Constraints to Pulses in North-Western Bangladesh

Summary Proceedings of a Project Inception Workshop

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Editors
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Abstract

These proceedings summarize the outcomes of the Inception Workshop of ACIAR Project SMCN/2005/001, entitled “Addressing constraints to pulses in cereals-based cropping systems, with particular reference to poverty alleviation in north-western Bangladesh”. The Project uses methodologies intended to hasten transfer of technology to the target resource-poor farming communities. These methodologies include on-farm research and development, business development services, whole family training and farmer field school approaches; brief descriptions of these methodologies are included. Activities proposed for the 2006-07 season are presented under the four objectives of the Project:

- Promotion of chickpea in the High Barind Tract
- Expansion of cultivation of chickpea and lentil in northern Rajshahi Division
- Mechanization of sowing of pulses using power tiller attachments
- Fertilizer placement studies.

Currently recommended integrated crop management (ICM) packages for lentil and chickpea are presented. Plans for conduct of demonstrations of this ICM technology are outlined and on-farm trials to examine some nutrient components of these packages are specified (effects of method of Rhizobium inoculation and response to Mo, B and lime application). The present state of development of seeder attachments for power tillers is described. As the project requires interaction of multiple partners, guidelines for management and coordination of the Project are elaborated.
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INTRODUCTION

These proceedings summarize the outcome of an inception workshop for ACIAR Project No. SMCN/2005/001, held at RDRS Main Campus, Rangpur, Bangladesh on 5 November 2006. The project, entitled “Addressing constraints to pulses in cereals-based cropping systems, with particular reference to poverty alleviation in north-western Bangladesh”, began on 1 October 2006 and is due to run for four years. The overall aim of the project is to improve livelihoods of resource-poor rural communities in north-western Bangladesh through increasing their knowledge and practice of pulse cultivation. This aim will be underpinned by research to be conducted in Bangladesh and Australia to optimize crop establishment and fertilizer use efficiency of pulses under rainfed and residual moisture conditions. The specific objectives of the Project are to:

1. Assemble, improve and disseminate packages of best practices for chickpea cultivation to new areas in the High Barind Tract.
2. Expand cultivation of winter pulses into the northern Rajshahi Division as represented by Dinajpur and Thakurgaon Districts.
3. Develop, test and disseminate power tiller mounted drills to appropriately place seed of pulses and required fertilizer in the seedbed.
4. Assess the benefits of deep placement of fertilizers for pulse crops and their variation with soil, time of placement, row spacing, and season.

Further elaboration of the rationale and major intended activities for each objective is reproduced from the project document as an appendix.

An inception workshop for this project was intended to:
- provide an opportunity for project participants to meet together, establish a basis for coordination and clarify the mode of operation;
- finalize specific workplans for the first year and general workplans for the entire project duration; and
- arrange logistics and procurements required for the 2006-07 season’s programme.

It was originally planned to hold the workshop in early October, well before the optimum planting time for lentil and chickpea, but political disturbances through October caused postponement of the workshop until 5 November. As a result the scope of the workshop had to be limited, some project participants and intended invitees could not attend and it was already well into the recommended lentil planting period. Nevertheless, the workshop objectives were achieved and the exercise allowed successful initiation of project activities. The workshop programme and the participants are listed in the appendices. It is expected that these proceedings will prove useful as a baseline for the project and, more specifically, as a documentation of the first year’s work plans.

The Editors
METHODOLOGY

On-Farm Research and Development

C. Johansen

On-farm research and development (OFR&D) is generally described as a method of conducting diagnostic and adaptive research in farmers' fields in combination with the extension process (Johansen 2001). It necessarily involves interactive participation among researchers, extension personnel and farmers. The purpose of an OFR&D approach is to hasten adoption of agricultural technologies by resource poor farming communities to improve their livelihoods. It is intended to follow this approach in the current project.

It is proposed that an OFR&D approach, or similar, is required for sustainable stimulation of agricultural development of economically depressed rural regions. Rural poverty remains pervasive, particularly in Africa and Asia, even after decades of international efforts to alleviate it. Stagnation of agricultural development inevitably results in rural poverty, with consequent adverse effects on human health, education, social stability, environment, and other factors relating to human well-being. The original top-down, flow-on paradigms for dissemination of agricultural technology have not been effective in many situations, particularly in rainfed agriculture and for resource-poor farming communities. The traditional pathway of technology flow to improve farming systems has followed the sequence of:

1) Generation of basic scientific knowledge, e.g. at universities.
2) Use of such knowledge in applied, problem-solving research, such as at agricultural research institutes.
3) Passing on of derived technologies to specialist extension organizations.
4) Extension to farmers.

Problems with this traditional paradigm are:
• discontinuities between the steps in the process, typified by an attitude of "I have done my job (e.g. a scientist publishes a journal article), now you do yours";
• lack of feedback from "farmer needs" to research priorities, a top-down approach;
• no follow-up to facilitate impact; and
• lack of social and economic analysis of constraints to technology adoption (i.e. the procedure is technology-dominated).

A more participatory approach across the entire research-to-adoption spectrum is needed, incorporating feedback as well as feed-forward.

A diagram depicting the OFR&D approach, used for previous on-farm studies (Johansen 2001), referred to later, is given in Figure 1. A feature of this approach is that all activities except the component of station/laboratory research, which is usually minor, are conducted on-farm. There is continuing feedback from each step in the process, facilitating modulation of preceding steps. Scientists, extension personnel and farmers are each involved in almost every step, although with different degrees of emphasis.
Figure 1. An example of an On Farm Research and Development approach (Johansen 2001).

Advantages of an OFR&D approach include:
- ownership of the process and outcomes by all partners;
- on-going education and broadening of understanding for all;
- better focus for research, on real bottlenecks;
- working within the target environment and not several steps removed from it, as in research stations;
- multi-location testing to sample spatial environmental variability – many dispersed replications are possible;
- many “degrees of freedom” are possible allowing for robust statistical analysis; and
- farmers readily adopt technologies they try themselves and that work in their circumstances – which compresses the adoption lag.
Nevertheless, there are some difficulties in implementing an OFR&D approach, such as:
- convincing donors of the need for multiple partners;
- difficulties of coordination among partners (but the advent of email and mobile phones have alleviated this problem); and
- less "control" over plots in farmers’ fields as compared to those within a research station (but increased replication compensates any such increased variability).

Examples of projects that have used an OFR&D approach and have achieved measurable impact are as follows:

a) Chickpea in the HBT. The mode of operation of DFID-funded projects on promotion of chickpea in the HBT, during 1999-2006, has involved multiple partners – national and international research organizations, NGOs, DAE and farmers of the target region – interacting across the research-to-adopt spectrum (Salam et al. 2007). All activities of these projects were conducted on-farm and comprised:
- constraint surveys;
- diagnosis and on-farm diagnostic trials;
- on-farm trials (OFT) to establish effects of promising technology components;
- on-farm evaluations (OFE) conducted by farmers at an operational scale to determine if the technology is of use to them;
- wide-scale demonstration of improved technology packages, implemented by farmers; and
- adoption and impact analysis, to establish whether livelihoods are really improved by the technology.

b) Participatory varietal selection (PVS) and client-oriented breeding (COB). These procedures, for example as described by Stirling and Witcombe (2004), are a form of OFR&D in that farmers are intimately involved in the plant selection process, largely on their own farms. Farmers test potential germplasm for direct use or as parents in plant breeding programs. In addition to standard agronomic observations, farmers’ opinions are an important component of the selection criteria. In COB, there are farmer inputs on traits and their relative priority, to assist selection of appropriate parents. There is farmer involvement in selection from segregating populations, and the selection is conducted within the target environment. Nevertheless there is no lack of scientific rigour as, for example, there is testing for pest and disease reaction and quality parameters in early generations. Stirling and Witcombe (2004) give examples of several successful outcomes using PVS and COB, which generally results in:
- a feeling of ownership in the varietal production process by farmers and their more ready acceptance of identified varieties;
- hastening of the plant introduction and breeding process, such that better plants reach more farmers more quickly;
- lower costs than conventional plant breeding;
- more efficient sorting out of location-specific adaptation; and
- by integrating farmer-level seed production schemes, more rapid dissemination of improved varieties.

c) Short duration pigeonpea in northern India. Until the 1990s, short to medium duration (150-200 days) pigeonpea (Cajanus cajan (L.) Millsp.) was grown during the rainy season in the central and western Indo-Gangetic Plain of India, as an alternative to rice. These varieties of pigeonpea matured in late November or December, too late for the optimum sowing time of winter crops, such as wheat, pulses and oilseeds. During the 1990s, there was a concerted effort to introduce short and extra-short duration pigeonpea genotypes into this cropping system, such that pigeonpea yields could be maintained or enhanced and winter crops could be sown on time (Dahiya et al. 2001). This programme followed the OFR&D approach outlined above, particularly in facilitating farmers to conduct their own testing of alternative genotypes, and consequently adoption of the improved technology was widespread (Dahiya et al. 2001).
d) **Groundnut technology in Vietnam.** Also during the 1990s, there were intensive efforts under ICRISAT programmes to introduce and evaluate improved technologies for groundnut (*Arachis hypogaea* L.), including improved varieties and agronomic options, in Vietnam. An OFR&D approach was also followed in this case, with intimate involvement of farmers in technology assessment and experimentation on their own farms. It is acknowledged that these efforts lead to substantial increases in production of groundnut of improved quality, and substantially improved the livelihoods of groundnut cultivators in Vietnam (Ngo The Dan et al. 2000).

It is therefore proposed to follow an OFR&D approach in the conduct of ACIAR Project SMCN/2005/001. It is also to be noted that previous efforts by WRC/CIMMYT in promoting development of power tiller attachments have also followed an OFR&D approach, in that it has been a highly participatory process involving farmers, equipment manufacturers and retailers, farm machinery contractors as well as agricultural scientists and engineers. This has resulted in ready acceptance of machinery developed so far. This Project hopes to continue and expand that process.

**References**


Business Development Services – an interpretation

C Johansen

Business Development Services (BDS) refers to the promotion of commercially viable solutions to sub-sector and MSME (micro, small and medium enterprise) constraints (Lusby and Panilibuton 2004). A commercially viable solution is one which addresses business constraints in a sustainable manner. It not only refers to such factors as finance, training and technical assistance but also to advocacy, market access, inputs and infrastructure, information, input development and technology. A sub-sector refers to a group of all enterprises that buy and sell from each other in order to supply a particular set of products or services to final consumers. It includes producers, processors, input providers, exporters, retailers, etc. (i.e. both vertical and horizontal linkages) and can be defined by a particular finished product or service; e.g. we are concerned with the “pulses in NW Bangladesh” sub-sector. The advantages of a sub-sector based approach are that it focuses on specific needs of all participants in the sub-sector, identifies and promotes business-to-business linkages and identifies opportunities for leveraged impact.

Target MSMEs can be benefited by, and thus should have links to, design services, management and technical training and consultancies, accounting and financial management services, a source of raw materials and input supply, financial services, equipment supply, repair services, transportation services and intermediaries or buyers providing market access. A BDS approach entails shifting to a new paradigm. The original approach with assisting MSMEs was for government or non-government agencies to directly use public funds to assist MSMEs. The new paradigm requires an interface between commercial suppliers and MSMEs with donor intervention only to facilitate that process. In a commercially viable solutions approach, sustainability of benefits to MSMEs is ensured by establishing commercial interactions, and not by government or donor provision of direct assistance. There should be decreased public and donor subsidies as these distort markets. Emphasis is given to facilitation to sustainably increase demand and supply of commercial solutions.

The major actors in a BDS approach, and their roles, are as follows:

- **MSMEs** - actual or potential consumer of commercial solutions/services;
- **Providers** - directly provide commercial solutions and business services to MSMEs; they can be individuals, private commercial firms, industry associations, other MSMEs, etc., and could also include NGOs and government agencies if their provision is commercially sustainable;
- **Facilitators** - develop the supply of commercially viable solutions/services (build the capacity of the solution providers) and also develop demand for commercially viable solutions (promote awareness of solutions among MSMEs);
- **Donors/governments** - fund business development projects and programmes and provide an enabling environment for MSMEs and providers.

Examples of facilitation interventions before provision of a solution include:
- conduct of market research to establish commercial viability;
- promotion of innovation of a solution or service;
- development of capacity of providers;
- promotion of market linkages; and
- informing consumers about availability of solutions/services.

Facilitation of interventions after provision of a solution include:
- monitoring and evaluating impact;
- quality assessment of solutions/services; and
- analysis of feedback from MSME users of solutions.

Key steps in the design of a BDS programme are:
- Sub sector selection.
- Sub sector analysis and identification of constraints.
- Identification/selection of commercially viable solutions.
- Assessment of solutions/services.
- Identification and selection of interventions.
It is intended to follow these steps for Project SMCN/2005/001, beginning with a workshop to map out and analyze the "lentil and chickpea in north-western Bangladesh" sub-sector. Constraints and bottlenecks to sub-sector development, such as supply of seed, fertilizers, \textit{Rhizobium}, seed storage capability, etc., will be analyzed. Commercially viable solutions will be explored and appropriate interventions facilitated.

\textbf{Reference}

The Whole Family Training approach and programme

Md Enamul Haque and SR Waddington

Crop and cropping systems technologies have been developed by several National Agricultural Research System (NARS) institutions in Bangladesh. Many attempts have been made to disseminate these to farmers using different models, including Training and Visit (T and V), Village AID (V-AID), various group approaches and some farmer field schools (FFS). In these models, commonly only a single (usually male) family member is considered "a farmer" for the training. Because of the traditional, gender-biased, part-participatory nature of most of these approaches, some very valuable agricultural technologies have not been successfully used by farmers.

Crop production in Bangladesh is a whole-family activity because all immediate family members participate in the crop production cycle and all family members are affected by production decisions and results. Additionally, families have different mechanisms for determining intra-household labour allocations.

As an improvement and complement to the models mentioned above, the Wheat Research Center of the Bangladesh Agricultural Research Institute, and the International Maize and Wheat Improvement Center (CIMMYT) developed a new approach to technology dissemination which became known as Whole Family Training (WFT). Initiated in 1994, the defining elements of the WFT approach are that it is highly participatory, it uses the farm family as its target for training, it is gender neutral or unbiased (incorporating up to two adult males and two adult females who are actively engaged in agriculture per family) and it is cost effective (Meisner, et al. 2003).

Proof of concept was established through an AusAID pilot project (during 1996-1998) in which more than 98% of the trained families adopted 95% of a range of wheat production and seed preservation technologies. Equally important, follow-up studies showed that they retained the technologies and methods. With the wheat WFT-targeted families, wheat productivity increased by 30% compared with that achieved by untrained families.

Field level organizers, usually from government and non-government organizations, were trained on how to conduct the training with invited families from their working areas, using simple demonstration techniques, picture posters, video, and audience participation. Practical and cheap incentives, that had been useful in the training, were distributed after completion of the training including seed, certificate and production manuals (Meisner, et al. 2003). For wheat and other crops, WFT is normally conducted in a one-day session, just prior to the start of the crop season.

Recognizing the success of the WFT program and its potential for enhancing wheat production and seed preservation, beginning in 1998, USAID funded a four-year extension of the programme. After some impressive results, the programme was granted a further four-year extension by USAID in 2002 for maize promotion. To promote dual-purpose triticale and maize fodder, a project is being funded by DANIDA using the WFT concept. Based on these successes, Winrock International and the
Department of Agriculture Extension (DAE) have also adopted the approach. Some 10,000 wheat producing families and almost 20,000 maize producing families have benefited from training using this approach in Bangladesh.

The WFT concept and programme has proven to be successful in Bangladesh for the promotion and adoption of productive wheat and maize technologies, agricultural machinery, resource conservation measures, fodder production and utilization, and the promotion of high calcium vegetable production (to mitigate rickets in rickets-prone areas). While especially suited as an introduction to farmers wishing to produce a new crop, WFT approaches can be incorporated as part of other longer term and complex approaches such as FFS that may be used to improve a range of management and enterprise options in farming systems with farmers over many months or years. The blending of WFT with FFS may be a very powerful and cost effective training approach in this new project.

Reference
Farmer Field School methodology of technology dissemination used by RDRS

MG Neogi and S Samsuzzaman

Most donor-driven agricultural development projects that target resource-poor farming communities do not continue after the support is withdrawn. A more sustainable approach is needed for better utilization of improved technologies for the production, processing and marketing of agricultural products. An effective extension approach may overcome such deficiencies, helping farmers access technologies through effective extension media. This will continue to guide them in improving their agricultural production and income.

The Farmer Field School (FFS) concept is a farmer-led agricultural extension procedure. Based on experiences from different bilateral projects implemented by RDRS, the FFS concept has been refined by RDRS in accordance with is targeted beneficiaries, and is now implemented in RDRS as its core programme. With FFS, farmers have a key role in identifying their agricultural problems, testing technology for its appropriateness and local adaptation and implementing locally-viable and demand-based technologies to improve their livelihoods. Under FFS as practiced by RDRS, Farmer Promoters have a key role in extending technology and women are prominent participants. The FFS approach is village-based and requires a conducive socio-environment.

FFS, or similar approaches, are needed because of:
- a lack of a continuous information flow system towards end users;
- limited availability of locally identified and tested technologies;
- inadequate knowledge by farmers about the benefits of the latest improved technologies and farming systems;
- non-availability of village- or community-based extension systems; and
- lack of effective institutional linkages, for farmers (especially women) to be involved in mainstream agriculture.

Thus, enhancing self reliance in agricultural management and effective involvement of women requires a continuous information approach with farm-level participatory research and linkages with relevant stakeholders.

The objectives of FFS are to:
- establish an extension capability on a regular and sustainable basis in the locality;
- develop a village based extension approach to ensure active and free participation of farmers;
- improve farmers’ analytical skills and decision making capacity;
- generate critical ways of thinking about and of solving farmer problems;
- ensure participation of end users;
- create opportunities for innovation;
- increase access of women to improved technologies and their empowerment at household and community levels;
- improve use of local resources;
- establish linkages among government, non-government and farmer organizations to make maximum use of resources in the community in an integrated way; and
- enhance research-extension linkages.

The methodologies followed by RDRS in the FFS approach are to:
- establish an FFS in the village/community, where farmers act as extensionists and promoters;
- organize monthly FFS sessions on a regular basis at fixed dates and times;
- establish demand-led farmer participatory research in the locality with the farmers acting as researchers;
- establish women FFS separately to access the technologies and increase their empowerment;
- develop Farmer Promoters as extension agents through training, study visits, field days and workshops to improve their facilitation skills;
• develop commercially viable enterprises at FFS level through provision of revolving fund/credit, to continue the project activities after the project period;
• develop a bottom-up approach in relation to National Agricultural Extension Policy (NAEP).

The step-wise process for transfer of technology through an FFS approach is:
1) Transfer technology to Farmer Promoters and ensure adequate facilities in the FFS centre.
2) Identify and prioritize farmer problems in the FFS centre through Farmer Promoters.
3) Farmer Promoters help prepare lesson guidelines.
4) Conduct FFS sessions.
5) Establish action research programmes in farmers’ fields to overcome farmers’ problems.
6) Prepare and refine lesson guides based on previous FFS sessions and according to findings of action research programmes.

In our FFS concept, the Farmer Promoter plays the lead role instead of staff from the facilitating organization. The Farmer Promoter has been developed and linked to other stakeholders, through training, workshops, study visits, participatory research, etc. All FFS members are encouraged to raise issues concerning their development and RDRS assists in meeting these demands through the FFS.

Our experience shows that one or two training sessions given to farmers in isolation are not enough to successfully disseminate technology, whereas FFS provide an on-going mechanism of technology dissemination. FFS efforts can be improved by coordination and resource sharing between research and extension agencies and NGOs, to provide a more holistic package that is sustainable on farmers’ fields. Most of the technologies developed in research institutes are focused on production aspects and have not been integrated with other factors required to improve livelihoods through technology intervention, including post-harvest operations and marketing. The FFS approach encourages the integration of components that will improve livelihoods.

Thus the experience of RDRS with the FFS approach has been that:
• development of Farmer Promoters is a key factor in the success of FFS;
• the operation of FFS improves the social environment;
• as FFS is village based, participation in the FFS is far more regular compared with an institutionalized training center away from the village;
• due to regular information flow in the locality, farmers are better able to implement introduced technologies;
• Farmer Promoters are now recognized as Extensionists by the community members;
• farmers from neighbouring villages also readily assimilate information from Farmer Promoters through FFS sessions, study plots, and farmer participatory research; and
• as the FFS is an open forum, any issue in relation to agriculture or other areas can be raised.

In conclusion, RDRS has identified the FFS approach as an efficient and cost effective option in agricultural development. Our FFS model has enabled RDRS to innovate an organizational extension model, whereby RDRS has incorporated the FFS into its core program. Women-led FFS is very useful and effective for household development and the empowerment of women.
PROJECT COORDINATION

Linkage to other projects

C Johansen

The present project (SMCN/2005/001) builds on findings and methodologies of several recently completed projects. Firstly, DFID-funded projects (R7540 and R8269) during 1999-2006 conducted research and development on chickpea, and improving the rainfed cropping system in general, in the High Barind Tract (HBT). Secondly, there was an ACIAR project (CIM/2001/039) on integrated management of botrytis grey mould of chickpea conducted in western Bangladesh during 2002-06. It is hoped that DFID funding of projects relating to rainfed farming in the HBT will resume during 2007, and that the present project will operate collaboratively with any new DFID projects in the target region, to create synergies in output.

There is a new ACIAR project beginning in 2007 entitled “Expanding the area for Rabi-season cropping in southern Bangladesh” (ACIAR Project No. SMCN/2005/146). This has the objectives of:

- delineating and characterizing the feasibility of Rabi season cropping in fallow lands;
- fine-tuning agronomic practices to efficiently utilize water and fertilizer; and
- providing farmer training in improved technology.

As both projects involve CIMMYT and WRC, it is intended that many synergies can be gained through close collaboration in implementation of these projects. For example, Project SMCN/2005/146 will utilize APSIM cropping systems modeling capability, now widely used in agricultural research and practice in Australia, which would make it feasible to introduce cropping systems modeling capability into Project SMCN/2005/001. The power tiller seeding attachments developed under Project SMCN/2005/001 should also have applicability for use in Project SMCN/2005/146. There are several other areas of activity and methodology that could benefit through close cooperation between these projects.

Project SMCN/2005/001 would also cooperate closely with a USAID-funded Cornell University project on rice-wheat systems in Bangladesh, particularly with respect to improving tillage techniques and ameliorating acid soil conditions. The proposed project would also attempt to link with rural development projects, such as AusAID food security projects focusing on northern Bangladesh, to promote sustainability of project outcomes. BARC is also coordinating a Government of Bangladesh Project to promote development of pulses and oilseeds in Bangladesh, especially production of seed of improved varieties, and the present project should provide technologies relevant to that effort.
Planning, coordination, monitoring and reporting

R Bell and C Johansen

Both Chris Johansen (CJ) and Enamul Haque (EH) have coordination roles with the Project in Bangladesh. CJ would provide coordination for on-farm demonstrations and trials (Objectives 1 and 2, with PROVA and RDRS) and EH for machinery development and testing (Objective 3, with WRC). On-farm trials involving testing of machinery would be done in liaison with CJ. Each would monitor and evaluate progress, coordinate reporting and plan further steps under their respective objectives. When CJ is out of Bangladesh, EH would be the designated coordinator for liaison with partner organizations in Bangladesh. To facilitate clear communication, Richard Bell, CJ and EH need to copy all email communications to one another, as well as to other relevant project members, so that all remain aware of progress.

EH has suggested that a Project Coordinating Committee would be useful, to meet 2-3 times per year - to plan trials before planting (September-October), to monitor crops during the growing season (Feb-March), and to compile annual reports (May-June). It could comprise representatives of PROVA, RDRS, WRC, CIMMYT, BARC and CJ. The Inception Workshop will serve the purpose of coordination for the 2006-07 season, and further meetings will take place when CJ visits in February during the constraints analysis. EH will coordinate the meeting in May-June to prepare an annual report for the 2006-07 Rabi season. Completion of annual reports for ACIAR should be aimed at 30 June, according to the timing prescribed by ACIAR. These reports are to be submitted by MU but their compilation will rely upon the timely inputs of all partners.
Financial management and accounting

RW Bell, SR Waddington and Anton Adhikari

ACIAR has a requirement for a six-monthly acquittal of funds from Murdoch University (MU) (31 December and 30 June). Hence CIMMYT will also need to provide a six-monthly acquittal to MU of project funds. MU also expects to receive acquittals from the project partners receiving funds from CIMMYT. At each submission of an acquittal, Chris Johansen (CJ) and/or Enamul Haque will obtain a report, verbal or written, on progress against milestones during that period and report to Richard Bell (RB). A written report is required by ACIAR every 12 months, but the 6-monthly report could be either written or verbal. Any carry over of funds may be deducted from the next payment from ACIAR unless there is a clear commitment of the funds. However, significant under-expenditure in any six-month period needs to be explained as it may be an indication that the workplan is behind schedule or that some significant blockage in the work needs to be addressed, with a possible change in the existing plan.

The project has the authority to vary items in the budget by up to 10% or $10,000, whichever is less. Hence CIMMYT, in consultation with RB and CJ have a degree of flexibility in the release of funds to other agencies. Larger variations from the allocated budget have to be approved by ACIAR.

Funds allocated for Department of Agricultural Extension (DAE), for on-farm demonstration trial materials, per diem payments to DAE staff, etc., will be reimbursed by CIMMYT from the DAE allocation on presentation of a financial report.

With signing of the Project document by CIMMYT, MU and ACIAR, funds became available for the Bangladesh component by about 20 November. These funds would be distributed from CIMMYT office according to the following guidelines:

1. Invoicing would be required quarterly, beginning 1 October 2006, or sooner if >75% of the previous allocation had been spent. The amount invoiced for each quarter should be guided by budget allocations in the project document, until and unless deviations from that are approved.
2. Expenditure statements with receipts and vouchers attached for the previous quarter need to be submitted with an invoice for an approaching quarter.
3. If it is not possible to submit original receipts and vouchers (e.g. NGOs need to keep originals for their own auditing), then photocopies may be submitted but with a stamp and initial on each indicating "original held by xxx organization".
4. Receipts or other documents indicating purchase or expenditure need to have "paid" stamped on them.
Concluding remarks

Some overall observations and conclusions emerged during the course of, and in the final session of, the Workshop. These remarks, that are not otherwise mentioned in these proceedings or the Project document, are summarized as follows:

• This Project is timely in addressing the rapidly declining availability, through scarcity and high market prices, of pulses for the diets of the people of Bangladesh. Initiatives are needed to establish the scope for fitting pulses back into the cropping systems of the country. (S Samsuzzaman)

• Among the methodologies presented at the beginning of this workshop, there are several similarities as well as differences in approach. One example is the extent to which women would be involved in the various planned activities, and their mode of involvement. Further efforts are needed to coordinate methodologies, and merge the strong points of each. (C Johansen)

• It remains a challenge as to how best to diffuse the information generated in the Project, in a sustainable manner beyond the life of the Project. Mechanisms for doing this need to be specified. One such mechanism is ensuring "ownership by all" of project activities and outcomes. Another is the use of self-contained revolving funds to cover input costs. (S Samsuzzaman)

• Although there is private sector involvement in development and manufacture of seed drill attachments, such private sector participation also needs to extend to other facets of the Project, such as input supply and marketing. (S Samsuzzaman)

• The Project should utilize the Focal Area Forum for northern Rajshahi Division as a means of disseminating information about the Project and maintaining contact with similar research and development activities within the region. (MG Neogi)

• As there are many partners in this Project, and many who do not often meet, effective coordination will require regular updating of activities and progress via email. Poor email connections, such as at WRC, will need to be remedied if the Project is to function efficiently. (C Johansen)
PROJECT OBJECTIVES AND PROPOSED ACTIVITIES

Objective 1. Promotion of chickpea in the High Barind Tract

Photograph 2: Project personnel approaching a chickpea plot in the Barind Tract, Rajshahi, December 2006
The current recommended chickpea integrated crop management package and workplan for the 2006-07 season

AM Musa and C Johansen

The ICM package for chickpea

In Bangladesh, chickpea has been traditionally cultivated on recent alluvial soils in the western districts of Bangladesh (e.g., Jessore, Faridpur and Pabna). These soils have better soil moisture holding characteristics and fertility levels than those of the High Barind Tract (HBT). Thus optimum agronomic practices developed for traditional chickpea growing areas would need modification for the HBT, particularly with respect to coping with soil characteristics. DFID-funded projects managed by the Plant Sciences Programme, University of Wales, UK addressed limitations to chickpea in the HBT caused by soil moisture deficit and nutrient deficiencies, as well as major biotic stress factors. The recommended agronomic package for chickpea in the HBT, as applicable up to 2003, was summarized by Musa and Johansen (2003), but since then recommendations on applying molybdenum (Mo) and *Rhizobium* in the priming water for acid soil locations have been included (Johansen et al. 2006). Table 1 summarizes the current recommendations for growing chickpea in the HBT, and compares them with those applicable to the traditional chickpea growing areas of the country (Kumar et al. 1995). Recommendations differ for many of the components.

It needs to be emphasized that the recommended package of practices for chickpea in the HBT is dynamic, evolving from year to year. For example, there are on-going studies to determine if phosphorus can also be applied in the seed priming process, if biological antagonists such as *Trichoderma* spp. can inhibit collar rot and to identify chickpea varieties for the HBT superior to BARI chola 5. There are also attempts being made to commercialize the production and distribution of *Helicoverpa* nuclear polyhedrosis virus (HNPV) and of Mo + *Rhizobium* sachets for adding to priming water.

**Table 1.** Recommended package of practices for chickpea cultivation in the High Barind Tract (HBT) (see Musa et al. 2003), as compared with recommendations for traditional chickpea growing areas (recent alluvial soils) (after Kumar et al. 1995).

<table>
<thead>
<tr>
<th>Practice</th>
<th>Recommendation for HBT</th>
<th>Recommendation for traditional growing areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
<td>BARI chola 2 or 5</td>
<td>Mostly BARI chola 5</td>
</tr>
<tr>
<td>Sowing time</td>
<td>15-30 Nov</td>
<td>22 Nov to 7 Dec</td>
</tr>
<tr>
<td>Land preparation</td>
<td>Sow seed and add soil-applied fertilizer before any tillage, then 1 or 2 ploughings and laddering</td>
<td>Plough twice before sowing and fertilizer application, and plough and ladder afterwards</td>
</tr>
<tr>
<td>Seed rate</td>
<td>40-45 kg/ha</td>
<td>35-40 kg/ha</td>
</tr>
<tr>
<td>Seed priming</td>
<td>Required</td>
<td>Mostly not required</td>
</tr>
<tr>
<td>Collar rot protection</td>
<td>Avoid continuous cultivation of chickpea</td>
<td>Avoid continuous cultivation of chickpea and treat seed with Vitavax-200®</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Broadcast 100 kg/ha triple superphosphate (TSP)</td>
<td>Same</td>
</tr>
<tr>
<td>Boron</td>
<td>Generally not needed</td>
<td>Site specific needs, of 1 kg B/ha</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>Apply in seed priming process @ 2 g sodium molybdate/l, if soil pH&lt;5.5</td>
<td>Not required</td>
</tr>
<tr>
<td>Weeding</td>
<td>Weeding usually not required</td>
<td>Hand weeding usually necessary</td>
</tr>
<tr>
<td>Botrytis grey mould (BGM) protection</td>
<td>Only required if there are humid conditions in late Feb-early Mar</td>
<td>Always required; maintain plant population &lt;20 plants/m², spray Bavistin® ® @ as required</td>
</tr>
<tr>
<td><em>Helicoverpa</em> pod borer protection</td>
<td>Practice IPM of scouting, placing bird perches, and need based spraying of HNPV or chemical insecticide</td>
<td>Same</td>
</tr>
<tr>
<td>Seed/grain preservation</td>
<td>Sun drying, sealed plastic bags, use of naphthalene or neem leaves, store in elevated, well aerated location</td>
<td>Same</td>
</tr>
</tbody>
</table>
Workplan for 2006-07 Season

Field activities planned for the 2006-07 season are as follows. They comprise a set of demonstrations of the optimum recommended chickpea cultivation practice and an on-farm trial to evaluate a new form of applying rhizobial inoculum. Evaluation of power tiller attached seed drills will also be undertaken in the HBT, as described under Objective 3.

Chickpea Demonstrations

**Objective:** To demonstrate to resource-poor farmers currently understood packages of best practices for chickpea cultivation in new areas of the HBT.

**Location:** Ten demonstrations in each of Porsha, Shapahar, Niamatpur, Gomostapur, Tanor and Panchbibi Upazilas. Site selection criteria would be: a) land not suitable for intensive, full irrigation, b) farmers willing to allocate about 1 ha of land to grow a cluster of at least 5 demonstration plots in close proximity to each other (to discourage damage/theft as may occur from isolated plots), c) land available for sowing by 30 November, d) adequate soil moisture status at sowing.

**Number of demonstrations:** Total targeted at 60.

**Demonstration plot size:** 1 bigha (= 1,333 m²)

**Sowing time:** 15-30 Nov.

**Variety:** BARI chola 5

**Seed rate:** 5 kg/bigha (= 37.5 kg/ha), with a total of 300 kg seed needed for 60 demos. But conduct germination tests before sowing on representative seed lots to determine if seed rate needs to be increased (increase seed rate if germination is <80%).

**Seed treatment:** Priming for 8 hr overnight before sowing with Mo and Rhizobium inoculum (from BINA) added to the priming water:

\[
\text{Mo: } 1.5 \text{ g sodium molybdate (Na}_2\text{MoO}_4\cdot2\text{H}_2\text{O) per liter of priming water, i.e. 7.5 g sodium molybdate per 5 liters of water (for 5 kg seed). This is equivalent to } 1.5 \times 95.94/242 = 0.5947 \text{ g Mo/L. For 37.5 kg seed/ha need 37.5 L priming solution. Therefore, by adding Mo to priming water, and assuming all of it goes into the seed, we are adding 22.3 g Mo/ha.}
\]

\[
\text{Rhizobium: } 4 \text{ g inoculum per liter of priming water, i.e. 20 g inoculum per 5 liters of water (for 5 kg seed).}
\]

Dissolve sodium molybdate first, then add Rhizobium and dissolve to the extent possible, then add to the 5 kg seeds in a plastic bucket, making up the volume of water to 5 L if necessary.

Sodium molybdate and Rhizobium will be supplied to farmers in 7.5 g and 20 g packets, respectively. For these OFEs need a total of at least 450 g sodium molybdate and 1,200 g Rhizobium inoculum.

**Fertilizer:** 13 kg TSP/bigha (= 100 kg TSP/ha). To be hand broadcast at the time of sowing seed.

**Sowing:** The test site should be well away from any pond or dwellings, where considerable organic matter may have been added to the soil. Hand broadcast seed and fertilizer onto undisturbed land and immediately plough and ladder. Use country plough or power tiller, according to local availability. If a power tiller is used, project staff should be present to ensure that tillage as deep as possible is achieved.

**Water status:** Grow entirely rainfed, without any pre-sowing irrigation.
**Weed control:** Hand weed within 30 days after emergence.

**Disease control:** For Botrytis grey mould, need-based application of Bavistin (see pamphlet)

**Insect control:** For *Helicoverpa armigera* (pod borer) control, identification of eggs and small larvae to initiate action, use of bird perches, timely spraying with insecticide (see pamphlet)

**Harvest:** Record grain yield per plot from total amount of grain harvested per plot by the farmer and from 5 x 1 m² quadrats per plot by PROVA/DAE staff.

**Seed collection:** Farmer to return 10 kg seed per plot to PROVA for use in future demonstrations.

**Farmer seed storage:** Training will be provided to farmers in seed preservation and storage techniques.

**Farmer training:** To be conducted jointly by PROVA and DAE, based on “chickpea ICM for the HBT” pamphlets newly revised by PROVA and DAE. Seed and fertilizer for each demonstration is to be provided to farmers at the time of training. In-the-field training for management of pod borer and BGM to be given in early February 2007. Field days to be held at selected locations where farmer training in seed preservation will also be given.

**Records**
1. Locational details.
2. Soil pH at sowing with pH probe at each demonstration site.
3. Dates of all operations and of maturity and harvest.
4. Nodulation rating for each plot at 40-50 days.
5. Plant symptoms.
7. Plant stand at maturity.
8. Grain and straw yields in quadrats: 5 x 1 m² in each demonstration plot.
10. Also record yields, by quadrat and total plot, in a farmers' practice field in the vicinity, such that the extent of yield improvement obtained by the improved package can be assessed.
11. Farmer's opinion of technique and outcome.

**Responsibilities**
PROVA to arrange training and distribution of supplies, along with DAE Sub-Assistant Agricultural Officers (SAAOs [formerly Block Supervisors]) in blocks where demonstrations are located. At least one PROVA field staff or SAAO to be present at all sowings, and regularly monitor progress, to be recorded in a field book.

**Chickpea On-Farm Trial**

**Evaluation of ALOSCA as a rhizobial inoculant for chickpea.**

**Background**
ALOSCA is a granular rhizobial preparation that can be stored dry at ambient temperatures. Bacterial spores are impregnated in clay particles. This material has proved suitable for legume inoculation under dryland conditions in Australia. It would be suitable for delivery adjacent to the seed in a seed drill. It is proposed to test ALOSCA with chickpea *Rhizobium* to determine its effectiveness for chickpea under Bangladesh conditions.

**Treatments**
1. Control treatment as for demonstrations but *without* *Rhizobium* added to the priming solution.
2. Control treatment as for demonstrations with *Rhizobium* added to the priming solution but ALOSCA granules placed in the seed furrow.
3. Control treatment including *Rhizobium* added in the priming solution.
**Design:** Randomized block with four replications.

**Plot size:** 6 rows 25cm apart and 3 m long (to give a 1.5 x 3 m = 4.5 m² plot)

**Location:** A field where chickpea has not been grown for many years. Surround by a buffer plot of chickpea to minimize interference with treatments.

**Procedure:**
Inputs per plot:
- **Seed:** 17 g/plot; 136 g primed with Mo but not *Rhizobium* and 68 g primed with Mo + *Rhizobium*.
- **ALOSCA granules:** Recommended rate is 10 kg/ha = 4.5 g/plot
- **TSP:** 45 g/plot

Open the six furrows (5-8 cm depth) of only one plot at a time, immediately evenly distribute seed, ALOSCA granules and TSP throughout the furrows, and then close the furrows and compact the soil.

**Records**
1. Locational details.
2. Soil sample at each rep at 0-15 cm for pH, organic C, total or available N, Olsen P.
3. Dates of all operations and of maturity and harvest.
4. Plant stand at 30 days after sowing and at maturity.
5. Nodulation rating in each plot at 40-50 days.
6. Plant symptoms.
7. Weed, disease and pest incidence, and details of remedial measures taken.
8. Grain and straw yields in 4 central rows of a plot leaving 25 cm buffer at each end of a row.

**Responsibilities**
AM Musa, AKM Shahidullah and C Johansen.

**References**


Objective 2. Expansion of cultivation of chickpea and lentil in northern Rajshahi Division

Photograph 3: Lentil farmer in the field at Thakurgaon, 2006-07
Constraint analysis for legumes in the target region

RW Bell, Md Abeed Hossain Chowdhury and C Johansen

Up-to-date information on lentil and chickpea is available to a lesser extent in the northern Rajshahi Division than in traditional growing areas further to the south. A spatial analysis of constraints, firstly based on the extensive database of land resource and agro-climatic information under the custodianship of the Bangladesh Agricultural Research Council (BARC), will be conducted using geographic information systems (GIS). The approach will be to identify the key risk factors, select appropriate spatial data sets from the database to represent these factors and then use weight-of-evidence modelling to produce maps of constraints and of areas most suited to Rabi pulses. This will be conducted jointly by BARC and Murdoch University (MU). In the first season, a comprehensive constraints survey will be conducted across the target region, involving subject matter specialists from MU, RDRS, BARI and DAE. This information would also feed into the GIS analysis. This constraint information will provide a basis for establishing OFTs and OFEs in subsequent seasons, designed to alleviate the major constraints. As part of the constraint survey, and in conjunction with planting the demonstrations, a baseline survey to establish pre-project cultivation of chickpea and lentil in the target region and farmer opinion regarding these crops will be conducted. This will serve as a baseline against which adoption of these legumes will be measured in the final year of the project.

The biophysical analysis of constraints and land suitability for lentil and chickpea will proceed at national and upazilla scales.

National 1:250,000 scale

The current 1:250,000 national spatial database (in Access) has attributes assigned to polygons.

The AEZ mapping units were subsequently dis-aggregated into component AEZ types using a 300 m DEM.

Using this data set, areas of land suitability were assessed nationally for 48 crops including lentil and chickpea. The original report only gave land suitability for T. aman and wheat (FAO, 1997). The rules for assessing land suitability of lentil/ chickpea were developed later by Dr Gulam Hossain and are shown below. It was assumed that lentil and chickpea have similar soil requirements. This needs to be tested by reference to the current guidelines for growing chickpea and lentil and by the on-farm trials and demonstrations. However, generally lentils are not considered suitable for heavy HBT soils, unlike chickpea. Ali (2006) suggests sandy loam to silty loam soils are optimal for lentil, a more limited range of preferred soil texture types than suggested below.

Research plan:

National level
a. Produce maps of nationwide land suitability for lentil/chickpea using existing rules
b. Revise rules for lentil and chickpea land suitability based on input from CJ/ RB and PRC, and re-run land suitability
c. Prepare short report on results.

Upazilla 1:50,000 scale

A second spatial database was developed at the Upazilla scale, covering the whole of Bangladesh, with the attributes (11 land qualities) assigned to mapping units. Mapping units may comprise one or more soil series and land types. There is a possibility of segregating these mapping units into soil series using a 90 m SRTM-derived DEM. This would create a better match of land suitability with land types on the ground. The original point data for profiles has not been entered in the database.

There is a limited socio-economic database, from data acquired in 2001, but the coverage is for only 200 Upazillas over the whole of Bangladesh.
Research plan

Upazilla level

a. Select 4-5 Upazillas for pilot study. Selected Upazillas would range in relief from flat, limited elevation difference (where the DEM may not have sufficient resolution) to highland with clear relief. Upazillas with prospects for pulses should be chosen from Thakurgoan (Ranishankail, Baliaadangil, Thakurgoan upazillas), Dinajpur (Birganj, Kaharole upazillas), and Nilphamari (Kishoreganj, Dimar, Nilphamari upazillas) districts.

b. Set up GIS project with DEM and land mapping units for selected Upazillas

c. Segregate mapping units in selected Upazillas into soil series using DEM

d. Ground truth segregated map for accuracy in predicting soil series and uniformity of soil texture, slope, topsoil consistence, available water holding capacity, soil depth, soil pH. Use sites of Demonstration trials where possible.

e. If successful, proceed to complete the same exercise in other Upazillas across the northern region with highland and medium-highland soils.

f. If not, contact Survey of Bangladesh to see if they have digitised contour maps (< 2m) for northern Bangladesh. Attempt to create DEM from this and test segregation of Upazillas land unit maps to soil series. Another option is to explore whether other finer resolution DEM exist for Northern Bangladesh.

g. Ground truth segregated map for accuracy using especially sites of Demonstration trials

h. If successful, proceed to complete the same exercise in other Upazillas across the northern region with highland and medium-highland soils

i. Map land constraints for lentil and for chickpea based on attributes for soil series, particularly soil texture, slope, topsoil consistence, available water holding capacity, soil depth, soil pH.

j. Map socio-economic factors affecting lentil and chickpea production (e.g. availability of irrigation) based on constraints analysis conducted in February-March 2007.

k. Map land suitability for lentil and for chickpea

l. Compare with RDRS constraints map for lentil and chickpea

m. Compare to constraints identified in demonstration trials in 2007-08 and if necessary revise land suitability rating.

n. Prepare report

Responsibilities

Abeed Chowdury of BARC-GIS will conduct this activity and consult with Richard Bell. Ground truthing will need input from RDRS and possibly Soil Resources Development Institute (SRDI). Mr Shahidullah of PROVA previously worked for SRDI and could be able to assist with ground truthing of the soils in the target upazillas in the north. RDRS will prepare their own constraints map for the Northern Region based on their own network with Farmer Field Schools. In addition the constraints analysis led by CJ, he will provide input to the socio-economic factors affecting chickpea and lentil cultivation.
Acid soil conditions of northern Bangladesh

M Bodruzzaman

Soil colloids (clay and humus) bear negative charge and thus adsorb cations such as H\(^+\), Ca\(^{2+}\), Mg\(^{2+}\), K\(^{+}\), Na\(^{+}\), Al\(^{3+}\), etc. Soils vary in their ability to hold cations. If the ratio of Al\(^{3+}\) and H\(^+\) ions to other cations is higher, the soil is acidic. Soils of a vast area of Bangladesh, including greater Dinajpur and Rangpur districts are acidic. The entire high land and medium high land of these districts are strongly acidic (pH = 4.5-5.5).

The soil of high and medium high land of northern Bangladesh is light in texture and is exposed to heavy rainfall every year. Basic cations (Ca\(^{2+}\), Mg\(^{2+}\), K\(^{+}\) and Na\(^{+}\)) are leached down from the upper to the lower portion of the soil profile due to heavy rainfall. This phenomenon is dominant in light textured soils compared to heavy textured soils and consequently, surface soils are becoming more and more acidic in northern Bangladesh. Furthermore, farmers of this area are practicing intensive cultivation with high yielding modern varieties and removing the crop residues. As crops are grown, large quantities of calcium and magnesium are taken up by the crops. Without replacing these elements, the soil is likely to become more acid with each crop cycle. Again, farmers use heavy doses of nitrogen fertilizer to grow crops, while they use suboptimal doses of other fertilizers (e.g. P, K, S) and they rarely use Ca\(^{2+}\) and Mg\(^{2+}\) fertilizers. These factors also increase the severity of soil acidity.

Soil acidity limits crop yields. Liming can ameliorate soil acidity and improve crop yields. Bodruzzaman et al. (2006) reported that the soil pH was increased and, consequently, the yield of wheat and maize was increased substantially due to liming with dolomite in northern Bangladesh. They also reported that lime (dolomite) at 1 t/ha should be applied 10-15 days before sowing winter crops. Once in three years is enough for achieving higher yields and maintaining soil pH.

Along with soil acidity, northern parts of Bangladesh are deficient in macro and micronutrients. It is reported that macronutrients (N, P, K, S) and micronutrients (Zn, B) are deficient in these soils. Again, some other micronutrients (e.g. Mo, Mg) are gradually becoming deficient in these areas due to no recycling of organic matter and negligible use of micronutrient fertilizers. Bodruzzaman et al. (2005) observed that the yield of wheat and rice increased significantly when using seed enriched with Mo. Mo deficiency was not previously reported in northern Bangladesh.

It is well documented that acid soils possess toxic concentrations of Al\(^{3+}\), Fe\(^{3+}\) and Mn\(^{2+}\), deficient concentrations of P and low availability of bases and micronutrients, which together reduce crop yields. Again, pulses are more sensitive to soil acidity, and Mo and B deficiencies. So, research should be conducted on liming and micronutrient deficiency (especially on Mo and B deficiency) to achieve higher yield of pulses in northern Bangladesh.

References
Current recommended integrated crop management package for lentil

Md Omar Ali and M Shahabuddin Khan

Food legumes, particularly pulses, play a significant role in rainfed agriculture and the supply of protein to the human diet in Bangladesh. Pulses are also a vital component in diversification of Bangladesh’s predominantly rice-based cropping system. Among the pulses, lentil (*Lens culinaris* Medik) is the second most important pulse crop in terms of area and production, but ranks the highest in consumers’ preference and food consumption. Being a legume, lentil is restorative in nature and its seed contains an average of 25.8% protein (Erskine and Witcombe 1984), 59% carbohydrate (Baksh et al. 1991) and several essential elements (Fe, Zn and β-carotene)(Bhatty 1988). Lentil can fix atmospheric N up to the rate of 115 kg N/ha/season (Satter 1997). Lentil straw is valued as animal feed.

Despite the above qualities and the high market prices, the area and production of lentil are decreasing due to various biotic and abiotic constraints. The main genetic and cultural factors contributing to the low productivity of lentil in Bangladesh include:

1. **Low yield potential of local cultivars**, owing to less branching, low podding intensity and very small seed size.
2. **Susceptibility of "local" cultivars to major diseases**, such as lentil rust and stemphylium blight. Collar rot is becoming a serious threat at the seedling stage, especially in saturated soil.
3. **Poor response to high inputs of fertilizer and irrigation**, as genetic erosion has occurred in most of the pulses due to continuous cultivation in marginal, poor soils.
4. **Yield instability due to biotic and abiotic stresses** discourages farmers from growing lentil. In the last few years, heavy rainfall and foggy weather during the flowering stage has caused considerable yield loss. Development of improved, stress resistant varieties is essential.
5. **Delayed sowing**, due mostly to delays in rice harvest, reduces lentil yield by shortening the period for vegetative growth, in the already short winter season of 100-110 days.
6. **Farmers’ lack motivation** to put effort into lentil production. They think that lentil can be grown without due care, so they do not follow the recommended production package and focus their attention and resources on rice and wheat instead.
7. **Low soil pH (4-5) and sometimes high water table** are major limitations for lentil cultivation in Dinajpur and Thakurgaon Districts. Here, there are non-calcareous soils, with less Na, Ca, Mo, B and the soil organic matter content is <1%.

In an effort to become self-sufficient in pulse production, and reduce the drain on foreign exchange, the Government of Bangladesh, policy makers, scientists and the DAE have launched a pulse improvement and development program in the country.

Considering the above problems associated with lentil cultivation, pulse scientists have developed an integrated crop management (ICM) package for lentil cultivation, as described below:

**Cropping pattern:** (1) Broadcast Aus paddy/jute-fallow-lentil; (2) Jute-fallow-lentil; (3) Aus paddy/jute-fallow-lentil + mustard; (4) Broadcast/Transplanted Aman rice-lentil relay; (5) Transplanted Aman rice-lentil-jute/upland rice; (6) Sugarcane + lentil intercropping.

**Location:** High to medium-high land, avoiding soils with excessive soil moisture.

**Soil:** Lentil can be grown in all types of soil but sandy loam to silty loam having pH 6.5-8.0 is more suitable. However, soils of Thakurgaon and Dinajpur Districts are acidic (pH 4.0-5.0), and in some cases the water table is high. These are the major limiting factors for lentil cultivation. Soil pH can be increased through liming @ 1.5-2.0 t of dolochun/ha.

**Land preparation and seeding method:** Land preparation depends on soil type. However, 3-4 cross ploughings are given to produce a fine tilth, followed by 3-4 ladderings. Seeds are sown by broadcasting or line sowing with rows 25 cm apart. If seeds are sown by broadcasting, one ploughing followed by two crossed ladderings should be done after the seed is sown.
Variety: BARI masur 4, BARI masur 5, BARI masur 6 and BINA masur 2.

Date of sowing: Date of sowing is the most important factor determining yield as it has a tremendous effect on the flowering and yield attributes of lentil. The optimum date of sowing is the last week of October to first week of November. Late sowing enhances disease and insect infestation and hampers growth, to finally result in low yields (Khan and Miah 1986).

Seed rate: Plant stand density of 250 plants/m² is optimum for maximum yield of lentil in Bangladesh (Rahman and Miah 1989). To achieve such plant populations, 30 kg/ha seed is required.

Seed treatment: Seed borne pathogens may affect viability and reduce germination of seeds. Seed borne disease infection can be effectively reduced if the seeds are treated before sowing with Vitavax-200 @ 2.5g/kg of seed.

Relay cropping: Relay cropping entails sowing a second crop before harvesting the first crop. This gives plants more time for vegetative growth, makes use of residual moisture, and reduces cost of production (45 %) by dispensing with tillage for the second crop. This technology is suitable in the medium lowlands, where lentil sowing is almost impossible after rice. BARI masur 4 has performed well under relay cropping at a seed rate of 45-50 kg/ha. Lentil seeds should be broadcast 10-15 days before rice harvest in saturated soil. Rice plants should be harvested retaining 25-30 cm straw height.

Seed Priming: Seed priming is an old technology, but many farmers are unaware of its benefit and do not practice it. Moreover, the farmers are not aware of the safe limit of seed priming. It is common to find patchy plant stands as a result of poor and uneven germination when lentil is sown after several tillage operations. During land preparation, soil moisture is depleted through evaporation, which reduces germination. Seed priming is a process whereby seed is soaked in water, usually overnight before sowing, surface dried and then sown. Seed priming improves plant stand, enhances early growth vigour, and results in earlier maturity, reduced disease, and increased yield. Research with improved varieties has shown a yield increase of 34 % from priming (Ali 2004).

Mixed cropping and intercropping: More than half of the lentil cultivated in Bangladesh is grown mixed or intercropped with other winter crops, such as wheat, mustard, linseed, barley and sugarcane. This helps farmers avoid the risk of total crop failure and increases total productivity per unit land area. For example, the most compatible and economically profitable seeding ratios for wheat:lentil were 2:1 or 1:2 (Ahmed et al. 1987). The highest yield advantage was achieved in mixed cropping of mustard:lentil with a seed ratio of 3:1. Intercropping of lentil with sugarcane is most widespread. BARI masur 4, being an erect type, is suited to intercropping with sugarcane – more plants can be accommodated per unit area and canopy geometry of the crops is compatible with good light interception.

Fertilizer application: Balanced fertilizer application enhances lentil growth and yield. Bhuiyan et al. (1998) reported that a starter dose of nitrogen @ 30 kg N/ha as urea, phosphorus @ 50 kg P₂O₅/ha as triple superphosphate, potash @ 50 kg K₂O/ha as muriate of potash, molybdenum @ 1.0 kg Mo/ha as sodium molybdate and boron @ 1.0 kg B/ha as Solubor at sowing, and rhizobial inoculum with seeds @ 50 g/kg seeds, should be applied for lentil cultivation. For relay cropping of lentil, extra N @ 20 kg/ha should be applied at 20-25 days after emergence.

Irrigation and drainage: Normally, lentil is cultivated under rainfed residual soil moisture conditions. If drought stress is observed, limited water could be supplied through flood irrigation but no water would be retained on the soil surface. It is established that lentil requires well-drained soil because it cannot tolerate waterlogging. Waterlogging, even for a few hours, results in rotting of roots and death of plants.

Weeding: Weed control, especially during the early stages of growth is necessary to realize maximum yield of lentil. Ali et al. (2003) reported that one hand weeding at 30 days after emergence should be done to achieve higher yield.

Diseases control: There are 17 diseases of lentil identified in Bangladesh but among them four diseases are major - collar rot, wilt, stemphylium blight and rust. BARI masur 4 is relatively tolerant to
these diseases. These diseases are more likely to occur if the crop is sown late. To control collar rot and wilt, seed should be treated with Vitavax-200 @ 2.5g/kg seed. Besides this, repeated cultivation of lentil on the same land should be avoided. To manage stemphylium blight, Rovral-50 wp @ 0.2 % should be sprayed at 7 day intervals. Rust may be controlled through sowing in time. If it does occur, Tilt-250 E.C. @ 0.5ml/L water should be sprayed.

**Insect control:** The incidence of insect pests in lentil is usually not yield threatening but aphid (*Aphis craccivora*) can be a problem. To control aphid, malathion/meladon-10 @ 2 ml/L water should be sprayed.

**Harvesting, threshing and cleaning:**
The lentil crop should be harvested when almost all the pods have turned brown, by either pulling plants out of the ground or by cutting the plants at ground level with a sickle (the latter method is desirable as it leaves the organic matter and fixed nitrogen in roots in the soil for use by future crops). Plants are then dried in the field or on a threshing floor, until the pods are brittle enough for threshing. Threshing may be done by beating the plants with a stick, trampling by cattle, or with a power thresher. Seeds should be cleaned by winnowing, which is generally done by tossing the seed and debris in the air with forks on a windy day.

**Storage:** Lentil should be properly stored because seed is vulnerable to severe damage by insects, mainly bruchids. The seeds should be cleaned, thoroughly sun-dried such that moisture content is 8-9 %, the seeds cooled, and then stored in either sealed polythene bags along with naphthalene balls, which are placed in jute bags, tin containers or air-tight earthen pots in storerooms. Finally seed should be stored in dry locations above ground level.

**Yield:** By using improved varieties and management practices, lentil yields can reach 1.5-1.8 t/ha.

**References**
Workplan for northern districts in the 2006-07 season

MG Neogi and C Johansen

LENTIL

Lentil Demonstrations

Objective: To demonstrate to resource-poor farmers currently understood best practice for lentil cultivation in north-western Bangladesh.

Location: To be determined, but clusters of demonstrations at a minimum of 5 villages in the districts of Dinajpur, Nilphamari and Thakurgaon. Site selection criteria would be: a) land not suitable for intensive, full irrigation, b) farmers willing to allocate about 1 ha of land to grow a cluster of at least 5 demonstration plots in close proximity to each other (to discourage damage/theft as may occur from isolated plots), c) land available for sowing by 10 November, d) adequate soil moisture status.

Number of demonstrations: The total was originally targeted at 50, but due to availability of extra seed of SARI masur 4, 120 demonstrations were implemented - 60 in Nilphamari District, 52 in Thakurgaon and 8 in Dinajpur (however, due to a shortage of Mo, 28 demonstrations in Nilphamari and 10 in Thakurgaon were implemented without Mo).

Demonstration plot size: 1 bigha (= 1,333 m²)

Sowing time: Soonest possible from 7 Nov, with cut-off date of 15 Nov.

Variety: BARI masur 4

Seed rate: 34 kg/ha, which is 4.5 kg/bigha, with a total of 225 kg seed needed for 50 demos. But conduct germination tests on representative seed lots before sowing to determine if seed rate needs to be increased (i.e. if germination is <80%).

Seed treatment: Priming for 6 hr overnight before sowing with Mo and Rhizobium inoculum (from BINA) added to the priming water; Mo: 1.5 g sodium molybdate (Na₂MoO₄·2H₂O) per liter of priming water, i.e. 6.75 g sodium molybdate per 4.5 liters of water (for 4.5 kg seed). This is equivalent to 1.5 x 95.94/242 = 0.5947 g Mo/L. For 34 kg seed/ha need 34 L priming solution. Therefore, by adding Mo to priming water, and assuming all of it goes into the seed, we are adding 20.3 g Mo/ha. N.B. A germination test will be conducted prior to sowing to establish if this level of Mo adversely affects germination.

Rhizobium: 4 g inoculum per liter of priming water, i.e. 18 g inoculum per 4.5 liters of water (for 4.5 kg seed).

Dissolve sodium molybdate first, then add Rhizobium and dissolve to the extent possible, then add to the 4.5 kg seeds in a plastic bucket, making up the volume of water to 4.5 L if necessary.

Sodium molybdate and Rhizobium will be supplied to farmers in 6.75 g and 18 g packets, respectively. For these OFEs need a total of at least 337.5 g sodium molybdate and 900 g Rhizobium inoculum.

Fertilizer: 13 kg TSP/bigha (= 100 kg TSP/ha); 1 kg B/ha as boric acid (= 5.88 kg boric acid/ha = 0.78 kg boric acid/bigha). To be hand broadcast at the time of sowing seed.

Sowing: The test site should be well away from any pond or dwellings, where considerable organic matter may have been added to the soil. Give the soil pre-tillage and laddering; hand broadcast seed
and fertilizer; immediately plough and ladder. Use country plough or power tiller, according to local availability.

**Water status:** Grow entirely rainfed, without any pre-sowing irrigation.

**Weed control:** Hand weed within 30 days after emergence.

**Disease control:** For management of stemphylium blight apply Rovral-50 wp @ 0.2% at 7 days interval. If rust occurs, spray Tilt-250 E.C. @ 0.5ml/L water.

**Insect control:** If aphid becomes yield threatening, spray malathion/meladon-10 @ 2 ml/1 L water.

**Harvesting, threshing and cleaning:** When almost all the pods turn brown, the plants may be pulled out or cut at ground level with a sickle. Then dry in the field or on a threshing floor, and when the plants and pods become dry and brittle they are threshed by beating with a stick, trampling by cattle or with a threshing machine. Seeds should be cleaned by winnowing, which is generally done by tossing the produce in the air with forks on a windy day.

**Seed exchange:** Farmer to return 10 kg seed per plot to RDRS for use in future demonstrations.

**Storage:** Lentil should be properly stored because seed is vulnerable to severe insect damage. The seeds should be cleaned, dried thoroughly in sun and moisture content should be lowered down to 8-9%; then seeds should be cooled and placed either in sealed polythene bags along with naphthalene balls covered by jute bags, tin containers or air tight earthen pots in storerooms. Seed containers should be stored in dry locations above ground level and the containers regularly checked for rodent or ant damage.

**Training:** A familiarization program, for both lentil and chickpea, to be given for participating DAE personnel (mainly Sub-Assistant Agricultural Officers [SAAOs], formerly Block Supervisors) and field staff of RDRS, where locations of demonstrations would also be selected (done on 6 Nov). Farmer training to be conducted district-wise jointly by RDRS and DAE. Seed and fertilizer for each demonstration is to be provided to farmers at the time of training. In-the-field training for disease management to be given in early February 2007. Fields days to be held at selected locations where farmer training in seed preservation will also be given.

**Records**
1. Locational details.
2. Soil pH at sowing with pH probe at each demonstration site.
3. Dates of all operations and of maturity and harvest.
4. Nodulation rating for each plot at 40-50 days.
5. Plant symptoms.
7. Grain and straw yields in quadrats: 10 x 1 m² in each demonstration plot.
8. Farmer’s whole plot yields.
9. Farmer’s opinion of technique and outcome.

**Responsibilities**
RDRS to arrange training and distribution of supplies, along with SAAOs from blocks where demonstrations are located. At least one RDRS field staff or SAAO to be present at all sowings, and regularly monitor progress, and record all required information in a field book.
Lentil On-Farm Trials

1. To determine the effect of application of *Rhizobium* + molybdenum, boron and lime on lentil.

**Objective:** To assess the extent of response of lentil to Mo + *Rhizobium* and boron and determine if there is an additional response to lime in overcoming an acid soil constraint other than Mo.

**Treatments:**
1. Control, as described for demonstration plots.
2. Control but priming with water only and **without** Mo + *Rhizobium*.
3. Control but **without** boron applied.
4. Control with 1.5 t/ha lime, as dolachun (CaCO$_3$ + MgCO$_3$), **added**.

**Design:** Randomized block with 6 dispersed replications, e.g. 3 around one village and another 3 in another village.

**Plot size:** 5 x 5 m = 25 m$^2$.

**Location:** At locations where lentil demos will be placed. Treatment plots will be surrounded by demo plots or a buffer zone of lentil to minimize interference with treatment plots. The four treatment plots are to be placed side-by-side in the same bunded field.

**Variety:** BARI masur 4.

**Inputs per plot:**
- **Seed:** 85 g/plot; 510 g for 6 plots – to be primed in 510 ml water for treatment 2. For treatments 1, 3 and 4, prime 1,530 g seed in 1,530 ml water to which 2.3 g sodium molybdate and 6 g *Rhizobium* inoculum is added.
- **TSP:** 250 g/plot
- **Boron:** 2.5 g B/plot (= 14.7 g boric acid/plot) (except treatment 3).
- **Lime:** 3.75 kg/plot (for treatment 4 only)

**Records**
1. Locational details.
2. Soil pH in 0-15 cm soil sample in each control and limed plot before lime application and at 1, 2 and 3 months.
3. Soil sample at each rep at 0-15 cm for organic C, total or available N, Olsen P
4. Dates of all operations and of maturity and harvest.
5. Plant stand at 30 days after sowing and maturity, in 5 x 1 m$^2$ quadrats.
6. Nodulation rating in each plot at 40-50 days.
7. Plant symptoms.
8. Plant samples for analysis if distinct treatment differences.
10. Grain and straw yields in quadrats: 5 x 1 m$^2$ in each treatment plot.

**Responsibilities**
At least one of M Omar Ali, M Bodruzaman and C Johansen to be present at sowing, nodulation assessment, and harvest, and regular monitoring through the season. On-site supervision by RDRS field staff, who will record all field operations.
2. Evaluation of ALOSCA as a rhizobial inoculant for lentil.

Background

ALOSCA is a granular rhizobial preparation that can be stored dry at ambient temperatures. Bacterial spores are impregnated in clay particles. This material has proved suitable for legume inoculation under dryland conditions in Australia. It would be suitable for delivery adjacent to the seed in a seed drill. It is proposed to test ALOSCA with lentil Rhizobium to determine its effectiveness for lentil under Bangladesh conditions.

Treatments

1. Control treatment as for demonstrations but without Rhizobium added to the priming solution.
2. Control treatment as for demonstrations without Rhizobium added to the priming solution but ALOSCA granules placed in the seed furrow.
3. Control treatment including Rhizobium added in the priming solution.

Design: Randomized block with four replications.

Plot size: 6 rows 25 cm apart and 3 m long (to give a 1.5 x 3 m = 4.5 m² plot)

Location: A field where lentil has not been grown for many years, preferably a farmer’s field but a field at RDRS farm may be suitable. Surround by a buffer plot of lentil to minimize interference with treatments.

Procedure:

Inputs per plot:
Seed: 15 g/plot; 120 g primed with Mo but not Rhizobium and 60 g primed with Mo + Rhizobium.
ALOSCA granules: Recommended rate is 10 kg/ha = 4.5 g/plot
TSP: 45 g/plot
Boron: at 1 kg B/ha = 0.45 g B/4.5 m² = 2.65 g boric acid/plot
Open the six furrows (5-8 cm depth) of only one plot at a time, immediately evenly distribute seed, ALOSCA granules, TSP and B fertilizer throughout the furrows, and then close the furrows and compact the soil.

Records

1. Locational details.
2. Soil sample from each rep at 0-15 cm for pH, organic C, total or available N, Olsen P.
3. Dates of all operations and of maturity and harvest.
4. Plant stand at 30 days after sowing and maturity.
5. Nodulation rating in each plot at 40-50 days.
6. Plant symptoms.
7. Weed, disease and pest incidence, and details of remedial measures taken.
8. Grain and straw yields in 4 central rows of a plot leaving 25 cm buffer at each end of a row.

Responsibilities

C. Johansen, MG Neogi and Rumana Begum to implement and regularly monitor through the season. On-site supervision by RDRS field staff, who will record all field operations.