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On-Farm IPM of Chickpea in Nepal

International Crops Research Institute for the Semi-Arid Tropics

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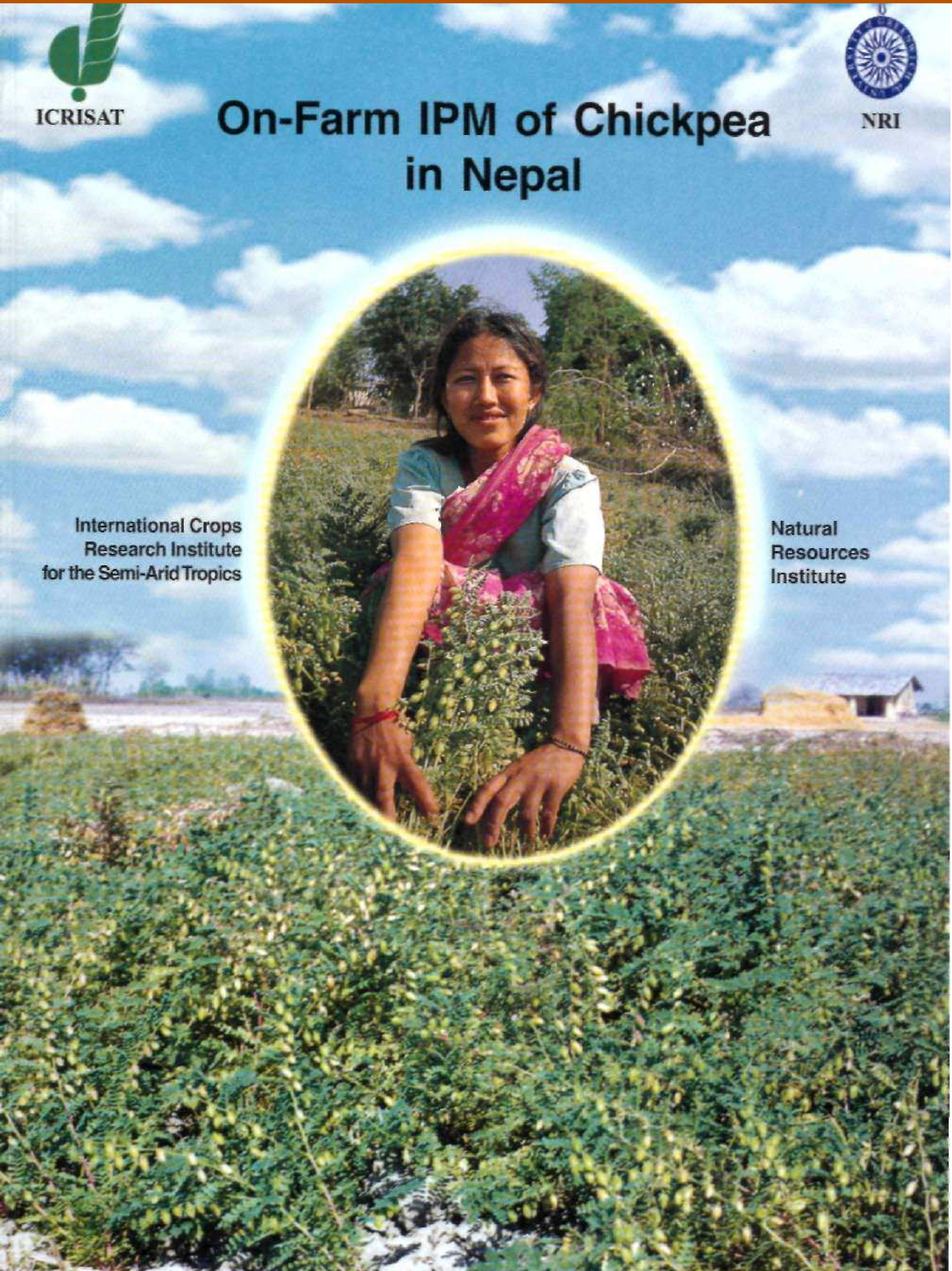

Citation: Pande, S., Johansen, C., Stevenson, P C, and Grzywacz, D. (eds.) 2001. On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute. 132 pp. ISBN 92-9066-438-X. Order code: CPE 134.

Abstract

Chickpea is a traditional crop, and is an important component in the daily diet of the Nepalese. It is one of the major grain legume crops grown as a sole or mixed crop in the rice- and maize-based cropping systems in Nepal. Area under chickpea has shown a decreasing trend for the last two decades, as a result of increasing incidence of diseases (botrytis gray mold) and insects (pod borer). Additionally abiotic constraints have also been identified, causing low and unstable yields at the national level. Consequences of decreased chickpea cultivation in Nepal include reduced opportunities for ameliorative effects of legumes on cropping system and sustainability, and decreased local accessibility of chickpea as a nutritious dietary component, particularly for poor sections of the community.

Scientists from Nepal Agricultural Research Council (NARC), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Natural Resources Institute (NRI), non-governmental organizations, and farmers (women and men) participated in the meeting. The present status of various components of on-farm integrated pest management (IPM) in Nepal were discussed and accounts of current research on IPM in different institutions were presented. Good progress has been made and prospects of continued collaborative research and development on IPM are encouraging. Site specific work plans and role of partners with the funding for the period of three years (2000-03) from the Crop Protection Programme (CPP) of the Department for International Development (DFID), UK were finalized. High priority was given to participatory on-farm validation and scale-up of the available components of IPM of botrytis gray mold and pod borer and their integration with other improved agronomical practices for sustainable chickpea production in Nepal.

ON-FARM IPM OF CHICKPEA IN NEPAL

Proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal

6-7 September 2000, Kathmandu, Nepal

Editors
S Pande, C Johansen, P C Stevenson, and D Grzywacz

Natural Resources Institute
University of Greenwich, Chatham, Kent ME4 4TB, UK

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics
Patancheru 502 324, Andhra Pradesh, India

2001

Acknowledgments

The authors and editors are particularly indebted to the contribution to word processing of original manuscripts and subsequent corrections by Ms I Radha. All contributors to this volume are appreciative of the competent technical editing of Ms Sheila Vijayakumar to enhance the final output. The coordination of the production process by T R Kapoor is gratefully acknowledged.

The research activities were funded by the Department for International Development (DFID), United Kingdom

Workshop Sponsors

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Natural Resources Institute (NRI)

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R K Neupane
J Narayana Rao

Inaugural Session

Contents

Preface

The International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal was held from 6 to 7 September 2000, at Kathmandu, Nepal. The workshop was sponsored by Nepal Agricultural Research Council (NARC), Natural Resources Institute (NRI), and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). It was funded by the Crop Protection Programme (CPP) of the Department of International Development (DFID), UK.

The workshop was specifically designed to expand on the earlier ADB (Asian Development Bank)-funded ICRISAT project on crop diversification in cereal-based cropping system for South and Southeast Asia (designated as the S4 project) by increasing chickpea yields on target farms within the time frame of the new DFID-funded project "On-farm chickpea IPM in Nepal". We expect this project will encourage large number of farmers to adopt integrated pest management (IPM) technologies with greater confidence to rehabilitate chickpea in rice-fallow lands as a cash crop in Nepal.

Participants from Nepal [NARC, Department of Agriculture (DOA), non-governmental organizations, Village Development Councils, IPM specialists, and farmers], NRI, and ICRISAT discussed the present status of IPM of chickpea in Nepal and its application in profitable chickpea production. The workshop proved to be a timely initiative and prospects of collaborative research and development in IPM are encouraging.

We sincerely believe that this volume on IPM of chickpea in Nepal with emphasis on on-farm farmers' participatory research and development will provide a useful guide to the present status of IPM of chickpea in Nepal and stimulate more coordinated work on major biotic and abiotic constraints.

Editors

OPENING SESSION

Welcome Address

W D Dar[1]

Honorable Secretary; Mr Suresh K Verma, Joint Secretary, Ministry of Agriculture and Cooperatives; Mr A Jha, Director General, Mr S S Shrestha, Agriculture Extension Division, and Mr K K Shrestha, Plant Protection Division, Department of Agriculture (DOA); Mr Dhruv Joshy, Executive Director, Dr D S Pathic, Director, Crops and Horticulture, Nepal Agricultural Research Council (NARC); Drs Philip C Stevenson and David Grzywacz, Pest Management Department, Natural Resources Institute (NRI), Chatham, UK; and Dr Suresh Pande, Natural Resource Management Program (NRMP), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), distinguished farmers and representatives of farmer groups, non-governmental organizations (NGOs) [Ms Bhawani Rana, Saathi, and Mr Santosh Kumar Bohara, Public Awareness Center (PAC)] from chickpea (*Cicer arietinum* L.)-growing districts of Nepal and distinguished participants, ladies and gentlemen, on behalf of ICRISAT and on my own behalf, I welcome all of you to this two-day workshop on Planning and Implementation of On-farm Chickpea IPM (integrated pest management - the term includes all pests and diseases) in Nepal. It is my privilege to participate in this meeting being held in collaboration with NARC, the leading agricultural research institute in Nepal. The choice of Kathmandu for this meeting is most appropriate, especially considering the interest of stakeholders in interacting with many Nepalese scientists who have recently made notable contributions to collaborative on-farm research on the management of chickpea diseases and insects.

I am pleased to take this opportunity to spell out certain aspects of cooperation between ICRISAT and NARC. Informal technical collaboration between Nepal and ICRISAT started in late 1970s. The first high-level ICRISAT mission in Nepal, headed by the then Director General Dr L D Swindale was in 1987 and was followed by the signing of the Memorandum of Understanding (MOU) for cooperation between the Ministry of Agriculture, His Majesty's Government of Nepal and ICRISAT in Kathmandu on 24 December 1987. Since then, the Director General, and ICRISAT scientists have made countless visits to Nepal. Some of the

1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India.

Dar, W.D. 2001. Welcome address. Pages 5-7 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000. Kathmandu, Nepal (Pande, S., Johansen, C, Stevenson, P.C., and Grzywacz, D., eds). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resoueres Institute.

notable visits to strengthen legumes research especially chickpea research and IPM research have been made by ICRISAT breeders, agronomists, entomologists, and plant pathologists. We have developed and implemented collaborative work plans with Nepal, the most recent being on-farm IPM of chickpea which was implemented during 1998/99 and 1999/2000, soon after the botrytis gray mold (BGM) disease epidemic (caused by *Botrytis cinerea)* in chickpea in 1997/98. This farmers' participatory IPM was a part of the Crop Diversification Project (commonly known as S4 Project), which was funded by the Asian Development Bank (ADB). More than 56 Nepalese scientists and technicians have participated in various training programs at ICRISAT. Germplasm exchange has been a major activity. ICRISAT has supplied Nepal with a total of 1025 germplasm accessions, and breeding lines and advanced generation lines of chickpea.

Collaboration with NARC, its regional agricultural research stations (RARSs), and through its network with farmers on chickpea diseases and insect pests has been encouraging, especially on BGM and pod borers, and basic and applied information on this pest complex has been generated. Identification of boron (B) deficiency, its association with flower drop and interaction with BGM and pod borer, and the management of these constraints in a holistic manner is a good example of a partnership approach in tackling complex problems.

ICRISAT's medium-term plan (2001-2003) "Science with a Human Face" emphasizes the core responsibility of all scientists to ensure that results of their research reach end users through appropriate partnership and training and collaboration. Partners are considered equally and engaged throughout the project cycle, from brainstorming, planning, and fund raising through execution and impact assessment. Beside assuring joint priorty setting and commitment to outcomes, this approach builds real-world research skills that help develop national partners' ability and sustain their own programs over the long term. Natural resource management research will become more participatory in its approach in the coming years, in order to fulfill its objective of increasing the adoption of management technologies. Participatory IPM (P3) research is applying innovative on-farm trial approaches that allow farmers to choose the technologies they are most interested in among the menu on offer.

Botrytis cinerea and the gram pod borer *(Helicoverpa armigera)* are the two economically important pests of chickpea in Nepal. These two pests cause >70% losses in grain yield and BGM alone can completely destroy the crop in some years. Also B deficiency is responsible for flower drop and prevention of pod set, which can limit the realization of potential yields of chickpea cultivars in certain regions of Nepal. To minimize losses caused by these biotic and abiotic constraints, an IPM technology was developed and evaluated in seven villages in five districts in Nepal during the 1998/99 and 1999/2000 postrainy seasons. This farmers' participatory research has provided an excellent understanding of the effects of cultural practices and minimum use of pesticides for the management of BGM and pod borers. Following successful on-farm demonstrations of simple and affordable IPM packages for BGM and pod borer of chickpea, 700 farmers re-introduced this crop (which had been nearly abandoned primarily due to BGM epidemics in the rice-fallow lands in five districts of Nepal). Today, we have assembled here to launch the new project "On-farm chickpea IPM in Nepal" which is funded by the UK Department for International Development (DFID) and will involve extensive stakeholder brainstorming and project pre-planning workshops at both NARC and ICRISAT. I can cite it as being a model for participatory priority-setting and project planning.

I trust that as a result of this project, with the widespread adoption of improved chickpea production technology and with greater emphasis on on-farm IPM, higher yields will be realized. This would further motivate the farmers to expand the area under this crop because chickpea production would then be perceived as less risk-prone and more profitable. Additional benefit will accrue from greater sustainability of the production systems into which chickpea is grown or expected to expand into institutional incentives and farmer-friendly policy that would ensure dependable income to farmers for rapid adoption of IPM technologies. We believe that this focused research and development project on on-farm IPM of chickpea could quickly result in greater availability of chickpea and reverse the declining trends in area and production under this crop in Nepal.

We at ICRISAT sincerely hope that the recommendations of this meeting will further strengthen international collaborative research to find and provide cost-effective solutions to manage BGM and pod borer infestation, the most important constraints to chickpea production in Nepal.

Opening Remarks from ICRISAT

J M Lenne[1]

I welcome all participants of the initial planning workshop for the project "Promoting the adoption of improved disease and pest management technologies in chickpea by resource-poor farmers in the mid-hills and hillside cropping systems of Nepal" funded by the UK Department for International Development (DFID)-Crop Protection Programme (CPP).

Although regrettably other commitments prevent me from participating in the workshop, I thank you for your contribution to the development of the excellent proposal and wish you well in the formulation of detailed plans for conducting a successful project.

My interests in supporting this proposal have grown substantially from initial discussions with Chris Johansen and Suresh Pande in early 1999 and follow-up discussions with Phil Stevenson and David Grzywacz in mid-1999.1 was also very fortunate to meet collaborators from the national agricultural research systems (NARS) of Nepal during a visit to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The ideas discussed then have grown into an excellent project that undoubtedly will make a substantial contribution to chickpea (*Cicer arietinum* L.) production in Nepal with opportunities for spillover to India, Bangladesh, and elsewhere where similar biotic constraints are important.

For some years the CPP and ICRISAT, often in close collaboration, have actively worked with NARS partners to develop sound strategies for managing major pests and diseases of chickpea. There is a growing need to validate and promote these technologies through participatory procedures into sustainable uptake pathways. We look to this project to further validate some very promising integrated pest management (IPM) and crop management technologies for chickpea in Nepal and to promote them to enthusiastic farmers who will further promote them for wider adoption and uptake. Achievement of these aims will make a substantial contribution to reducing poverty and malnutrition in hillside systems and in urban areas in Nepal.

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1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India (formerly Programme Leader-Strategy, DFID Crop Protection Programme. UK).

On behalf of Dr J M Lenne, S Pande read the opening remarks.

Lenne, J.M. 2001. Opening remarks from ICRISAT. Pages 8-9 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal. 6-7 September 2000, Kathmandu, Nepal (Pande, S., Johansen, C, Stevenson, P C , and Grzywacz, D., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics, and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

I wish you an enjoyable and productive workshop. I look forward to visiting Nepal when the trials are well established and concrete outcomes of your discussions will be obvious.

Thank you!

Opening Remarks from NRI

P C Stevenson[1]

I would like to welcome all of you to this meeting on the implementation of integrated pest management (IPM) of chickpea (*Cicer arietinum* L.) in Nepal on behalf of the Agricultural Resources Management Department of the Natural Resources Institute (NRI) and I would like to thank all the participants of this meeting for making, in many cases, a considerable effort to get here. As a visitor to Nepal I would like to thank our hosts, the Nepal Agricultural Research Council (NARC), particularly the Executive Director, Mr Dhruv Joshy without whose support the project would not have been possible. I would also like to thank Dr William Dar, Director General of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) for providing us with his support and endorsement. I would also like to extend my personal thanks to Dr Suresh Pande who has gone to great lengths to organize this meeting on behalf of the project.

NRI was formerly the scientific wing of the British Overseas Aid program with a predominantly natural resources development focus in pest management, horticulture, postharvest and food processing, fisheries, and forestry. It is now part of the University of Greenwich, UK where its predominant focus remains deeply rooted in development and consultancy but has the added advantage of providing opportunities for the study of natural resources development programs as part of taught and research-based degrees. In fact, many of our MSc and PhD positions are filled by students from developing countries.

The collaborations between ICRISAT and NRI go back to the 1970s when ICRISAT was a small collection of village buildings at Manmool and the Agricultural Resources Management Department of NRI was the Centre for Overseas Pest Research at Kensington in London, UK. Since then both institutes have undergone many changes and have enjoyed many successful collaborations, with both an upstream scientific research focus, where I have had most of my collaborations, and the more recent field-based and socioeconomic-based projects. A notable recent collaboration that has been very successful and has particular

1. Natural Resources Institute. University of Greenwich, Chatham, Kent ME4 4TB, UK.

Stevenson, P.C. 2001. Opening remarks from NRI. Pages 10-12 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal(Pande.S.,Johansen,C,Stevenson.PC.andGrzywacz,D.,eds).Patancheru502324, Andhra Pradesh,India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

relevance to this project was the work on insecticide resistance that now continues at many national institutes in India. This project drew awareness to the increasing problems of excessive use of insecticides to control the pod borer *(Helicoverpa armigera)* and has been central to the motivation of funding bodies to develop more sustainable approaches to pod borer management. My sincere hope is that this project like many of the preceding NRI/ICRISAT collaborations continues in the same communicative, cooperative, and friendly way but more importantly that we are able to achieve our ambitions and goals in the Terai of Nepal.

One of the principal aspects of the present project that appeals to me personally is that it links strategic research outputs with adaptive field-based application. It is an opportunity to show that strategic research provides outputs that actually reach farmers' fields; these are adopted and make a difference to farmers' livelihoods. It is fairly straightforward to conduct research with the assumption that your work will reach practical application. It is not so easy to actually see the research reach the field. The process of adoption and promotion will be entirely dependent on the third principal collaborator, NARC, and non-governmental organizations (NGOs) associated with this project. I take this opportunity to thank you for your support and also to emphasize my hope and optimism that, with your field stations and experienced and dedicated field officers, we will be able to make a difference to the farmers and the livelihoods of their families within the time frame of the project and beyond. However, I am also aware that we should maintain our ambitions for the scale of the project (in the first year we hope to reach at least 500 farmers) and that the success of the project is wholly dependent upon the activities, contributions, and communications from farmer representatives and NGOs. None of the ground-based work would be possible without you and I would like to express my particular thanks to you for coming to the meeting.

I would like to give you some idea of the funding source and also, more importantly, what the expectation of the funding source is. After all, we will be monitored continuously throughout the project and we need to ensure that we are funded continuously. To do this we need to ensure that we satisfy our time bound objectives and if the project goes well, and I have no reason to think it will be otherwise, then we may even be in a position to continue the work beyond 2003.

The funding will come from the Crop Protection Programme (CPP), one of twelve research programmes of the UK government's Department for International Development (DFID). The program operates between 60 and 70 projects worldwide that are directed towards eliminating poverty in developing countries. The CPP funds projects over a spectrum of strategic to applied and adaptive research and addresses socioeconomic issues as well as natural science. Priority is given to demand-led research that addresses problems recognized within developing countries as major constraints to the improvement of rural livelihoods.

In this project, and under the CPP directive, we aim to better understand the interactions between crop protection options in chickpea, farmers' access to control over resources and also their farming and livelihood systems. Many of these issues have, of course, been established through the forerunner Asian Development Bank (ADB) project and we hope that this information will allow us to make greater leaps forward in improving chickpea production bearing in mind the farming systems. We also hope to develop crop protection technologies appropriate to different farmer circumstances and resource levels. Again, we have learned much on this front from the ADB project but we aim to make considerable improvements in the introduction of Nepalese farmers to environmentally benign bio-pesticides, particularly *Helicoverpa* nuclear polyhedrosis virus (HNPV). Communication with different stakeholders who have different awareness of pests and management options will be essential for the success of the project. We are hopefully making inroads in this area today and tomorrow by having scientists, government representatives, and farmer representatives together at this workshop. I hope that we are able to continue this communication and interaction on this project over the coming three years but it is up to all of us to ensure that this continues. It will also be essential to take account of the different stakeholders involved in pest management, including farmers, laborers, and pesticide dealers, and to influence policy makers to encourage the wider adoption of the technologies during the project and beyond. It will be very important for us to build long-term linkages and mechanisms with development partners that will support improved uptake and promotion of crop protection research outputs. My hope is that we can demonstrate through the results of this project how improved and novel technologies can be taken up by our collaborating farmers and also, through the national program, how these can be further adopted by many more. It is also my ambition that the success of this project would provide a model on which similar promotion and adoption strategies could be employed in other crops in Nepal and in other chickpea-growing regions of South Asia including India, Pakistan, and Bangladesh.

The CPP views this project as the culmination of many years of directly funded or related predecessors which are seen as linking in with the present project and their results being taken up here. This is poignant since it illustrates how valued the current project is and how we can now take many years of research and bring together all aspects of pest management to the farmer's field. I believe that we have an opportunity to make an important difference to the livelihoods of the rural poor in Nepal and impact positively upon the food and income security of farmers and families in these areas and I call upon all of us to work together as a team to achieve these ambitions.

Keynote Address from NARC

D Joshy[1]

Let me at the outset tell you about myself in relation to chickpea (*Cicer arietinum* L.). I am a person who had never worked with chickpea, but I like chickpea very much in my daily diet. I am neither an agronomist/breeder nor an entomologist, pathologist, or economist and therefore, had no direct association with chickpea research in Nepal. I, therefore, feel that I may not be an appropriate person to address on the subject. Nevertheless, I am privileged to have this opportunity to deliver the keynote address in this workshop on "Planning and Implementation of On-farm Chickpea IPM in Nepal" and share some of my views with you.

Chickpea is one of the major grain legume crops grown as a sole or mixed crop in the rice (*Oryza sativa* L.)- and maize (*Zea mays* L.)-based cropping pattern in Nepal. Although it has the sixth position among the grain legumes, it shares only 6% of the total area and production of grain legumes. It is the second most important crop after lentil (*Lens culinaris* Medic.) among winter legumes grown in the Terai and inner Terai of the country. If 30% of the area under rice-fallows in the country, i.e., 420,000 ha could be brought under chickpea cultivation there would be enough chickpea not only to meet national needs but also to export.

The workshop has been held at a very opportune time. Despite high rates of return demonstrated on investment in agricultural research, the resources for agricultural research have been severely constrained nationally as well as globally. Therefore, in such a planning workshop we need to assess the impact of past research and the benefits farmers and the society, at large, have received in relation to this commodity.

The introduction of wheat (*Triticum aestivum* L.) as a winter crop after rice has relegated the legumes including chickpea to more marginal rice fields with the more fertile lands devoted to rice-wheat rotations that use high input technology including seeds and fertilizers. But in recent years, there have been increasing concerns that continuous cereal-based rotation has caused mining of soil nutrients and increased incidence of diseases, pests, and weeds, resulting in environmental degradation. Therefore, the necessity of inclusion of legumes in rice-wheat

1. Nepal Agricultural Research Council, Khumaltar, Lalitpur, PO Box 5459, Nepal.

Joshy, D. 2001. Keynote address from NARC. Pages 13—17 in On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S., Johansen, C, Stevenson, P.C., and Grzywacz, D., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

cropping systems is recognized more than ever due to their ability to enrich soil fertility, through biological nitrogen fixation (BNF), tolerate drought hazards, and provide a cheaper source of protein to the human diet.

Unlike lentil and pigeonpea (*Cajanus cajan* (L.) Millsp.), the cultivation of chickpea has been declining in the country over the past decade. However, it should be noted that its cultivation has concentrated in the same three western districts where lentil and pigeonpea intensification has taken place. This shift in chickpea. cultivation from eastern to western parts of the country relates to the severe incidence of botrytis gray mold (BGM) in the eastern part compared to the western part of the country.

Production constraints in chickpea

Although some technologies for chickpea production, in terms of varieties, agronomic package of practices, plant protection measures, *Rhizobium* culture are available, a number of major constraints and the non-adoption of available technologies on a wider scale are responsible for the declining trend of chickpea cultivation in the country. The important constraints to chickpea production are:

- Biotic constraints such as BGM (caused by *Botrytis cinerea),* fusarium wilt (*Fusarium oxysporum* f. sp *ciceris),* and pod borer (*Helicoverpa armigera*).
- Abiotic constraints such as boron (B) deficiency, especially in Chitwan and Nawalparasi areas, poor nodulation, pre- and post-sowing moisture stress, and poor agronomic practices.
- Socioeconomic constraints such as instability of crop yield, increasing irrigation facility causing farmers to divert their land to wheat or other high-value, less risky crops, and non-availability of improved seeds of chickpea in adequate quantities.

NARC and ICRISAT collaboration

It will not be out of place to recollect the cooperation and collaboration between the Nepal Agricultural Research Council (NARC) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in improving production and productivity of chickpea and other legume crops. The collaborative activities were initiated in the early 1980s through the exchange of genetic materials and information on three legume crops—chickpea, groundnut (*Arachis hypogaea* L.), and pigeonpea. A memorandum of understanding between Nepal and ICRISAT signed on 24 December 1987, further helped to expand the cooperation between NARC and ICRISAT.

During this period of collaboration, effective linkage was maintained through organization of networks, working group meetings, scientific and material exchange, specialized projects, workshops/training, and information sharing/ publications. Special mention may be made of the Asian Grain Legumes Network (AGLN) that was coordinated by ICRISAT and facilitated direct interaction among scientists, exchange of materials, and human resource development.

Since 1990, greater emphasis was put on adaptive research to increase production and productivity at farm level through initiation of Asian Grain Legumes On-farm Research (AGLOR). The ICRISAT-led collaborative on-farm activities on chickpea, pigeonpea, and groundnut were conducted in potential production pockets in Nepal on the basis of production constraints identified and prioritized through diagnostic surveys [such as rapid rural appraisal (RRA)]. These AGLOR activities greatly enhanced the dissemination and adoption of improved production packages on chickpea, pigeonpea, and groundnut. These activities were further intensified under the Cereals and Legumes Asia Network (CLAN), coordinated by ICRISAT from 1995, and specifically by the project "S4" or "Crop Diversification" funded by the Asian Development Bank (ADB) from 1997.

Accomplishments of collaborative projects

Let me note here briefly some of the gains from the collaboration between NARC and ICRISAT.

Varietal improvement/utilization of genetic resources

- Six varieties of chickpea, viz., Dhanush, Trishul, Sita (ICCC 4), Radha (JG 74), Koselee (ICCV 6), and Kalika (ICCL 82108) have been released, of which 4 varieties are derived from materials supplied by ICRISAT.
- Selections of crosses K 850 x Dhanush and Sita x Dhanush are at the prerelease stage.
- Identification of BGM tolerant chickpea varieties (ICCL 87322, Avarodhi).
- Identification of chickpea lines less susceptible to pod borer.
- In pigeonpea, Bageshwari (ICP 11384) and Rampur Rahar 1 (ICP 6997) have been released and varieties for rabi season planting (Pusa 9 and Pusa 14) have been selected.
- Four varieties of groundnut, viz., B 4, Janak, Jyoti, and Jayanti have been released.

Improved production package testing and dissemination

Large-scale on-farm trials have facilitated faster dissemination of improved seed of chickpea, pigeonpea, and groundnut varieties which has complemented the public sector seed supply.

Manpower development

During 1995-99, 45 scientists have visited ICRISAT for training, workshops, and meetings through collaborative arrangements in the fields of genetic enhancement, microbiology, resource management, and information technology. There were 83 ICRISAT-scientist visits to Nepal during the same period.

Training

More than 90 Nepalese scientists and technical staff have been trained in on-farm adaptive research methodologies, statistical design and analysis of experiments, and chickpea and pigeonpea production during 1989-97 through in-country training programs.

Publications

Two ICRISAT publications were translated into Nepali and are widely being used by the farmers concerned, and extensionists and researchers as well. They are:

- Pigeonpea and Chickpea Insect Identification Handbook (Nepali)
- Field Diagnosis of Chickpea Diseases and their Control (Nepali)

Future outlook

Despite the technologies generated by the research over the years, a significant gain in the production and productivity of chickpea has yet to be seen at the national level. It is obvious that the impact of research can only be realized when farmers practice the generated technologies on a wider scale.

A fundamental problem to be overcome in increasing chickpea production is to change the prevailing perceptions of its status as a subsistence crop and accept it as a commercial crop. This will require aggressive on-farm demonstration of the viable technical options to alleviate the major biotic and abiotic production constraints. There is a continuing need for focused strategic research efforts to effectively address some of the biotic and abiotic constraints. To move towards commercialization of chickpea and other legumes cultivation, an integrated approach by the relevant public sector research and extension agencies, non-governmental organizations (NGOs), and private sector needs to be considered.

For effective delivery of research outputs, involvement of stakeholders in planning and implementation phases of the project is a vital issue. The participation of farmers and NGOs in this workshop will help to develop need-based research and development portfolios and their effective implementation program.

Let me take this opportunity to speak a few words on the research management strategy that we are following. In recent years, NARC has been faced with greater demands on its research capacity. The research agenda of NARC, therefore, needs to match the changing demands of clients, be they consumers, farmers, or agro-entrepreneurs. The issue does not end here. Above all, the researchers are expected not only to produce more but also to do it in a way that is not harmful to the environment. This demand is going beyond the limits of conventional research methods and the establishment of participatory approaches. This evolution is bringing a new paradigm in the priority setting and management of research in NARC. As a consequence, NARC has adopted the concept of institutional plurality in conducting research in its agenda. This workshop fits very well with the approach NARC is following as we see the participation of different stakeholders from the beginning of the planning process.

I hope the deliberations in the workshop will focus on the major issues related to increasing the production and productivity of chickpea and come up with a realistic action plan on on-farm chickpea IPM (integrated pest management) research in Nepal.

Thank you!

Genesis of the Project and its Objectives

S Pande[1]

I would like to extend my welcome to all of you to this stakeholder workshop on "Planning and Implementation of On-farm Chickpea IPM in Nepal". In his introductory address, Dr William D Dar, Director General, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has adequately explained the shift in ICRISAT's new vision (medium-term plan (MTP) 2001-2003] that is built on the overarching objectives of poverty reduction—putting a human face on science, with a focus on improving livelihoods of the poorest of the poor. This alters the Institute's thinking and priority-setting paradigm, viewing agricultural development from a systems perspective (including socioeconomic system dimensions) rather than a perspective of commodity or "science for science's sake".

In emphasizing science with a human face and bridge broker and catalystic roles, the new vision portrays an outward-looking ICRISAT, closely engaged with partners, focused on the relevance and impact of its work, and strongly biased towards the needs of the poor and marginalized rural people in Asia and Africa. It is in this new MTP period that we are aiming at the implementation of this new project in continuation of the Asian Development Bank (ADB)-funded special project "Crop diversification in the cereals based cropping system: legumes technologies for the rice and rice-wheat based cropping systems of South and Southeast Asia" (designated as the S4 project).

The S4 project is currently in its final year and is due to complete by April 2001. This project in Nepal, in partnership with scientists from the Nepal Agricultural Research Council (NARC), has taken research station based studies to farm locations to establish the value of various control measures for botrytis gray mold (BGM) disease and pod borer (*Helicoverpa armigera*) in combination with alleviation of boron deficiency and other important constraints to chickpea *(Cicer arietinum* L.) production. Field sites have been established that will be used for the present project. This earlier project has identified farmer networks that will be used for an on-farm field survey in the first month of the present project. The S4

1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India.

ICRISAT Conference Paper no. CP 1420.

Pande, S. 2001. Genesis of the project and its objectives. Pages 18-20 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S., Johansen, C, Stevenson, P C , and Grzywacz, D., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

project has also determined that the present project approach is valid and can work through on-farm trials in Nepal. Progress made in two years of on-farm trials has shown that improvements in pest and disease management can have an impact on yields.

Furthermore, scientists from NARC and its regional stations and especially from the National Grain Legumes Research Program (NGLRP), Rampur, Nepal have also determined the importance of different aspects of BGM disease management and the need to move station trials to farms.

A visit to the Bangladesh Agricultural Research Institute (BARI) in June 1999 by Dr J M Lenne" [then Consultant, Natural Resources International, UK, now Deputy Director General (Research), ICRISAT] further clarified the need for a major initiative to improve chickpea production in BGM endemic areas. The call from the Department for International Development (DFID)-Crop Protection Programme (CPP), UK for proposals on chickpea production in Nepal arose from this visit.

Visits of Nepalese scientists and their meetings with ICRISAT directors, scientists, and Dr J M Lenne in September 1999 followed by another meeting with directors and other scientists of NARC, Khumaltar, Nepal in November 1999, made clear the importance and need for such a collaborative project and confirmed their support for the aims and objectives of this project.

The present project seeks to expand on the ADB-funded S4 project by increasing the chickpea yields on target farms within the time frame of the project through further demonstrating better management of the major production constraints in combination with improved cultural practices. The number of farmers directly participating in the project will increase each year through the project's farm workshops, and farmers' field school (FFS), and through the distribution of promotional material by NARC, non-governmental organizations (NGOs), and ICRISAT. This should encourage the expansion of the area under chickpea production, particularly land that lies fallow [420,000 ha, 30% of the rice (*Oryza sativa* L.) area] during winter (November-March) after the main cereal crop (rice). The technologies that will be used in this project are inexpensive, safe, and have no adverse effect on environment. These technologies when adopted will improve the economic conditions for chickpea production and benefit both men and women farmers. By providing women with a winter cash crop (grown on land currently left fallow), family incomes and food security will be enhanced.

This project is mainly adaptive but has strategic aspects. It is adaptive in that it will be based principally on-farm in Nepal using pest management technologies developed in earlier projects by NARC, ICRISAT, and the Natural Resources Institute (NRI). It is strategic in that it will develop a clear understanding of the limitations and compatibility of these technologies when combined in this production system and on this crop.

A competitive research facility project "What makes it so tasty for the pest—*Helicoverpa armigera*—a feeding stimulant on pigeonpea pod surface" has been active for one year. This project is conducted as a collaboration between ICRISAT and NRI, and Royal Botanic Gardens, Kew, Surrey, UK and has established a substantial culture of laboratory reared insects of *H. armigera* at ICRISAT. The present project will be able to benefit from this facility and a similar facility will be established in Nepalgunj in Nepal.

The project will function at the production system scale using an interdisciplinary approach. It will scale up technologies by extrapolating results from site specific research to wider application domains. Socioeconomic studies will examine policy and institutional issues that are likely to encourage or constrain adoption of appropriate profitable technologies. At ICRISAT, this project will be housed in center project P3 titled "Farmer Participatory Approaches to Integrated Pest and Disease Management" in the Natural Resource Management Program (NRMP).

Specific research objectives of the project are to:

- Integrate proven knowledge with the base technologies of integrated pest management (IPM) developed by collaborators and to promote them as a chickpea production package to poor farmers of Nepal.
- Reduce poverty by increasing chickpea production through adoption of effective and appropriate IPM technologies by resource-poor farmers in Nepal.
- Measure the impact of chickpea adoption by following IPM.

The present pre-project workshop of farmers, NARC, NGOs, NRI, ICRISAT, and other stakeholders has been organized before the first planting to achieve the following objectives:

- Motivate the stakeholders in the project's objectives and activities.
- Design and implement project activities.
- Discuss and fine tune stakeholders' or site specific work plans.

I hope that our united efforts will be able to reestablish chickpea in resource-poor farmers' fields, and expand it into regions where it can play a greater role in the sustainability of the cereal-based cropping systems in Nepal. I wish you a comfortable, successful, and fruitful stay here at the Hotel Narayani. I and my colleagues are looking forward to working with you to successfully complete this mission in promoting IPM of chickpea in Nepal.

SESSION I

BUILDING ON THE PAST: CONSTRAINTS AND OPPORTUNITIES FOR SUSTAINING CHICKPEA PRODUCTION

Chickpea Research in Nepal: An Overview

R K Neupane[1]

Chickpea (*Cicer arietinum* L.) is an important winter pulse crop of Nepal mainly grown in the Terai and inner Terai and in some pockets in lower valleys and river basins in maize (*Zea mays* L.)- or rice (*Oryza sativa* L.)-based cropping patterns. It is grown either as a sole crop or a mixed crop with rapeseed (*Brassica napus* L.) and other winter crops. It occupies the sixth position in area and production of grain legumes in the country (Table 1). Area under chickpea has decreased over the last decade, as a result of increasing incidences of several biotic and abiotic stresses (Pandey et al. 2000), although there is a slight increase in productivity reflecting the impact of improved technologies and their dissemination in past years.

The major biotic stresses are botrytis gray mold (BGM), fusarium wilt, and pod borer (Pande et al. 2000). Abiotic stresses include: growing of chickpea in poor and marginal lands with minimum inputs, delayed sowing as a result of late harvesting of rice, poor plant establishment and sub-optimal plant population, nutritional deficiencies (nitrogen, phosphorus, potassium, and boron), foggy weather, and high relative humidity during flowering. Socioeconomic constraints are lack of government support price, consideration of chickpea as a secondary crop, inadequate seed supply, inadequate extension of relevant technologies, increase in irrigation facilities pushing chickpea to more marginal lands, and instability of production over years and its consideration as a risky crop as compared to other crops such as lentil (*Lens culinaris* Medic.) (Pande et al. 2000).

Research conducted over the years has resulted in the release of six varieties, Trishul, Dhanush, Radha, Sita, Koselee, and Kalika, and identification of disease and insect tolerant varieties such as Avarodhi and ICCX 840508-36. Improved packages of practices for the cultivation of chickpea have been evaluated in farmers' fields and their superiority over farmers' practices established (Neupane et al. 1994).

1. National Grain Legumes Research Program, Nepal Agricultural Research Council, Rampur, Chitwan, Nepal.

Neupane, R.K. 2001. Chickpea research in Nepal: an overview. Pages 23-32 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu. Nepal (Pande, S., Johansen, C, Stevenson, P.C, and Grzywacz, D., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

Table 1. Area, production, and productivity of grain legumes in Nepal, 1997/98.

Crop	Area ('000 ha)	Production ('000 million t)	Productivity (kg ha^{-1})
Lentil	174.9	132.2	758
Grass pea	16.5	10.4	634
Black gram	27.3	18.3	670
Pigeonpea	22.6	18.3	808
Soybean	23.0	17.8	773
Chickpea	16.0	13.2	798
Horse gram	9.0	5.6	622
Others[1]	18.7	13.1	705
Total	308.0	229.0	743

1. Mung bean, cowpea, groundnut, and faba bean.

Source: Ministry of Agriculture, His Majesty's Government, Nepal.

Research thrusts on chickpea

Current research activities on chickpea are focused on:

- Development of bold-seeded desi and kabuli type varieties with high and stable yield.
- Development of diseases (BGM and wilt) and pod borer resistant/tolerant varieties.
- Development of suitable packages of practices for chickpea cultivation.
- Development of suitable management options for biotic and abiotic stresses (BGM, wilt, pod borer, nutritional deficiencies, etc.).
- On-farm research for the effective transfer of technology.

Collaboration with ICRISAT

- Technical collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) was initiated in late 1970s with the exchange of germplasm and trial materials in the form of international nurseries, and technical information on chickpea. This was further strengthened with the signing of memorandum of understanding between Department of Agriculture (DOA)/ICRISAT in December 1987 at the initiation of the Asian Grain Legumes Network in 1987.

- Greater emphasis was laid on the transfer of technology in early 1990s and the Asian Grain Legumes On-farm Research (AGLOR) was initiated in 1991 with support from United Nations Development Programme (UNDP)/ICRISAT. Technical collaboration with ICRISAT continued through the Cereals and Legumes Asia Network (CLAN). Current collaborative activities have been linked with the project "Legume based technologies for enhanced productivity of rice-wheat system in the Indo-Gangetic Plains" funded by the Asian Development Bank (ADB).

Recent research activities

Research activities on chickpea during 1998-2000 included varietal evaluation, agronomic management, disease and insect pest management, and on-farm activities.

International trials were received from ICRISAT as International Chickpea Screening Nursery-Duration Medium (ICSN-DM) and International Chickpea Screening Nursery Desi-Duration Long (ICSN Desi-DL) for evaluation and selection of genotypes under Nepalese conditions. National trials consisting of observation nurseries, initial evaluation trials, and coordinated trials were conducted as multilocation trials at different agricultural research stations (ARSs) and regional ARSs (RARSs) under the Nepal Agricultural Research Council (NARC).

Disease management trials were conducted at RARS Tarahara in the eastern region. Agronomic trials including evaluation of chickpea under rice/chickpea relay system and pod borer management trials were conducted at RARS Nepalgunj in the mid-western region.

On-farm trials on the validation of improved production practices for the management of BGM were conducted in collaboration with ICRISAT at Banke, Bardia, Nawalparasi, Sarlahi, Mahottari, and Sirha districts with active participation of RARS Tarahara, RARS Nepalgunj, National Oilseeds Research Program (NORP), Sarlahi, and National Grain Legumes Research Program (NGLRP), Rampur.

Major research findings (1998-2000)

Varietal improvement

- In ICSN-DM, the genotypes ICCV 97104 (1.84 t ha^{-1}) and ICCV 97117 (1.76 t ha^{-1}) were superior to Dhanush (1.27 t ha^{-1}) (Table 2).

- In ICSN-DL, the genotypes ICCV 97201 (1.07 t ha^{-1}), ICCV 97202 (1.27 t ha^{-1}), ICCV 97203 (0.86 t ha^{-1}), ICCV 97204 (0.67 t ha^{-1}), ICCV 97206 (1.24 t ha^{-1}), ICCV 97207 (0.91 t ha^{-1}), ICCV 97208 (0.77 t ha^{-1}), ICCV 97209 (0.84 t ha^{-1}), and ICCV 97210 (0.74 t ha^{-1}) were selected for elite varietal trials.
- In observation nurseries, ICCV 95126 (1.52 t ha^{1}) and BG 1033 (1.54 t ha^{-1}) produced highest mean yield during 1998/99 and 1999/2000 respectively.
- In initial evaluation trials, ICCV 10 produced significantly higher mean grain yield of 2.12 t ha^{-1} as compared to Dhanush (1.79 t ha^{-1}) during 1998/99 (Table 3) while BG 1206 produced significantly higher grain yield of 1.41 t ha^{-1} as compared to Dhanush (1.15 t ha^{-1}) during 1999/2000.
- In coordinated varietal trials, significantly higher mean yield over years and locations was recorded by ICCX 840508-36 (2.12 t ha^{-1}) followed by ICCX 840508-21 (2.05 t ha^{-1}) as compared to Dhanush (1.42 t ha^{-1}) (Table 4).
- In farmers' field trials, genotype ICCX 840508-36 (1.88 t ha^{-1}) and ICCX 840508-21 (1.72 t ha^{-1}) produced higher mean yield as compared to Dhanush (1.45 t ha^{-1}) (Table 5).
- In an elite varietal trial genotype ICCV 97104 (1352 kg ha^{-1}) produced higher yield than Dhanush (601 kg ha^{-1}).
- The genotypes ICCX 840508-36 and ICCX 840508-21 produced higher yields both in coordinated varietal trials and farmers' field trials over years and

Table 2. Performance of selected chickpea genotypes in International Chickpea Screening Nursery-Duration Medium (ICSN-DM), Rampur, Nepal, 1998-2000.

Genotype (G)	Days to maturity	100-seed mass (g)	Yield (Y) (t ha^{-1}) 1998/99	1999/2000	Mean
ICCV 97104	136	14.4	1.03	2.66	1.84
ICCV 97117	133	16.8	1.23	2.29	1.76
Dhanush	133	9.8	1.02	1.52	1.27
ICCV 97111	135	15.2	1.21	1.29	1.27
ICCV 97106	138	15.6	1.66	0.61	1.23
ICCV 97114	135	26.3	1.01	1.41	1.21
Trial mean (n = 22)	136	18.7	0.81	1.13	0.96
F test	**	**			*
LSD (0.05)	1.94	5.0			0.403
G x Y	NS[1]	NS			*
LSD (G x Y)					0.557

1. NS = Not significant.

locations. The seed mass of these genotypes is also higher and so these lines are candidates for release.

Agronomy

In a study on the performance of relay crops in rice-based cropping systems under rainfed lowland conditions at RARS Nepalgunj, chickpea variety Sita relay sown with rice produced seed yields of 1.20 t ha^{-1}, compared with yields from lentil (1.36 t ha^{-1}) and wheat (*Triticum aestivum* L.) (2.16 t ha^{-1}). When the yields were converted into wheat equivalents, rice/lentil, rice/chickpea + toria (*Brassica.* sp) and rice/chickpea systems were at par (Dutta and Chadaro 1999).

Table 3. Grain yield of chickpea genotypes in Initial Evaluation Trials at two locations in Nepal, 1998/99.

	Grain yield (t ha^{-1})		
Entry	ORPN[1]	RARSN[2]	Mean
BG 1206	1.44	1.69	1.57
GNG 1000	2.46	1.15	1.80
ICCV 10	2.95	1.28	2.12
ICCV 90134	2.47	1.65	2.06
ICCV 90152	2.73	1.68	2.21
ICCV 90254	2.27	1.72	1.85
ICCV 95104	2.71	1.11	1.91
ICCV 95105	2.74	0.78	1.76
ICCV 95118	2.26	1.48	1.87
ICCV 95125	1.52	1.00	1.26
KGD 1168	2.73	1.72	2.23
KWR 108	1.85	2.05	1.95
PantG 114	2.32	1.69	2,00
Dhanush	2.38	1.19	1.79
Mean	2.35	1.42	1.88
F test	**	**	**
CV (%)	13.27	17.47	15.12
LSD	0.511	0.420	0.331
Pooled analysis G x E*			0.468
Location**			0.314

1. ORPN = Oilseeds Research Program, Nawalpur.
2. RARSN = Regional A gricultural Research Station. Nepalgunj.

Plant pathology

- A three-year study on the integrated management of BGM of chickpea at Tarahara (Chaurasia 2000) showed that higher yields can be obtained by cultivating a BGM tolerant variety such as ICCL 87322, and sowing at wider spacing (40 x 10 cm) with 15 days delay in sowing compared with BGM susceptible genotypes (e.g., H-208), narrow row spacing (30 x 10 cm), and normal sowing.

Table 4. Mean grain yield of chickpea genotypes in Coordinated Varietal Trials at five locations in Nepal, 1998/99 and 1999/2000[1].

	Grain yield (t ha^{-1})					
Entry	ORPN	ARSS	RARST	RARSN	ARSH	Mean
ICCL 87312	2.49	2.88	1.11	1.55	1.08	1.82
ICCL 87332	2.37	2.96	1.27	1.85	0.88	1.87
ICCV 90143	1.90	2.30	1.41	1.74	0.55	1.58
ICC V 92101	1.73	2.70	1.21	1.78	0.74	1.63
ICCX 840508-21	2.52	2.97	1.50	2.04	1.20	2.05
ICCX 840508-31	2.15	2.38	1.54	1.70	1.06	1.77
ICCX 840508-32	2.20	2.71	1.18	1.85	0.99	1.79
ICCX 840508-33	2.28	2.83	1.05	1.86	0.71	1.75
ICCX 840508-36	2.66	2.84	1.61	2.19	1.32	2.12
ICCX 840508-38	1.92	2.89	1.37	1.83	0.93	1.79
ICCX 840508-40	2.25	2.96	1.15	1.75	0.94	1.81
ICCX 840508-41	2.15	2.51	1.42	1.70	1.14	1.78
ICCX 840508-44	2.25	2.66	1.24	1.82	0.94	1.78
ICCX 840511-25	1.94	2.67	1.10	1.64	0.84	1.64
ICCX 840511-26	2.12	2.33	1.00	1.76	0.62	1.57
Dhanush	1.95	1.91	1.03	1.56	0.77	1.44
Mean	2.12	2.65	1.27	1.85	0.92	1.77
Pooled CV(%)						20.38
F test genotypes**						0.176
Year x Location**						0.139
Year**						0.62
Location**						0.99
Genotype x Year*						0.250
Location x Genotype*						0.367

1. ORPN = Oilseeds Research Program, Nawalpur; ARSS= Agricultural Research Station. Surkhet; RARST - Regional Agricultural Research Station, Tarahara; RARSN = Regional Agricultural Research Station, Nepalgunj; and ARSH = Agricultural Research Station, Hardinath.

- In a study on the management of BGM with bio-agents at Tarahara during 1997-2000, three sprays of Bavistin® (0.1%) plus *Trichoderma viridae* gave the highest yield.
- In a study on host plant resistance to BGM at Tarahara, GL 88341, GL 90236, and ICCL 87332 showed low disease severity and good pod formation (Chaurasia, in press). Other promising lines were ICCX 840508-33, ICCX 840508-36, ICCX 840508-32, and ICCX 840508-26.
- A wilt sick plot was developed at RARS Nepalgunj.

Entomology

- Yield loss assessment due to *Helicoverpa* pod borer: There was 0-75% damage due to pod borer during 1996-98 in Banke and Bardia districts. Damage was more in closely planted and late-sown crops that did not receive any plant protection measures (Thakur 1998).
- A pheromone trap study in the last few years has revealed that *Helicoverpa* pod borer attains its peak between 15 March and 15 April.
- Genotypes less susceptible to *Helicoverpa* pod borer have been identified: PDG 84-16, ICCV 88102, GL 88341, Avarodhi, ICCX 840508-36, ICC 506, and ICCX 900239-BP.

Table 5. Performance of chickpea in Farmers' Field Trials at four locations in Nepal, 1999/2000[1].

	Grain yield (t ha^{-1})				
Entry	GLRP	TRPB	RARST	NORP	Mean
ICCX 840508-21	1.95	0.56	1.46	2.96	1.72*
ICCX 840508-36	2.01	0.60	1.54	3.37	1.88*
ICCX 840508-40	1.40	0.42	0.75	3.00	1.40
ICCX 840508-41	1.60	0.39	1.18	2.93	1.53
ICCX 840511-25	1.21	0.51	0.61	2.68	1.25
ICCX 840511-26	1.17	0.59	0.96	2.46	1.30
Dhanush	1.52	0.40	1.25	2.62	1.45
Mean	1.56	0.50	1.11	2.86	
F test					*
CV(%)					20.14
LSD (0.5)					0.280

1. GLRP = Grain Legumes Research Program; TRPB = Tobacco Research Program, Belachapi; RARST = Regional Agricultural Research Station, Tarahara; NORP = National Oilseeds Research Program.

- In a study on the efficacy of biopesticides [neem and nuclear polyhedrosis virus (NPV)] on *Helicoverpa* management, insect mortality was significantly higher in all the treatments compared to the control plots.
- Intercropping chickpea with wheat, barley (*Hordeum vulgare* L.), or linseed (*Linum usitatissimum* L.) was effective in lowering the population of *Helicoverpa* pod borer.
- Syrphid fly (*Syrphus* spp) (a predator of *Helicoverpa)* was observed in chickpea intercropped with coriander (*Coriandrum sativum* L.) at the flowering stage, and ladybird beetle (*Coccinela septpunctata*), a coccinelid predator, was high in chickpea intercropped with wheat.

Mineral nutrition

- In on-farm trials at Nawalparasi and Chitwan districts, application of boron at 0.5 kg ha^{-1} resulted in 25.9% to 57.9% increase in seed yield of chickpea over the control. Variation in crop response to boron among the farmers was attributed to variation in the application of compost.
- Critical level of boron concentration in the apical tissue associated with 90% of grain yield was 17.5 ppm at the physiological maturity stage.

IPM study on chickpea in farmers' fields

Improved packages (IP) of chickpea production consisting of improved variety Avarodhi, *Rhizobium* inoculation, seed dressing with fungicides, need-based application of Bavistin® and Thiodan®, and recommended fertilizer dose were compared with farmers' practices (FP). In 105 farmers' participatory on-farm trials in 1999/2000, at Rajahar (Nawalparasi district), Lalbandi (Sarlahi district), and Bardibas (Mahottari district), results showed that in FP the incidence of wilt/root rot was 40-133%, BGM 30-50%, and pod borer damage 330-900% higher than in IP. Variation in disease and pod borer damage was recorded across locations and farms. In IP, nodulation, pods $plant^{-1}$, and grain yields were higher by 64-97%, 44-103%, and 44-196% respectively as compared with FP. Economic analysis (1999/2000) revealed a marginal benefit-cost ratio of 3.84-5.72 for additional inputs in IP. Farmer's reaction about the IP was very positive.

Future research strategy on chickpea

- Evaluation of new germplasm and breeding materials.
- Collaborative breeding.

- Evaluation of chickpea in rice-maize based systems.
- Research on integrated crop management [agronomy, soil science/ microbiology, integrated pest management (IPM)/integrated disease management (IDM) for major insect pests and diseases].
- Development of a BGM forecasting model for assured chickpea production.
- On-farm trials on chickpea for alleviating the biotic and abiotic constraints.

Acknowledgments

I wish to express sincere gratitude to Mr D Joshy, Executive Director, Mr D S Pathic, Director, Crops and Horticulture, and Dr B Pradhan, Director, Planning and Coordination, NARC for timely guidance and support to NGLRP. I am highly indebted to the support provided by the Chiefs of Disciplinary Divisions, Regional Directors and ARS Chiefs under NARC. Sincere thanks are due to the ICRISAT team, and Dr Suresh Pande in particular, for providing trial materials and technical guidance in the conduct of experiments. Last but not the least, I am thankful to the scientists of NGLRP and collaborating stations for the conduct of experiments and compilation of results.

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Opportunities for Increasing Chickpea Production in Nepal

C Johansen[1]

Grain legumes provide important and traditional components of the Nepalese diet. They are grown mainly as subsistence crops by resource-poor farmers but their per capita availability is low, currently standing at <10 kg per capita per annum (Pandey et al. 2000). Although production of some grain legumes, such as lentil (*Lens culinaris* Medic.) and pigeonpea (*Cajanus cajan* (L.) Millsp.), have been increasing over recent years (FAOSTAT 2000), grain legumes generally are being relegated to marginal lands by the increased requirement for cereal crop production, primarily rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.), and also due to their riskiness of cultivation as perceived by farmers.

Lentil is by far the major grain legume crop of Nepal, with 132,290 t produced on 174,594 ha in 1998/99 (FAOSTAT 2000). Chickpea (*Cicer arietinum* L.) ranks after pigeonpea, khesari (lathyrus) (*Lathyrus sativus* L.), black gram (*Vigna mungo* (L.) Hepper), and soybean (*Glycine max* (L.) Merr.) in area and production, with nearly 13,000 t of chickpea grain produced on about 16,000 ha in 1998/99 (FAOSTAT 2000). A major reason for the decline in chickpea cultivation and production in recent years has been epidemics of botrytis gray mold (BGM) disease caused by *Botrytis cinerea* (Pandey et al. 2000). This disease is most severe in the more humid eastern part of Nepal and there has consequently been a shift in chickpea cultivation from the eastern to the western Terai (Pandey et al. 2000).

There are several compelling reasons why the present downward trend in chickpea cultivation in Nepal should be reversed and production substantially increased. A prime reason is improvement of human nutrition, as chickpea is an important source of protein, vitamins, and minerals, and is already a traditional component of the Nepalese diet but is becoming increasingly scarce. Due to this scarcity, the increasing prices of chickpea relative to other staple foodstuffs make cultivation of the crop an increasingly profitable enterprise. As the demand and prices for chickpea are also increasing throughout South Asia, there are good

1. Consultant in Agricultural Research and Development, Apartment 2-B, Palmdale, Plot No. 6, Road No. 104, Gulshan-2, Dhaka. Bangladesh.

Johansen, C. 2001. Opportunities for increasing chickpea production in Nepal. Pages 33-47 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S., Johansen, C, Stevenson, P.C., and Grzywacz, D., eds.). Patancheru 502 324, Andhra Pradesh. India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB. UK: Natural Resources Institute.

prospects for export markets of chickpea from Nepal, as has happened for lentil. This could simultaneously benefit resource-poor cultivators of the crop and the national economy as a whole. Chickpea can be an important contributor to soil fertility of cropping systems, through its additions of biologically fixed nitrogen (N) and organic matter to the cropping system (Kumar Rao et al. 1998). This is particularly important in Nepal where usually less than optimum fertilizer is applied and nutrient depletion of cropping systems is an increasing problem (Pandey 1991).

Although chickpea in Nepal faces several biotic and abiotic constraints, causing low and unstable yields at a national level, the environment of the Terai at least is conducive to a high yield potential (>2.5 t ha^{-1}) if the major constraints can be alleviated. Documentation of constraints to chickpea production in Nepal has recently been updated and alleviatory measures are available for most of these (Pandey et al. 2000). However, there remains a large technology gap between existing farmers' practices and alleviatory measures that can feasibly be applied to substantially increase and stabilize yields of chickpea in Nepal. Recent on-farm research and development endeavors have demonstrated that it is possible for resource-poor farmers in Nepal to implement improved chickpea cultivation practices that result in attractive profits (Pande 1999, Pande and Narayana Rao 2000). This paper elaborates on a proposed methodology for reducing the technology gap and for placing improved cultivation practices for chickpea in the hands of resource-poor farmers in Nepal so as to substantially improve their farm income and thus make inroads into endemic rural poverty.

Recent trends in chickpea production in Nepal

Statistics collated by the Food and Agriculture Organization of the United Nations (FAO) indicate trends of declining area and production, but increasing yields, of chickpea in Nepal over the last decade (Table 1). The increasing trend in yields may be a result of the gradual shift over time in chickpea cultivation from the eastern to the drier western Terai, where the crop is less prone to BGM attack (Pandey et al. 2000). However, these statistics do not tally with monitoring tour observations made during the 1997/98 and 1998/99 seasons (Pande 1999). In 1997/98, there was a severe BGM epidemic on chickpea throughout Nepal, coinciding with the heavy winter rains of that season. In the subsequent season, very little chickpea seed was available locally and most seed planted was seemingly derived from India. Thus, official statistics seem to have overestimated actual chickpea production in both these seasons, as observed from monitoring tours and farmer interviews across the Terai of Nepal. If declining trends in area and production are to be reversed then reliable parameters for these statistics are

Table 1. Annual values for area, production, and yield of chickpea in Nepal from 1988 to 1999.

Year	Area (ha)	Production (t)	Yield (kg ha^{-1})
1988	29,690	15,620	526
1989	28,830	17,090	593
1990	28,190	16,620	590
1991	27,040	16,700	618
1992	26,970	16,570	614
1993	28,140	15,950	567
1994	24,098	13,565	563
1995	22,793	16,058	705
1996	19,080	13,640	715
1997	19,130	14,030	733
1998	19,280	13,512	701
1999	16,046	12,798	798

Source: FAOSTAT (2000).

essential. A properly quantified baseline against which any improvements can be measured is necessary if adoption and impact of improved chickpea production technologies are to be monitored. The project on chickpea integrated pest management (IPM) funded by the UK Department for International Development (DHD) needs to be proactive in assembling and verifying such data, at least for project credibility.

Demand and need for increased chickpea production in Nepal

There is an ever-increasing shortfall of chickpea in South Asia which is being met by imports primarily from Australia, North America, and Turkey (FAOSTAT 2000). In Nepal, there is a need to increase chickpea production to both meet internal demand as well as exploit export opportunities to neighboring countries, as has occurred for lentil. Due to relatively high prices for chickpea grain, and continuing upward trends, and low input costs compared to other major crops (e.g., rice and wheat), chickpea presents a major opportunity for resource-poor farmers, the traditional cultivators of chickpea, to enhance their incomes.

Inadequate nutrition is recognized as a problem among the rural poor in Nepal and increased consumption of chickpea could alleviate this problem. Chickpea is a rich source of protein, minerals, and vitamins which supplements and complements a cereal-based diet (ICRISAT 1991). Further, chickpea is already a traditional component of the Nepalese diet and so there are no problems of consumer acceptance as experienced with exotic or novel foodstuffs. Thus promotion of chickpea production and consumption should be a major strategy to improve human nutrition in Nepal.

Depletion of major nutrients and declines in soil organic matter are an increasing problem for agriculture in Nepal, particularly under conditions of crop intensification (Pandey et al. 1998). Chickpea is well known for its positive residual effects in cropping systems of the Indo-Gangetic Plain (Kumar Rao et al. 1998). Chickpea cultivation contributes biologically fixed N, increases soil organic matter, breaks pest and disease cycles for non-leguminous crops, and perhaps increases availability of soil phosphorus (P) in the system. The deep and robust root system of chickpea allows extraction of soil moisture at deeper layers than other rabi (postrainy season) crops, such as wheat or lentil (Yusuf Ali et al., personal communication). This is a particularly useful trait in the western Terai where winter rains are less and soils are light textured, making chickpea less prone to drought stress than lentil and other rabi crops.

Major technical constraints and their alleviation

The major technical constraints to chickpea production in Nepal are discussed below. They are defined as major as they can cause a yield reduction of at least 500 kg ha^{1}. They are listed below, not in order of severity, but according to when they are most likely to occur in the crop calendar. Although it is apparent that there are many potential and actual serious constraints, for each there are alleviatory measures available that can feasibly be applied in the fields of resource-poor farmers. The challenge is to find the appropriate combination of alleviatory measures for specific agro-ecosystems. But a first step is to list out the major constraints and relevant alleviatory measures.

Late sowing

Sowing of chickpea in late November or early December results in restricted vegetative growth, due to limited availability of surface soil moisture for seedling establishment and exposure of seedlings to low temperature stress. The resultant restricted biomass formation limits the number of nodes for pod formation and the delayed phenological development exposes the crop to terminal drought and heat stress. Root development is also retarded by late sowing and hence the crop has limited capacity to extract moisture from deeper soil layers. Late sowing of chickpea in rice-based cropping systems in Nepal is often necessitated by the late harvest of rice.

This problem can be minimized if farmers adopt improved cropping system management strategies, to adjust timings of crops in rotation so as to ensure timeliness of operations for each crop. For rice-based systems, use of shorter duration rice varieties and timely transplanting or direct seeding of rice could ensure that rice is harvested by early November, in time for optimum planting of chickpea.

Poor plant stand

In Nepal, as in much of South Asia, chickpea seed is normally hand broadcast into uneven seedbeds prepared by animal-drawn plows (Jagdish Kumar et al. 1997). Often seedling emergence is uneven and the plant population is suboptimal for maximum yield formation. Seedling diseases can be prevalent when the crop is sown after rice or when chickpea is repeatedly grown in the same plot of land.

An adequate plant stand can be ensured, with little additional financial cost, by taking the necessary precautions at crop establishment (Jagdish Kumar et al. 1997). A first consideration is use of quality seed with adequate germinability (which farmers themselves can easily test). Care in preparing an even seedbed with good tilth and with adequate soil moisture for seed germination is required. Practices of fungicidal application to seeds to protect against seedling diseases and *Rhizobium* inoculation to ensure good nodulation are well known (Jagdish Kumar et al. 1997). Seed priming, which is simply soaking the seed overnight prior to sowing, can also be beneficial to chickpea sown in problem soils (Musa et al. 1999).

Nutrient deficiencies

The more important nutrient deficiencies limiting chickpea in Nepal are N, P, boron (B), and possibly molybdenum (Mo) (Srivastava et al. 1997, Pandey et al. 2000). These deficiencies, particularly Mo deficiency are exacerbated by acid soil conditions which are found in the eastern Terai, inner Terai, and foothills of the Himalayan Range (Pandey et al. 2000). Low soil pH itself may have direct adverse effects on the *Rhizobium* nodulation process and root growth.

Once diagnosed for a particular target region, there are a range of remedies available for these mineral nutrient problems, that are amenable for use by resource-poor farmers. In acid soils (pH <5.5) it is advisable to lime pellet the seed, as part of the process of inoculating it with *Rhizobium.* Acid soils can of course be amended by direct application of lime to soil or by raising soil organic matter levels, but large applications of lime or organic materials are needed to meaningfully ameliorate the soil. Soil applied fertilizer can remedy P, B, and Mo deficiencies and B and Mo can also be applied in a seed pellet. Further, B can be applied as a foliar spray when it is most needed at the time of reproductive development. Although these treatments require care and precision to ensure their effectiveness, they can be implemented by resource-poor farmers if appropriate training is given [S P Srivastava, Nepal Agricultural Research Council (NARC), Rampur, personal communication, 1999].

Root and lower stem diseases

In Nepal, root and lower stem diseases of chickpea are mainly attributed to fusarium wilt (caused by *Fusarium oxysporum* f. sp *ciceris)* and collar rot *(Sclerotium rolfsii)* (Pandey et al. 2000). Collar rot manifests itself at the seedling stage while *Fusarium* can attack at either early or late growth stages.

There are high levels of host plant resistance (HPR) to fusarium wilt in chickpea and most of the recently released cultivars have wilt resistance as they pass through wilt sick plots in the breeding process. However, wilt incidence can be further minimized by seed fungicidal treatment and avoidance of repeated chickpea cultivation in the same field (Jagdish Kumar et al. 1997). On the other hand, there are no substantial levels of HPR for collar rot in chickpea but the disease can be minimized by fungicidal seed treatment, removal of undecomposed organic matter from the previous crop prior to sowing, and appropriate crop rotation (Jagdish Kumar et al. 1997).

Botrytis gray mold

Botrytis gray mold is by far the most serious constraint to chickpea in Nepal, and it can reach epidemic proportions in wet winters (Chaurasia 1998). The disease is favored by a humid microclimate in dense canopies. The major effect of the disease is to attack flowers and developing pods, thereby limiting yield formation.

There are a range of options that can be deployed to limit effects of the disease in farmers' fields (Pande et al. 1998). As yet, no substantial levels of HPR have been identified in the chickpea germplasm or in released cultivars. But there are genotypes with lesser susceptibility to the disease (e.g., ICCL 87322) which can be deployed in disease-prone locations (Pande et al. 1998). There are long-term prospects of developing chickpea cultivars with high levels of resistance to BGM through interspecific crosses (Singh et al. 1998) or genetic transformation. However, despite HPR not being a currently viable option against BGM there are several management practices that can be used to alleviate the disease. A first consideration is to use seed harvested from disease-free fields, as BGM can be seedborne. Fungicidal seed treatment can also impede disease development. A major consideration is to prevent development of a dense crop canopy conducive to disease development. This can be achieved by avoidance of early planting, prevention of dense plant population, and canopy thinning (Saxena and Johansen 1997). Foliar application of a fungicide such as Bavistin® can also effectively control BGM development. These techniques of managing BGM have been shown to be effective in farmers' fields in Nepal (Pande 1999, Pande and Narayana Rao 2000).

Gram pod borer

The gram pod borer *Helicoverpa armigera* emerges as a major threat to chickpea yield formation once BGM is controlled. In general, this pest has been observed to be increasing in its incidence and severity on various crops in northern India and Nepal. Increased use of chemical insecticides is exacerbating the situation by their effects in reducing natural enemies and the development of insecticide resistance in *Helicoverpa.*

Although a formidable foe, it is possible to manage *Helicoverpa* pod borer in chickpea crops, by careful surveillance of pest incidence such that corrective action can be taken when threshold levels of the pest are breached (Ranga Rao and Shanower 1999). Use of biological pesticides, such as *Helicoverpa* nuclear polyhedrosis virus (HNPV), can potentially overcome problems like decimation of natural enemies and development of insecticide resistance. A major objective of the current project is to implement such techniques in farmers' fields.

Terminal drought and heat stress

Grain filling of chickpea is sensitive to rapidly rising temperatures (maximum >30°C) and depleting soil moisture in spring in Nepal (during March) and this can be a particular problem for late-sown chickpea. The problem can be avoided by timely sowing of the crop and use of varieties of shorter duration.

Seed storage pests

Chickpea seed is particularly susceptible to bruchid (*Callosobruchus* spp) attack and precautions are necessary in storing chickpea seed (Ranga Rao and Shanower 1999). Bruchids can infest a standing crop and so the seed should be cleaned and sun dried prior to storage. Effective storage can be achieved, even at village level, by adequate sun drying, adding naphthalene balls to the seed, sealing in a polythene bag, placing the bag in an air-tight container and placing the container in a dry place well above ground level (Musa 1998).

Socioeconomic constraints

Like most pulse crops in South Asia, chickpea is still generally considered as a subsistence crop, locked in a cycle of low inputs and low returns (Johansen et al. 2000). There needs to be greater realization, by all concerned, that it can indeed become a commercial crop with remunerative returns. This realization can only be achieved by widespread on-farm demonstration of the profitability and reliability of chickpea cultivation, in relation to other farming enterprises.

Some of the inputs required for alleviation of the major constraints mentioned above are not generally available to resource-poor farmers in Nepal. These include such inputs as appropriate pesticides, *Rhizobium* inoculum, and trace element fertilizers. Where such inputs have been demonstrated to have a high benefitxost ratio, it is suggested that some Government facilitation is necessary to ensure timely availability of inputs and credit for their purchase. However, with wider realization by farmers and commercial suppliers of high returns on investment in such inputs, their general accessibility should increase.

Although many chickpea varieties have been released in recent decades through publicly funded breeding programs in South Asia, adoption of improved varieties by farmers has been at an unacceptably slow pace. Publicly funded seed production enterprises have failed to provide adequate seed of newly released varieties for them to significantly replace existing varieties, which largely remain as traditional landraces. Commercial seed producers usually concentrate on hybrid seed because of the relatively low returns to be obtained from self-pollinated crops, including chickpea. Therefore, improvement of village level seed production, storage, and distribution capability offers the best hope of more widespread distribution of quality seed of improved chickpea varieties.

Again, as a consequence of its status as a subsistence crop, farmers have little knowledge of the various technologies, as referred to above, that can effectively alleviate constraints to the crop. It is proposed that this situation can be overcome by adoption of an on-farm research and development (OFR&D) approach, as described in the next section.

Another socioeconomic constraint, important for chickpea as well as most crops, is marketing (Joshi et al. 2000). This includes various problems such as storage, transport, low price to farmers at harvest, and export procedures. Government facilitation may be needed to overcome some of these problems for such a relatively minor crop as chickpea but it is suggested that a continuation of high prices of chickpea grain will favor rationalization of these constraints.

Proposed methodology to increase chickpea production

The earlier discussion suggests that it is indeed feasible to reverse chickpea production trends in Nepal and substantially increase production in a matter of a few years. However, implementation of this goal would require adoption of a holistic approach to technology transfer and refinement. The appropriate approach suggested is that of OFR&D, developed from ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) experience over the past 15 years or so. The approach is outlined in Figure 1.

Figure 1 illustrates that the pathway from problem identification to impact of an improved technology can, and should, essentially remain "on-farm" with appropriate linkage and feedback amongst the different steps in the process.

The starting point is adequate characterization of the target environment and definition of extrapolation domains (other locations where site specific findings may also apply). The importance of thorough constraint analysis, highlighting farmer perceptions, is emphasized, to reach a prioritization of constraints that can be addressed. In the case of chickpea, as for most crops, there exists a range of potential solutions "on the shelf", usually derived from on-station and laboratory research. But it is necessary to evaluate these in farmers' field situations to establish what modifications may be needed if they are to be of practical benefit. There needs to be a close interaction between on-station trials and simple on-farm trials in order to identify technologies that may be further evaluated on-farm. Where single factor treatments have been shown to be beneficial, the next step is to assemble simple packages of technology and test them in comparison with existing farmer practices in operational scale on-farm plots. Farmers would become increasingly involved in the design of such trials, modifying treatments to suit their particular needs and circumstances. Successful results obtained with improved packages should lead to wider scale evaluation and then demonstration of the improved technology. At this point it becomes possible to measure farmer adoption of the technology and, eventually, assess whether the introduction of the technology affects the well-being of the farming family, the rural community, and the nation as a whole.

This approach has essentially been followed in OFR&D primarily aimed at managing BGM of chickpea in Nepal over the previous two seasons (Pande 1999, Pande and Narayana Rao 2000). Yields exceeding 2 t ha^{-1} have been consistently obtained across the Terai of Nepal in farmer-managed plots where improved IPM practices have been followed; yields in plots where unimproved practices were followed remained at around 1 t ha^{-1} or below (near the national average yield for chickpea in Nepal). This process now needs upscaling and broadening in scope,

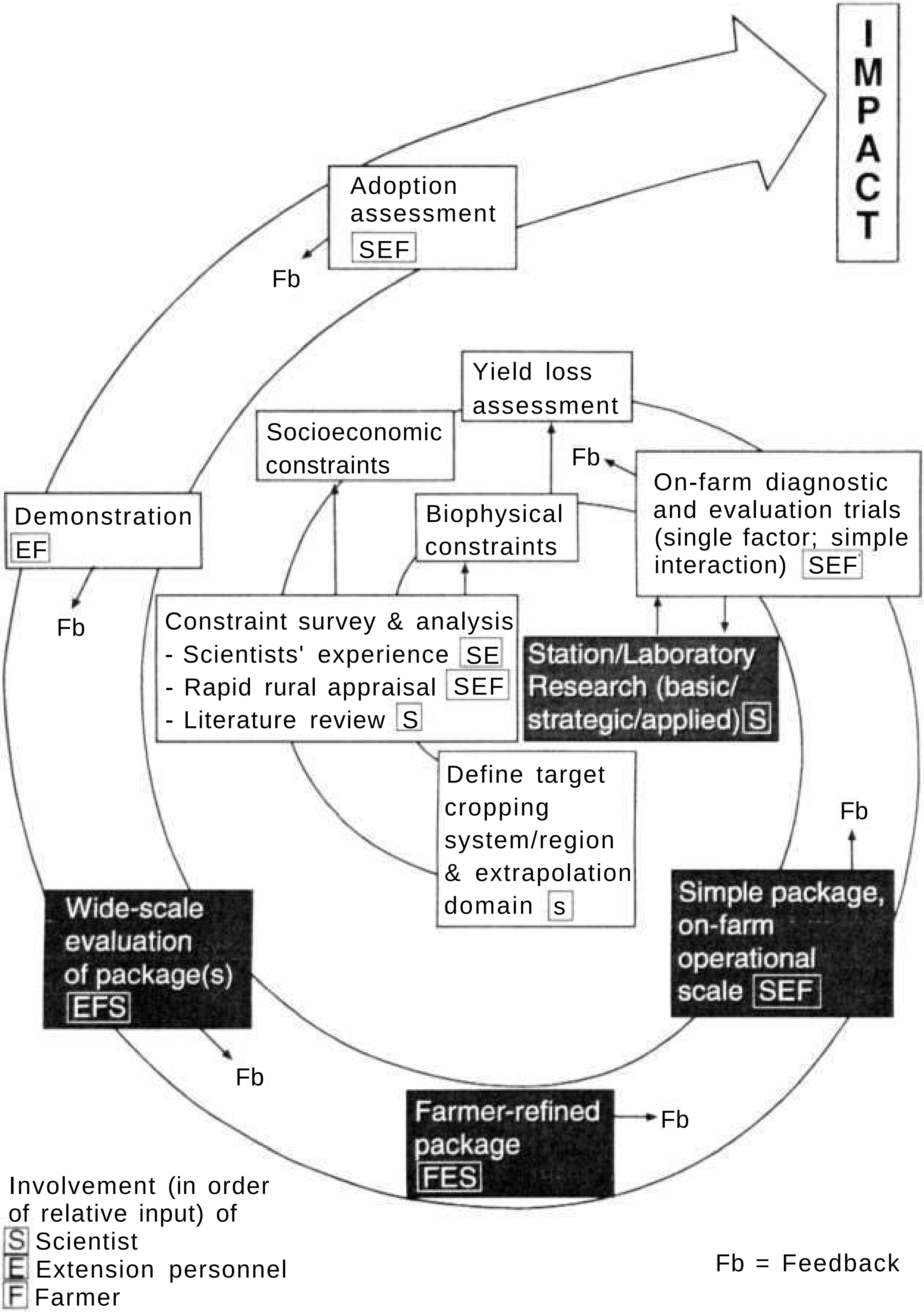

Figure 1. On-farm research and development approach in the legumes in Rice and Wheat Systems Project.

which is to be attempted under the current DFID-funded project. Previous efforts concentrated on management of BGM, the primary constraint of chickpea in Nepal, but in the context of integrated crop management (ICM). Once damage due to BGM is minimized, and pod formation can proceed, pod borer takes over as the major threat to realizing reasonable grain yields. Thus the present project focuses on sustainable pod borer man4agement options, but again with an ICM perspective. This ICM perspective should be reinforced and also an integrated systems management (ISM) approach needs to be followed, whereby chickpea cultivation is considered in the context of the total farming enterprise and overall well-being of the rural community. Such considerations are in any case necessary in order to eventually be able to measure impact of project activities.

To carry forward this OFR&D process for chickpea in Nepal it is essential at this stage to ensure that all of the relevant players adopt "ownership" of the project, in order to feel the necessary motivation to contribute their respective inputs. Those involved at this stage, along with the participating farmers of course, are the research entities [NARC, Natural Resources Institute (NRI), ICRISAT], Government extension agency (Ministry of Agriculture), non-governmental organizations (NGOs), and local administrative bodies. It is also intended that commercial suppliers and entrepreneurs will become interested and involved in the project.

As this project evolved from the agricultural research perspective there is a temptation to give undue emphasis to following up on further research aspects, as "one question answered reveals many other interesting questions". Although there is indeed some adaptive research that needs to be followed up under the project, most of the technologies required to make a difference are known and have been tested on farmers' fields and therefore most effort and resources should be directed towards package evaluation and demonstration. The project should provide increased opportunities for subject matter specialists to visit farmers* fields, assess uptake of the technologies with which they are associated and better understand how their specialization interacts with other aspects of the total farming process.

It is proposed that particular care be given to planning how to quantify adoption and impact of technologies introduced under the project. For this purpose a sound baseline needs to be established. Adequate pre-planning is also needed for appropriate dissemination of information regarding the project, from field days to formal publication of results. One aspect that needs to be thought at an early stage is how to establish and implement an appropriate and sustainable seed processing, storage, and distribution scheme for chickpea. Failure to adequately pre-plan can result in inefficiency of effort and information gaps at the end of the project.

This project is predominantly farmer field oriented and therefore subject to the uncertainties faced by resource-poor farmers, such as vagaries of weather, input supply, markets, etc. Therefore, there needs to be flexibility in project management procedures, especially fund allocation, so as to allow timeliness of operations, particularly with the occurrence of unpredicted events.

Expected outcomes

By the end of this three-year proposed project, there should be some tangible outputs indicating project progress. These can be summarized as follows:

- Farmers, researchers, extension personnel, and NGOs should become sensitized to the OFR&D process, which would also be applicable to cropping systems other than those incorporating chickpea and other agro-ecosystems generally.
- Effective management of BGM and pod borer, the main constraints to chickpea in Nepal, would have been widely demonstrated on an operational scale.
- A refined package of practices for chickpea for the target agro-ecosystems would have been established.
- A better focused basic and applied research agenda for chickpea and related cropping systems would have been formulated.
- A viable, sustainable chickpea seed production scheme would be operational.
- It is considered feasible that chickpea area in Nepal would return to 30,000 ha with the national average yield being around 1 t ha^{-1}.
- There would be a measurable increase in income of farmers attributable to increased chickpea cultivation in the original project target areas.
- There would be a measurable increase in commercialization of farm enterprises additional to chickpea cultivation in the original target areas, i.e., a perceptible move away from subsistence farming to small-scale commercial farming, catalyzed by the chickpea experience.
- Environmental benefits of introduction of eco-friendly pesticides and positive residual benefits to cropping systems by growing chickpea would be apparent.

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Constraints and Opportunities for Sustainable Chickpea Production in Nepal

D S Pathic[1]

Chickpea (*Cicer arietinum* L.) is an important winter pulse crop of Nepal mainly grown in the Terai and inner Terai in maize (*Zea mays* L.)- or rice (*Oryza sativa* L.)-based cropping patterns. It occupies the sixth position in area and production of grain legumes in the country. Area under chickpea has shown a decreasing trend for the last decade, as a result of increasing incidence of a number of biotic and abiotic stress factors, although a slight increase in productivity has been recorded in recent years. Several constraints to higher production of chickpea in Nepal have been reported (Neupane et al. 1994, Pandey et al. 2000) (Table 1).

Chickpea is a traditional crop, and is an important item in the daily diet as various food products. Therefore, there are ample opportunities for the expansion of area under the crop and increase in production as given below:

- Available technologies: Six improved varieties of chickpea—Dhanush, Trishul, Radha, Sita, Koselee, and Kalika—have been released. Varieties with tolerance to diseases and pod borer have been identified, e.g., Avarodhi, ICCX 840508-36, and ICCL 87332.
- The demand for chickpea is increasing and in the year 2020, 30,000 t of chickpea would be needed to meet the demand of increased population. Hence, there is a need to increase its production. The production can be increased as there is an increasing trend in the productivity of chickpea.
- After rice harvest, there is a great scope of introducing chickpea, a drought tolerant crop, in rice-fallows. Current estimate of rice-fallows in the country is about 420,000 ha.
- Research on low cost production of chickpea could lead to its exports.

1. Director, Crops and Horticulture, Nepal Agricultural Research Council, Khumaltar, Lalitpur, PO Box 5459, Nepal.

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Table 1. Constraints to chickpea production in Nepal	
Constraint	Importance
Diseases (causal organism)	
Botrytis gray mold *(Botrytis cinerea)*	Important
Wilt (*Fusarium oxysporum* f. sp *ciceris)*	Important sometimes
Collar rot *{Sclerotium rolsfii)*	Important sometimes
Root rot *(Rhizoctonia bataticola)*	Important sometimes
Chickpea stunt (bean (pea) leaf roll virus)	Important sometimes
Insect pests	
Pod borer *(Helicoverpa armigera)*	Important
Cut worm (*Agrotis ipsilon)*	Important sometimes
Variety	
Inadequate number of high-yielding varieties	Important sometimes
Lack of varieties for late-sown condition	Important
Lack of disease and insect resistant varieties	Important
Lack of genotypes suitable for light soil conditions	Important sometimes
Unavailability of improved seeds in adequate quantity	Most important
Abiotic constraints	
Sudden rise of temperature during pod-filling stage	Important sometimes
Uneven distribution of rainfall during growing season	Important sometimes
High relative humidity	Important
Variable and unpredictable winter duration	Important
Suboptimal plant population	Most important
Pre- and post-sowing moisture stress	Important sometimes
Lack of proper fertilizer use	Important sometimes
Lack of an improved technological package for chickpea cultivation	Important sometimes
Socioeconomic constraints	
Instability of crop yield and grain prices	Important
Increased irrigation facilities motivating farmers to shift to wheat and other crops	Important sometimes
Inadequate motivation in integrated management of biotic and abiotic constraints of chickpea	Important sometimes

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Revival of Chickpea Cultivation in Munalbasti Village in Nepal

B V Khanal[1]

More than 80% population of Nepal is engaged in agriculture. People living in the western part of Nepal began agriculture on the lands cleared by deforestation. Wheat (*Triticum aestivum* L.), mustard (*Brassica* sp), and grain legumes are our main winter crops. In the beginning when the soil was new, every crop yielded high. Amongst several options, farmers used to give high priority to chickpea (*Cicer arietinum* L.) cultivation. Emphasis was laid on good chickpea crop cultivation, but its cultivation became uneconomical and yields started decreasing. Most of the plants used to die and insects infested the surviving ones and caused total damage.

Over a period of time, farmers started thinking of alternative crops and in the last 12-13 years chickpea became a dying crop. It was virtually eliminated from the cropping system. In 1998, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh, India and the Regional Agriculture Research Station (RARS) of Nepalgunj, Nepal started a joint effort that included on-farm demonstration of improved chickpea cultivation. It included treatment of seed and other advanced agronomical practices for cultivation of chickpea. In 1998, farmers who grew chickpea on an experimental basis were satisfied with the yields obtained. Consequently, in the second year (1999/2000) more and more farmers participated in chickpea cultivation as they got free counseling and seeds of better varieties than the locally available chickpea seeds. Following the improved chickpea production technology, participating farmers harvested 1-1.5 t ha^{-1} of chickpea grains. Several of the participating farmers now have a good amount of seed stored for next year sowings. Some of us have even sold seeds to other farmers and earned a good profit.

We are grateful to scientists from Nepal Agricultural Research Council (NARC) and ICRISAT for introducing a new technology for chickpea cultivation—chickpea revolution. Now we are marching towards betterment with respect to

1. Lead Fanner (Group 1), Village Munalbasti, Kalika VDC, District Bardia, Bheri Zone, Nepal.

Translated from Nepali.

Khanal, B.V 2001. Revival of chickpea cultivation in Munalbasti village in Nepal. Pages 51-52 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S. Johansen. C., Stevenson, PC, and Grzywacz, D., eds). Patancheru 502 324. Andhra Pradesh. India: International Crops Research Institute for me Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

chickpea cultivation and family nutrition. We are heartily indebted to Dr Suresh Pande who painstakingly took the job and has been taking considerable interest in the program. When chickpea was totally a crop of the past, he revived it and we are now getting good production. We hope that he will continue to do good for us in the coming years too.

We will definitely do our part to promote the cultivation of chickpea in our district. We are again grateful to ICRISAT, NARC, and RARS, Nepalgunj for inviting us to participate in this symposium and hope that we will get the same opportunity in future too.

Rehabilitation of Lost Crop - Chickpea in Munalbasti Village in Nepal

R Thapa-Magar[1]

Nepal is an agriculture-based country with more than 80% of our population engaged in agricultural activities. In Bardia district, we have two crop seasons in a year, the rainy season (*Barkha*) and the winter season (*Hiunde*). In winter, we grow legume crops including chickpea (*Cicer arietinum* L.). If we look back at the history of cultivation of chickpea, it was quite popular in the past but gradually the plants became infected by diseases (and insects) and production became almost negligible. Thus we were forced to abandon its cultivation.

A few years ago Dr Suresh Pande of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and scientists from the Regional Agriculture Research Station (RARS), Nepalgunj, Nepal gave us free seed, fertilizer, and pesticide and also provided guidance in chickpea cultivation. In the first year, 1998/99, a group of only 28 farmers started chickpea cultivation with great reservations. We obtained good yields with the use of improved seed (Avarodhi), fertilizer, pesticide, and the recommended management techniques. We sent a request to ICRISAT for further guidance. In the second phase (1999/2000) the number of participating farmers increased to 180. This time also we received the required inputs and assistance from the scientists. Many of the farmers also received financial benefit by selling chickpea seeds. This had a great impact on the farmers. But now the seed stored for the next crop is being attacked by insects. Therefore we need training in seed storage.

We do not have advanced ways and means to preserve seeds. The experience of last two years shows that if we continue to get good inputs from ICRISAT and RARS, we can overcome the dependence on imports of chickpea. Our region is also appropriate for cotton (*Gossypium* sp) cultivation. We have been growing cotton ever since we settled here. But after receiving reports that chemical inputs used for this crop are hazardous to life, production has been reduced substantially. We would like to know whether the inputs being used for chickpea will in any way

1. Lead Farmer (Group 2), Village Munalbasti, Kalika VDC. District Bardia. Bheri Zone, Nepal

Translated from Nepali.

Thapa-Magar, R. 2001. Rehabilitation of lost crop - chickpea in Munalbasti village in Nepal. Pages 53-54 *in* On-farrn IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu. Nepal (Pande, S., Johansen, C., Stevenson, P.C., and Grzywacz, D., eds). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

affect the well-being and life style of our poor farmers. We request you to give guidance.

We have received full support for chickpea cultivation through Dr Suresh Pande of ICRISAT, Nepal Agricultural Research Council (NARC), and RARS, Nepalgunj. We are thankful to them. We pray for the betterment of Dr Pande and his institution.

Finally, we are obliged to ICRISAT and NARC for inviting us to this prestigious symposium and hope that we will get the same kind of help and support in the future also.

Insect Pest and Disease Management for Successful Cultivation of Chickpea in Village D-Gaon in Nepal

S Khatri[1]

An integrated insect-disease management program has been *conducted jointly by* Nepal Agricultural Research *Council* (*NARC) and* International Crops *Research* Institute for the Semi-Arid Tropics (ICRISAT) for the last two years. The farmers of Bageshwari Village Development Council (VDC) were highly benefited by this program known as integrated pest management (IPM), for the management of insects and diseases of chickpea (*Cicer arietinum* L.). Prior to the start of this program we used to cultivate chickpea in our traditional way, and the crop used to suffer heavy losses due to disease and insect damage. Thus it was a wastage of labor, seed, and other resources. In the implementation of the IPM program, we treated the seeds and sprayed the crops with appropriate types and amounts of pesticides. We are now getting good yields from our fields. We are thankful to NARC and ICRISAT as they have contributed a lot to the development and progress of Bageshwari VDC. A total of 150 farmers in this VDC participated and benefited from on-farm IPM of chickpea.

While working with NARC and ICRISAT, VDC's roles with participating farmers and new participants are to:

- Arrange seminars and meetings of all concerned parties in advance to know about preparation of better fields suited for cultivation.
- Involve other non-governmental organizations (NGOs) and research units to approach the nearest cooperative banks in case of shortfall of inputs.
- Impart training to the farmers on various aspects of chickpea cultivation right from the selection of fields to harvesting, including mixed cultivation, weeding, and how to differentiate the varieties of seeds.
- Invite the farmers from the nearby villages and to tell them about the importance of chickpea cultivation.

1 Lead Woman Farmer and Group Leader, Village D-Gaon. Bageshwari VDC, District Banke, Bheri Zone, Nepal.

Translated from Nepali.

Khatri. S. 2001. Insect pest and disease management for successful cultivation of chickpea in village D-Gaon in Nepal. Pages 55-56 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S., Johansen, C., Stevenson. P.C., and Grzywacz, D., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham. Kent ME4 4TB. UK. Natural Resources Institute.

- Arrange tour programs for farmers to different research centers and recognize their participation.

Our Council will work continuously for the welfare of the farmers for better yield from their fields and encourage them for better living.

Rejuvenation of Chickpea Cultivation in Rajahar Village in Nepal

B K Aryal[1]

We used to grow chickpea (*Cicer arietinum* L.) by mixing it with wheat (*Triticum aestivum* L.) and mustard (*Brassica* sp). In general, we used to get good germination and plant stand, but due to diseases and insects we never used to get good yields. We therefore stopped the cultivation of chickpea almost 10 years ago. It is only two years ago, when Dr Suresh Pande of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) came here and insisted for chickpea cultivation under an Integrated Crop Management Program and assured us full cooperation, we once again started chickpea cultivation. In the first year (1998/99) we tried chickpea with local seed and an improved variety in each half of a field. We sprayed the chickpea field with Bavistin® for controlling disease and Thiodan® for controlling insects, in specified quantities and at specified time. We followed the integrated pest management (IPM) technologies for the control of diseases and insects in chickpea as suggested by the scientists from Nepal Agricultural Research Council (NARC) and ICRISAT. We found that yield per *hatha* (338 m^2) was much more (three folds) in the IPM plots than in plots where IPM was not followed. This proves that proper use of IPM technology can result in good production of chickpea crop.

1. Lead Woman Farmer and Group Representative, Village Rajahar, c/o NK Yadav, NGLRP. Rampur, Chitwan, Nepal.

Translated from Nepali.

Aryal, B.K. 2001. Rejuvenation of chickpea cultivation in Rajahar village in Nepal. Page 57 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S, Johansen, C., Stevenson, P.C., and Grzywacz, D., eds). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

Constraints and Opportunities for increasing Chickpea Cultivation in Eastern Nepal

R D Yadav[1]

Traditionally, we the farmers of Hanuman Nagar, Dhangadi village, Sirha in eastern Nepal used to grow chickpea (*Cicer arietinum* L.) after rice (*Oryza sativa* L.) in our fields. Normally we used to broadcast chickpea as a mixed crop with wheat (*Triticum aesrivum* L.) or mustard *(Brassica* sp). About 20 years ago our yields were very good (1.5 t ha^{-1}) but then gradually yields started declining because of several reasons. Some of the factors of declining yields and disappearance of the chickpea crop from our cropping system are poor crop stand, foggy weather, diseases (flower drop disease), and insects on pods. Therefore, for the last four years we have stopped growing chickpea because we do not have seed and the seed which we get from India or from the village market is not of good quality as many plants die after emergence.

In 1998, Dr Suresh Pande of the International Crops Research Institute for the Semi-Arid Tropics (ICRLSAT), visited our village along with Nepal Agricultural Research Council (NARC) staff and provided seeds of chickpea variety Avarodhi and disease and insect control chemicals (to 20 farmers). With great reservations we agreed to grow chickpea and used the chemicals. The researchers also suggested when to use these chemicals and also how much to use. We followed their suggestions and technology and all of us harvested more than 1 t ha^{-1} of chickpea. Two farmers harvested more than 2 t ha^{-1} of chickpea grain from their fields. These farmers sold seeds of chickpea to several other farmers who visited our village. In the second year (1999/2000), 75 farmers participated in chickpea demonstrations with ICRISAT and NARC and successfully grew and harvested chickpea. We are convinced that we can grow chickpea once again if we follow new technology for disease and insect control. We request you to continue your

1. Lead Farmer, Village Dhangadi-2, District Sirha. Zone Sagarmatha, Nepal.

Translated from Nepali.

Yadav, R.D. 2001. Constraints and opportunities for increasing chickpea cultivation in eastern Nepal. Pages 58 59 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S., Johansen, C., Stevenson, P.C., and Grzy wacz, D. eds) Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics, and Chatham, Kent ME4 4TB, UK. Natural Resources Institute.

support, especially Dr Pande, to guide us in chickpea cultivation and provide us seed and other inputs such as chemicals to control diseases and pests. We ensure our support to this new program on chickpea cultivation in eastern Nepal.

Farmers' Participatory IPM in Chickpea in Nepal: Opportunities and Constraints

S Pande and J Narayana Rao[1]

Chickpea (*Cicer arietinum* L.) is the second most important grain legume in Nepal. It is particularly important as a source of protein to the people of Nepal. The annual production of this crop was 13,640 t on 19,080 ha. Though the yield potential of chickpea cultivars grown in Nepal is around 4 t ha^{-1}, actual yields are only 0.7 t ha^{-1} (Pandey et al. 2000). Chickpea production at this level is inadequate to meet the local demand, and the deficit is met through imports.

The occurrence of diseases and pests and associated abiotic factors is the main cause of poor yields of chickpea in Nepal (Fig. 1). Among diseases, botrytis gray mold (BGM) caused by *Botrytis cinerea,* and among insects the pod borer *Helicoverpa armigera* are the major biotic constraints to chickpea production in Nepal (Karki et al. 1993, Pandey et al. 2000).

Botrytis gray mold can cause yield losses up to 100% if the conditions are favorable during vegetative and reproductive growth stages (Grewal and Laha 1983, Karki et al. 1993, Pande et al. 1998a, 1998b). Frequent outbreaks of BGM have not only discouraged the farmers to grow chickpea in Nepal but also exhausted the valuable genetic resource of chickpea available with them.

Resistant cultivars is the cheapest and most effective method to combat BGM, but an adequately high level of resistance is not available in germplasm and improved chickpea lines (Laha and Khatua 1988, Ahmad 1989). Therefore the management of the disease using host plant resistance alone is not possible. Several seed dressing and foliar fungicides have been found effective to control BGM (Grewal and Laha 1983, Singh and Kaur 1990) but the use of fungicides to manage BGM has not been widely adopted by resource-poor farmers (Singh and Bhan 1986).

The pod borer *H. armigera* not only damages pods, but also feeds on the foliage, buds, and flowers and this may greatly reduce the number of harvestable pods. The yield losses due to this insect ranges from 20% to 90% (Reed et al. 1987). The pod

1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, 502 324, Andhra Pradesh, India.

ICRISAT Conference Paper no. CP 1421.

Pande, S., and Narayana Rao, J. 2001. Farmers' participatory IPM in chickpea in Nepal: opportunities and constraints. Pages 60-78 *in* On-farm IPM of chickpea in Nepal: proceedings of me International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S., Johansen, C., Stevenson, P.C., and Grzywacz, D., eds). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

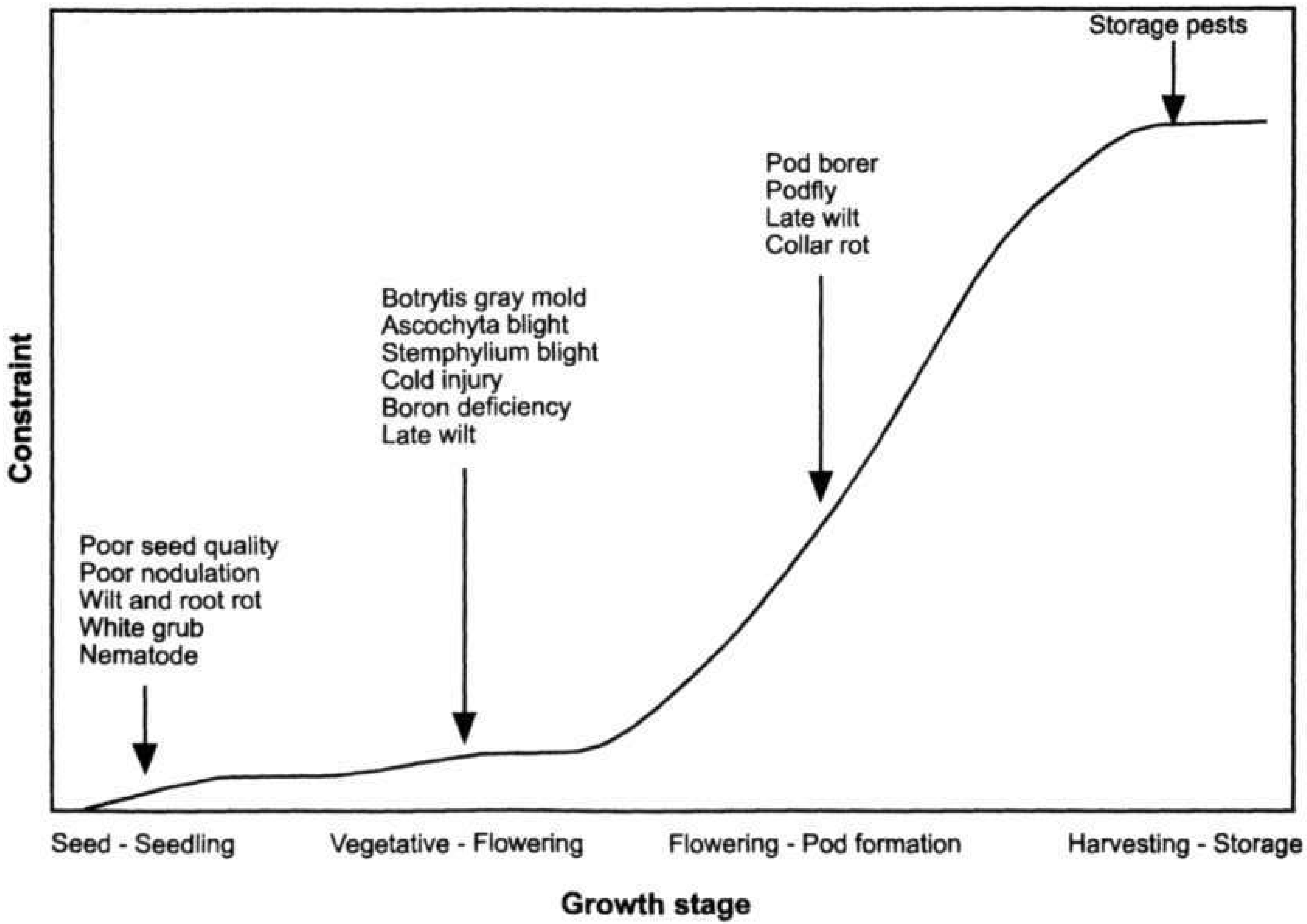

Figure 1. Sequential occurrence of biotic and abiotic constraints in legumes.

borer is a serious pest in Nepal and can cause more than 60% yield losses (Thakur 1997). Though genotypes resistant to *H. armigera* are available, unfortunately they are all highly susceptible to diseases particularly BGM and fusarium wilt (Reed et al. 1987).

Uncertainty of chickpea yield is also attributed to aberrant weather conditions which cause extremes of water stress, from drought to excessive soil moisture (waterlogging), and high atmospheric humidity. When protracted wet periods (high humidity) coincide with flowering and podding stages, as often prevails in the chickpea-growing areas of Nepal, the conditions are favorable for the development of BGM and other foliar diseases such as ascochyta blight (*Ascochyta rabiei*) and stemphylium blight (*Stemphylium botryosum*). A close relationship between microclimatic conditions and incidence of BGM and ascochyta blight has been documented in chickpea (Butler 1996, Jhorar et al. 1997).

Above-average and well-distributed winter rainfall during the crop season, and protracted rainfall at the end of the monsoon period induces excessive vegetative growth, lodging of crops, disease incidence, and ultimately lower yield. On the other hand, deficient and early cessation of monsoon rains, and inadequate winter rainfall, results in terminal drought (because chickpea is grown only as a rainfed crop in Nepal) and heat stress specially during flowering and pod-filling in eastern Nepal (Pande 1999). Yield losses due to drought in cool season crops including chickpea have been estimated to range between 20% and 50% (Saxena et al. 1993). Also, higher incidence of pod borers and late wilt (*Fusarium* spp) is often observed in years when there is a greater degree of terminal drought and heat stress.

Chickpea varieties currently used by farmers include local landraces, mixtures of improved released cultivars, and commercially available imported varieties mainly from India. These varieties are susceptible to the adverse effects of soil and climate, diseases, and insect pests, even though they have evolved with them. Farmers, therefore, consider cultivation of chickpea as highly risk-prone. In comparison, rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.), the most important cereal food crops in Nepal, produce more assured and stable yields. Rice and wheat also enjoy government policy support. These factors have motivated farmers to favor cereal-dominated production systems. Expansion in rice and wheat area in Nepal has been at the cost of area under legumes (Pandey et al. 2000). However, in many recent reports from Nepal, questions have been raised about the sustainability of rice-wheat production systems because of the declining trends in factor productivity. This potential threat, though a cause of serious concern, offers new opportunities to introduce chickpea as a legume in rice-based cropping systems especially in the rice-fallow lands, because legumes have long been known to alleviate the adverse effects of continuous cropping with cereals. Another factor that would favor promotion of cultivation of chickpea and other legumes is that the demand for these crops is predicted to increase considerably in the next decade (Kelley et al. 1997). Additionally farmers feel that cultivation of rice-wheat is no more profitable (S Pande, personal observation).

Thus, successful introduction or inclusion and enhancement of chickpea in rice-based and/or maize (*Zea mays* L.)-based cropping systems could indeed be realized, or new sustainable production systems formulated which have chickpea as a component crop. Research publications on chickpea grown in South Asia at least indicate that there is adequate knowledge and information available on this crop, and technologies or components of technologies have been formulated, to feasibly alleviate the major constraints (diseases and insect pests) to its production. A major lacuna seems to be inadequate formulation of potential technology packages by multidisciplinary teams of scientists, and their validation in on-farm trials.

Constraints and opportunities - an analysis

A general increase or decrease in crop production is a direct function of cultivated area and yield. Relative contribution of each component depends upon which of the two has been limiting production most. In chickpea, either of these factors could play a dominant role, depending upon the situation. For example, a large-scale expansion in chickpea area in Turkey and Australia, and an associated impact on chickpea production has taken place in the past two decades (Saxena 1996). In Turkey, area expansion occurred through introduction of chickpea in fallow lands, while in Australia the crop has primarily replaced wheat and ley pastures. Recently in Bangladesh, successful attempts have been made to establish and expand chickpea in the rice-fallow lands of the High Barind Tract (A M Musa, C Johansen, and J Kumar, personal communication). The impact of area expansion (e.g., in Barind in Bangladesh) was so large that a considerable increase in production occurred despite the fact that there were decreasing trends in productivity. This decrease in productivity may be because the new areas brought under chickpea were not ideally suited for chickpea cultivation. The development of appropriate technology (including adapted varieties) for the new areas did not precede the rapid expansion in chickpea area.

In contrast, increase in chickpea productivity (yield) in India not only offset the effect of huge decline in chickpea area in the past two decades, by nearly 1.0 million ha, but also contributed to a small although insignificant increase in production. A major decrease in chickpea area in India occurred in Haryana and Punjab states, in the past two decades. Something similar has happened in Nepal, where chickpea area and production declined drastically in the eastern districts (Pandey et al. 2000).

Constraints to production

A number of constraints—biotic, abiotic (climatic and edaphic), agronomic management, and socioeconomic—affect chickpea in Nepal. Instability of chickpea yield is mostly due to abiotic and biotic constraints and because of these farmers are reluctant to grow this crop with the present-day varieties and technology available to them.

Biotic constraints

Diseases

Almost all diseases reported in the literature that affect chickpea occur in Nepal (Pandey et al. 2000). However, the constellation of major diseases seems to vary from one ecoregion to another. For example, in chickpea, BGM is of major concern in the eastern parts of Nepal (Pandey et al. 2000). As a result the area under chickpea in this region has shown a declining trend and the chickpea area has shifted from the eastern to western Terai districts. However, recent surveys indicate that it is a major biotic constraint to chickpea production throughout Nepal and at times along with stemphylium blight causes complete crop losses (Pande et al. 1998a, 1998b). This is primarily due to similar climatic conditions, in particular, microclimate conditions in eastern and western Nepal (Butler 1996). Other important and widespread diseases of chickpea are fusarium wilt, collar rot, and black root rot. The relative importance of various diseases across Nepal is summarized in Table 1.

Insect pests

There are a large number of insect pests that infest chickpea (Table 2) but only some of them are a threat to the crop. For example, the pod borer (*H. armigera)* is a very serious pest that can cause more than 60% yield damage in chickpea on farmers' fields in Banke and Bardia districts alone located in the western part of the country. Similar losses caused by the pod borer in other chickpea-growing districts of Nepal are also reported.

Nematodes

Nematodes are not recognized as major constraints in Nepal. In surveys conducted recently, chickpea area was found infested with different species of nematodes (Sharma et al. 2001).

Table 1. Diseases of chickpea, their distribution, and status in Nepal.			
Disease	Causal organism	Distribution	Status
Botrytis gray mold	*Botrytis cinerea*	Major in all chickpea-growing areas but less in western Terai	Major
Fusarium wilt	*Fusarium oxysporum* f. sp *ciceris*	Major in all chickpea-growing areas but less in western Terai	Major
Alternaria blight	*Alternaria* sp	Sporadic across whole of Terai	Minor
Sclerotinia stem rot	*Sclerotinia sclerotiorum*	Sporadic across whole of Terai	Minor
Black root rot	*Fusarium solani*	Major in moist soil conditions	Major (sometimes)
Collar rot	*Sclerotium rolfsii*	Major in moist soil conditions	Major (sometimes)
Dry root rot	*Rhizoctonia bataticola*	Sporadic across whole of Terai	Minor
Chickpea stunt	Bean (pea) leaf roll virus	Sporadic across whole of Terai	Minor

Source: Pandey et a). (2000).

Table 2. Insect pests of chickpea in Nepal.	
Insect pests	Status
Agrotis ipsilon Hufnagel	Major pest in Terai
Agrotis segetum Schiff	Major pest in Hill
Plusia orichalceaF.	Major pest in some, regions
Helicoverpa armigera Hubner	Major
Callosobruchus chinensis L.	Major
Callosobruchus maculatus Fab:	Major

Source: Pandey et al. (2000).

Weeds

Farmers generally do not weed chickpea but allow them to grow and cut them as forage for cattle. Hence weeds compete with chickpea for light, water, nutrients, and space and can cause substantial yield losses. Little research work has been done in this area. Depending upon the duration of the crop, the critical period for weed competition in chickpea varies from 20 days to 45 days after sowing. Most farmers perform only two operations (sowing and harvesting) in the cultivation of chickpea. As a result, crops are often heavily infested with weeds. Several species of weeds have been recorded in the chickpea crop of which *Cyperus rotundus* L. (nut grass), *Chenopodium album* L. (lamb's quarters), and *Vicia sativa* L. (common vetch) are noted as major ones (Table 3).

Climatic and soil constraints

Various climatic and soil factors limit the productivity of chickpea grown in different agroecological zones in Nepal. Among these, early and terminal drought, excess moisture, adverse temperatures, high humidity, and poor soil fertility are major constraints.

Early and terminal drought

Early and terminal drought stress is a major problem of chickpea production. Chickpea is grown on conserved soil moisture in the postrainy season and invariably suffers from terminal drought if there is little or no winter rainfall. If the monsoon rains finish early or chickpea is sown late, there may be insufficient soil moisture for proper germination and emergence, especially in lighter soils.

Table 3. Common weeds of chickpea in Nepal.

Botanical name	Common name	Family
Cyperus rotundus L.	*Motha;* nut grass	Gramineae
Cynodon dactylon (L.) Pers.	*Duvo;* Bermuda grass	Gramineae
Anagalis arvensis L.	Pimpernal	Primulaceae
Capsella bursa-pastoris (L.) Moench	Shepherd's purse	Cruciferae
Chenopodium album L.	Lamb's quarters	Chenopodiaceae
Spergula arvensis L.	Corn-spurry	Caryophyllaceae
Sciene-biera pinnatifida	Swinecress	Crucifereae
Vicia hirsuta S.F. Gray	Tiny vetch	Leguminosae
Vicia sativa L.	Spring vetch; common vetch	Leguminosae
Alopecuros pratensis L.	Meadow foxtail	Gramineae
Phalaris minor Retz.	Small canary grass	Gramineae

Source: Pandey et al. (2000).

Excess soil moisture and humidity

Excessive rainfall can occur during the late monsoon season. This delays sowing and can cause substantial yield loss to chickpea. If rainfall occurs at the reproductive stage, it damages flowers and encourages foliar diseases such as BGM. The disease in turn can cause complete yield loss.

High temperature

A sudden rise in temperature in late February and early March severely reduces vegetative growth and pod formation especially in late-sown crops of chickpea. This phenomenon has been frequently observed in eastern parts of the country than in western Nepal.

Mineral nutrition

Soil acidity poses a serious constraint to legumes in Nepal, where surface soil pH falls below 5.0. Acidity problems are greater in the eastern part of the country due to leaching of bases because of high rainfall. Consequently, legumes face phosphorus (P) deficiency and nodulation problems. Boron has been shown to be a major yield reducer of chickpea and lentil (*Lens culinaris* Medic.) at least in the inner Terai (Srivastava et al. 1997, 1999). These researchers also report molybdenum responses in chickpea and zinc responses in lentil. As legumes are generally relegated to more marginal soils, the likelihood of them being limited by nutrient deficiencies increases (Kelley et al. 1997).

Poor crop establishment

In rice-based production systems, it is common to observe poor and non-uniform plant stands. The problem seems to be more severe in chickpea following a rice crop because of the atypical soil physical conditions that result from soil puddling. Field surveys of plant stands of chickpea in farmers' fields in central, north, and northeast Nepal, covering important chickpea-growing areas, show that the plant stands usually are less than one-half of the recommended plant population.

As a consequence of the lower status given to pulse crops, farmers take inadequate care of them at sowing, despite availability of knowledge of optimum sowing techniques. Recommended seed rates to obtain optimum plant stands are not followed and usually seed of poor quality (having low germination rate) is used. Chickpea is usually broadcast sown on an inadequately prepared seedbed. The net result is poor and uneven plant stands, which mitigate against achieving high yields at an early stage.

Socioeconomic and policy constraints

Despite the importance of chickpea in farming systems of Nepal, it has only subsidiary status in the total farming systems due to the greater importance given to cereals as staple food crops. Chickpea has lower stability in production and higher losses in storage than cereals. Its market prices also fluctuate widely. The priority of Government as well as farmers is the production of cereal crops such as rice, maize, and wheat. Farmers consider chickpea as very sensitive to diseases, pests, and weather conditions; thus high and stable yields cannot be assured.

Input use

Farmers give least preference to applying agricultural inputs such as fertilizers or pesticides to chickpea. In Nepal, such inputs are relatively high priced and often scarce, and thus reserved for cereals or high-value crops. Further, application of fertilizers and irrigation to chickpea crops can result in excessive vegetative growth, with resultant lodging, disease infestation, and low yield.

Profitability

Lack of knowhow and capability of storing chickpea grains results in a low farm gate price, with high seasonal fluctuations. Thus, despite low input costs, profitability is low for farmers. There are no organized marketing channels or Government support prices for grain legumes, as for cereals. Low-income farmers bear most of the risk associated with chickpea production.

National policies and emphasis towards legumes production

In Nepal, a major portion of cultivated area in the country is under rainfed conditions and pulses have adjusted well in different mixed and intercropping situations and crop rotations. There has been a 30% increase in availability of grain legumes during 1984/85 to 1995/96, as compared to the 2.5% per annum population growth rate. Future research strategies should emphasize the development of short-duration, high-yielding, disease-resistant varieties for multiple cropping systems. Despite the importance of legume crops in Nepal, the 20 years Agriculture Perspective Plan has not considered them as priority crops. However, recently their importance has been realized in national policy considerations.

Opportunities - Technological options readily available for alleviating constraints and increasing productivity

Options to significantly alleviate most of the biotic and abiotic constraints to chickpea production in Nepal are readily available (Summerfield 1988, Muehlbauer and Kaiser 1994, Asthana and Chandra 1997). However, it is disappointing to note that despite concerted efforts and progress made so far in identifying effective genetic and integrated management technology, very little progress is apparent in on-farm conditions in alleviating the major yield reducing constraints to chickpea production. The declining trends in chickpea area and production in Nepal, perhaps is a result of this gap in transfer of technology. One may speculate that the recommended solutions to problems have not reached the farmers or are not being adopted.

Role of chickpea in cropping systems

Chickpea is mostly grown under rainfed rice-based systems. Therefore, it has a special role in the rainfed agricultural system. Because of its deep root systems, ability to produce at least some grain under drought conditions, and general hardy nature, chickpea has historically been used by farmers as a risk reduction crop and is intermixed or relay cropped with major cereals. In the monsoon climate that prevails in Nepal, 80% of rainfall occurs during July to September. Moisture is a major limiting factor to successful crop production during winter, from about November to April, where irrigation is not available. Legumes in general and chickpea in particular present various opportunities under these conditions.

Chickpea helps in increasing soil fertility by fixing atmospheric nitrogen (N) and improving the soil structure through its deep root system and additions of organic matter to the soil. Since N is the most deficient plant nutrient in Nepalese soils, input of N into the soil is, therefore, essential to increase crop productivity. Thus, the role of chickpea in this regard is very important. The amount of N fixed by legumes under various on-farm conditions in Nepal is 33-56 kg ha^{-1} (Pandey et al. 1998). Chickpea has also proved ideal for growing as mixed crop and for intercropping under dryland farming situations of the country. Farmers' response in 11 districts on residual effects of legumes on subsequent crops also revealed that legumes, in comparison to wheat or fallow land, contribute to enhanced yields of rice to the extent of 10-35% (Pande and Joshi 1995).

Strategies to realize impact of IPM

It seems quite reasonable to conclude that there is a big gap between the availability of technology and its on-farm popularization. We believe strongly that a significant impact in the near term (2 to 3 years) can be made and a substantial increase in area and production of chickpea can be achieved with the existing information/technologies. We point out some of these options and suggest that these be implemented as "Operational Research Projects". Soon after the 1997/98 epidemic of BGM which completely destroyed the chickpea crop in the whole of the Indo-Gangetic Plain including Nepal, a humble beginning has been made in this direction in the past two seasons 1998/99 and 1999/2000. The results clearly indicate the establishment of chickpea with profitability in rice-fallow lands of Nepal (Table 4; Figs. 2 and 3). These results also suggest farmers' acceptance of the integrated pest management (IPM) technology for the management of chickpea crop in Nepal.

Intensified seed production program

There is a great and continuing shortage of seed of improved varieties of chickpea (Table 5). There is thus an urgent need for a large-scale seed production program in the country that will facilitate the availability of quality seeds of improved varieties to farmers.

Improvement in plant stand

It should be possible to double the prevailing low yields under on-farm conditions through improvement of plant stands alone. A number of factors which are known to affect plant stands can be overcome with relative ease through adoption of simple agronomic management practices. For example, seedbed preparation can be improved; recommended seed rate can be used; seeds can be primed (pre-germinated); seed dressing with chemicals can be applied to overcome soilborne insect pests and diseases; and seed can be sown with country seed drills in moist soil instead of sowing by the broadcast method.

Diseases

For soilborne diseases, high levels of genetic resistance are available. For example, chickpea cultivar Avarodhi used in recent on-farm IPM studies in Nepal, is resistant to fusarium wilt. Genetic resistance to BGM is low or not available at present but integrated management options are available (Pande et al. 1998a, 1998b). These options should be able to minimize the yield reducing effects of these diseases at least by 50% in most of the years, except perhaps when they appear in severe epidemic form when farmers will have to rely on fungicide appreciation.

Table 4. Grain yield (t ha^{-1}) of chickpea in on-farm farmers' participatory integrated pest management (IPM) and non-IPM trials in five districts in Nepal during the postrainy season, 1998 and 1999.

		1998		1999	
District	Village	IPM	Non-IPM	IPM	Non-IPM
Banke	D-Gaon	1.73	0.89	2.14	0.98
Banke	Bankatuwa	2.81	1.46	2.26	0.97
Barida	Munalbasti	3.04	1.69	3.15	1.49
Nawalparasi	Rajahar	1.29	0.39	2.55	0.89
Sirha	Dhangadi	1.24	0.87	2.48	1.29
Sarlahi	Lalbandi	NT[1]	NT	2.35	0.87
Sarlahi	Bardibas	NT	NT	2.38	1.25
Mean		2.02	1.06	2.48	1.12
LSD (0.05)		0.25		0.70	

1. NT = Not tested.

Table 5. Chickpea varieties released in Nepal.

Variety	Year of release	Origin	Days to maturity	Yield potential (tha^{-1})	Released for region
Dhanush	1980	Nepal	144	1.8	Terai/inner Terai
Trishul	1980	Nepal	144	1.7	Terai/inner Terai
Radha	1987	India (JG 74)	142	1.6	Terai/inner Terai
Sita	1987	ICRISAT (ICCC 4)	140	1.5	Terai/inner Terai
Koselee	1990	ICRISAT (ICCC 31)	154	1.6	Western Terai
Kalika	1990	ICRISAT (ICCL 82198)	152	1.4	Western-Central Terai
Avarodhi[1]	1998	India	145	2.5	Terai/inner Terai

1. Introduced by ICRISAT soon after the botrytis gray mold epidemic of 1997/98 season.
Source: Pandey et al. (2000).

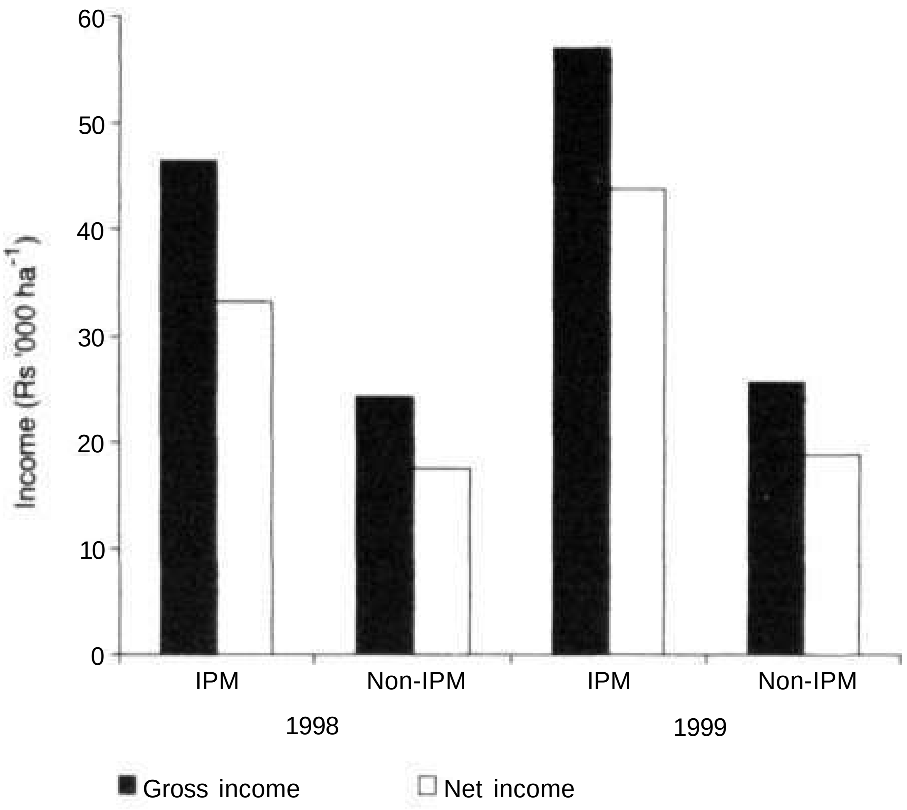

Figure 2. Gross and net incomes of chickpea in IPM and non-IPM treatments in on-farm experiments, Nepal, 1998 and 1999 postrainy seasons.

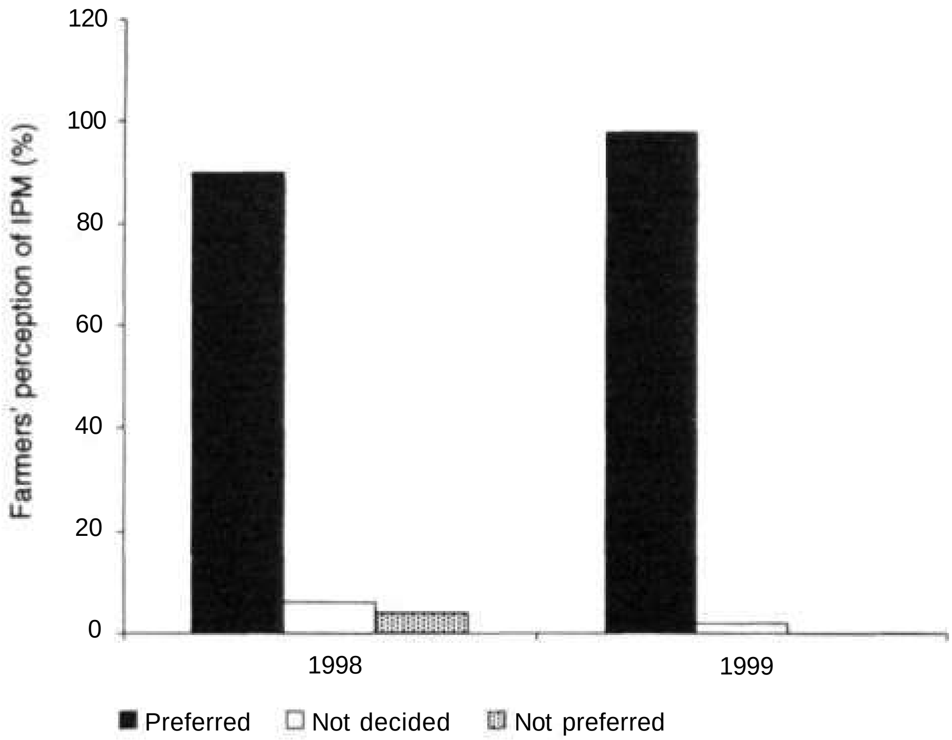

Figure 3. Farmers' perception and preference for IPM package.

Insect pests

Stored grain pests can be easily managed and virtually eradicated (Reed et al. 1987). Among all constraints the pod borer *H. armigera,* a polyphagus insect pest, appears to be the most difficult to manage. Recent reports on the integrated management of this insect pest shows that some progress has been made (Chari et al. 1998). IPM of pod borer would involve greater use of cultivars showing some resistance to insect attack or the ability to escape from it, combined with need-based use of pesticides, both chemical and biological [nuclear polyhedrosis virus (NPV)].

Adaptation of chickpea in available niches

The wide gap between the potential and the national average yields shows that there is a great scope for increasing chickpea production in Nepal. Moreover, about 30% of the rice area (~420,000 ha) still remains fallow during winter due to various reasons such as lack of soil moisture and late rice planting and harvesting. This is a potential area that can be tapped for extending chickpea cultivation by focused efforts on on-farm research and development specifically on IPM.

It is now feasible to fit chickpea into various niches in the highly productive rice-rice or rice-wheat production systems. Adaptation of chickpea has been improved greatly in recent years by developing varieties of extra-short, short-, and medium-duration to fit these appropriately into available niches of rice-based cropping systems. Also, combinations of cultivar and appropriate agronomy to adapt chickpea to late-sown conditions, a necessity in most rice-based cropping systems, are now available (Krishnamurthy et al. 1983).

Profitability of cultivation

The general belief that it is less profitable to grow chickpea is primarily related to the risk-prone nature (instability in yield due to abiotic and biotic stresses) of the present-day varieties of this crop. If this constraint can be alleviated, or the risk substantially reduced, the cultivation of chickpea will be equally or even more profitable (Fig. 2) than cereals with a modest but assured yield level of 1-1.5 t ha^{-1}, which is around 30-50% of potentially realizable yield of the present-day cultivated varieties (Pande et al., in press). Other factors that would be in favor of high economic returns from chickpea production are the high price, at least 3 to 4 times more than that of cereal crops, and low requirement of chemical fertilizers because of high efficiency in accessing essential nutrients through root traits (Saxena 1996), e.g., N through efficient biological nitrogen fixation (BNF)

(Rupela and Saxena 1987) and P through acidification of rhizosphere (Ae et al. 1991). Recent identification of high mineral N-tolerant symbioses (Rupela and Johansen 1995) shows promise in further enhancing efficiency of BNF in the presence of high levels of soil mineral N, which generally exist after the harvest of high input rice crops.

Conclusions

From the evidence presented it seems quite realistic to expect that a substantial impact can be made on chickpea production in a short period following improved IPM techniques. This can be achieved with the available knowledge and technology, or components of technology which would result in enhancing the on-farm realizable yield and also area expansion under the crops. An urgent need is to demonstrate that these improved packages of practices are indeed viable in on-farm conditions. A dedicated multidisciplinary team of scientists and extension personnel along with the target farmers, need to be involved together in the technology evaluation process. Trouble shooting of unanticipated problems encountered could be done by the team and new research programs undertaken to refine the technology. An example of such an approach is underway to attempt to rehabilitate chickpea in participation with farmers in Nepal after cultivation of the crop had been almost eliminated by the severe BGM epidemics of 1996/97 and 1997/98 (Pande 1999, Pande et al. 2000).

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Socioeconomic Issues and Institutional Policy: Constraints for Increasing Chickpea Production in Nepal

P K Joshi[1]

Chickpea (*Cicer arietinum* L.) used to be an important pulse crop for the Nepalese farmer with respect to production and consumption. In production, the crop being a legume, improves soil fertility, and in consumption, chickpea is a rich source of protein. With the introduction of irrigation and widespread adoption of high-yielding varieties of rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.), the chickpea area has substantially declined. During the last two decades, chickpea production has declined by 20,0001 from about 33,0001 in 1980-82 to 13,0001 in 1996-98. The decline in production was mainly due to decrease in area under chickpea. Chickpea area has reduced to 19,000 ha in 1996-98 from about 54,000 ha in 1980-82. A large chickpea area was substituted by wheat and to some extent by lentil (*Lens culinaris* Medic), rapeseed (*Brassica napus* L.), and mustard (*Brassica* sp). Chickpea production has declined annually by about 5% during the 1981-98 period. Chickpea area has declined at 6% per annum. During 1990s, the situation has improved slightly with production declining at only 3% per annum. The interesting feature was that during this period chickpea yields rose by 3.6% annually.

With declining chickpea production, per capita availability has reduced from 2 kg annum^{-1} in 1980-82 to 0.6 kg annum^{-1} in 1996-98. The available estimates are that the demand for chickpea in 2010 would be 21,000 t, while with the existing trends in production, the supply would be about 7,000 t, i.e., an excess demand situation of about 14,0001. To meet the future demand of chickpea in the country, there are two possible options: (i) government should import chickpea from other countries, and (ii) increase chickpea production in the country. The second option is more sound considering the status and subsistence condition of poor producers and consumers of chickpea. It is well recognized that chickpea is a crop for the resource-poor farmers. Therefore, the import option may not be of any benefit to

1. National Centre for Agricultural Economics and Policy Research, Post Box 11 305. Pusa, New Delhi 110 0 12. India.

Joshi, P.K.. 2001. Socioeconomic issues and institutional policy; constraints for increasing chickpea production in Nepal. Pages 79-82 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S., Johansen, C., Stevenson, P.C., and Grzywacz, D., eds). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

the resource-poor producers. Production has to be increased by understanding the constraints of chickpea. Chickpea production can be increased by either increasing its area or raising the productivity from existing levels of 700 kg ha^{-1} to more than 1000 kg ha^{-1} in areas where chickpea is grown. Technology intervention is needed to increase both chickpea area and yield. Introducing high-yielding varieties, which are resistant to abiotic and biotic stresses, can potentially increase chickpea yields. To increase chickpea area, it is important to understand the socioeconomic, policy, and institutional constraints. This paper highlights these constraints that have affected chickpea production in the past.

Constraints in increasing chickpea production

A framework presented in Figure 1 shows the technology flow from on-farm demonstration to the target domain. The process starts from technology introduction through on-farm demonstration. Once on-farm demonstrations are undertaken, farmers decide whether to adopt technologies or not. Farmers' decision to adopt a technology would depend upon: (i) technology traits, (ii) policy environment, (iii) existing and new institutional arrangements, and (iv) infrastructural facilities.

The most important component in adoption decisions is related with the technology traits. The technology traits must suit the farmers' needs and consumers' requirements. It should be profitable, and must fit in the farmers' existing production system. The technology should also have traits to minimize the risk. The available varieties are not resistant to many insect pests and diseases. A large share of area decline in chickpea was due to increased incidence of insect pests and diseases. Therefore, there is a need for introducing varieties or improved management techniques which overcome the abiotic and biotic constraints.

Another important component in declining chickpea area was an unfavorable policy environment. The output prices were highly unstable and farmers were not sure of future prices. During higher production, prices fall sharply, while during low production periods, benefits tend to go to the middle men. Even research allocation to chickpea has declined in proportion to its importance. To increase the production of chickpea, the Government needs to intervene through assuring some minimum support prices to overcome the price uncertainty.

Institutional constraints are equally important. The seed sector is too weak. Neither public sector nor the private sector is producing and distributing improved varieties of chickpea seeds to the farmers. The Agricultural Input Corporation (AIC) can play an active role in producing quality chickpea seed. To increase chickpea production, future demand for seed must be met. It can be done with either the AIC playing a proactive role or some non-governmental organizations

(NGOs) developing a mechanism of 'seed cooperatives' to produce quality seeds. In the absence of adequate quantities of seed, the potential of improved technologies and management practices cannot be tapped. Besides, there is a need for strong support for credit facilities. In the case of pest management, farmers need sprayers.

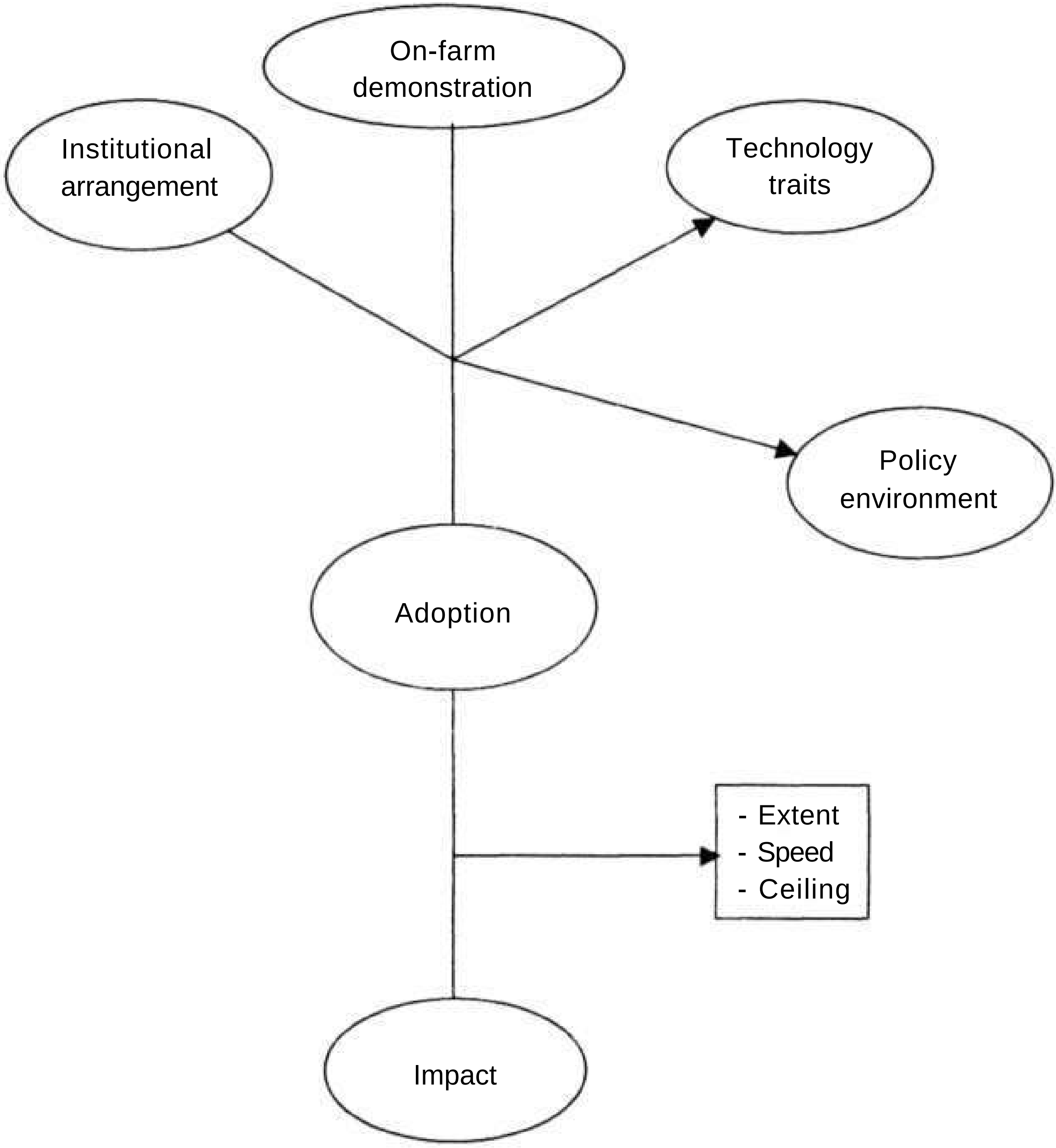

Figure 1. Technology flow, adoption, and impact.

Farmers living at the subsistence level cannot afford to buy sprayers. Credit facilities or development of some mechanism for providing sprayers at community level could alleviate that constraint.

The chickpea output market is very thin and fragmented. Poor farmers, who produce chickpea normally have a very low quantity of marketable surplus and they find it difficult to sell the produce. Even proper transport is not available to adequately market these small amounts of produce. The middle men exploit these poor farmers. The price spread (difference between the price paid by consumer and the prices received by farmer) in case of chickpea is relatively higher than the competing crops such as wheat and lentil. Cooperative systems for transport and marketing of chickpea would alleviate these market-related constraints.

Chickpea seed is prone to damage due to insects. There are heavy losses of seed during its storage. Therefore, farmers do not normally store the seed and rely on purchase of seed at sowing time. But seed is a limiting factor, which affects the area expansion of chickpea.

Farmers lack information about new technologies. Improved varieties and management options are now available to alleviate many abiotic and biotic constraints. The new technologies are knowledge-intensive and cost-saving, which call for aggressive campaigns to improve the knowledge of the farmers Mass media may be the cheapest and quickest source of information dissemination It should also be supplemented by on-farm demonstrations and farmer training programs.

Conclusion

Chickpea production is declining at a fast rate in Nepal. Due to several constraints, chickpea area has declined and this has adversely affected the national production. To meet the future demand for chickpea, the chickpea yields and area must be increased. To increase chickpea area, the existing constraints related to markets, chickpea prices, availability of quality seed, credit, etc. must be addressed. A strong seed sector and targeted technology would have great potential to increase the yield levels and expand chickpea area in the existing fallow lands. Government support is needed to protect the interest of poor farmers. This should be appropriately supplemented by location-specific technology to raise yield levels, increase profitability and minimize risk. An integrated approach by amalgamating targeted technologies, appropriate policies, required institutions, and necessary infrastructure would increase chickpea production.

SESSION II
PROJECT PLANNING AND ROLE OF PARTNERS

Project Outputs, Dissemination, Adoption, and Promotion Strategies

P C Stevenson[1]

The problem facing chickpea (*Cicer arietinum* L.) production in Nepal has been presented clearly in many papers today and previous publications (S Pande, this volume). The array of constraints including botrytis gray mold (BGM), pod borer, nutrient deficiencies, etc. has had a severe negative impact on farmer confidence in chickpea over the past few years and the area under production has declined to just 15,000 ha in 1999. However, the recent Asian Development Bank (ADB) project between the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and Nepal Agricultural Research Council (NARC) has clearly demonstrated that with improved practice farmers can grow chickpea successfully and profitably. Some trials have demonstrated that more than 300% yield increases can be achieved. These current solutions include the judicious and need-based use of pesticides and fertilizers. Seed treatment with fungicides to eliminate seedborne diseases and the subsequent inoculation with *Rhizobium* have become standard procedures for collaborating farmers too. Good root nodulation can provide additional plant available nitrogen and even have sustainable benefits to subsequent crops by improving soil fertility (C Johansen, this volume).

The awareness of problems associated with excessive spraying is growing amongst farmers and during this meeting farmer representatives have shown a keen interest to learn about alternative and new approaches to crop management. The present project aims to incorporate a bio-rational approach to pod borer management based on the use of nucleopolyhedroviruses (NPVs) and this is discussed in detail in this volume by David Grzywacz. Additional strategies that will be integrated include a greater emphasis on the use of BGM tolerant lines and seed priming. Seed priming is a basic and low cost technology that has been shown in a recent project funded by the UK Department for International Development (DFID) to have substantial benefits to various aspects of plant growth development and grain production. Specifically in the High Barind Tract of Bangladesh farmers

1. Natural Resources Institute, University of Greenwich, Chatham, Kent ME4 4TB, UK.

Stevenson, P.C. 2001. Project outputs, dissemination, adoption, and promotion strategies. Pages 85-93 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kammandu, Nepal (Pande, S., Johansen, C., Stevenson, P.C., and Grzywacz, D., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

have achieved 20% increase in plant emergence and in plant height, 50% reduction in disease rating, 20% fewer unfilled pods, and 40-50% increase in number of pods and in grain yield. Several local varieties including Tara have shown good tolerance to BGM, and other ICRISAT lines including ICCL 87322 which have previously been shown to have appropriate plant architecture and active mechanisms of resistance will also be incorporated. Additional socioeconomic inputs will help to direct the implementation of the strategies and demonstrate the impact of the project. Finally the project will also highlight the need for the appropriate infrastructure to cope with the predicted increase in chickpea production including processing and distribution facilities as well as market studies.

What will the project contribute to resolving the needs of Nepal?

The successful conclusion of the project will result in an increase in the production of chickpea in Nepal, thus increasing the nutritional status of the rural and urban poor, and improving poor farm family incomes. In addition, increased local supplies of chickpea should improve urban consumption and reduce foreign exchange expenditure.

Through increasing local productivity the long-term benefits of the project will be a reduction in the need for Nepal to import chickpea thus reducing costs to consumers particularly the urban poor and thus also increasing consumption. Increased local production of chickpea will have a positive impact on the nutritional status of the low-income farmers. It is these farmers who will be the target for the project and who currently either do not grow chickpea or grow low-yielding traditional varieties of chickpea or the lower yielding but more pest resistant varieties of lentil (*Lens culinaris* Medic).

A socioeconomic analysis within the project will assess the feasibility of various technology interventions in the target domain. The analysis will provide insights of the technologies beyond their technical performance and will assess the benefit to the farming communities and the distribution of gains across different farm size groups.

The preceding ADB project (RETA 5711) 1997-2000 has sought to take station-based IPM trials based on the use of chemical pesticides to improve chickpea yields in Nepal. In doing so it has demonstrated to farmers that through the use of these technologies chickpea can provide an economically viable secondary crop. The technologies that will be used in the present project are inexpensive, safe, and have no adverse environmental impact and so when adopted will improve the economic conditions for chickpea production and benefit both farmers and consumers directly.

The present project seeks to expand on the ADB project by increasing chickpea yields on target farms within the time frame of the project through encouraging better management of the major biological constraints in combination with improved cultural practices. Through the projects farm workshops and through the distribution of promotional material by NARC and non-governmental organizations (NGOs) up to 2000 farmers will be directly targeted by the project. This should encourage the expansion of the area under chickpea production particularly land which presently lies fallow (estimated to be >300,000 ha) during winter (November-March) after the main cereal crops of rice (*Oryza sativa* L.) and maize (*Zea mays* L.).

By increasing the land under chickpea production the nutritional status of soil for subsequent cereal production will be improved within the time frame of the project on target farms thus reducing the direct and indirect costs of fertilizers and increasing the economic benefits of chickpea production to farmers.

There will also be benefits to rural women who are the family members often responsible for winter farming in many areas after men migrate to the towns for seasonal winter work in the tourism or building industry. Family incomes and food security will be enhanced by providing women with a winter cash and food crop that is high yielding and valuable and can be grown on land currently left fallow.

The foreign exchange costs to Nepal of importing these essential food legumes (90% chickpea is currently imported) from outside will be reduced as local production increases.

Project outputs/activities

Output 1. Presentation of project activities and projected outputs in pre-launch project workshop to NARC/NGO staff and farmer representatives

This workshop is intended to commence the process of engaging the participating collaborators in the design and implementation of project activities as well as motivating stakeholders in the project's objectives and activities. Feedback from this meeting will be used to amend and fine tune activities occurring later in the project to improve implementation and the delivery of outputs. The crucial socioeconomic factors specific to the stakeholders will also be identified to determine the most useful process of evaluation and implementation of improved technologies.

Output 2. Survey of the constraints to chickpea production and the impact of possible chickpea production improvements on family income, nutrition, and poverty in Nepal

2.1 Farmer participatory survey of chickpea production

The farmer family survey will be carried out in the target areas to define current crop management strategies and will involve up to 500 farmers in six locations, two in each of the areas around Nepalgunj, Rampur, and Tarahara. The survey will be carried out by end December 2000 by the ICRISAT staff led by Suresh Pande and it will include the project socioeconomist P K Joshi. The survey will look at the current biotic, abiotic, and socioeconomic constraints to the production of chickpea in Nepal. It will seek to understand farmers' perceptions about chickpea production, as data on these will be central to designing and implementing new integrated pest management (IPM) packages. It will also seek to quantify the costs of production, identify pest and disease control methodologies currently in use and their costs. In addition it will identify and quantify unused fallow that could be brought into chickpea production if improved technologies were promoted. Included in the survey will be a component survey on farmer family income and nutritional status and identifying gender issues of relevance to the farming system. These data will be used to provide a baseline against which the impact of the project will be quantified. It will also be used to help design the IPM package, the promotion strategy, and to select and design the promotion tools. These activities are covered in detail in P K Joshi's paper in this volume.

2.2 Analysis of survey data and survey report

Using the standard socioeconomic procedures and statistical methods survey report will be prepared for future use in the project.

Output 3. An improved IPM package appropriate for poor farmers in the mid-hills and hillside regions of Nepal developed and validated

3.1 Study of NPV-plant chemistry compatibility

Prior to promoting the IPM package some initial validation work will be carried out on station and in the laboratory to determine the optimal mix of technologies. A laboratory study to investigate the compatibility of NPV and chickpea varieties being promoted through the project will be carried out at the Natural Resources Institute (NRI), University of Greenwich, Chatham, UK. Bioassays and plant chemistry studies, including glasshouse trials, using various HaNPV (*Helicoverpa armigera* NPV) formulations will be conducted to study the efficacy of different formulations and their persistence. This work will be conducted by a PhD student at the University of Greenwich, UK from October 2000. The data will be used to identify the most appropriate application rates for field-testing on chickpea. Laboratory work to quantify and identify the chemical factors in chickpea that reduce the effectiveness of HaNPV will continue into the second year as this information will be used to help improve HaNPV formulation recommendations, particularly on the addition of simple locally available adjuvants that improve the efficacy of NPV.

3.2 Quantification of *Rhizobium* treatment and seed priming benefits through on-station farmer demonstration trials

On-farm evaluation of the effect of inoculation with *Rhizobium* will be undertaken. In addition the incorporation of seed priming based on the results of CPP (Crop Protection Programme, DFID), project R6395 will provide farmers with additional production enhancement providing a low-cost boost to the establishment of the crop. Interaction of these effects with seed chemical treatment to control seedling diseases, and improved seedbed preparation techniques will also be studied in on-farm situations. Emphasis will be on evolving techniques that can be adopted by the target farmers.

3.3 On-farm and on-station demonstration IPM trials

In the first field season 2000/01, trials validating the use of the new varieties of chickpea and evaluating them in comparison to traditional varieties will be conducted on station in the target areas. On-station demonstration trials of selected HaNPV formulations at provisional field use rates will be carried out to validate the pod borer control recommendations. Based upon these studies, and the preliminary farmer survey, the form of the most appropriate IPM package combining all the best pest management practices can then be finalized for farmer evaluation.

3.4 Integrated IPM package initiated and validated on farm

During the 1999/2000 season, more than 500 on-farm trials evaluating total improved package (improved variety and optimum agronomy) as compared to farmer practice will be grown across the Terai and adjacent foothill areas of Nepal. The main improved agronomic practices will include management of BGM by fungicide and maintenance of an open canopy, pod borer management by NPV and/or chemical insecticides, seed fungicidal treatment, and boron application in boron-deficient areas (e.g., Chitwan). In subsequent seasons the package will be modified towards a more bio-rational approach. Target locations will also move into foothill locations. The adoption of technologies introduced previously will be tracked and NGOs will take an increasing role in implementation of the on-farm trials.

Output 4. New IPM promotion tools produced and disseminated to hillside farmers in Nepal

During subsequent years the promotion of the improved IPM package will aim to reach 2000 farmers. The package will be promoted through the extension service and NGO links. A central facet of the project will be to use the farmer participatory techniques previously employed and developed by ICRISAT and NARC under previous grain legume projects. The implementation and performance of the package based upon grain yields will be monitored in all farms for overall impact. An appropriate subset of farms will be selected for more in-depth studies to help understand and evaluate the interaction of the technologies. More specific factors including the incidence of fusarium wilt and root rot, BGM, pod borer attack, nodulation, plant stand density, and pod numbers will be assessed.

4.1 IPM promotion tools developed

Using data from the farmer surveys and the previous ADB project the NARC/ NGO/ICRISAT team will develop promotion tools for the new chickpea IPM system. These will include simple information cards in local languages detailing all stages of chickpea growth, when they are affected by the principal target constraints of the project and how best to manage them.

4.2 Promotion tools tested through participatory survey

During the 2000/01 season initial promotion tools for new integrated technologies will be tested. The results will be evaluated through a participatory survey at the end of the season. The results will then be incorporated into redesigning tools where needed so that improved models are available for the following season.

4.3 Promotion tools produced

Promotion tools will be produced and used during the main promotion phases in years 2 and 3. They will be produced and disseminated to at least 500 farmers in the target areas in year 2 and at least 2000 in year 3.

Output 5. New IPM technologies for chickpea production promoted to mid-hill and hillside farmers in principal chickpea-growing districts of Nepal

5.1 Workshops for NARC and NGO extension workers on IPM package

In year 2 of the project before the 2001/02 cropping season the major promotion activity will start with workshops for the NARC and NGO personnel who will be interfacing directly with the farmers to discuss, inform, and motivate the promotion teams on the objectives and the technology package being promoted. This workshop will be repeated before the two main growing seasons in 2002 and 2003 so that project staff are updated on developments in promotion tools and lessons learned from previous year's work can be disseminated rapidly to team members.

5.2 Conduct farmer schools on new IPM package in target areas

In order to start the promotion process farmer field schools will be conducted with all farmers prior to the chickpea-growing season to inform participants and distribute promotional tools. These will be held prior to all the three growing seasons.

5.3 New IPM package promoted to initial group of target farmers

Starting in the cropping season 2001/02 the validated package will be promoted to the target farmers. In the first season the aim is to involve an initial target group of 500 representative farmers from the main target areas.

5.4 Scale up of promotion of package

In the cropping season 2002/03 promotion will be scaled up to reach a minimum of 2000 farmers.

Output 6. Socioeconomic survey to determine the impact of improved chickpea IPM on rural livelihoods, poverty alleviation, and nutrition in target districts

6.1 Complete impact evaluation on IPM package uptake

This will be the last field-based project activity and will take place in March-June 2003 during and after the harvest of chickpea in the final year. Surveys of farmers involved in the project will quantify the economic implications and gains from uptake of the new technology. Data on nutritional impact and any gender issues will also be collected. Many of the factors relevant to this analysis will have been determined through discussion with NGOs, NARC staff, and farmers and their representatives at the pre-project workshop and through discussions with farmers and NGOs during the course of the project.

6.2 Produce evaluation report and final project report

A report on the impact assessment will be completed by the end of June 2003 so that data can be incorporated in the final technical report.

Output 7. Project dissemination

7.1 Produce information bulletins and refereed journal articles on new IPM technologies for chickpea production in Nepal

It is intended to publicize the results of the project to the Nepali farming community, international scientific community, and development organizations using the most appropriate media for each target community. The dissemination to the Nepali farming community will be carried out directly through project promotion activities and through established NARC network and activities. In addition local media will also be the target for press releases and articles.

Articles will be submitted to Asian-based scientific or agricultural journals to inform the scientific community in South Asia. These journals will have good circulation in India, Bangladesh, or Nepal. At appropriate national and regional conferences, presentations of results will also be made. For dissemination to the international scientific community the project will publish refereed papers in international journals.

In order to target the development community, reviews of the project for more general agricultural IPM journals both in India and Nepal, and also internationally will be produced. The project will also aim to produce outputs suitable for the wider public including international and national television, radio, and press.

Proposed promotion pathways for the uptake of the project outputs

Farmer workshops will be conducted to demonstrate the use and implementation of the IPM tools that will be used on farms during the project. Regular NARC and NGO workshops to transfer knowledge of new IPM technologies to extension participants will be carried out from the outset. The distribution of simple information bulletins and extension brochures produced by the project will be disseminated to NGOs and farmers. The wider farming community will be informed through articles in the local press and national television.

Nucleopolyhedrovirus: Potential in the Control of Pod Borer (*Helicoverpa armigera*) on Chickpea in Nepal

D Grzywacz[1]

The nucleopolyhedrovirus (NPV) of *Helicoverpa armigera* (Hear NPV, formerly HaNPV; HearNPV is the preferred alternative to avoid confusion with other *Heliothis/Helicoverpa* NPVs) is a safe and effective biological control technology that should be exploited in Nepal to control pod borer on chickpea (*Cicer arietinum* L.). It can provide farmers with a safe alternative to the use of environmentally damaging chemical pesticides, many of which, through the development of resistance by pod borer, are no longer effective as crop protection agents. In addition, the ability to use simple low cost technology for mass production of NPV makes it particularly appropriate for local production in countries such as Nepal and India.

Nucleopolyhedroviruses (previously nuclear polyhedrosis viruses) are a naturally occuring genus of a family of viruses, the Baculoviruses, that cause specific diseases of insects and some other arthropods. About 600 species of these viruses have been identified to date (Hunter-Fuijita et al. 1998). Most NPV species are host specific causing lethal infections in one or more closely related host species. The NPVs have been studied now for over 50 years and all studies have confirmed that they are restricted to their invertebrate hosts and are completely safe for man, domestic animals, and plants (Ignoffo and Heimpal 1965, Black et al. 1997). Another advantage is that NPV has no effect on predatory or parasitic insects and are thus completely compatible with all biologically-based integrated pest management (IPM) approaches that seek to preserve or enhance the natural enemies of crop pests.

The difficulties in controlling Heliothine species using chemical insecticide, due to insecticide resistance, became marked by the early 1970s and stimulated efforts to develop alternative control techniques. Attention focused on NPV in

1. Natural Resources Institute, University of Greenwich, Chatham, Kent ME4 4TB, UK.

Grzywacz, D. 2001. Nucleopolyhedrovirus: potential in the control of pod borer *(Helicoverpa armigera)* on chickpea in Nepal. Pages 94-98 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000. Kathmandu, Nepal (Pande, S., Johansen, C., Stevenson, P.C., and Grzywacz, D., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

particular and as a result of extensive research efforts mainly in America a commercial *Heliothis* NPV pesticide was developed and registered by Sandoz as early as 1976. Commercial interest in NPV subsequently waned with the appearance of new pyrethroid insecticides and this product disappeared by the early 1980s (Cunningham 1995). However, the widespread appearance of resistance to pyrethroids in the late 1980s (King 1994) subsequently led to renewed commercial interest in NPV insecticides.

An NPV of *H. armigera* was identified as endemic to the Indian subcontinent in 1965 and early work showed its potential as a control agent. However, technical difficulties such as characterizing strains, maintaining strain purity and efficacy impeded the practical development of this technology as a control agent. But significant field work in India on crops such as cotton (*Gossypium* sp), chickpea, pigeonpea (*Cajanus cajan* (L.) Millsp.), and tomato (*Lycopersicon lycopersicum* (L.) Karst.) was carried out during the 1980s and showed that NPV had potential as a biocontrol agent (Easwaramoorthy 1998). In 1993 the Natural Resources Institute (NRI), UK in collaboration with Professor Rabindra's research group at the Tamil Nadu Agricultural University (TNAU), India established the first laboratory dedicated to NPV identification and characterization. The collaboration also involved a program of field work to develop and promote NPV. The Government of India (Gol) through its IPM initiatives strongly supported the development of NPV as part of its program to control chemically resistant pod borer that by the late 1980s had become a major factor in reducing the production of cotton and some grain legumes (King 1994). In Australia too, *H. armigera* has become the most serious pest of cotton, legumes, and cereals such as sorghum (*Sorghum bicolor* (L.) Moench) stimulating efforts to develop NPV as part of sustainable insect resistance management packages. The use of NPV in Australia to control this insect on cotton and sorghum is now expanding rapidly and the use of 50,000 L in 1999 met only about 30% of the estimated demand (C Hauxwell, personal communication). In China too HearNPV is being produced and is used on 100,000 ha of crops primarily cotton (J Vlak, personal communication), but there are concerns about product quality.

In India there has been extensive work on selecting the best strains of NPV, testing field application and evaluating formulations of endemic HearNPV on various crops including chickpea (Jayaraj et al. 1987, Rabindra and Jayaraj 1988), other legumes, cotton, and vegetables. Our own work in field trials on chickpea in India showed that HearNPV at economic application rates could control *H. armigera* more effectively than either chemical insecticides or commercially formulated *Bacillus thuringiensis* (Cherry et al. 2000). It also showed that simple water suspension of unpurified HearNPV was the most effective formulation.'

One of the most attractive characteristics of NPV is that it can be produced using relatively simple production techniques (McKinley et al. 1989, Shieh 1989). By 1996 production of HearNPV in India had commenced in both the state and private sector (Puri et al. 1996) and by 1999 some 33 producers of commercial NPV had been established. Some of these were existing agricultural input businesses but many were small-medium enterprises established with minimum capital by entrepreneurs, academics, and even farmers themselves. In addition, a village-level production scheme has been established by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India.

This program of local production has not been without problems. Quality control has been a key issue and early products were often highly contaminated and had very low NPV content (Kennedy et al. 1998). This has also impaired many research efforts as much of the work was and in some cases still is being carried out using NPV of very dubious quality characterized by very low content of NPV and high microbial contamination by bacteria/protozoa. During 1995-97, NRI in collaboration with the Indian Council of Agricultural Research (ICAR), ICRISAT, and TNAU conducted courses for scientists, government staff, and commercial pro^{-1}ducers to teach improved production and quality control techniques. This effort also focused on providing producers with pure properly characterized virus seed stock with which to mass-produce NPV. This has had impact (Jenkins and Grzy wacz 2000) and many producers are now producing an acceptable quality NPV though some poor quality NPV products can still be found. The Gol new pesticide act amendments due to be introduced in 2000 making NPV registration compulsory and establishing quality standards should reduce this problem in future.

The field use of HearNPV has also produced problems. Many of the earlier recommended field application rates were not adequately validated before being promoted. This may explain why some control failures have been reported by farmers (Grzywacz and Warburton 1999). It is possible that field use rates validated in one agroclimatic zone may be inappropriate for other areas where climatic conditions and agricultural practices vary (R Bambawale, personal communication). Thus although work to date has shown NPV used at 1.5×10^{12} viral particles ha^{-1} has worked successfully in southern India, this should be validated by trials in Nepal before it is recommended to farmers.

Field and laboratory work has also shown that the effective application rate on chickpea needs to be much higher than for some other vegetable crops such as tomato. The indications are that there is some biotic factor, probably plant chemistry that reduces both the impact and persistence of the NPV. It is likely that if this can be identified and suitable cheap adjuvants added to the formulation to neutralize this effect then much lower application rates could be employed thereby reducing the costs. In 2000, NRI will start a research project to study this effect and investigate suitable adjuvants.

In the forthcoming on-farm chickpea IPM project a major activity will be to work with Nepalese farmers to develop and promote HearNPV as a practical tool for controlling pod borer and increasing crop yields. We will also seek to develop a locally sustainable supply of NPV. Initially NPV will be sourced using Indian produced NPV that is already commercially available. In addition local production options will be investigated and if appropriate will be implemented. Some village-level production of HearNPV has been developed by ICRISAT. If this model is found to be appropriate and if adequate quality control procedures can be established in Nepal this model will be transferred to Nepal. Possible implementation of this could be through the Nepal Agricultural Research Council (NARC) or the non-governmental organizations (NGOs). Local NPV production could be set up either by users themselves, by farmer cooperatives or NGOs as an income generating activity perhaps for rural women's groups. A third option is to interest a local entrepreneur or small-scale agribusiness. All of these options will be explored and the most effective will be established.

In conclusion, while promoting the effective use of NPV as an improved replacement for existing pod borer control measures presents several challenges, I see none that cannot be overcome. The potential for this technology to make a real impact in improving rural family incomes and nutrition (while avoiding the environmental and health problems inseparable from the use of chemical pesticides) is considerable and should be exploited to the full.

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Role of NARC in Enhancing On-farm Participatory Research and Linkages with the Proposed IPM Program on Chickpea in Nepal

M Joshi, D Gauchan, and N Thakur[1]

On-farm participatory research in NARC

On-farm participatory research is a vital component of the Nepal Agricultural Research Council (NARC) research systems. Outreach research (OR) is the main venue for NARC on-farm participatory research, linkages and partnerships with farmers, extension services, non-governmental organizations (NGOs), the private sector, and other research and development organizations in Nepal. On-farm participatory research on grain legumes, particularly chickpea (*Cicer arietinum* L.), was emphasized with the establishment of the National Grain Legume Research Program (NGLRP) at Rampur during the mid-1980s. Later, after institutionalization of the Outreach Research Program (ORP) in NARC in 1995 and establishment of OR sites in various representative domains of the districts, on-farm participatory research in the form of Farmers' Field Trials (FFT), Farmers' Advanced Trials (FAT), Pre-production Varietal Trials (PPVTs), etc. were promoted (Gauchan and Yokoyama 1999, Gauchan and Joshi 2000). These trials were distributed and conducted by NGLRP and concerned ORPs of Regional Agriculture Research Station (RARS) in their OR sites and collaborative farmers of their command areas in central, far western, and central Terai districts of Nepal. Presently, farmer participatory on-farm trials are being conducted in OR sites and other pockets of Banke, Bardia, Nawalpur, Sarlahi, and Sirha districts.

Need for chickpea IPM research in Nepal

Chickpea is an important winter legume crop in the foothills and Terai of Nepal. It is grown in maize (*Zea mays* L.)-based systems in upland conditions of the foothills and in rice *(Oryza sativa* L.)-based systems in the Terai. Botrytis gray

1. Outreach Research Division, Nepal Agricultural Research Council, Khumaltar, Nepal.

Joshi, M., Gauchan, D., and Thakur, N. 2001. Role of NARC in enhancing on-farm participatory research and linkages with the proposed IPM program on chickpea in Nepal. Pages 99-103 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S., Johansen, C., Stevenson, P.C., and Grzywacz, D., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute

mold (BGM) is the major disease and *Helicoverpa* pod borer the major insect pest that cause significant yield and economic losses to chickpea production. During the 1997/98 BGM epidemic, there was total crop failure of chickpea in the Terai of Nepal.

Farmer participatory integrated pest management (IPM) research on chickpea can bring significant improvement in the crop productivity and welfare of resource-poor farmers in Nepal. The results of last few years of NARC-ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) collaborative farmer participatory chickpea research have been quite encouraging. Integrated use of improved varieties, plant and disease protection methods, and *Rhizobium* inoculation in chickpea has resulted in significant yield gains of 200 to 300 kg ha^{-1} over farmers' traditional practice. This has amply demonstrated that it is a potential winter crop that can be cultivated successfully with integrated management of pests and resources.

Overview of linkage scenario

Although at a low level, there exist formal NARC linkages with collaborating farmers, extension programs [Directorate of Agriculture (DOA)] at OR sites, RARS, and at national level. At grassroot level, linkages exist through Village Level Planning Workshop (VLPW) and other on-farm activities through demonstrations, trials, farmers' field days, joint monitoring tours, and minikits. At regional level, Regional Technical Working Group (RTWG) and planning and coordination meetings and regional review meetings are the main activities in the regions. At the national level, there is a national technical panel for research review and screening of projects. There is a participation of research and development (R&D) executives, farmers, and agro-entrepreneurs' representatives in NARC. There is also a technical panel in all research work plan exercises. From the DOA, mainly Subject Matter Specialists (SMSs) and field technicians of the districts and Agriculture Service Centers (ASCs) are involved with NARC, RARS and commodity scientists, and OR officers. In the international level, NARC has also been closely working with many international agencies such as ICRISAT, Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), and Hill Agricultural Research Program (HARP) project funded by the UK Department for International Development (DFID) in Nepal.

With the advent of globalization and liberalization processes, various new actors such as international non-governmental organizations (INGOs), community-based organizations (CBOs), and other private sector organizations are emerging and taking part in agricultural R&D in the country (Gauchan et al. 2000a). However, traditionally, NARC has limited formal linkage with NGOs, agro-entrepreneurs and other public development institutions (e.g., irrigation projects, etc.). Realizing this problem, NARC has already held consultation meeting with NGOs and the private sector separately and the recently established NGO cell in NARC to initiate a process to enhance its partnership with NGOs and the private sector.

NARC's new strategy for on-farm participatory research

Integrated pest management in Nepal presently is recognized as one of the high priority areas in the National Agricultural Development Plan (NPC 1997). Since IPM research is more knowledge and information intensive, a complex participatory approach with partnership and linkages with diverse actors from both the public and private sector will be key factors in solving the problems of BGM and insect pest (*Helicoverpa)* management in chickpea in Nepal.

NARC is developing partnerships with multiple actors (government organizations, INGOs, private sector, etc.) for efficiently serving the technological needs of target groups such as small/marginal farmers, rural women and other disadvantaged groups in the farming community. It intends to appropriately link the on-farm activities/programs of the NARC institutions with various public and private sector/non-governmental extension and research programs in the country. Partnerships and linkage with INGOs and private sector is essential to utilize complementary skills, knowledge, and resources available with them (Gauchan et al. 2000b). NARC has recently revised its strategy to institutionalize on-farm participatory research through a greater emphasis on collaborative and collegiate approaches to participatory technology development (PTD) such as IPM, integrated plant nutrient management system (IPNMS), participatory plant breeding (PPB), etc. (Biggs and Gauchan 2000). A coordinated and rather mandatory approach that is acceptable to all concerned parties has to be developed to achieve a successful functional linkage between these organizations.

In this context NARC will see its role as more of coordination of IPM research with the partnerships of various stakeholders such as farmers, CBOs, NGOs, public institutions, and international agencies [e.g., ICRISAT, DFID, Natural Resources Inistitute (NRI)] both within and outside the country. Emphasis would be on the location specific needs of the rural clients being served. The actors involved in each location would be different, depending on the research and technology development capabilities of the partners and the technological needs of the clients in those locations. Therefore, there will be different strategies for managing different types of linkages with different actors based on the local capabilities, socioeconomic composition, and circumstances of the actors, local problems, and resources and expertise available (Gauchan et al. 2000b).

Proposed linkage mechanisms

A much closer working relationship and functional coordination between various actors of chickpea IPM R&D are needed. This will include, for example, involvement of researchers together with extension and development actors of both public and private sectors in feedback collection, action research, and problem solving and technology promotion. Efforts have to be made from all institutions to improve the technical capabilities on IPM R&D and facilitate development of functional linkages. Site-specific program activities should be designed in such a way that it should be implemented and monitored effectively.

- Roles, modalities, and operational mechanisms of linkage for each institution need to be defined and spelled out clearly.
- RARS or concerned commodity programs should be lead institutions in NARC for coordination with farmers, NGOs, CBOs, and others in IPM research.
- Monitoring supervision, evaluation, and final reporting lies with the concerned research programs and NARC headquarters.
- Program-level functional linkages are needed with relevant line agencies; e.g., DOA-SMSs and field technicians, INGOs, farmers' groups, CBOs, etc.
- Provision of regular meeting for coordination and program implementation is needed. Monitoring schedules: at farm level, at district and regional level, and at national level.
- Training of field staff of NARC, DOA, NGOs, CBOs. and collaborating farmers on chickpea IPM.
- Documentation, communication, and information sharing of field activities in terms of video, booklets, pamphlets, etc.
- Detailed establishment of linkage mechanisms for site-specific work plans in terms of programs (activities and monitoring), training of technicians and farmers, seed production, and program packaging.

Some issues and suggestions for NARC-ICRISAT collaborative research on IPM

Interactive dialogue and discussion is needed to trace the following:

- How are the proposed outcome and information of collaborative research activities sustained, utilized, and linked to normal outreach research programs in NARC?
- How can partnerships and linkage mechanisms developed in the project period be made functional even after completion of the project?

- What incentives and operational modalities are effective to motivate actors and partners for linkage, partnerships, and overall success of the project?
- What level of linkages and partnership are needed with the private sector for issues other than IPM such as postharvest activities, value addition, and product diversification?

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We Can Make a Difference

B Rana[1]

Saathi is a non-profit, apolitical, research action and counseling oriented organization established in Nepal in December 1992 by a group of dedicated, professional women to address problems on violence against women (VAW), women's rights, and women empowerment at the national level. Since then, Saathi has researched and published the findings of the survey on sexual harassment on the streets of Kathmandu in Nepal. Research was also done on the status of VAW in Nepal. The present strategies of Saathi to work on VAW has been based on these studies.

Programs have expanded in recent years to meet the pressing needs such as opening "Ashreya Shivir", a shelter for victims of domestic violence and "Sumitra" a counseling center for men and women with emotional problems.

With a similar approach, Saathi Banke Branch was established in 1995 to deal with VAW and women empowerment in the mid-western region of Nepal. In order to empower women this branch has taken up social mobilization as a key activity. At present Saathi is working in 11 village development councils (VDCs) and municipality of Banke district. The objectives and activities of Saathi are given below.

Objectives

- Empower the women of mid-western Nepal through social mobilization.
- Make the women of mid-western Nepal decision makers and implementers in development process at the family, community, and regional levels.

Activities

- Community and social mobilization
- Training and workshop on gender and leadership
- Victim support program

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1. Saathi Banke Branch, Sadar Line, Nepalgunj, Banke, Nepal.

Rama, B. 2001. We can make a difference. Pages 104-107 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S., Johansen, C., Stevenson, P.C., and Grzywacz, D., eds.). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

- Jail support program
- Free legal services
- Advocacy
- Income-generation projects

Impact

Victim support programs

The impact of this program can be seen in the increased number of reported VAW cases in Banke district. Government agencies, hospitals, and police are more sympathetic in dealing with women on VAW cases due to our effort. Saathi Banke has managed to make aware and take positive steps towards reducing VAW in the district and in the region. Within a short time of its existence in Banke, there has been a remarkable change in the VAW situations. There are now trained human resources to deal with such situations. There has been a good progress in networking with other government and non-governmental organizations, and international non-governmental organizations (INGOs) working in similar fields.

Women police cell

A women police cell has been recently established in Nepalgunj to deal with all the women-related cases. The formation of this cell can be attributed to Saathi Banke's continuous efforts of conducting training programs and orientation on VAW.

Increase in women participation

There has been an increase of women participation in development sectors.

On-farm chickpea IPM in Nepal

Chickpea cultivation - women empowerment

As Saathi Banke is working on awareness raising, mobilization, and women empowerment in Banke district it could help in integrating the project "On-farm chickpea IPM in Nepal" in coordination with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and Nepal Agricultural Research Council (NARC).

Saathi Banke's vision

- Make the women of mid-western Nepal to build up self-confidence and become self-reliant.
- Make them decision makers and implementers at the family, community, and regional levels.

Project vision

- Active participation of the women in agriculture [chickpea (*Cicer arietinum* L.) cultivation] to generate their own income.

Process

- Women group formation: Saathi Banke is working in 11 VDCs and municipality of Banke district. In each VDC Saathi has five women groups consisting of 25 women in each group.
- Motivate and educate the women groups about the program and prepare them for technical training.
- Identify the socioeconomic status of the women groups.
- Initiate the groups to work together as a team.
- Support them in building up leadership quality and self-confidence.
- Organize training and workshop on gender, legal rights, and leadership.
- Maintain coordination with ICRISAT and NARC.
- Organize workshop on marketing.

Expected outputs

- Women empowerment
  - Women will learn to work in a team
  - Access and control over their own income
  - Increase self-confidence and become self-reliant
  - Knowledge on gender and legal rights
  - Develop leadership quality
  - Participate in decision making at family, community, VDC, and regional levels
- More women participation in agriculture (chickpea cultivation)

- Community people will be gender sensitive
- Poverty alleviation in rural sector

Sustainability

- Establishing women cooperative farming
- Saving and credit scheme
- Establishing Banke district as the center for chickpea production

Need for Chickpea Cultivation in Nepal

U K Shrestha[1]

The People Awareness Center (PAC) is a non-governmental organization in Nepal which helps the poor and deprived people in their socioeconomic activities. Various government, non-government, and other social advancement oriented agencies cooperate with the Center in its endeavor. One of the main activities of this organization is to keep farmers informed of improved cultivation practices such as innovative methods, improved seeds, and other inputs. Apart from its base headquarter at Nepalgunj, this organization is taking up different kinds of socioeconomic uplift programs in nearby districts too. It has a long list of achievements in different areas of its operation.

Agriculture is essential for us. More than 95% of the population in Nepal depends on crop production related activities and our per capita income is very low. An adequate protein intake is essential for healthy development of the human body, which we can get from legumes.

In general, we receive 416 calories in 100 g of chickpea (*Cicer arietinum* L.), and lots of vitamins including thiamine and riboflavin. Chickpea not only plays an important part in our diet, but also helps in increasing soil fertility. The crop is being cultivated successfully in Nepal especially in Terai, inner Terai, and in the hills. Chickpea is used in a range of different preparations in our cuisine. There is a need to rehabilitate chickpea into the vast agriculture system of Nepalgunj where it was traditionally grown. But now the crop area is reduced. We were told by farmers that they cannot grow chickpea because of diseases and insect problems. PAC would like to work with Dr Suresh Pande of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and Nepal Agricultural Research Council (NARC), Khajura, Nepal to promote this crop and integrated pest management (IPM) technologies to farmers in Nepalgunj.

1. People Awareness Center (PAC), Adarsha Nagar-13, Surkhet Road, Nepalgunj, Nepal.

Translated from Nepali.

Shrestha, U.K. 2001. Need for chickpea cultivation in Nepal. Page 108 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S., Johansen, C., Stevenson, P.C., and Grzywacz, D., eds). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for me Semi-Arid Tropics; and Chatham, Kent ME4 4TB, UK: Natural Resources Institute.

Role of ICRISAT

S Pande[1]

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has a long history of close partnership in research-for-development with the national agricultural research systems, subregional fora, networks, governments, development agencies, non-governmental organizations (NGOs), and other institutions in Asia, and this partnership is very much a feature of the project "On-farm chickpea IPM in Nepal". Despite much good work, poverty is still increasing and productivity is declining on a per capita basis. The forces of population growth, land degradation, social upheaval, and impaired institutions and policies still plague the region and impoverish its people. Much remains to be done, and time is running out.

ICRISAT seeks to capture the spirit of the new millennium to put a "human face on science", targeting it towards reducing poverty and improving the livelihoods of the 80 million poor. It is in this context that this is a step forward and our role in this project will be as:

- an active partner - research and development
- a bridge - technology gaps
- a broker - exchange of technologies
- a catalyst - bold new initiatives

We believe that by adopting these roles in partnership with Nepal Agricultural Research Council (NARC), NGOs, and other voluntary organizations we will be able to overcome the problems of rehabilitation of chickpea in Nepal.

Based on consultations with partners from NARC and Natural Resources Institute (NRI), ICRISAT is proposing a collective focus on the main constraints limiting chickpea (*Cicer arietinum* L.) productivity, and indirectly declining soil fertility. Improvement of soil fertility and chickpea as a crop of fallow lands could trigger a virtuous cycle of increasing returns to investments in improved technology.

1. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India.

ICRISAT Conference Paper no. CP 1422.

Pande, S. 2001. Role of ICRISAT. Pages 109-110 *in* On-farm IPM of chickpea in Nepal: proceedings of the International Workshop on Planning and Implementation of On-farm Chickpea IPM in Nepal, 6-7 September 2000, Kathmandu, Nepal (Pande, S., Johansen, C., Stevenson, P.C., and Grzywacz, D., eds). Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics; and Chatham, Kent ME4 4TB. UK: Natural Resources Institute.

Diversification of cropping systems

A recent study on marginal lands indicated that diversification of crops and enterprises was crucial to escaping poverty in less-optimal agricultural zones. While in Nepal staple crops are critical to establish a foundation of food security, the cultivation of more diverse, higher-value crops, such as chickpea, could further enhance incomes while reducing the environmental risks associated with monoculture. ICRISAT's agenda proposes to investigate opportunities to enhance smallholder incomes and system stability through the cultivation of high-value and nutritious crops such as sesame (*Sesamum indicum* L.), finger millet (*Eleusine coracana* (L.) Gaertn.), soybean (*Glycine max* (L.) Merr.), cluster bean (*Cyamopsis tetragonoloba* (L.) Taub.), bambara groundnut *(Vigna subterranean* (L.) Verde), pigeonpea (*Cajanus cajan* (L.) Millsp.), and many others.

A key theme of this strategy will be the diversification of cereal-based systems through the introduction of fertility-enhancing leguminous crops, an area in which ICRISAT has expertise. Legumes reduce the need for external fertilizer inputs while simultaneously improving household nutrition and gender equity as these crops are especially cultivated and marketed by women. The potential for increased consumption of pigeonpea is huge, and the confectionery groundnut (*Arachis hypogaea* L.) market could also expand greatly. The importance and potential of chickpea in the consumer place has also been underestimated in the past.

The importance of crop diversification and crop enhancement in breaking the bonds of poverty in environments such as in Nepal highlights the importance of genetic wealth as a key asset for agricultural development. ICRISAT holds the world's largest collection of agricultural genetic resources of the semi-arid tropics, and if the means become available to do so, it intends to develop regional gene banks so that its partners in Africa can have intimate and ready access to this precious resource.

The present Asian Development Bank (ADB)-Nepal Terai project has shown that if botrytis gray mold (BGM) losses can be overcome and pod borer damage controlled, dramatic improvements in chickpea yield and therefore increased farm incomes can be attained. The ADB project has shown that with adoption of appropriate BGM management strategies and suitable chickpea varieties, BGM damage can be reduced and yields can be increased by 300%. Adopting effective pod borer management further ensures an additional 20-39% increase in yields.

SESSION III

WORK PLANS: OBJECTIVES AND ACTIVITIES

Work Plan for 2000-03

Site characterization

For the purposes of deciding on levels of treatment (e.g., fertilizers), interpretation of crop growth and yield data, and reporting/publication of results, it is necessary to record several basic site parameters, such as soil and weather characteristics and locations of trials.

Weather

Arrangements should be made with the nearest weather station for each target village site to obtain daily data on rainfall, minimum and maximum temperatures, and if available, relative humidity and sunshine hours. Pre-season rainfall data are also required.

Soil

At each target village, samples of soil representative of the sites on which trials will be grown should be taken. For each village location, there should be a minimum of 4 separate samples of 0-15 cm and 15-30 cm soil depth. The samples from 0-15 cm depth should be a composite sample of at least 6 cores, but the samples from 15-30 cm depth can be one core each. Basic analyses of texture (% sand, silt, clay), pH, soil organic carbon, Olsen phosphorus (P), and available nitrogen (N) (ammonium + nitrate) (total N not mandatory but desirable) are needed. Soil color within the profile and soil classification (Nepal system) should also be noted.

Location

A global positioning system (GPS) recording of coordinates of each location, and clusters of trials if possible, should be taken [GPS is available from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)].

Economic assessment of chickpea IPM in Nepal

Objectives and activities

Objective 1. To identify constraints in increasing chickpea production in the target domain

- To undertake a base line survey focusing on technical, socioeconomic, and policy related constraints to chickpea (*Cicer arietinum* L.) production.
- Assess the extent of fallow lands which can be allocated to chickpea cultivation.
- Assess the profitability of chickpea with competitive crops.
- Risk assessment of chickpea and competitive crops.

Objective 2. To assess losses due to botrytis gray mold (BGM), pod borer, and other biotic and abiotic constraints

- Estimate probability of occurrence and assess economic damage due to BGM, pod borer, and other constraints.
- Examine farmers' coping strategies to manage different constraints, with more focus on BGM and pod borer.
- Assess the extent of pesticide use to manage BGM and pod borer.

Objective 3. To assess farmers' perceptions about integrated pest management (IPM) in chickpea

- Interview farmers on different traits of IPM in chickpea.
- Prioritize desirable and undesirable traits of IPM to refine technology for larger adoption.
- Assessment of farmers' responses on collective action in IPM.

Objective 4. To measure impact of IPM in chickpea.

- Undertake reconnaissance survey before and after introduction of IPM package.
- Estimate extent and speed of adoption in the target domain.
- Quantify impact of IPM at farm and regional levels.

Farm-level impact indicators:

- Farm income
- Cost reduction
- Risk
- Food security
- Nutritional status
- Women empowerment

Regional-level impact indicators:

- Chickpea production
- Chickpea prices
- Saving in imports
- Estimates on consumers* and producers' surplus

Objective 5. To conduct environmental impact assessment of IPM in chickpea

- Environmental impact assessment:
  - Saving of pesticides
  - Health related effects of pesticides
  - Improving soil fertility
  - Saving soil nutrients in subsequent crop
  - Utilization of fallow lands

Objective 6. To examine conditions for wider adoption of IPM in chickpea

- Assess constraints in adoption of IPM package.
- Suggest appropriate strategies for wider adoption and larger impact of IPM in chickpea.

Methodology

Study area

A total of 500 farmers in six locations in each district of Nepalgunj, Rampur, and in Tarahara.

Data

Data will be collected on rainfall pattern, cropping pattern, resource endowments (including land and water), resource use pattern, input and output prices, labor availability and wage rates, nutritional status, farm income, and sources of income. Data will also be collected on the extent and intensity of damage due to various constraints in chickpea production.

Analytical approach

- Constraints in chickpea production will be prioritized based on the economic damage.
- Partial budgeting to assess the economic feasibility of IPM in chickpea.
- Tobit approach to assess adoption in short term and long term.
- Economic surplus approach to quantify impact of improved chickpea production methods.

Outputs

- Constraints in chickpea production.
- Impact of improved chickpea production at farm and regional levels.
- Impact of improved chickpea production methods on environmental aspects.
- Documentation of farmers' perceptions on IPM in chickpea, and constraints to adoption.

General layout of on-farm trials and demonstrations

The core design would comprise two treatments, with and without the IPM package. The IPM package would comprise the improved cultivar Avarodhi, seed treatment with commercially available fungicides Thiram® + Bavistin® (1:1) at 2 g kg^{-1}, inoculation with *Rhizobium,* need-based application of diammonium phosphate (DAP) and boron (B) fertilizer, and need-based application of pesticides to control BGM and the pod borer *Helicoverpa armigera.* The non-IPM treatment would comprise a locally available chickpea cultivar with none of the above inputs. One *hatha* (338 m^2) plots would be equally divided between the two treatments to give paired comparisons. There would be a minimum of 6 (but preferably more if manageable) such paired comparisons per target village, laid out on typical soil and under typical agro-environments for that village.

Additional demonstration plots of at least one *katha* area would be planted with the IPM treatment, the number of plots depending on farmer interest, capability, and logistics. These would also serve as seed production plots.

To quantify the effect of *Rhizobium* inoculation and to determine the effect of seed priming there would be a minimum of 4 (but preferably 6) plots per target village. Each plot has two treatments (0.5 *katha* plot per treatment): (1) IPM (as defined above) minus *Rhizobium;* and (2) IPM plus seed priming (soaking seed 8-10 h overnight, surface drying, and application of other seed treatments and sowing on the next day). These plots should be placed next to plots with standard IPM treatments. A 2 x 2 arrangement of (1) Non-IPM; (2) IPM; (3) IPM minus *Rhizobium;* and (4) IPM plus priming would be ideal if manageable. The *Rhizobium* and priming test plots could also be adjacent to IPM demonstration plots if the 2 x 2 arrangement is not feasible.

Boron deficiency of chickpea has been demonstrated as a major constraint of chickpea in the Chitwan valley and thus application of B fertilizer at a rate of 1 kg B ha^{-1} would be incorporated in the IPM treatment there. In Banke and Bardia districts near Nepalgunj, no evidence of B deficiency symptoms on chickpea or other crops could be found in previous seasons and so B could be fairly safely omitted from the standard IPM treatment there. However, some small on-farm test plots (see below) could be planted to confirm absence of a B response. At Nawalpur and Tarahara, however, there is evidence of B deficiency affecting various crops and thus small on-farm plots to test B response of chickpea should be laid out. The IPM treatment with and without soil application of B should be laid out in adjacent 3 x 3 m plots. Six such comparisons per target village should suffice. Sites with more soil organic matter, particularly with recent additions of compost (which either contains B or makes soil B more available), should be avoided.

Site-wise activities

RARS, Nepalgunj (coordinated by V K Dutta)

On-farm activities

There would be 200 participating farmers from D-Gaon and 50 from Bankatua villages in Banke district and 200 from Munalbasti village in Bardia district. Activities would include:

- IPM/non-IPM trials (including minus *Rhizobium* and plus seed priming trials, and demonstrations on sequential cropping pattern) - 425 sets. Some sites in maize (*Zea mays* L.)-based systems to the north could be included if non-governmental organizations (NGOs) could manage this.

- On relay cropping pattern - 25 sets.
- Base line survey of 40 farmers.
- Pre-sowing orientation at 3 locations, including training of trainers.
- Farmers'field day at 3 locations.
- One field monitoring visit, involving farmers, extension personnel, scientists, NGOs, private sector, local leaders, etc.
- One interaction workshop, combined with the Regional Technology Working Group (RTWG) meeting at RARS, Nepalgunj.

On-station activities

- Test efficacy of nuclear polyhedrosis virus (NPV) products as well as some on-farm tests if possible.
- Trial to understand interactions between *Rhizobium* inoculation, seed fungicidal treatment, and seed priming.
- Seed increase of promising cultivars: 1 ha of Avarodhi; and 0.5 ha of Tara.

Collaboration

Nepal Agricultural Research Council (NARC) - RARS, Nepalgunj, Divisions of Entomology, Plant Pathology and Soil Science; Plant Protection Directorate (PPD), Ministry of Agriculture (MOA); Saathi; Peoples Awareness Center (PAC); ICR1SAT; Natural Resources Institute (NRI).

NGLRP, Rampur (coordinated by N K Yadav)

On-farm activities

Some 75 farmers at Rajahar would be involved. Major activities would include: baseline survey, pre-sowing training, IPM/non-IPM trials and demonstrations as described above, NPV management trials, farmers' day, farmers' visit to other sites, and monitoring and evaluation of all locations.

On-station activities

On-station activities would include chickpea varietal trials, seed multiplication and testing, on-station demonstration of IPM, testing effectiveness of NPV and of compatibility of fungicides and *Rhizobium* inoculum, and study of the interaction between BGM (with and without Bavistin®) and B (with and without application).

Collaboration

NARC - NGLRP, Rampur, Divisions of Entomology, Plant Pathology and Soil Science; PPD, MOA; ICRISAT; NRI; NGOs.

Oilseeds Research Program (ORP), Nawalpur (coordinated by R N Chaudhary)

On-farm activities

Some 30 farmers at Lalbandi (Sarlahi district), 50 at Bardibas (Mahottari district), and 20 at Saksoula (Mahottari district) will be involved to test relay cropping of chickpea in rice (*Oryza sativa* L.)-based systems. Activities will include socioeconomic survey, farmers' training, conduct of IPM trials and demonstrations, field days and farmers' visits to research stations and other sites.

On-station activities

On-station activities would include conduct of chickpea varietal trials, IPM demonstration plot, studies on effectiveness of NPV, and seed multiplication of Avarodhi, Tara, and ICCL 87322.

Collaboration

NARC - ORP, Nawalpur, Divisions of Entomology, Plant Pathology and Soil Science; PPD, MOA; ICRISAT; NRI.

RARS, Tarahara (coordinated by C R Yadav)

On-farm activities

There would be a socioeconomic survey of target villages, pre-sowing training for about 25 farmers at Dhangadi, 100 sets of on-farm IPM trials at Dhangadi, 25 sets at Simeria/Saptari, farmers' field day at Dhangadi and other site and station visits, provision of technical support, and supervision for on-farm seed production of Avarodhi.

On-station activities

On-station activities would include evaluation of chickpea genotypes against BGM, compatibility of commonly available fungicides with *Rhizobium,* efficacy of NPV in controlling pod borer, and on-station demonstration of IPM.

Collaboration

NARC - RARS, Tarahara, Divisions of Entomology, Soil Science, Plant Pathology; DPP, MOA; NRI; ICRISAT.

NGOs (Saathi and PAC)

In collaboration with site coordinators, responsibilities will include:

- Identification and survey of target villages in Banke and Bardia districts.
- Social mobilization and farmer selection for on-farm trials.
- Orientation, implementation, and demonstration of improved technologies, in collaboration with specialists.
- Women empowerment motivation and activities.
- Data and information collection, collation, and analysis.
- Monthly meetings at district level.
- Technology transfer, with specialists and after training of trainers.
- Seed processing and storage at village level.
- End-of-season workshop.
- Mid-season and end-of-season reporting.

Seed production, storage, and distribution

Although not specifically written into the UK Department for International Development (DFID) project proposal, it was generally recognized that project impact would depend on development of a sustainable seed production, storage, and distribution (in the next season) procedure for project target areas, and eventually beyond. This was particularly the case if improved cultivars are to be disseminated and adopted at a reasonable rate. It was recognized that traditional procedures of on-station seed multiplication for subsequent distribution to farmers for on-farm trials and demonstrations would not suffice, and in any case are not sustainable. As chickpea seed production and marketing is not likely to be attractive to large-scale commercial seed producers (because of relative low value of chickpea seed as compared with hybrid seed, for example), it was suggested that contract seed production with farmers or village-level seed production schemes need to be developed in conjunction with project activities. Thus a supplementary project proposal is required to obtain funding for this activity. Training is also required in appropriate chickpea seed processing and storage at village level, to ensure adequate seed viability for the next season and thus encourage village-level entrepreneurs to invest in chickpea seed production, storage, and marketing.

(*Note: Site specific and activity specific detailed experimental protocols were prepared separately and site coordinators and their teams were responsible to execute these experimental protocols.*)


WORKSHOP ON PLANNING AND IMPLEMENTATION OF
ON-FARM CHICKPEA IPM IN NEPAL
6-7 September 2000
Venue: Hotel Narayani, Patan, Kathmandu

Invitees and Participants

Nepal

Ministry of Agriculture and Cooperatives (MOAC) and Directorate of Agriculture (DOA)

Honorable Secretary
A Jha, Director General, DOA
S K Verma, Joint Secretary, MOAC
S S Shrestha, Agriculture Extension Division, DOA
K K Shrestha, PPD, DOA

Nepal Agricultural Research Council (NARC)

Khumaltar
Lalitpur
PO Box 5459

D Joshy
Executive Director

D S Pathic
Director, Crops and Horticulture

B R Pradhan
Director, Planning and Coordination

S K Shrestha
Professor and Head, Department of Plant Pathology

D N Manandhar
Professor and Head, Department of Entomology

S P Pandey
Senior Soil Scientist, Department of Soil Science

C B Karki
Senior Scientist, Department of Plant Pathology

S Bhattarai
Senior Soil Scientist, Department of Microbiology

S Joshi
Senior Plant Pathologist, Department of Plant Pathology

S L Maskey
Senior Soil Scientist, Department of Soil Science

B M S Basnet
Chief, Communication, Publication & Documentation

Regional Agricultural Research Station (RARS), NARC

S B Pandey
Regional Director
Khajura, Dist. Bardia
Nepalgunj

C R Yadav
Regional Director
Tarahara, Dist. Sunsari

P C P Chaurasia
Senior Plant Pathologist
Tarahara, Dist. Sunsari

V K Dutta
Senior Scientist
Department of Agronomy
Khajura, Dist. Bardia
Nepalgunj

National Grain Legumes Research Program (NGLRP), NARC

Rampur, Chitwan

R K Neupane
Coordinator

N K Yadav
Senior Breeder, Grain Legumes

Other programs

R N Chaudhary
Senior Scientist
Department of Plant Pathology
National Oilseeds Research Program (NORP)
Nawalpur

D Gauchan
Outreach Research Division (NARC)
Khumaltar

B N Jha
Oilseeds Research Program (NARC)
Sarlahi, Janakpur Zone
Nawalpur
(representative farmer from Bardibas)

NGOs

B Rana
President
Saathi Banke Branch
Sadar Line
Nepalgunj
Banke

S K Bohra
B P Shrestha
U K Shrestha
People Awareness Center
Adarsha Nagar-13,
Surkhet Road
Nepalgunj
Phone:977-081-22177, 21196
Fax: 977-081-22177, 21196

K D Subedi
SSMP
Khatmandu

Farmers

B V Khanal
R Thapa-Magar
Village Munalbasti
Kalika VDC, Dist. Bardia
Bheri Zone

B K Aryal
Village Rajahar
c/o N K Yadav, NGLRP
Rampur, Dist. Chitwan

S Khatri
Village D-Gaon
Bageshwari VDC
Dist. Banke
Bheri Zone

B N Jha
Village Bardibas/Lalbandi
c/o Oilseeds Research Center
Nawalpur

R D Yadav
Village Dhangadi-2
Dist. Sirha
Zone Sagarmatha

UK

D Grzy wacz
Pest Management Department
Natural Resources Institute
University of Greenwich
Chatham
Kent ME4 4TB
Phone: 44-1634-883360

P C Stevenson
Natural Resources Institute
University of Greenwich
Chatham
Kent ME4 4TB
Email: P.C.Stevenson@greenwich.ac.uk

Bangladesh

C Johansen
Apartment 2-B, Palmdale
Plot No. 6, Road No. 104
Gulshan-2
Dhaka
Phone: 8802-608537
Email: ijohanse@citechco.net

India

P K Joshi
Principal Scientist
National Centre for Agricultural
Economics and Policy Research
Post Box 11305
Pusa
New Delhi 110 012
Phone: 011-5713628, 5819731
Fax: 5731978
Email: Pjoshi@iasri.delhi.nic.in
Ncap@x400.nicgw.nic.in

ICRISAT

Patancheru 502 324
Andhra Pradesh
India
Phone: 040-3296161
Fax:40-3241239

W D Dar
Director General

S Pande
Principal Scientist
Natural Resource Management
Program

About NRI

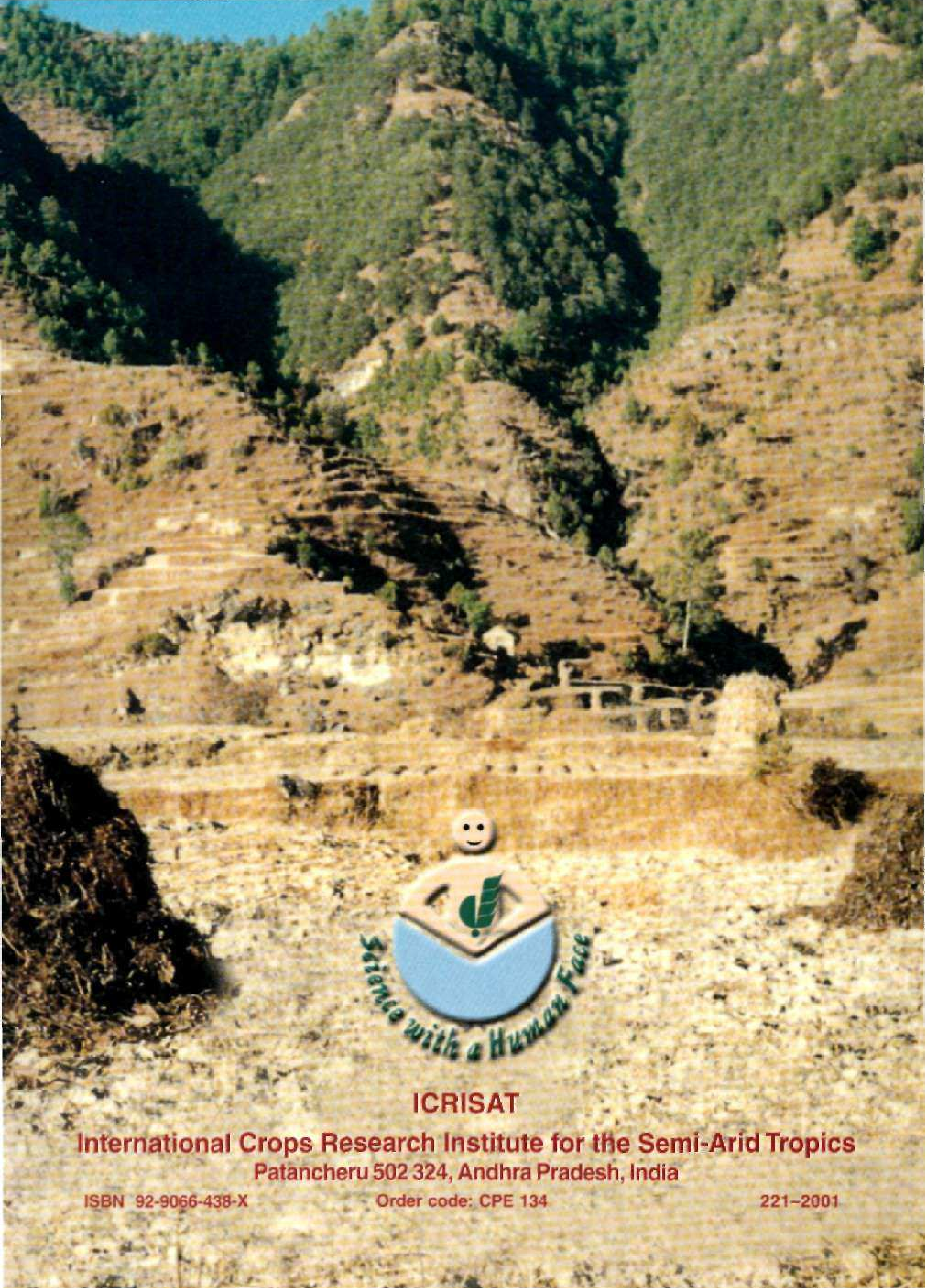
The Natural Resources Institute (NRI) of the University of Greenwich, UK is an internationally recognized center of expertise in research and consultancy in the environment and natural resources sector. The Institute carries out research and development and training to promote efficient management and use of renewable natural resources in support of sustainable livelihoods.

About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one-sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate crops are sorghum, pearl millet, finger millet, chickpea, pigeonpea, and groundnut; these six crops are vital to life for the ever-increasing populations of the SAT. ICRISAT's mission is to conduct research which can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

ICRISAT was established in 1972. It is one of 16 nonprofit, research and training centers funded through the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of approximately 50 public and private sector donors; it is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Bank.



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Patancheru 502 324, Andhra Pradesh, India

ISBN 92-9066-438-X Order code: CPE 134 221–2001