# 12. Research and Development Priorities for Legumes and Legume-based Cropping Systems in the Indo-Gangetic Plain

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## Introduction

In this chapter, attempts have been made to synthesize, in summary form, the major recommendations presented in the previous chapters and discussed during the workshop. Although, for the convenience of classification, warm season and cool season legumes have been differentiated in the previous chapters, henceforth both groups are considered in unison. There are similar trends and constraints in both groups and they are indeed merging in terms of their adaptation and distribution, due to development of genotypes of wider adaptation than traditional landraces and with less sensitivity to environmental factors such as photoperiod and temperature.

There is a need to substantially reverse the overall negative trends for legumes area and productivity in the Indo-Gangetic Plain (IGP). Development of sustainable cropping systems requires reintroduction of legumes in cereal dominated cropping systems, and crop diversification generally. Food legumes are complementary to, rather than competitive with, cereal crops in both the cropping system and the human diet. Suggestions for progress are discussed. But progress will ultimately depend on formation of multidisciplinary working groups implementing focused research and development (R&D) endeavors. The major requirement is for an integrated approach to R&D and associated policy issues.

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## System Characterization

While the current study presents a broad picture for the IGP, there is a need for more specific geographic information systems (GIS), modeling, and genotype x environment analyses to establish options and priorities in particular niches. Some of the regional or country-wide generalizations made here may need modification when scaled down to specific target sub-regions (Fresco 1995). Care is thus needed in using maps and datasets of appropriate scale in the process of scaling up or down. As was apparent in an earlier GIS workshop (Pande et al. 1999), remote sensing techniques may have progressed to the extent of being able to use them to verify and accurately monitor the area sown to specific crops. This possibility needs to be followed up because of the urgent need to improve crop statistics, particularly of legumes which are generally considered as minor crops and given less attention in all respects. Sound data on crop statistics are a prerequisite to developing sound R&D strategy and to monitoring changes in cropping patterns (which will influence future R&D strategy). A reliable database is also necessary for systematic and meaningful constraint diagnosis and yield loss assessment, and for opportunity assessment.

There remain uncertainties about some of the grain legumes area and production data that will need validation by ground survey. There is an urgent need to institute systematic recording of area and production data for green manure and fodder legumes; at least sample ground surveys are needed in the short term to obtain some idea of their extent. These crops represent considerable actual and potential value in terms of soil amelioration and animal production and deserve

better quantification than hitherto attempted. Better statistics are also needed on legumes in mixed cropping and intercropping systems, to avoid currently apparent problems of both over- and underestimation of legume cultivation.

## Policy Issues

In developing a conducive policy environment for promotion of legume cultivation, a starting point would be to examine recent examples of rapid increases in legume production. Some examples within the IGP are referred to in this volume [e.g., mung bean (*Vigna radiata* (L.) Wilczek) in Pakistan; and lentil (*Lens culinaris* Medic.) in Nepal and northern India], and there are several from adjacent to the IGP [e.g., soybean (*Glycine max* (L.) Merr.) in Madhya Pradesh; and black gram (*Vigna mungo* (L.) Hepper) in coastal Andhra Pradesh] and from further afield (e.g., as mentioned in Muehlbauer et al. 1998). It can then be assessed how such success could be emulated for other legume x agroecosystem targets in the IGP, by focusing on alleviation of the most relevant biological, environmental, or socioeconomic constraints.

As reported in the country chapters, there appears to be large scope for increased grain legume production in the IGP without competing for rice (*Oryza sativa* L.) or wheat (*Triticum aestivum* L.) area. This can come from legume yield gap reduction, increased legume cultivation on marginal lands usually not sown to rice or wheat or in rice fallows, and utilization of the cropping window between wheat and rice crops. Occasional replacement of a rice or wheat crop with a legume can be argued as sustaining long-term cereal production, as compared to the risk of declining system yields with continuous cereal cropping. It is particularly suggested that more focused and concerted efforts are needed to better adapt legumes to post-rice environments and for exploiting the wheat-rice summer cropping window. Constraints to adoption of green manure and fodder legumes need closer examination (Lauren et al. 1998).

At least over a longer time frame, cropping systems change in any case, irrespective of conscious human effort to change them. But now appropriate tools (e.g., GIS, crop and systems models, and remote sensing) are available that would permit realistic scenario analyses to illustrate possibilities of better cropping options and adverse consequences of following particular cropping patterns. These tools should be made widely available and applied to cropping systems analysis in the region. However, cropping system diversification should be considered an overall goal and not just confined to legumes as alternatives to cereals; in the IGP, crops such as vegetables, potato (*Solanum tuberosum* L.), sugarcane (*Saccharum officinarum* L.), cotton (*Gossypium* sp), and mustard (*Brassica* sp) need to be considered.

In view of the technical difficulties of rotating crops with rice (flooded soils), greater use of upland rice cultivation should be explored—a paradigm shift. There is a need for quantification and pricing of the "sustainability value" of various legumes x agroecosystems.

The perception of pulses as a "crop of the poor" needs to be changed in view of the rapidly increasing demands from urban middle income earners. Improved production will rely on considering pulses as commercial crops rather than traditional subsistence crops. Lack of technical change characterizing most legume crops in the IGP has resulted in their relatively high price to consumers, as compared to cereals. World trade liberalization may exacerbate these effects if steps are not taken to make legumes of the IGP commercially competitive with grain legumes that can be imported. A policy environment that does not discriminate against grain legumes, without unduly advantaging them over other alternative crops, needs to be carefully considered. Excessive price support and input subsidies may

not help in the long term. Policies favoring production and dissemination of quality seed are an essential first step.

## Strategic Research Requirements

There is a need to more specifically design ideotypes and breed legume genotypes for defined agroecological niches in the IGP. In most cases of rapid expansion of legume production, the process has been led by development of novel, better adapted genotypes. In the IGP, there is a particular need to develop grain legume genotypes with high yield potential and stability of yield for well-endowed (in terms of water, nutrients, and climate) environments. High partitioning to reproductive structures is needed to accompany the usually existing potential for high biomass production. A long-term approach and commitment for genetic improvement efforts along these lines is required. Recent advances in plant physiology and molecular biology make it more feasible to design and create appropriate plant types for specific niches in the IGP, in a shorter time scale than possible by conventional breeding approaches. Some case studies need to be initiated and followed through. The possibility of incorporating botrytis gray mold resistance into chickpea through genes derived from other species (Pande et al. 1998) could be a suitable candidate. Recent research also indicates the greater feasibility, than earlier considered, of incorporating genes conferring greater resistance of legumes to waterlogging and salinity/sodicity, thereby conferring greater stability against problems faced by legumes in irrigated areas. Consumer preference and seed quality parameters should be considered in the breeding program, to have a better adapted genotype which produces grain preferred by the consumers.

Rather than merely focusing on breeding of better legumes for particular cropping systems in the IGP, a holistic cropping systems approach is needed to recommend to plant breeders appropriate traits for all crops that would fit into the system. An example would be shortening of the duration of rainy season rice to allow more timely planting of post-rice legumes or other winter crops.

Research is needed to develop practical options of improving stand establishment of legume crops that follow rice as well as in upland areas. There are various seed treatment options, such as seed priming, fungicide application, rhizobial inoculation, and fertilizer pelleting, that do not yet seem to have been fully explored or exploited. The need for "starter doses" of nitrogen (N) for legumes (e.g., in late planting of winter legumes) is still debatable and can only be resolved by further experimentation. Weed competition is an increasing constraint for legume crops in the IGP and strategies, taking account of the total cropping system, need to be formulated. Use of herbicides and exploitation of herbicide resistance in legumes are issues that must be addressed.

Water management is the key to successful legume cultivation in areas with access to irrigation, whether to apply enough water to alleviate drought stress or prevent waterlogging.

More long-term experiments (> 10 years) with legume treatments are needed to better understand residual effects and confidently develop and validate systems models for use in scenario analysis. The concept of "soil health" should provide a focus in considering residual benefits of legumes, accounting for both detrimental and beneficial (e.g., mycorrhizae) effects.

There is a need for intensified research on mechanization and labor-saving options applicable to small holdings of resource-poor farmers. This is another prerequisite to commercialization of legume crops.

### Development Efforts

In the first instance, intensified efforts are needed to narrow the yield gap for legumes between what is possible on research stations and

what is realized in farmers' fields. On-farm research approaches, linking efforts of researchers and extensionists in farmers' fields, are recommended (Gowda et al. 1993). Demonstration that high and stable yields are possible could stimulate development of agro-processing industries, in turn creating increased and reliable demand for the legume crop. Along with on-farm research and extension activities, it would be necessary to establish viable seed production and distribution schemes with appropriate quality control. Self-contained farmer-to-farmer schemes would seem most viable. The technology transfer process should also be directed towards consumers, by promoting greater understanding of quality and human health aspects of consuming legume products (e.g., proteins, vitamins, and minerals).

## Conclusion

Despite declining production trends for most legumes in most parts of the IGP, there is a case for attempting to substantially reverse these trends. Compelling reasons for this are ever-increasing demands for legume products by the population of the IGP and the need to improve cropping system sustainability through increased cultivation of legumes. A fundamental problem to be overcome in significantly increasing legume production is to change the prevailing perceptions of their status as subsistence crops and have them considered as commercial crops. This will require aggressive on-farm demonstration of the many seemingly viable technical options to alleviate the major abiotic and biotic stresses constraining the production of legume crops in the region, involving both improved genotypes and better agronomic management. Careful targeting of strategic research will be required to tackle some of the more intractable problems. Demonstration of high and stable yields with cost efficient management should encourage farmers to increase legume cultivation, in a process of technology-led production increase. To achieve this, a more holistic and integrated approach by relevant public sector research and extension agencies, non-governmental organizations, and the private sector, than hitherto achieved, is required.

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