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Project final report

project	**Lentil and *Lathyrus* in the cropping systems of Nepal: improving crop establishment and yield of relay and post rice sown pulses in the terai and mid-hills**
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prepared by	Professor C. M. Francis CLIMA, University of Western Australia
Co-authors/ contributors/ collaborators	Mr S. Srivastava Nepal Agricultural Research Council (NARC), Nepal Dr R. Shrestha Nepal Agricultural Research Council (NARC), Nepal
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1 Acknowledgments

Significant progress has been made in all 5 of the objectives defined for the extension. This progress is thanks largely to the combined efforts of NARC staff, notably Mr S Srivastava, Dr R Shrestha, Mr NK Yadav and Mr RK Neupane who assured that the substantial completion of the Nepal project objectives were achieved in the favourable 2006/07 season. ICARDA lentil breeder, Dr Ashutosh Sarker, has continued to supply latest germplasm to the project backed up by annual visits and reporting.

2 Executive summary

Despite a difficult first year with the unsettled political situation, significant progress in the 5 defined objectives has been made as the political situation improved greatly in the second year of the extension. The progress with each objective is summarized in (1-5) below.

1. Continued investigation of wilt and Stemphyllium tolerance in lentil to identify tolerant lines for use as potential genotypes for direct release to breeding programs in Nepal and Australia.

Disease represents the major threat to the short rotation systems used by the numerous small farmers of Nepal. Hence disease screening for resistance both for wilt and Stemphyllium comprised a major part of the research in both 2005/06 and 2007. Particularly encouraging was the fact that a number of selections demonstrated tolerance of both diseases. ILL 7982, ILL7164 and ILL 6408 continued to perform well at a range of sites. The fact that lines like ILL 6256, ILL 6811, ILL8093 which were selected for farmer participation on the basis of wilt and/or Stemphyllium did not perform as well as in 2005/06 trials strongly indicates the need for several years of data from different sites before final conclusions can be drawn on disease resistance. Nevertheless, the results and associated yield and seed quality data will continue to be major criteria for introduction into the farmer participatory research. Associated with the disease screening were trials based on plant density, crop mixtures and time of planting; all of which proved to have no major impact on disease incidence. Fungicide application, however, proved effective in reducing disease incidence in a susceptible commercial cultivar, Simal. Depending on the cost and availability of herbicides 2 sprays can be an economic treatment. However widespread use amongst the small farmers is not anticipated in the immediate future because of cost and problems of distribution of the chemicals.

2. Investigation of the efficacy of seed priming for improving the seedling establishment, vigour and yield in post rice cropping systems.

Seed priming of post rice sown crops is now a recommended practice for lentil production in the Terai. The NGOs extend the practice to farmers practicing post rice cropping. Increases in yield of around 20-40% have been recorded in a series of trials - most recently in post rice sown crops at Rampur. It is important that the lentil is dry sown as any excesses of moisture in the ground will reduce the value of priming. Several experiments, where crops were sown into moist soil, showed no response to seed priming. Reduction in days to emergence has been the main effect of the recommended 12 or 24 hour wetting period in water or cow dung mix. Despite the yield value of priming dry sown lentils, Neupane et al. (2007) still recommend relay sown cropping as having potentially higher yields.

3. Development of new Lathyrus low toxin, (ODAP) lines for Nepal.

Lathyrus sativa lines were grown in Perth as F4 and F5 populations. Growth vigour, maturity and single plant seed yields were assessed. After testing for the neurotoxin ODAP only low ODAP lines were forwarded to Nepal for field evaluation. Pale flower colour, which can be used as a marker, has also been selected in Perth and 28 F4 lines

sent to Nepal for row evaluation in 2006/07. Based on Nepal yield data in 2006 Perth grown seed of the best 6 lines was sent to Nepal with Ms Shrestha in April 2007 to enable NARC to commence immediate bulking in 2007/08. This will be backed by seed of these best lines sown in Perth in 2007/2008 after the completion date of the project.

4. Training of Nepalese scientists.

This has been a feature of the extension. Training of Nepalese scientists in improved methods of statistical analysis and data presentation was continued. A follow up course on statistical analysis was planned for 2006 in Nepal, but due to DFAT travel warnings this was deferred until August 2007. The course was successfully undertaken by Dr Jens Berger, as in the past, and involved 16 Nepalese scientists. The GxE data used included yields of a mix of varieties derived by Dr Renuka Shrestha during her Ph D studies at UWA 2003-2005. In 2006 the project supported 5 delegates to the international Grain Legume conference in New Delhi at which poster papers were presented.

In 2007 the project supported 4 delegates to attend an invaluable travelling workshop to Bangladesh organised by Dr A Sarker of ICARDA and BARI scientists. This enabled study of progress with the ICARDA supported lentil and Lathyrus research, both on farm and on research stations, as well as providing opportunities for joint research and seed exchange.

Visits by Dr Sarker to update NARC on ICARDA germplasm and by Professor Neil Turner for suggestions on physiological studies, made invaluable contributions to keeping NARC scientists to the forefront of lentil development.

5. Support for continued development and improvement of direct farmer seed increase and extension systems for promotion and release of new varieties.

Termed participatory varietal selection (PVS) this approach has been strongly promoted by ICARDA and widely employed by NARC National Grain Legume Improvement Program (NGLRP) scientists through the farmer participation trials in the mid hills, Nepalgunj and Rampur districts. In these different regions of Nepal farmer participation has been a feature of NARC activities. More than 250 farmers in the various regions have received seed samples or participated in NARC trials. Lines ILL7723, ILL7164, ILL7982, ILL7537, ILL4402 and ILL 7979 have been distributed to farmers in the terai (Central, East and West) and the midhill regions. Decision on formal registration of new lines is to be considered prior to next planting season. Already one new cultivar, Shital, has resulted directly from the program. ILL 7982 is a pending new release.

In respect to project administration, communications and publications, NARC staff has fully documented their results despite a number of administrative changes. The return to Nepal of Dr Renuka Shrestha after her successful PhD studies considerably strengthens the NARC team. Mr Surendra Srivastava, now coordinator of the grain legume research in Nepal, along with Dr Shrestha, provided much of the data involved in project reporting as well as the summary of the latest results for the terai.

3 Background

The parent CSI/1999/064 project was designed to follow on from a previous 3½-year project (PN9436) “Improvement of drought and disease resistance in lentils in Nepal, Pakistan and Australia” which terminated in July 1999.

3.1 Lentil and Lathyrus Production in Nepal

Lentils are cultivated in the terai, inner terai, valley and hills regions up to 2000 m altitude (Neupane and Shrestha 1991). Currently the export market exceeds $20M and is an invaluable source of income for farmers and the country alike. The exciting prospects for lentil in the terai region of Nepal provided a clear case for an extension of the project. Varietal development in Nepal could be regarded as in its infancy and a project length of

greater than the initial 3 years of CIM/1999/064 was necessary to achieve the best outcome (Francis et al. 1997). The project has successfully aimed to improve the yield and quality of lentil in marginal and drought-prone environments of Nepal by identifying genotypes with improved yields and disease tolerance (especially wilt), methods for seed priming to increase yield, as well as breeding strategies for lentil in water-limited environments. G x E studies have identified South East Asian and crossbred germplasm developed at ICARDA with SE Asian parents as the best adapted material and this was be fast tracked in the project extension. Increased farmer participation was used to rapidly introduce the varieties and technologies to families in the 2 year project extension.

The major constraints in lentil production in Nepal are wilt disease caused by a fungal complex (Bayaa 1998) and more recently Stemphyllium, a damaging stem and leaf disease. Wilt and Stemphyllium tolerant lines identified during this project will serve as important parental genotypes to be included in the Australian lentil breeding program.

Late planting (due to the long duration of rice) has lead to increased soil moisture stress and lower yields (Shrestha 1998). Other factors contributing to low yield and quality are that lentil is given fewer inputs compared to the major cereal crops in Nepal (rice, maize and wheat). It is cultivated on marginal lands often with poor management practices in the form of low seeding rate, late establishment especially in relay cropping with rice, weed infestation, poor water management, no or little fertiliser use and poor seed quality at sowing time. The parent project was aimed specifically at both improvement of the agronomic practices and well as rapid introduction of improved cultivars largely based around material jointly developed with ICARDA. The extension builds upon this aim especially methods involved with on farm testing (PVS) of new germplasm and technology (like seed priming) selected by NARC researchers.

Poor adoption of new cultivars by farmers is a problem for the Nepal breeding program. Dr A Sarker (Private Communication) has noted that whilst 7 cultivars have been released over the past decade their adoption rate has been slow, in part due to the inadequacies of the seed increase, seed distribution and extension services. Accordingly technology transfer through on farm demonstration and seed increase forms an important part of the project extension.

Another important area needing further development in the extension was the development of low toxin (ODAP) lines of Lathyrus. Being essentially a breeding program fixed lines could not be available in the 3.5 year time frame of CIM/1999/064 hence the project extension was essential to progress the objective. In Nepal1985/86 the area sown to Lathyrus sativus (grasspea) was approximately 53,000 ha (Shrestha 1998) and may have been as high as 170,000 ha in the early 1980s (Neupane pers. com.). Its production has fallen dramatically with ‘officially’ 6255 ha producing 5389 tonnes in 2002/03, due to a government ban on the marketing of the seed consequent upon knowledge of toxicity to human0s. The crop is well adapted in Nepal and breeding of low ODAP lines with Nepalese lines should increase the potential of this crop in the Terai region in particular. Research and development is seen as of high priority by NARC researchers. The major obstacle for Lathyrus development in Nepal is suitable germplasm. As an additional component to the project, Lathyrus genotypes have been developed with emphasis on types suited to Nepal but with lower ODAP contents. Lines (approx. 30) under development in Western Australia include crosses of Nepali landraces with Mediterranean adapted lines. The Chemistry Centre of Western Australia has the technology to rapidly test for ODAP content. Although lentil has largely replaced Lathyrus there are still large areas of potential for the crop as it is considered reliable in poor seasons and tolerant to waterlogging and drought. Great potential as food and animal feed exist for Lathyrus in Nepal if the toxicity risk can be removed by reducing ODAP.

With such a diversity of problems and experimentation, well trained research and extension personnel are seen as essential, Continuation of the in-service training in terms of data analysis, international links and conferences were again priorities for the extension.

4 Objectives

The report describes a 2 year extension of ACIAR supported project CIM/1999/064 - Lentil and Lathyrus in the cropping systems of Nepal: improving crop establishment and yield of relay and post rice sown pulses in the terai and mid-hills.

Specific objectives of the extension were:

1. Continued investigation of wilt and Stemphyllium tolerance in lentil to identify tolerant lines for use as potential genotypes for direct release or in the breeding programs in Nepal and Australia.
2. Investigation of the efficacy of seed priming for improving seedling establishment, vigour and yield in lentil post-rice ('paira') cropping systems in Nepal
3. Development of new Lathyrus germplasm with low content of toxin beta-N-oxalyl-L-alpha, beta-diamino- proprionic acid (ODAP), for Nepal.
4. Training of Nepalese scientists in improved methods of statistical analysis and data handling.
5. Support for the continued development and improvement of direct farmer seed increase (PVS) and extension systems for promotion and release of new varieties.

5 Methodology

5.1 Selection of lines with combined resistance to wilt and Stemphyllium

5.1.1 Wilt

With the intensification of lentil cropping in the Terai in particular, diseases are a major threat. Wilt and Stemphyllium are considered the major disease problems and combination of dual resistance into productive varieties is a major requirement. Wilt screening has become very efficient with the maturity of ‘wilt sick’ plots at Khumaltar and Nepalgunj. NARC through Ms Sarada Joshi has developed considerable skill in disease screening. This is backed by the ICARDA program.

Stemphyllium research

Stemphyllium was not recognised in Nepal as a major problem until recent years after the project commenced. It is now clear that the disease is spreading rapidly in both Nepal and Bangladesh and release of tolerant varieties is of prime priority. The trials so far have shown large variation between seasons and sites in the severity of the disease. Further research is a priority to understand seasonal and site effects and their interaction with variety. In Bangladesh the Pulses Research Centre, Ishurdi, besides the selection of Barimasur 4 for resistance, has developed about 12 new lines from segregating populations supplied by ICARDA. These have high levels of resistance against rust and Stemphylium blight diseases. The lines x96S-40-50134-5, x95S-136 and BLX 98005 are the candidates for future release. NARC and ICARDA should make every effort to have these lines introduced into Nepal. Reciprocal visits between NARC and BARI can be part of the initiative.

Activities

- Reciprocal visits between BARI and NARC pathologists to update each other on latest data and germplasm of promise.

- Stemphyllium screening at Rampur: It is essential that common control varieties be included at all sites and in both years. One control must be Bari Masur 4. All the best rating varieties for wilt should be included.
- Extensive wilt screening on 'wilt sick' plots in Khumultar and Nepalgunj. Ensure controls common to both sites and that the best rating of previous years are included.
- Fast tracking to farmers in most prone zones any varieties with dual resistance
- Research into disease control packages, row spacing, crop mixtures, and strategic spray application, to establish if cost effective.

5.1.2 Development of methods including seed priming for better crop establishment and yield.

This part of the project assesses the value of seed priming, which has proven effective in increasing and stabilising yields in on-farm trials in India for chickpea and other crops (Harris et al. 1999). Results in the ACIAR project have indicated that a method comprising 12 hours soaking with a short period of air drying has increased yields of lentil in Nepalgunj for the post-rice sowing system by 20%-40% or more. Further experiments can be conducted to include additional treatments including animal dung extract (used by farmers traditionally in the Indian subcontinent) and soluble fertilizers in the soaking solution. Data recorded will include time to 50% emergence, plant establishment (plants per m2), root penetration depth at 14 days after sowing, biomass at 7 weeks after sowing, yield, and biomass at harvest. For the subsequent years, the best two treatments will be repeated at Nepalgunj and Khumaltar and at farmers' sites to test the method over years and sites. Farmers' field days will be undertaken at these sites.

5.1.3 Identification of Lathyrus with adaptation and lower ODAP for Nepal farming systems.

Suitable low-ODAP homogeneous lines (F4 and beyond) selected from crosses developed at CLIMA will be assessed in small replicated plots in Nepal. The best of these will be carried on to be tested at 3 sites for the following two years with appropriate local checks. ODAP contents will be assessed at the Chemistry Centre of WA during both of those years. Biomass and seed production will be recorded also to enable the selection of lines for grazing and seed production.

Previous CLIMA research on Lathyrus crop improvement has evaluated progeny of crosses between Indian subcontinent (including Nepal) germplasm and low ODAP lines from specific sources for which intellectual property issues are not a restriction. Successive generations will be increased rapidly in Perth in single plant rows with flowering dates and vigour of individual plants recorded. Single F4 and F5 plants will be selected and small seed samples tested for ODAP prior to sending to Nepal. Best lines F6 with low ODAP will be carried forward and increased off-season in Nepal for evaluation in small replicated plots at one site during the winter growing season in Nepal. A back up population will be retained in Perth.

Activities

- Grasspea is better adapted to waterlogging than lentil and should out yield lentil in the relay system both in terms of dry matter and seed yield. This needs to be confirmed or otherwise and an economic analysis needs to include the value of the dry matter.
- CLIMA lines 20 B (Ceora), 19B, new crossbreds and CLIMA Pink should be compared to Sarlahi and a lentil like ILL 7723 in seed yield and dry matter in relay and dry sown crops.
- NARC should seed increase these lines for future assessment.

- NARC and CLIMA should make single plant selections from low ODAP Salahi x 20B F3 selections supplied by CLIMA as a back up and for comparison with a similar set of selections to be undertaken by CLIMA in Perth where ODAP analysis can be performed.

5.1.4 Training of Nepalese scientists In Biometrics and data handling

In 2003 Dr. Jens Berger (Senior Research Officer, CLIMA) and Ms. Jane Speijers (Senior Biometrician, WADA) ran a short, three day course on data handling using Excel, and multivariate analysis using SPSS, at the Lumle Agricultural Research Station (Nepal) for NARC scientists associated with the ACIAR project, CIM/1999/064 'Lentil and Lathyrus in the cropping systems of Nepal: improving crop establishment and yield of relay and post-rice-sown pulses in the terai and mid-hills'. The course was a subset of a longer, more comprehensive course covering experimental design and analysis, which was run on several occasions in India and Cambodia in 2003. While the short course was very much appreciated by NARC scientists, there was considerable interest in covering the additional areas that comprise the full course at a later date

Nepal delegates strongly requested further training in design and statistical analysis, including G x E. The participants of the previous courses expressed the opinion that they very much benefited from the course and promised that they would utilize the skills in their daily work. They also expressed the desire that such short courses be continued in future for the specific benefit of NARC research workers. A weeklong course on "Introduction to modern PC based data handling and methods of analysis can be held at the Regional Agricultural Research Station, Lumle, was planned to be held March or April 2006. The course was organized jointly by NARC and CLIMA as a part of the activity, 'Capacity building of NARC Scientists'. This would be a follow-on training for participants of 2003 and 2004 courses. (Course deferred to July 2007 due to travel restrictions in 2006)

Lumle is a picturesque hill research station situation at an elevation of 1600 m, 32 Km west of Pokhara valley in the western region. Altogether 16-18 participants from various NARC stations could attend the course. The course would be conducted through power point presentation and practical sessions, which enables participants to acquire practical knowledge on data handling and analysis. The course would represent a progressive attempt to add to the statistical knowledge already acquired in an area where NARC scientists are not strong. Ms Renuka Shrestha could, given her recent training and knowledge of G x E interactions, assist Dr Jens Berger in the construction and operation of the course.

5.1.5 Farmer participation improving the rate of seed increase and distribution to farmers

This has been perhaps the best investment for the project in developing systems for rapid uptake of new cultivars. Too often in the past newly bred material takes many years to enter the farm system. Project funds will be used for farmer buy back and to provide low cost seed to farmers. The system employed to further the release of ILL 7723 for large scale plantings in 2004/05 has also seen the approval in June 2004 for release of Shital (ILL 2580), a line broadly adapted throughout the Terai and successful particularly in the relay rice system. Other promising lines include ILL 7982 (with wilt and Stemphyllium resistance) and ILL 6829 which require additional farmer exposure prior to release.

The research station specialists in lentil production and seed increase have some problems with off-station sites in terms of transport of personnel, organisation and finance. Extension officers are often not well enough versed in seed increase systems to manage them alone. As a consequence, the initial distribution and effective culture of new varieties is usually limited to areas close to the stations. This, together with difficulties of subsequent distribution of seed, is hindering the widespread uptake of new cultivars. To extend the benefits of the improved cultivars, more farmers' fields over wider locations are

required as recommended in the ACIAR review 2005. These would be coupled with demonstrations and field days. It is a specific interest of ICARDA in being a problem common to several countries within their network. Against this backdrop, it was important to include technology transfer as part of the project extension. Farmers' field demonstrations with improved cultivars and proven elite lines will be conducted in 4-5 villages in the intensive lentil growing areas. A farmer's local check will be included among the test material so that the farmers can easily compare and be motivated towards adoption of the improved varieties. The varieties/lines will be evaluated within a strip planted in the available land area. At crop maturity, field days, farmer rallies, and farmer training will be organized at the demonstration sites. The farmers, researchers, extension agents, and NGOs will be involved in evaluation of test material. With their native wisdom, first hand knowledge of the crop and cropping systems and other local conditions, farmers can be effective collaborators in this endeavour. Involving the farmers in the variety selection not only leads to the development of appropriate high yielding varieties suited to local conditions but also facilitates their faster and wider adoption. Equally, farmers are better motivated to exchange seeds among themselves.

6 Achievements against activities-outputs/milestones

Objective 1: Continued investigation of wilt and Stemphyllium tolerance in lentil to identify tolerant lines for use as potential genotypes for direct release or in the breeding programs in Nepal and Australia

No.	Activity	outputs/ milestones	Completion date	Comments
1.1	Midhills	New varieties with resistance	Continuing	At least 1 new Variety scheduled for release. Good prospects of varieties with dual resistance
1.2	Terai	New varieties with resistance	Continuing	2 varieties scheduled for release, Good prospects of varieties with dual resistance

PC = partner country, I = ICARDA A = Australia

Objective 2: Investigation of the efficacy of seed priming for improving seedling establishment, vigour and yield in lentil post-rice ('paira') cropping systems in Nepal

No.	Activity	outputs/ milestones	Completion date	Comments
2.1	Research midhills	Recommendation for farmers	Essentially Complete	Recommended for dry sown lentils
2.2	Research terai	Recommendation for farmers	Essentially Complete	Recommended for dry sown lentils

PC = partner country, A = Australia

Objective 3: Development of new Lathyrus germplasm with low toxin, beta-N-Oxalyl-L-alpha, beta-diamino- proprionic acid (ODAP), for Nepal.

No.	Activity	outputs/ milestones	Completion date	Comments
2.1	Midhills	Trials in 2006 2007	Continuing	Continuing for farmer participation Low ODAP varieties promising

2.2	Terai	Trials in 2006 2007	Continuing	Continuing for farmer participation Low ODAP varieties promising
2.3	CLIMA	2006-08	Continuing	Seed supply and ODAP tests

PC = partner country, A = Australia

Objective 4: Training of Nepalese scientists in improved methods of statistical analysis and data handling.

No.	Activity	outputs/ milestones	Completion date	Comments
2.1	Specialis t courses	Courses completed	July 2007	3rd course successfully completed

PC = partner country, A = Australia

Objective 5: Support for the continued development and improvement of direct farmer seed increase (PVS) and extension systems for promotion and release of new varieties

No.	Activity	outputs/ milestones	Completion date	Comments
2.1	Midhills	PVS on farmers properties	Continuing	Strong uptake by NARC Varieties scheduled for release
2.2	Terai	PVS on farmers properties	Continuing	Strong uptake by NARC Varieties scheduled for release

PC = partner country, A = Australia I = ICARDA

7 Key results and discussion

7.1 Data from 2005/06 and 06/07 relating to the main project objectives of the extension of project CSI/1999/064

There were five objectives of the extension, and the data is summarised below with a focus on the most recent 2006/07 data. The progress toward these objectives has been the main thrust of the project extension and is covered in the reports below (1-5).

1. Continued investigation of wilt and Stemphyllium tolerance in lentil
2. Investigation into the efficacy of seed priming for improving yields in post rice systems
3. Development of new low toxin Lathyrus germplasm
4. Training and capacity building of Nepal scientists
5. Continued support for farmer participation (PVS) in seed increase and extension systems for the release of new varieties.

Additional reports by the Nepal or Australian participants having a bearing on the above objectives are provided in full (see reports Appendices 1-5).

7.2 Key results:

7.2.1 Continued investigation of wilt and Stemphyllium tolerance in lentil.

Investigation into wilt and Stemphyllium logically continues to be a major input of NARC research. The importance is accentuated by the numerous small farmers with limited land

requiring continuous cropping with short rotations. This provides an ideal breeding ground for diseases and an increasing problem for small farmers who can ill afford modern fungicides. Vascular wilt caused by Fusarium oxysporium f.sp. lentis, root rot caused by Fusarium solani, Fusarium spp. and Rhizoctonia spp. are very important diseases of lentil in Nepal where cropping is frequent. For small farmers the most efficient and suitable method to control the disease is the use of resistant varieties. This work has been a priority in the project extension along with an increased effort to select for resistance to Stemphyllium which has emerged as a serious pest and considerable emphasis is placed on disease screening, crossbreeding and selection during the project extension.

More than 120 varieties were included in major screening programs at Rampur and Nepalgunj which duplicated most of the lines. The Stemphyllium was more severe at Nepalgunj and very few selections rated less than moderate (rating 5). Only ILL 8191 was relatively resistant to Stemphyllium in both trials, however, its susceptibility to root rot appears responsible for its very low overall yield. It is important for NARC pathologists to establish whether there are different strains of Stemphyllium involved or that it is merely an effect of the disease onset in terms of time and severity. A listing of the best rating varieties is presented in Table 1.1 below.

A promising development is that new advanced cultivars Bari Masur 5 and Bari Masur 6 were imported from Bangladesh by NARC delegates at the 2007 travelling workshop. These are two of the most resistant lines under evaluation by BARI scientists. This research is also supported by ACIAR and ICARDA and given the relative success of Bari Masur 4 in Nepal; it is likely that these advanced lines will also prove invaluable. Barimasur-5 performance in Bangladesh was excellent. Resistant to Stemphyllium blight, Barimasur-5 is also resistant to rust, tolerant to root rot and moderately resistant to aphids. Barimasur-6 has similar traits to Barimasur-5, but matures 5-10 days earlier and has about 15% higher seed yield than Barimasur-5. The Nepal team should fast track assessment of these lines especially as they appear capable of performing in environments similar to large areas of Nepal terai.

Table 1.1: Best rating varieties Rampur and Nepalgunj 2006/07

Genotype	**Rampur (score = 1-9)**			**Nepalgunj**
	Stemphyllium	Wilt	Yield (kg/ha)	Stemphyllium (1-9)
ILL 1704	3	5	330	5
ILL 6025	1	5	171	7
ILL 6818	3	7	73	5
ILL 8603	1	5	102	5
x 94529	1	5	136	5
ILL 9990	1	5	54	5
ILL 9931	1	7	222	5
ILL 9996	1	7	143	5
Mangal Bazar	1	7	95	5
Bari Masur 4	3	5	150	7
CUMARA	3	5	318	5
X94-S-38	3	5	365	
ILL 7715	3	5	420	5
ILL 8186				3
ILL 8191	3	9	33	3
ILL 7164 (Control)	3	7	326*	6
Shital (Control)	6	7	235*	7
Previous selections				

ILL 6408	3	9	74	5
ILL 8093	7	9	291	
ILL 7982	5	5	395	7
ILL 6256	5	9	170	
ILL 7723	3	5	204	5

Although inherited resistance remains the main focus of the NARC and ICARDA research 0ther possible methods of disease management were researched in the project extension.

a) Sowing of lentils in mixtures, b) the possible use of fungicide sprays and c) seeding date and row spacing).

Mixed cropping research (2005-06)

Farmers practice mixed cropping lentils with winter cereals and oil seeds and other legumes, as insurance to failure of any one individual crop. In experiments conducted over the years, rapeseed mustard (Brassica campestris var toria), which matures in December was the found the most compatible intercrop with lentil. Seed rates of 30 kg of lentil and 2 kg of mustard per ha was the best seeding ratio for realizing higher yield and profit from mixed cropping under rain fed conditions (Darai et. al., 2000).

Inter cropping lentil with mustard was found to the most profitable combinations with the high labour unit land equivalent ratio found on most of the labour intensive small farms of Nepal. (Table 1.2). The yield improvement and profitability however, needs further documentation and research as to whether some combinations such as the waterlogging tolerant linseed sown with lentil in a relay system are viable. Further research was thus undertaken as part of the extension to tighten up the recommendations and express them in economic terms for the drier Terai. This was planned for 2006/07 to be linked with the measure of any effect on key lentil diseases.

Table 1.2: Intercropping trial of wheat, lentil and mustard, Khumaltar, 2005/06

Intercropping Combination	**Seed yield (kg/ha)**			**Cost of production (Rs/ha)**	**Gross return (Rs/ha)**	**Net benefit (Rs/ha)**
	Wheat	Lentil	Mustard			
Wheat + Lentil	1669	448	-	7702	11152	3450
Wheat + Mustard	1613	-	369	7487	11247	3760
Lentil + Mustard	-	338	580	6199	10914	4715
Lentil (Simrik)	-	790	-	6114	7903	1789
Mustard (local B campestris)	-	-	736	5984	9590	3606
Wheat (Lerma-64)	2114	-	-	7789	8456	667

Effect of crop mixtures on Stemphyllium blight of lentil Rampur and Nepalgunj, 2006/07

There is considerable evidence from previous research that sowing lentil in mixtures with other crops resistant to Stemphyllium is more profitable than lentil alone and the practice is widely adapted by farmers for post rice cropping. This series of experiments entailed mixed cropping as a possible means to control Stemphyllium without sacrificing yield. The data from both Rampur and Nepalgunj supports the practice of mixed cropping (Tables 1.3 and 1.4). Normally mustard which is easily mixed with lentil seed, widely consumed and easily saleable, is most popular with farmers but needs earlier sowing than was the case at Rampur 2006 (Table 1.3).

Table 1.3: Effect of seeding lentil in crop mixtures for profit and possible disease control – Rampur 2006

Crop mixtures	**Diseases (1-9)**	**Grain Yield (kg/ha)**

	Stem	Wilt	BGM	Lentil	Mix	Total	Value
Lentil Mustard 2:1	3	5	3	585	15	600	Rs17920
Lentil Mustard 3:1	3	5	5	397	13	410	Rs12235
Lentil Linseed 2: 1	3.5	5	7	527	457	983	Rs 27215
Lentil Linseed 3:1	3.5	5	7	395	640	1035	Rs 27850
Lentil Coriander 2:1	4	5	7	320	303	623	Rs 21720
Lentil Coriander 3:1	4	5	7	453	140	593	Rs 19190
Lentil alone	7	5	9	-	-	643	Rs 19290
Mustard alone	-	-	-	-	-	94	Rs 2350
Coriander alone	-	-	-	-	-	483	Rs 19320

Planted on 22/11/2006, Lentil @Rs 30/kg, Mustard @Rs 25/kg, Coriander @ Rs 40/kg, Stem = Stemphyllium, Wilt = Black root rot (Fusarium solani), BGM = Botrytis grey mould

Table 1.4: Mixture trial Nepalgunj, 2006/07

Treatment	**Plant stand/m2**	**Disease score**	**Lentil (kg/ha)**	**Mix (kg/ha)**	**Value**
Lentil mustard 2:1	74	6	1320	403	Rs 49695
Lentil mustard 3:1	50	6	1016	500	Rs 42980
Lentil linseed 2:1	44	5	1316	500	Rs 51980
Lentil linseed 3:1	51	6	816	330	Rs 32730
Lentil coriander 2:1	56	6	1200	250	Rs 46000
Lentil coriander 3:1	50	5	1033	330	Rs 44190
Lentil alone	58	6	1330	-	Rs 39900

Planted on 2/11/2006, Lentil @Rs 30/kg, Mustard @Rs 25/kg, Coriander @ Rs 40/kg

The crop mixtures were chosen to achieve as near as possible 2 lentil:1 mustard or 3 lentil as to 1 mustard in the case of the easily mixed seed of lentil and mustard. This is achieved by farmers mixing 20 kg lentil with 2.5 kg of mustard per hectare for the 2:1 mix and 22-30kg of lentil with 2 kg mustard for the 3:1 ratio of plants. For species mixes not stable when mixed like lentil/linseed and lentil/coriander the ratios were achieved by sowing in separate rows e.g. 2 rows lentil vs. 1 of linseed. Controls of lentil alone are sown at 30kg per hectare in common with recommended practice.

Fungicides

Although spraying may help with Stemphyllium it is ineffective against root rots and not recommended currently to farmers of the region despite having some benefit for Stemphyllium control (Table 1.5).

Table 1.5: Effect of fungicide application on lentil diseases Rampur, 2006-07

Fungicide	**Diseases (1-9)**		**Grain Yield (kg/ha)**
	Stemphyllium	Root rot complex	
Carbendazim 50 wp -one spray	5	7	265
Carbendazim 50 wp -two sprays	3	7	292
Mancozeb 75 wp -one spray	5	9	163
Mancozeb 75 wp -two sprays	3	7	272
Copper Oxychloride -one spray	5	7	269
Copper Oxychloride -two sprays	5	7	230
No spray	7	7	330

Carbendazim @ 2.0gm per litre of water Seeding: Nov 20, Cu Oxychloride @2.5 gm per litre of water, c) Seeding date and row spacing research 2005/06

Seeding date and row spacing was investigated in 2005/06 to establish whether disease control could possibly be improved. In the trial completed at Nepalgunj in an unfavourable season the only significant response was to time of seeding, with the earliest time, 31st October, as is currently recommended, showing the best yield. In this trial there was little evidence that any of the systems significantly improved disease control or that row seeding had any benefit over broadcasting as is commonly employed by the majority of the small farmers (Table 1.6).

Table 1.6: Date of seeding cum spacing trial conducted at RARS, Nepalgunj, 2005/06 using ILL 7164

Treatment	Plant population	Seed yield (kg/ha)	Disease score (1-9)
Date of seeding 30th Oct			
T1	139	773	5.6
T2	125	657	5.0
T3	134	677	4.3
T4	41 xx	315 xx	3.0 xx
Mean	132	702	4,8
Date of seeding 7th Nov			
T1	152	677	3.6
T2	121	530	5.6
T3	146	560	5.6
T4	217	643	5.0
Mean	159	602	4.9
Date of seeding 14th Nov			
T1	183	460	5.6
T2	165	300	4.3
T3	170	467	6.3
T4	253	643	7.0
Mean	192	467	5.9
Date of seeding 21st Nov			
T1	179	343	5.6
T2	219	227	7.0
T3	199	400	5.6
T4	149	273	5.6
Mean	186	310	5.9

xx data excluded due to seeding error, Plot size 4 m x 3 m, Replications 3, Row Spacing: T1 = 20cm between rows; T2 = 25cm between rows; T3 = 30cm between rows; T4 = Broadcast

7.3 Seed priming research

7.3.1 Seed priming research 2005-06

Lentil in Nepal is grown on conserved residual moisture of the summer monsoons and is a recommendation for the terai. Suboptimal stands of lentil due to poor emergence are also often a problem in upland areas. This occurs in areas where rice is harvested late resulting in delays in the sowing time of lentils. Previous research results have indicated that yield improvement is likely with seed priming for post rice lentils. Days to emergence, plant establishment and yield were improved by priming seeds for 12 hours in plain water followed by 2 hours air drying the seeds before sowing. Approximately 40% increase in seed yield due to priming alone was recorded from experiments conducted over the years

at Nepalgunj. Whilst seed priming with water remains a recommendation for dry sown lentils. Priming has not always been effective as was the case at Rampur 2005/06 Table 2.4. In this dry season at Rampur, for example, seed priming had no effect other than to slightly reduce days to emergence. This appeared to be because of excessive moisture in the field after the rice harvest. The dry finish also would not have helped. It does however bring into question the value of post rice rather than relay sown lentils. Previous data also indicates that primed seed dry sown crops still did not yield as well as relay crops - a result confirmed in 2006-07 trials. Relay sowing is strongly favoured by NARC and confirmed by the recent data of Dr Shrestha below:

In data from 2 experiments provided by Dr Shrestha there was no advantage in seed priming for relay sown crops where soil moisture conditions at seeding are typically wet. For crops sown after rice, as is common in the midhills, there can well a significant advantage in seed priming if dry conditions prevail (see Table 2.1).

7.3.2 Method of planting and seed priming in lentil, Khumaltar

Sowing methods (relay/post rice) significantly affected grain yield, while no effect of seed priming (dry sown, seed priming in plain water or 2% K2H2PO4) on seed yield was noted at Khumaltar. Relay sown lentil produced double the grain yield of post rice lentil. (Tables 2.1, 2.2).

Table 2.1 Performance of lentil with different methods of planting and seed priming in lentil, Khumaltar 2006/07

Treatment	Bran	ES	Flr	Grain yield	Swt	Plht	Pod	Seed	Epod	StrawDM
Dry sown	11	157	109	743	1.8	51	85	1.1	4	1856
Seed priming with plain water	10	168	109	620	1.7	50	52	1.0	4	1973
Seed priming with 2% K2H2PO4	8	180	109	757	1.8	57	59	1.0	5	2074
Post rice	8	213	107	470	1.9	59	43	1.0	3	2468
Relay	11	123	111	944	1.7	47	88	1.1	5	1467
F test										
Priming (P)	0.20	0.81	0.667	0.481	0.266	0.182	0.201	0.342	0.709	0.763
Sowing method (SM)	0.03	0.01	<.001	<.001	<.001	0.002	0.009	0.083	0.076	<.001
P*SM	0.29	0.72	0.017	0.599	0.595	0.949	0.386	0.342	0.824	0.774
Lsd (0.05) priming			0.6							
Lsd (0.05) sowing method	3	61	0.5	212	0.1	7	32		2	514
CV (%)	32	42	1	34	5	15	56	6	59	30

Table 2.2 Performance of lentil with different methods of planting and seed priming in lentil, Khumaltar 2006/07

Treatments	Bran	ES	Flr	GrainY	Swt	Pl,ht	Pod	Epod	StrawY
Relay lentil – dry sown	13	125	111	1044	1.7	45	105	5	1468
Relay lentil – seed priming with plain water	10	123	112	796	1.6	44	64	5	1373
Relay lentil – seed priming with 2% KH2PO4	11	120	111	992	1.7	51	95	6	1562
Post rice lentil – dry sown	9	189	108	442	1.9	56	65	3	2244

Post rice lentil – seed priming with plain water	9	212	107	445	1.9	57	41	3	2573
Post rice lentil – seed priming with 2% KH2PO4	6	240	107	523	1.9	63	22	4	2587
F test	0.08	0.103	<.001	0.006	<.001	0.022	0.048	0.481	0.023
Lsd (0.05)			0.8	367	0.1	12	55		890
CV (%)	32.1	41.6	0.5	34.4	4.6	14.8	55.6	58.6	30

Bran = Main branches per plant, Es= Early stand per m2, Flr = Days to 50% flowering, GrainY = Grain yield in kg/ha, Swt = 100 seed weight in g, Plht = Plant height in cm, Pod = Number of pods per plant, Seed = Seeds per pod, StrawY = Straw dry matter yield in kg/ha, and Epod = Unfilled pods per plant

7.3.3 Seed priming trials Terai 2006/07

Seed priming was more successful in the drier terai where seed priming of dry sown lentil can be beneficial with 50% yield benefit at least in some years. There was however little no benefit in priming at Nepalgunj 06/07 when rainy conditions prevailed. Considerable benefit was achieved at Rampur in the latest crop (Table 2,3) with a 48% increase in yield of the primed seed. This result was in contrast to that reported for Rampur in 2005/06 when in the post rice crop no response was evident (Table 2.5). It is clear that from research into relay sowing as recommended by NARC that this system is capable of producing higher yields than dry sown crops. Research particularly into inexpensive weed control options and time of sowing needs to continue.

Table 2.3: Effects of priming on lentil at Rampur, 2006/07

Treatment	Days to 50% emergence	DF	DM	Root length (cm)	Plant height (cm)	Pods /plant	Seeds /pod	Grain yield (kg/ha)
T1	7.54	75	124	4.53	28	30	17	757
T2	8.6	80	126	6.0	27	31	16	623
T3	8.6	80	129	5.19	32	30	17	653
T4	9	77	127	5.63	27	31	17	497
F-test	NS	NS	NS	*	NS	NS	NS	NS
CV%	12.23	3.6	1.53	11.22	15.4	18.05	4.56	21.39
LSD				1.12				

Cultivar: Simal, plot size= 4 m x 2 m (3 replications), Date of planting:Nov 2, T1 = Priming with water, T2 = Priming with cow dung (1 kg cow dung +2 kg water make a slurry) and priming in 12 hours, T3 = Priming with 2 % KH2PO4 in 12 hours (Potassium Dihydrogen orthophosphate), T4 = Non Priming (check)

The previous data has indicated that primed seed dry sown crops still did not yield as well as relay crops. At Rampur in 2005/06 seed priming had no effect other than to slightly reduce days to emergence. This appeared to be because of excessive moisture in the field after the rice harvest. The dry finish also would not have helped. It does however bring into question the value of post rice rather than relay sown lentils. More trials are needed directly comparing seed priming post rice with relay sown lentils particularly if cheap weed control is available.

Table 2.4: Seed priming post rice at Rampur 2005/06.

Treatment	Root length in cm (5 days)	Days to emerge	Days to flower	Seed Yield (kg/ha)	Total biomass kg/ha
1	4.1	10.6	81	125	640
2	7.5	9.3	85	104	434
3	5.3	5.6	82	112	613
4	5.7	6.0	80	208	730

Control	5.6	11.6	81	238	746

Plot size= 4x2= 8 sq. m, No. of reps = 3, Variety = Simal, Date of planting= 062/8/9, No.of treatments = 5, T1= Seed priming with soluble fertilizer (KH2PO4), T2= Lathyrus seed priming (seed soaking 24 hours), T3= Seed priming with cow dung, T4= Seed priming (soaking in plain water), T5= Control (non-priming)

7.4 Development of new low toxin Lathyrus germplasm

7.4.1 Background

In the seventies, grasspea was a leading grain legume crop of Nepal with the coverage of more than 100,000 ha. In recent years, drastic reduction in the area under the crop has been recorded as a result of government policy to discourage its sale because of the inherent dangers of the content of the nervous system degenerating (neurotoxin) ODAP. Although in many ways it is an ideal crop to grow in ration with rice and lentils as it provides a disease break, puts nitrogen into the soil and provides a major animal feed contribution via its traditional high dry matter production, its use is diminishing. It is currently cultivated 'officially' on 6255 ha with the production of 5389 Mt. with an average yield of 0.75 t/ha (MOAC 2002). However, many farmers have continued to grow the crop under conditions where other crops fail due to drought or excess moisture and often continue to grow crops in the hills (1500-1700 m). It is estimated approximately 60,000 farm families are still involved in the cultivation of grasspea. The crop still has special significance to the poorer sections of the society where it is used as a pulse crop for human consumption while its high herbage production makes it an invaluable livestock feed in a country where such shortages can be critical. Grasspea seeds are regarded as highly nutritive and are fed to the lactating and draft animals. The seeds are also used for the payment of wages for agricultural labourers.

Lathyrus research in the ACIAR project is aimed at producing early maturing and vigorous low toxin cultivars suitable for Nepal. In the time available, fixed lines of low ODAP crossbred selections incorporating Nepal landraces could not be produced until the latter years of the project. These are will now available as F6 lines for further evaluation and seed increase. The new lines involve a cross between Nepal landrace, Sarlahi, and CLIMA low ODAP selection 20B (Ceora). One advantage of the new lines is their pale flowers, which enable them to be readily distinguished from high ODAP naturalized lines which have deep blue flowers. Further reselection for yield in Nepal is needed along with seed increase of any lines showing promise as interim cultivars. A further seed increase generation in Perth in 2008 will help accelerate the program. Essentially a breeding program it will take 2 additional years at least in Nepal to verify possible yield advantages of the new low ODAP selections. Only small plot selection has been possible to date.

Lathyrus lines were grown in Perth as an F4 population in 2005. Growth vigour and maturity assessed. After testing for the neurotoxin ODAP, only low toxin lines were forwarded to Nepal for field evaluation. Pale flower colour which can be used as a maker has also been selected in Perth and 24 F4 lines, plus controls, were was forwarded to Nepal for row evaluation in the 06/07. Seed increase these was conducted in Perth during 2006 (table 3:1) and 2007 (table 3:2) to supplement seed supplies for further bulking by NARC and will continue as an insurance in 2008.

Table 3.1: Perth seed increase rows of low ODAP selections 2006

Line	First Flower	Flower Colour	Vigour	Number in Row	Harvest ready	Comments
2.2	15/8/2006	Pale	Fair	31	8/11/2006	
2.3	16/8/2006	Pale	Fair	31	8/11/2006	
5.1	16/8/2006	Pale	Good	28	8/11/2006	
5.5	18/8/2006	Pale	Good	30	8/11/2006	
5.9	17/8/2006	Pale	Fair	33	8/11/2006	

13.2	18/8/2006	Pale	Fair	19+2	8/11/2006	
13.3	17/8/2006	Pale	Good	18+9	8/11/2006	Stemmy variable
26.2	15/8/2006	Pale	Uneven	33	15/11/2006	Blue removed
26.3	16/8/2006	Pale	Good	32	8/11/2006	Blue removed
31.2	18/8/2006	Pale	Good	8+13+17	8/11/2006	Healthy mature
31.3	15/8/2006	Pale	Good	32	8/11/2006	
31.4	15/8/2006	Pale	Good	30	8/11/2006	blues removed
36.1	17/8/2006	Pale	Fair	31	8/11/2006	
36.2	16/8/2006	Pale	Poor	21	15/11/2006	
36.3	16/8/2006	Pale	Good	27	8/11/2006	
38.1	15/8/2006	Pale	Fair	19	8/11/2006	Early lacks vigour
38.2	15/8/2006	Pale	Good	37	8/11/2006	
45.2	16/8/2006	Pale	Good	18	8/11/2006	Pale uniform
45.3	16/8/2006	Pale	Poor	18	8/11/2006	
45.4	16/8/2006	Pale	Poor	4	8/11/2006	
45.7	16/8/2006	Pale	Poor	11	8/11/2006	Earlier
57.3	17/8/2006	Pink	Poor	9	15/11/2006	Not early
59.1	16/8/2006	Pale	Good	22	8/11/2006	
59.7	16/8/2006	Pale	Good	27	8/11/2006	
Ceora	16/8/2006	Pale	Good	10	15/11/2006	Blue removed
Sarlahi	16/8/2006	Blue	Fair	2	8/11/2006	Early speckled
Pink	15/8/2006	Pink	Fair	2	8/11/2006	

Nepal data

Seed of best single plant lines was forwarded to Nepal and the same set grown in Perth in 2007 as an F5 population. NARC was able to organise a preliminary yield trial at Nepalgunj Research station and several of the new lines were impressive with grain yields to 1750 kg/ha. In Perth, in 2007 opportunity was taken to harvest bulks of the lines performing best in Nepal. These are indicated below in table 3.2 viz. 31.4, 36.3, 38.2, 59.1.

Table 3:2: Lathyrus performance for identification of lathyrus with adaptation and low ODAP for the Nepalese farming system at RARS, Nepalgunj, 2006/07

Entries	Days to flowering	Days to maturity	Grain Yield (kg/ha)
2.2	104	171	600
2.3	104	168	425
5.1	105	170	450
5.5	102	170	150
13.2	109	173	225
13.3	111	175	125
26.2	104	173	325
26.3	102	173	700
31.2	102	170	1200
31.3	104	168	350
31.4	102	173	1750 ●
36.1	103	171	425
36.3	101	167	1200 ●

38.1	101	167	1100
38.2	102	168	1250 ●
45.2	104	167	925
45.3	104	168	375
45.4	103	171	200
45.7	104	172	250
57.3	102	172	425
59.1	102	171	1400 ●
59.7	101	168	950
Sarlahi local	99	165	1150
Mean	103	170	693
Max	111	175	1750
SD	2.56	2.57	469.48

Lines indicated with ● also performed very strongly in Perth. Seed from best individual plants of these lines (now F6) has been forwarded to Nepal to boost seed stocks for wider evaluation and bulking in Nepal in 2007-08. They are clearly also suitable for local production and after bulking will be tested on farm as an Australian by-product of the program. Opportunity was taken of a brief visit to CSIRO by Dr Renuka Shrestha to return much of the seed of the best lines to Nepal. This seed, now F6, can be used for further trials and to bulk in Nepal 2007/08 with a back up of the key lines grown in Perth 2008 by Ms Campbell after the finishing date of the project.

Future Activities

Grasspea is better adapted to waterlogging than lentil and should out yield lentil in the relay system both in terms of dry matter and seed yield. This needs to be confirmed or otherwise. An economic analysis needs to include the value of the dry matter.

7.5 Training and capacity building of NARC scientists

Training and capacity building has been a feature of the extension and was particularly active in 2006/07 with the improved political situation which had hindered travel related operations in 05/06. features of the in-service training reported were:

7.5.1 International travelling workshop Bangladesh.

This lentil international travelling workshop was jointly organized by Bangladesh Agricultural Research Institute (BARI), Bangladesh and lentil breeder Dr Ashutosh Sarker of the International Centre for Agriculture in Dry Areas (ICARDA), Syria. All together there were 28 participants. These included delegates from USDA-ARS, Washington State University (Grain Legume Genetics & Physiology) and ICARDA, Syria; 5 from University of Saskatchewan, Canada; 3 from India (India Institute of Pulses Research, Kanpur; National Bureau of plant Genetic Resources; Pulses and Oilseeds Research Station, Berhampore, Murshidabad, West-Bengal); 4 from NARC, Nepal, 2 from Pakistan (National Agricultural Research Center, Islamabad; Pulses Research Institute), and 12 from Bangladesh Agriculture Research Institute (BARI), Bangladesh.

NARC delegates were Dr Renuka Shrestha, Mr NK Yadav, Ms Sharada Joshi, and Mr R K Neupane who have been key Nepali scientists involved in the ACIAR project. A full travel report on this invaluable exercise, provided by Dr R Shrestha, is presented in Appendix 4. ACIAR funds received by ICARDA scientist Dr Ashutosh Sarker were used to support the workshop and his subsequent visit to Nepal. Additional funds to support the Nepal delegates were provided by CLIMA from ACIAR funds and delivered to NARC by Professor Neil Turner during his visit prior to the conference. Bangladesh is an invaluable country with which to forge research linkages and exchange germplasm. Situated immediately South East of Nepal it shares very similar cropping systems and agronomic

problems with Nepal especially those related to poorly drained soils which are widespread in the river delta country of Bangladesh

In day one of workshop, eight country papers on lentil improvement and research, and six other papers related to disease, quality control and drought were presented (Appendix 1). Field visits covered major lentil growing areas: Tangail, Natore, Ishurdi, Faridpur, Kustia, Pabna, Jessore, Rajshahi, Madaripur and Barishal. This trip was particularly useful to forge linkages with the Bangladesh team who were advanced in many aspects of lentil and grasspea research and disease management. New lentil germplasm with resistance to wilt and Stemphyllium, (Bari Masur 5 and Bari Masur 6) was supplied by the BARI scientists to NARC team which could save years of breeding and selection in Nepal.

7.5.2 Visit of Dr Sarker to Nepal with Canadian team

The continued support of Dr Sarker (and through him ICARDA) to the project has been critical to the success of new lentil germplasm in South East Asia generally. This is a region with which he is completely familiar as he conducted his original research in Bangladesh. He has been able to visit Bangladesh and Nepal each year of the extension and previous project and is a key player in the success of lentils in the region. During his visit to Nepal following the Travelling Workshop in Bangladesh he was accompanied by 5 scientists from the University of Saskatchewan who were able to discuss linkages and possible future initiatives with NARC scientists, Dr NP Shrestha (Executive Director-NARC), Dr K Adhikari (Director-Crops), Mr PL Karna (Director Finance), Mrs S Joshi (Pulse Pathologist), Mr RK Neupane (Outreach), Mr NK Yadav (Pulse Breeder), Dr R Shrestha (Agronomist), Mr SP Srivastava (Leader, Grain Legume Improvement Program), Mr R Derai, Mr A Adhikari, Mr NK Khanal (FORWARD-an NGO).

During the discussions, the senior management of NARC emphasized the great value of the NARC-ICARDA collaboration in germplasm exchange and human resources development. Through expansion of Biofortification and PVS programs, lentil research is getting a boost in Nepal. The ED thanked ICARDA management for its continued support to Nepal which has been supplemented by this ACIAR project. During the field visit Dr Renuka Shrestha and Mrs S Joshi showed them all experiments at the Khumaltar station. Experiments on chemical weed control by “Verdict”, (supplied by C Francis ex Australia at suggestion of R Shrestha) used in relay cropping along with application of fertilizer looked very promising. Chemical weed control should be extended to farmers as weeds are the major limiting factor of lentil cultivation in Nepal. This is especially so where the popular relay system is used.

It was noted two ICARDA lines, ILL 7982 and ILL 6829 are proposed for release. Other promising lines are: ILL 6819 and ILL 7164. Seed multiplication of these lines is underway. Dr Sarker noted that others of his lines were in the pipeline. The following lines have been tested for several years and found to be promising for possible future release. ILL 6465, ILL 7723, ILL 3490, ILL 6811, ILL8186, ILL 7537, ILL 7979.

7.5.3 Ph D award Dr Renuka Shrestha visit by supervisor- Professor Neil Turner

Professor Turner added a trip to Nepal, financed by ACIAR project funds, to his regular visit to India in support of the COGGO (WA) supported chickpea project. His eminence as a plant physiologist with emphasis on drought stress, was seen as very relevant to Nepal and the studies to be conducted by his former Ph D student Dr Renuka Shrestha. Dr Shrestha was funded by a John Allwright scholarship 2002-2005. Because of his knowledge of physiology drought stress in particular it was decided to support this visit from project funds to give a broader perspective to the project as well as the opportunities to discuss and recommend on future research directions. He concluded that the ACIAR project CSI/1999/064 is on track to meet its objectives of developing improved cultivars of lentil with multiple disease resistance and bold seeds adapted to both the terai and mid-hills regions of Nepal and promoting and evaluating these in farmers’ fields (PVS). He noted also that new low ODAP lines of lathyrus have been developed and are being

bulked up in Nepal, but this part of the project has been subject to some delays. What was noticeable in visiting farmers' fields was the level of resources of manpower, fertilizer and irrigation being applied to wheat and fodder crops, while inputs to food legumes were minimal. He was advised that this was because of the low yield of pulses relative to wheat. However, with the current high prices for pulses, particularly lentil and chickpea, there is an opportunity to develop pulses into a cash crop, rather than a protein source for the local families. Trade figures show that less than 5,000 tonnes of lentil were exported from Nepal to Bangladesh in 2005-2006 for an income of about AUD3.5 million (the average for the past 5 years is 5,300 tonnes), but these figures do not account for trade with India which is not monitored. There is considerable potential to increase the export of pulses especially if yields were higher.

Prof Turner recommends that agronomic packages be developed that highlight the need for good seedbed preparation, timely sowing, fertilizer inputs and supplemental irrigation to lift the yields and income from the cool-season pulses. This will require an experimental and extension program to determine the best time of planting, seedbed preparation and inputs within the farming system. ACIAR should be approached to see whether they could support such a program (see full report Appendix 3).

7.5.4 Third in-service training course on data analysis and presentation, Lumle August 2007.

Dr Jens Berger now of CSIRO/CLIMA, conducted a third data analysis course to build on the 2 previous courses funded by the project. 16 Nepal scientists attended the course at Lumle research centre for what has proven to be a very popular and successful innovation in the current project and its extension. Scientists and technical officers from different research stations under NARC received the training. The courses covered were GxE analysis and interpretation, use of Genstat and online biocopying The GxE course presented by Dr Berger used very relevant data on Nepal adapted genotypes data derived during the PhD studies of Dr Renuka Shrestha at CSIRO in Perth. Details of this work are published in a series of papers noted in the publication list (see appendix 5 for details).

7.5.5 Specialist equipment supplies (John Allwright Scholarship recipient)

On completion of her successful PhD studies ACIAR provided small project funding for John Allwright Fellowship returnee Dr Renuka Shrestha. These equipment items will be used to measure adaptation response of lentil to environmental changes with the aim of earlier and more specific selection of genotypes in research specifically related to the project CSI/1999/064. Their total value was $9635 and the project extension funded freight and administration to guide the materials through the Nepal customs which required much paperwork.

The equipment forwarded and received by NARC was

- Light Meter Second generation
- Quantum Sensor 10ft cable
- Dew Point Micro voltmeter
- Sample Chamber
- Sample Discs (5000 ea)

7.5.6 International Grain legume conference New Delhi (October 2005)

5 delegates (Mr R Neupane, Dr R Shrestha, Mr Purusottam Jha, Plant pathologist from RARS, Nepalgunj. Ms Sharada Joshi, Plant Pathologist Khumaltar and Mr R Darai, Legume specialist Rampur) attended with support from ACIAR project funds held by NARC.

Two posters (see Appendix 3.1) were presented at the conference

7.5.7 Herbicide for narrow leaf weed control (supplied by CLIMA from ACIAR funds)

Grass infestation is a serious problem especially in relay sown crops. At the request of Dr Shrestha, Verdict 520 post emergence herbicide for grass control with wetting agent was forwarded in early September 2006. It was delivered by courier arriving in good time for use on the immediately forthcoming lentil crops.

7.6 Farmer participatory PVS research

Research conducted on farmer's property has been a feature of the project and summarized in section 3.1 of this report (Farmer-level, community or policy impacts (economic, social and/or environmental). PVS is featured also in the reports of Mr S Srivastava (Appendix 1) and R Shrestha, Neupane R K and Neupane R (Appendix 2).

Activities to be completed

The development of low toxin Lathyrus is essentially a breeding project and as such needs more time to complete the necessary field testing and seed bulking prior to release

8 Impacts

8.1 Scientific impacts – now and in 5 years

The project has largely applied aims and new varieties and technologies would be rapidly taken up by extension personnel in particular. Training in data handling and biometrics was provided. Opportunity for 4 delegates to attend the international travelling workshop in Bangladesh has proven invaluable as the countries share common problems. Linkages were developed with Canadian and US delegates while the project has maintained the strength of the ICARDA linkage. If lentil lines resistant to both wilt and Stemphyllium are a product of the project. These will be invaluable for use in breeding programs in Australia and SE Asia.

8.2 Capacity impacts – now and in 5 years

Whilst extension and technology transfer procedures do exist in Nepal, it is important that the varietal development system involves coordinated farmers' field trials and that as many farmers as possible have the opportunity to view the potential new varieties. Whilst this has always been a NARC objective it needs finance to ensure that it operates efficiently and in all years. This ACIAR project has enhanced the current system through use of on-farm demonstration of the best varieties and specifically provides funds for an on-farm seed increase program to ensure much larger quantities of seed of new varieties become available to farmers at the time of release. This has involved contracting farmers' fields for increase and demonstration sites. At least 4 villages per year would be involved.

The courses in biometrics and data handling should markedly increase the capacity of NARC scientists to more accurately assess their data. It will improve the project planning and give more confidence to any extension of the data from the trials conducted. The ability of key researchers to analyse and present trial data has been a success of the project.

A NARC researcher Dr Renuka Shrestha has completed her Ph D during the extension. Her return greatly strengthens the research capacity for lentil adaptation to environmental constraints especially moisture stress so common in Nepal

Strong international links have been developed during the project. All the impacts have long term benefits of 5 years or more.

8.2.1 Community impacts – now and in 5 years

This project, with directly applied aims is designed to benefit the multitude of relatively poor small farmers in Nepal. It is unlikely that the system of small labour intensive farms will change in Nepal so that any impacts of the program, e.g. new cultivars with disease resistance, improved technology or agronomy arising, will have lasting benefits.

8.2.2 Economic impacts

It is planned that any lines identified and methodologies developed in this project will be adopted quickly by agricultural scientists and extended to farmers. In all 25% of the Nepal funds have been earmarked for extension and seed increase, related to the adoption of the techniques and cultivars suited to the 'utera' system. Funds were specifically set aside to ensure this is the case. This initiative was further enhanced by farmers' field days conducted in the Nepalgunj and Rampur regions, and elsewhere, in both years of the extension.

In Australia, information from the 3 year G x E study has assisted breeders in Horsham in targeting low rainfall environments both in Eastern and Western Australia. New promising germplasm is available to Australian grower organisations. Joint scientific publications between participating scientists will be published in international scientific journals.

8.2.3 Social impacts

Benefits to women are likely through the use of improved lines of lentil and Lathyrus and other methods provided by this project. Resource poor farmers grow lentils and Lathyrus, and benefits will increase cash incomes. There is benefit to the diets of women and children whilst providing employment for women who are largely responsible for weeding and harvesting of crops. Overall no negative effects can be foreseen as a result of this project

8.2.4 Environmental impacts

Legumes are an integral and valuable component in farming systems in Nepal and Australia due in part due to the benefits attributable to nitrogen fixed, which is then made available to subsequent crops. Various studies in Australia and overseas suggest that lentils can contribute between 20 to 60 kg N/ha to the following non-legume crops. In addition, legumes provide a disease and weed break for oilseed and cereal crops in the rotation, reducing the use of fungicides and herbicides. Legumes are known to lower the pH of soils after long-term use. However, since lentils are grown mainly on neutral to slightly alkaline soils in Australia and Nepal this is unlikely to be a significant factor. The availability of profitable low ODAP Lathyrus cultivars would lengthen the rotation between lentil crops and reduce Fusarium wilt, even in the absence of resistant cultivars. Lathyrus could be used strategically in regions where the Fusarium complex is already established and emerging as a major threat. Greater use of lentil and Lathyrus would result in reduced use of artificial N and future reliance on fungicides.

Low ODAP Lathyrus will reduce the health risk in areas where poorer people still rely on the crop. These lines will reduce severe outbreaks of Lathyrism and its crippling effects. Introduction of lentils into Nepal and Australia will be in accordance with respective quarantine regulations in order to avoid the introduction of exotic pests and disease

8.3 Communication and dissemination activities

It is planned that any lines identified and methodologies developed in this project will be adopted quickly by agricultural scientists and extended to farmers. Funds have been

specifically been set aside by NARC to ensure this is the case. Whilst extension and technology transfer procedures do exist in Nepal, it is important that the varietal development system involves coordinated farmers' field trials and that as many farmers as possible have the opportunity to test and view the potential new varieties. Whilst this has always been a NARC objective, it needs finance to ensure that it operates efficiently and in all years. This project enhances the current system through use of on-farm demonstration of the best varieties and specifically funds on farm seed-increase programs to ensure much larger quantities of seed of new varieties become available to farmers at the time of release. This involves contracting farmers' fields for seed increase and demonstration sites. At least 4 villages per year are involved in the key regions of Nepal where farmers' field days have been an important and popular part of the NARC program.

Joint scientific publications between participating scientists have and will be published in international scientific journals.

9 Conclusions and recommendations

9.1 Conclusions

The extension has allowed intensified testing for resistance to the major diseases, wilt and Stemphyllium. As yet however although progress has been made, lines with high levels of resistance to both diseases are yet to emerge. Soon to be released ILL 7164 is a promising advance but the ICARDA lines in Nepal seem inferior to Bangladesh x ICARDA lines, Bari Masur 5 and Bari Masur 6, of which small samples of seed have been obtained by NARC.

Seed priming is now recommended for dry sown lentil by NARC and associated NGOs. NARC however recommends relay sowing as the higher yielding aternative where seed priming is unlikely to benefit.

Low toxin lathyrus lines based on a cross between Nepali farmer line Sarlahi and CLIMA low ODAP pale flowered release Ceora, have produced low toxin early flowering, pale flowed lines. In limited Nepal trials so far these have been equal or superior to the local high toxin lines.

The Nepal scientists have now received 3 training courses in statistical analysis and data handling as a result of the project. The feed back is highly favourable and course attendance very popular. The farmer involvement in seed increase and research trials PVS is proving an excellent method to ensure earlier release of new varieties and technologies to practical farmers.

9.2 Recommendations

More legumes in the system to improve or maintain fertility are recommended. Lentil is a logical crop to continue development. It has an excellent market, and an expanding one, in rapidly developing India, into which lentils can be transported without restriction across the common border. Linkages with ICARDA are important for latest germplasm and the benefit of a Bangladesh linkage has become obvious after the current travelling workshop. The Bangladesh team have produced lines with good resistance to wilt and Stemphyllium and a more formal link with the Bangladesh, ICARDA and Indian program should be developed. ACIAR should be approached to see whether they could support such a program to be backed with the excellent farmer participation PVS system NARC have developed.

It is important that agronomic studies as recommended by Professor Turner remain a priority. He recommends that agronomic packages be developed that highlight the need for good seedbed preparation, timely sowing, fertilizer inputs and supplemental irrigation

to lift the yields and income from the cool-season pulses. This will require an experimental and extension program to determine the best time of planting, seedbed preparation and inputs within the farming system.

Grass pea, which produces the extra high protein dry matter essential for the nation's animals is a logical crop to upgrade and grow on poorly drained soils so common in the Terai. Advanced lines will be available for the 2007/8 crop. With the field work and bulk up required these will take 3 or more years to release. ACIAR should consider a modest project linked with Bangladesh where the species is popular and well adapted to the wet soils common in that country.

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Shrestha R., Siddique K.H.M., Turner N.C., Turner D.W., Berger J., (2005) Growth and seed yield of lentil (Lens culinaris Medikus) genotypes of West Asian and South Asian origin and crossbreds between the two under rainfed conditions in Nepal

10.2 List of publications produced by project

Shrestha, R., Turner, N.C., Turner, D.W., Siddique, K.H.M., and Speijers, J. (2005) Flower, pod and seed production in lentil (Lens culinaris Medikus) are more sensitive to terminal drought than the seed size. Fourth International Food Legumes Research Conference: Food Legumes for Nutritional Security and Sustainable Agriculture Abstract (18 to 22 October) IARI, New Delhi, India (Ed. MC Kharkwal) p. 85

Shrestha, R., Siddique, K.H.M., Turner, N.C., Turner, D.W., and Berger, J.D. (2005). Growth and seed yield of lentil (Lens culinaris Medikus) genotypes of West Asia, South Asian Origin and crossbreds between the two under rainfed conditions in Nepal. Australian Journal of Agricultural Research 56: 971-981.

Shrestha, R., Turner, N.C., Siddique, K.H.M., Turner, D.W., and Speijers, J. (2006). A water deficit during pod development in lentils reduces flower and pod numbers but not seed size. Australian Journal of Agricultural Research 57: 427-438.

Shrestha, R., Siddique, K.H.M., Turner, N.C., Turner, D.W., and Berger J.D. (2005). Growth and seed yield of lentil genotypes of West Asia and South Asian origin and crossbreds between the two under rainfed conditions in Nepal. Australian Journal of Agricultural Science 56: 1-11

Shrestha, R., Neupane, R.K., and Neupane, R. (2007) Participatory evaluation and promotion of lentils in the midhills. Paper presented at the Eighth National Outreach Research Workshop ‘Participatory technology for development and promotion for sustainable rural livelihood’ 19-20 June 2007, Nepal Agricultural Research Council, Outreach Research Division, Khumaltar, Lalitpur, Nepal (This paper is presented in full in appendix 7)

Neupane, R.K., Shrestha, R., Sarker, A., Erskine, W., and Francis, C. (2007) Lentil Improvement in Nepal. Lentil extension publication - with APAARI New Delhi (In Press).

Posters:

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Joshi, S., and Jha P., (2005) Food legume diseases of Nepal: An overview. In 'Fourth International Food Legumes Research Conference: Food Legumes for Nutritional Security and Sustainable Agriculture (Abstract). IARI,New Delhi, India (18 to 22 October). Ed. M.C. Kharkwal p. 341

Farmer Field days or demonstrations in Nepal

Pithuwa, and Devnagar village, Chitwan

Purena Village, Nepalgunj region

Dhading, Gorkha, Syangya, Ramechap region.

Non Government Organisations, ‘Forward’ and ‘Local Media’ were involved in farmer field days and demonstrations.

This type of work is well summarized for the midhills program in a very recent presentation at NARC Headquarters in Khumultar (see paper by Shrestha, R., Neupane, R.K., and Neupane, R. (In appendix 2).

An extension paper prepared largely by Mr R K Neupane on the basis of his many years of experience is not yet available as a formal publication. Plans are well underway however and it should be ready for the 2007/08 season viz.

Neupane, R.K., Shrestha, R., Sarker, A, Erskine, W., Francis, C. (2007)

Lentil Improvement in Nepal. Lentil extension publication with APAARI New Delhi (In Press).

Registration of Shital Lentil

N.K.Yadav,* A. Sarker**, W. Erskine**,C.M. Francis***

Agriculture still predominates in Nepal where 66% of the population depends on agriculture for their livelihood. Sixty one percent of total cultivated land (3,091,000 ha) is rain-fed where food legumes can be successfully grown under different cropping systems. Food legumes, commonly known as pulses are important crops of Nepal. They play a crucial role in attaining food & nutritional security and alleviating poverty by raising farm income and uplifting the living standards of poor farmers in rural areas. Total area of food legumes is 316,010 ha with production of 265,360 Mt (a productivity of 840 kg/ha). (MOAC,2004). Lentil is the leading pulse crop of Nepal. Its cropped area has increased from 119,490 ha to 187,380 ha (1990/91 to 2003/04). The productivity has also increased from 611 kg/ha to 810 kg/ha during that period. There is thus an ascending trend of area and productivity of lentil over years in Nepal. Adoption of the newly released variety will lead to further increases.

The Shital variety of lentil (Lens culinaris Medik) originated in Pakistan but was introduced into Nepal as ILL 2580 through the International Centre for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, and released for cultivation in terai (plain) areas of Nepal in 2005 by the Variety release, recommendation and registration committee of Nepal, Ministry of Agriculture and Cooperatives. Shital is a high yielding, red cotyledon lentil cultivar with lodging resistance and resistance to lentil vascular wilt disease [caused

by Fusarium oxysporium f. sp. Lentis). The cultivar is tolerant to drought, a consequence of its rapid grain filling capacity and early maturity.

The National Grain Legumes Research Program of Nepal Agricultural Research Council (NARC) received the line ILL 2580 from ICARDA in 1990. It was developed at ICARDA through pure line selection from a local land race of Pakistan using bulk-pedigree methods. It was included in the international testing program as ILL 2580 in the ICARDA's Lentil Germplasm Catalogue. It was identified as a promising line from the Lentil International Yield Trial (small seed) during the 1990/91-winter season. After seed increase in the 1991/92 season, it was evaluated at 10 research stations of NARC (representing lentil-growing environments in Nepal) in the national yield testing program from 1992/93 to 2003/04. Compared to the widely grown Simal cultivar variety ILL 2580 has given 30.7% higher grain yield in national yield trials (CVT) and 28.7 % higher grain yield in farmers' fields (CFFT). It has wide adaptability - from the terai to the hill station at Jumla (2300m). It is moderately resistant to wilt caused by Fusarium oxysporium f .sp lentis and root rot caused by Fusarium solani. It is less affected by Botrytis Grey Mould (BGM) and Stemphylium blight than Simal. Farmers are attracted to the variety because of its consistent yield over the years and its better cooking quality. In trials it produced an average yield of 1182 kg/ ha compared to 904 kg/ha for the check, 'Simal ' (LG7), an increase of 30.7%. Results of on-farm trials from 1996/97 to 2003/04 across 9 locations of farmers' fields revealed that Simal gave a mean yield of 1274 kg /ha compared to 990 kg/ha for Simal, an increase of 28.7%. Shital produced an average straw yield of 1731 kg/ha. This variety is recommended for whole terai region and the mid hill region in rice or maize based cropping systems. It is suitable- for relay cropping on paddy and mono cropping after rice or maize for rain fed upland condition. It is also found suitable for mixed cropping with mustard at the combination of 30kg seed of lentil with 2 kg of mustard.

High moisture after rice harvest is the serious problem in terai area of Nepal where 70 % of the total lentil is grown. Shital is well suited to relay sowing. In this system Lentils should be broadcast uniformly into the standing rice crop two weeks before rice harvest after the drainage of excess water from the field. This practice saves the time of land preparation. As a result the lentil crop is established earlier and improved yields result. For relay sowing with rice, optimum soil moisture is a prime factor. If not possible, seed priming is recommended. Lentils seeds soaked overnight (12 hrs) followed by 2 hours air-drying before sowing is recommended for seed priming. This practice will ensure even germination and emergence of lentils. It has increased seed yield of this variety up to 28%.

Shital plants have semi erect growth habit and strong stems with upright branching, thus providing the lodging resistance that is needed for mechanical harvesting. Plants of Shital are medium-stature (40 cm). It forms its lowest pods at about 18 cm above soil level, which reduces harvest losses. It has an average of 12 primary and 9 secondary branches. It has brown pigmentation on vegetative parts. Flowers are violet with an average of three flowers per peduncle. Leaflet size is medium (<15-30mm). .It bears an average of 73 pods plant -1, with an average of 1.8 seeds pod -1. It has round seed shape with seed weight of 1.43 g 100-1 seed. Colour of the testa is gray with densely dotted black spots, and the cotyledons are red. Shital flowers after 92 days and matures in 134 days 2. Shital has 27.28% protein concentration in the dehulled seeds and 6.8% protein in straw. It has 2.53 % ash content. Its cold-water absorption is 87.1% while hot water absorption is 180.19%.

For Shital 15th Oct. to 15th Nov. is the optimum time of sowing in Nepal. As soil moisture decreases earlier in the western part, it should be sown earlier in the western terai than the eastern and central terai of Nepal. Small quantities seeds of Shital may be obtained from NGLRP, Rampur, Nepal upon written request

Corresponding authors

* Senior scientist, NGLRP Rampur, Nepal, Email, nkyadav56@rediffmail.com

** Lentil Breeder and ADG, ICARDA. Email, A.Sarker@cgiar.org

*** Deputy Director, CLIMA, Australia.

11 Appendices

Data (largely from 2005-07) relating to the main project objectives of the extension of project CSI/1999/064

There were five objectives of the extension and the data is summarised under 7) Key results and discussion, with a focus on the most recent 06/07 data. Additional reports by the Nepal or Australian participants having a bearing on the above objectives are provided in full (see reports Appendices 1-5).

Appendix 1. Mr S Srivastava paper on the ACIAR project extension

Appendix 2. Summary of Mid hills farmer participation data. R Shrestha, Neupane R K, Neupane R.

Appendix 3. Report, visit of Prof Neil Turner

Appendix 4. Report on International Travelling Workshop on Lentil, Bangladesh (12-19 February 2007)

Appendix 5. Workshop Report: Introduction to Modern PC-based Data Handling and Statistical thods (Nepal 2007)

11.1 Appendix 1. S. Srivastava paper on the ACIAR project extension.

This paper provides an excellent summary of the 2 year extension (and some previous data) and the NARC planning toward the project objectives with emphasis on the terai.

Problem to be addressed:

Justification

Lentil is the main cool season food legume in Nepal. It occupies 60% (188,895 ha) of the area and 59% (160,716 tonnes) of the production of grain legumes in the country. Lentil is relay planted on more than 75,000 ha out of the total cropped area of 188,895 ha. However, yields overall are low because of poor plant stand, poor growth, water logging and wilts. Plant stands remain low or sub-optimal due to variations in soil moisture content at the time of planting. Weed infestation (narrow leaved) is a serious problem at the reproductive stages under rice/lentil relay system particularly when coupled with poor plant establishment.

This project will help identify varieties suitable for relay sowing with rice in the terai and midhills. In the midhills high yield and quality seeds can be obtained due to the long growing season in the hills. Results from seed priming trials will be useful for ensuring better plant stands in rice lentil system. Generation of these technologies will help in commercialisation of the crop leading to increased production and productivity as emphasised in APP. Income levels of the farmers will be improved and export volume of lentils will also be increased.

Project extension OBJECTIVES

- To identify Stemphyllium and tolerant lines.
- To identify dual resistance in Stemphyllium and Wilt tolerant lentil genotypes.
- Optimum seed priming time and its efficiency for improving seedling establishments, vigour and yield (soaking time) of lentil and lathyrus will be investigated.
- New Lathyrus lines with low toxin (beta-N-Oxalyl-L-alpha, beta-diamino propionic acid (ODAP) will be identified /developed.
- To provide opportunities for in-service training of NARC staff.

- Seed increase systems strengthened, technology dissemination system improved and new high yielding varieties released with direct farmer input (PVS).

REVIEW OF PAST WORK

Highlights up to 2006/07:

- In the current on going ACIAR project, the following technologies have been developed or identified:
- Improved varieties
- Medium bold seeded lentil genotype ILL 7723 identified as promising in terms of wilt and Stemphyllium blight disease resistance and seed yield for the mid western terai.
- Identification of medium bold seeded lentil genotypes ILL 7982 and ILL7979 for the mid hills.
- ILL 2580 released under the name of Shital for the inner terai and mid-hills by National Seed Board.
- Other promising high yielding lentil genotypes: ILL 3230, ILL 7982, ILL 7164, ILL 7537R, ILL 7543 are being evaluated in PVS.
- Farmers preferred ILL 8006 as a result of the earlier maturity, resistance to wilt diseases and compatibility with the existing rainfed farming system. However, ILL 7164, ILL7982 were the highest yielding lines from the PVS trials in Rampur. The promising line ILL 7164 was also found to have earlier maturity (120 days) than the local varieties. The yield of lentil varieties overall was however very low because of long periods of erratic rainfall in the implemented sites.
- In Nepalgunj, the genotypes ILL 7982, Shital and ILL 7716 were the highest yielder's in PVS. The lowest yield was obtained from the genotype ILL 7723 (360 kg/ha).

Disease Resistance

- Wilt disease tolerant lentil genotypes have been selected from mature wilt sick plots at Nepalgunj and Khumaltar and used in breeding program.
- Work on the management of Stemphyllium blight disease in lentils has been initiated through introduction of resistant varieties from Bangladesh.
- Fifty genotypes in Rampur and eighty genotypes in Nepalgunj were evaluated in the Stemphyllium screening nursery in 2004/05. The combined analysis over locations revealed that genotypes LN00136, ILL 7538, ILL 3338, ILL 4139, IL-1, AERIAL, Shital, ILL 2712, ILL 7164 and ILL 6447 had some resistance to Stemphyllium blight. Moreover these genotypes produced seed yields of more than 1200 kg/ha.
- Fungicides copper oxychloride (CuOCl), Indofil Z-78 and Dithane M-45 were found effective against Stemphyllium at Rampur when multi sprayed.

The early November sowing date recorded the best values both for the higher seed yields and the lowest severity and incidence of the Stemphyllium blight. The optimum plant spacing was also found 25 cm in terms of seed yield with lowest Stemphyllium disease scores in rows 30 cm apart.

A total of 137 lentil genotypes, including resistant checks (ILL 7164 and Bari Masur 4) and most of the recommended varieties were tested in 2006 in the Rampur nurseries to evaluate the resistance of lentil genotypes against Stemphylium blight under natural inoculum conditions. The highest score (score 9) was used for the exercise. Weather conditions were however not very congenial for disease development. Out of 137 genotypes 33 were found highly resistant (score 1), 55 were resistant (score 3 or less), 38 moderately resistant (score 5) and 8 genotypes were moderately susceptible. No genotype was found highly susceptible. Among released varieties Simal was found highly

resistant, Simrik, Shikhar and Shishir were resistant, Sindhur, Khajura-1 and Khajura-2 were moderately resistant while Shital was moderately susceptible. Pipeline genotype ILL 7982 was highly resistant, ILL 3490 and ILL 6829 were resistant, and ILL 4402 and ILL 7723 were moderately resistant at Rampur station whereas ILL 3490 and Bari Masur 4 were resistant, ILL 4402, ILL 7723, ILL 7982 and ILL 6829 were moderately susceptible in farmer's field. These results, which showed variation between sites and previous data, suggest the need for more rigorous screening in the research station trials.

Effect of crop mixtures on incidence of Stemphylium blight of lentil. At Rampur lentil + linseed and lentil + rape seed mustard at 2:1 ratio showed the least Stemphyllium blight severity (3 in 1-9 scale) followed by lentil + coriander in 2:1 ratio (3.33). Lentil alone showed the highest disease severity (4.33) followed by lentil + rape seed (rating 4) when sown in 3:1 ratio.

Three sprays of Uthane M–45 @ 2.5 g/litre were found the most effective to control Stemphyllium blight under Rampur condition. Efficacy of Bavistin, Kriloxyl and Dithane Z-78 to control Stemphyllium blight was at par and far below than Uthane M-45. Overall crop condition was very poor because of poor soil health and soil heterogeneity. Disease severity within individual treatments was also much affected by soil heterogeneity and soil health.

Effect of date of planting cum spacing on Stemphylium blight of lentil were tested at Rampur during 2005/06. The treatments included four planting dates viz. Nov. 22, Nov.29, Dec.6 and Dec. 13 and four crop seeding systems such as broad casting, 20 cm between rows, 25 cm between rows and 30 cm between rows. Stemphylium blight severity effect was minimal in this season but least in Nov 29 planting followed by Nov 22. Among the row spacing treatments, 25 cm between rows was found the best in reducing Stemphyllium blight severity while broadcasting, 20 cm between rows and 30 cm between rows were at par with respect to Stemphyllium blight severity.

Agronomy of seed priming

Development of seed priming technologies in lentils. Priming treatment is also supposed to hasten germination, enhance crop establishment and promote seedling vigour (Harris et al., 1999)

The effect of priming produced significant differences in the root length of seedling stage, days to emergence and days to flowering under post rice condition. Emergence of seedling was the earliest (5.33 days) in seed priming with cow dung at 12 hours and seed priming with plain water at 12 hours (6 days) compared to the control non-priming (11 days). Root length of seedlings was also increased in seed priming with water at 12 hours.

The effects of seed priming were found to produce statistically significant differences in root length of seedling stage, plant stand per square meter, days to emergence, biomass with seed and grain yield. However, the biomass yield and grain yield was only slightly improved and the highest yield was recorded in seed priming with water at 12 hours (465 kg/ha) and seed priming with cow dung at 12 hours (450 kg/ha) compared with the non priming (398 kg/ha).

At Nepalgunj in a dry year of 2006/07, seed priming did not produce significant differences under post rice conditions. However, the priming with cow dung at 12 hours produced the higher yields (588 kg/ha) than the non-priming (560 kg/ha) control. Plant stand per square meter was at par with the control.

Grasspea

Identification of low ODAP/ toxin free exotic grasspea genotypes adapted to Nepalese conditions. These investigations are underway in NGLRP.

In 2005 year the grasspea evaluation trials failed due to the soil sickness. Most of the germplasm lines were lost from the field. Hence, we informed CLIMA of the justifiable

reasons and requested the seeds of low toxin grass pea lines from CLIMA for the following years (seed was supplied).

Capacity building and farmer participation

NARC Scientists were provided opportunities for training to enhance their research capability by a combination of international expert visits, participation in workshops specialised training courses.

- Farmer participation (PVS) is improving the rate of seed increase and distribution of lentil varieties to farmers.
- Maintenance of elite lentil lines in seed increase at NGLRP, Rampur and on farm (Devnagar and Pithuwa) were achieved with the active participation of farmers, research scientist and extension workers.
- Elite lines ILL 8006, ILL 7164, ILL 7982 and IL L3490 were also produced on station. About 500 g seed of these promising lines are maintained at Rampur station.
- Varieties Simrik, Khajura-2, ILL7164 and ILL3490 were scaled up on farm. The farmers save all the produced seeds for the next season.
- At RARS, Nepalgunj, varieties ILL7723, Khajura-1, ILL6829, ILL7537, ILL7982, Shital, LL 4402, Shikhar, Simal, PL406, Nuri, ILL 7716, Khajura-2 were reserved for the seed increase program.
- Released cultivars i.e. Khajura-1, Khajura -2, Simrik, Sikhar, Sindur and pipe line cultivars ILL 7723 and ILL 7164, were scaled up in large plot sizes under the seed production program in Nepalgunj

11.2 Appendix 2. Summary of Mid hills farmer participation data (Shrestha R., Neupane R.K., Neupane R.)

This paper very professionally summarizes the contribution on the project in the midhill region of Nepal.

11.2.1 Participatory evaluation and promotion of lentils in midhills

Shrestha R.[1], Neupane R.K.[2]b and Neupane R.[1]

Abstract.

The minikits and seed increase activities were carried out in the hilly districts: Lalitpur, Bhaktapur, Kaski, Ramechap, Palpa, Gorkha, Magdi and Baglung. Five lentil genotypes all bred in ICARDA using parents from South Asia and West Asia and the released variety Simal were evaluated for their adaptation and performance in hill districts. Grain yield ranged from 600-1400 kg/ha in Gorkha, 237-2900 kg/ha in Khumaltar, 800-1456 kg/ha in Bhaktapur, 680-1455 kg/ha in Dhankuta, 425-1030 kg/ha in Palpa, 160-480 kg/ha in Magdi, 170-675 kg/ha and 660-3200 kg/ha in Ramechap. The highly variable grain yield was due to various factors such as sowing time, early plant establishment (initial soil moisture), water deficits at reproductive stage (terminal drought), incidence of wilt/root rot disease, and other management practices (weeding, soil nutrients, irrigation etc). There is a tremendous scope for increase in productivity and production in the hills with the adoption of suitable varieties and improved agronomic practices, and area expansion in rice based cropping system. Lentil can be grown in the fallow period between rice and spring maize in the river basin, or can be grown after rice in sequence or relay sowing

[1] *Agronomy Division, Nepal Agricultural Research Council, Khumaltar, Nepal*

[2] *Outreach Research Division, Nepal Agricultural Research Council, Khumaltar, Nepal*

where only rice is grown and land is left fallow during winter. The active collaboration of district agricultural development offices (DADOs) in implementing seed kit distribution/demonstration and seed increase program is also crucial for the success of the program.

Introduction

Lentil is the major legume of Nepal that occupies about 80% of area and production (Figure 1a), and the steady increase in area since 1960 is due to area expansion, adoption of improved technologies, technical support, popularity of lentil dhal (cook in less time compared with other dhal) (Shrestha 2005). Lentil is either grown after rice harvest (post rice) or relay in rice (1-2 weeks to harvest), or to smaller extent as mixed cropping with tori (Brassica campestris), mustard (Brassica juncea), peas, linseed. Lentil being a leguminous crop helps to improve soil fertility and lentil dhal is an effective and cheap source of protein.

Terai and inner terai contribute the majority of the lentil growing area. Lentil has been introduced to the mid hills and mountains in recent years, which contributes about 5% of total area under lentil (Figure 1b) (ABPSD 2005). There is a huge potential of increasing lentil area in hills either by utilizing fallow land (0.3 m ha remains fallow after rice in Nepal) or fitting in the existing cropping system (rice-fallow-maize). In addition, production per unit area is higher in hills due to cooler climate.

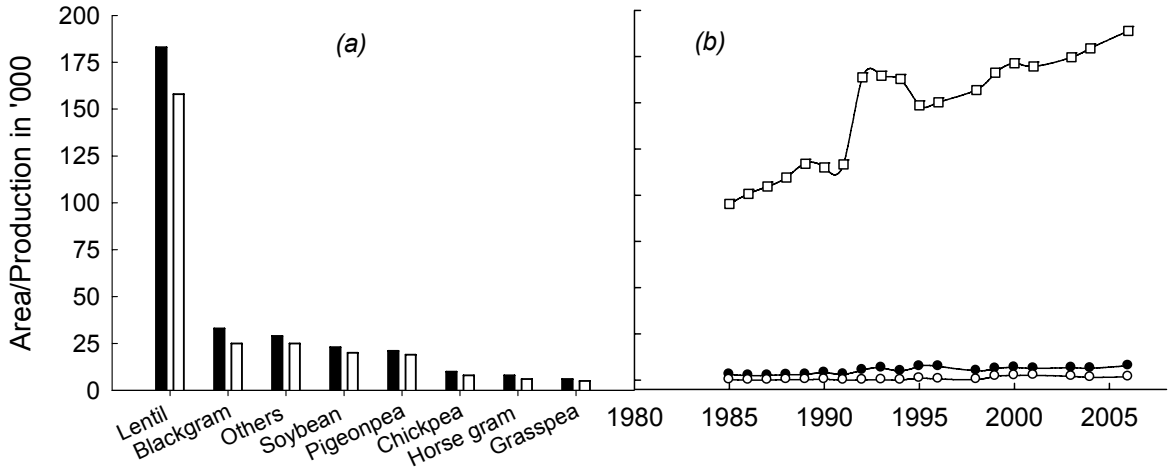

Figure 1: (a) Area (■) and production (▯) under different grain legumes (2006), and (b) lentil area in terai (▯), hill (●) and mountain (○) regions of Nepal (1985-2006).

Materials and methods

Details on lentil genotypes, number of farmers and sowing dates are presented in Table 1.1. In Khumaltar, six promising genotypes including three released varieties were evaluated with the aim to demonstrate their performance to farmers visiting Khumaltar. In Khumaltar, sowing time varied depending upon the harvest of the previous crop and soil moisture availability. In Bhaktapur, lentil genotypes were tested in Katunje and Bageswori. In Gorkha district, ten sets of minikits consisting of four genotypes (ILL 7979, ILL 7982, ILL 6829 and ILL 7537R) and 3 sets of ILL 7982 and Simal (2 kg each) were distributed to farmers through District Agriculture Development Office. Seeds were broadcast after land preparation, and seedlings emerged in about 10 days. In Magdi and Baglung districts, five minikit sets (variety Simal) were distributed to farmers through the Magdi Enterprises Iink. Seeds were broadcasted after land preparation and seedling emerged also in about 10 days, flowered in Dec-Feb. and harvested in Apr-May.

In Ramechap, minikits (ILL 7982, ILL 6829, ILL 7537R and Simal) were distributed to 19 farmers through the District Agricultural Development Office (DADO), Manthali during

2005/06 with the aim to introduce lentil in cereal based cropping system and thereby increase cropping intensity, improved soil fertility and nutritional security in the region. Lentil was sown late (late Nov. to early Dec.) due to delayed delivery of seed to farmers. Plant stand was normal to dense, and most farmers top dressed the crop with nitrogen fertilizer after irrigation which was advantageous in case of delayed sowing. Some farmers reported yellowing of seedlings due to water logging. In 2006/07, 2-5 lentil genotypes were evaluated with 13 farmers of 5 village development committees.

In Jumla, five promising lines were tested under farmer's fields but sowing here was relatively late (Table 1).

Table 1. Number of genotypes and sowing dates in farmer's field of hill districts.

SN	District	No. entry	No. farmers	Sowing time
1	Lalitpur Khumaltar (2001-2007) Dukuchap	 6 -	 7 -	 13 Oct-17 Nov -
2	Bhaktapur: Bageswori, Katunje	5	2	2002
3	Gorkha: Prithvi Narayan municipality		6	18 Nov.- 4 Dec. 2005
4	Ramechap: 2005/06: Manthali, Pakarbas, Bhatauli and Chisapani 2006/07: Bhaluwajhor, Bhatauli, Chisapani, Pakarbas, Bhirpani	4 7	12 13	23 Nov.-13 Dec. 2005 6-25 Dec. 2006
5	Palpa: Deurali	7	3	28 Oct. 2004
6	Magdi: Arman, Biple Baglung: Narayanthan, Baglung	1	5	9-18 Nov. 2005 6 Dec. 2005
7	Dhankuta: Fikal, Belhara	6	4	19 Oct. 2004
8	Jumla: ARS Mahat, Chandannath, Depalgao	5 5	1 8	8 Dec. 2003 8 Dec.- 14 Jan. 2006

Results and discussion

Phenology and plant growth

In Khumaltar, the mean maturity days of the promising genotypes were comparable with Simal though these genotypes flowered about a week later (Table 2.1). ILL 7979 and ILL 7982 were short in plant height, where greater number of branches may have contributed to greater biomass (Table 2.1). In Bhaktapur, genotypes matured earlier and produced less number of pods per plant as compared with Khumaltar (Table 2.2), that may be related to delayed sowing. Similarly, under Gorkha conditions, crop duration and plant height were further shortened (Table 2.3) which may be related to warmer climate of the site. In Magdi and Baglung , severe drought at early stage resulted in extremely poor yield (Table 2.4). In Derail, Papa regions, crop duration was similar to that of Khumaltar (Table 2.5).

Table 2.1 Phenology and yield parameters of promising genotypes including released varieties in Khumaltar (2000/01-2006/07).

Genotype	Days to flowering	Days to maturity	Plant height (cm)	Pods/ plant	100 seed weight (g)	Straw dry matter (kg/ha)
ILL 6829	95	161	36	91	1.9	2335
ILL 7979	102	161	30	105	2.0	2273
ILL 7982	113	164	32	82	2.1	2525
ILL 7537R	101	162	37	108	1.9	2324
Khajura 1	89	169	41	64	1.4	2175

Khajura 2	67	170	44	82	1.5	3235
Simal	91	160	36	74	1.8	1892

Table 2.2 Phenology and yield parameters of promising genotypes and released variety Simal in Bhaktapur (2002/03).

Genotype	Days to flowering	Days to maturity	Plant height (cm)	Pods/plant
ILL 6829	100	139	33	36
ILL 7537R	102	145	38	24
ILL 7979	103	143	36	38
ILL 7982	97	142	34	33
Simal	98	140	30	22

Table 2.3 Performance of promising genotypes and released variety Simal in Gorkha (2005/06).

Genotype	Days to flowering	Days to maturity	Plant height (cm)	Pod/plant	Seed yield (kg/ha)
ILL 6829 (2)	75	113	21	59	780
ILL 7979 (2)	92	114	25	75	620
ILL 7982 (1)	82	110	25	52	900
Simal (1)	89	116	30	50	1400

Figures in parenthesis are the numbers of farmers

Table 2.4 Performance of lentil (var. Simal) in Magdi and Baglung (2005/06).

District	Plant height (cm)	Pods/plant	Seed yield (kg/ha)	Remarks
Magdi	25-40	30-40	160-480	Drought during seedling stage, later heavy rainfall causing lodging, bird damage
Baglung	25-32	30-38		hailstones at harvest

Table 2.5 Performance promising genotypes (FFT) in Deurali (1250 m), Palpa .

Genotype	Days to flowering	Days to maturity	Plant height (cm)	Pod/ plant	100 seed weight (g)	Seed yield (kg/ha)
ILL 7982	120	169	29	97	2.2	1034
ILL 6829	111	167	32	137	2.0	958
ILL 7537R	113	166	33	136	2.1	870
ILL 7979	115	170	31	121	2.1	571
Simal	109	165	29	56	2.0	428
Shital	122	168	27	45	1.6	634

In Ramechap, lentil flowered from second week of January to first week of February (about 53 days) and matured around last week of March to first week of April (114 days) (Table 2.6). Crop duration ranged from 109-117 days in the river basin of Ramechap where temperature rises quickly in February. Simal grew taller (30–43 cm) as compared with ILL 7537R (25–33 cm), ILL 7979 (25–30 cm) and ILL 7982 (30 cm) (Table 2.6).

Although lentil flowered 3-5 weeks earlier in Belhara as compared with Fekul, there was no difference in days to maturity (Tables 2.7, 2.8). Lentils grew vigorously (mean plant height of 41 cm) in Belhara than Fekul (27 cm). In Fekul, ILL 7982 was the shortest in plant height followed by ILL 7537R and ILL 7979 (27 cm).

Under Jumla conditions, time to flowering and maturity did not vary much among genotypes (Table 2.9). Very late sowing resulted in short crop duration of 154-164 days and short plant height (17-34 cm).

Table 2.6 Phenology of promising lentil genotypes in Ramechap (2005/06-2006/07).

Genotype	2005/06			2006/07		
	Days to flowering	Days to maturity	Plant height (cm)	Days to maturity	Plant height (cm)	Pods/ plant
ILL 7982 (n = 8)	48	111	30	110	43	49
ILL 7537R (n = 13)	49	110	29	113	38	42
ILL 4402 (n = 4)	-	-	-	-	32	29
ILL 7723 (n = 3)	-	-	-	-	37	39
ILL 7979	56	117	28	-	-	-
Khajura 1 (n = 4)	-	-	-	114	35	38
Shital (n = 6)	-	-	-	109	33	40
Simal (n = 4)	55	116	35	115	35	43

Number in parenthesis is the number of farmers for 2006/07

Table 2.7 Performance of promising lentil genotypes in Belhara VDC (1420 m, 1510 m), Dhankuta, 2004/05 (mean of 2 replicates).

Genotype	Days to flowering	Days to maturity	Plant height (cm)	Pods/ plant	100 seed weight (g)	Seed yield (kg/ha)
ILL 7982	73	149	42	138	2.5	2042
ILL 6829	78	151	42	73	2.5	1939
ILL 7537R	76	149	39	152	2.0	1474
ILL 7979	79	154	40	70	2.5	2100
Simal	77	151	40	102	2.5	2209
Shital	80	154	45	98	2.3	1816

Table 2.8. Performance of promising lentil genotypes Fikal VDC (1275 m), Dhankuta, 2004/05.

Genotype	Days to flowering	Days to maturity	Plant height (cm)	Pods/ plant	Seed yield (kg/ha)
ILL 7982	106	158	24	102	683
ILL 6829	104	157	30	125	765
ILL 7537R	103	157	26	111	725
ILL 7979	103	157	27	120	733
Simal	95	155	28	115	738
Shital	100	155	28	121	742

Table 2.9 Seed yields and yields parameters of lentil (FFT) in Jumla (2003/04, 2005/06).

Genotype	Flowering days	Maturity days	Plant height (cm)	Pods/ plant	Seed yield (kg/ha)	100 seed weight (g)
ILL 6829	123	159	18	34	315	2.4
ILL 7573R	124	158	18	32	288	2.1
ILL 7979	123	159	17	22	359	2.8
ILL 7982	123	160	18	18	332	2.8
Simal	122	159	20	17	356	2.2

Grain yield and yield components

Under Khumaltar and Bhaktapur conditions, genotypes ILL 6829 and ILL 7982 produced significantly higher grain yield than any of the check varieties tested in both (Figure 2.1a,b). In Khumaltar, ILL 7982 and ILL 6829 had 76% and 57% higher seed yield as compared with Simal, while the seed yield increment was about 25% in Bhaktapur. Under Khumaltar conditions, seed size in ILL 7982 and ILL 6829 were 11-17% larger than Simal

(Table 2.1). Higher number of pods per plant and larger seed size contributed to greater grain yield.

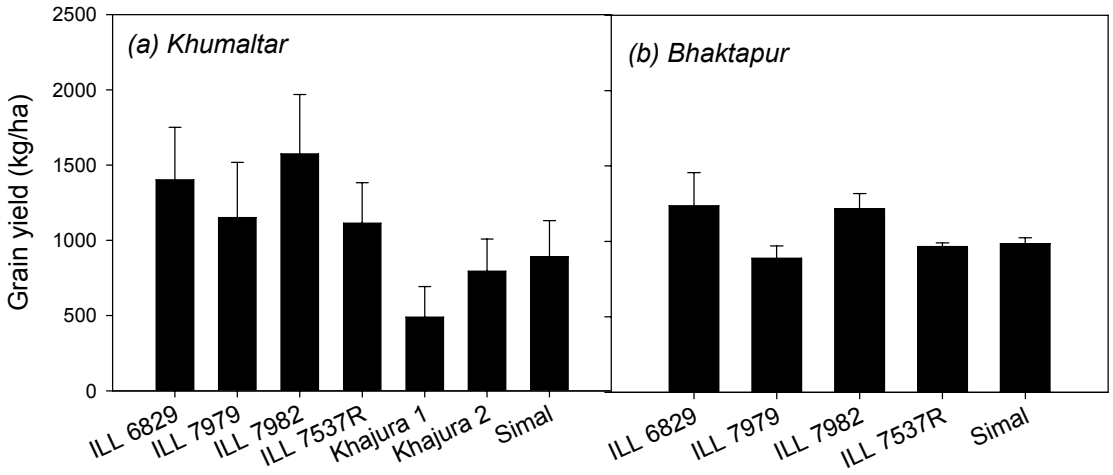

Figure 2.1 Seed yields of promising genotypes in (a) Khumaltar (2001-2007) and farmer's field in (b) Bhaktapur (2005).

In Gorkha, though sowing was done late, the results were encouraging. Simal performed the best in Gorkha condition, however, ILL 7982 and ILL 6829 produced 900 kg/ha and 780 kg/ha of grain yield, respectively (Table 2.3). In Magdi and Baglung Seed yield was generally poor due to moisture stress caused by delayed sowing (Table 2.4).

In Deurali Palpa, ILL 7982, ILLL 6829 and ILL 7537R produced 142%, 124%, 103% and 33% higher grain yield than Simal, respectively (Figure 2.2a). These genotypes had larger seed size (25-38%) and 73-145% higher numbers of pods per plant as compared with Simal (1.6 g/100 seed weight) (Table 2.5). Also, the maturity of these genotypes, except ILL 7979 was comparable with Simal and Shital. In Dhankuta, there was not much variation in mean grain yield among the genotypes tested, primarily due to greater grain yield variation among the farmers (Figure 2.2b). However, Farmers of Fekul and Belhara would like earlier lentil materials in order to fit maize into the bari land system.

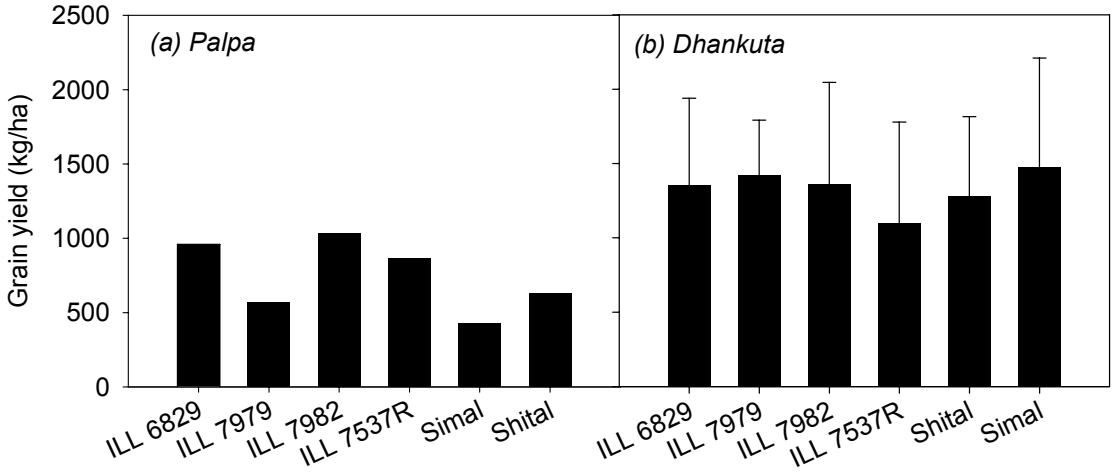

Figure 2.2 Seed yields of promising genotypes in farmer's field of (a) Deuralai, Palpa and (b) Pakhribas, Dhankuta (2005).

In Ramechap, grain yield of ILL 7982 was highly variable among farmers field in 2005/06 (Figure 2.3a). However, farmers were able to harvest up to 2200 kg of grain per hectare. In 2006/07, ILL 7982 was the highest yielder followed by ILL 7537R (Figure 2.3b).

Farmers rated the performance of the crop as good and indicated that late sowing resulted in shortening of crop duration and therefore short seed filling period (about 10% pods were unfilled pods).

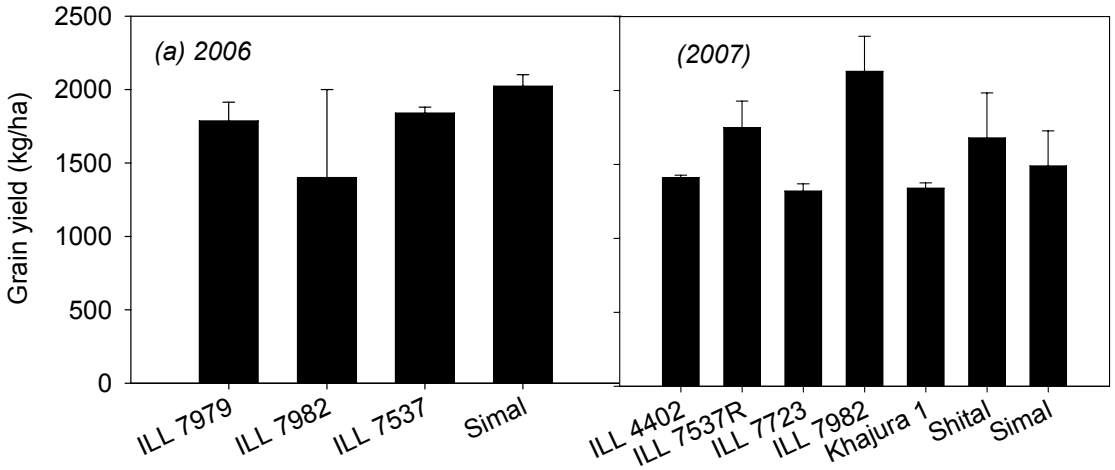

Figure 2.3 Seed yields of promising genotypes in farmer's field in Ramechap.

Grain yield and soil moisture

Lentil is grown as rainfed crop entirely dependent on the residual soil moisture. The winter rainfall is erratic (Figure 3.1b), and the success of the crop depend on the rainfall during the growing season. However, residual soil moisture from the preceding rice crop, time of sowing and incident of root rot and wilt complex are equally important (Shrestha et al 2006). In the year where the amount of total rainfall received from sowing (October) to flowering (February) was zero, the grain yield was almost zero (Figure 3.1). The higher grain yield in year 2003/04 was also contributed by timely sowing (October 3rd week), while soil moisture constraints together with incidence of root rot complex (particularly in Simal) had reduced grain yield in 2000/01. In 2002/03, early soil moisture stress and root rot/wilt disease had caused reduced plant stand (26-82 m2) and hence low grain yield while in 2002/02, early sowing (Oct 13) caused vigorous growth leading to lodging and poor yield.

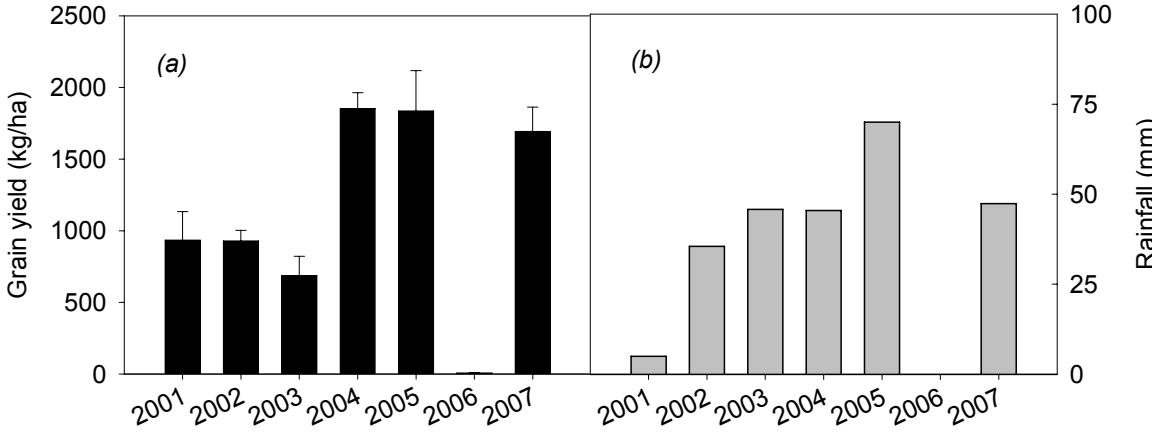

Figure 3.1 (a) Mean grain yield of lentil genotypes and (b) rainfall from sowing to flowering during 2000/01-2006/07 in Khumaltar.

In lentil, the success of the crop depends on the rainfall during flowering (Shrestha 2005). There is a linear relationship between grain yield and the amount of rainfall received from sowing to flowering, while the rainfall during pod filling stage may reduce the grain yield (Figure 3.2).

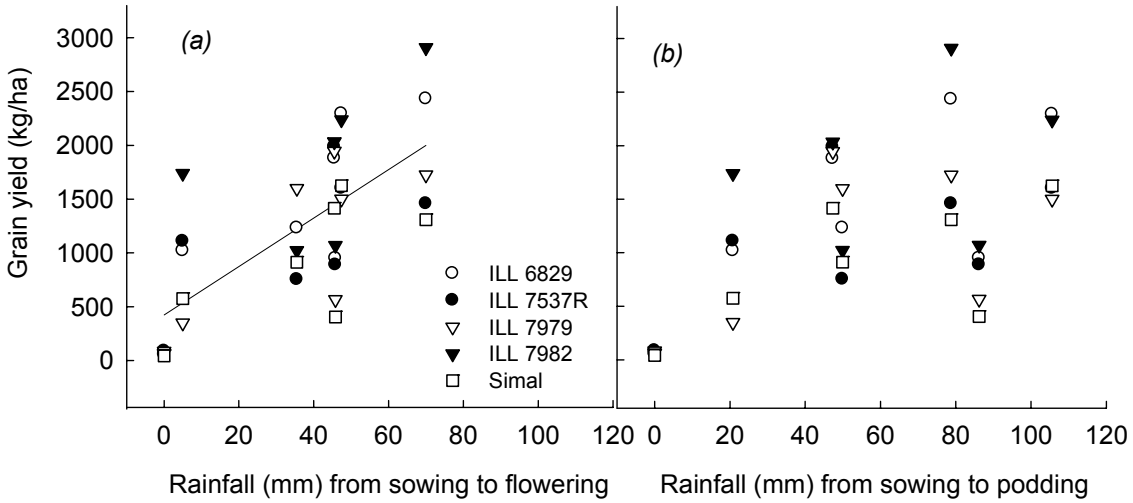

Figure 3.2 Relationship of grain yield with (a) amount of rainfall from sowing to flowering, and (b) amount of rainfall from sowing to podding.

Diseases and insects

In Khumaltar, Gorkha and Dhankuta wilt root rot have been observed. However, the disease was not very serious. Generally, insect pests are not a serious problem in lentil.

Training and interaction program

In Manthali, Ramechap and Dukuchap, Lalitpur, technical staff (officers, junior technicians, junior technical assistant in DADO, Manthali) and farmers were given a half day training and interaction program on lentil cultivation and its improved production technologies. The technical staff and farmers actively participated in the discussion session.

Conclusion

There is a tremendous scope for increase in productivity and production with the adoption of desirable varieties and improved agronomic practices, and expansion of area under rice based cropping system. Timely sowing and soil moisture are the major factors for realizing higher seed yield. Active collaboration of DADO in implementing seed kit distribution/demonstration and seed increase program has been a great success.

Acknowledgements

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11.3 Appendix 3. (Visit of Prof Neil Turner)

Professor Neil Turner current director of NARC was invited by his successful PhD student Dr Renuka Shrestha and Professor Francis to visit Nepal in the current growing season. Because of his knowledge of physiology drought stress in particular it was decided to support this visit from project funds to give a broader perspective on the project as well as the opportunities to discuss and recommend on future research directions

11.3.1 Report on Visit to Nepal 20-27 January 2007

I visited Nepal from 20-27 January to look at progress in an Australian Centre for International Agricultural Research (ACIAR) funded project “Lentil and Lathyrus in the cropping systems of Nepal. Improving crop establishment and yield of relay and post rice sown pulses in the Terai and mid hills” (CSI/1999/064). The original plan was to meet with the directors of the Nepal Agricultural Research Council (NARC) and present a seminar ‘Improving the yield and rainfall use efficiency of dryland crops: the Australian experience’ on 21 January, travel by road to Rampur in the central terai and visit on-farm and on-station trials on 22 January, travel by road from Rampur to Nepalgunj visiting on-farm and on-station trials and farmers’ fields en route on 23 January and then return to Kathmandu by air on 24 January. Visits to Khumaltar and sites in the Kathmandu valley were planned for the 25 January. A nationwide general transport strike meant the meeting with the directors on 21 January had to be delayed as everyone had to walk to the NARC headquarters and the seminar was postponed.

On 21 January, Mr R.K. Neupane, Dr Renuka Shrestha and I met with Dr N.P. Shrestha, Executive Director of NARC, Dr P.L. Karma, Director of Crops and Horticulture at NARC and Mr S.L. Shrestha, Director of Administration at NARC. The directors expressed satisfaction with the progress of CSI/1999/064 and were very thankful for the funding provided by ACIAR and the training of Dr Renuka Shrestha at the University of Western Australia. With the onset of political stability in Nepal, the directors indicated that they anticipated greater emphasis by the government on the agricultural sector and the upgrading of research facilities and emphasis on innovation, research and development in agriculture and horticulture. They expressed the wish that the cooperation between CLIMA and NARC would be maintained and that ACIAR would continue to provide funding for agricultural research in Nepal.

In a revised plan (quickly re-revised again) when the airport at Bharatpur (near Rampur) was closed by fog, saw Dr Renuka Shrestha, Mr R.K. Neupane and me fly to Nepalgunj in the late afternoon of 22 January. On 23 January we were accompanied by Mr D.N. Pokhral (agronomist), Mr A.R. Ansani (entomologist), Mr P. Jha (pathologist) and Mr N.H. Ghimire (entomologist) and shown on-station trials at the NARC regional station near Nepalgunj. The on-station trials of lentil included the nation-wide CVT trials that included lines selected as part of the ACIAR project, an Elite Variety Trial (EVT) of lines selected for their adaptation to the region, and a disease screening nursery of 116 lines for Fusarium wilt, Stemphyllium which has arisen as a major problem on the terai, Altenaria and Cladosprium. ILL 6829, ILL 7716 and ILL 2501 were all showing good disease resistance at the time of the visit. Shital (ILL 2580) is a lentil cultivar arising from the project that has already been released and 4 or 5 additional lines are being evaluated in farmers’ fields for potential release. Of these foundation seed of ILL 7723 and ILL 6829 is being bulked up for release next season. ILL 7723 has a large seed size (22 g/1000 seeds compared to 18 g/1000 seeds for local cultivars), but is later than current cultivars and hence does not yield well in dry environments and years.

I was also shown a seed priming experiment with lentil where seed had been primed for 12 h with water, cow dung, or 2% KH2 PO4 and then air dried for 2 h. Measurements at 28 days after sowing indicated that priming had increased root penetration and above-ground biomass compared with no priming, but there were no differences among the priming treatments at that stage.

Also at Nepalgunj 23 lines (some developed at CLIMA as part of the project and some from China) of low ODAP lines of lathyrus were being grown in a screen house to prevent cross pollination with high ODAP lines and to bulk up the seed for further evaluation next season.

In addition to lentil and lathyrus, experiments were being conducted with chickpea and pigeon pea. The chickpea trials included a CVT, an EVT, a disease nursery and also a Participatory Variety Selection Trial (PRVT) in which lines had been selected by farmers from segregating material grown on farm. Avrodi, Tara (K 850 x Dhanush), KPG 59, KWR 108, KPG 173-4 and ICCV 97717 are all released varieties that are doing well in farmer trials. BG 1206 is a vigorous and high yielding line that has been rejected by farmers because it has a rough seed coat and poor mouth feel. The major problem in chickpea is Helicoverpa damage. The incidence has been so severe that farmers in the terai have virtually stopped growing chickpea. No resistance has been found and spraying with insecticides and BT is too expensive. Entomologists at Nepalgunj have been trialling biopesticides, particularly Helicoverpa nuclear polyhedrosis virus (HNPV). The virus is effective in controlling the insect if sprayed when the larvae are small (2nd-3rd instars).

ICP 7035 is pigeon pea that is widely grown in the western terai. It is resistant to Fusarium wilt and sterility mosaic virus and if sown in September rather than June it produces the same yield, is shorter and easier to spray and can be sown as a relay crop after maize.

On 24 January accompanied by the same group of scientists we visited several farms in the Barcia District where lines of lentil and chickpea were being evaluated on farm. The lentil line ILL 7723 was growing well where it followed rice, but not in upland areas where there was low fertility and water shortage. In the region lentils are usually broadcast as a relay crop and grown in association with Brassica campestris, linseed and/or lathyrus. Planting density was low, particularly when relay planted at the rice harvest. The Brassica is harvested first and the lentil and other crops harvested as they mature. Chickpea seed is usually broadcast, but only after the rice is harvested and the field is ploughed which can leave the soil very cloddy. The tips of the branches of chickpea are usually picked for a fresh vegetable and to encourage branching at least twice and the some of the young pods harvested as a green vegetable, before the crop is allowed to mature for seed. On-station trials have shown that the chickpea can be tipped twice up to 50 days after sowing without any loss of yield. The poor seed bed, low planting density, lack of fertilizer and lack of supplemental irrigation in the pulse crops was noticeably different from the resources of manpower, fertilizer and irrigation provided to the wheat crop in adjacent fields. Notable was a chickpea field in which the farmer had sown chickpea after rice, prepared the seed bed properly and sown the chickpea in rows after the plough and with alternate or every third row sown to coriander to deter Helicoverpa moths from laying their eggs (and is also used as a spice). This had been a farmer initiative after seeing chickpea grown the same way in on-farm trials the previous year.

We also visited a farm where the World Bank and ICRISAT have funded a small on-farm production facility for HNPV (Helicoverpa Nuclear Polyheydrosis Virus). Helicoverpa larvae were being raised on nuclear polyhedrosis virus-infected chickpea seeds. When the appropriate size, the larvae will be put in a blender and then centrifuged and the supernatant kept in a refrigerator to use as a spray against Helicoverpa during the next season. Entomologists from the station will evaluate its effectiveness compared to HNPV produced commercially in India.

On 25 January, I visited the headquarters of the Nepal Agricultural Research Institute (NARI)* and field station at Khumaltar near Kathmandu. I met with Mr Shree Krishna Adhikary, the Director of NARI, Dr R.C. Adhikari, Senior Scientist in Horticulture and Dr R.P. Upreti, Head of the Outreach Division. The Director expressed interest in collaboration with the University of Western Australia in training and upgrading the skills of NARI scientists and offered the facilities of NARI to enable students to conduct their experimental work in Nepal. I also visited experimental plots of lentil in which 137 lines were being screened for a range of diseases (but not Stemphyllium which is not a problem

in the mid-hills region) by Mrs Joshi as part of the ACIAR project and the plots of lentil being evaluated by Dr Renuka Shrestha for the mid-hills region. As many of the lines of lentil selected at Rampur do not grow well in the mid-hills region, Dr Shrestha is screening F3 segregating lines from ICARDA as well as advanced lines from ICARDA for their yield and disease resistance in Khumaltar and bulking up superior lines (ILL 6829 which is bold seeded and ILL 7982) for final approval to release. Grass weeds are a major problem in relay sown crops of lentil after rice. Dr Renuka Shrestha is conducting an experiment to see whether Verdict® is effective in controlling grass weeds in lentil. Her work suggests that seed priming is not proving very effective in improving establishment in relay sown lentil, particularly in years when there is rain during the rice harvest.

In the morning I also visited NARI's Communications Unit and was shown the various publications, library facilities and exhibition room and told about the regular television (weekly) and radio opportunities that there to discuss the research outcomes from NARI and get the message to rural farmers. In the afternoon I gave a seminar entitled "Improving the yield and rainfall use efficiency of dryland crops: the Australian experience" that generated a number of questions and a request from the Director of NARI for a copy of my Power Point presentation.

On 26 January Dr R.P. Upreti, Mr R.K. Neupane, Dr Renuka Shrestha, Mrs Joshi, Dr Siva Lohani and I went to the Dukuchap village in Lalitpur District and met Mr Sundar Khadka, a farmer in the village who acts as a coordinator between NARI scientists and the local farmers. NARI scientists are involved in introducing improved technology for the production of maize, rice, soybean, pigeon pea, lentil, cowpea, onions, oats for fodder, other fodder species, and goats. In the village I saw oats being grown and cut for fodder for the cattle and goats, short-season pigeon pea (Rampur HAR 1) introduced to stabilize the bunds and for use as a vegetable, improved pear varieties grafted to local rootstocks and lentil varieties such as Khajura 2, ILL 7982 and ILL 6829 being tested in farmers' fields.

I was also given brochures in Nepali (also produced in local languages) that the Outreach Division have written for farmers and describe new varieties and technologies (example attached).

Finally, I also made arrangements to part fund Mr R.K. Neupane and Mrs Joshi to attend a travelling workshop in Bangladesh being organized by ICARDA.

Conclusions and recommendations

I conclude that the ACIAR project CSI/1999/064 is on track to meet its objectives of developing improved cultivars of lentil with multiple disease resistance and bold seeds adapted to both the terai and mid-hills regions of Nepal and of promoting and evaluating these in farmers' fields. New low ODAP lines of lathyrus have been developed and are being bulked up in Nepal, but this part of the project has been subject to some delays.

What is noticeable in visiting farmers' fields is the level of resources of manpower, fertilizer and irrigation being applied to wheat and fodder crops, while inputs to food legumes were minimal. I was advised that this was because of the low yield of pulses relative to wheat. However, with the current high prices for pulses, particularly lentil and chickpea, there is an opportunity to develop pulses into a cash crop, rather than a protein source for the local families. Trade figures show that less than 5,000 tonnes of lentil were exported from Nepal to Bangladesh in 2005-2006 for an income of about AUD3.5 million (the average for the past 5 years is 5,300 tonnes, but these figures do not account for trade with India which is not monitored). There is the potential to increase the export of pulses to the region, if yields were higher.

I recommend that agronomic packages be developed that highlight the need for good seedbed preparation, timely sowing, fertilizer inputs and supplemental irrigation to lift the yields and income from the cool-season pulses. This will require an experimental and extension program to determine the best time of planting, seedbed preparation and inputs

within the farming system. ACIAR should be approached to see whether they could support such a program.

Acknowledgements

I would like to thank Professor Clive Francis for financial support and Dr R. Shrestha and Mr R.K. Neupane for their planning, assistance and hospitality while in Nepal.

* All disciplinary divisions are under NARI while Regional Agric Research Station (RARS), Agric Research Station (ARS) directly under NARC.

11.4 Appendix 4. Report on International Travelling Workshop on Lentil, Bangladesh

(12-19 February 2007)

11.4.1 Renuka Shrestha, Agronomy Division, NARC, Nepal

This lentil international travelling workshop was jointed organized by Bangladesh Agricultural Research Institute (BARI), Bangladesh and International Centre for Agriculture in Dry Areas (ICARDA), Syria. All together there were 28 participants, each from USDA-ARS, Washington State University (Grain Legume Genetics & Physiology) and ICARDA, Syria; five from University of Saskatchewan, Canada; three from India (India Institute of Pulses Research, Kanpur; National Bureau of plant Genetic Resources; Pulses and Oilseeds Research Station, Berhampore, Murshidabad, West-Bengal); four from NARC, Nepal, two from Pakistan (National Agricultural Research Center, Islamabad; Pulses Research Institute), and 12 from Bangladesh Agriculture Research Institute (BARI), Bangladesh (Photo 1). In day one of workshop, eight country papers on lentil improvement and research, and six other papers related to disease, quality control and drought were presented (Appendix 1). Field visits covered major lentil growing areas: Tangail, Natore, Ishurdi, Faridpur, Kustia, Pabna, Jessore, Rajshahi, Madaripur and Barishal.

Photo 1: Participants of International Travelling Workshop

In Bangladesh, rice is major crop grown that occupies about 72% of area, while pulses area is 4%. Early rice (Boro rice) is popular in Tangail (Photo 2). Bangladesh ranks third in lentil area (154 000 ha) after India and Nepal in Asia Pacific region. Though lentil comes second after Lathyrus in terms of area, it is highly preferred dhal in Bangladesh, and more than half of the country demand (140 000 tonnes) is met by export. Lentil is grown a mixed crop with mustard, wheat, linseed; intercropped with sugarcane; relay in transplanted rice or as a sloe crop depending upon topography and soil characteristics.

Nine lentil varieties: BARImasur-1, BARImasur-2, BARImasur-3, BARImasur-4, BARImasur-5 (X95S-136), BARImasur-6 (X95S-167), BINAmasur-1, BINAmasur-2 and BINAmasur-3 (BARI, BINA=Bangladesh Institute of Nuclear Agriculture) have been released from 1991 to 2006. The yield potential of these varieties ranged from 1700 kg/ha (BARImasur-1) to 2500 kg/ha (BARImasur-6). BARImasur-4 popular in farmer's field in Tangail, however, found to be susceptible to Stemphylium blight from last year (Photo 3). In participatory varietal trial, farmers select lines based on plant type and seed characteristics. BARImasur-5 performance was the best in the area, resistant to rust and Stemphylium blight (Photo 4). BARImasur-5 is also resistant to rust, tolerant to root rot and moderately resistant to aphid. BARImasur-6 has similar trait as BARImasur-5, but matures 5-10 days earlier and about 15% higher seed yield than BARImasure-5.

Photo 2. Rice major crop in Bangladesh

At RARS, Ishurdi, large numbers of line were screened for diseases (wilt, rust and Stemphylium) were observed. The generation lines comprised of the crosses from susceptible parent ILL 5888 and the resistant lines: ILL 4605 and ILL 6002. Besides, hybridisation, generation advancement yield trials, management trials (seed priming cum irrigation trial, boron trial, biofertilization) and variety maintenance programs were conducted (Photo 5). In RARS Jessor, lines L5x87272 and 107-41x87012 were found to be highly susceptible to Stemphylium blight, while BARImasur-4, -5, -6 were tolerant. Rust disease was also observed during initial stage of growth. Two spray of Rovral (@2 g/Litre) was found to be effective in controlling Stemphylium blight and rust.

Photo 3: (a) Good crop of BARImasur-5 in farmer's field, and (b) International scientists sharing their experiences in respective countries to lentil farmers in Bangladesh

Photo 4: Scientists of RARS, Ishurdi showing the lentil experiments

In summary, this international travelling workshop in lentil not only gave the opportunity to see and understand the agriculture system of Bangladesh in particular, but also brought together scientists working on lentil crop to share their experiences.

11.5 Appendix 5. Workshop Report: An Introduction to Modern PC-based Data handling and Statistical Methods (Nepal 2007)

Dr Jens Berger
Centre for Legumes in Mediterranean Agriculture
The University of Western Australia
Nedlands, WA. 6907 Australia
Email: Jens.Berger@csiro.au

Background

Since 2003 a number of ACIAR-funded statistical training courses have been conducted at Lumle, presented principally by Dr. Jens Berger (CSIRO) and Ms. Jane Speijers (Senior Biometrician, DAFWA). These have covered a variety of techniques from data handling to univariate and multivariate analysis, and have always been treated with great enthusiasm by the Nepali scientists. In response to Nepali interest in dedicating a week to the analysis of multi-environment data, a course was put together by Dr. Berger and presented with the help of Dr. Murari Singh, Senior Biometrician at ICARDA.

The aim of the course was to familiarize the students with the entire range of skills required to handle multi-environment data in an extremely hands-on manner. Students learnt how to check data on a site by site basis, assemble the data in a database using MS Access, and finally perform a range of analytical techniques such ANOVA, Finlay-Wilkinson regression etc using Genstat to come to grips with the patterns underlying the genotype by environment interaction:

Time	Program: An introduction to the analysis of multi-environment trial data
Day 1: Tuesday, 17 July 2007	
AM	Brief Introductory Session -What are we all working on, where will this course go?
	Data management and Excel basics. -Where do you save files, what names should you give them? -Spreadsheet skills: the Excel platform, customizing your workbook, data entry, moving around the worksheet, selecting cells, auto-fill, editing, copying, pasting, saving data. Sorting, adding notes, simple formatting, using simple formulae, paste special, Pivot tables. Practicals: Excel 10.
PM	Database fundamentals-introduction to MS Access -Linking workbooks using MS Access. Linking to Excel files, creating queries, join properties, extracting and exporting data. Practicals: MS Access 1-4.
Day 2: Wednesday, 18 July 2007	
AM	Introduction to Genstat -Opening files, importing data. Selecting cases. Data manipulation. The analyse menu.
	ANOVA refresher. Example 1: Randomised complete block design (RCBD) with simple treatment structure (One-way ANOVA in Genstat; Dataset: Cane.xls) -Comparing differences within and between groups. Error distribution. Fixed and Random Factors. Estimated means and standard errors. Factorial designs, interaction. Practical sessions: Genstat 1: Introduction, ANOVA, descriptive stats.
PM	Example 2: Randomised block design with factorial treatment structure -Interaction. Practical sessions: Genstat 3.5: 1 & 2-way ANOVAs with blocks.
Day 3: Thursday, 19 July 2007	
AM	Using treatment levels in the analysis - Polynomial contrasts. Sums of squares models. Practical sessions: Genstat 4, 5: More advanced ANOVA: constructing polynomial contrasts, 2-way ANOVA with polynomial contrasts

PM	Linear Regression: curve estimation (Dataset: Jab00 means) Simple Linear Regression with Groups (GLM Curve Fits.xls) Practical sessions: Genstat 11: Introduction to regression with GLM, Genstat 12: Introduction to regression with GLM, 2-way models.
Day 4: Friday, 20 July 2007	
AM	Analysing Data: GxE Analysis, G x E as a 2-way ANOVA, G x E as a general linear model (GLM), Finlay-Wilkinson Analysis in Genstat (Fin-Wilk.xls, see Pivot Tables), G x E Analysis Flowchart. Practical sessions: G x E
PM	Practical sessions: G x E 3: Lentil GxE.
Day 5: Saturday, 21 July 2007	
AM	Practical sessions: re-analyse G x E 1: Simple GxE..; G x E 3: Lentil GxE. Brief introduction to REML.
PM	Demonstration analysis of lentil GxE dataset using balanced and unbalanced approaches.

Workshop Evaluation: Strengths and Weaknesses

The course is extremely interactive, being based on lectures, demonstrations and extensive practical exercises. Having run the course repeatedly it has become abundantly clear that most of our participants really struggle with data management (Windows skills-saving data in the right place with the right name) and manipulation (Excel skills). To address this issue the course now contains many exercises where students are required to build trials from the ground up (randomisation using Excel), append data from another source (sorting skills using common fields), save their work, and access it some days later in GENSTAT in order to analyse it using an appropriate model. This tests their ability to manage data, and use the model checking facilities in GENSTAT (residual plots etc.) to confirm that the analysis is valid, and the data in good shape. As such it is a realistic simulation of the processes that are routinely applied in experimental agricultural research.

These exercises are extremely effective because they expose the participant's weaknesses very clearly. In the current course many of the students had trouble finding their data again after only a few days. Appending data using common field headings (such as variety name, rep, treatment etc.) also proved to be very troublesome, and was revealed by some very strange looking residual plots. While these sorts of errors slowed down the course program considerably, they were extremely valuable because they unequivocally demonstrated the necessity of systematic, logical data management and manipulation, and taught the students not only how to do this, but also how to recognize that data had been tainted using the model checking facilities in GENSTAT.

Summary and Recommendations

The participants now have a reasonable grasp of data management and handling, simple experimental designs and their appropriate analysis. They can detect balance using Pivot tables, data errors using residual plots, and understand how these should be rectified by checking the original field books or deletion if necessary. Moreover, the participants understand how to check whether ANOVA or regression is appropriate using residual error plots and Q-Q plots, and how and why to transform data if necessary. The more advanced students have a clear understanding of how these methods pertain to the analysis of GxE data. Finally, all participants are able to present results in attractive manner using the graphing and tabulation facilities in MS Excel.

These Nepali scientists have been very well served by ACIAR funded training in 2003, 2004 and finally 2007. While there is never enough time to cover everything at a rate that all will understand, I'm confident that most participants know enough to stand on their own, and now need to put the exercises into practice to make the most of their training.

List of Participants

Participants	Position
Mr. S. P. Srivastava	Grain legume leader
Mr. B.R. Baral	Technical Officer
Mr. T. Akthar	Senior scientist
Dr. R. Shrestha	Senior scientist
Mr. R.K. Neupane	Senior scientist
Mr. S. Gautam	Technical officer
Mr. S. Shrestha	Technical Officer
Mr. R. Darai	Senior Technical Officer
Mr. B.N. Adhikari	Technical Officer
Mr. H.K.Upreti	Senior Scientist
Mr. K.H. Ghimire	Technical Officer
Mr. D.N. Pokhrel	Technical Officer
Mr. J.B. Sah	Technical Officer
Mr. K.B.Thapa	Technical Officer
Dr. E.M. Bhattrai	Technical Officer
Dr. S. Khan	Senior scientist