumes are the main sources of their raw materials for development of food products such as soybean milk, noodles, meat analogues, confectioneries and others. At present, this institute, in cooperation with Department of Health, has initiated a lunch programme for school children aimed at using plant protein to improve nutrition. These new food products are gaining popularity to a certain extent.

Conclusion

Close investigation has revealed that the production of these three grain legumes in Thailand has significantly increased. Several factors are responsible for the expansion. In the first place more and continuous research and technological supports provided to the farmers make grain legumes profitable, reliable and competitive. The trend of changing cultivation and field management from that of a marginal crop into commercial method has been observed. In addition to these, recent development of food technology has encouraged Thai people to consume more grain legumes and their products in order to achieve better nutrition. Competition for raw materials in food, feed and oil extracting industries, as well as exportation, has been observed in the last five years and has caused the demand and price to rise in both local and international markets. Thus, it is logical to forecast that grain legumes, especially mungbean, peanut and soybean will become leading crops in Thailand in both production and consumption in the near future.

Table 1. STATISTICS OF MUNGBEAN, PEANUT AND SOYBEAN PRODUCTION AND VALUE IN THAILAND FROM 1961 - 1973

Year	Mungbean				Peanut				Soybean			
	Acreage 1,000 ha.	Prod 1,000 ton	Value mill.$	Export mill.$	Acreage 1,000 ha	Prod 1,000ton [1/]	Value mill.$	Export mill.$	Acreage 1,000 ha.	Prod 1,000 ton	Value mill.$	Export mill.$
1961	37	40.6	4.7	3.0	83	108	10.7	2.6	24	24.2	3.1	.26
1965	121	124.8	13.1	5.1	99	131	16.0	3.7	19	19.1	2.6	.23
1969	192	152.0	18.7	7.8	103	124	15.7	1.4	48	48.2	5.8	.66
1970	238	148.0	19.0	6.6	104	124	15.3	1.5	59	50.4	5.9	.81
1971	135	125.6	14.9	6.7	118	134	22.2	.9	60	54.3	6.9	.86
1972	214	190.5	33.8	7.3	120	153	25.5	.8	83	72.0	10.6	1.15
1973	243	191.7	39.9	-	-	-	-	-	150	152.3	41.0	-

[1/] Unshelled pods.

Source: Thailand Agricultural Statistics in Brief. No. 33, 1975. Division of Agricultural Economics, Office of the Under-Secretary of State, Ministry of Agriculture and Cooperatives.

Remark: Wholesale price in the past ten years varied; for mungbean from 10 to 15 US ¢/kg. with 20 US ¢/kg. in 1973; for peanut from 18 to 21 US ¢/kg. with 27 US ¢/kg. in 1973; for soybean from 10 to 17 US ¢/kg. and 27 US ¢/kg. in 1973.

GRAIN LEGUMES IN THE PHILIPPINES

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ABSTRACT

Mungbean, peanut and soybean are the main grain legumes cultivated in the Philippines. One crop per year is normally grown in the winter season as monoculture. Very little fertilizers are used by the farmers, but experimental trials have shown significant response to N, P and K-fertilizers which at least can double the yields.

Breeding work are being carried out at the College of Agriculture, University of Philippines at Los Baños and Bureau of Plant Industry, Department of Agriculture and, successful varieties have been released for practical use. Some mutation breeding work has been started by the Philippine Atomic Energy Commission's Research Institute, Section of Agriculture.

1. Principal grain legumes in the Philippines

Mungbean, *Vigna radiata*
Peanut, *Arachis hypogeae*
Soybean, *Glycine max*

Field beans are also grown in the Highland areas and *Dolichos lablab* and wing bean are grown in backgardens for use as green vegetables.

2. Uses of legumes

The most commonly used grain legume in the Philippine diet is mungbean. This is cooked with leafy vegetables in the form of a soup, flavored with meat or fish. This is taken with rice. Mungbean is also processed into noodle which is commonly used in making native food preparations.

Peanut is not a part of the diet. It is eaten as snack foods - boiled in the pod, fried in deep fat or roasted. It is also processed into peanut butter.

Soybeans are utilized in limited quantities in the form of fermented curds which are used in very small quantities as flavoring materials in preparing native dishes. Much of our requirements for soybeans goes to the feed industry, which is applied from imports of the meal.

Prices of grain legumes are quite high. Current prices are:

(1) Mungbean, ₱4.00 - ₱6.00 per kg or US$ 0.50 - $ 0.80 per kilogram,
(2) Peanuts - ₱5.00 - ₱8.00 per kg or US$ 0.60 - $ 1.00 per kilogram;
(3) Soybean - ₱1.80 - ₱2.20 per kg or US$ 0.24 - $ 0.30 per kilogram.

3. Area under production

Mungbean - 38,130 hectares
Peanut - 32,450 hectares
Soybean - 15,000 hectares

4. Season of growing

Mungbean - October to November as an upland crop, harvested in December to January

- December to January as 2nd crop after rice, harvested in February to March

Peanut - Planted in October to December, harvested in February to April

Soybean - Planted in October to November, harvested in January to February

5. System of growing

Legumes are grown as monoculture; mungbean is also grown following paddy rice; paanut is also grown in mixed cultures with corn.

6. Architecture and maturity

The native varieties are usually very leafy and tall-growing Pod setting and maturity occur over a wide period of time and hand picking of pods has to be done several times. Varieties have been bred in the Philippines which are short-maturing and in which major defects have been improved. The new varieties lend themselves to full mechanization if necessary.

7. Fertilizers

Very little fertilizers are used by farmers on legumes. This is especially so when they plant the crop after paddy rice.

We get very little response to nitrogen fertilization due to Rhizobial action. We get substantial effects due to phosphorus and potassium. As a general rule, we recommend 20-25 kg of N, 30-45 kg each of P and K per hectare.

8. Varieties

Varieties used in commercial production are indigenous ones for mungbean and peanuts, and introduced in the case of soybeams.

9. Average yields

Average yields of grain legumes in the Philippines are:

Mungbean - 419 kg/ha.
Peanut - 505 kg unshelled/ha
Soybean - 825 kg/ha

Best yields in hectare-size plantings in the experiment station of the University of the Philippines are:

Mungbean - 2 tons/ha
Peanut - 3 tons shelled/ha
Soybean - 2.5 tons/ha

10. Obstacles to Production

Principal obstacles to production are pests (cutworms and pod borers) and diseases.

Mungbean - cercospora leafspot, powdery mildew, mosaic and root rot
Peanut - leaf spot, mosaic, rust
Soybeans - rust, bacterial pustule

Commercial seeds of recommended varieties are limited; loss of viability is very fast in soybeans and it becomes an added problem to seed dissemination. Viability of soybeans may be as little as 3 months when stored in the Philippines.

11. Nitrogen fixation

Effective rhizobial strains have been isolated for soybean and mungo in the Philippines. Rhizobial inoculation studies have shown tha crops' requirements for nitrogen can completely rely upon Rhizobial action.

Hoever, commercial cultures of the Rhizobia are available in limited quantities only and can be had by advanced orders from the Bureau of Soils. Farms in more remote areas have no accessibility at all to commercial Rhizobia.

12. Mutation breeding

Mutation breeding has been done for mungbean and soybeans principally by the Philippine Atomic Energy Commission, Agriculture Section. Work has been concentrated on visual, heritable agronomic characters. I am not aware of any tangible results that have led to the release of new varieties.

13. Breeding activity

Breeding work is quite active at two organizations:

1) College of Agriculture
University of the Philippines at Los Baños

2) Bureau of Plant Industry
Department of Agriculture

Variety releases have been made by both agencies which have found their way in the farmers fields not only in the Philippines but in Southeast Asia.

GRAIN LEGUMES IN INDONESIA
(With soybeans as a priority)

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ABSTRACT

Soybean, peanut and green gram are the three main legumes in Indonesia but several others are also grown to a smaller extend. Yields are generally low in farmer's field as no fertilizers are used.

Soybean and peanut both local and introduced varieties are grown but in green gram and the other grain legumes mostly local varieties are grown.

Breeding work has mainly been done with soybean which is given researoh priority because of the large acreage grown. In the new breeding programme other grain legumes, particularly peanut and mungbean will also be emphasized. Mutation breeding project has been started with the three main legumes.

1. Principal grain legumes crops produced in Indonesia

Scientific name	English name	Indonesia name
Glycine max	Soybean	Kedele
Arachis hypogea	Groundnut or peanut	Kacang tanah
Phaseolus mungo and Phaseolus aureus	Mungbean	Kacang hijau
Phaseolus radiatus	Greengram	Kacang hijau
Phaseolus vulgaris	Kidneybean	Kacang jogo
Phaseolus lunatus	Limabean	Kara
Phaseolus calcaratus	Ricebean	Kacang uci

Dolichos lablab	Hyacienthbean	Karawedus
Canavalia ensiformis	Jackbean	Kara pedang
Vigna sinensis	Cowpea	Kacang panjang
Voandzeia subterranea	Barbara groundnut	Kacang Bogor
Cajanus cajan	Pigeonpea	Kacang hiris
Psophocarpus tetragonolobus	Manila bean	Kecipir

2. Usage of grain legumes

All the grain legumes may be used as a side dish with rice, or as snacks as a beverage, as vegetables or as cooking oil. More specific uses for the three main legumes are:

Soybean

a) Side dish with the rice: tempe (fermented soybean), tahu (Soybean cake), tauge (Soybean sprout), kecap (Soysauce), tanji (fermented mixture of tauco and tahu).

b) Snacks: roasted soybeans, kerupuk tahu (tahu chips), bubukdele (flour), boiled young soybean seeds, candies (sugar, chocolate, coated).
Beverage: Soybean milk.

Peanut

a) Side dish with the rice: Rempeyek kacang (chip), bumbu gado-gado (vegetable sauce), oncom (fermented peanut).

b) Snacks: Toasted, fried, boiled, cookies, candies.

Greengram

a) Side dish with the rice: beansprout, greengram soup.

b) Snacks: Greengram porridge, cookies.

Food eaten together with grain legumes may be rice, tuberous crops or vegetables.

Vegetable proteins are cheaper than animal protein foods and the most common form of protein consumption by the people. Availability may depend upon the area: for instance Java with its extremely large population consumes less than the rest of Indonesia viz.

Food consumed (per day) by children

Average for Indonesia	1528.0	calories (67% from rice)
	42.8	protein (51% rice, 19% animal protein, 30% vegetable protein).
	20.0	g fat
Average for Java	1404.0	calories (49% from rice)
	37.8	g protein (38% rice, 12% animal protein, rest vegetable protein).
	21.0	g fat

The cost per kilo of various legumes and cereals is approximately:

Soybean	Rp. 180 - Rp.	225/kg
Peanut		300/kg
Greengram		300/kg
Rice	Rp. 80 - Rp.	160/kg
Corn		150/kg
Wheat (imported)		100/kg

1 US$ = 415 Rp

3. Area under production

The area under production for soybean and peanut are given in Table 1.

Table 1. TOTAL HARVESTED ACREAGE, PRODUCTION AND YIELD PER HECTARE OF SOYBEAN AND PEANUT (1969-1973)*)

Year	Soybean			Peanut		
	Acreage (ha)	Production (tons)	Yield qt/ha	Acreage (ha)	Production (tons)	Yield **) qt/ha
1969	553,783	388,707	7.02	372,279	267,158	7.18
1970	694,732	497,883	7.17	380,060	281,309	7.40
1971	679,625	515,644	7.59	375,752	283,773	7.55
1972	697,500	518,229	7.43	353,818	282,205	7.98
1973	743,000	541,000	7.30	416,000	290,000	7.00

*) Resource date: Directorate Generale of Food Crops; Directorate of Production.

**) Shelled peanut

In 1974, 29,000 hectares of green gram were grown in Java.

The most important grain legume is soybean. About 80% of the production is in Java. Nine counties produce more than 10,000 tons of soybeans per year - these one, Jember (54,000 tons); Pasuruan (20,000 tons), Ponorogo (17,000 tons), Nganjuk (16,000 tons), Brebes (12,000 tons), Jombang (12,000 tons), Madium (11,000 tons), Banyvwangi (11,000 tons) and Blitar (10,000 tons).

4. Months of sowing and harvest

April to August is the dry season

September to March is the wet season

Soybean

Land use	Irrigation condition	Crops before soybean	Months of sowing soybean	Months of harvesting soybean
Rice field	I. Irrigated during dry season	A. Wet rice, soybeans	April-May	August-Sept. Nov.-Dec.
		B. Wet rice, crop other than rice, soybeans	Aug-Sept.	Dec.-Jan.
		C. Wet rice, dry rice, soybeans	Aug-Sept.	December
		D. Sugarcane, soybeans	Sept.-Oct.	January
	II. Not irrigated during dry season	A. Wet rice, soybeans	Sept.-Oct.	January
Rainfed	Depend only on rain	A. Wet rice	April	August
		B. No rice after rainy season, soybeans	Oct-Nov.	Feb.-March
Upland	Depend only on rain	A. Multiple cropping with soybeans	January	March-April
		B. Dry rice or corn, soybeans	Feb.-March	May-June

Peamut

Land use	Sowing	Harvest
Upland	Oct. - N v.	Jan - February
	March - April	June - July

Greengram

Land use	Sowing	Harvest
Rice field	April - May	June - July
Upland	Nov. - Dec.	Jan - February

5. Cultural Practices

a. Soybean

Soybean is cultivated in the "Sawah" fields in the dry season as well as in the dry fields (tegalan) in the wet season. In both places, the crops may be planted in single (mono-culture) or in mixed condition with other upland crops.

In the sawah fields there are three systems of cultivation. These are a simple, a semi-intensified and an intensified method of cultivation. The cultivation in tegalan is exercised with either a semi-intensified or an intensified method of cultivation.

The simple method of cultivation is mostly practised by farmers in the regions with pronounced dry seasons. In this method, land preparation or soil tillage is not practised.

The purpose of avoiding soil tillage is to hasten the planting time, that the crops can make a good use of soil moisture, which is still available at the end of the wet season. Seeds are sown either after, or before, the rice is harvested. Most farmers, however, broadcast or dibble the seeds in the field after rice is harvested. The planted fields are usually covered with straw in order to prevent or to reduce the evaporation.

The semi-intensified method of cultivation is done with soil tillage and usually found in the regions without a pronounced dry season. Seeds are either broadcast or dibbled, 2 to 5 cm deep with 2 to 3 seeds per hill on plant distances of 25 x 25, 30 x 30, 40 x 15 or 20 x 20 cm, depending on the growth habit of the plant.

The intensified method cultivation is carried out with soil tillage, dibbling the seeds at regular distances, weeding, irrigation and pest control. Fertilizers are not usually used in soybean cultuvation. It is commonly believed that soybean is unresponsive to fertilizers, but soybean grown on rice field usually benefits from residual effect of fertilizers in the previous crops. This is generally true when soybean is grown following sugarcane.

Most farmers practise the simple method of cultivation in their sawah rice field. This is because they regard this method of cultivation as the most efficient and practical way of growing soybean.

b. Other grain legumes

Can be grown either as a single crop or in multiple cropping systems.

6. a. Architecture

The architectural type of soybeans, peanuts and green gram does not appear to be a major problem at present.

b. Maturity

Soybean varieties range from 73 to 110 days at present, peanuts 100 days and green gram 70 days. Short duration high yielding varieties of these legumes would be useful.

7. Fertilizers

Not generally applied in Indonesia on grain legumes, but liming may be necessary on andesite laterite soils for soybeans (1 qt/ha) and for peanut (5 - 10 qt/ha).

8. Varieties

a. Many commercially grown soybean varieties have been derived from germ plasm which has been in the country for many years and they are generally thought of as local, viz:

Local name	Seed colour	Days to maturity
Genjah slawi	white	75 days
Sindoro	white	75 days
Lawu	white	85 days
Welirang	white	80 days
Pandan	white	90 days
Petek	white	74 days
Davros	white	85 days
Presi	white	85-90 days
Sinyonya	white	90-95 days
Krawe	white	90-100 days
Ijo	white	90 days
Jepun	white	85-90 days
Mentik	black	80 days
Klungkung	white (mottled)	90 days

Other varieties now grown and encouraged by the Government are:

	Name	See colour	Days of maturity
Introductions	TK-5	white	85 days
	Shakti	white	85 days
Selections	No. 16	Black	90 days
	No. 29	White	90-100 days
	No. 27	Black	90-100 days
	No. 1248	White	85 days
	Merapi	Black	80 days
From crosses	Orba	White	80 days
	Sumbing	White	75 days
	Ringgit	White	85 days

The variety Orba, produced in Indonesia is particularly good and has constantly outyielded exotic varieties in trials (Sumarno & Sumarno 1974).

b. Peanut

Both local varieties and introduced varieties are grown. Kacang cina is a late maturing local variety. Palembang and Kidang are local early varieties with red seed coats and "Africa", a similar type exotic. Big seeded varieties grown are Gajah, Macan and Banteng (all local) and Schwartz 21 (introduction).

c. Green gram

All the varieties grown are local. Bhakti has a yellow seed coat and ripens uniformly. Arta ijo and Siwalik are green seeded varieties.

9. Yields

Yields for soybeans and peanuts are given in Table 1. The average yields on farmers' fields for green gram are approximately 6 qt/ha: highest yields on an experiment station to date are 7 qt/ha.

10. Obstacles to increased production

Soybeans

a. Seed viability and seed supply. Viability of seed of soybeans falls very fast after 3 months of storage in Indonesia. Soybean fields therefore suffer from poor germination and weak seedlings, and the farmer is lucky if 50-60% stand remains by harvest time.

Seed merchants supply seed for planting to farmers and it is possible that if they used modern methods of storage for seeds, the viability problem would be alleviated. Drying, cleaning, bagging and storage of the seed by manipulating temperature and relative humidity are needed to ensure good quality of seed for planting. Treatment of seed with insecticide, fungicide and rhizobium would also ensure better stands of the crop.

b. Insect pests

At present, Phaedoria inclusa, Riptortis linearis, Nezera viridula, Etiella zinckenella and Agromyza phaseoli are of economic importance in attacking soybeans in Indonesia (Oka & Wedanimbi, 1973).

c. Diseases

Up to 1961, the diseases of soybean were not considered so important as the insect pest. The occurrence of rust disease in Kuningan in the wet season 1961/62, however, emphasized the importance of soybean diseases. Rust disease caused by Uromyces sojae may occur in regions with high relative humidity and destroy the whole crops. Other diseases such as bacterial wilt caused by Xanthomonas solanacearum, bacterial disease on leaves caused by Xanthomonas phaseoli and Pseudomonas glycinae; sclerotial blight caused by Sclerotium rolfsii; anthracnose caused by Colletotrichum and witches broom caused by "Virus" may also occur.

d. Varietal improvement

There is still a great deal of scope for future breeding work on soybeans - production of fertilizer-responsive varieties and resistance to pest and diseases. The newly released variety ORBA can be used as a standard, at present.

e. Organisation of multi-locational trial for assessment of genotype and environment interaction would help in identifying varieties with broad and/or specific adaptability.

f. Marketing facilities are not yet organised in an efficient manner and there is much scope for improvement here.

11. Nitrogen fixation

Very little intensive work has been done.

12. Mutation Breeding

None to date.

13. Breeding activity

Breeding research on soybeans is being carried out at:

a. the Central Research Institute for Agriculture (CRIA), Bogor, and its substations at Sukamandi and Makassar.

b. Bogor Agricultural University, Bogor.

c. Gadjah Mada University, Jogyakarta

d. Brawijaya University, Malang.

e. Atomic Energy Commission, Pasar Jum'at, Jakarta

f. National Biological Institute, Bogor.

Soybeans are given research priority because of the large acreage grown, its acceptability as a food and the fact that demand exceeds supply. Some research on other grain legumes, particularly groundnuts, is also being carried out.

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GRAIN LEGUMES IN PAPUA NEW GUINEA

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ABSTRACT

There are four main traditional legume species, namely: winged bean, hyacinth bean, lima bean and Pueraria lobata. Only winged bean is grown on a larger scale for its tubers and pods and it is recognized as an important source of protein.

Recently, introductions of other legume have been tried where peanut, soybean, mungbean and cowpeas are the most important. These legumes are considered to be very important for improving the protein consumption of the human population which is very low.

It is, therefore, essential that plant breeding work can be developed in these crops.

Papua New Guinea, a newly independent nation, is the largest member of the Pacific community and is richly endowed with both Agricultura and mineral resources. The majority of its 2½ million inhabitants subsist on traditional agriculture, where staple food crops include sweet potato (Ipomoea batas (L) Lam), taro (Colocasia esculenta (L.) Schoot.), Yam (Dioscorea dlata L.), banana (Musa sp.) and cassava (Manihot esculenta Crantz). In common with other Pacific Islands, there is a marked absence of grain legumes in traditional agriculture, and consequently protein deficiency in the diet is widespread. The introduction and development of legumes is therefore of vital importance in the agricultural development of this country.

There are four main traditional legume species, which include winged bean (Psophocarpus tetragonolobus (L.) DC.), Hyacinth bean (Dolichos Lablab L.), lima bean (Phaseolus lunatus L.) and Pueraria lobata Will. Of these, winged bean is grown on a large scale for its tubers and pods, but it's seed is seldom eaten. Winged bean has recently been recognized internationally as an important source of protein.

Amongst legumes introduced more recently, peanuts (Arachis hypogea L.) soyabeans (Glycine max (L.) Mar.), mung bean (V. radiata (L.) Wil.), and cowpeas (Vigna unguiculata (L.) Walp) are important in that order. Other species including kidney beans (Phaseolus vulgaris L.), rice beans (Phaseulus calcaratus Roxb.), jack beans (Canvalia ensiformis (L.) DC.) and pigeon pea (Cajanus cajan, Mill sp.) are under experimental consideration. The Government's Department of Agriculture, Stock and Fisheries (D.A.S.F.) and the University of Papua New Guinea are the only organizations engaged in grain legume improvement. The D.A.S.F. is mainly concerned with the peanut and soybean where as the University's efforts are primarily directed to the winged bean and cowpea.

A limited amount of imported grain legume is consumed by the urban population but in villages grain legumes are virtually absent from the diet. This is due to unavailability and the inability of grain legumes to to be cooked by the traditional method of steaming food by hot stones in a pit (calle "mumu") or roasting in open fire. The only legume which is widely used in the Highlands is the winged bean, and peanuts are roasted "green" in shells throughout the country. Malnutrition is, therefore, widespread, particularly in women and children. Children are weaned on the starchy diets of sweet potato, banana and taro depending upon the area, with negligible amounts of meat, legume or milk products. In coastal areas, however, fish may form an important source of protein.

The growing and marketing of grain legume is in its infancy, and it is not possible to quote prices excepting the retail prices of imported grain legumes including kidney beans, broad beans (Vicia faba L.), Lima beans, Lentil (Lens esculenta Moe.) and soyabean which vary between U.S.$1.50 to 2.00 per kilogram. However, official price of soyabean is about U.S. $0.35 per kilogram. Peanuts in shells are sold in the local markets at approximately U.S.$1.25 per kilogram, and the price of winged bean seeds, which are mainly sold as planting material, may also reach as high as U.S.$1-2 per kilogram. Cowpeas (Vigna unguiculata (L) Walp.) and Mungbean (Vigna radiata (L) Wil.) are currently being sold at U.S. $0.50 per kilogram on an experimental basis by the University. Although these inflated prices must encourage the production of grain legume, at present the consumption is unlikely to increase as legume protein is far more expensive than the animal protein.

Official statistics are not available on either area or production of legumes. Peanuts are possibly the most widely grown amongst recently

introduced species. Soyabean cultivation is increasing. Mungbeans and cowpeas are grown mainly as stock feed by the expatriate farmers. The total area under other legumes is negligible. Legumes can be planted both in pure stand as well as in mixed gardens with a variety of other tuber crops, sugarcane and vegetables. Inter-planting with cereal is, however, rare excepting in some instances with maize. Because of the equatorial climate and sufficient rainfall in most of the country, planting and harvesting can be done at almost any time. A clear spell of dry weather at maturity, however, is very important for grain production, which may very from area to area. In the dry belt of Papua, rainfed crops are planted in December-January and harvested in April-May. Another crop can be planted in June-July if a source of irrigation is available. Fertilizer is not normally used by most farmers.

Almost all the grain legumes currently grown for cash have been introduced since the country was colonized, and came to Papua New Guinea mainly through Australia. The breadth of genetic variation is generally very narrow, excepting soyabeans where over one hundred introductions have recently been made. The yields obtained under experimental conditions from various grain legumes are shown in Table 1. Such estimates from farmers field are unfortunately not available. Work done at the University in Port Moresby has shown that in cowpeas better yields are obtained in the dry season than the wet season.

A great deal of work has been done in this country on Rhizobium requirements (Shaw et al, 1972), and inoculation is important in many areas. Suitable Rhizobium inoculum is freely available on request from the Department of Agriculture. However, the use of this service by the local farmers is not very extensive due to a lack of education and extension in this area.

Suitable plant types should be available in most legumes if introductions with a broad genetic base are made. At this stage, simple selection from the introductions can possibly make significant headway in legume improvement. However, a major plant architectural problem is encountered in the traditional legume winged bean. Here, all known varieties in the world are known to be of viny indeterminate growth habit requiring staking for support. A bush type variant will make a revolutionary contribution in the development of this crop. Mutation breeding in winged bean is thus currently in progress at the University of Papua New Guinea to evolve such a mutant, and this programme is partly financed by the International Atomic Energy Agency. It is considered that mutation breeding would be premature in any other legume species at this stage.

The poor state of grain legume production and consumption will be alleviated by both education and research. A compaign to promote grain legumes in the diet, through cooking demonstrations and education on their nutritional value, is of vital importance. Concurrently, with this campaign an increase in grain legume growing, marketing and availability to consumers at reasonable prices, will need to be tackled. At present, close communications exist between the Department of Public Health, Department of Agriculture and the University of Papua New Guinea on this matter.

Table 1

Estimated yield potentials of various legumes in Papua New Guinea

Species	Seed Yield Potential Kg/Ha	Reference
Winged bean	720 - 1976	Author
Soyabean	2730	Sumbak (1974)*
Peanuts	2184	Vance (1974)*
Mungbean	1482	Author
Pigeon Pea	1112	Author
Rice bean	954	Author and
Cowpeas	2600	Author (E. Erskine)
Beans	699	Author

* See Science in New Guinea Vol. 2 No. 1, 1974.

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GRAIN LEGUMES IN TAIWAN

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ABSTRACT

The activities with grain legumes of the Asian Vegetable Research and Development Center located at Taiwan are reviewed. The principal grain legume crops are, soybean, mungbean, multiflora bean, Adzuki beans and peanuts.

Grain legumes are mainly used for human consumption in combination with boiled rice and it seems that grain legumes are easily and widely available in Taiwan.

Yields are fairly good and fertilizers are applied at optimal levels. Intensive breeding and screening of world germ plasm collection are going on at AVRDC.

1. Principal Grain Legume Crops

Soybean, Mungbean, Multiflora Bean (Scarlet Runner), Adzuki Beans (*Vigna angularis*) and Peanuts.

2. Usage of Grain Legumes

a. Main use: -

Soybean: Taiwan annually consumes from 650,000 to 700,000 M.T. of soybean. Only 10-20% of this total is produced locally (See Answer #3). Thus, the Taiwan is very dependent upon soybean imports, mostly from U.S.A. (See Answer #3). C.P. Cheng (1972) indicated that "of the total amount of soybean consumption, over 80% are for oil extraction, leaving the soybean-meal for feed, and only less than 20% are used for foods in forms of soybean curd, mil,, sauce, sprouts and many other uses as a main source of vegetable protein".

Peanuts: National production of this crop is adequate. Approximately 46% of the output is for making foodstuffs such as roasted or salted peanuts, peanut confectionary and peanut butter and 36% for oil extraction and peanut-meal production (Cheng 1972).

Mungbean: About 20% of total consumption of mungbean is locally produced (See answer #3). It is consumed mainly as bean sprouts, noodle, soups, cakes, sweet porridge, etc.

Adzuki bean: The annual domestic consumption is estimated at about 3,000 M.T. and is locally supplied. Although it is a minor legume crop in Taiwan, its economic importance has increased recently due to its export potential (3). This bean is used primarily for making confectionaries and sweet gruel.

b. Grain legumes are mainly used in combination with boiled rice.

c. It seems that various kinds of legumes and their products are easily and widely available to most of the population in Taiwan.

d. The main diet of the Taiwanese children are mother's milk, milk, thin rice-gruel, cooked vegetable and fishes.

e. The cost per kilo of various legumes and cereals in Taiwan at September, 1975 was -

	Farmer's price	Consumer's price
Soybean	US$ 0.28	US$ 0.50
Mungbean	0.31	0.68
Peanut	0.28	0.96
Rice	0.28	0.45
Corn	NA	0.40

Figures from Taiwan Agric. Prices Monthly
Dept. of Agriculture and Forestry

3. Area, Production, and Yield of Major Legume Crops in Taiwan

a. Soybean

Year	Area (ha)	Production (mt)	Yield (kg/ha)	Farmer's Price (US$/kg)
1971	40,151	60,990	1,519	0.16
1972	36,123	60,221	1,670	0.17
1973	36,491	60,596	1,662	0.27
1974	44,454	66,918	1,505	0.29

b. Peanut

Year	Area (ha)	Production (mt)	Yield (kg/ha)	Farmer's Price (US$/kg)
1971	86,531	97,579*	1,130*	0.21
1972	76,284	94,032	1,233	0.22
1973	72,620	97,932	1,351	0.27
1974	64,435	93,939	1,458	0.38

(*unshelled)

c. Multiflora bean

1971	5,150	7,474	1,451	0.15
1972	5,042	7,282	1,444	0.15
1973	4,748	7,176	1,512	0.18
1974	3,894	5,921	1,521	0.24

d. Adzuki bean

1971	2,655	4,308	1,623	0.37
1972	5,475	9,733	1,778	0.25
1973	6,878	12,366	1,798	0.21
1974	4,714	7,723	1,638	0.33

e. Mungbean

1971	8,066	5,904	732	0.29
1972	3,453	1,321	422	0.38
1973	4,333	2,812	649	0.41
1974	4,705	3,160	672	0.41

The following figures are import data of soybean and mungbean for Taiwan (1971-73).

	Year	Weight (mt)	Value (US$)
Soybean	1971	524,877	68,540,322
	1972	711,611	96,344,963
	1973	626,034	163,024,646
Mungbean	1972	15,212	2,276,833
	1973	1),024	3,220,000

4. Growing Seasons of Grain Legumes in Taiwan (Cheng 1972 and Meregay 1975)

	Crop Season	Duration		% (1973)
		Planting	Harvesting	
Soybean	Winter	Sept.-Oct.	Dec.-Jan	79
	Ist Crop	Mar.-Apr.	Jul.-Aug.	11
	2nd Crop	Jul.-Aug.	Oct.-Nov.	10
Mungbean	Spring Crop	March	May-June	Major
	Fall Crop	Aug.-Sept.	Oct.-Dec.	Very minor
Adzuki bean	Winter Crop	Sept.-Oct.	Dec.-Jan.	
Peanut	Spring Crop	Jan- Mar.	May-Jul.	70
	Fall Crop	Jul.-Sept.	Oct.-Dec.	30

5. Cropping Patterns of Major Legumes in Taiwan

Soybean: Mostly grown as monocultures after rice (No-tillage, rice-stubble culture)

Adzuki bean: Very similar to that of soybean.

Mungbean: Monoculture and intercrop with sugar cane (approximately 80% and 20%, respectively)

Peanut: Monoculture, but sometimes intercrop with sugar cane (two rows of peanuts are simultaneously planted between two sugar cane rows spaced 1.2-1.4 meter apart).

6. Architecture

Soybean: The soybean breeder in AVRDC (Mr. S. Shanmugasundaram) is satisfied with the present soybean plant types, but a cold tolerant soybean would be useful.

Mungbean: The plant type of mungbeean should be drastically changed if this legume is to become economically competitive with other crops in Taiwan. Mungbean is hand harvested at present. Plant type characteristics which could be useful in mungbeans are as follows:

i) Plant type responsive to high population density,
ii) more internodes (production units),
iii) non-shattering,
iv) synchronous flowering,
v) natural senescence,
vi) shorter peduncles,
vii) vigorous and effective root systems,
viii) resistance to environment stress (moisture, temperature, etc.).

7. Fertilizers

The best soybean yield in different seasons (spring, summer and fall crop in AVRDC) were obtained when the plants were given both organic and chemical nitrogen. The yields ranged from 1.8 (summer-without fertilizer) to 3.9 tons per ha (spring-20 tons/ha compost and 90 kg/ha N). Among components of yield, the number of soybean pods was not affected, but 100-seed weight was increased as nitrogen levels increased. Varietal differences in nitrogen response was observed (AVDRC, Annual Report 1974). The recommendations for fertilizer application in Taiwan are as follows (Cheng 1972). -

	Nitrogen (AI kg/ha)	P_2O_5 (kg/ha)	K_2O (kg/ha)
Soybean	20 - 40	40 - 90	30 - 75
Peanut	10 - 20	50 - 60	40 - 50
Mungbean	30 - 40	50 - 90	30 - 75

8. Origin of Commercial Legume Varieties in Taiwan (Cheng 1972)

a. Mungbean: Purelines selections from indegenous germplasm or unknown origin of introductions.

b. Soybean:

Variety	Source
Sankuo	Introduced from Japan (1952) Selected and released (1956)
Palmetto	Introduced from USA (1953) Selected and released (1957)

Variety	Source
Shih Shih	Introduced from Japan (1954) Selected and released (1957)
Tainung No. 3	PI 200492 x Nunghi H-11 (1968)
Tainung No. 4	PI 200492 x Nunghi H-11 (1970)
Kaoshiung No. 3	PI 200492 x Shih Shih (1971)

c. Peanut:

Tainan No. 7	Java Small x Tainan Pai-yutao (1956)
Tainan Sel. No. 9	Introduced from Vietnam (1962) released (1967)
Tainung No. 3	Introduced from USA (1953) released (1963)
Tainung No. 4	Spanish White x Kinorales (1971)
Penghu No. 1	Pure line selection from Yuang-yen-tao (1961)

9. Comparision between Farmer's and Experimental Station's Legume Yield (Taiwan Agric. Yearbook 1975 and personal communications with breeders).

	Farmer's Field (kg/ha)	Experimental Station (kg/ha)
a) Soybean		
Winter crop	1,600	3,000 - 7,000
1st Crop	1,200	
2nd Crop	1,100	
b) Mungbean		
Spring Crop	600 - 700	1,500 - 2,700
Summer Crop		1,500 - 1,700
Fall Crop		1,500 - 2,400
c) Adzuki bean	1,600 - 1,800	2,500 - 3,000
d) Peanut	1,400 - 1,600	

10. Obstacles to Increased Production

i) Low and unstable producitivity of grain legumes makes them poor competitors with other crops.

ii) labor-consuming operations (especially peanut and mungbeans),

iii) farmer's profit is not guaranteed (Adzuki beans),

iv) mungbean: Damping-off, Cercospora leaf spot, powdery mildew several viral diseases, bean fly, pod borer and weevils.

v) Soybean: Soybean rust, bacterial pustule, bean fly, pod borer and soybean mosaic virus.

11. Nitrogen Fixation

Studies are in the initial stages in this area, but AVRDC's soybean breeder has indicated that it does not appear to be a factor for higher production in soybean.

For mungbean, there is an interest to find out whether there is any significant genetical variability for nodule activity among the germ plasm. Dr. Talekar (AVRDC chemist) has initiated research using the acetylene reduction method.

12. Mutation Breeding

There is not much active mutation breeding effort in legume improvement programme in Taiwan at present. C.P. Cheng (1972) reported that "although breeding through treatment of x-ray and neutrons was also tried, the results were only partially successful".

Dr. Y.C. Lu (Professor, National Chung Hsing University, Taichung, Taiwan) developed a soybean variety (R-10) through a chemical mutagen, which appeared to possess some tolerance to soybean rust.

Drs. Tsou and Park in AVRDC treated 15 mungbean varieties with γ-rays and neutron of 3 dosages each to widen protein content variability. Results from M_1 appeared to be very promising. However, single plant selection from promising plants did not produce seeds having high content of protein at the M_2 generation. It is still to be determined whether the high protein content (about 33%) found in M_1 seeds are heritable or not. These studies will be pursued further, since the range of protein content is mungbean is very narrow ($24 \pm 4\%$). The apparent narrow variability for protein content may more be environmental than genetical!

13. Breeding Activity

The National breeding programmes of soybean and peamut in Taiwan, started in 1953 and in 1949, respectively, are considered to have been very successful (see answer No. 8 for varieties developed in Taiwan).

Since its inception in 1972, AVRDC's legume programme has made a large germ plasm collection (5,133, acessions for soybean and 2,362 for mungbean) from all over the world, and these have been carefully observed, screened, and identified as genetic sources for varietal improvement.

Major institutes involved in grain legume breeding

National Taiwan University, Taipei.
National Chung Hsing University, Taichung.
Taiwan Agricultural Research Institute, Taipei.
Kaohsiung District Agricultural Improvement Station, Pingtung.
Asian Vegetable Research and Development Center, Shanhua, Tainan.

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GRAIN LEGUMES IN AUSTRALIA

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ABSTRACT

The principal grain legume crops in Australia are soybeans, peanuts, navy beans, cowpea and green gram in the warm season while lupins and field peas are the most important in the cool season.

Grain legumes form a very limited portion of Australian diets and the majority of the grain legume production (lupins and soybeans) is used for high protein animal feed.

The area devoted to grain legumes is relatively small but the yield per unit area is relatively high.

Fertilizer N is not normally applied to grain legume crops but other fertilizer elements are used depending on the soil conditions.

Breeding work on grain legumes has been relatively minor. Detailed breeding work has been restricted largely to field peas, lupins and soybean. Some mutation breeding have also been carried out in soybeans and lupins.

1. Principal Grain Legume Crops

(a) Permanent commercial basis

Cool-Season (April-Sept)	Warm-Season (Oct-March)
Lupins - *Lupinus spp.*	Soybeans - *Glycine max*
Field peas - *Pisum sativum*	Peanuts - *Arachis hypogeae*
	Navy beans - *Phaseolus vulgaris*
	Cowpea - *Vigna sinensis*
	Green gram - *Vigna radiata*

(b) Limited or potential commercial basis

Vetches - *Vicia spp.*	Black gram - *Vigna mungo*
Broad bean - *Vicia faba*	Guar - *Cyamopsis tetragonoloba*
Lentil - *Lens culinaris*	Adzuki bean - *Vigna angularis*
	Lablab bean - *Lablab purpureus*

(c) Under investigation

Chickpea - Cicer arietinum

Pigeon pea - Cajanus cajan

Lima bean - Phaseolus lunatus

2. Usage of Grain Legumes

Grain legumes form a very limited portion of Australian diets. With the exception of peanuts, navy beans, green gram and field peas, the majority of grain legume production (lupins and soybeans) is used for high protein animal feeds. Direct human consumption of grain legumes is primarily as confectionary and processed vegetables, and is a small component of the diet generally available to all people.

Cost of grain legumes is difficult to characterize in Australia. Approximate estimates for 1974/75 are as follows:

Soybeans - $160-190/tonne - farm contracts
Lupins - $120/tonne - farm contracts
Navy bean - $390/tonne - farm contracts
Green gram - $150/tonne - farm contracts
Peanuts - $265/tonne - farm contracts
Field peas - $140/tonne - farm contracts

Average weekly income for adult male Australians in September 1975 was approximately $157.

3. Areas and Production

(a) Areas sown to various grain legumes from 1968/69 to 1973/73 (ha x 10^{-3})

Year	Cool-Season Crops		Warm-Season Crops				Total	Cereals for Grain
	Field Peas	Lupins[1]	Soybean	Peanuts	Navy bean	Cowpea		
1968/69	20.6	-	2.1	31.8	4.0	2.6	61.1	
1969/70	27.4	-	5.0	33.6	5.3	3.9	75.2	12960
1970/71	24.7	-	7.3	38.6	4.6	7.5	83.1	10810
1971/72	23.6	34.4	18.0	33.8	8.4	12.6	120.8	11720
1972/73	15.6	46.5	28.0	29.1	9.5	7.0	135.8	11600
1973/74	16.4	66.4	40.8	25.9	4.5	2.1	156.2	12760

[1]Lupins plus other minor crops: mainly lupins; lupins not recorded separately before 1971/2

(b) Production (tonnes x 10^{-3})

Crop	Year				
	1969/70	1970/71	1971/72	1972/73	1973/74
Soybean	5.0	9.2	33.6	37.9	62.5
Navy bean	2.5	1.1	6.5	1.8	2.5
Peanuts	42.7	31.1	46.1	38.5	29.2
Cowpea[1]	26.6	27.3	39.0	15.3	18.4
Lupin[2]	-	-	24.2	15.5	51.2

[1]Includes cowpea, poona pea and field pea

[2]Lupins for processing only

(c) Yields (t/ha)

Crop	Year				
	1969/70	1970/71	1971/72	1972/73	1973/74
Soybean	1.01	1.26	1.87	1.37	1.53
Navy bean	0.48	0.24	0.77	0.19	0.56
Peanuts	0.85	0.85	1.08	0.68	0.99
Cowpea	1.27	0.81	1.36	1.32	1.13
Lupin[1]	-	-	0.74	0.34	0.76

[1]Lupins for processing only

(d) Production by States 1973/74 (ha x 10^{-3})

Crop	State							
	N.S.W.	Vic.	Q'ld.	S.A.	W.A.	Tas.	N.T.	A.C.T.
Soybean	8.6	0.0	32.2	-	-	-	-	-
Navy bean	0.1	-	4.1	-	-	0.3	-	-
Peanuts	0.2	-	25.7	-	-	-	-	-
Cowpea	1.7	2.9	2.1	10.2	0.6	1.0	-	-
Lupin	0.7	0.3	-	1.1	64.1	0.2	-	-
TOTAL	11.3	3.3	64.1	11.3	64.6	1.5	-	-

Several points are clear regarding grain legume production in Australia.

1. The area devoted to grain legumes is relatively small; for example in 1972/73, 96% of the total area of seed crops was for cereal grains and only 1.1% was for grain legumes.

2. Grain legume production is increasing rapidly, particularly since 1970. Most of the production increase results from expansion of lupins in W.A. and of soybeans in Queensland and New South Wales. Areas and production for the other grain legumes have been erratic without major trends.

4. Area of Culture and Cultural System

(a) Soybeans - primarily in the sub-tropics (25° - 33°S) of Queensland and New South Wales. Grown as a summer crop, with planting from November-January, and harvest in April-May.

(b) Navy beans - primarily grown in the sub-tropics particularly in the South Burnett region near Kingaroy (26° - 27°S) in south-east Queensland. Grown as a summer crop, with sowing in mid-December - January, and harvest in March-April.

(c) Peanuts - primarily grown in the sub-tropics with 85% of the production from the Kingaroy region (26° - 27°S). Some culture has occurred in northern Australia - Athertor Tablelands of Queensland (17°S) and in the Northern Territory (13° - 14°S). Grown as a summer crop, with planting October-December, and harvest in March-April.

(d) Cowpeans and green gram - primarily grown in sub-tropics (23° - 28°). Grown as summer crops with planting in November-December and harvest in April.

(e) Field peas - grown in southern Australia, primarily in South Australia, Victoria and Tasmania. Grown as a winter crop, with planting in May - June and harvest in November-December.

(f) Lupins - primarily grown in Western Australia (30° - 35°S). Grown as a winter crop, with planting around May-June.

5. All grain legumes in Australia are grown in mono-specific and single-cultivar plantings. In general they form portion of rotations with other crops such as cereals and oil-seed crops, depending on the region of culture.

6. (a) Architecture - greatest interest in plant habit - architecture is involved with ease of harvestability by machine ie. uprightness, non-shattering pods, evenness of maturity etc Some study of canopy physiology has been conducted in certain crops, e.g. soybeans.

(b) Cropping season - most grain legume culture in Australia is under dryland (non-irrigated) conditions as portion of an annual rotation of crops. Double cropping is thus of doubtful relevance in most areas. For irrigated culture, soybeans and other crops can be manipulated as portion of multiple cropping systems, and timing and duration of cropping season become important.

Major modifications of habit and architecture result from variation in planting time and latitude in some crops; that is, large genotype x environment interactions exist and can be used in modifying cropping systems.

7. Fertilizers

Relatively little detailed study of fertilizer response has occurred on most grain legumes. Fertilizer treatment of each crop depends primarily on the soil types used in each case.

Lupins are grown primarily on low fertility, coarse textured, moderately acid soils in Western Australia for which applications of phosphate, potassium and certain trace elements are necessary. Lupins have been less successful on the heavier textured, more fertile soils of eastern Australia.

Field peas are grown on a wide range of soil types, and in South Australia, on black self-mulching soils for which phosphorus application is necessary.

For harvest reasons, peanuts are restricted largely to lighter textured soils, and particularly to the red earths. Phosphorus and other nutrients are applied as necessary.

Soybeans and other warm-season grain legumes are grown on a range of soil types and fertility regimes, ranging and highly fertile black earths to coarse textured alluviums. Apart from nitrogen, nutrient applications of phosphorus and potassium are generally made following established guidelines for other crops. Deficiencies of molybdenum and zinc have been encountered on low and high pH soils, respectively. Genotype differences in response to low zinc soils have been demonstrated, as has responses to manganese toxicity, in soybeans.

Clearly, nutrient demand is related to yield level. Thus it is expected that more consistent responses to applied nutrients will occur with high yielding cultivars and improved management.

Australian soils are commonly low in nitrogen availability and the importance of leguminous crops in supplying N to the cropping system is apparent. In southern Australia, evidence of reduced rates of decline in nitrogen status following field pea - cereal and lupin - cereal rotations exists. Relatively little information exists on the nitrogen contribution of the warm-season grain legumes in Australia.

8. All of the major and minor grain legumes grown in Australia are introduced species. Plant introduction has received major attention in Australia. Introductions are used directly as cultivars and/or as germplasm in breeding programmes. Numerous sources of accessions exist throughout the world.

Soybeans - primarily introduced cultivars; some locally bred
Cowpeas - primarily introduced cultivars; some local breeding
Lupins - locally bred cultivars for grain production
Grain - introduced cultivars
Field peas - locally bred cultivars
Peanuts - introduced cultivars
Navy bean - locally bred cultivars
Most other crops - primarily examination of introduced accessions.

9. Average yields for the major grain legumes were shown in Table 3d.

It is difficult to cite maximum experimental yields that are meaningful. Some might be: -

Soybean - 6.5 t/ha in replicated multi-row plots
Peanut - up to 5 t/ha peanuts in shell experimental small plots
Gram - 3.5 t/ha in experimental plots (replicated)
Lupin - up to 5.0 t/ha experimental plots
Field pea - $>$ 2.3 t/ha in rotation experiments
Navy bean - approximately 3.0 t/ha experimental

Pigeon pea - > 4.5 t/ha over 12 months; 2.5 t/ha single harvest
Chick pea - > 1 t/ha broad acre; > 3.0 t/ha experimental plots
Vetch - 3.8 t/ha experimental peak yield
Cicia faba - 2.2 t/ha experimental yields
Lablab bean - > 1.0 t/ha experimental plots

10. Obstacles to Increased Production

A number exist, operating at different levels.

(a) Market influences

Grain legume production in Australia is commercially oriented. Until recent years, most production had been to supply local demand, and only very limited exports of split peas, peanuts and cowpeas had occurred. Recent expansion of grain legume production, particularly soybean and lupin, for protein meal production has approached saturation of present local demand. Pulses for direct human consumption in Australia have only a limited market. Therefore, future trends in grain legume production are directly related to expansion of the local market and development of overseas markets. In the case of navy beans, expansion for import substitution is still possible.

Substantial area for potential expansion exists for most of the grain legume crops presently grown in Australia. Thus expansion of production beyond existing levels depends primarily on markets and on the acceptability of these crops to producers relative to other crops such as cereals and oil seeds. In general, the grain legumes have been lower yielding and more erratic in yield than are the cereals. Furthermore, they appar to be more sensitive to the vaguaries of production environments, so that their production has tended to be restricted to the more favourable environments and to require greater management skill. While the higher market value of grain legumes compensates in part for their lower yield, these factors of uncertainty and inexperience militate against rapid expansion in the immediate future.

(b) Restricted research and extension activity

The relatively low level of scientific attention given to grain legumes in Australia inevitably reduces the likelihood that identified problems in production will be investigated and alleviated. The large gap between genetic potential and farmer yields in most of the crops reflects sub-optimal management, lack of management skill and the lower status or priority commonly given to grain legume crops by producers.

(c) Specific factors

The basic priority in all crops is attainment of higher and more reliable yields. Specific problems exist in each crop, and some are mentioned: -

(i) Soybeans
- improved cultivars for lower latitudes
- improved definition of optimal agronomic techniques
- disease and insect resistance; particularly to *Sclerotinia sclerotiorum*, *Macrophomina phaseoli*, *Pseudomonas tobaci*, *Xanthomonas phaseoli*, and *Phakopsora pachyrhizi*; and to the green vegetable bug (*Nezara viridula*) and lucerne crown borer (*Zygita diva*).

(ii) Lupins
- earlier maturing cultivars
- adaptation to less acid, heavier soils of eastern Australia - genotypic and species studies
- resistance to various diseases and insects

(iii) Field peas
- earlier maturing cultivars
- shatter resistance
- more erect growth
- resistance to *Asochyta spp.*

(iv) Navy beans
- resistance to rust and peanut mottle virus
- high yield determinate bush habit
- broader adaptation

(v) Other crops - vetch, broad bean, lentil, chick pea
- cowpea, gram, adzuki, guar, lablab, pigeon pea

All require: -
- further study of climatic and agronomic requirements, potential and limitations
- detailed evaluation of germ-plasm collections
- definition of potential role in farming systems.

11. Nitrogen Fixation

As far as I can determine, all grain legume crops are either inoculated or nodulate naturally in the field. Fertilizer N is not normally applied to grain legume crops in Australia.

Considerable research into the legume - Rhizobium symbiosis has occurred in Australia. Most of this has involved pasture legume species, but some work has occurred on the grain legumes. Most of the research has been directed towards the physiology of nitrogen fixation, to cross-inoculation studies, and to factors influencing nodulation and fixation. Recommended strains of Rhizobium exist for each grain legume crop, and for some crops (e.g. soybeans), cultivar x strain interaction studies have been made as a bssis of strain recommendation and varietal testing.

Relatively little research into N fixation by grain legumes in the field has occurred in Australia. Field studies of long term rotations involving cereals and field peas in southern Australia have demonstrated reduced rates of depletion of soil nitrogen. The situation on different soil types and with different grain legumes in the lower latitudes is not known. The implications of potential differences among grain legume crops, of management practices, and of manipulation of plant habit and seed yield, on N fixation and residual effects are substantial, important to definition of long term rotations and require clarification.

Study of the symbiosis and N fixation occur in C.S.I.R.O., most State Departments of Agriculture and most Universities. Comparative studies of N fixation by various grain legumes are presently being conducted by Dr. R. Lawn,

C.S.I.R.O. Division of Tropical Agronomy, Brisbane.

12. Mutation Breeding

Two instances of the use of mutagenesis in grain legumes in Australia are known to me: -

(a) Soybeans - by the author, using gamma irradiation of two cultivars. Seeking resistance to soybean rust (Phakopsora pachyrhizi). No success, but a small programme.

(b) Lupins - induced and spontaneous mutations have been used extensively and successfully by Dr. Gladstones, W.A. Department of Agriculture, in the domestication and improvement of lupins for seed production.

(i) non-shattering in L. angustifolium and L. digitatus. Two morphologically and genetically distinct lines with reduced shatter in each species, each due to a single recessive gene.

In each species, the double recessive homozygote was fully non-shattering.

(ii) Low alkaloid mutant - in L. digitatus. Obtained following E.M.S. treatment of a line which was derived following X irradiation.

(iii) Zero vernalisation requirement in L. angustifolium cv. Borre. Dominant gene designated K . Occurred as a naturally occurring mutant, and is 2-5 weeks earlier flowering.

13. Breeding Activity

Breeding work on grain legumes in Australia has been relatively minor. Most of the crops mentioned in item 1 have received some scientific attention, primarily at the level of evaluation and testing of accessions from overseas collections. Detailed breeding work has been restricted largely to field peas, lupins and soybeans.

Some of the institutions involved in breeding or testing are as follows: -

Field peas	- Roseworthy Agricultural College
	- Waite Agricultural Research Institute
	- Victorian Department of Agriculture
Lupins	- University of Western Australia, Perth
	- Western Australian Department of Agriculture, Perth
	- C.S.I.R.O. in Western Australia and Canberra.
Soybean	- Department of Agriculture, University of Queensland.
	- Queensland Department of Agriculture, Warwick
	- Department of Agricultural Botany, University of Sydney.
	- C.S.I.R.O. Division of Tropical Agronomy
Navy beans	- Queensland Department of Agriculture, Kingaroy.
Cowpeas	- Queensland Department of Agriculture
	- Bureau of Sugar Experiment Stations
Peanuts	- Queensland Department of Agriculture
Gram	- C.S.I.R.O. Division of Tropical Agronomy
	- Queensland Department of Primary Industries
	- Department of Agriculture, University of Queensland.
Pigeon pea	- Department of Agriculture, University of Queensland.
Lima bean, Adzuki bean, Chick pea, Guar, Lablab bean	- C.S.I.R.O. Division of Tropical Agronomy

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ALTERATION OF PLANT ARCHITECTURE AND THE DEVELOPMENT OF THE LEAFELESS PEA

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ABSTRACT

The John Innes Institute has developed an extensive collection of peas from different parts of the world. This pea collection has recently been used in order to try to restructure the plant and to breed peas with smaller leaves and stiffer stems. Crosses were made between three mutants with leaf and stipule modifications and a number of good cultivars. Two plant types (semi-leafless and leafless) were selected from these crosses and yield trials have been carried out with these phenotypes over a number of years in several locations in England. The results have demonstrated that it has been possible to breed leafless and semi-leafless with yields as good as and, in some instances better than those of existing conventional cultivars. The potential value of these genotypes for increased pea production in England has been discussed. This research approach can definitely be applied successfully to other grain legumes.

Some 60-80 hectares of peas are grown in the United Kingdom each year either to be harvested green for freezing or canning or to be harvested dry for packeting, for rehydration and canning, for pea flour, for animal feed etc. The requirements of the vining pea industry seem largely to have been met by the plant breeders and agronomists but those of the dried pea industry have not and consequently about one third of our dried peas still have to be imported.

If dried peas could be grown, and more to be point, harvested easily in England then imports would be unnecessary. At the same time peas could well provide a more reliable protein source than beans whose yield levels are notoriously unstable. Peas, however, are not grown on a large enough scale because they tend to develop an excess of foliage, especially on fertile soils and in northern environments. Heavy plants

such as these lodge easily and this combined with the heavier rainfall at harvest time often leads to a damaged and stained seed crop which cannot easily be mechanically harvested.

With rapidly increasing labour costs the more traditional harvesting methods, such as those using trapods and other drying frames, are no longer feasible and so the pressure is upon the plant breeder to develop plants which can be combine harvested, preferably with conventional cereal combines. The incentive to develop new kinds of peas is easily understood when losses due to inefficient harvesting and damaged seed can amount to as much as 50 per cent of the crop. In addition, the average yield of dried peas per plant in England amounts to a mere 18-20 seeds and this could be accounted for by just four pods, each bearing four or five seeds. These pods would come from two nodes and would probably represent about one third only of a conservatively estimated potential yield level.

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The John Innes Institute has, over the years, developed an extensive collection of peas from different parts of the world and this includes not only modern cultivars but also primitive and obsolete cultivars as well as accessions from the wild. The information about this collection is so extensive that a computer-based information retrieval system had to be devised in order to handle it efficiently. This pea collection has recently been used in order to try to restructure the plant and to breed peas with smaller leaves, also to see if stiffer straw characters could be introduced. Among the mutant forms used in a series of crossing programmes were a number of naturally-occurring leaf and stipule modifications, Plate I. These were,

<u>afaf</u> which converts all the leaflets into tendrils (found spontaneously occurring in Finland in 1950, Russia in 1954 and Argentina in 1964)

<u>tltl</u> which converts all the tendrils into leaflets (found spontaneously occurring in the USA in 1917)

<u>stst</u> which reduces the stipule size very considerably (found, also spontaneously occurring, in England in 1923).

Crosses have been made between these three mutant forms and a number of successful cultivars. All eight combinations of the three genes in plants bearing as many as possible of the agronomically desirable characters and components of yield were thus developed.

Experience with growing these new phenotypes in microplots quickly demonstrated that peas without tendrils have no standing ability and are even worse than conventional plants. Discarding these unwanted forms left just three new combinations for further consideration,

1. afaf.StSt.TlTl (semi leafless pea) Plate II
2. afaf.ststst.TlTl (leafless pea) Plate III
3. AfAf.ststst.TlTl (small stipule pea)

The standing ability of type three was no better than that of conventional plants and so it too was discarded. Two plant types were left, the first being called the semi-leafless pea because it had normal sized stipules, and the second, the leafless pea. Work has since been concentrated only upon these two phenotypes in order to develop a wide range of forms taking into consideration maturity time, maturity spread, yield components, seed type, seed colour, standing ability, disease resistance and economic yield.

Yield trials with these novel phenotypes over a number of years at a range of sites, including Western England and the Scottish borders, have demonstrated that it has been possible to breed leafless and semi-leafless peas with yields as good as and, in some instances, better than those of existing conventional cultivars. Therefore it is possible to breed peas with reduced leaf areas which can yield competitively and which may be of value in changing the nature of the crop canopy in such a way as to minimise damage due to shading and excessive moisture retention. There is more, however, to leafless and semi-leafless peas than canopy structure. One very obvious advantage to be seen in the field is that of standing ability which is somewhat improved in semi-leafless peas but greatly and significantly improved in leafless peas. The combination of a reduced haulm and an increased standing ability leads to,

1. A microclimate which should be far less conducive to pathogen attack since there is more light and more air movement in it.

2. An increased machinery throughput which may also be of value to the vining pea industry.
3. Less obstruction of sieves, screens etc. in harvesting machinery.
4. Less leaf area for egg-laying by insect pests such as pea moth.
5. A crop which should mature and dry faster than the conventional one.
6. A crop which remains standing and keeps its pods and seeds above the damp ground and minimises staining, premature germination and disease attack.
7. The possibility of machine harvesting, which is by far the most important improvement of all. Increasing the efficiency and reliability of machine harvesting could allow even low-yielding peas to become competitive with conventional crops.

In the United Kingdom therefore, it should now be possible to consider growing peas with a degree of confidence in relation to the actual harvesting of the dried seed crop not only in the drier, Eastern regions but also further North and West where rainfall is higher. Peas grow well and yield well in Northern and Western areas but they have always proved very difficult to harvest. The introduction of a crop with a low fertilizer requirement which can be machine harvested and which would be welcomed as a new break crop has an important bearing upon our import requirements. Hopefully, we can increase our pea acreage sufficiently to do away with imported peas entirely. The degree of reliability associated with the harvesting of leafless peas suggests that they may compete with beans as a protein crop for animal feed. Beans are more susceptible to disease than peas and their yields are incredibly variable and unpredictable which means that alternatives should be seriously considered. Spinning and texturisation of pea protein have also been achieved so that there could eventually be an alternative source of textured vegetable protein should the demand arise.

When the requirements for grain legume breeding in South East Asia are considered then, although the pea crop itself is relatively

unimportant, there are a number of lessons to be learned from this European breeding and genetic exercise.

1. As much genetic variability as possible should be collected and preserved ready for use in breeding programmes.
2. The breeding programmes should be extensive with a large number of crosses being made in order to encompass as wide a range of genetic variability as possible. Experience with the peas has shown that the background genotype is extremely important in its interaction with the mutant genes and in determining if the resultant phenotypes are likely to be of any agronomic value.
3. Intuitive dismissal of slender plants or plants with smaller leaves, or plants that appear to have reduced photosynthetic potential may be wrong.

A more dramatic restructuring of plant shape than that involved in the leafless pea is hard to imagine and yet agronomically useful plants are not being bred. The photosynthetic efficiency per unit area of leaflets converted into tendrils seems to be much the same as that of conventional leaflets. A balance seems therefore to have been struck between the vegetative and the reproductive requirements of the plant resulting in no more vegetative development than is required to support the yield of grain. It would therefore seem pointless for the plant breeder to select for increases in the amounts of haulm unless there are concomitant increases in economic yield. More efficient types of rice, wheat and soyabean have, of course, been recognised in plants with canopy restructuring permitting lower light extinction coefficients. No plants with the extreme reductions to be found in peas appear to have been developed but perhaps they would have been dismissed on intuitive rather than experimental grounds. In areas of high humidity, so characteristic of many parts of S.E. Asia, perhaps it would now be

wise to look seriously at plants with extensive reductions in leaf area in order to develop healthier crops with better growth rates and with a more useful partitioning of photosynthates.

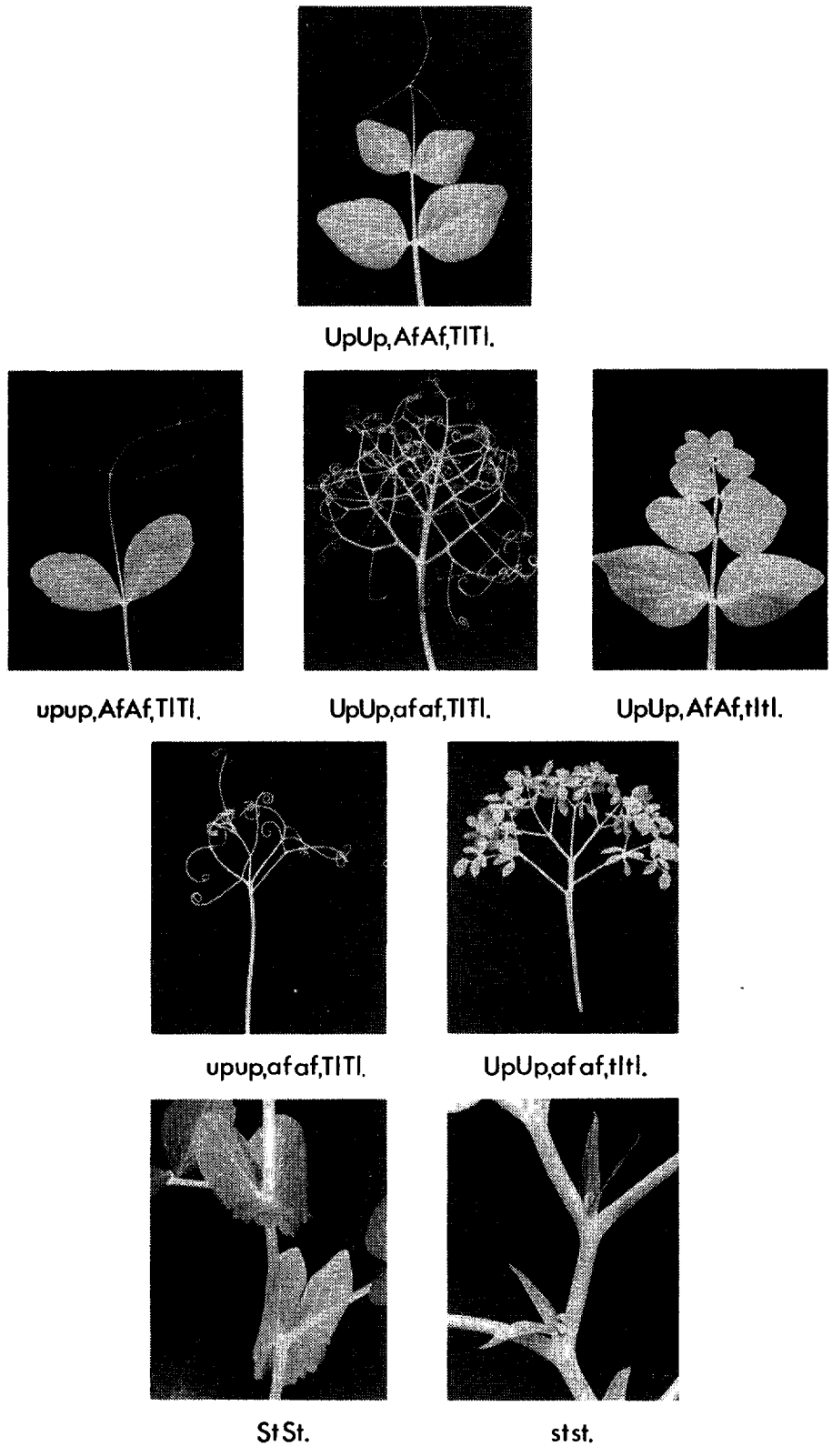

Plate I.

Modifications to leaf and stipule structure in the pea resulting from different combinations of four genes.

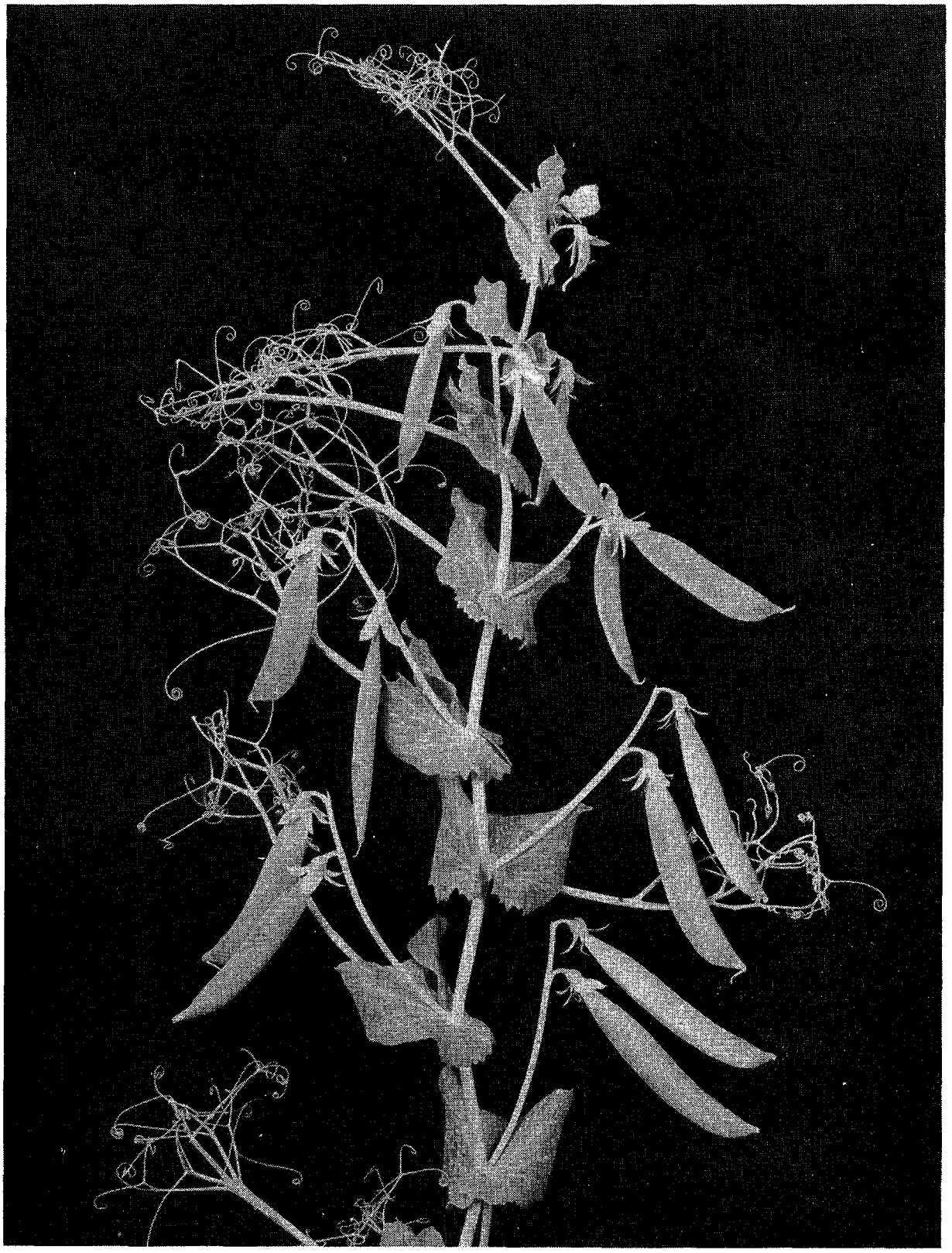

Plate II.

The semi-leafless pea.

Plate III.

The leafless pea.

BREEDING CHICKPEAS AT ICRISAT

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ABSTRACT

This paper deals with the chickpea breeding programme at the International Crops Research Institute for Semi-Arid Tropics (ICRISAT). Within the cultivated species of chickpea there are two main groups of practical importance to plant breeders, namely the small seeded "Desi" and the large seeded "Kabuli" type. The East Asian types plantings are largely desi-types while the West Asian chickpeas are largely kabuli-types. ICRISAT has assembled a germplasm collection of approx. 10.000 lines. This collection is under investigation at Hyderabad, India, but should also be studied in other environment. ICRISAT can supply germplasm lines on request.

The world's average productivity of chickpea is now very low. ICRISAT aims at the development of high yielding cultivars for farmers and high quality for the consumer and a large cross-breeding programme has been started for that purpose.

Introduction

The Crop Improvement Programme at ICRISAT caters for Sorghum, Millet, Pigeonpea and Chickpea. Groundnut is, in the near future, to be added to ICRISAT's mandate as a world centre for the genetic improvement of those crops. While Sorghum, Millet, Pigeonpea and Groundnuts are largely grown in the semi-arid regions of the world, the area covered by chickpea extends into the arid zones of the Near East and North Africa.

ICRISAT has initiated a multidisciplinary team of breeders, pathologists, entomologists, physiologists, agronomists and biochemists to tackle the problems of chickpea improvement. A microbiologists is to be appointed soon. This paper largely confines itself to the breeding of chickpeas.

Origin and Diversity of Chickpeas

Chickpeas (*Cicer arietinum*) originated in Turkey (Ladizinsky and Adler 1976) and the probable progenitor is *Cicer reticulatum*, which crosses readily with the cultivated form. It may, because of its non-shattering qualities, have been one of the earliest pulse crops to be cultivated by man - say 10,000 years ago.

Within the cultivated species there are two main groups of practical importance to plant breeders. These are:

1. '*Desi*': The small seeded (less than 25 gms per 100 seeds) type, irregularly shaped and of various colours. Flowers are usually purple and leaflets small (6-9 mm). This type is characteristic of East Asia, Ethiopia and parts of Afghanistan and Iran.

2. '*Kabuli*': The large seeded (more than 25 gms per 100 seeds) type, ramshead shaped and of white creamy colour. Flowers are white and leaflets large (10-20 mm). This type is characteristic of the Middle East, North Africa and Southern Europe.

The mountains dividing Pakistan and Afghanistan delineate the winter planted (October to November) chickpeas in East Asia from the spring planted (March/April) chickpeas in West Asia. The East Asian plantings are largely desi types and suspected of being 'adapted' over centuries to this area and the contingent climatic conditions. Kabuli types are said to have been introduced to East Asia about 400 years ago (Van der Maesen 1972): some are grown but they yield poorly here in comparison to desis. The West Asian chickpeas are largely kabuli types, which yield well in the area (Singh and Auckland 1975) and are adapted to the spring plantings. In Iran and Afghanistan, both desi and kabuli types are grown as a summer crop and these desis are adapted to spring plantings there.

The nature of adaptation of desi types to winter plantings in East Asia and kabuli types to spring plantings in West Asia is not known todate but it is proposed to investigate the photoperiodic and thermosensitive responses of these types more thoroughly. The breeding behaviour of kabuli x desi crosses grown in Lebanon in 1975 indicated pronounced divergencies in adaptation patterns between kabulis and desis.

Areas of Production

The total world area grown to chickpeas in 1974 was about 9.50 million hectares, producing approx. 6.25 million metric tons. 82% of the production was in East Asia (India, Pakistan, Burma and Bangladesh) with a further 9% of the production in West Asia, North Africa and Southern Europe. The remaining production was divided between Central and South America and Sub-Saharan Africa, chiefly in Ethiopia. It is estimated that between 10 and 15% of the total world production is of kabuli types.

Germplasm Collection at ICRISAT

ICRISAT has assembled a germplasm collection of approx. 10,000 lines. The evaluation of this collection for agronomic, physiologic and yield characters, resistances to pests and disease, responses to fertilizers, tolerance to drought, plant architecture etc. is underway. Preliminary investigations of a limited range of lines at the Hyderabad site indicated a considerable range of natural variability between genotypes eg. number of pods per plant varied from 9 to 618, 100 seed weight varied from 6 to 68 gms per 100 seed and plant height from 16 to 71 cms.

Some of the apparent variability in Hyderabad may result from the fact that some genotypes are adapted to that environment and others are not. The fact that there is extant in 1975 such a large collection of genotypes of an ancient crop may be indicative of the specificity of cultivar adaptation to environments. It is likely that each of these "surviving" cultivars is adapted to some special niche in some part of the chickpea growing parts of the world. The germplasm collection therefore requires evaluation in different environments: particularly in the contrasting environments of West Asia and East Asia and probably also in Northern and Southern sites within East Asia.

It is possible that some of these germplasm lines may be of immediate value to other countries and ICRISAT can supply them on request. Their main value at present is envisaged as parental material for ICRISAT's breeding programme: they serve as a constant source of replenishment for our dynamic hybridization programme.

The Low Yield of Chickpea

The world's average productivity of chickpea is now very low: about 710 kg/ha. The average yield on the Indian sub-continent (Bangladesh, Burma, India and Pakistan) is 625 kg/ha - mostly desi types. The average

yield in the Middle East (Iran, Iraq, Jordan, Lebanon, Syria, Turkey, Israel) is 992 kg/ha - mostly kabuli types. High yields were reported from Egypt of 1984 kg/ha in 1970, of kabuli types grown under irrigation. Yields have continued to increase in Turkey and averaged 1478 kg/ha in 1972.

The causative factors of low yield may be:

1. The inherently low yielding capacity of the indigenous land races.
2. Lack of stability of yield (which may be due to cultivar specificity).
3. Losses caused by pests and diseases.
4. The growing of the crop under conditions of low fertility and the unresponsiveness of present day cultivars to high fertility.

The aims and objectives of ICRISAT's Breeding Programme

ICRISAT aims at the development of high yielding cultivars for farmers and a high quality product for the consumer. It is unlikely that one universal high yielding cultivar can be produced and thus early generation segregating populations are produced which can undergo further selection in different environments in other countries.

The objectives of the breeding programme are, in order of priority:

1. High Yield and Stability of Yield

   Our approach to this may be subdivided as follows:

a. The hybridization of cultivars of diverse geographic origins and adaptations: Kabuli x Desi crosses produce transgressive segregation of a greater magnitude than either desi x desi or kabuli x kabuli crosses and are therefore more likely to ensure quantum yield increases. Adaptation is however important and we must retain the adaptive gene complexes of desi types to winter planting environments and kabuli types to spring planting environments. We have evidence that a (desi x kabuli) x desi backcrosses will produce adapted segregants for East Asia and a (desi x kabuli) x kabuli backcross will produce adapted segregants for West Asia.

   This introgression of desi into kabuli germplasm and kabuli into desi germplasm is anticipated to be the best means of ensuring a good reassortment of "yield genes".

b. The development of fertilizer responsive cultivars: Chickpeas are said to be unresponsive to fertilizer application and this appears to be largely true. Some cultivars do respond however and by using these as parents in the hybridization programme and subsequently selecting from segregating populations under conditions of high fertility, it is hoped to select out fertilizer responsive types.

c. Ideotype breeding: The plant habit of present day cultivars is bushy and there is often excessive vegetative growth. An improved plant architecture would mitigate yield losses caused by lodging, lack of canopy aeration and diseases.

The germplasm collection contains tall types with compact habits having a few major branches emerging from the lower nodes - most of these are kabuli types and unadapted to East Asian conditions. Their habit and height may be a consequence of their unadapted nature when grown in a different environment but we are trying to incorporate their attractive architecture into locally adapted cultivars by introgression.

An attempt is also being made to produce an upright plant having a maximum number of pod bearing nodes with short internode lengths.

The relationship between number of pods per peduncle and yield is still controversial. It would appear however that two pods per peduncle in a cultivar with an adapted genetic background would, conceptually, yield higher. ICRISAT physiologists are actively engaged in studying this characteristic and, other characters which may enable an 'ideotype' to be formulated.

2. Resistance to Diseases and Pests

a. Diseases: A number of pathogens like fungi (Fusarium, Rhizoctonia, Operculella and Sclerotium) and viruses may be responsible for Wilt, which is the major cause of loss of yield in chickpea. Specific resistance have not yet been fully

identified due to the inadequacy of proper screening techniques but the Pathologists at ICRISAT are now perfecting such techniques which will enable them to identify resistances and to screen the germplasm. As and when specific resistances are identified the breeders will launch a resistance breeding programme.

Ascochyta Blight is sporadic in occurrence but can be devastating in certain years in Northern India, Pakistan, Iran and Turkey. Field testing for resistance is difficult because of the sporadic nature of the disease but a screening technique is in the process of being perfected in ICRISAT's laboratories. Once known resistances have been identified, they will be incorporated into the breeding programme.

b. Pests: The main pest of chickpeas, on a world basis, is Heliothis armigera. It attacks many crops and it is difficult to make recommendations for this ubiquitous insect, though spraying regimes are available. It is possible that the exudate of malic/oxalic acid from the glandular hairs on chickpeas may confer some resistance to Heliothis and ICRISAT's entomologists are investigating this.

Breeding Procedures

Chickpeas are strictly self-pollinated and diploid (2n=16). Hand crossing is tedious and laborious but we employ about 60 men per year specifically for this and have made about 4,500 crosses todate.

Single, 3-way, 4-way and composite crosses have been made. Large populations of F2 crosses are grown at Hyderabad (17°N) on the ICRISAT site and at Hissar (29°N) on Haryana Agricultural University land. The Hissar site is situated in the main chickpea belt of India and Pakistan. It is hoped eventually to also develop a major breeding and selection site in West Asia.

Single plant selections made from F2 populations in Hyderabad and Hissar, undergo further pedigree selection by growing plant to progeny rows at both these sites, in advanced generations and other seasons. F4 progenies are also tested under conditions of high and low fertility at both sites. Off-season generation advancement has been carried out in the Lahaul Valley, Himachal Pradesh (Northern India), and in the Lebanon.

F2 populations considered very promising are also harvested by the modified bulk method and supplied as F3 seed for growing by other countries in other environments in order that National Programmes may select from them genotypes best adapted to their specific environments.

This classical approach to breeding is considered appropriate but we are also investigating ways and means of maximizing recombination by, in particular, using Jensen's diallel selective mating procedure.

Cooperative International Breeding Programme

It should be emphasized that while the main site of our operations is in India, ICRISAT's mandate is to serve as a world centre for the improvement of chickpeas. Our cooperative programme with other countries is therefore most important. Its objectives are:

1. To make direct introductions of cultivars into other countries

2. To supply segregating populations to strengthen national and regional programmes

3. To identify genotypes with specific qualities for use in breeding programmes throughout the world.

Any of our material is available, on request, to any nation. We do, however, run an annual cooperative programme - testing germplasm lines, cultivar trials, segregating populations and, in the near future, elite lines produced by ICRISAT. During the 1975/76 winter season, we sent these trials to cooperators in Pakistan, India, Burma, Bangladesh, Thailand, Philippines, Ethiopia, Sudan, Mexico, Chile and Yemen. We hope to extend this cooperation to West Asia and expand it as time goes on.

Induced Mutations

There has been very little intensive work done on chickpea improvement todate and there is a wide range of natural genetic variability which has not yet been exploited within *Cicer arietinum*. The wild species of *Cicer reticulatum* may contain sources of disease resistance. Until the natural variability has been fully investigated and exploited it is unlikely that induced mutations as a tool for genetic improvement will be important to us at ICRISAT.

One can, however, envisage specific areas where it may be important:

1. If we cannot find natural resistance to either the wilt complex or *Ascochyta*.
2. For the production of early maturing cultivars for specific regions (e.g. a short term chickpea is required for Sind, Pakistan).
3. Producing photo or thermo insensitivity
4. Producing an erect plant habit
5. Shortening internode length
6. Producing more than one pod per node in an adapted genotype

We may need to use every available means of improvement, on this ancient crop which has been so neglected by plant breeders.

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MUTATION BREEDING IN WINGED BEAN

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ABSTRACT

Winged bean is the most important traditional legume in Papua New Guinea. Only recently the nutritional importance of this crop has been recognized both nationally and internationally. Almost all parts of the plant are edible including dry seeds, green pods, green seeds, young leaves, flowers and root tubers.

A programme for the improvement of this species was started in 1973. The primary objective was to collect and conserve the genetic variation and to formulate a breeding programme. A Mutation Breeding Programme was initiated in 1975 and the primary aim was to search for an erect bush-type mutant. Gamma radiation and the chemical mutagen, EMS have been used for the induction of mutations.

Introduction

Winged bean (Psophocarpus tetragonolobus (L.) DC.) is the most important traditional legume in Papua New Guinea, which is grown in the Highlands around an altitude of 1500-1800 metres. It appears to have been introduced to this country at least 300-400 years ago from South East Asia (Khan, 1975). It is now deeply entrenched in the agriculture of the Highlands and in certain areas it occupies the status of a major crop being next to only sweet potato (Ipomeae batatas) in importance. Through centuries of experience, the Highland farmers have evolved a very satisfactory system of cultivation which ensures reasonable yield and relative freedom from insect pests and diseases (Khan, Bohn and Stephenson, 1975). However, only recently the nutritional importance of this crop has been recognized both nationally and internationally.

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Almost all parts of the plant are edible including dry seeds, green pods, green seeds, young leaves, flowers and root tubers. Dry seeds contain 30-40% protein and 15-17% oil (Masefield, 1973). In the Highlands the most favoured food is root tuber and mature green pod. Leaves and flowers are also consumed. The tubers or pods are wrapped in banana leaves and are cooked in a pit with hot stones (Khan, Bohn and Stephenson, 1975). When dry seeds are eaten, they are cooked by frying in fat or roasting on a hot pan. Apart from its nutritional qualities, this plant produces abundant nodules which enrich the soil (Masefield, 1973).

In view of its acceptability to the local consumers and the long tradition of winged bean growing in Papua New Guinea a programme for the improvement of this species was started in 1973. The primary objective was to collect and conserve the genetic variation and to formulate a breeding programme. This work revealed that a wealth of genetic variation existed in the traditional winged bean growing areas of Papua New Guinea, and a germ plasm collection of 121 lines was established (Khan, 1975). Variation in yield and yield related characters, and in morphological characters including flower, stem and pod colour, pod shape and pod surface was uncovered. These findings coincided with world wide interest in this species (N.A.S., 1975) and this opened the possibility of winged bean becoming an important legume crop throughout the tropic and sub-tropics.

A review of our plant breeding objectives was therefore undertaken and as a result both long term and short term objectives were defined. All the available variation in Papua New Guinea as well as that in overseas material has not revealed the existence of an erect bush-type determinate variety. The currently available varieties are indeterminate, viny types which require stakes or other support for trailing. This is an expensive and labour intensive practice and is not suited to intermediate and higher levels of technology.

Mutation Breeding

A mutation breeding programme was therefore commenced in March, 1975 with the financial support by the International Atomic Energy Agency and the cooperation of the Division of Plant Industry, CSIRO, Canberra. The primary aim was to search for an erect bush-type mutant. However, it is envisaged that all potentially useful variants will be preserved to enrich the gene pool available at present. It was decided to use both chemical and physical mutagens and E.M.S. and gamma rays have been used.

The gamma ray treatment was given from a cobalt-60 source located at the Division of Plant Industry, CSIRO, Canberra, Australia, and seeds were returned to Port Moresby for planting.

A pilot experiment with radiation doses ranging from 5-50 Krad showed a progressive decrease in seedling emergence and growth up to 25 Krad, above this dose the mortality was 100%. Further work was therefore confined to the doses ranging from 10-25 Krad. It was noticed in some experiments where planting after irradiation had to be delayed for some practical reasons that none of the treatments above 10 Krad emerged. Post-irradiation storage damage was confirmed in subsequent experiments.

Planting directly into field was found to reduce seedling emergence in the irradiated material when compared with the glasshouse results, although control seeds gave almost identical results in both conditions. This reduction in emergence was very severe in treatments with 10 Krad (11%), 15 Krad (50%), 20 Krad (32%), and 25 Krad (7%) are presently being raised in Port Moresby. It is intended to raise a total 10,000 M_1 plants by the middle of 1976. The M_2 screening will commence as soon as seed is available.

Ethyl methane sulphonate (E.M.S.) was applied in a phosphate buffer solution with pH 7. The results of the first experiment with E.M.S. concentrations 0.1, 0.15 and 0.20% applied for 16 hours at room temperature with constant gentle shaking revealed that, when compared with unsoaked seeds, germination was reduced by approximately 50% by mere soaking of the seeds in buffer solution. The germination percentage of the seeds treated with E.M.S. solution was reduced to 21-25% of the buffer control. Reduction in the seedling growth measured 2 weeks following the treatment showed progressive reduction with higher concentration of E.M.S. Reduction of the time the seed was immersed by reducing the time of pre-soaking, treatment and post-treatment washing did not improve seed germination. Neither did aeration during immersion improve germination. The available information suggests that an 8 hour treatment with 0.05 to 0.15% E.M.S. will be satisfactory. As sufficient seed becomes available for treatment 5000 M_1 plants will be grown.

General Remarks

Selection criteria for subsistence agriculture may vary widely from those for commercial crops. This stems from a relatively greater supply of labour, and a need to ensure continuity of food supply. Consequently, indeterminate crop varieties may be favoured even if they are more labour intensive. Also, the multiplicity of uses is an advantage to a crop variety for subsistence agriculture.

As the level of agricultural technology is raised and supply of labour becomes limiting a change from indeterminate to determinate and from multi-purpose to specific crops must follow. This has happened in Asia and Africa already, where the unavailability of suitable variants may have already resulted in a decline in winged bean cultivation. Papua New Guinea is now striving for intermediate technology and the above factors may become important in the not too distant future. Therefore if winged bean is to retain and extend its present status in Papua New Guinea, and if it is to contribute to the agriculture of the other countries, restructing of the plant will be necessary. One of the obvious needs is an ereot mutant. Seed crops will require a deterinate plant with no tuber formation, greater retention of flowers and young pods, an increase in shelling percentage (ratio of seed weight to pod weight) to direct the greatest part of the assimilates to the seeds. A tuber producing variety should have greater flower drop and little seed yield in order to encourage tuber production. A horticultural winged bean will need to have long and thick pods, low shelling percentage, an absence of tubers and smaller seeds, and the desired pod colour. A multi-purpose plant with bush type growth habit can similarly be reconstructed.

It is hoped that variants from this mutation programme, together with the naturally occurring variation that has been and will be assembled, will form the basis of a recombination programme to produce the desired genotypes.

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MUTATION BREEDING IN IMPROVING GROUNDNUT CULTIVARS

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ABSTRACT

Groundnut is an important grain legume in India occupying nearly 7.5 million hectares.

An important breeding objective for the export market was to produce a large kernel groundnut which would obtain a good price on the world market.

At the Bhabha Atomic Research Centre, Bombay efforts were made to develop such a large kernel type by γ- ray induced mutations. One selected large kernel mutant, IG-1, showed also high yield potentials in large scale trials all over India and was released as a new variety in 1973. This and other mutants have been used in various cross combinations and a number of selected lines have given even higher yields.

Groundnut is an important grain legume in India occupying nearly 7.5 million hectares and producing 5.5 million tonnes of pods. This contributed more than 35% to the total production of grain legumes. Besides its food value as grain legume, groundnut is one of the main sources of edible oils contributing more than 60% to the total oil seeds production in the country. Therefore, it is grouped under oil seeds, unlike other grain legumes which are commonly known as pulses.

Groundnut kernels have 25-30% protein. Deoiled 'cake' is very rich in protein (55-60%), the biological value of which is about 65%. It is used on a small scale in nutritious foods like biscuits and beverages. If all the deoiled 'cake' (1.5 million tonnes) were made available for human consumption, it is expected that it add about 5 g of protein per person per day, thereby reducing the protein deficiency gap in the Indian diet. The conarchin of groundnut protein is reported to be excellent for body growth and hence, groundnut flour is generally used in industrially mamufactured baby foods. According to some reports the protein fraction has anti-haemorrhage properties. In addition, the groundnut kernels are directly used

in the preparation of Chutney, curries, peanut butter, roasted nuts etc. indicating popularity of kernels as food.

India enjoyed a premium position in the groundnut export market before 1950. Acute shortage of edible oils in the recent years, however, has reduced exports to a negligible quantity of 40-50,000 tonnes per annum yielding about 30 million dollars at the rate of 700 U.S. dollars per tonne of kernels. According to exporters of HPS (Hand Picked Selection) kernels there is a preferential demand for large kernels giving 28-32 counts/28 gm which fetch as high as 860 U.S. dollars per tonne.

Research efforts to develop large kernels at the Bhabha Atomic Research Centre, Bombay resulted in the isolation of TG-1 (Trombay Groundnut-1) variety having 0.7-0.9 gm/seed compared to 0.4-0.5 gm in the unirradiated parent. TG-1 kernels with 28-32 seeds/28 gm are bolder than Bold-1 (44/28 gm of ISI standard) and hence, better suited for HPS export. This variety was developed by using X-rays (75 kR) and repeated selection for improved kernel weight. In the All India Coordinated Research Project in Oilseeds (AICORPO) during 1979-72 TG-1 produced 1332 Kg/ha compared to 1206 Kg. pods of T-64, a bold seeded variety. Subsequently it has yielded more than 23-25 quintals/ha at Ludhiana in Punjab, Mainpuri in Uttar Pradesh and Rajkot in Gujarat compred to 2200 Kg of C-501, 2085 Kg. of TMW-10 and 2400 Kg. of Punjab-1. Based on the performance in the AICORPO experiments, TG-1 is released as 'Vikram' for cultivation in 1973 by the Central Varietal Release Committee (CVRC), Ministry of Food and Agriculture, New Delhi. Other varieties with large and extra large kernels and improved kernel recovery were developed after intercrossing the induced mutants. They are being evaluated for their performances.

The development of these large kerneled varieties has necessitated a change in the present ISI standards for HPS in the country. A projected export of 100,000 tonnes kernel of this variety in 1978 would bring in 16 million dollars of additional income at the current market rate.

Fluctuations in groundnut production very much influence the edible oil industry in the country. Average pod yield per hectare is varying from 700 to 850 Kg which is about 50% of that obtained in the United States of America. This suggests a scope for improving national production through increased yield/ha. Increased production of edible oil is possible also by improving the oil content in the kernel. Some progress in these directions has been made by isolating high yielding varieties and cultures with improved oil content. According to AICORPO reports (1970-72) and National Seed Corporation Bulletin of 1974 TG-3, TG-8, TG-9, TG-10 and TG-14 varieties have

produced 10-20% higher yields compared to those of the standard varieties. TG-8, TG-9 and TG-10 have, in addition, 2-4% improved oil content.

It may be emphasized that TG-3 have shown superior yielding ability in central and southern states. At Dharwar in Karnatak, TG-3 produced 4483 Kg/ha pods compared to 4108 Kg/ha of J-11 during kharif 1973. Even at Tifton, Georgia in the USA this variety produced promising results (4874 Kg/ha) during 1972-74. The CVRC has recommended this variety for district level trails in the country.

Further increase in pod yield has been recorded in the recent cultivars viz. TG-15, TG-16 and TG-17 which are developed after crossing different mutants. TG-15 is high yielding apparently due to its excellent germination and 'plant stand'. TG-16 and TG-17 are characterised by the reduced number of branches and consequently improved reproductive growth. TG-17 having least number of branches produced an average yield of 2874 Kg/ha compared to 2495 Kg. of TG-3 at Trombay during 1972-74 kharif seasons. This variety has the distinction of producing 30 quintals/ha compared to 20-27, quintals of other varieties on the farmers' field at Rajkot during kharif 1975.

Another approach to achieve higher production/ha is through increased 'inputs' including pest and disease control methods. Application of pesticides to protect crops, therefore, is unavoidable. Since many of them are fat-soluble, there is a danger of their accumulation in the edible oil of groundnut and pose a health problem. Development of cultivars with genetic resistance to pests and diseases would alleviate this problem.

Spoilage of groundnut and its products is often related to infection by Aspergillus fungi capable of producing a carcinogenic substance known as aflatoxin. Recent reports show that these fungi are infecting other foods and food grains stored under bad conditions. Thus, it is apparently a post harvest infection and may be controlled by developing proper post-harvest handling technology. Breeding for resistant varieties may be difficult because of the saprophytic nature of the infecting organism. Information regarding the exact relation between these fungi and hosts would help in breeding for resistance in grain legumes.

CONSUMPTION OF GRAIN LEGUMES IN SINGAPORE

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ABSTRACT

About 20 per cent of the land in Singapore island is under cultivation and the total farming area is 11,832 hectares (1973). Most farmers are growing vegetables, fruit trees and ornamental. Only a few legumes are grown locally as vegetables, such as yard-long beans, french beans, hyacinth beans, winged beans. Practically no grain legumes are grown in Singapore and exclusively important for own consumption. Mainly soybeans and secondly peas are the most important grain legumes for human consumption in Singapore.

For specific reasons, this report deals with the consumption rather than production of grain legumes in Singapore. Singapore is a small nation with a total land area of 633.4 km^2 (244.5 square miles), including its adjacent islets. It is populated by about 2.2 million people (1974 figures). Due to its heavy population and small land, farming in this nation is limited and emphasis is placed on intensive vegetable cultivation, pig and poultry production, ornamental plant and orchid growing, and aquarium fish breeding. A large proportion of the farms in Singapore undertake mixed farming, i.e., most farms not only grow vegetables and ornamental plants, but also rear pigs and poultry.

According to a survey conducted in the year 1973, there were 15,741 farms in Singapore, of which 14,110 or 89.6% were engaged in some form of horticultural activities, i.e., growing vegetables, fruit trees or ornamental plants. About 20% of the land on the island is under cultivation. The total farming area in the Republic was 11,832 hectares, with an average size of only 0.75 hectare per farm. The total number of persons who undertook farm employment, i.e., persons who had put in at least 1 hour of farm work during the reference week, was found to be 45,650 (Wong, 1975). This indicates that only about 2% of the total population of Singapore were engaged fully or partly in farming activities.

With the above statistics in mind, it is not surprising that there are practically no grain legumes grown in Singapore. Only a few legumes are grown locally as vegetables, such as yard-long beans (Vigna sesquipedalis), French beans (Phaseolus vulgaris), Hyacinth beans (Lablab niger), four-angled beans (Psophocarpus tetragonolobus), etc.

Being an important commercial and trading center, Singapore not only imports grain legumes from the producing countries for the consumption of its own people, but also transports them to other consuming areas for entrepot or trading purpose. Some of the imported grain legumes are repacked or processed before exportation. In 1974, Singapore imported a total of 73,730 metric tons of various grain legumes, and exported 16,996 metric tons, thus about 56,734 tons of grain legumes were consumed locally in Singapore. With its population of about 2.2 million, every Singaporean consumed an average of about 26 kilograms of grain legumes in 1974. This figure includes the grain legumes used for oil extraction, animal feeding, and soya sauce making, bu excludes the products made or processed from beans, such as oil pressed cake, bean vermicelli, soya sauce, margarine, vegetable oil, etc. In 1974, Singapore imported 1,326 metric tons of soy bean oil and 7,613 metric tons of peanut oil. Table 1 presents the imports and exports of some grain legumes by Singapore in 1974.

Soybean ranks foremost in quantity among the grain legumes consumed in Singapore (Table 1). Over 35% of the soybeans is imported from Brazil, U.S., and China, with about 15 thousand metric tons for each. Thousands of people use soybean in countless ways. Soybean contains about 40% of protein and 20% of oil, and is by far the most valuable of all known beans. It forms a substantial part of the people's diet and is a major source of protein as well as vegetable oil.

In addition to oil extraction, soybeans are soaked, ground and processed to give soybean milk which is a common and cheap drink and is a good substitute for milk. Bean-curd (tao-fu), dried cakes of bean curd and fried bean curd all made from soaked and ground soybeans form a number of tasty and nutritious dishes. They are widely consumed every day and are good substitutes for meat. Sprouted beans of 6 to 10 cm long are often used as green vegetable. Dried beans after soaked for a day in water are cooked like peas or Lima bean and make delicious and nutritious vegetable dish or soup. Soya sauce made from fermented soyabeans is one of the principle flavoring sauces for Chinese dishes. Soya meal and soybean oil pressed cake are important feeding stuffs for livestock.

Peanuts ranks next to soybean in importance among the grain legumes used as human food in Singapore. Over 50% of the peanuts is imported from China. In addition to oil extraction, peanuts are eaten after roasted, fried or boiled in salt water. Peanut butter either imported or locally made is commonly consumed with bread. Whole or chopped pieces are used in making candies, cakes, cookies and other confections. Peanut-oil pressed cake is an excellent animal feed supplement which contains high percentage of protein and oil.

Dried beans of different Leguminous species are used as food in a variety of forms. The most common form is the soup. Red gram (Cajanus cajan) and green gram (Phaseolus aureus) are boiled in sugar water or spiced salt water and eaten as soup. Then there is a wide variety of dishes in which dried beans constitute the main or an important ingredient and are prepared in different manners. Green gram is commonly used as vegetable after sprouted to the length of 5 to 8 cm. Its flour is used to make bean vermicelli and bean cake. Hyacinth bean (Lablab niger) is grown locally and its young pods are used as vegetables.

Peas (Pisum sativum) are consumed in a variety of ways. The fresh young pods are commonly used as vegetable. The cooked green seeds are one of the leading canned or frozen vegetables in Singapore. The dried seeds are eaten after fried or roasted.

TABLE 1

Imports and exports of some grain legumes by Singapore in 1974

Grain legumes	Imports	Exports	Difference (Im.-Ex.)
	M. ton	M. ton	M. ton
Soya bean	52,466	5,415	47,051
Peanuts	5,646	3,529	2,127
unshelled	(584)	(---)	(584)
shelled	(4,122)	(2,955)	(1,167)
roasted	(950)	(574)	(376)
Dried beans	4,468	3,060	1,408
Dried peas	8,380	3,339	5,041
Chick pea and gram	2,810	1,653	1,157
Total	73,780	16,996	56,784

Source: "Singapore External Trade Statistics 1974", Department of Statistics, Singapore.

TABLE 2

Average prices of various grain legumes and cereals in November 1975

Grain legumes or cereals	Average Price
	US$/kg
Soya bean (*Glycine max*)	0.37
Peanuts (*Arachis hypogaea*)	
unshelled	0.50
shelled	0.70
roasted	0.90
Green gram (*Phaseolus aureus*)	0.47
Broad bean (*Vicia faba*)	0.40
Pea (*Pisum sativum*)	
frozen green	0.80
dried	0.45
Rice milled whole	0.45
milled broken	0.40
Wheat unmilled	0.23
meal and flour	0.30
Maize unmilled	0.14
meal and flour	0.23
Barley	0.27
Ray	0.23

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CONCLUSIONS AND RECOMMENDATIONS

I. Introduction

There are roughly thirty species of grain legumes which are grown in South-East Asia and of these the major ones are cultivated on many millions of hectares (55,000,000 ha - 1973 FAO Yearbook) either as monocultures or in combination with other crops. From the economic standpoint, these crops represent, in some cases, very substantial resources for obtaining hard currency through export. However, the crucial importance of these crops lies in their key role in the nutrition of the peoples of South-East Asia. Grain legumes constitute the major source of protein in the diet when consumed in combination with root crops such as cassava or cereals such as rice, wheat, sorghum and millets. The legumes play another important nutritional function in providing the balance for optimizing the value of whatever cereal protein is available. Thus from the dietary standpoint they are, with the cereals and root crops, absolutely essential. Unfortunately, few countries in South-East Asia are self-sufficient in grain legume production; this results in the commitment of precious foreign exchange for the import of grain legumes.

The past decade has witnessed dramatic changes in the agriculture of this region with the introduction of higher yielding varieties of cereals. These changes have produced notable shifts in the proportions of the various crops grown by farmers. In general, it has been more profitable to grown high yielding cereal varieties than grain legumes. As a consequence, many of the lands traditionally planted to legumes have been preempted by cereals while the grain legumes have been relegated to more marginal lands. In some countries the area devoted to legume cultivation has shrunken. Concommittantly, there has been a noticeable rise in the price of grain legumes over and above the general price rises encountered world wide. Nevertheless, there appears to be no trend, in general, to plant more area in grain legumes. The reason for this is that the farmer, on the average, obtains only poor yields with these crops. In a number of cases, the grain legumes are grown as a secondary and supplemental crop, taking advantage of residual moisture. Besides whatever compensation can be derived from grain legumes, they also offer nitrogen replenishment to the soil in that they possess the capacity for symbiotic nitrogen fixation.

Despite the obvious importance of these crops, the amount of attention given to the breeding and other cultural aspects has been surprisingly little. Many of the varieties which are used are traditional ones which are in need of much genetic improvement if higher yields are to be realized. Also the improvement of cultural practices would provide substantial yield increases. In addition, the losses from storage of grain legumes are discouraging large. Without minimizing the importance of the latter points, what follows is an attempt to define the plant breeding problems associated with the major crops of the region.

Any undertaking of the nature immediately collides with the vast physical dimensions of the region, the enormous number of environments involved, the local needs and tastes as well as many other considerations. Even a cursory examination of the situation immediately defies making any easy generalizations. However, some of the problems are common to several countries making a co-operative, concerted approach both feasible and desirable. In viewing the problems, the participants have not attempted to extrapolate beyond their scope of knowledge, nor have they failed to note that they represent only a fraction, albeit a sizeable one, of the entire region. In making a first cut at these problems, the group acutely felt the absence of input from entomologists, agronomists, physiologists and others of ancillary disciplines. Nevertheless, it is thought that the problems identified are indeed a good reflection of some of the major plant breeding needs for grain legumes of the region.

II. General Conclusions and Recommendations

Before presentation of the specific breeding objectives for the various grain legumes, some more general comments should be made.

1. This meeting was organized with the dual purpose of identifying breeding objectives in the grain legumes and also to suggest ways in which induced mutations might be employed. The group, at the outset, recognized no distinction between the origins of germ plasm for breeding purposes, whether it derives from spontaneous or induced genetic alterations. What is paramount is whether there are germ plasm resources for a particular character and whether these may be used to achieve the breeding objective. Corollary to this is that there is no one road with respect to breeding procedures which is to be used for all problems; the particular circumstances should dictate the approach to be used.

2. With respect to germ plasm, the group agreed that there must be materials collected and maintained. In order for this to be done properly, national

and international institutions must undertake responsibility for this and funds be allocated for such purposes. The maintenance of such collections imply keeping the seeds in viable condition, codifying the material, cooperating in the evaluation of the genotypes and making material readily available to breeders upon request. It is also recommended that a system for the efficient identification and "typing" of the pathogens and pests of the grain legumes should be developed and implemented.

The task of evaluation of the material must be shared among numerous institutions. This is because of the highly diverse genetic-environmental interactions which have already been noted in grain legumes within the region. It follows that the concept of "wide adaptability" which has been used in irrigated cereals may not be as applicable in the grain legumes. It is thus totally inappropriate to base the success or failure of a genotype on how well it has performed under one distinct set of environmental conditions. The same may sometimes also be said about performance in different seasons at the same location. Investigation on indicators of adaptability of genotypes must be done in order to determine how best to breed. In this context the group emphasized the need for better techniques for analyzing the genetic-environmental interactions of materials which might ultimately lead to a predictive capability for evaluating these interactions.

3. The question of identifying optimal plant types or "ideotypes" was discussed but the group felt that it would be premature to specify such characters in more than a general fashion. This is because the underlying physiological mechanisms contributing to yield are presently incompletely understood. Furthermore, for a number of crops the different requirements within the region make such a generalization difficult. Relevant to such considerations, however, it was noted that on the basis of data from pea with respect to morphological changes, breeders should consider the usefulness of what may seem "peculiar characters" in working toward improved cultivars. Recalling that many of the legumes are still only semi-domesticated and retain characteristics suited to subsistence, low input agriculture, there appears to be much progress possible, but this may require drastic changes in the plant structure. The participants cautioned, however, that in the quest for improved plant types, it would be disastrous if such exceptional features of grain legumes as nitrogen fixation capability and high nutritional quality were to be eroded. Therefore, it was recommended that such characters be monitored during the breeding process to be certain that they are maintained at the very least.

4. Clearly, more work must be done to determine the constraints to yield in grain legumes in South-East Asia. In some instances it is quite possible

to attribute part of the yield limitations to major diseases, e.g., rust in soybean, yellow mosaic virus in mung bean, cercospora in groundnut, but in other cases as in chickpea the limitations to yield are not as easily defined. These kinds of investigations will often involve a collaborative effort of scientists from several disciplines. Only when there is a better understanding will the breeder be able to design the plant more rationally.

The group attempted to come to grips with these problems of yield limitation by considering the potential limitations as falling into four major categories:

A - plant architecture
B - diseases, insects and other pests
C - physiological factors
D - product quality.

Realizing that there was some overlap between categories, nevertheless, it was a way of systematically defining the problems. Notation was also made as to the prospects of applying mutation induction to the characters identified.

5. The group felt that the most important role for induced mutations is to be found where the germ plasm is limited either in quantity or quality. However, some data on groundnuts also suggest that induced mutant lines when combined can produce new genetic recombinants which could prove very useful. There is a trend towards the diversification of grain legume production. This trend should be encouraged. In this context it is recommended to review the position of presently little grown legumes, e.g., wing bean, rice bean and others. Some of these crops are kitchen garden species, but have some extremely desirable features which make them attractive if they can be domesticated. In these species there has been especially heavy genetic erosion of resources so that the genetic base is limited. Efforts should be directed towards enriching the germ plasm resources above those presently available through the use of induced mutations.

6. There is a lack of marker stocks in most grain legume species. Such stocks should be established and distributed freely to help breeders to monitor and utilize the out-crossing mechanism which has received little attention in the past. Such stock will also be helpful in maintaining the varietal purity which is of vital importance.

7. One of the clear contributions to enhancing grain legume production would be the provision of "clean" seeds (free of devastating pathogens) to farmers.

More efforts are recommended in achieving this practice. This would entail production of this seed, monitoring for pathogens and a network for distribution.

8. There still exist certain taxonomic controversies over the labelling of certain species. The group feels that continuation of this situation is inimical to progress and that a speedy settlement of outstanding questions would be most helpful.

9. It is strongly recommended that a system of regional cooperation be established. This is important in a number of respects. It is essential that there be easy and frequent exchanges of information and genetic materials in order to make rapid progress in breeding. Furthermore, such a system could be used as an early warning net for plant diseases. The evaluation of breeding materials could also be possible within this system in order to identify better adapted and better performing cultivars.

Such a system would involve a programme with participation by all cooperating countries of the region which would be administered by an international agency. It is felt that such a network would provide something which is currently absent and badly needed in the region. In both the short and long term a cooperative programme would stimulate more rapid progress in grain legume improvement in the region.

10. The question of cooperative trials within the region was discussed and the conclusion was that these should be instituted with standardized conditions so that valid comparisons of performance may be made. From the point of view of determining yield potential trials with rigid disease and pest control are desirable but when evaluating the potential for farmers' fields conditions similar to those normally used by farmers should be practiced, i.e., no additional control measures against pests and diseases than an average farmer might use. The recommendation was made for instituting cooperative trials with the participation of institutions representing a cross-section of the South-East Asia region. The group felt that standardized conditions for trials are achievable only when specifications are designated. There is a need for these to be produced and made available. Therefore, the recommendation is made that an international agency, such as FAO, should undertake the production of a manual for the design, execution and analysis of standardized performance trials.

III. Crop Conclusions and Recommendations

A. Soybean - The low farm yields characterizing most soybean cultures in South-East Asia are the result of many interacting agronomic and genetic factors common to agricultural crops.

A diversity of modes of culture and rotations for soybeans exists in South-East Asia. For convenience, only two modes of culture are identified herein, namely subsistence farming and non-subsistence farming.

Where necessary and practicable, aspects peculiar to each of the modes of culture will be specified.

Plant architecture

(1) Poor stands - This is considered to be a major cause of low farm yields particularly under subsistence farming involving sowing seed into cereal stubble. Clearly, a part on of the problem is involved with non-breeding aspects such as inadequate availability of fresh seed, climatic limitations, etc. Cheap and efficient methods of seed storage in sealed plastic bags are used in Taiwan and Thailand and should be promoted elsewhere.

However, it is felt that breeding can make considerable impact on alleviating the problem of poor yield. Specifically, genetic improvements in physical quality of the seed, storability, resistance to germination in the pod, and improved seedling vigor are emphasized. It is clear that small seed has superior storability and emergence. No knowledge of genetic variability for dormancy exists, but the universality of the problem of pre-harvest damage to seed quality, and thus to viability and storability, emphasizes the importance of its investigation.

(2) Plant habit - For most areas rotations demand soybean genotypes with uniform pod maturity, complete leaf senescence for ease for drying and harvest, with a crop duration of 80 - 100 days. Particular exceptions exist and will be indicated later.

Both determinate and indeterminate cultivars are required. For the purpose of definition, indeterminacy is used to indicate that the growing point does not terminate in a reproductive bud, and that vegetative growth, flowering and podding occur simultaneously. It is considered that the indeterminate habit is useful as a compensating mechanism where situations involving poor stands and low levels of management continue to exist, and where prolonged serial picking is practiced. However,

determinacy is considered desirable where adequate management and good stand exist.

Improvement of efficiency of hand harvesting will result from relatively high individual plant yield, i.e., relatively large plants and/or high pod densities per node. Compact aerial branches to increase potential podding sites are considered desirable for hand harvesting, but are not necessary for mechanical harvesting. Minimum pod height is universally important, and the lowest pod should be no less than 15 cm above ground level. It is noted that substantial adjustments to podding configuration can be made by varying plant density and arrangement. A plant height of 60 - 80 cm is considered desirable for most circumstances.

(3) Dry matter productivity - Plant residues are utilized in most cases. Consequently, the biological yield per se is relatively important since the plants are used as stock feed in certain areas of India. Breeding for high dry matter yield and possibly leaf retention may be necessary. Such usage imposes additional different problems to breeders than simply breeding for grain yield; and local solutions are necessary.

(4) Rooting habit - Periodic moisture stress is characteristic of most areas where soybean is grown in South-East Asia. Clearly, the rooting habit must influence the plant's ability of exploit available soil moisture. However, little or no hard information exists on genetic variability for root development and habit in soybeans, nor of their implications in drought escape. It is considered that, at this stage, plant performance in yield and dry matter production above ground is the most sensible measure of ability to tolerate moisture stress. More basic research on these questions should be encouraged.

(5) Lodging - Lodging can be a significant problem throughout the region, and has implications on ease of harvesting, yield depression, disease attack and reduction of seed quality. Non-lodging cultures are an obligatory objective.

It is felt that stem thickness may condition an upright habit, but may have undesirable side effects. Rooting habit may also have importance in lodging resistance. Tolerance of water-logged conditions in early plant establishment, and early development of deep rooting, may reduce basal lodging; this requires investigation. Agronomic practices in land preparation and use of plough pans, particularly in paddy, must also be considered.

(6) Shattering resistance - Pod shattering is a major problem, and breeding for resistance is obligatory. It is particularly acute where harvesting is delayed, and for hand harvesting which involves multiple handling of plants from the field to threshing. Significant problems may be encountered when exotic cultivars are introduced. It is recognized that the incorporation of shatter resistant characters presents little problem in practice where a significant local breeding programme exists. The solution involves variety replacement.

(7) Field components - Pod number is the major consideration in improving seed yields on the farm. In view of the relatively short plants desired, this necessitates high node number, short internodes, and/or high pod density per node. Terminal and axillary raceme development are considered desirable, and they provide a homeostatic mechanism of plant growth regulation.

Seeds per pod is relatively invariate (range: 1-4; generally 2-3), and genetic attention is unnecessary.

Large seed size potential is desirable for homeostatic reasons, particularly in non-irrigated crops. However, other important considerations exist (see Product Quality (4).

Pest and diseases

(1) Diseases - Soybean rust (Phakopsora pachyrhizi) is considered to be the most important disease influencing yield throughout South-East Asia. Suitable research exists at the Asian Vegetable Research and Development Center, in Australia, India, Philippines and Thailand, and immune and horizontal resistance reactions are reported. However, this research requires intensification as a matter of priority.

Baterial blight (Xanthomonas phaseoli) and pustule (Pseudomonas glycineae) can be major diseases throughout the tropics. Their incidence varies greatly across seasons, but genetic sources of resistance exist and can be incorporated. Contacts between and exchanges of sources of resistance and reactions among institutes should be fostered.

Various viral diseases are reported in soybeans, particularly for winter plantings in Indonesia. Yellow mosaic virus is a major problem in India, but as far as is known, no sources of resistance exist. Major attention should be given to production of virus-free seed. Entomological and pathological research is needed regarding vectors, micro-environments and rotations vis-à-vis transmission of the virus.

Numerous diseases caused by such organisms as Sclerotinia, Macrophomina, Diaporthe, Cercospora and others occur commonly as minor infestations, and occasionally are severe. The utilization of clean seed and exercising crop hygiene appear to be realistic approaches at present. Canopy re-design and reduction of excessive leaf area index may create conditions less suitable to disease build-up. Seedling diseases (Pythium, etc.) are thought to be a major cause of poor stands, particularly in low-input systems. Seed dressings with fungicides are effective, but these create difficulty with seed consumption as food and with nodulation where inoculation is necessary.

(2) Pests - A wide range and diversity of insect pests exists and varies with country, region and season. In most cases, these involve bean fly attack in seedlings, and sucking and chewing insects at the later stages. Sucking bugs and chewing insects appear worst in dry and wet periods, respectively.

Limited preliminary research on insect resistance has been done, e.g., on bean fly resistance of the Asian Vegetable Research and Development Center and in Thailand, and or Nezara viridula in Australia, but no clear resistances have been found. Intensification of research is vital in searching for genetic sources of resistance, and in collaborative work on biological control and integrated pest management.

No major nematode problems are reported but the possibility of root knot nematode problems arising exists in isolated cases.

Physiological factors

(1) Seasonal and regional adaptation - This consideration involves primarily interactions of phtoperiod, temperature, soil and moisture with the genotype. In general, a stable, photo- and temperature insensitive response is desired for most purposes, i.e., genotypes which are characterized by uniform vegetative growth and flowering initiation, and which possess similar and acceptable vegetative development prior to termination of flowering, regardless of planting date. It is recognized that such photoperiodic and temperature insensitivity may be difficult to attain, even at very low latitudes. Special problems exist in the sub-tropics when year-round soybean culture may require two or more different cultivar types suited for each season of planting. Photoperiodic sensitivity may be useful in scheduling crop development in such situations, and also where seasonal constraints require longer crop durations. It is considered that genetic solutions should allow

development of photoperiod insensitive lines of different cropping duration to suit various rotational demands. A detailed study of this entire area is recommended.

In general, broad environmental adaptation is desirable, particularly in terms of reducing the complexity of seed production, maintenance and distribution. It is considered that selection for such adaptation is possible and of high priority. However, local quality preferences must be taken into account as well.

(2) Flower and pod abortion - High flower and pod abortion occurs in soybeans at all yield levels; this behavior appears inate. Flower abortion may be relatively less severe in short-season cultivars which also reveal the highest harvest indices and leaf-stem ratios. Abortion is clearly an inefficient process physiologically, but it may serve useful homeostatic purposes. It is not considered to be a realistic breeding problem at the farm yield levels presently existing.

(3) Sink - source relationships and assimilation - These aspects have limited relevance as limitations at the present subsistence farm yield levels; other limitations are operative. However, improvements in yield potential and in farm yields under intensive management clearly require analysis of canopy shape, leaf size and leaf orientation in the lower latitudes. Therefore, detailed physiological investigations are warranted. Canopy structure may also have implications on disease build-up (see Pests and Diseases (1).

(4) Soil fertility - In general, most farmers make no fertilizer applications to soybeans. It is considered that selection conducted under such potentially mineral deficient conditions is ineffective. Breeding should be conducted under improved nutritional conditions in order to identify potential genetic differences; and rigorous testing for performance should occur subsequently under farm conditions. The breeding objectives for intensive management situations are clearly quite different.

Specific problems exist, e.g., Al toxicity, Mn toxicity and Zn deficiency and available genetic variation in response to such conditions should be investigated.

(5) Soil pH - Soybeans are grown in soils ranging from pH 4.5 to 6.0 in most Asian countries; their culture also extends into alkaline soils (pH 8.0 or higher) in Australia. Liming to correct acidity is not considered feasible in most areas. Performance testing under actual conditions is regarded as the only practical approach.

(6) Nodulation - In South-East Asia naturalized Rhizobium japonicum exists with attainment of nodulation, but the effectiveness of the symbiosis is unknown.

Virgin areas in Indonesia and Australia commonly require inoculation and offer the opportunity to introduce known, highly effective nitrogen fixing strains. In Thailand some success has been experienced in replacing naturalized Rhizobium with exotic strains. However, it is considered that the best general strategy is to breed for compatibility of the host genotype with the naturalized strain(s). Collaborative research with legume and soil microbiologists is necessary.

Product Quality

(1) Oil and protein percentage - It is noted that local demand for soybeans exists in the absence of knowledge of the oil or protein percentage.

Contrasting demands exist for processing purposes. For example, soybeans for oil extraction or export in Thailand are required to have high oil contents (greater than 19 - 20%), whereas high protein (greater than 41 - 42%) is required in Indonesia for production of soybean for direct human consumption and animal feed. It is recognized that local demand will continue to influence breeding strategies and choice of parents to attain these objectives. However, it is noted that wide segregation with respect to chemical composition can occur and considerable opportunity exists for exchange of superior segregations which may be undesirable locally but of advantage elsewhere. Large genotype-environmental interactions occur for chemical composition, but evidence exists that selection for relatively stable composition is possible.

(2) Anti-nutritional factors - Since soybeans are uniformly processed or cooked prior to consumption, the subject is considered to have only limited relevance at this stage (refer to PAG Report). However, basic research in these areas should not be discouraged.

(3) Chemical quality - At present, this has limited relevance for local consumption or, in general, for export purposes. Soybeans form part of a mixed diet for local consumption, so that the implications of amino acid composition must be considered in terms of total diets. Research is to be encouraged in these topics.

(4) Consumer preferences - Cultivar release should consider consumer preferences such as seed size, colour, flavor, etc. For edible purposes, cream colour and colourless hilum are usually desired, while black seeds

are used only for soy sauce manufacture. For oil extraction, some flexibility in hilum colour is allowed. A demand exists for small seed (9-10 g/100) for fermented products, and for medium seed (14-17 g/100) for ground products and export purposes. No particular demand exists for very large seeds (greater than 20 g/100). Breeders must therefore develop a diversity of sizes and allow for local and market demands. Attention to ease of cooking has not been an important breeding point in soybean.

Role of mutation induction

It is considered that adequate genetic variability exists for most characters in soybeans, and that it should be exploited by conventional breeding methods. Limitations of recombination appear to exist, and multiple crossing and recurrent selection schemes have relevance. Mutation breeding may have value for certain situations where restricted genetic variability is documented to exist or where access to it presents significant difficulties; for example in soybean rust resistance. Further, increase in recombination frequency can result from mutagenic treatment, and may provide a faster and less labor intensive solution in particular situations of close linkage.

B. Mungbean and Black Gram - Mungbean (Vigna radiata) black gram (Vigna mungo) are important crops in South-East and South-Asia. In South-East Asia they are normally grown in association with paddy rice or as monocrops under upland conditions. In the other countries of Asia the crops are generally grown in monoculture.

Farmers yields are characteristically low as a result of (1) generally poor management of the crop, especially under paddy conditions in South-East Asia where mungbeans are grown on residual moisture, and (2) the little attention given in the past to improvement of certain varietal characteristics that impose a low yield ceiling on the crop.

Cultivars of mungbeans presently in use are thought to be unfit for specialized cultivation practices; they have a tendency for leafiness and over-vegetative development, especially under wet and long-day growing conditions and are prone to lodging. Flowering and pod setting occur over a very wide period of time, resulting in uneven maturation which necessitates hand-harvesting. The pods shatter badly, especially during exceedingly dry conditions such as those obtaining in the paddy fields at crop maturity.

The natural enemies of mungbean are legion. Both pest and disease problems pose serious threats to production. Leaf diseases, soil-borne diseases and bean flies are serious problems in South-East Asia. The yellow mosaic virus which is insect transmitted is very serious in the Indian sub-continent and there is indication of its spread into South-East Asia.

Improving plant architecture

Improvement of the plant type can be made by modifying certain morphological structures that obviously relate to yielding ability. Over-vegetative development which predisposes the crop to loding can be minimized if the plant were to be made shorter in stature (50 - 60 cm). This could be through a reduction of internode length, preferably without necessarily reducing node number. Leaf size can be reduced and angle modified to allow for greater light penetration to lower canopy levels. Stems can, likewise, be made more rigid. There is sufficient genetic variability with which to achieve these objectives.

Pod length, seed number and seed size can definitely be improved. The question that needs to be answered is whether pod number per plant can be maintained under increasing plant densities. It is also thought that pod number per plant can be enhanced by increasing the number of nodes from the current range of 8 to 12.

Flowering and pod maturation should occur over a narrow period to allow for ease in harvesting.

The location of pods above the leaf canopy may add to the photosynthetic assimilation levels and certainly would offer ease in hand-harvesting. Resistance to pod shattering should definitely be a breeding objective.

There is every indication that such plant architecture can be achieved in V. radiata species as evidenced by an evaluation of available genetic resources. Some of these agronomic combinations have, in fact, been partly assembled into some of the emerging plant types observed in the new varieties developed in South-East Asia.

It is not certain if the desirable plant characters are available in the V. mungo species, but if not, they may be introduced to the species through hybridization with V. radiata. Alternatively or simultaneously a programme of inducing variability through radiation or other mutagens can be undertaken.

Improving disease and pest tolerance

Mungbean and black gram are generally considered to be relatively disease-free crops in Indochina and Eastern Asia, although several fungal diseases like Cercospora leafspot, powdery mildew, soil-borne diseases and virus disease

occur seasonally. However, in Burma and South Asian countries, yellow mosaic virus which is transmitted only by white fly is one of the major limiting factors for high yield due to its serious damage and persistence. Therefore, intensive research and breeding efforts are urgently needed in this area. Moreover, international cooperation is desperately needed to monitor and develop a warning system of the movement of this disease, especially towards Thailand, Indonesia and the Philippines which, at the moment, are still free of the disease.

Several genotypes have been identified as being tolerant to the yellow mosaic virus. These are MC-5, mung 24-2- and Pak 22. Seeds of these varieties are available in AVRDC and Pakistan.

With reference to the other diseases and pests, international cooperation is needed in identifying geographic races of major diseases and insects as well as the corresponding genetic sources resistance. Varieties that are resistant to Cercospora leaf spot and powdery mildew are available in AVRDC and the Philippines.

Improving physiological make-up

Essential information bearing on characters influencing yield is presently not available, although AVRDC, University of Missouri (USA) and several institutes in India have recognized this as a major problem area and have started to generate information results.

(a) Plant response to wide regimes of environmental factors such as photoperiod, temperature, moisture and soil fertility should be intensively studied along with the complex interactions of these factors. Mungbean is considered as a short-day plant; the photoperiodic responses being expressed not only in flowering but also in plant height. However, the majority of mungbeans are less sensitive to photoperiod and more universally sensitive to temperature. Black gram is generally sensitive to photoperiod, although there are varietal differences.

(b) Sink-source relations and assimilation. High economical yields will be achieved by the development of varieties which are more efficient in photosynthesis and specifically with a high harvest index. About 60% of the nitrogen remains in the non-grain parts of the plants at harvest. Therefore, this precious nutrient should be better utilized by more efficient translocation from vegetative parts to the seeds.

(c) Nodulation. Nodulation and nitroger fixation should be two of the most important study areas in these legumes, but have been surprisingly

little studied. The amount of nitrogen fixed by mungbean Rhizobial bacteria was reported to be much less than those of soybean and some other legumes.

Studies should be conducted on (1) varietal or racial differences with respect to both plant and bacterium, (2) the analysis of activity of nitrogen fixation throughout the life cycle of the plant, and (3) the effect of environmental factors on the amount and N fixation activity of the nodule bacteria.

(d) Flower and pod dropping is reported to be a serious problem under dry conditions and high temperatures. The causes of these undesirable phenomena

(e) The morphological selection criteria which are highly correlated with high yielding potential should be investigated and this information made available to breeders.

Recommendations

1. For mutation work in mung and black gram, the following characters merit attention:

   (a) Resistance to yellow mosaic virus. At the moment only some degree of tolerance is observed with the resistant lines.

   (b) Protein content. The range is from 20-28%. Elevation of protein content in combination with good yield is an important objective.

   (c) Dormancy. Seed germination in the pod is a problem which can be minimized with a period of short dormancy.

   (d) Leaf senescence. A better synchronized leaf development and drop would facilitate harvesting and threshing.

   (e) Upright growth habit in black gram.

   (f) Number of nodes. The range is 8-14 and there is indication that it can be increased. Pod number per plant will increase concomittantly.

   (g) Nodulation activity. Inducing mutations in Rhizobium bacteria might produce more active and better adapted strains.

2. The breeders should have greater contact and more frequent exchanges of genetic materials should be undertaken.

3. Information on the spread of diseases, especially of the yellow mosaic virus, should be available; this would include the development of a monitoring system. Genetic sources of resistance to important pests and diseases

should be verified in the countries of the region through collaborative efforts among plant breeders, plant pathologists and entomologists of the countries.

4. More studies on the components of plant morphology and physiology as they relate to increased yield potential should be undertaken.

5. A programme of testing the performance of elite lines of mung and black gram of the different countries' breeding and mutation programmes should be undertaken.

C. Pigeon Pea - Among grain legumes, pigeon pea (Cajanus cajan L. Millsp.) ranks sixth in total world production (1.7 million metric tons) and is surpassed only by chickpea (FAO Production Year Book 1972) of the crops discussed at this seminar.

In the South-East Asian region, it is a major grain legume crop in Bangladesh, Burma, India and Sri Lanka. It is a crop suited to the dry areas of the tropics as it is able to withstand prolonged periods of drought by exploiting residual soil moisture because of its deep root system. It is susceptible to water logging. It adapts itself well to a wide range of soil conditions - from light red soils to heavy clay soils, and in alkaline (to pH 8) to acid soils (to pH 5).

Plant architecture

Probably, pigeon pea has the lowest harvest index among grain legumes. It has a smaller leaf area facilitating better interception of sunlight by leaves at the bottom of the canopy. Thus, it would appear that a reduction in the number of leaves leading to an optimum leaf area index would be a logical step in improving canopy structure.

For intensive monoculture of the crop, and thereby to increase yield per unit area, a botanically determinate short duration plant (plan 110 days from emergence to maturity) and also that has a short flowering to maturity duration is considered desirable. Other characteristics are for possible alteration including greater number of nodes, few primary and secondary branches, and clustered arrangement of pods. Cultivars with few primary branches are known to exist and under close spacing even these are known to be suppressed. Such a plant type would enable the establishment of denser plant populations, facilitate harvesting and limit the duration of pest control operations, especially insecticidal applications for pod borer control.

However, a possible limitation of having pods in clusters is that it is likely to increase the incidence of pod borers which are serious pests on pigeon pea. Also, the above ideotype will not be suitable for mixed cropping systems.

Physiological aspects

Early maturity and photoperiod insensitivity are known to be correlated. Selection for early maturity therefore will lead to isolation of insensitive cultivars.

Studies on the response of pigeon pea to fertilizer has to be combined with studies in the efficiency of different rhizobial strains and response to trace elements. Generally, the response to nitrogen and potassium has been found to be negligible whereas a positive response to phosphate application has been shown. Pigeon pea exhibits a high degree of susceptibility to zinc deficiency and there seems to be little difference among varieties in this respect.

The relative and combined effects of applied and biologically fixed nitrogen in increasing production have to be determined. Assessment of symbiotic nitrogen fixation under different conditions, particularly soil conditions, is indeed a prime requisite.

The slow growth of the crop during the initial stages of growth is marked in pigeon pea, and this is associated with the vulnerability of the crop to competition from weeds during the early stages of growth. The development of cultivars with early seedling vigor and growth would be important.

Only by improving the genetic potentiality for photosynthesis along with altered architecture can we achieve better production under improved management practices (fertilizer application, plant spacing, etc.).

To increase "economic sink" capacity, it is important that we increase the number of pods (also indirectly by minimizing 'pod drops'), increase the number of seeds per pod and breed for larger seed size (within the limits of consumer acceptability).

A higher shelling recovery is another factor to be improved.

Clear-cut leaf senescence at the time of maturity which is markedly absent in pigeon pea, is another physiological trait to be sought.

Pigeon pea, as in the case of other legumes, is deficient in the sulphur containing amino acids cystine, methionine as well as tryptophan. Methionine and tryptophan contents have been found to differ among varieties. While it may be possible to improve protein quality by agronomic practices (such

as by sulphur application), the improvement of the amino acid profile would be a realistic breeding objective with suitable parent material and rapid screening techniques.

Pests

Only pests considered to be of major economic consequence are discussed, particularly to highlight the need for research on them.

Pod boring insects are known to devastate pigeon pea and are the most severe constraint on production. Several pod borers infest pigeon pea. The more important of these are Heliothis (Helicoverpa) armigera and Maruca testulalis. The tur pod fly Malanagromyza obtusa probably ranks next in importance.

The most serious disease is Fusarium wilt.

While it appears that some sources of resistance to Fusarium wilt are available, genetic resistance to pod borers present a dismal picture. Sources of resistance are yet to be identified, the wide array of insects involved and the mode of infestation complicating the issue.

It is strongly suggested that studies on the nature of resistance be undertaken with the hope that it would provide some avenues of strategy for genetically controlling this pest. The use of induced mutants as a source of resistance to pod borers is a possibility.

D. Chickpeas - The cropping season in the Indian sub-continent for chickpeas varies from 90-160 days. In the main chickpea producing belt of North India and Pakistan, the season is long (planting October/November, harvesting March/April). The crop is grown on residual moisture and the months December and January have cold nights with occasional frosts.

The following considerations should be taken into account in formulating breeding objectives.

Architecture

1. Plant habit - The plant habit of the present day cultivars is bushy and there is excessive vegetative growth (low harvest index). Farmers sometimes reduce this growth by grazing animals on the plants prior to flowering. The crop tends to lodge and the canopy restricts light penetration; this encourages blight or Botrytis grey mold, if late rains occur.

An improved plant architecture would mitigate yield losses caused by lodging, lack of canopy aeration and diseases. We recommend (a) plants with

a compact habit, having a few major branches emerging from the lower nodes, or (b) an umbelliferous type plant habit.

Plant habits of this nature are available in the ICRISAT germ plasm collection. Recommended type (a) ICRISAT Nos. 6260, 7721, 7722, 6262, 6263 ex-Russia, and (b) ICRISAT No. 7716 ex-Greece. These cultivars are 'kabuli' type and we recommend them for incorporation into national breeding programmes, possibly by using a locally adapted cultivar as the recurrent parent of a backcross.

2. Distribution of pods - The ideal plant is surmised as having a maximum number of pod-bearing nodes with short internode lengths. The relationship between number of pods per peduncle and yield is still controversial. Before we can define specific breeding recommendations, these correlations should be ascertained.

3. Seed size - The literature suggests a parabolic relationship between seed yield and seed size, i.e., seed size increased yield to a certain size and thereafter decreases the yield. The inverse relationship should be broken either by cultivar hybridization or mutation breeding.

4. Consumer preference - Breeding programmes should be oriented to producing light coloured seeds with good cooking quality.

Diseases

1. Wilt - A number of pathogens such as fungi (species of Fusarium, Rhizoctonia, Operculella, Sclerotium and Sclerotinia) and viruses may be responsible for wilt. The relative importance of one or more of these pathogens may vary according to the region where the crop is grown.

Specific cultivar resistance have not yet been fully identified due to the inadequacy of proper screening techniques but probable sources of resistance have been reported from Pakistan, Mexico, Iran, India and cultivars within the ICRISAT germ plasm bank.

2. Ascochyta blight - This disease is sporadic but can be devastating. No known specific resistances have so far been identified, though tolerance has been reported in certain cases.

We recommend that the entire ICRISAT germ plasm (about 10,000 lines) be screened for resistances, as a priority. Crosses between tolerant lines to build up polygenic resistance and/or inducing resistance by mutation are recommended.

3. Other diseases - Rust, Botrytis grey mold and viruses do not pose a serious problem at present, but may do so eventually in certain areas. Sources of resistance should therefore be recorded.

Pests

The main pest of chickpeas on a world basis is Helicoverpa (Heliothis) armigera. It attacks many crops and it is difficult to make recommendations for this ubiquitous insect. Spraying regimes for control are available.

Physiological

Very few physiological studies on the chickpea plant have been carried out and we recommend that systematic investigations be initiated. In particular, we feel that the following points to be worthy of note:

(1) Local adaptabilities appear to be important in chickpeas, as are differences between 'kabuli' and 'desi' types and cultivars adapted to winter plantings in South-East Asia and summer plantings in West Africa. Cultivars with wide-spectrum adaptation should be sought by the ICRISAT chickpea breeding programme for incorporation into locally adapted germ plasm.

(2) Nodulation is an important aspect of chickpea physiology requiring close attention. Breeding programmes should be carried out under conditions where nitrogen is not applied so that cultivars having the ability to nodulate well can be selected.

E. Lentils - Lentil is grown as a major crop in Bangladesh and Pakistan and as a minor crop in India, Australia, and some other countries. The production covers an area of well over 2 million hectares with a total yield of over one million metric tons. Improvement in production of this crop is necessary since a large number of people of this region obtain a sizeable amount of their daily protein needs from this crop.

The crop at present produces low yields per hectares and appropriate methods of breeding and production practices should be formulated to improve the production figure. To achieve this end, a broad line of approach involving the following factors may be considered.

(a) Change of plant architecture. The lentil plant under dry and normal conditions (residual moisture) grows about 45 cm tall and possesses 2-3 primary and 4-5 secondary branches. Variants with more primary and secondary branches with commensurate increase in the number of pods may be selected so that harvest index is improved. The canopy

size of the plant may be changed through induced mutations. Since residual moisture is used in growing this crop under the existing cropping pattern, attempts should also be made to breed for varieties with root systems having increased depth and extent.

(b) Diseases and pests. Fortunately, not too many diseases are encountered in this crop. Under high soil temperature and moisture conditions, Fusarium wilt may pose a threat on certain occasions. Breeding efforts may be directed towards incorporating or inducing resistance to this disease in lentils.

(c) Physiological factors. Nodule formation in the lentil roots is less prevalent in areas exposed to prolonged and heavy showers and canal irrigation. But moderate nodule formation occurs in other areas. Endeavours to breed varieties with capacity to form more nodules under varied soil and climatic conditions should be undertaken.

Water stress, both on the excess and deficient side take a heavy toll on lentil yields. Varieties with decreased sensitivity to such conditions should be bred.

The nutritional response of this crop has not been studied thoroughtly. The scanty results indicate that it does not respond to fertilization. This is perhaps due to selection by farmers during the long time past for suitability for growth of lentils under low-input conditions. Under such a situation, the genetic variability to adapt to improved agronomic practices is unlikely to be present. Responses to both macro- and micro-elements in available germ plasm and in induced mutations should be studied.

The quality of the seed in terms of protein percentage and amino acid content of the protein should be given consideration by the plant breeder. High protein content in the seed with commensurate increase in sulphur-containing amino acids is an objective for quality improvement.

The seed setting pattern in lentils seems to be one of the important causes of low yields. Some pods are empty and some flowers do not culminate in pod formation. Breeding efforts should also be directed to improve upon this situation.

F. Cowpeas - Cowpea is grown for several purposes, namely fodder, green manure, green vegetable and finally grain production. Each of these uses poses different questions for breeding. However, in concentrating on pulse production, several avenues of breeding could be fruitful and are outlined below.

Plant architecture - physiological attributes

Amongst yield components, the number of pods per plant is most variable and most consistently correlated to grain yield. Breeding for high pod number per plant at high plant density should result in increased grain yields. The average seed size is a highly heritable character and selection for bold seeds can also be made a breeding objective. However, other seed characters like colour and testa thickness will probably be influenced by local taste preferences.

Cowpea development is profoundly influenced by photoperiod. Photo-insensitivity genes are recessive to photosensitivity genes; the former is a highly desirable character. Early flowering with an extended period of pod ripening is also an important developmental character since the period of pod ripening is critical to the realization of high yields.

The extend of vegetative growth is extremely variable and main stem height may vary by 200% depending on moisture availability and the nitrogen status. In some cases, excessive vegetative development appears to preclude high grain yields. The use of a strictly determinate growth habit with an inflorescence at the apex of the main stem combined with high planting densities and photo-insensitivity may overcome this problem of inconsistency in vegetative growth in the lowland tropics and sub-tropics. Harvest index is also a useful character in this regard. Long peduncles and even pod ripening are both characters important for mechanical harvesting.

The above inconsistency in vegetative growth because of large genotype x environment interactions leads to inconsistent grain yields and it is vital to test cowpea genotypes at several locations and years to select for relative stability of yield. The use of wide genetic diversity of cultivars could be important in this respect.

In addition to the above, tolerance to Mo and Mn deficiency and moisture stress in Sri Lanka, and tolerance to low temperatures in the highlands of Papua New Guinea and Sri Lanka are also important.

Diseases and pests

There is a range of resistance to most cowpea diseases, e.g., anthracnese (Colletotrichum lindemuthianum), bacterial pustule (Xanthomonas sp.), Cercospora leaf spot (C. cruenta and C. canescens), rust (Uromyces vignae) and cowpea mosaic virus. Resistances to many of the above diseases have been isolated at I.I.T.A., Ibadan, Nigeria. Little leaf virus caused by Mycoplasma in Papua New Guinea and mosaic virus in Sri Lanka have been recorded but are of little importance at present.

Amongst cowpea pests tolerance to Melanagromyza phaseoli is found. But resistance to Maruca testulalis and the myriad of other flower and pod feeders has not yet been discovered. Although the infestation of seeds in storage by Bruchidae can be controlled by using seed with thick testa, consumer preferences may require thin testas. Resistance to Aphis caccivora is also important in Papua New Guinea.

Nutrition

The percentage protein in seed varies from 19-26% but seeds with a protein content of up to 35% have been recorded emphasizing that the variation necessary for the selection of high protein levels is available. Similarly high methionine and cysteine, the limiting amino acids in cowpea, were found in the wild subsp. dekindtiana. Selection for increased nodulation may lead to cultivars with higher levels of nitrogen in the seed, but care must be taken to avoid Rhizobium x genotype interactions which may give misleading results in screening.

Mutation

All variation necessary for the above improvements in plant type are already present amongst the germ plasm currently held at the International Institute of Tropical Agriculture, Ibadan, Nigeria, the United States Department of Agriculture, U.S.D.A., and the Indian Grassland and Fodder Research Institute, Jhansi, U.P., India. Mutation breeding has therefore little role to play in the cowpea improvement at present.

G. Winged bean - Winged bean (Psophocerpus tetragonolobus [L.] DC.) is a back yard crop for horticultural purposes throughout South-East Asia. In Papua New Guinea it enjoys the status of field crop but is grown mainly for domestic consumption within the framework of subsistence agriculture.

It is only recently that the potential of winged bean as a grain crop has been recognized. However, as its root tuber, young leaves, flowers, green pods and immature seed all are important source of protein and are edible, it is desirable to encourage its production in all forms. This, however, creates the problem of conflicting objectives and necessitates either striking a right balance or resorting to the breeding of varieties suitable for a special purpose. At this stage, it is important to delineate breeding objectives into two: -

(a) breeding for existing system of agriculture,

(b) breeding for future.

(a) Breeding for existing system

Within the existing system, winged bean will need to be bred mainly as a vegetable and tuber crop with small amount of seed production for planting needs and for snack purposes. The breeding objectives would thus be as follows:

1. Architectural problems: Relatively even and early maturity requiring 100 - 120 days, increased harvest index, intermediate leaf size, tender leaves, long and fleshy pods, greater number of pods per plant, bold seeds, intermediate tuber size and greater number of tubers, smooth pod surface, rectangular pod.
2. Diseases and pests: Resistance/tolerance to root knot nematode (Meloidogyne incognita), resistance to Cercospera psophocarpii and Uromyces spp. in humid lowlands and tolerance to Maruca testulalis, leaf minor (unidentified) and Aphis caccivora.
3. Physiological: Insensitivity to day length, greater tolerance to cooler temperatures, better seedling vigor, tolerance to water stress with respect to tuber production, greater nodulation.
4. Others: High protein content in all edible plant parts, improved cooking quality of tubers and seeds and high oil content in seed.

(b) Breeding for future

In view of the nutritional significance of this crop, it is important to commence breeding programmes which will enable this species to compete with other legume and tuber crops within the framework of intermediate and higher levels of technology. This will require complete restructuring of this plant to suit the special needs of tuber and seed production separately. A restructured horticultural winged bean should also be an objective. Mutation breeding should be used to evolve a determinate erect mutant and to enrich the germ plasm.

Seed type winged bean of future

(1) Plant architecture: Erect and determinate growth habit, greater number of nodes, 100 - 120 days maturity, high harvest index, higher shelling percentage, non shattering, greater pod retention and greater number of pods per plant, flat pod and absence of tuberous roots, small leaf size with optimum leaf area index and large seed.

(2) Disease and pests: as in a(2).

(3) Physiological: Insensitivity to day length, greater tolerance to cooler temperatures, better seedling vigor and greater nodulation.

(4) Others: High protein content in pods, and preferably in leaves and flowers, pod colour according to consumers' choice.

H. Rice bean - Rice bean (Phaseolus calceratus) is an important crop in the Philippines and has potential value for the rest of South-East Asia in view of its high nutritional value. Less than 100 cultivars of rice bean are known to occur and this may pose a major constraint on this very useful species. All known varieties are of indeterminate, viny growth habit. The following breeding objectives can be formulated with the little existing knowledge available on this species.

(1) Plant architecture: Determinate erect growth habit, greater harvest index, smaller leaves, greater node number, larger and more numerous pods and greater seed size.

(2) Disease and pests: Currently little problem.

(3) Physiological: Insensitivity to photoperiod and greater nodulation.

(4) Mutation breeding should be used to evolve determinate types and enrich the limited amount of germ plasm availabe at present.

I. Peanut

Introduction - Peanut is one of the important grain legumes of the South-East Asia region occupying nearly 12 million hectares (20% of the total area under grain legumes) and producing about 8 million tons in shell compared to about 35 million tons of total grain legume production in this part of the world. The produce of peanut is used mainly as a source of edible oil, unlike other legumes that are used for direct consumption in the daily diet. Therefore, this crop is grouped under oilseeds, unlike the other grain legumes which are known as pulses. It is cultivated primarily as monoculture and occasionally intercropped with Cajanus, cotton, sugarcane, maize, etc. and is grown in two seasons, viz, June-July to October-November and January-February to April-May (duration 110 - 150 days).

Being a legume, its kernels have 25% - 30% protein. Decoiled 'cake' is very rich in protein (55-60%) whose biological value is about 65%. Therefore, it is used in the nutritious foods like biscuits, candies and beverages. The conarachin fraction of this protein is reported to be excellent for body growth and hence, the peanut flour is generally used in industrially manufactured baby foods, especially in India. According to some reports, the protein fraction has anti-haemorrhagic properties. In

addition, the peanut kernels are directly used in the preparation of peanut butter, curries, roasted nuts, etc., indicating the popularity of kernels as an item of food.

Objectives:

Although it is one of the important crops of this region, the per hectare yield is very low (on farmers fields 500 to 800 kg) compared to that obtained in the USA (1600 kg/ha). This low yield may be attributed to the cultivation in the areas of marginal productivity, lack of application of agricultural inputs, and inadequate cultural practices. Most of the present varieties have been in cultivation for decades and replacing them by improved varieties is handicapped due to the large quantity of seed required (100 kg/ha). Besides, the seed multiplication index in this crop is very low (approximately 10 times) compared to all other crops. As a result, effective distribution of improved cultivars becomes more difficult. Consumer preference is for medium and large kernels.

The spread of the crop to the areas of marginal productivity has necessitated breeding for varieties which should be high yielding under moisture stress conditions. Changing plant architecture may be one of the ways of overcoming this problem. In this connection, information on the root system and its contribution to the development of vegetative and reproductive systems of the plant should be obtained.

Remunerative price for peanut produce in recent years has brightened the prospect of its cultivation in the irrigated areas of the region. In fact, most of the cultivation during January - February to April - May is concentrated in the irrigated tracts. It is clear from the yields obtained at the research stations that the present varieties are capable of producing up to 3.5 tons/ha. In the absence of remunerative prices, the yield of 3.5 tons would not be comparable to those obtained in high yielding cereals. Varieties responding to higher agronomic inputs have to be evolved in order to make peanuts economically competitive.

Among the grain legumes, peanut (and Voandzeia) is characterized by aerial flowering and subterranean fruiting. Yield performance of plants in experiments is, therefore, unpredictable until maturity. Characterization of yield components and their relative contributions to the commercial yield is essential. Appropriate information in this area would help in screening the experimental material at early stages of plant growth.

Grain legumes generally have abundant vegetative growth leading to a low harvest index. Improvement of the harvest index resulting in higher productivity should be one of the aims of plant breeding. However, caution is needed when the vegetative parts are utilized as cattle feed.

Lack of genetic markers and the low number of successful crosses due to the peculiar floral morphology (stigma completely covered by the tubular keel petal) have also contributed to the slow rate of genetic improvement. Recent reports have identified at least two useful markers (a dominant krinkle leaf and a foliaceous stipule mutant) and an improved crossing technique.

Plant architecture:

The growth habit of branches in peanut varies from erect to trailing. Considering the agronomic requirements two types of plant postures viz., bunch habit and spreading habit, could be recognized in the cultivars. These groups are comparable to those with determinate and indeterminate habit respectively of other grain legumes. These groups are reported to differ in such important characters as number of branches, maturity period, seed dormancy, drought tolerance, etc. However, no special advantage in respect to yield potency is reported.

According to the distribution of cultivars, spreading varieties are being replaced by the bunch types excepting in some problem areas. This suggested the popularity of bunch types which are easy to harvest.

Information about the canopy size and its effect on the yield potential is not available in this crop. Induced mutations for changed canopy are available for studies.

The availability of variation in the induced mutations for characters such as plant height and numbers of branches are still to be evaluated and utilized in breeding programmes to develop the requisite canopy. In this respect, plant density studies are vital. However, there may be some limitations because of the large quantities of seed necessary for sowing purposes.

Number of seeds per pod is apparently one of the important yield components. Yet in peanuts an increased number of seeds per pod has not contributed to the improvement in pod yield. Genetic studies combined with anatomical aspects should be initiated to understand the utility of this character.

Diseases and pests:

From the discussions and reports of this meeting, it is clear that the diseases and pests are generally common in all the South-East Asian countries. The following are given in order of priority with regard to peanut:

Diseases:
1. Cercospora leaf spot
2. Phytopthera and Sclerotial rot (collar rot and root rot)
3. Virus 'bud rot'
4. Bacterial rust

Pests:
1. Aphids
2. Hairy caterpillars
3. Jassids
4. White grubs
5. Leaf rollers
6. Mites.

In addition, there are other pests such as crows (damaging germinating seeds), field rats and jackals (damaging matured pods).

Wild species of Arachis (2 n = 40) are resistant to several main diseases and pests. However, transfer of this resistance has not been successful probably due to the sterility barrier. An intensive mutation breeding programme in this connection may be useful along the lines used in wheat and barley.

Application of pesticides and fungicides to protect crops is commonly advocated in the high production technology. Since many of these pesticides are fat-soluble, there is a danger of their accumulation in the edible oil of peanut and pose a health problem. Therefore, top priority should be given to breeding for resistance in this crop.

Physiological studies:

This is one of the neglected fields and information on the physiological aspects of important characters is lacking. Casual observations without proper experimental data would not be helpful to the breeder. Therefore, a systematic programme of work should be encouraged on the following subjects.

1. Photo- and thermal sensitivity
2. Nodulation and its contribution to pod yield
3. Water stress in relation to root development and pod production
4. Response in yield to added micro- and macro-elements based on the soil types
5. Photosynthetic efficiency and contribution of it to commercial yield

6. Synthesis and composition of fatty acids and proteins - this is related to the quality aspects of the kernel.

Spoilage of peanuts and its products is often related to the infection by Aspergillus fungi capable of producing a carcinogenic subsistance known as aflatoxin. This problem is not restricted to peanut, but also applies in other foods and food grains. The saprophytic nature of this organism suggests that it is a post harvest problem. Therefore, proper post-harvest handling technology should be developed to minimize such losses.

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