Trends in support for research and development of cool season food legumes in the developing countries[1]

C.L.L. Gowda[1], M. Ali[2], W. Erskine[3], H. Halila[4], C. Johansen[1], I. Kusmenoglu[5], S.A. Mahmoud[6], B.A. Malik[7], M. Meskine[8], M.M. Rahman[9], R.P.Sapkota[10], and X. X. Zong[11]

1 ICRISAT, Patancheru, A P 502324 , India; 2 Indian Inst of Pulses Research, Kalyanpur, Kanpur 208024, Uttar Pradesh, India; 3 ICARDA, PO Box 5466, Aleppo, Syria; 4 Food Legumes Laboratory, INRAT, Avenue Hedi Karray, 2049 Ariana Tunisia. ; 5 Central Res Inst Field Crops, PO Box 226, Ulus, Ankara, Turkey; 6 Agriculture Research Centre Field Crops Research Institute Giza, Egypt; 7 NARC, PO Box NARC, Islamabad, 45500, Pakistan; 8 INRA/CRRA, Meknes B.P. 578 Morocco; 9 Pulses Research Centre, BARI, Joydebpur, Bangladesh; 10 Nepal Agricultural Research Council, Khumaltar, Lalitpur, P.O. Box No.5459, Nepal; 11 Institute of Crop Germplasm Resources, 30 Bai Shi Qiao Road,Beijing 100081, PR China

Abstract

In addition to their role in human nutrition, food legumes are an integral part of farming systems world wide. Their role in diversifying cropping systems and in maintaining soil fertility to sustain agricultural production is being realized increasingly among scientists and policy makers in most developing countries. Current (1996) world production is around 57 million tonnes. The population in developing countries is expected to be 6.06 billion by 2010, and the demand for food legumes is expected to be around 110.65 million tonnes. This poses a challenge to scientists and policy makers to meet this demand. The growth trends during 1990-94 for area, production, and productivity globally were negative, with few exceptions. Many countries in Asia need to increase production by at least 50% by 2010, and double it by 2020, to meet the needs of the growing population.

The current research and development (R&D) thrusts, in developing countries, are geared towards increased production, but with varied success. An increased reliance on plant breeding and extensive cultivation of legumes in marginal areas has lead to over-exploitation of the limited genetic resources (breeding for adaptation to harsh conditions thus losing genes for high yield). Some national governments (eg Turkey and India) have programs to increase production. The early successes have plateaued, and shifts in direction are needed.

Research infrastructure, staff, and funding for agricultural research are inadequate in most developing countries. Compared to 3.29% of agricultural gross domestic product (GDP) invested in R&D by the developed countries, the developing countries were spending on average only 0.39% in the late 1980s. This has declined further in the 1990s. The major proportion (50 to 75%) of the R&D funds in the developing countries is allocated to staple cereals, and only a small portion of the remaining budget is available for legumes. Although there are specialized research institutes or programs for major cereals, food legumes are lumped together and hence research efforts are scattered and superficial when compared with cereals.

The following strategies are suggested to strengthen support for food legume research.

Integrated cropping systems management (variety + agronomic practices + crop rotations) to bridge the yield gap in different agroclimatic conditions.

Initiate strategic research to breach yield ceilings, and to develop cultivars that can produce high and stable yields in better-endowed environments and thus compete with cereals.

Strengthen research collaboration within and among national programs and with the international agricultural research centers.

Increased role of regional, networks and working groups to enhance technical co-operation among developing countries (TCDC).

Increase the collaboration between public and private sectors and exploit their comparative advantages to achieve mutual goals.

Create Food Legume Councils (that include farmers, traders, and exporters) which support R&D by levying taxes or cesses on commodities and value-added products.

R. Knight (ed.), Linking Research and Marketing Opportunities for Pulses in the 21st Century, 47–58.

INTRODUCTION

Food legumes (pulses) play a role in human nutrition and more recently as animal feed, in the developing world. They contain minerals and vitamins essential for a balanced diet in humans. In many developing countries food legumes provide the necessary protein and amino acids (in predominantly vegetarian India, Bangladesh, Nepal, Myanmar and Sri Lanka) and supplement the protein diet of people in other countries. Since 1980-82 per capita consumption has declined by 6 % in developing countries where relative pulse prices have gone up and consumption of animal protein (eg milk) has increased. The importance of legumes as animal feed is increasing. The compound growth rate for feed use during 1980-95 was 7.97% compared to 1.5% growth for food use during the same period (Kelly et al., 1997). As an integral part of farming systems, food legumes, in rotation with cereals and tuber crops, assist in maintaining soil fertility and the sustainability of production systems (Rego et al., 1996). Owing to higher prices in comparison with cereals, food legumes are increasingly being grown to supplement farmers' incomes. The major food legumes grown in developing countries are: dry bean *(Phaseolus vulgaris)*, faba bean *(Vicia faba)*, dry pea *(Pisum sativum)*, chickpea *(Cicer arietinum)*, lentil *(Lens culinaris)*, mung bean *(Vigna radiata)*, black gram (Vigna mungo) pigeonpea *(Cajanus cajan)* and Lathyrus (*Lathyrus sativus)*. Oil crops such as groundnut (*Arachis hypogaea*) and soybean (*Glycine max*) are food legumes but are not discussed in this paper. The terms food legume and pulse are used synonymously in this paper.

Cool season food legumes (faba bean, chickpea, lentil, and pea) contribute almost 60% of total world pulse production and 40% of the area (Oram and Agcaoili, 1994). Chickpea and lentil are produced predominantly in developing countries and dry peas in developed countries, while faba bean production is more evenly distributed. Overall yields in developing countries are only about half of those of developed countries (Oram and Agcaoili, 1994).

The world's population in 1994 was around 5.5 billion. It is expected to double by the year 2050. Most of this growth is expected to occur in developing countries in Asia, Africa, and Latin America (Swaminathan, 1995). This implies that food legume production needs to doubled or triple to meet the needs of the human population alone, not accounting for the demand for animal feed. The need to meet nutritional requirements (protein, amino acid, vitamins, minerals, etc) will be much greater in countries where people are likely to suffer deficiencies from predominantly cereal-based diets (James, 1997). The population in developing countries is 4.6 billion in 1997, and is estimated to be 6.06 billion in 2010 (assuming an average 2% growth rate). Current (1996) production of food legumes is around 57 million tonnes. Per capita consumption at a moderate rate of 50 g per day (18 kg per annum) will need at least 110.65 million t by 2010. This is the challenge facing food legume scientists, policy makers, and national governments and requires a meticulously planned approach. This calls for an R & D strategy developed by scientists, supportive funding support from research administrators and the political will of governments.

GROWTH TRENDS AND PROJECTIONS FOR FOOD LEGUMES

During the period (1990-'94) global growth rates for area, production and yield for the pulses under review were negative, although chickpea showed a marginal growth, and lentil recorded a 2 to 3% growth. Africa had highly negative growth rates for area and production, although yields showed positive trends for all crops, except chickpea. In Asian, positive growth trends were observed for area and production, but were negative for yield. Growth trends of selected countries in Asia and Africa are given in Table 1.

In Asia, growth rates for area are positive for all countries except Nepal, while production has shown negative trends in China, Nepal, and Pakistan. Yield growth rates were positive only in Bangladesh and India. Egypt, Morocco, Tunisia, and Turkey recorded negative growth rates for both area and production, with the exception of Tunisia that showed positive production growth. However, growth rates for yield are positive for all countries, except Morocco.

Current and projected demands for pulses in selected countries in Asia and Africa are given in Table 1. In many countries, production has to be increased by about 50% by year 2010 and to double by the year 2020 to meet the projected demands. Based on available data, it is expected Nepal and Myanmar will have surpluses and the remaining countries deficits.

Table 1. Current and projected demand (million tonnes) and growth rates (1990-94) for all food legumes in selected developing countries of Asia and Africa[1]

Country	Demand		Growth rates (1990-94) (%)		
	Current	Projected (Year)	Area	Production	Yield
Bangladesh	0.56	0.70 (2010)	0.50	0.66	0.16
China	8.00	15.00 (2020)	0.84	-2.84	-3.64
India	18.00	25.90 (2010)	0.36	1.76	1.62
Myanmar	NA[2]	NA	27.46	22.92	-3.58
Nepal	0.19	0.33 (2010)	-1.46	-1.54	-0.20
Pakistan	0.87	1.21 (2010)	0.64	-7.02	-7.64
Egypt	0.54	0.68 (2010)	-2.74	-15.92	8.82
Morocco	0.27	0.52 (2000)	-11.92	-12.94	-0.96
Tunisia	0.05	0.07 (2000)	-7.10	1.36	9.00
Turkey	1.95	3.00 (2010)	-4.76	-4.52	0.28

1 Sources : FAO Year Books (1990-94) for area, production and yield. Current and projected demands estimated / supplied by co-authors. 2 Data not available.

CURRENT RESEARCH IN FOOD LEGUMES

Current research in food legumes in most developing countries is geared towards increasing production to meet domestic demand and/or export. Activities include a) developing high yielding varieties with resistance to diseases and pests, and b) agronomic practices to increase productivity. Because of the demand, food legumes are being grown in marginal lands as better lands are devoted to high yielding stable and remunerative crops such as cereals. This has necessitated breeding for tolerance to poor soil fertility, drought, and salinity. In some areas there is a build-up of pests and diseases due to crop intensification. For example, intensification of chickpea and lentil cultivation in some areas in Turkey has resulted in epidemics of soil-borne and leaf diseases, mostly *Ascochyta* blight. This has necessitated breeding for resistance and for research on integrated pest management. Delayed or early sowing, to fit into cropping systems, has lead to the breeding of varieties adapted to the changed sowing dates, and for early maturing varieties. All these activities were more of 'fire-fighting' efforts to meet immediate needs. Few countries have invested in long-term improvement programs to improve yields and the stability of production.

Realising the need to maintain soil fertility and the sustainability of agricultural production, natural resource management research should receive priority in many countries. Now both agronomic management and varietal improvement are receiving equal emphasis in many developing countries.

SPECIAL PROGRAMS AND POLICIES TO INCREASE LEGUME PRODUCTION

Faced with deficits in the supply of pulses, many countries (especially in Asia) resorted to imports to meet demand in the 1980's. Some countries such as Turkey and Australia have increased their production for export. In Turkey, for example, the production of chickpea and lentil was increased by expanding to marginal areas, utilizing fallow lands, and including legumes in cereal-cereal rotations. The government also provided policy incentives to increase production and exports. As a result the chickpea and lentil area increased from 3% of the total cropped area in late 1970 to 11% in late 1980s (Anonymous, 1990). On the other hand, importing countries initiated 'Special Programs' to increase production. For example, the Indian National Agricultural Research Systems (NARS) initiated the 'Technology Mission on Pulses' in 1991 to co-ordinate the efforts of different agencies and boost production of chickpea, lentil, pigeonpea, mungbean, and black gram. Various 'Micro-missions' operate under the "Technology Mission" to deal with crop production; post-harvest technology; input and resource support to farmers; and price support, storage, processing, and marketing. The mission has been reasonably successful, and has been extended to the 9th five-year plan period. The Crop Diversification Program (funded by Canadian and Dutch projects) in Bangladesh (1990-'95) was aimed at increasing the production of some non-rice crops to increase food supplies. A project to increase production of chickpea and other pulses funded by the Pakistan government during 1994-96 has been highly successful. Chickpea production increased from 0.41 million t in 1993-94, to 0.68 million t in 1995-96. Because of this increased production, there have been no imports of *desi* chickpea during 1995-96. The project has been extended to cover other legumes in the 9[th] five-year plan. If the developing countries have to meet the projected demands for food legumes by the year 2010, such special programs are essential to accelerate production.

RESEARCH INFRASTRUCTURE, INSTITUTES, STAFF, FUNDING

After the 'Green Revolution' of the 1960s and 1970s, there was concern among the national programs of many developing countries regarding the need for diversification from cereal mono-cultures. Many national programs initiated crop improvement programs on food legumes in the late 70s and early 80s. New institutes, divisions, or projects were started. Multi-disciplinary teams were either appointed or identified however, funding of R & D has been meagre (Table 2). Investment by developed (high-income) countries showed continued growth, with an average 3.29% of agricultural gross domestic product (GDP) invested in R&D by the late 1990s, with Japan reporting 3.36% in 1992, and Australia 3.54%. However, corresponding figures for developing (low-income) countries was approximately 0.39%. Agricultural research expenditures relative to total government funding have declined over time. Latest available figures of government funding in low-income Asian countries (Bangladesh, China, India, Pakistan) range from 0.25 to 0.52% (Pardey et al., 1997). Current actual funding in selected countries, along with the number of institutions and staff working on food legumes research is given in Table 3. Compared to the total human resources in each country, resources allocated to food legumes are small. The proportion of full time researchers on legumes in China is 0.3%, in Bangladesh 1.5%, and in India 6.8%. Data are not available for other countries, but the number is likely to be <3% in most developing countries.

Table 2. Investments in agricultural research and development (expressed as percentage of national agricultural GDP)

Country	1971-75	1976-80	1981-85	1986-90	Latest Year
Bangladesh	0.13	0.16	0.25	0.26	0.25[b]
China	0.40	0.48	0.41	0.38	0.43[c]
India	0.21	0.33	0.38	0.48	0.52[a]
Indonesia	0.13	0.21	0.26	0.27	0.27[a]
Pakistan	0.39	0.52	0.58	0.59	0.47[b]
Sri Lanka	0.40	0.53	0.50	0.37	0.36[c]
Low-income	0.27	0.37	0.39	0.40	0.39[a]
Malaysia	0.51	0.85	1.04	1.08	1.06[b]
South Korea	0.27	0.26	0.36	0.39	0.56[c]
Taiwan	1.14	1.70	2.34	3.03	4.65[b]
Thailand	0.73	0.65	0.89	0.94	1.40[b]
Middle-income	0.60	0.65	0.89	0.94	1.34[b]
Australia	2.56	2.93	3.51	3.11	3.54[b]
Japan	1.97	2.24	2.81	3.03	3.36[b]
High-income	2.06	2.33	2.92	3.04	3.29[b]
Total	**0.48**	**0.58**	**0.60**	**0.59**	**0.58[a]**

a 1990 figure b 1992 figure c 1993 figure Source: Pardey et al., 1997

Despite the already low level of funding for agricultural research (including pulses), many national governments are imposing further cuts in research budgets. In a few countries, such as China, research institutes are being asked to generate their own funds and link up with the private sector to attract grants; while in Morocco the semi-public institutes are already generating 8-12% of their budget from internal income. Most of the national programs receive substantial contributions from bilateral or multilateral donors to support agricultural R&D. If this funding is withdrawn, it will severely affect the research in many countries.

Table 3. Research institutions, staff, and funding (US$m) for food legumes research in selected countries.

Country	No. of Institutions[1]	No. of Staff[2] (Approx.)	Total Budget[3] (for legumes)	Total Agri. Res. Budget[4]
Bangladesh	6	25	5.3 (1990-95)[5]	132.8
China	29	150	1.5 (1986-96)	1867.6
India	37	345	10.0 (1992-97)	1561.8
Myanmar	2	35	NA [6]	NA
Nepal	4	30	0.3 (1985-95)	NA
Pakistan	9	102	0.4 (1989-98)	198.3
Egypt	1	50	0.08[7] (1997)	60.0
Tunisia	2	8	0.43[8] (1996)	NA
Turkey	6	15	0.15 (1997)	4.7
Morocco	6	25	3.27[9] (1993-96)	26.9

1. Consists of institutes working on food legumes
2. Not necessarily full time staff, but indicates total person years. Based on information supplied by co-authors
3. Approximate amount allocated / spent for legumes. Figures are estimates by the co-authors representing the country
4. Source: Pardey et al., (1997). For comparison, local currency units are converted to US dollars
5. Local budget figures not available. Given figures are from a donor project
6. Data not available
7. Excluding salaries and donor supported project funds
8. Excluding donor supported project funds
9 Including external project funds, excluding salaries. Total agricultural research budget (of Institut National de la Recherche Agronomique) excluding external support project funds.

INTERNATIONAL AGRICULTURAL RESEARCH SYSTEM

Five International Agricultural Research Centers (IARCs) have food legumes as mandate crops:

Asian Vegetable Research and Development Centre (AVRDC) - Mungbean, soybean

Centro International de Agricultura Tropical (CIAT) - Phaseolus beans

International Center for Agricultural Research in the Dry Areas (ICARDA) - Lentil, faba bean and a regional mandate for chickpea (with ICRISAT)

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)-, Chickpea pigeonpea, and groundnut

International Institute of Tropical Agriculture (IITA) - Cowpea

With the exception of the bean program at CIAT, the emphasis at these centers on food legumes (in terms of research funds, staff, and resources) is less than for cereals or tuber crops. A comparative study of fund allocation during 1985-95 to cereals, legumes, and resource management programs at ICARDA and ICRISAT is presented in Table 4. At ICARDA, the four legumes received 25.4 % of the funds compared with 29.5% for two cereals and 45% for resource management. At ICRISAT, core funds (excluding special projects) for two cereals were higher (29.3%) than for three legumes (28.3%) during 1985-94. These comparisons indicate that the cereal crops garnered more funds because of the perceived need to produce more staple food. We cannot possibly hope to reverse the trend, but could influence a more equitable share of R&D support to legumes. With the recent funding cuts experienced by the Consultative Group on International Agricultural Research (CGIAR) it is likely that there will be further reductions in funds to legume research. Because of the reduced resources, and other reasons, the IARCs will now concentrate more on basic and strategic research, and are expected to work with their NARS partners in applied and adaptive research. IARCs will conduct research that will provide 'international public goods' for use by the national programs. They will also not develop any finished products or technologies, but will supply enhanced germplasm, intermediate products, and components of technology. The NARS would use these intermediate products (segregating materials, populations, etc) to develop varieties or a complete set of technologies. All this change puts the onus on the NARS for the applied/adaptive research and development oriented programs.

Table 4. Funding (thousand US$) for research programs at ICRISAT and ICARDA, 1985-95.

Program	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Total
ICRISAT												
Cereals (2)	3969	4080	4330	4426	5443	5727	5943	4963	5000	4501	NA[1]	40333
Legumes (3)	2870	3520	4076	3660	3948	3850	4248	3920	3886	4892	NA	38870
Res. management	2236	2393	2986	2932	3263	3686	3852	3747	3685	3586	NA	32366
Tech. transfer	1666	1986	2011	2717	3500	3511	3943	2828	2065	1814	NA	26041
ICARDA												
Cereals (2)	NA[2]	2352	2467	2568	2806	2729	2825	2700	2970	3055	3083	27555
Legumes (4)	NA	2091	2559	2579	2596	2523	2577	2017	2214	2276	2298	23730
Res. management	NA	3431	3528	3917	4075	3913	3976	3833	4059	5147	6215	42094

1 Data for programs is not available as programs were re-organized in to research divisions. 2 Data are not reported for 1985.

Source: Finance Division, ICRISAT, Patancheru, India & W. Erskine, ICARDA, Aleppo, Syria.

FUTURE RESEARCH TO INCREASE FOOD LEGUME PRODUCTION

Future food supplies are to come from increased productivity both by harnessing the genetic potential of crops and agronomic management to increase yields (Islam, 1995). This will need sustained research to develop technologies that can overcome the ever-changing constraints to production, and to contribute to sustainability. To achieve this, national governments must invest more in R & D in the next decade. Previous investments in food legumes are not encouraging and national governments must now act to save their countries from food shortages.

Although reliable data on funds and personnel involved in cereal research *vis-à-vis* pulses are not easily available, the lopsidedness in favour of cereals is evident in all countries. Major cereals such as rice and wheat receive almost 50 to 75% of the national research funds, while all the other crops (> 25) share the remaining 25-50% resources. There are individual national research institutes for rice, and wheat (eg, the Bangladesh Rice Research Institute, Directorate of Wheat Research in India, etc). However, three or more pulses are grouped together in research programs or institutes (e.g., Pulses Research Center, Bangladesh; Food Legumes Programs in Egypt, Morocco, Turkey, Tunisia). This change itself is a welcome development in a few countries where legumes were either clustered with oilseeds or as secondary crops, or as other field crops. However, more recently individual programs and projects are being initiated, such as the bifurcation of chickpea and pigeonpea as separate co-ordinated programs in India. It is imperative that other national programs emphasise the role of legumes in systems, and establish R&D programs.

Legumes are largely cultivated as rainfed crops, or under residual moisture conditions in post-rainy seasons. Through years of natural selection under low-moisture, low-fertility, and allied harsh conditions, they have been adapted to survive and produce minimal acceptable yields. The advent of high yielding cultivars of rice, wheat, maize, sorghum and soybean and the expansion of their cultivation to the better and more productive areas, has pushed the 'poor-cousin' legumes to marginal and less fertile lands. These factors have resulted in legumes being non-responsive to inputs (irrigation and fertilizers). The excessive growth of legumes under good fertility and moisture conditions leads to increased disease, lodging and lower yields. Good progress has been made with peas in Europe, changing the ideotype (e.g. reduced leaf area) to make the crop responsive to inputs and to mechanised cultivation. Limited progress has been made in faba bean, lentil and chickpea to develop input responsive ideotypes to fit into changed cropping systems and production needs.

Increasing production can result from a) expanding the area, including irrigation and b) increasing yield. However availability of land is limited. Swaminathan (1990) has estimated that by the year 2000, per capita land availability will be 0.1 ha in China and 0.11 ha in India. A similar situation is likely in much of Asia, but not to the same extent in Africa or Latin America. Land resources can be extended to some extent by utilising fallow lands (as in Bangladesh, China, India, and Turkey) and increasing cropping intensity (intercropping, etc). Other possibilities are: a) introducing short-duration pulses to fit into cropping sequences, b) substituting low-profit cereal crops with high-value pulses, and c) shifting pulse cultivation from marginal areas to limited irrigation areas where yields can be increased 2-3 times with one or two irrigations and d) developing value added products and the use of legumes by industry to increase demand and remuneration to farmers.

VARIETIES, CROP MANAGEMENT AND CROP PRODUCTION.

Improving yields is a major component of increasing the production of pulses. As a result of efforts by IARC and NARS scientists, improved varieties have been developed. Many are high-yielding, and combine resistance/tolerance to pests or diseases. However, the farmer's realised yields are one-fourth the yields on experiment stations. Bridging this gap, by improved management (nutrition, soil and water conditions, crop husbandry) and protection against biotic and abiotic stresses are essential to achieve increased production (Plucknett, 1995). There is need for more strategic agronomic research, to improve yields and sustainability. Research needs to be focused on both genetic and management improvements when attempting to close the gap between potential and realised yields.

BRIDGING THE YIELD GAP

A review of literature indicates the technology exists (variety and agronomic management) for increasing production of most pulse crops. For example, in groundnut the highest dry pod yields recorded (the potential yield) on large plots range from 10 t ha^{-1} in Zimbabwe to 11.2 t ha^{-1} in China (Johansen and Nageswara Rao, 1996). At ICRISAT Patancheru in peninsular India (tropical environments) yields up to 7 t ha^{-1} on small plots and up to 5 t ha^{-1} on large plots have been reported. However, the realized average national yield in many developed countries (with the exception of China) is around 1 t ha^{-1} pod yield. As apparent in Figure 1, the yield gap (the difference between the farmer's realised yield and potential yield) is large, and is usually greater than 5 t ha^{-1} in most developing countries (Johansen and Nageshwara Rao, 1996). Such yield gaps exist in other legumes, implying there is a considerable scope for increasing yields through appropriate management and by identifying and alleviating the constraints to higher productivity.

BREACHING THE YIELD CEILING

In addition to bridging the yield gap, there is a need to raise the yield plateau or breach the yield ceiling to enable higher yields in the better environments. This can be achieved in two ways. One is by modifying the effects of limiting environments by management. For example, by using a polythene mulch to alleviate low temperatures in temperate regions. This has been used to increase groundnut yields in China and South Korea and is being evaluated in north and north-eastern India for spring season groundnut. The second is genetic alteration of the plant to tolerate stress, or to make better use of the ambient environmental conditions (Johansen and Nageshwara Rao, 1996).

FUTURE TRENDS IN RESEARCH COLLABORATION

Since-World War II there has been an increased exchange of knowledge of advances in agriculture among countries. Prior to this, most countries developed and used technologies in relative isolation (Plucknett, 1995). Today, the 'global agricultural research system' is in place, and many countries have benefited. The system consists of the NARS of developing countries, IARCs, and research institutes in developed and developing countries. The interaction includes bilateral and multilateral agreements, contract research, consortia, and networks. This has lead to collaborative research that has helped many NARS overcome production constraints. A major constraint to plant breeding/crop improvement in the developing countries is the reduction in public funds for research. Many NARS depend on IARCs for breeding material and improved varieties (Duvick, 1995). Because of the reduction in funding to the IARCs they are reducing their applied/adaptive research. Instead of releasing improved varieties they are developing intermediate products, and enhanced germplasm. Some programs have been cut and others are likely to be pruned in the near future. Although commercial (private sector) plant breeding is getting established in a few countries, it cannot replace public sector NARS and IARC plant breeding, especially for self pollinated crops. Many small-scale private seed firms will still depend on public-domain breeding for advanced material and finished varieties. Continued and increasing support of publicly funded plant breeding is essential for continued yield gains in the developing countries (Duvick, 1995).

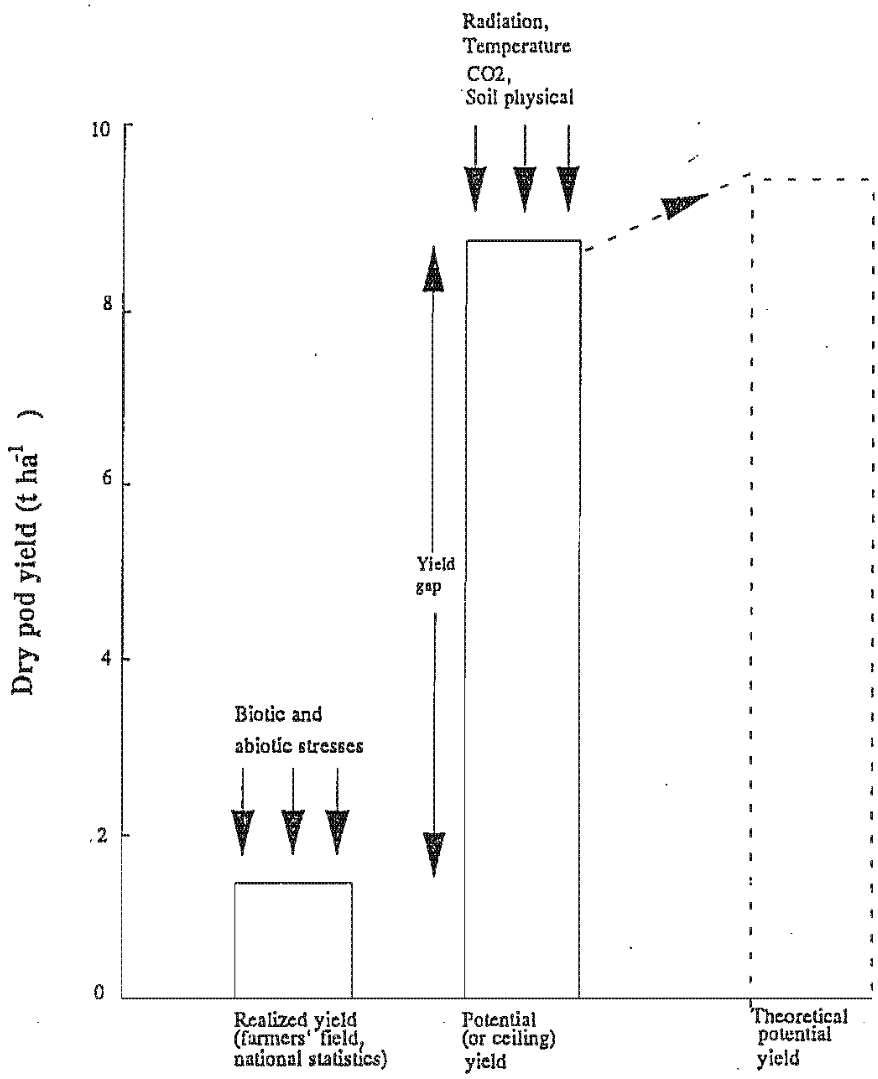

Figure 1. Representation of realized and potential yields and their relationships. (Source: Johansen and Nageshwar Rao, 1996)

TCDC APPROACH FOR RESEARCH AND DEVELOPMENT COOPERATION

The concept of Technical Co-operation among Developing Countries (TCDC) was approved at the United Nations Conference held in Buenos Aires in 1978. It recognises the role of developing countries in promoting and implementing TCDC but also the responsibility of the international community for TCDC. The main objective is to promote the individual and collective self-reliance of developing countries through the sharing of experience, knowledge, and technology. The South-South co-operation is seen as complementary to North-South co-operation. TCDC is initiated, managed, and principally financed by partner countries but is facilitated by the FAO of the United Nations (FAO, 1992). TCDC encompasses a range of social and economic activities according to the needs and capabilities of co-operating countries. Some of the activities are:

Information exchange, using directories or inventories of capabilities and needs.

Technology transfer using experts from one country to assist/facilitate R&D in other countries.

Group training, using faculties and facilities within developing countries.

Exchange of equipment among countries.

`Twinning', where a comparatively mature country/institution assists in developing another institution by providing technical assistance.

Networks, where a group of institutions/countries come together for technical co-operation to address common problems.

REGIONAL FORA AND RESEARCH COLLABORATION

As an extension of research collaboration, regional fora are becoming important in the R&D. Examples are the Southern Africa Development Council (SADC), the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), the Association of Agricultural Research Institutes in the Near East and North Africa (AARINENA), and the Asia Pacific Association of Agricultural Research Institutions (APAARI). These fora aim to exchange research technology and materials among member countries and to strengthen the weaker NARS in the region. These fora also represent the region in various `Global Forums' to ensure their needs are addressed and to influence policies and the allocation of resources for R&D. APAARI for example, is playing a role among its member countries in setting priorities for regional research, liaising with regional and international research organisations and donor groups to achieve equitable technology and information exchanges in the Asia-Pacific region. APAARI also plans to help the member NARS by supporting research collaboration directly or through regional networks. In future, the regional fora are likely to play a greater role in food legumes R&D.

COLLABORATIVE RESEARCH NETWORKS

Networks are groups of individuals or institutions linked together to collaborate on common problems, and to use existing resources more effectively (Faris, 1991). The reduction in funds for agricultural R&D is motivating scientists and institutions to work together and use their resources more effectively.

Networks, such as the Cereals and Legumes Asia Network (CLAN) appear to be crop related, but include natural resource management research (NRM) in the appropriate production systems. On the other hand, the Crop and Resource Management Network (CREMNET) looks at NRM issues in the rice-based cropping systems. The main advantages of the networks are that research is planned and executed by members, and the results are shared. Examples are the exchange of germplasm and breeding material, production technologies, information, training to improve research capabilities, and the exchange of scientists to help the weaker NARS.

RESEARCH WORKING GROUPS OR CONSORTIA

Individual laboratories are unable to undertake comprehensive research due to a scarcity of funds facilities, expertise and staff. Working Groups (WG) are defined as groups of scientists with a common interest in finding a solution to a high priority regional problem (Gowda et al., 1996). International Working Groups facilitate co-operative research by bringing together expertise from developed and developing countries, international research centers, universities, private sectors, and non-governmental organizations, to achieve the critical mass needed to achieve objectives.

The concept is not new, and scientists around the world have been pooling resources, and sharing research agenda and results. What is new is that it is now more structured, has set objectives and a focus, and the `Working Group' Co-ordinator provides leadership in the research effort. The Working Groups also provide a forum for its members to meet every 2 to 3 years to review the research and plan for the future.

COLLABORATION BETWEEN THE PUBLIC AND PRIVATE SECTORS

The challenge posed by the global food situation requires the limited resources to be used effectively to develop sustainable systems. There is a need for collaboration between the public and private sectors to ensure production is doubled or tripled in the next 50 years (James, 1997). The private sectors' investment in R&D, especially in the seed sector, biotechnology, post-harvest, food processing, and agricultural implements is large and is expected to increase at a faster rate than public sector investments (Anderson et al., 1994).

Governments in developing countries must build partnerships with the private sector to use the comparative advantages of the public and private sectors to achieve national goals. Governments can use policy incentives to encourage private sector involvement in joint ventures, and donors can facilitate implementation of such programs (Anderson et al., 1994)

Many governments in developing and developed countries are encouraging the participation of the private sector in areas where it has a comparative advantage such as the seed industry and biotechnology. A challenge is to find ways to transfer appropriate technologies, which are often proprietary, from the private sector to the public sector. Current private sector investments in agriculture R&D are about $11 billion in developed countries and $2 billion in developing countries; compared to $8.5 billion and $8.8 billion, respectively, by the public sector. In most instances the sectors are spending their funds independently and there would be a synergy if the same amount were invested in a co-ordinated manner (James, 1997). Even then the private sector will be targeting those who can pay for their products. There will still be the need for public sector research to develop technologies relevant to poor farmers.

The establishment of the "Private Sector Committee of CGIAR" is an example of such co-ordination. The CGIAR institutes are expected to work with the private sectors in developed and developing countries to conduct research and to ensure that the CGIAR's research reflects the goals of its research partners (James, 1997).

PARTICIPATORY RESEARCH METHODS

The generation of new technology and adoption of existing technologies needs capable on-station and on-farm research scientists, a good extension service, and a committed government. Many NARS follow a top-down approach to technology transfer that is not suitable for the varied agroecological conditions where pulses are grown in the developing countries. Participatory technology development, including plant breeding, on-farm research, indigenous knowledge, and empowerment of poor farmers, should be disseminated at all levels – from undergraduate curricula to upgrading of senior research and extension staff. This requires a greater investment in education to produce a new generation of scientists and for the retraining of staff.

FUTURE TRENDS IN FUNDING FOR FOOD LEGUMES RESEARCH

Traditionally, agriculture research in most developing countries has been funded by the government. As discussed earlier, this has declined over the years, especially during the 1980's and 1990's. Apart from lobbying governments for increased funds, scientists have to look beyond government funds. The following are suggested:

Linking public and private sector efforts for their mutual benefit (as mentioned above).

Involving non-government organizations. In Turkey, for example, the Mediterranean Exporters Union supported projects on disease management in lentil. Involving the private seed sector and biotechnology groups would be welcome but it is likely public sector research in developing countries will continue to be the primary source of technologies for poor farmers.

Creating "Food Legume Councils" that include farmers, traders, and exporters to support research. Such councils exist in Australia, Canada, USA and some European countries. The councils could, in association with government agencies, levy a tax or cess on the commodities and any value-added products. This will create awareness among the stakeholders (farmers, traders, etc.) in research planning, technology generation, and dissemination. The feeling of 'ownership' of the research process is a big asset.

Highlighting the role of legumes in nitrogen fixation, sustainability of agriculture, providing a balanced diet for humans, and feed for livestock and poultry. This has to be a planned public relation exercise by advertising to the general public and by convincing policy makers of the long-term benefits of food legume R&D.

Influencing national policies to support production and marketing. These policies should include the inputs (seed, fertiliser, pesticides, etc.), support price, and export policies to ensure profitability to farmers.

The IFLRC should provide a forum for linkage between research leaders, policy makers, research institutions, development agencies, NGOs, and donor agencies. This would create a better understanding of the research needs by the policy makers. It could also lead to a co-ordinated effort among funding bodies and research groups to avoid competition and duplication of R&D efforts.

CONCLUSIONS

An increasing world population will create a huge demand for food legumes for human consumption and animal feed. However, the global trends for legumes (1990-94) in the area cultivated and production have been negative, except in Asia. The challenge to scientists is to reverse this trend. Investment in research in developing countries is meagre and is declining rapidly. The IARCs are also facing funding constraints, and are shifting their emphasis to strategic research, and the development of intermediate products. The burden of the applied and adaptive research will be on the developing countries.

Future research on pulses should emphasise both varietal improvement and agronomic management, including strategic research on crop ideotypes, bridging the yield gap, and breaching the yield ceiling. Developing countries should collaborate with other countries, and with regional and international institutes to access information, material, and technology. Regional fora, networks, and consortia will play a critical role in technology exchange.

Partnerships between the public and private sectors will be essential to harness their comparative advantages and to be cost effective. The creation of "Food Legume Councils" that levy taxes or a cess on commodities to support R&D should be pursued. Scientists should lobby for support, and influence national policies on R&D. IFLRC should evolve into a forum for linkage and dialogue between scientists, policy makers, the private sector and the donor community.

References:

Anderson, J.R. , Pardey, P.G. and Roseboom, J. 1994. *Agricultural Economics* 10:107-123.

Anonymous, 1990. *The summary of agricultural statistics.* Publication no.8, Printing Division, State Institute of Statistics, Ankara, Turkey.

Duvick, D.N. 1995. . In: *Population and food in the early twenty-first century: meeting future food needs of an increasing population* (ed Islam, N.). Washington, D.C., USA: International Food Policy Research Institute.

FAO 1992. *Handbook on TCDC.* Rome, Italy: Food and Agriculture Organization.

Faris, D.G. 1991. *Agricultural research networks as development tools: Views of a network coordinator.* Ottawa, Canada: International Development Research Centre; and ICRISAT, Patancheru, 502 324, Andhra Pradesh, India:.

Gowda, C.L.L., Ramakrishna, A., Reddy, D.V.R., and Renard, C. 1996. In: *Groundnut Virus Diseases in the Asia-Pacific Region:* Fourth Meeting of the International Working Group, 12-14 Mar 1995, Khon Kaen, Thailand and ICRISAT Patancheru, 502 324, Andhra Pradesh, India:

Islam, N. 1995.. In: *Population and food in the early twenty-first century: meeting future food demands of an increasing population.* (ed Islam, N.). Washington, D.C., USA: International Food Policy Research Institute.

James, C. 1997. *Issues in Agriculture,* No.9, Washington, D.C. USA: Consultative Group on International Agricultural Research, 48pp.

Johansen, C. and Nageshwara Rao, R.C. 1996. In: *Achieving high groundnut yields*: Proceedings of an international workshop, 24-29 Aug 1995, Laxi City, Shandong, China (Gowda, C.L.L., Nigam, S.N., Johansen, C. and Renard, C. eds.) ICRISAT Patancheru 502 324, Andhra Pradesh, India:

Kelly, T.G., Parthasarathy Rao, P. and Grisko-Kelley, H. 1998. *Proceedings IFLRC-III: Linking Research and Marketing Opportunities for the 21st Century.* (ed. R. Knight) Dordrecht: Kluwer Academic Publishers (in press).

Oram, P.A. and Agcaoili, M. 1994. In: *Expanding the Production and Use of Cool Season Food Legumes* (eds Muehlbauer, F.J. and Kaiser, W.J.). Kluwer Academic, The Netherlands.

Pardey, P.G. and Alston, J.M. 1995. *Revamping agricultural R&D.* Brief 24, 2020 Vision of IFPRI Washington, D.C.; USA: International Food Policy Research Institute.

Pardey, P.G., Roseboom, J. and Fan, S. 1997. In: *Financing Agricultural Research: A Sourcebook* (eds Tabor, S.R., Janssen, W. and Bruneau, H.). The Hague, Netherlands: International Service for National Agricultural Research.

Plucknett, D.C. 1995. In: *Population and food in the early twenty-first century: meeting future food demands of an increasing population* (ed. Islam, N.). Washington, D.C., USA: International Food Policy Research Institute.

Rego, T.J., Nageshwara Rao, V. and Kumar Rao, J.V.D.K. 1996. *Presented at the Workshop on Residual Effects of Legumes in Rice-Wheat Cropping Systems of the Indo-Gangetic Plains,* 26-28 Aug 1996, ICRISAT Asia Center, Patancheru 502 324, Andhra Pradesh, India.

Swaminathan, M.S. 1990. *Sir John Crawford Memorial Lecture,* Consultative Group on International Agricultural Research, Washington, D.C., USA.

Swaminathan, M.S. 1995. *Issues in Agriculture,* No.7, Washington, D.C., USA: Consultative Group International Agricultural Research.