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Food legumes in cropping systems and farmers participatory approaches

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Abstract

Food legumes or pulses are an important component of cropping systems and provide an opportunity to increase food supplies, particularly in the developing world, in a sustainable way, through intensifying and diversifying agricultural systems. Food legumes are more positive crops, in terms of resource conservation, than cereals and a rotation of food legumes with cereals makes cereal production more economic and sustainable. In the developing world legumes is a major source of nutrition for the poor. However, in the past three decades the production of food legumes has gradually fallen in comparison with a rapid growth in cereals, and livestock products. Yields of the majority of the legumes have stagnated as they have been relegated to more marginal and unfavorable environments; and no major yield breakthroughs have been apparent. Concurrently, the first generation of Green Revolution Technologies used to increase food production are being reduced in effectiveness and have become unable economically to sustain the present, or desired increased levels in productivity. This is due, in part, to the increasing dominance of monocropping with cereals and the subsequent displacement of legumes. The role of food legumes as a key component of second-generation green revolution technologies is therefore crucial and timely. Large variations in yields are presently experienced which is compounded by intense biotic and abiotic stresses, and an inadequate supporting policy environment. We review the potential role of legumes in cropping systems in developing countries and make little effort to distinguish between cool and warm-season pulses as trends in supply and demand have

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been similar and most factors influence both types of pulses. Recent examples of diversification of cereal based cropping system emphasizing farmer participatory approaches are discussed.

Introduction

The reality of the intervening two decades or so since the First Food Legumes Research Conference (IFLRC-I) in Spokane, Washington, USA in 1986, is that support for agricultural research in general and that for legumes in particular has declined. This decline accelerated not only for national programs in most countries but also at the international centers. Faced with the declining support, the target of improving yields of food legumes by an average of 25-30 kg per hectare per year, so prominently mentioned in the previous conferences as required to meet the demands of an ever-growing population in Asia and Africa, remains a daunting challenge in many regions. Nevertheless there have been exceptions to declining research support. The Center for Legumes in Mediterranean Agriculture (CLIMA) has been established in Australia, strong federal and industrial support provided in Canada and recently Government of India in its tenth five year plan has emphasized the accelerated support to food legumes research, development and promotion to farmers.

The fourth International Food Legumes Research Conference (IFLRC-IV) held at the Indian Agricultural Research Institute (IARI) popularly known as the "Pusa Institute" which is having its Centenary Celebrations in the year 2005. On this occasion organizers have rightfully decided to hold IFLRC-IV for the first time in an Asian country specifically the India where food legumes are the integral part of the daily diets of the people. Furthermore the title of the conference "Food Legumes for Nutritional Security and Sustainable Agriculture" has been rightfully chosen and it is indicative of the need, felt by many, to ensure continued support from governments and funding organizations. It was essential to illustrate that the research being undertaken by National Agricultural Research Systems (NARS) and International Agricultural Research Centers (IARC) on food legumes was aimed at increasing the yields and increasing financial returns- doubling the incomes. The International Steering Committee (ISC) of the IFLRC-IV has decided in one of its meetings that it should primarily target cool season legumes and any additional legumes of major regional importance depending on the geographical location of the conference (e.g. among the two bids for IFLRC-IV, if it is held in Turkey, then possibly add *Phaseolus vulgaris*; if in India, then possibly add Asiatic *Vigna* spp., *Cajanus cajan* and *Arachis hypogaea*). ICRISAT is fortunate that IFLRC-IV is being held in India and its mandated three legumes (*Cicer arietinum*, *Cajanus cajan* and *Arachis hypogaea*) were focused in the agenda of the conference.

In general food legumes are perceived to warrant less support than the cereals, a perception that has arisen as a result of the substantial improvements in yield achieved the cereals and by concerns to warrant less support than cereals and by concerns for food sufficiency in the face of increasing populations. Those allocating resources for research often overlook the advantages of including food legumes in rotation and their role in human and animal nutrition.

The world continues to be challenged by the need to produce sufficient food to meet the growth in population and incomes. The current best projections in that grain supply for developing countries to increase at least 50% by the year, 2020 (Rosegrant *et al.*, 1997). At the same time traditional sources of growth in production, through expansion of land area, developing irrigation, and applying Green Revolution type technologies are being exhausted. Indeed annual growth in world grain production has slowed sharply from 2.7% in 1967-76 to 1.3% in the 1987-1997. Presently the world grain production is >1900 million tones.

Cereal cropping covers close to half of the world's cultivated land area but the system is under threat due to increased reliance on mono-cropping, and the mismanagement of irrigation and agriculture chemicals. Yet intensification of cereals system is critical to meeting world food requirements in this and next century. Cereals system as an important cropping systems needs to be diversified in order to provide food security on long term basis and enhance the sustainability by protecting the natural base. Food legumes complement cereals in production and consumption. On the production side, legumes in rotational cropping, intercropping, and alley cropping, can be a source of nitrogen, which is ecologically sustainable and economically viable. Rotation with legumes also raises crop responsiveness to fertilizer, increases the organic matter, reduces leaching losses, and helps control diseases and pests. Their restorative powers were extolled as early as the first century BC. The introduction or in many cases reintroduction and intensification of food legumes into the cereals systems through farmers participatory approaches will be central to increasing productivity and sustainability of the cropping systems.

Opportunities: Inclusion of Le

The last four decades have witnessed the phenomenal growth of rice and wheat productivity in the developing world, particularly in Asia, triggered by the green revolution. To an extent the trend continued in well endowment regions in Africa. Increased irrigation resulted in the rapid intensification and became the primary source of food supply for Asia's escalating population. Rice-wheat cropping system in South Asia emerged as the most important source of food supply (Kataki *et al.*, 2001). Continuous mono-cropping of cereals is causing deterioration of soil fertility and quality. There are greater opportunities to include legumes to break the cereal mono-cropping, and to increase income per unit of cultivated area. Cereals rotation and diversification with legumes provides continuous income and variety of food items for family consumption while ensuring the optimum utilization of fertilizer, labor and water. However, the progress of diversification with legumes depends mainly on its inputs and market constraints, and financial profitability to the farmer. The adoption of legumes for crop diversification schemes is dictated by a combination of physical factors *viz.*, land capability, rainfall patterns, water quality, crop suitability and available technology options ~~and economic factors (Dar, 2004).~~

In this context, there is a great scope for introducing legumes in the irrigated rice and rice-wheat based cropping systems, and in rain-fed rice-fallows. Concurrently there are opportunities to introduce and expand improved crop and pest management technologies to make legumes cultivation sustainable and profitable in the rain-fed African and Asian cropping systems. At present, the production of legumes compared to cereals is ~20% in area and ~10% in production (Fig. 1; FAO, 2001). Rice-legume crop rotation can enhance the efficiency of land use by increasing productivity of land as well as production of grain legumes. Legumes require minimum tillage and provide high quality protein in food and feed.

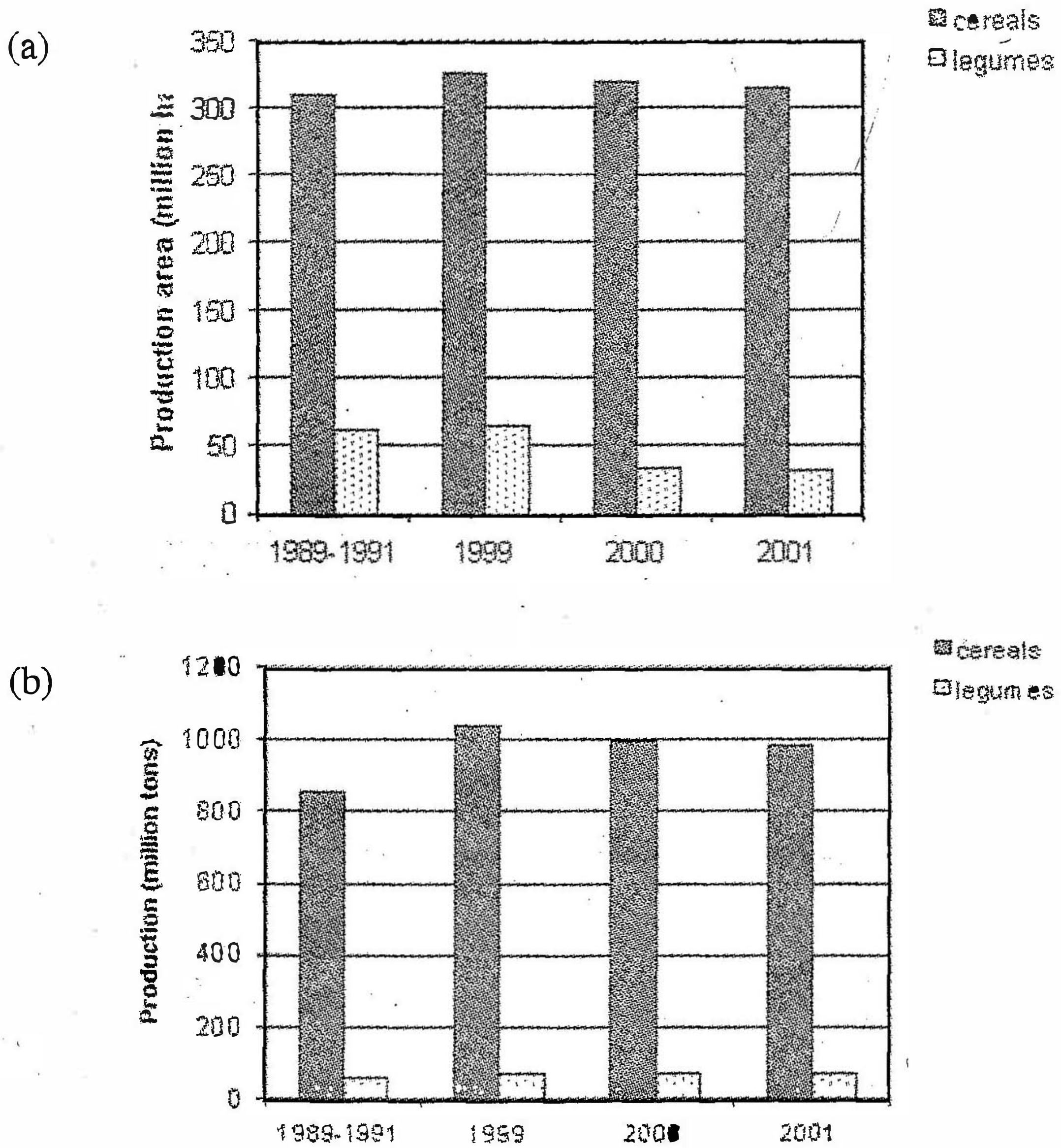

Fig. 1 Harvested area (a) and production (b) of legumes in comparison to cereals in Asia

In south-east Asia, large proportion of land is under a single crop, usually rainy season rice, with the land remaining fallow during the following post-rainy season. This largely occurs for rain-fed rice, where irrigation facilities for rice or a post-rice crop are not available. Nevertheless, residual soil moisture can support growth of a legume crop after rice. There are greater scope and opportunities for popularization of legumes in cereal based cropping systems (CBCS) by farmer-participatory development of integrated crop management practices (ICM) [integrated pest management (IPM), integrated disease management (IDM), and integrated nutrient management (INM)] and farmer-preferred cultivars of legumes (lentil, mungbean, soybean, chickpea, pigeonpea and groundnut) that are adapted to local growing conditions (Pande and Gowda, 2004). Possible niches for the inclusion of legumes in rice-based cropping systems in Asia are summarized in Table 1.

Table 1. Possible niches for inclusion of legumes in the cereals based cropping systems in South-East Asia, West Asia & North Africa and West Africa

Country	Cropping systems
South-East Asia	
Bangladesh	*Aus* rice/jute-fallow-winter legume; *Aman* rice-legumes; *Aman* rice-wheat; Mungbean-*aman* rice-legume (upland)
China	
Central China	Groundnut-rice; Rice-groundnut-soybean; Groundnut-wheat or rape seed; Soybean-rice in second year
Southern China	Groundnut-rice-soybean-rapeseed; Faba bean, pea, or sweet potato; Rice-groundnut-wheat or sweet potato; Soybean-rice seedlings-groundnut
India	
Northern India	Rice-wheat
Eastern & peninsular India	Rice-chickpea/grass pea/lentil/pea; Rice-rice
South-eastern coastal regions	Rice-mungbean/blackgram; Rice-rice
Indonesia	Rice-rice-groundnut; Rice-groundnut -groundnut; Rice-soybean-groundnut or groundnut + maize
Myanmar	Rice-legumes (chickpea, lentil, groundnut); Mungbean-Rice-legume; Sesame-rice-legume
Nepal	Rice-legume (chickpea, lentil, grasspea)-fallow; Rice-legume-early rice; Rice-wheat-mungbean; Rice-fallow-groundnut (spring)
Pakistan	
Sindh	Rice-wheat; Rice-chickpea
Baluchistan	Rice-chickpea/grasspea; Rice-flax-coriander/pea
Punjab	Rice-wheat; Rice-chickpea/lentil/pea/barseem clover
Philippines	Rice-mungbean/groundnut/soybean; Rice tobacco/ vegetables
Sri Lanka	Rice-other field crops; Rice-cowpea/mungbean; Rice-vegetables (onion, chillies, etc.); Rice-cowpea/ mungbean/other field crops
Thailand	Sesame/mung bean/groundnut/soybean/jute-rice; Rice-mungbean/blackgram/groundnut
Vietnam	Rice-groundnut; Rice-mungbean
West Asia & North Africa	
Turkey	Rainfed wheat system
West Africa	
Nigeria	Millet/sorghum-winter cowepea
Ghana	Maize-cowpea

1. Winter legumes include chickpea, lentil, grasspea and fieldpea.
2. '*Aus*' rice is sown early in the rainy season; '*Aman*' rice is sown after beginning of the main rainy season.

Faster agricultural growth and a structural shift towards legumes is the key for poverty reduction. The present status of poverty and grain legume production in different countries, and country specific opportunities for greater inclusion of legumes and role of legumes in poverty reduction in Asia are synthesized as follows.

Vietnam

In Vietnam, rice and maize are the major crops among cereals. During the last 10 years, agriculture has high growth rate (average 4.5% a year), and contributed to stabilize social life, and created basic prerequisites for industrialization. However, still about 15% of which 7% households are food insecure, especially during fallow season and natural disasters. The rate of malnutrition among children under 5 years and pregnant women still exceeds 40%.

Groundnut is an important legume crop, which can improve and generate income for farmers, particularly in North-Central coast, and North-east Mekong River delta regions. Of the total groundnuts produced in Vietnam, ~35% is for export. Export volume was 78,000 tonnes in 2001, which went up 105,000 tonnes in 2002. Soybean is the second most important legume grown traditionally in Vietnam. In the last 25 years, area of soybean has increased continuously and reached 130,000 ha. Nevertheless, soybean production does not satisfy domestic demand. The country imports 400,000 to 500,000 tonnes annually worth ~US $ 100 m to meet material demand for animal feed and oil industry. The rapid increase of these industries contributes to create a stable market of soybean products.

Under upland, (1) groundnut-soybean-potato, (2) groundnut-mungbean-groundnut, (3) groundnut-rice-groundnut, (4) soybean-rice-groundnut, (5) rice-rice-groundnut/soybean, and (6) rice-soybean-rice have been recommended for cropping systems intensification and diversification. Intercropping of short-duration soybean with maize in spring and winter, groundnut with maize in spring has good potential for legume expansion in northern Vietnam. Groundnut, soybean and mungbean obtained additional yields when intercropped with cotton, sugarcane, cassava, maize and fruit tree, and increased the net returns by US $ 400-500 ha^{-1}.

Thailand

Soybean is the most important grain legume crop in Thailand. Soybean is sown in early rainy season or mid-rainy season or after rice harvest. Availability of high yielding varieties combined with appropriate management technologies increased the productivity of soybean from 981 kg ha^{-1} in 1978 to 1419 kg ha^{-1} in 2001. Greengram (mungbean) and blackgram (urdbean) are the second important grain legume crops in Thailand. The harvested area of these two crops progressively decreased from 0.45 m ha during 1988-91 to 0.29 m ha during 1998-2001. This reduction is mainly due to the continuous cultivation of rice both in rainy and post-rainy seasons in low lands, and cultivation of sugarcane and sunflower in uplands.

Groundnut is grown in all the regions of Thailand. About 70% of the crop is grown in the uplands both early rainy season and late rainy season. Though the productivity of groundnut is steadily increasing during the past 25 years (18.1 kg ha^{-1} $year^{-1}$), its production area is declining. Groundnut needs to be reintroduced and rehabilitated on these lands to increase the sustainability of the low land areas.

Philippines

As the overall economy in Philippines grew, the incidence of poverty has come (urdbean) down significantly from 41% in 1985 to 25% in 2002. In Philippines, 52.85% are wetlands and the favorable environmental conditions of the country offers opportunities to expand existing legume crop production and stimulate development of industry. The major legumes, mungbean and groundnut constitute only 0.27% and 0.21% respectively, of the total area planted to crops in 2002. As a result, the country remained as a major importer of grain legumes.

Crop diversification and intensification as a strategy was adopted by the country to promote and accelerate agricultural growth, maximize use of land and optimize farm productivity and availability. Pilot scale studies have been conducted on growing mungbean and groundnut in rotation or relay with upland crops. Results showed that these cropping schemes always had significant increase in yield, better labor-use pattern, and income distribution. Another crop diversification scheme studied was intercropping sugarcane with leguminous crops such as groundnut, mungbean and soybean (Eusebio, 2004). This cropping system generated additional income, minimized weed population, and improved soil condition due to the decomposition of leguminous crops in the field. The experience of Philippine Rice Research Institute (PRRI) shows that mungbean and groundnut planted after rice can produce 975 kg seeds ha^{-1} and generate a net income of USD 400 ha^{-1} and USD 456 ha^{-1}, respectively.

Pakistan

Major pulse crops grown in the country are chickpea, lentil, mungbean, blackgram and grasspea (*khesari*). As compared to cereals, area of pulses is 10%-13% and production is 2%-4% of the total area and production of cereal crops, respectively. As a result, Pakistan remained as an importer of legume grains. In addition to the biotic and abiotic constraints, socio-economic factors like comparatively low return per unit area as compared to other crops, illiteracy and unawareness of the farmers on new production techniques of grain legumes, inaccessibility of the farmers to inputs and marketing problems also hamper the production of legumes (Ali and Ulliah, 1996).

As elsewhere in South Asia, pulses in Pakistan were displaced to marginal lands during the 1960s and 1970s by high-yielding cereal varieties in a policy environment favorable to cereals. Recently efforts have been made to reintroduce mungbean in the CBCS both under rainfed and irrigated conditions in Pakistan. Successful research, technological and policy advances made since 1990s have stimulated mungbean production in three districts. The key to success was the new very-short season varieties (60 days to maturity) with good disease resistance, a preferred grain type, and a short, erect stature that was suitable to mechanical harvesting (Ali *et al.*, 1997). These varieties were rapidly adopted, displacing the traditional long-season variety, and almost tripling the area sown.

The average farmer yield was 45 percent higher than for local varieties. In addition, the larger seed and shiny seed coats were preferred by consumers, leading to higher prices (Table 2). Although farmers applied inputs to boost yields, these were offset by reduced labor costs resulting from lower weed growth. Net returns were three to four times higher than for local varieties (Ali *et al.*, 1997). In addition, farmers applied 40% less nitrogen to wheat following mungbean, while achieving 6% higher wheat yields (Table 3). Overall the program is estimated to have generated benefits of US$21 million in just three districts with 30% of the benefits resulting from higher returns in the following wheat crop.

Table 2. Benefits of mungbean-wheat rotation over fallow-wheat in Pakistan

Cropping system	Wheat yield (t/ha)	N applied (kg/ha)	Cost of cultivation (Rs/ha)	Returns (Rs/ha)
Fallow-wheat	2.65	119	8,209	2,731
Mungbean-wheat	2.80	84	6,524	5,036

Source: Ali *et al.*, 1997.

Table3. Benefits of improved mungbean variety over local in Pakistan

Variety	On farm yield (kg/ha)	Days to maturity	Price grain (Rs/kg)	Net returns (Rs/ha)
Local	579	90	894	1215
Improved	900	58	988	5109

Source: Ali *et al.*, 1997.

A remarkable success has taken place in several irrigated districts of Pakistan over the past five years, where short-season mungbean have substituted for fallow in the less intensive irrigated wheat-based systems of the Punjab. This occurred despite the decline in per capita production of pulses (especially cool-season pulses) since the Green Revolution from 9.5 kg a year in 1970 to 3.4 kg a year in 1993 (Haqqani 2004).

Nepal

Grain legumes occupy 10.38% of the total cultivated land in Nepal. Lentil, chickpea, grasspea are winter pulses and cover 66% of the total area and production of legumes. Summer legumes, pigeonpea, blackgram, soybean, horse gram, mungbean and cowpea etc. constitute 34% of legumes area and production in Nepal. Lentil and chickpea are the two major legume crops of the country. Over the past one decade there has been 3.96% decrease in area under pulses cultivation in Nepal. Production rose by 31% and productivity gained by 36% over the same period. Non-adoption of improved package of practices by farmers, unavailability of seeds of improved varieties in time, inadequate extension services, inadequate number of varieties/packages of practices for cultivation for varied agro-climatic conditions, and a number of biotic, abiotic and socio-economic constraints are the causes for the wide gap between yields at research station and farmers' field. Government of

Nepal under Agriculture Prospective Plan has given priority for the long term sustainability of the vast 0.5 million ha areas of rice-wheat-fallow cropping system of Nepal by inclusion of short duration legumes. Efforts of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Nepal to rehabilitate chickpea in rice fallow lands during winter season, through increased farmers' awareness on IPM practices, supply of seed material, and continued interest of its scientists, increased the grain yields by 125%, net income by 200%-400%. The successful rehabilitation of chickpea was evident by adoption of the recommended crop management practices by more than 20,000 farmers in 2005 compared to nearly100 in 1998 (Pande *et al.*, 2005).

Myanmar

Myanmar is an agricultural country, and the agriculture sector is the backbone of its economy. Agriculture sector contributes 45.1% of GDP; 18% of total export earnings; and employs 63% of the labor force. Food legumes cover 20% of the total cultivated land area and contribute 64% of the total agricultural product export income. Due to the increasing demand for domestic consumption and export, cultivation of pulses has increased substantially from 0.73 million ha in 1988-89 to 3.28 million ha in 2001-02. Among food legumes, blackgram (urdbean), greengram (mungbean), pigeonpea, chickpea, cowpea and soybean are recorded as major crops. Export of food legumes increased from 270,000 metric tonnes in 1988-89 to one million metric tonnes in 2001-02 and had an important role in earning foreign currency.

Rice followed by legumes is a popular cropping pattern in lower Myanmar and delta areas. Legumes are usually planted as an intercrop with sesame, groundnut, cotton or maize in central Myanmar and as a sequential crop with rice. Due to the availability of short-duration legume varieties, legumes can now be grown as a preceding or succeeding crop to rice in rice-based cropping system. Myanmar offers a vast scope for enhancing legumes production under both rainfed upland and post-rice conditions in the lowlands. The area extension can be covered both in time and space because prevailing agro-climatic conditions favor production of legume crops year-round in different regions with appropriate improved varieties and technologies.

India

India grows a variety of pulse crops under a wide range of agro-climatic conditions and is recognized globally as a major player in pulses contributing 25 per cent to the global production. In spite of being the largest producer in the world, India has to import pulses to the tune of 2 million tonnes every year to meet its domestic requirement. This is due to the fact that pulses are inseparable ingredients of vegetarian diet and one of the cheapest sources of dietary protein in the country. This, coupled with present emphasis on soil health, environmental quality and economic

cropping systems leading to the expansion of pulses in non-traditional areas (Ali, 2004, Ali and Kumar, 2005).

Latest estimates for 2003-04 indicate that the production of pulses in the country is 15.24 million tonnes from an area of 24.45 million hectares, an increase of 36 per cent over the last year's production of 11.14 million tonnes. The two most important pulses, chickpea and pigeonpea recorded production of 5.77 million tonnes and 2.43 million tonnes during the year. In chickpea and pigeonpea, India contributes 67% and 75% to the global production. In spite of having the largest area under chickpea, pigeonpea, lentil, dry beans and total pulses in the world, India's position in average productivity is yet to see a major breakthrough. Except chickpea and pigeonpea, average productivity of other pulses in the country is significantly lower than average yield in the world. The most important states for pulses are Madhya Pradesh, Uttar Pradesh, Maharashtra, Andhra Pradesh, Karnataka, and Bihar, which together account for 80 percent of production (Masood Ali, 2004).

The process of widespread expansion of cereal based cropping systems replaced most of the sustainable cropping systems over a period of time since cultivation of cereals was turned out to be more remunerative than pulses under intensive management practices in Rice-Wheat Cropping Systems (RWCS). As a result, net sown area under pulses, which was at around 16% in 1967-68 has not only declined to 13.2% but also shifted to marginal and fragile areas. Among the top ten popular cropping systems covering about 20 million ha area in the country, only two (rice-chickpea and maize-chickpea) contain a legume crop with less than 6% of the total 20 million ha area. Besides horizontal expansion through inclusion of pulses in cropping systems and introduction in new niches, the present emphasis is also on other critical inputs like seeds, water, fertilizers, insecticides and pesticides (Ahlawat *et al.*, 2004; Pande *et al.*, 2004). Since India is the largest producer and consumer of grain legumes and often leads the food legumes research that is usually followed elsewhere, attempts have been made in the context of cropping system diversification need to examine in detail the following aspects of food grains production (Gowda and Pande, 2004):

Research Priorities: The research priorities for diversification in cropping systems through pulses in the country should include: (1) inclusion of short duration varieties of pulses as a catch crop in irrigated areas, (2) introduction of pulses into new niches, (3) substitution of existing low yielding pulse cultivars in the prevailing systems, and (4) pulses as intercrop with wide space planted crops and relay crop.

Production Trends: Production of pulses, which was 8.41 million tonnes in 1951, has increased to 15.24 million tonnes in 2003-04. Similarly the productivity has increased from 441 kilograms per hectare in 1951 to 623 kilograms per hectare at present. It means that had there not been an improvement in yield, at least 10 million hectares of additional land would have been required to harvest the present production level. A study of the growth statistics in different periods shows that there are positive growths of 1.41% and 0.76% in production of pulses in pre-green (1950-1965) and post-green (1968-2004) revolution periods, respectively. However, the source of growth varied with the periods. If area expansion (1.72%) was the major factor for growth in pre-green revolution period, the yield improvement (0.73%) has come out to be the key element in the post-green revolution period.

Demand Projections: The decreasing per capita availability of pulses from 69 g in 1961 to 39 g in 2004 in the country has been a serious concern. With assured supply of

cereals at an affordable price, the main focus of policy makers and researchers is now on nutritional security in the country, which houses more
living in the world. To alleviate protein-energy malnutrition, a minimum of 50g pulses/ capita/day should be available in addition to other sources of protein such as cereals, milk meat and eggs, further demand from burgeoning population, at least 23.88 million tonnes of pulses are required by 2015 which is expected to touch 29.30 million tonnes by 2020.This necessitates an annual growth rate of 4.2 per cent in pulses production. We have to produce not only enough pulses but also at a competitive price since cheap import of pulses would be threat to indigenous supply as there is no effective provision to stop import under the WTO regime. Some of the countries like Canada, Australia, Turkey and Mexico have expanded cultivation of pulses in large areas with decent yield levels, thus offering serious challenge and competition to indigenous production of pulses. In view of this, progressively more productive and efficient technologies along with favorable developmental polices need to be adopted.

Development Strategies: The major research and development strategy should be to expand area under pulses and improve their productivity. To make the nation pulse sufficient, productivity level of pulses has to increase substantially to 1200 kilograms per hectare by 2020 and sizeable area has to be brought under pulses cultivation. The following options require immediate attention, which can have substantial bearing on the pulse production without further constraining natural resources:

Area Expansion: Pulse as group has tremendous scope for expansion in space and time. Sustainable agriculture oriented towards market economy also demands inclusion of pulses in major cereal based cropping systems so as to boost up the overall productivity sustainability and profitability of the systems. Recently developed early maturing varieties of pulses can fit well in various cropping systems thus increasing not only the area under pulses but also sustaining the cereal-based cropping systems in the long run. An estimated 2.5 million hectares of additional area can be brought under different pulses through cropping system manipulation, crop diversification and multiple cropping systems. These measures can lift the national average of cropping intensity from the present level of 136% to the level already achieved in Punjab, that is, 170%. In addition, there is a scope for introduction of pulses in new niche such as wasteland, reclaimed soils, and rice-fallow land by efficient watershed management and as a replacement of less remunerative crops by adopting various developmental activities.

In the Indo-Gangetic Plain (IGP) of India, the major cropping system is rice-wheat that covers 10.5 million hectares irrigated area. Continuous cultivation of cereals has caused heavy tolls resulting in deteriorating soils, declining water tables, frequent outbreak of insect-pests and disease epidemies, and other environmental problems. After the harvest of wheat and before the planting of rice, the land remains fallow for 65-70 days (late March/ April to Early July) in the IGP. This can be utilized for raising a catch crop of summer pulses like mungbean. In recent years a large number of MYMV resistant and high yielding varieties of mungbean (Samrat, SML 668, and Pusa Vishal) have been developed which have received wider acceptance from farmers during spring/summer seasons. This systems has the potential to increase farm income beside improving soil productivity and long-term sustainability of agriculture.

Similarly, in the irrigated areas of North India, spring cultivation of short duration pulse crops also provides good opportunity for increasing pulses production, farm income and employment. Urdbean and mungbean can be successfully grown as catch crop after the harvest of mustard, potato, rajmash, sugarcane, pea, and like.

Legumes for Rice-Wheat Rotations: Development of short duration varieties of pigeonpea has enabled their introduction in the irrigated areas of Punjab, Haryana, Delhi, north-west Rajasthan and western Uttar Pradesh bringing around 0.2 million hectares of additional area under the pigeonpea-wheat system in the recent past. To expand the area further, it is imperative to develop genotypes that mature by early November, well in time for land preparation and sowing of winter crops, and with a yield potential exceeding 2 t/ha.

Identification of chickpea varieties suitable for late planting (Pusa 547) has also led to diversification of rice-wheat system in North India especially in the tail end of command area where irrigation is not enough for wheat. Under resource constraints, rice-chickpea is more remunerative than rice-wheat. Eastern Uttar Pradesh and Bihar show more potential for this system. In lowland areas with excessive moisture, lentil is a more assured crop than chickpea. Consequently, the rice-lentil system is very popular in the lowlands of eastern Uttar Pradesh, Bihar and West Bengal.

Legumes on Rice Fallows for Doubling the Income: India has approximately 12 million hectares of area under rice fallow. The non-availability of irrigation water and delay in vacating the field after rice does not normally permit double cropping. Rain-fed rabi pulses in rice fallow have great potential for incomes, and improving food security and human nutrition. However, it is possible only with selection of appropriate varieties of rice and succeeding pulse crops. The rice fallow of Eastern India, where nutrient status and moisture availability is enough may support cultivation of short duration chickpea varieties if managed properly.

In the rice fallows of Chhattisgarh, the top-soil layer generally dries up at the time of harvest of rice and thus planting of a post-rainy season crop in not feasible. Under such conditions relay cropping of small seeded lentil or low toxin lathyrus genotypes (Bio L 212) could convert these mono-cropped areas into double cropped areas and thus increase pulse production and sustain productivity of the rice-based system.

In coastal rice fallows, urdbean and mungbean in rabi season have tremendous scope owing to mild temperature during winter season. With the availability of powdery mildew resistant cultivars, urdbean has been on expansion in rice fallows of Andhra Pradesh. About 0.5 million hectares of additional area has been brought under urdbean cultivation in Andhra Pradesh, Karnataka and Tamil Nadu since 1970-71.

Post Rainy Pigeonpea: The eastern Indo-gangetic plain receives heavy rains and experiences frequent floods during July-August, which causes considerable losses to normal sown pigeonpea. Recently released varieties such as Sharad, Laxmi and Pusa 9, which are resistant to Alternaria blight have proved boon for extension of post-rainy pigeonpea on the uplands of eastern Uttar Pradesh, Bihar and West Bengal.

Development of varieties that can be planted even in early October will provide further boost to expansion of pigeonpea cultivation in sequence with other upland crops such as sorghum and pearl millet.

Rabi Rajmash (Kidney beans): Traditionally, rajmash (*Phaseolus vulgaris* L.) is cultivated in the hills of northern India as a *kharif* crop. New varieties coupled with matching production technology have paved the way to introduce this highly remunerative and input responsive crop in eastern Uttar Pradesh, Bihar, Orissa and West Bengal as rabi crop. Unlike other pulse crops, rajmash is a stable cash crop, comparatively free from insect pests and diseases and does very well as intercrop with potato.

With the development of super early varieties of chickpea a new opportunity has emerged to plant chickpea as cash crop in North India. In this system, chickpea is sown in September and the green pods are picked up in November/December to market green seeds for vegetable purpose.

Intercropping with Sugarcane: At present, sugarcane is planted in about 4.32 million hectares and offers good scope for intercropping short duration pulse crops for horizontal expansion. Studies conducted in the past have revealed that short duration pulses with erect growth habit and close canopy are generally more suitable for intercropping with sugarcane. It is estimated that about one million hectares of additional area can be brought under pulses by intercropping urdbean and mungbean in spring planted sugarcane especially in Uttar Pradesh, Bihar, Punjab and Haryana.

Seed Sector and Productivity Enhancement: The present status of seed production in pulses indicates that conversion of breeder seed in foundation and certified seeds are dismally low resulting in poor seed replacement ratio (2-3 per cent). It is assessed that availability of quality seed along with critical inputs in time can uplift about 30% production even with the available varieties.

Development of drought management technology should be one of the major research agendas in the country. Efforts should also be made to exploit useful soil microorganisms to promote crop growth and enhance efficiency of applied inputs. Integrated nutrient management modules in cropping system mode need to be developed with major emphasis on crop residues, bio-fertilizers and micronutrients.

To insulate varieties against key diseases and insect pests, characterization of pathogens, pyramiding of resistance genes and multiple disease resistance are the focused areas of research. Efforts are underway to develop bio-intensive eco-friendly integrated pest management.

The 10th plan has fixed a growth rate of 4 per cent per annum for the agriculture sector. This would require availability of critical inputs like seeds, water, fertilizers, insecticides and pesticides in time. It also requires better post-harvest technology and a price mechanism which make pulse cultivation a more profitable proposition to the farmers. Subsidy in the form of critical inputs and easy credits besides crop insurance and reasonable minimum support price are some of the policy issues, which can propel the farmers to grow pulses with minimum risk.

Bangladesh

Agriculture is the main source of income and livelihoods of the major segment of the population in Bangladesh. Most farmers operate in smallholdings where poverty and malnutrition are widespread. Importance of agriculture in poverty reduction and economic development is recognized and a number of programs and projects are in operation. Area and production of grain legumes declined over the years and replaced with rice and wheat. Legumes occupy less than 5% of the total cropped area. The major legumes grown in Bangladesh are grasspea (*khesari*), lentil, mungbean, groundnut, blackgram, chickpea, cowpea, pea and pigeonpea.

Lesser or no comparative advantage of legumes due to low productivity renders the crops vulnerable to crop competition with high yielding cereals and high valued crops. Low yield potential, vulnerability to weather changes and widespread incidence of diseases and pests are responsible for drastic reduction in area and production of most legume crops. Cowpea has been introduced recently, but its cultivation expanded rather dramatically in southeastern coastal districts.

In recognition of the importance of the legumes in sustaining agricultural productivity and in order to increase the pulse production, Government of Bangladesh is contemplating a massive campaign in the form of Action Plan to grow legumes in the cereal-based cropping systems. The plan targets to increase production by nearly 50% in the next three years relying largely on the improvement of yields by replacing old varieties with modern ones and through expanding area where pulses are not traditionally grown. The six crops included in the plan are mungbean, grasspea (*khesari*), lentil, chickpea, cowpea and blackgram.

China

Legumes are important in terms of poverty alleviation, food security and sustainable rural development in marginal arable land and resource poor farms of China. At present, only 10%-11% of the total cropped area has a legume component with soybean (5%-6%), groundnut (2%-3%), and other legumes (~2%). The poor quality of grain legume products and low yield (only 30%-40% of that of cereal crops), seriously lagged the production and market development of grain legumes in China. The long-term objective for food legume improvement is (1) to improve the legume grain yield, sowing area and production, (2) to meet the diet needs of poor areas for protein, (3) to export and increase the profits of crop production and utilization for poverty alleviation for resource poor areas, and (4) to protect agro-ecology.

The strong demand of consumer markets, promoted the cultivation of legume crops in China in recent years. Around 10% increase in legume area and production is expected in the coming years. Among cereals and legumes, groundnut emerged as the most profitable crop in the last three years. Concerning efficient diversified utilization of food legume crops, efforts are being made for (1) germplasm collection and evaluation; (2) variety development for diversified use including food processing, vegetable, export and others; (3) production technology enhancement; (4) technology transfer to farmers; (5) processing technology development and market system, and (6) quality inspection of the products.

Fallow Substitution in Rain-fed Wheat Systems of West Asia and North Africa

Turkey

The substitution of fallow with chickpea and lentil crops is well documented for the medium rainfall wheat areas of the Anatolian plateau of Turkey (Dumatan, *et al.*, 1990; Wallis, 1997). The Government implemented a project to develop appropriate varieties and management practices for legumes, and launched an extension program to transfer the technology to farmers (Capper *et al.*, 1990). The program also provided credit and inputs to expand production. The transition to pulses and their widespread adoption was facilitated by a policy that paid farmers above world prices. High returns were also partly due to the low level of farm investment required for intensification.

The fallow area in Turkey fell by 37% between 1979 and 1992 while wheat production expanded 20% and barley 35% (Wallis, 1997). Nevertheless, the program depended on payment of high prices, including subsidies on exports, as well as inputs. The fall in the food legume area in the 1990s may indicate the program was not sustainable in light of the fiscal stringencies of the 1990s.

Iran

Iran is located in the world's cold desert belt in west Asia, and considered as arid to semi-arid region. The annual precipitation is about 250 mm which is 33% of the average world precipitation. Though the total land area of Iran is 165 million ha, only 18.5 m ha are used for crop production. Chickpea and lentil are the most important pulse crops in Iran and occupy nearly 64% and 23% of food legume area in Iran respectively. These two crops are grown as rain-fed and in marginal areas in the spring. Productivity of chickpea and lentil are low (400 and 457 kg ha^{-1}) due to poor agronomic practices followed by farmers such as broadcast sowing, use of furrow turning plough for covering the seed after sowing, low seed rate and late planting. Fungal diseases and insect-pests constitute a major threat for legume production. In the next decade, research emphasis will be on identification of host plant resistance in collaboration with the International Agricultural Research Centres (IARC), and expansion of improved legumes production technologies in partnership with farmers with emphasis on on-farm validation and training to adopt good agronomic and crop management practices.

Cowpeas in West Africa (Ghana and Nigeria)

In West Africa, traditional intercropping of cowpeas with cereals was displaced by monocropping with the introduction of improved maize production (Byerlee and Eicher, 1997). Over the past ten years, however, improved cowpea technologies have led to a rapid expansion usually in a maize-legume rotation. In Ghana, new cowpea varieties and a strong extension effort have led to adoption rates of over 70% by 1994 (Denkyi *et al*., 1995). Most farmers also adopted insecticides and row planting; however, problems with insecticide use have stimulated research into integrated pest management.

In irrigated areas of northern Nigeria, cowpeas are a profitable crop in the cool season, competing favorably with wheat in rotation with coarse grain cereals (Inaizumi *et al*., 1997). Production of cowpeas in the cool season has the advantage of reducing pest damage and hence costs. This example illustrates that in the tropics and subtropics, food legumes provide flexibility, often fitting into unexpected niches in cropping patterns. In addition, the distinction between cool-season and warm-season legumes no longer applies.

Constraints for including Legumes in the Cereals Based Cropping Systems

Legumes complement cereals in both production and consumption. Legumes improve soil fertility, require less water than cereals, and their rotation with cereals helps reduce the incidence of diseases and pests. Despite their value in production and consumption, the area under legumes in Asia has declined after the introduction of improved technologies for rice and wheat in mid 1960. Several reasons and constraints for declining and status of legumes and production have been reported (Johansen *et al*., 2000), which are summarized here:

- Production constraints - inadequate local production, lack of quality seeds, low productivity and high cost of production
- Biotic constraints - insect pests and diseases
- Abiotic constraints - soil salinity, water logging and frost injury
- Processing and utilization constraints - inadequate processing facilities and lack of product acceptability
- Policy constraints – pro-cereals national policies and inadequate minimum support price.
- Marketing - Non-organized marketing system, lack of quality standards, and inadequate and inefficient infrastructure facilities (roads, transportation and communication systems).

Farmers Participatory Approaches and Transfer of Legumes Technology

The success of cereal (specifically rice and wheat) production and other crops, especially among food legumes an exception – soybeans has often resulted from campaigns that have integrated production technology, input supply, market support, and extension information. The rapid expansion of rice and wheat during green revolution era and later on soybean production have been attributed to investments in research, mounting wide-scale extension programs, supporting producer prices, and encouraging industrialists to develop processing plants and export markets. Similar efforts on other warm-season and cool-season food legumes are needed. The advantages of incorporating legumes into crop rotations need to be widely demonstrated to farmers and policy makers.

Food legume production is often constrained by poor seed multiplication systems. In countless surveys in Latin America and Africa, farmers identify poor seed availability as the constraint limiting their adoption of new cultivars (Janssen 1989; Viana Ruano *et al.*, 1996; Pande *et al.*, 2001 and Pande *et al.*, 2005). Seed availability and viability are especially important for food legumes, which in many areas are minor crops and do not attract private sector participation in seed production. In addition, because of the large seed size, farmers have difficulty storing the seeds during the humid warm season and this compounds the problem of availability. In the absence of formal distribution systems, non- governmental organizations and local farmer associations have sometimes been effective in seed distribution.

Technological Challenges

The development of technologies and their transfer are the key to increased production of food legumes. In the past, research and extension have often ignored these crops in favour of cereals to improve food security. However, since about the mid-1970s, there has been substantial investment in pulse research and some of it has led to high returns (Bantilan and Joshi, 1996). Two decades ago, Oram and Agcaoili (1992) estimated that 8% of crop scientists in developing countries in the 1980s worked on food legumes implying a research intensity (percent of output value invested in research) of about 0.5% compared to about 0.2% for cereals. Likewise in India, Maruthyunjaya *et al.*, 1995 found that pulse research was well supported relative to other crops. These data and the increasingly constrained budgets for public sector research suggest that budgets for pulses might decline rather than increase in the future.

One of the arguments for investing in food legumes is the benefit they provide to the total cropping system. The experience of Pakistan described above indicated these can be substantial and may add up to 50 % to benefits computed for pulse production alone. Likewise in India wheat yields following legumes were as high as 50% greater than wheat yields following sorghum (Singh and Singh, 1991). More work is needed along these lines if we are to make a case for increased investment in research on pulses.

For now, the issue is how to utilize research resources more effectively. One decision to be made is on the relative balance between favored and marginal areas. The shift to marginal areas has understandably encouraged research into their problems. The international agricultural research centers (notably ICRISAT, ICARDA, and CIAT) direct most of their food legume research to less favored areas. However, the future potential may be in the more favored areas, from which the pulses have been displaced, and where mono-cropping of cereals is no longer sustainable. This question has implications for the type of food legume to grow and whether warm-season legumes will be favored over cool-season legumes.

The technological issues can be classified into: appropriate varieties for ecological niches, consumers and end users, risk management, and reduced production costs.

Varieties for Specific Niches

The development of improved varieties seems to us to be the key to a technical break through in most areas. Without them it is unlikely farmers will invest in inputs and labor. At the same time, experience suggests varietal development and adoption, is a daunting task. In food legumes, more than for cereals, there are many factors to "get right" if new varieties are to be accepted including maturity, resistance to biotic stresses, improved drought, heat or cold tolerance, erectness to facilitate mechanization, and grain type to fit consumer preferences.

The common ingredient in all of the success stories described above, was the development of varieties to fit specific niches in cropping patterns, especially ones with early maturity. In favored areas, the pulses compete with higher valued cereal and vegetable crops and farmers give priority for sowing and harvesting these crops. In addition, even where there is a gap in the cropping pattern to grow legumes, the gap is often made shorter by a lack of labor and of irrigation water. At the same time in marginal areas, early maturity is often needed to escape drought or heat stress. Thus early-maturity is often more important than yields in a farmers' acceptance of new varieties. Nevertheless, researchers need to be alert to opportunities to develop high-yielding varieties that will provide sufficient returns to allow substitution of cereals by legumes. This suggests that an important priority is to characterise existing and potential cropping patterns in terms of both agroclimatic and socioeconomic variables.

A pervasive factor in a farmer's acceptance of new varieties is his appreciation of consumer preferences. In many cases, a variety has been developed which has grain characteristics that lead to reduced market prices which negate any yield advantage. Consumer preferences for grain type in food legumes are more variable between regions than for cereals.

Management of Biotic and Abiotic Stresses: Varietal development will also be the main ingredient in reducing yield risks. Early maturity is important, as is increased resistance to biotic and abiotic stresses. In some cases, there are important interactions to be considered. In WANA, changing the date of sowing of chickpea from the spring to the more favorable winter season stabilizes yield but requires improved disease resistance (Pande *et al.*, 2004).

Development of Farmers Friendly Cost Effective Legumes Production Technologies: In middle income countries such as Mexico and those in WANA, where farm wages average $3-7 a day, weeding and harvesting by hand account for up to 70% of labour costs (Haddad and Snobar, 1990). In addition, if pulses are to fit into intensive cropping patterns, the timely completion of these operations is critical. Varieties suitable for mechanical harvesting will be an important part of the solution to labour constraints. In favored areas. the use of pesticides adds to the production and environmental costs. The development of integrated pest management practices is needed to reduce these costs and risks (Pande *et al.*, 2001; Pande *et al.*, 2005).

Marketing and Price Policy: Price risk is often high for food legume producers. The question then is what policy options are available to reduce risks, especially for small farmers? In the past, some governments have implemented price support programs through governmental marketing agencies. While this has been less common than for cereals, there have been instances in Turkey and Mexico. The question is, should governments use this policy more widely?

There are several reasons why this may not be the most efficient option. The first is that a high support price to producers must be paid either by consumers, to the detriment of the poor who are consumers of food legumes, or from tax revenues, a strategy which is unsustainable, given the pressure on governments to reduce budget deficits. In the long run, improvements in infrastructure, especially roads, grain storage facilities, and market information are the most efficient ways of reducing price instability and governments have an important role in facilitating these improvements. Secondly, legumes in the past have been neglected relative to other crops. This has led to indirect disincentives since input and price subsidies have been for competing crops, such as cereals, or for sources of nitrogen (chemical fertilizers). During the 1990s, most countries have been phasing out such subsidies and few continue to subsidize nitrogenous fertilizers. In some European countries, there is a tax on its use. This more level playing field should provide incentives for expanding legume production.

Markets can also be improved through promotion of legumes and by informing consumers of the nutritional and health benefits. For example, a major campaign in Nigeria has led to a change in consumer perspectives of cowpea, from a food legume for the poor, to one that is now widely consumed by higher income households. With rapid urbanization in the developing world, research is needed on quick and easy preparations for food legumes. In countries with high incomes, the consumption of pulses is increasing with public awareness of their role in healthy diets, the development of new "easy-to-use" food preparations, and the small but growing number of vegetarians for whom pulses are important to achieving a balanced diet. Some of the cost of the research and promotion campaigns could be met from a small levy on legume output, controlled by farmers' associations as is done in Australia.

Finally, if the cost of production can be sharply reduced, grain legumes may have value and a demand in animal feeding, which will be the major source of growth in grain consumption in the developing world over the next few years. This may also have implications for the breeding of grain that has a nutrient content suitable for animal diets.

National Policies and Emphasis towards inclusion of Legumes in Cereals Based Cropping Systems

On the supply side, the story for food legumes is generally consistent across countries and regions. Rapid technical change in cereal production has displaced food legumes from the favored areas toward marginal areas unsuitable for cereals. For example, prior to 1971, five northern states in India with good rainfall and irrigation accounted for over 70 percent of the chickpea area (Kelley and Parthasarathy, 1996). However, by 1989, the northern area had decreased to be equal to the more marginal southern zones. In such zones, pulses are produced under erratic rainfall and poor soil conditions. Intercropping and crop rotations have also given way to monocropping of both cereals and legumes in their respective production areas. For example, intercropping of beans with maize in Mexico has fallen from 50% of the bean area to just 15% in two decades, encouraged by labour-saving technologies in maize (mechanization and herbicide use) (World Bank, 1990). The spread of irrigation, especially in Asia, and the lack of suitable pulse technology for irrigated areas, has accelerated this trend.

Government policies have also played a part. Subsidies, have encouraged the use of nitrogen (N) fertilizer, for the higher-return cereal and cash crops. Governments, to achieve food security, have focused on cereals in research, extension, subsidized irrigation, marketing and price support policies.

The movement to marginal areas has increased the risks of production and has been a disincentive for farmers to invest in improved technologies. Yields of pulses in most countries are more variable than yields of cereals and the detrended coefficient of variation of chickpea yields between 1971 and 1989 was 19%, compared to 8% for wheat (Kelley and Parthasarathy Rao, 1994).

These problems are particularly severe with cool-season pulses, due to their direct competition with wheat, which has shown spectacular gains over the past thirty years. As a result, these pulses have declined relative to warm-season pulses and cereals. Stagnant production and increasing demand have led to an increase in imports of food legumes to many developing countries.

Cool season pulses have done poorly relative to competing legumes, especially soybeans. The area of soybeans has expanded in all regions over the past 20 years, often in association with cereals. In India where pulse production has stagnated, soybeans are a spectacular success in the state of Madhya Pradesh, with the use of previously fallowed land, strong extension efforts, high price supports and investments in processing (Wallis, 1997).

The thin and fragmented markets for pulses are also a problem. This is especially so for production in marginal areas. With poor infrastructure in these areas, localized consumer preferences, and variable production, market prices are unstable acting as a further disincentive. This contrasts with the relative price stability of competing crops such as wheat, where price support policies are the norm, or oilseed legumes which have the advantage of multiple uses for food, feed, and oil and an expanding demand. Legumes play a key role in soil improvement and income generation. Government interventions play a key role to sustain R&D activities, which are vital to the production of legumes industry.

Few Asian governments are currently promoting policies to prioritize and promote legume crops, i.e., investing in R&D for improved varieties and agronomic management for legumes, providing credit for legume farmers etc. Crop diversification as a strategy was adopted by few countries like Phillipines to promote and accelerate agricultural growth, maximize use of land and optimize farm productivity and availability. Countries like India, Nepal, Bangladesh, Pakistan and Philippines have included legumes in diversifying rice and wheat. The Ministry of Agriculture and Rural Development (MARD) of Vietnam is implementing a project on "Developing seed of groundnut and soybean in Vietnam during 2000-2005" with a layout of US$ 1.5 million. This opens up new orientation to legumes research and development program in Vietnam. The expansion of areas under legume production has been identified in the strategy of agricultural development for restructuring cropping systems in several Asian countries. Diversification with legumes should be considered as an important national policy in order to increase the factor productivity in low productive areas, because legumes need less water than rice and wheat.

Conclusion

Several programs were launched in the agriculture sector to increase domestic food production and reduce poverty. Yet most farmers in the rural communities remain poor and suffer from malnutrition. It is therefore imperative to develop a strategy to transform and modernize the smallholders and farms in the countryside into diversified rural agro-industrial economies, guided by a market-driven and technology-propelled research and technology promotion strategy for legumes. In our opinion, there still are critical roles for food legumes that merit their priority in future strategies for food security and environmental preservation. This is especially soon the production side, where the trend to mono-cropping of cereals has to be reversed if productivity is to be sustained to meet the challenge of the world's demand for food. Rotations must be more diversified with food legumes playing an integral part in these rotations.

Other legumes, especially soybeans and forage plants, will also play an increasing role in these systems. Policy makers and farmers in the developing world must be made aware that mono-cropping, especially of cereals, is unsustainable. Scientists, farmers and policy makers will need to find niches within existing systems for legume crops, or substituting them for existing crops, including cereals. In this paper we have discussed success stories that have involved imaginative leadership. Thus, the full implementation of government policies could provide a favorable environment for the public sector with private sector participation and diversify crop production systems so that the battle against poverty could be won. Scientists should enhance efforts to increase legumes productivity and total production to meet the increasing demand of legumes. This target could be achieved by integration of efforts by multidisciplinary teams of researchers. Development of varieties with resistance to major insect pests and diseases, and responsive to improved management practices could bring a highly significant change in the legumes production. Development of low cost, effective and eco-friendly production technologies to enhance grain legume production is desirable.

The development of new varieties is a key component in the promotion of legume crops. Early maturing varieties are essential in most systems, and maturity rather than yield is often a major factor in a farmer's decision to adopt a new variety. Besides maturity, yield stability is needed and will be obtained by breeding for resistance to biotic and abiotic stresses.

Research should also be aimed at producing high quality products for consumption that can be a driver for increased participation of food industry in the value chain. Partnership between national and international research institutions provides valuable opportunities for exchange of improved production technologies and human resource development needed to spur the legume production in Asia.

Future Strategies for Enhancing Legumes inclusion in Cereals Based Cropping Systems

The future strategies and policies in the area of production, research, extension, farmers, government policies and marketing with respect to enhance the production and productivity of grain legumes in the cereals based cropping system are summarized as follows:

Research

- Development of insect pest and disease resistant varieties with high yield potential and suitable for cereal based-cropping systems
- Optimization of production technologies
- Establishment of farmer seed production and distribution systems for proper dissemination

Extension Services

- Training farmers and extension workers in production technology
- Motivation of extension services for technology dissemination by providing them sufficient training, funds and mobility

Farmer's Community

- Increased awareness to the new improved varieties and production technologies
- Implementation of latest recommendations by the researchers/agricultural department for crop production

Government Policies

- Establishment of improved seed production and dissemination systems
- Increase in support price for legumes
- Efficient market channels
- Involving private sector in seed production and distribution
- Availability and quality control of pesticides through legislation

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