CROP PROTECTION PROGRAMME

PROMOTING THE ADOPTION OF IMPROVED AND INTEGRATED DISEASE AND PEST MANAGEMENT TECHNOLOGIES IN CHICKPEA BY POOR FARMERS IN MID HILLS AND HILLSIDE CROPPING SYSTEMS IN NEPAL

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Project Leader: Philip C Stevenson

Project Leader's institution: Natural Resources Institute, Chatham, Kent.

Table of contents **page number**

Tables and figures. **Page number**

THE KEY PROJECT TEAM MEMBERS

DR PHILIP C. STEVENSON, Project Leader.
MR DAVID GRZYWACZ, IPM Specialist.
Natural Resources Institute, University of Greenwich, Chatham Kent, UK.

DR SURESH PANDE, Project Coordinator.
MR NARAYANA RAO, Senior Scientist
ICRISAT Asia Centre, Patancheru PO, AP 502 324, India

MR R K NEUPANE, Regional Coordinator,
Grain Legume Research Centre, Rampur, Chitwan, Nepal.

MR R.N. CHAUDHARY, Senior Scientist
Department of Plant Pathology, Oilseeds Research Program (NARC), Nawalpur, Nepal

VA BOURAI, Reader and Head of Department,
Department of Economics, SGRR (PG) College, Dehradun (Uttranchal), India.

FARMER GROUP LEADERS

BV KHANAL & R THAPA-MAGAR
Munalbasti village, Kalika, VDC Dist Bardia, Bheri Zone.

BK ARYAL,
Rajahar Village, c/o NK Yadav NGLRP, Rampur, Chitwan Dist.

S KHATRI
D-Gaon village, Bageshwari VDC, Banke Dist. Bheri Zone

RD YADAV
Dhangadi-2, Sirha Dist. Zone Sagarmatha.

BN JHA
Bardibas / Lalbandi Village, c/o oil seeds research centre Nawalpur.

ABREVIATIONS, ACRONYMS AND LOCAL MEASURES

ADB	Asian Development Bank
BGM	Botrytis Grey Mould
CABI	CAB International
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	Centro International de Mejoramiento de Maiz y Trigo
CPP	Crop Protection Programme (DFID)
CR	Central Region
DoA	Department of Agriculture
FFS	Farmer Field Schools
GoN	Government of Nepal
Ha	Hectare
ICM	Integrated Crop Management
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IPM	Integrated Pest Management
MWR	Mid-Western Region
NARC	Nepal Agricultural Research Council
NARS	National Agricultural Research Station (Nepal)
NGLRP	National Grain Legumes Research Program
NGO	Non-governmental Organisation
NRI	Natural Resources Institute (UK)
ORP	Oil Seeds Research Program
PCI	Pesticide Control India
PRA	Participatory Rural Appraisal
RARS	Regional Agricultural Research Station (Nepal)
SUP	Safe Use of Pesticides

1Katha =	0.033 Hectare
1Ha =	33 Katha.
1Bigar =	0.05 Ha
1Ha =	20 Bigar
1000kg=	1qunitel

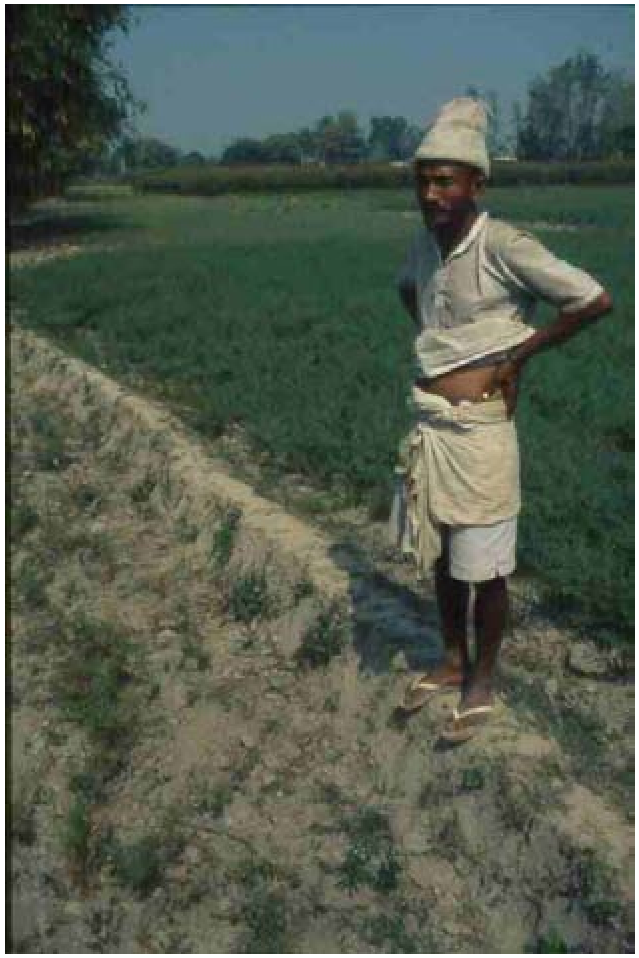
Rabi	Dry season (October – May)
Kharif	Monsoon season (June – September)

EXECUTIVE SUMMARY

This project has successfully validated, through on-farm participatory trials, the application and use by farmers of an integrated crop management strategy to increase productivity and reliability of *Rabi* (dry season) chickpea production on small-holder farms in Nepal. This strategy comprised the use of an improved cultivar Avarodhi (good yield and resistant/tolerant to Fusarium wilt and Botrytis Grey Mould [BGM]), seed priming, judicial fungal and insect control using easily available pesticides, application of boron and Rhizobium in deficient areas and management of fertilizer inputs and water to prevent dense canopy. One of the principal advantages of chickpea as a Rabi crop is that provided it can germinate using residual moisture from paddy with which it is rotated, it needs no further water owing to its drought tolerance and deep root system.

In addition, the value of the biological pesticide *Helicoverpa armigera* nucleopolyhedrovirus (*Hear*NPV) was also validated successfully in the laboratory and in the field both on-station and through farmer participation. Overall, the laboratory studies indicated potential problems with efficacy through an interaction between the virus and the leaf surface of chickpea. This was attributable to surface chemicals that appear to permanently neutralise the toxic effect of the virus and are presently being investigated in detail through a PhD studentship. Simple formulation ingredients based on milk powder improved the efficacy of *Hear*NPV on chickpea when sprayed as a mixture on to the leaves with the virus by up to 3 times. This was shown to be attributable to the protein component of the milk powder. Field trials, however, did not demonstrate the same effect and *Hear*NPV was highly effective at reducing the population of pod borer both on-station under optimal controlled field conditions but also when provided to farmers with basic coaching in their application. In fact, in several areas, especially on the improved variety Avarodhi, NPV was more effective than Thiodan, the insecticide provided to farmers to control the insect. Furthermore, on the same variety, when milk powder was added as a formulation additive it improved the efficacy of the bio pesticide even more. *Hear*NPV is clearly a viable alternative to chemical based pesticides and should be promoted widely. However, production of quality virus is difficult and a brief survey of various products available from India established that only one source provided material of a suitable quality for application. The establishment of production facilities in Nepal will be required to ensure this alternative option is available to farmers.

Since October 2000 this project has provided the information, support and technologies validated through on farm trials described above to more 3500 farmers to grow chickpea in Nepal using an integrated and economically and environmentally acceptable approach to the management of biotic and abiotic constraints. Overall, the chickpea yields of participating farmers have more than doubled from less than 900Kg ha^{-1} using local varieties with traditional management practices to more than 2100Kg ha^{-1} when employing ICM with improved varieties. The net cost of production has decreased from Nepali Rs. 17.5 kg^{-1} to NRs. 9.3 kg^{-1}. With a market price of approximately NRs 30 kg^{-1} this more than doubles profits from this crop. Overall farmers increased their wealth by more than US$200 per annum by growing chickpea using the technologies promoted by this project. Thus, by reaching 3500 farmers the project increased the overall wealth of project farmers by approximately US$ 730,000. The impact on livelihoods was substantial with the majority of farmers describing improvements in all aspects of domestic life although the extent of these impacts was dependent on size of holding. One dramatic change was in the number of farmers moving from mud houses to brick houses or even building them from scratch (5-10%). Up to 22% of farmers reported paying off debts with dramatic increases in expenditure on education for children, clothes and healthcare. Overall domestic expenditure increased by about 45% over the course of the project reflecting farmers' increase in wealth.



Farmers traditional practice produces the unpredictable and poor yields in front of farmer whereas ICM dramatically improves productivity as shown in the background.

Some of the impact in terms of land area is not clear from current data but in one village, Lalbandi, in Central Nepal 400 farmers were provided with a kilo of seed each in November 2002 – enough to sow approximately 13 Ha. However, owing to the promotion by this project and farmers' personal initiative the area sown in 2003 was 110Ha. In this village chickpea is rapidly taking over where in years before tomato lay rotting in fields or on roadsides fetching only NRs 2 Kg^{-1}.

Most farmers learn about new farming practices through farmer to farmer contact and estimates by in country scouts indicate that as many as 7500 farmers have assimilated some or all of the ICM components directly from this project or from other project farmers through local processes of dissemination. Furthermore an NGO FORWARD (Forum for Welfare, Agricultural Research and Development) is buying seed from the project's farmers to distribute to farmers in other areas involved in independent extension projects including the Plant Sciences Research Program project of DFID that aims to increase the use of Rice fallows in winter cropping. They are using our recommendations to advise farmers on how to optimize their production of chickpea.

The value of the private sector to the ultimate sustainability of chickpea ICM has not been ignored and the project has identified dealers in agriculture inputs, and helped develop market linkages with chickpea farmers, especially those in Lalbandi and Bardibas. At the end of 2003 guarantees with project farmers to buy 7000kg of seed (enough to sow 233Ha) were set up and will be distributed this October, along with the management practices promoted in the present project, to previously non-contacted farmers.

Farmers have almost entirely replaced tomatoes as the main source of winter income in Lalbandi (above). One of our project farmers, Mrs. Krishna Kumari Shrestha (below), was awarded the district agricultural prize for yielding more than 4000kg Ha^{-1}.

1. INTRODUCTION

Rural poverty remains pervasive throughout Nepal, a predominantly agrarian nation, with 60% of the GNP derived from agriculture and the country is the poorest in South Asia (Fig 1.).

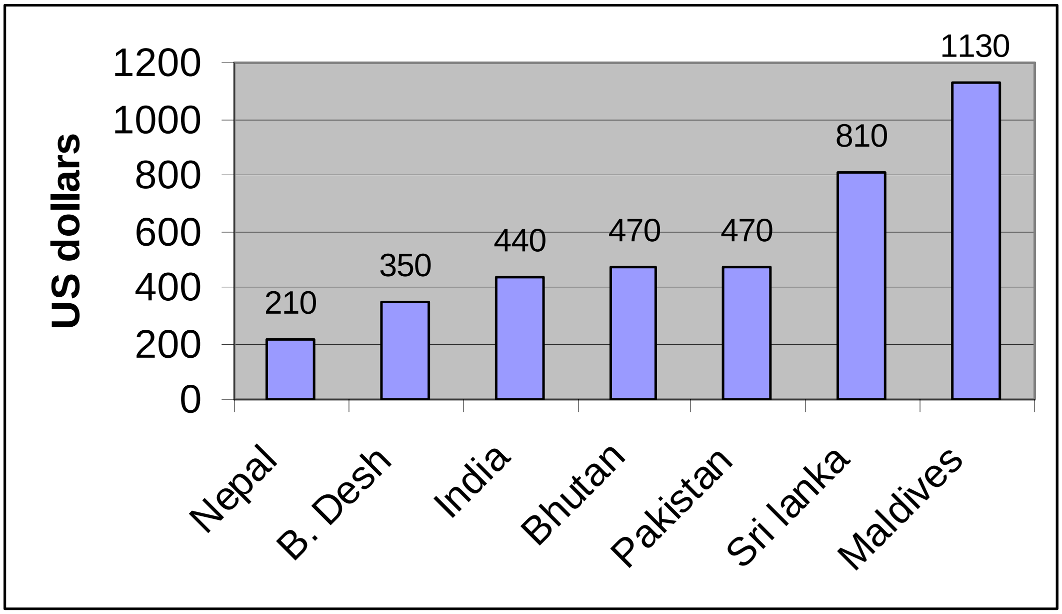


Figure1. Per capita income of SAARC nations in US dollars.

The principal foods are cereals (rice maize and wheat) with grain legumes grown as secondary crops during the winter, mostly in paddy fields using residual moisture for plant establishment. As the staple crop in Nepal rice is grown in 1.45 million hectares across the country but 400,000 Ha remain fallow in winter (Subba Rao *et al*., 2001). The exploitation of this uncultivated land offers one route to resolving problems of food security in Nepal and chickpea provides a high yielding and high value crop option for poor farmers. Unlike other legumes, chickpea is also especially valuable because it is a highly versatile grain and is used for making biscuits, breads and sweets as well as a soup vegetable. Chickpea is a very important source of protein for poor rural families but equally so for the urban poor.

However, the yields of legumes such as chickpea have decreased in recent years primarily due to disease and insect pest problems (Pande, 1999) and the reluctance of farmers to invest time and money in a crop which increasingly fails. This has resulted in a decline in grain legume consumption to about 25% of the level recommended by FAO; < 10Kg capita^{-1} annum^{-1} (Pandey *et al*., 2000). Owing to severe crop failures, especially in the 1997/98 season, up to 90% of chickpea consumed in Nepal is now imported (Johansen, 2001). This frequent insecurity associated with the production of chickpea over the past twenty years has seen a decline in area sown to chickpea drop from more than 50,000 Ha in 1980 to approximately 16,000 in 1999. Reduction in the production of leguminous crops has also had a negative impact on the sustainability of the cereals-based systems because legumes enhance soil fertility through nitrogen fixation and as organic matter.

The key biotic problems effecting chickpea production have been Botrytis Grey Mould disease (BGM) caused by *Botrytis cinerea* and pod borer (*Helicoverpa armigera*) damage (Pathic, 2001).

BGM infects flowers causing flower drop and reduced yield

BGM infects flowers causing flower drop therefore preventing pod development and dramatically reduces the yield potential (Pande *et al*., 2002). BGM has been a major factor in the recent decline in chickpea production in Nepal (Pande *et al*., 2000). The incidence of this disease has increased severely over the past ten years. In the 1997-98 season, high rainfall and humidity throughout the winter resulted in such high BGM incidence that little seed could be saved by farmers or government agencies at all and hardly any locally derived chickpea seed was sown in 1998-1999.

The pod borer, *Helicoverpa armigera* burrows into pod and eats the seeds and can decimate chickpea crops.

The pod borer emerges as a major pest threat where BGM has not occurred or once BGM has been controlled because there are pods to eat. The pest burrows into the pod and consumes the pea, but with the potential for population explosions the consequence is often devastating for the crop.

Heavy use of pesticides across the region to control this polyphagous insect, especially in cotton growing regions near the mid western and western regions, has exacerbated its pest status by reducing natural enemies and increasing insecticide resistance (Johansen, 2001; Armes *et. al*., 1992). Furthermore, locally available pesticides can be tampered with and results in farmers using poor quality materials to control the pest; again increasing the occurrence of pesticide resistance. An alternative is *H. armigera* nucleopolyhedrovirus (NPV). Work by NRI, under CPP funding, has developed a biological control strategy using NPV to control the pod-borer that is successful even against chemically resistant insects (Jones *et al.,* 1998, Rabindra *et al*., 1998).

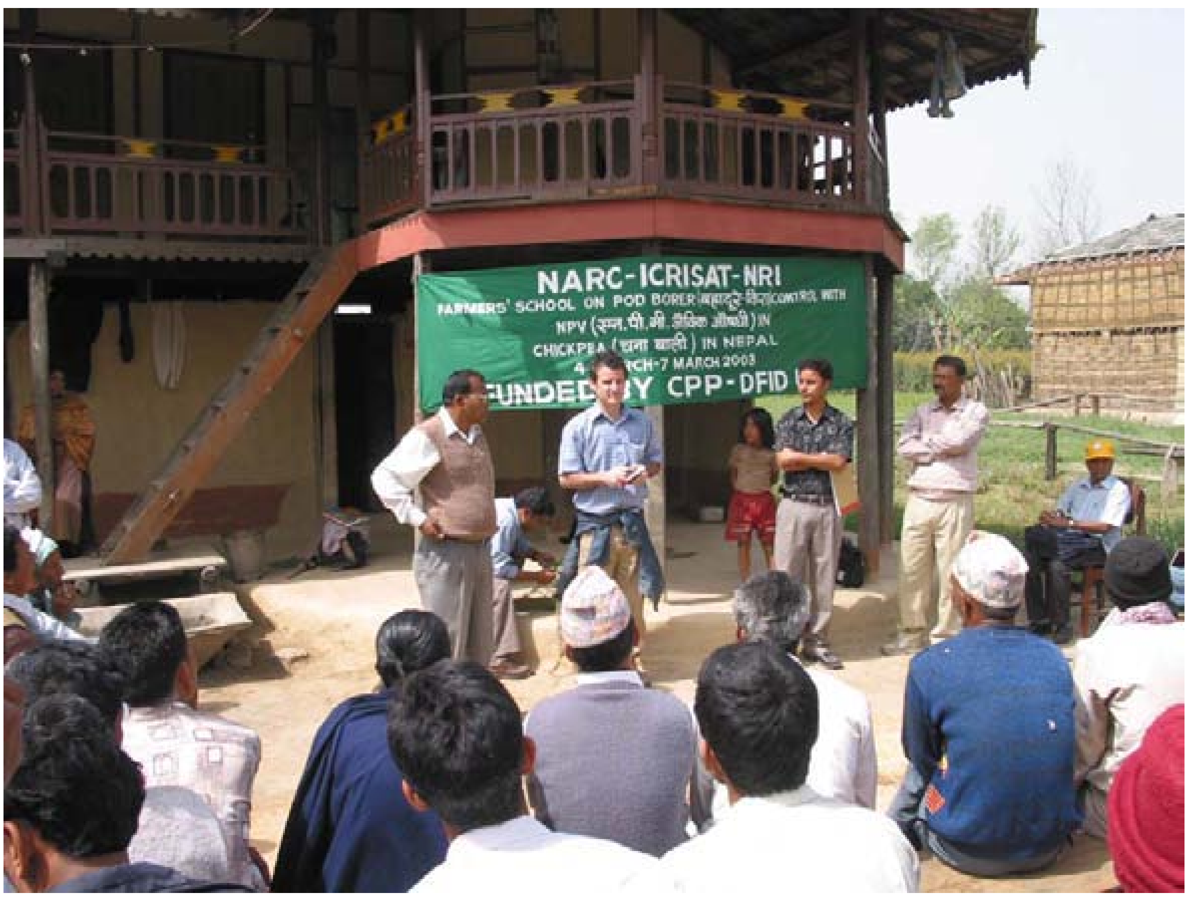
These CPP projects have included, R5540 (Use of virus to control *Helicoverpa)*, R7004 (Improvement of insect virus application) and R7299 (Promotion and uptake of microbial pesticides). Use of NPV can reduce losses to this pest and the adoption of this safe biologically based method in place of toxic, broad-spectrum chemical pesticides has significant environmental benefits. The work of the Indian government as part of its IPM initiative has promoted the local production of *Hear*NPV by both state sector and private companies (Puri, 1997). NRI has been active under R5540 to help to train local producers in improved production and quality control techniques for HearNPV pesticides (Kennedy *et al*.,1998). A recent survey under CPP project R7299 has confirmed that many of the small to medium enterprises trained under the previous projects in 1994-96 have continued and expanded production of HearNPV (Grzywacz and Warburton,1999). Thus both use and production of this agent can be established and sustained.

Field trials of HearNPV on chickpea carried out in Southern India under R5540 demonstrated that simple HearNPV suspensions could be used to control pod borer as successfully as chemical insecticide (Endosulfan) or commercial *Bacillus thuringiensis* products. It also showed that simply produced suspensions of the NPV were as effective as formulated products (Cherry *et al*., in press). However the results did suggest that NPV efficacy and persistence on chickpea was less than might be expected on some other crops such as tomato. Thus the appropriate application rate for HearNPV on chickpea needed to be higher (1.5×10^{12} ha $^{-1}$) than for some other crops such as tomato, although lower than on cotton (3×10^{12} ha $^{-1}$)). This effect was ascribed to plant chemicals on the chickpea surface or in the insect gut assimilated through eating the plant (Kimmins *et al*., 1995) where they may interfere with the activity of the NPV. Further trials in the glasshouse at NRI and the field in India have produced contradictory results concerning the possible antagonism between NPV and chickpea (Grzywacz 1998). This needs to be investigated further and the effective economic field application rate of HearNPV for pod borer control on chickpea is determined.

Considerable genetic diversity exists within chickpea (*Cicer arietinum)* with respect to fungal resistance (Haware, *et al*., 1992; Stevenson *et al*., 1997). Field trials have shown that farmers can achieve sufficient and stable yields through sound cultivar selection, particularly if combined with improved on-farm production and pest control technologies (Pande, 1999). However, surveys by NARS and ICRISAT scientists revealed that farmers use local varieties that are susceptible to diseases and apply inappropriate applications of pesticide. NRI, under CPP funding, have made considerable advances in understanding the chemical mechanisms of resistance in chickpeas to both BGM (Stevenson and Haware, 1997 and 1999) and Fusarium wilt (Stevenson, *et al*., 1997; Stevenson and Veitch, 1998). Additional collaborative studies between ICRISAT, and the Indian and Nepali NARS have also shown that resistance to BGM is also affected by the plant architecture (Haware and MacDonald, 1993) and several promising varieties have been identified with BGM tolerance and Fusarium wilt resistance. Despite this, when conditions are optimal, BGM will still destroy the harvestable product of chickpea so the only reliable control mechanism is prophylactic fungicidal spraying (Pande *et al*., 2002). Farmers, however, can depend upon Fusarium resistant cultivars for viable control of wilt.

Other agronomic problems in chickpea production include boron deficiency identified as a cause of flower drop which results in significant yield losses (Srivastava *et al.*, 1997). Germination and nodulation are often low indicating poor availability of good quality seed and appropriate Rhizobia (Johansen *et al.,* 1994). There is a considerable body of evidence that early crop establishment is crucial to success and poor establishment can be overcome by seed priming, and that this can substantially increase yields of chickpea, as has been demonstrated by the DFID project R6395 (Harris *et al*., 1999).

Recent studies by ICRISAT have shown that all of these problems can be addressed by the adoption of existing and proven technologies (Pande *et al.*, 1998) and attempts prior to this project to promote new technologies in Nepal showed very promising results in field trials. The aim of this project was to integrate this proven knowledge with the base technologies developed by the collaborators and to promote them as a chickpea production package to poor farmers in hillsides and mid-hills cropping systems of Nepal.



Farmer field schools are used to discuss problems and disseminate knowledge

2.0 PROJECT PURPOSE and JUSTIFICATION

To promote uptake and adoption of integrated pest management strategies for chickpea growers in Nepal.

Programme output: Hillside production system: Technologies that reduce the impact of pests; stabilise crop yields on hillsides; and are appropriate for use by the poor promoted and adopted.
Purpose - PU1: Yields from cropping systems on sloping land optimised and sustainability enhanced by minimising production losses caused by pests.
Specific research objectives of the project are: To reduce poverty by increasing chickpea production through adoption of effective and appropriate IPM technologies by resource poor hillside farmers. This will have impact by reducing the losses caused by the diseases and pests directly responsible for the recent decline in the supply of locally grown chickpeas in Nepal.

In the 1980s locations in India and surrounding countries reported severe and sometimes total yield losses to BGM (Haware and MacDonald, 1991). This increase in pest status initiated the formation of the Working Group on Botrytis Grey Mould of Chickpea consisting of scientists from NARS of India, Bangladesh, Pakistan & Nepal and researchers from ICRISAT and their collaborators. The group meets frequently to co-ordinate research activities and document advances in the management and control of BGM. The demand for the project was identified through the workshops of this network, through regular field reports from on-farm surveys and updates to research station based studies. Specifically, the National Grain Legumes Research Program (NGLRP), Rampur, Nepal determined the importance of different aspects of disease management (Chaurasia, 1998) and the need to move station trials to farms. Although the principal aim of the working group is to focus attention on BGM the importance of the pod-borer in any integrated strategy to control biotic constraints of chickpea is without question and could not be ignored. It is the single most important insect pest of chickpea worldwide (Saxena & Singh 1987).

A visit to the Bangladesh Agricultural Research Institute in 1999 by Dr. Jill Lenne, Deputy Program Manager of CPP (Natural Resources International) further clarified the need for a major initiative to improve chickpea production in BGM susceptible areas. The CPP call for proposals on chickpea production in Nepal arose from this visit to Bangladesh. A meeting with the Directors and other agricultural scientists of the NARC, Khumultar, Nepal (November 1999) made clear the importance and need for this work and confirmed their support for the aims and objectives of this project.

Water is scarce in the winter but owing to deep roots chickpea is drought tolerant and well adapted to this agro ecological region

2.1 OUTPUT 1. Project launch workshop for stakeholders and NARC/NGO staff.

A pre-project workshop for NARC, NGOs, farmers and other stakeholders was held in Nepal before the first planting to engage participating NARC staff and NGOs in the design and implementation of project activities as well as motivating stakeholders in the project's objects and activities. Feedback from this meeting was used to amend and fine tune activities occurring later in the project to improve implementation and the delivery of outputs. The crucial socioeconomic factors specific to the stakeholders were identified to determine the most useful processes of evaluation and implementation of improved technologies.

The Director General of ICRISAT, Dr. W. Dar, and the Executive Director of NARC, Dr Dhruv Joshey, inaugurated the workshop. Attended by some 45 staff from NARC, 6 representatives of the NGOs who contributed to the promotion of adoption of the IPM technologies and 7 farmer representatives from the four target districts in Nepal; the meeting engaged the participating collaborators in the design and implementation of project activities and also motivated stakeholders in the project's objectives and activities. Twenty one presentations were made and described the current status of chickpea production and problems that needed to be tackled. Feedback from this meeting was used to amend and fine tune project activities to improve implementation and the delivery of outputs. The crucial socio-economic factors specific to the stakeholders were also identified to determine the most useful process of evaluation and implementation of improved technologies. The scope for evaluating NPV in station and field trials in Nepal was discussed, welcomed and approved. Other important components of the new IPM strategy including seed priming, Rhizobium inoculation and the judicious use of fungicide were also discussed along with the most suitable means of promotion. Dr. Dhruv Joshey identified the need to increase seed production warning that the project would not be able to expand without this input. NGOs were identified as the primary collaborators to develop this strategy in coordination with NARC.

The proceedings of the workshop were published as a book –

Pande S Johansen, C. Stevenson, P.C. and Grzywacz, D (Ed.s) *On farm IPM of chickpea in Nepal: Proceedings of the International Workshop on Planning implementation of On-Farm Chickpea IPM in Nepal*. 6-7 September 2000, Kathmandu, Nepal. Patancheru 502 324 Andrha Pradesh, India: International Crops research Institute for the Semi-Arid Tropics and Chatham ME4 4TB, UK.,Natural Resources Institute. 125 pp. ISBN 92-9066-438-X

2.2 OUTPUT 2.
Farmer survey to determine the constraints to chickpea production and the impact of increased chickpea production on livelihoods alleviation in Nepal.

A farmer family survey was carried out in the target areas to define current crop management strategies and to identify participants from the hillsides farming community to take part in the promotion activities. This involved up to 500 farmers in six locations, two in each of the areas around Nepalgunj, Rampur and Tarhara (Table 1 & Appendix 1 &2). The survey was carried out in April-May 2001 immediately after the chickpea harvest by an ICRISAT team lead by the project socio-economist Mr Vinai Bourai. The survey asked farmers about their priorities for biotic, abiotic and socio-economic constraints to the production of chickpea in Nepal. It sought to understand farmer's perceptions of chickpea production as this would be central to designing and implementing new IPM packages. It sought to quantify the costs of production, identify pest and disease control methodologies currently in use and their costs. In addition it identified and quantified unused fallow that could be brought into chickpea production if improved technologies were promoted. The data were published as-

Bourai V A, Pande S, Joshi P K and Neupane R K. 2003. Chickpea production constraints and promotion of integrated pest management in Nepal. On-farm IPM of Chickpea in Nepal -1. Information bulletin no. 64. Patancheru 502324,Andhra Pradesh, India: International Crops Research Institute for the Semi Arid Tropics. ISBN 92-9066-462-2. Order code IBE064..pp.

Table 1. Area sown to Chickpea by region and numbers of farmers selected for initial survey and promotion.

Regions of Nepal	Chickpea Area (Ha)	Chickpea Area (%)	No of farmers in each region
Mid- West Region	9180	47	235
Western Region	3720	19	95
Far-West Region	1490	8	40
Eastern Region	2020	11	55
Central Region	3100	15	75
Nepal	19510	100	500

Sources : Agricultural statistics, Nepal 1997-98, his majesty's Govt. National Planning Commission Secretariat, Central Bureau of Statistics, Kathamandu, Nepal, December 1998.

The salient findings of the survey were:

1. Over the past 10 years all farmers experience indicated that the chickpea area in Nepal Terai had decreased. According to a recent report (Johansen, 2001) about 9000 hectare of chickpea has been lost from 1993-94 to 1997-98.
2. The majority of farmers (64%) rotate chickpea because they are aware of the soil fertility benefits of chickpea indicating a broad awareness of the agronomic value of chickpea. Few farmers (20%) rotated the crop to escape insects and soil born diseases suggesting farmers' awareness of pest management was poor.
3. In the factor share analysis of chickpea, it is found that farmers are not sharing for IPM.(1%only)
4. Integrated pest management practices are used by only 10% of farmers and even then – only sparingly. The reasons farmers give for this are the economic reasons: paying out

significant amounts for pesticides that do not work properly. This indicated farmers only had access to low quality products or were using them inappropriately.

5. Crop losses in storage ranged from 10% to 63.15% and seed germination losses are 6% to 51.25% yet few farmers adopt any method for seed protection. Some described the use of oils as a seed coating or Neem as an insect deterrent.
6. Farmers do not use ‘improved’ varieties of seeds because they are not aware of them or can not get access to them. Seed availability is a principal issue with developing chickpea farming systems in Nepal.
7. Among institutional constraints, Non availability of quality Agro Chemicals and lack of guidance of IPM are ranked first.
8. In infrastructure, constraints poor seed storage and marketing facilities are ranked highest by farmers.
9. Three major biotic constraints were reported the most by farmers including, Pod Borer, considered the most serious pest followed by BGM and Wilt.
10. Deficiency of fat, protein and calories in dietary system of Nepalese is causing health problems among poor masses of Nepal Terai.
11. The demand for IPM is very strong. The market possibilities of IPM are also very clearly visible. There is excess demand and insignificant supply of IPM.
12. The participatory development methods training seems to be an important one for the scientists and staff of NARC, it will facilitate dissemination of new technologies to traditional farmers with various social constraints.

One of the key constraints in adoption of IPM was non-availability of seed of recommended varieties – especially wilt resistant varieties. The household-level seed storage losses were also high and a decision was made to incorporate a component of this in to the project. On average farmers stored about 8kg of seed for subsequent years sowing – enough seed for about 6-7 katha. Yet during storage farmers reported up to 50% losses as normal due to insect damage and germination.

Other constraints reported were non-availability of reliable chemicals, and lack of appropriate knowledge about IPM practices. Community participation (particularly of women folk) in seed storage was identified as a focus in the chickpea growing areas of Nepal. A strong training program on IPM for chickpea producers would speed-up the percolation of benefits of a promising technology.

All farmers experienced a decline in chickpea area in the previous five years confirming the overall decline in crop status and reiterating the need for a focused strategy to rehabilitate this important crop. Farmers described a poor year as yielding on average as little as 3.66 Kg Katha $^{-1}$ (120kg Ha^{-1}) and a good yield of approximately 900Kg Ha^{-1}. Chickpea should, with optimal conditions and pest control, achieve more than 4000 Kg Ha^{-1}. The majority of farmers expressed knowledge of the importance of chickpea in their farming system above their use as food with many farmers rotating chickpea with other crops to improve soil fertility and some using this approach to escape soil borne diseases.

The costs to farmers who were using IPM from previous projects compared with those who weren’t gave a profound indication of the benefits of IPM (Table 2). Diseases and insects were the major constraints identified by farmers as the reason they were moving away from chickpea to less risky crops like lentil (Lens esculenta), especially wilt and BGM (Botrytis Gray Mould). Yet only 7% of farmers (not involved with earlier extension work) were employing any form of pest management despite farmers expressing knowledge of the methods and an interest for its adoption as illustrated by low investment inputs for pest management technologies in

Table 3. Application of insecticide was negligible and its relative cost in farm expenditure was very low <11% (Table 3). The average net income of those that had adopted IPM (IPM Farmers) through previous extension work was substantially higher (Rs. 1025/katha) than the non-IPM farmers (Rs. 310/katha). IPM farmers were producing chickpea more efficiently than the non-IPM farmers with the unit cost of production more than twice as much on non-IPM farms (Table 2).

Table 2 Chickpea production data katha^{-1} in NRs with and without IPM.

	Non-IPM	IPM
Total seed cost	143.75	145.00
Total operational cost	356.33	404.00
Total cost	505.82	554.80
Gross income	815.30	1580.00
Net income	309.49	1025.20
Unit cost of production/Kg	17.53	7.01

Table 3 Cost of agricultural inputs for chickpea in Nepal (%)

Inputs	Eastern	Central	Western	Far-west	Midwest	Nepal
Seed	13.0	14.8	8.6	18.2	10.0	13.0
Fertilizer	0	6.9	4.4	15.1	8.1	6.9
Pesticide	0	0	0	0	2.3	0.7
Insecticide	0	1.2	1.00	11.3	1.9	3.1
Herbicide	0	0	0	0	0	0
Irrigation	0	0	0	0	3.7	0.7
Labour	35.1	44.3	44.9	29.7	33.3	37.4
Bullock	51.9	32.8	41.1	25.7	40.4	38.4
Machine	0	0	0	0	0	0

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

2.6.7 *Study of NPV - plant chemistry compatibility and potential value of simple formulation ingredients.*

Effect of chickpea plant surface on efficacy of NPV.

The purpose of this study was to investigate how the susceptibility of *Helicoverpa armigera* larvae to *Helicoverpa armigera* nucleopolyhedrovirus (*Hear*NPV) is affected by the foliar factors in chickpea. Previous CPP funded work had established that HearNPV was as effective as chemical pesticides in controlling *H. armigera* on chickpea (Cherry *et al*., 2000). However there was also some experimental work, which indicated that NPV had a much shorter persistence on chickpea than on some other crops in which it is used to control the pod borer *H. armigera* (Grzywacz, 1998) .

Leaf compounds that increase the rate of NPV inactivation thus limiting its effectiveness may be present. A similar specific factor has been identified in cotton that limits the effectiveness of other NPV pesticides (Ali *et al*., 1994, Hoover *et al*., 1998, Hoover *et al*., 2000). In cotton the presence of high levels of peroxidases (POD) and plant phenol oxidases (PPO) within the leaf tissue reduce the infectivity of NPV. If such mechanisms existed in chickpea and could be identified the NPV formulations could be modified to overcome these mechanisms. Thus the effectiveness of *Hear*NPV can be increased and control costs reduced even further.

The efficacy of the *Hear* NPV on chickpea was studied by comparing it with two other crops, cotton (*Gossypium hirsutum*), and tomato (*Lycopersicon esculentum*). Cotton was known to have an NPV inhibiting factor while on tomato NPV persistence was known to be very good indicating no such factor was present. The effect of plant on the efficacy of the *Hear*NPV was investigated by spraying *Hear*NPV on to the leaf surfaces of the cotton, tomato and chickpea plants for 1 and 24 hours and then washing off and testing the virus in artificial diets against pod borer neonates.

The LC_{50} of *Hear*NPV that had been exposed to chickpea leaf surface was higher by a factor of x100, 000 indicating that considerable inactivation could occur to *Hear*NPV exposed to chickpea (Figure 2). This effect was observable after as little as one hour's exposure to chickpea leaf surface. *Hear*NPV that had been sprayed onto the leaf surface of cotton and tomato was not affected compared to untreated *Hear*NPV (D'Cunha *et al*., 2003).

This indicated the presence of a rapid inactivation of *Hear*NPV associated with the surface of chickpea foliage that could reduce the efficacy of NPV as a control agent on chickpea.

In another experiment leaves of the three different crops were dipped into suspensions containing different concentrations of *Hear*NPV and then fed to *H. armigera* larvae. This confirmed that chickpea foliage had a detrimental impact on the efficacy of *Hear*NPV (Figure 3) though the magnitude of the effect was less on leaves than in the previous study with artificial diet. As expected, cotton also reduced *Hear*NPV efficacy while tomato had no effect compared to the control.

Figure 2: Mean LC_{50} values (± SEM) for *H. armigera* neonates on untreated *Hear*NPV and *Hear*NPV exposed to cotton, tomato and chickpea for 1h and 24h (n = 5)

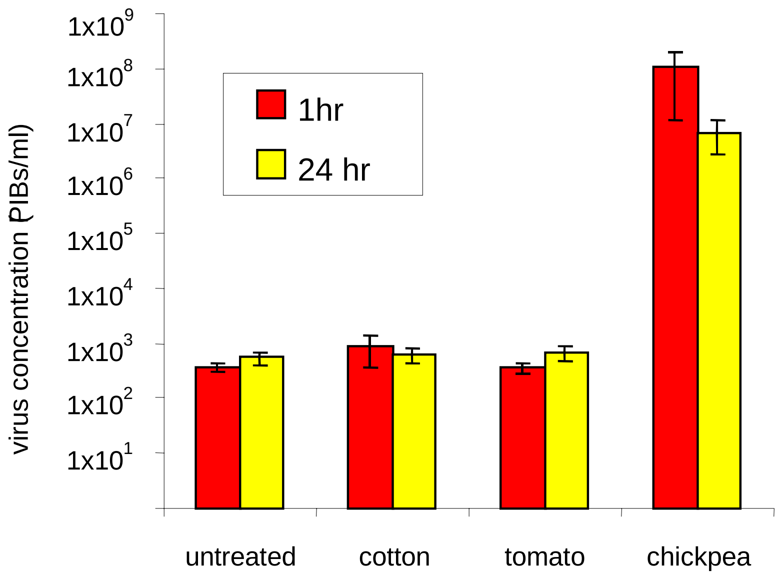
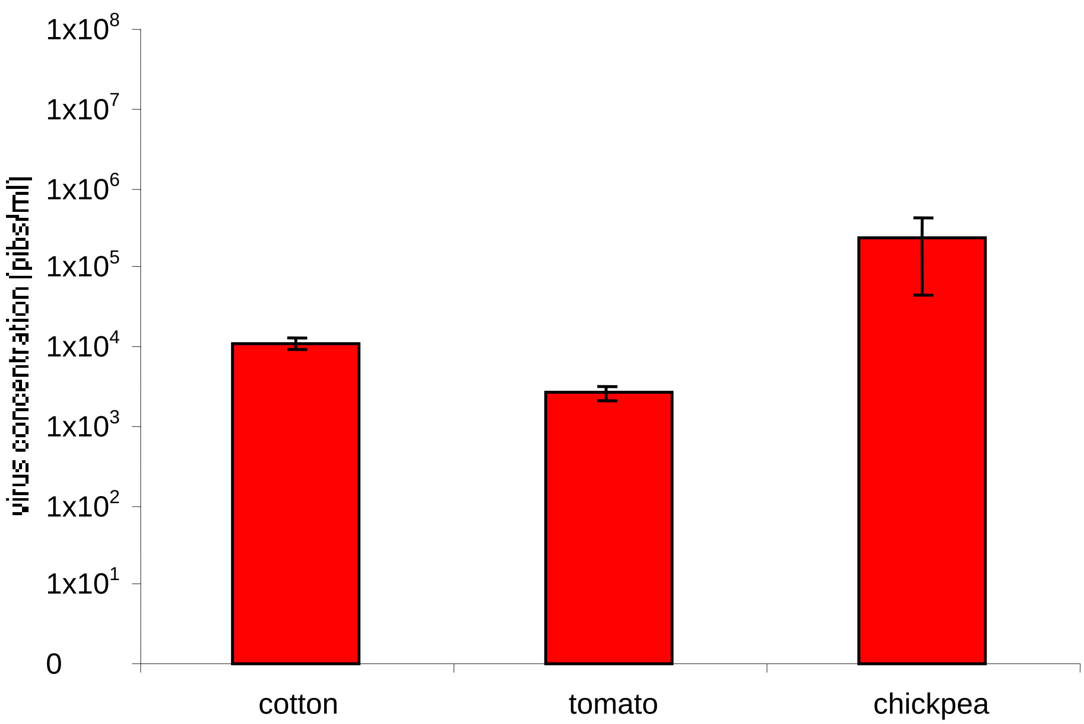


Figure 3: Mean LC_{50} (± SEM) of *Hear*NPV against *H. armigera* neonates fed on leaves of cotton, tomato and chickpea in a leaf dip bioassay method (n=5)



From these results it appears that chickpea has a surface factor that can rapidly inactivate *Hear*NPV. This would appear to differ from the NPV inactivating mechanism previously identified in cotton. In cotton inactivation only occurs when *Hear*NPV particles or occlusion bodies (OB) are ingested by the insect in the presence of leaf material (Hoover *et al*., 1998, Hoover *et al*., 2000). In chickpea placing OB of *Hear*NPV on the chickpea leaf surface produced inactivation even if the particles were afterwards removed from the leaf surface. This is the first scientific finding to confirm the existence of a chickpea leaf surface *Hear*NPV inactivating factor.

Leaf surfaces treated with the virus have been extracted and analysed with HPLC and shown that the spraying of the virus induces the production of genistein, an isoflavonoid previously identified on the leaves of chickpea (Stevenson and Veitch, 1998). Tests are currently underway to determine if this or related compounds are directly responsible for the loss of efficacy.

The identification of the *Hear*NPV inactivating factor will help in the development of improved formulations that could counteract this inactivation and so enhance the field persistence of the *Hear*NPV. This could make *Hear*NPV pest control more cost-effective on chickpea as reduced application rates of NPV could be used so reducing control costs. The development of more cost-effective non-chemical controls for *H.armigera* is important in the management of this worldwide pest.

2.3.2 Effects of Formulation ingredients on efficacy of HearNPV.

A laboratory study to investigate the compatibility of *Hear*NPV and chickpea varieties being promoted through the project was carried out at NRI. Bioassays using various *Hear*NPV formulations were conducted to determine if the addition of simple locally available adjuvants improve the efficacy of *Hear*NPV. The most promising could then be selected for field testing in Nepal.

Bioassays carried out as described above (section 2.3.1) have shown that the effect of *Hear*NPV varies significantly with plant type a result confirming previous field findings (Rabindra *et al*., 1994). Chickpea is one of the crops on which *Hear*NPV persistence is shortest (Grzywacz, 1998).

There was some evidence from Australia where *Heliothis zea* NPV is used to control *H.armigera* to suggest that the addition of simple additives could significantly and cost effectively improve the performance of NPV on chickpea (pers. comm. Carrie Hauxwell, DPI, Queensland) even though the mechanism by which this worked was unknown.

The most recent standard work on the formulation of biopesticides has identified a wide range of additives reported to increase the efficacy of biopesticides when applied to crops (Burges and Jones, 1998). These additives are gustatory stimulants, stickers and protectants that increase the infectivity or persistence of the biopesticides. It was known from published data and other CPP projects that the use of simple low cost additives such as molasses can reduce the application rate of a baculovirus such as *Hear*NPV by up to 90% (Ballard *et al*., 2000, Grzywacz *et al*., 2002) significantly reducing application costs. In these cases the additives are presumed to act by encouraging pest larvae to feed preferentially on *Hear*NPV formulation laden droplets thus increasing their effectiveness. However, given the identification of a leaf surface inactivation factor of chickpea, it could be that additives could act by blocking the effect of this factor.

This section of the report shows the results of a series of bioassays carried out to test the effect of four simple formulation ingredients on the LC_{50} value, in *H. armigera* first instars, of *Hear*NPV applied to chickpea.

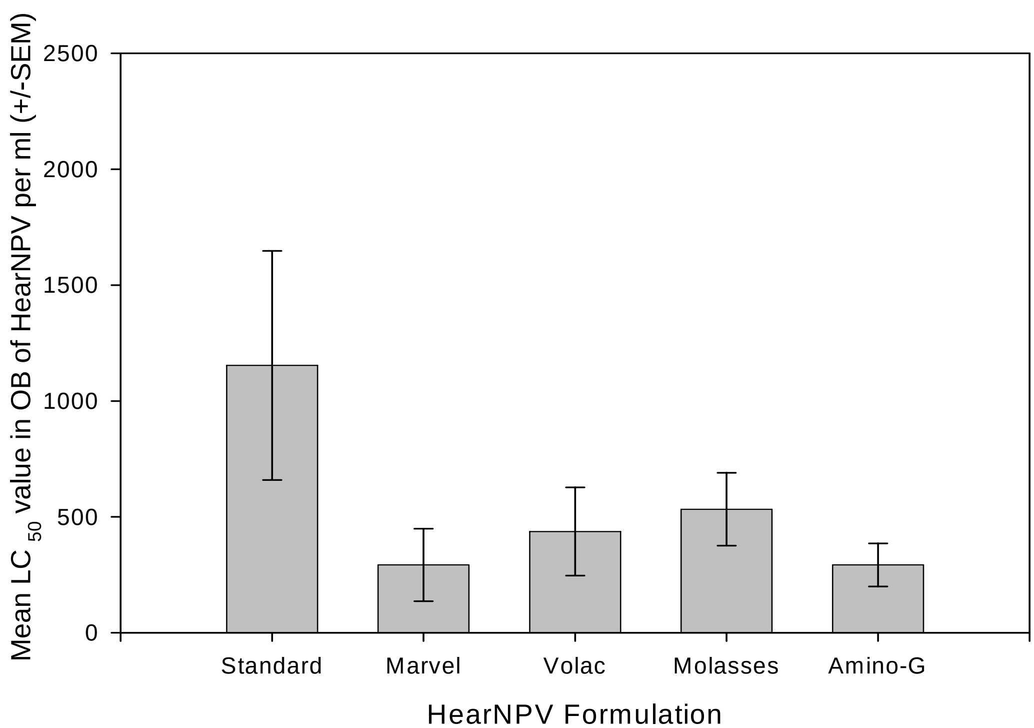
The bioassay procedure performed was a dose range; leaf-dip bioassay following protocols set out in Parnell (1999). Table 4 lists the treatments and formulation additives tested.

The additives tested were ones that had been demonstrated in other CPP projects to enhance baculovirus efficacy (molasses) or for which there were unpublished findings (Hauxwell pers. Comms.) suggesting that they had a synergistic effect with NPV on chickpea (milk powder, volac and Aminogreen). The last three were milk or commercial milk powder substitutes.

Table 4 Treatments included in bioassays

Treatment	Formulation components
Standard	HearNPV in 0.02% v/v Triton X100
Skimmed milk powder	Standard + 1% w/v Marvel skimmed milk powder
Volac replacement calf milk powder	Standard + 1% w/v Volac calf milk powder
Molasses	Standard + 1% w/v molasses
Amino-Green calf feed supplement	Standard + 1% w/v Amino-Green calf feed supplement

Figure 4 Mean LC_{50} value for different formulations of HearNPV on first instar *H. armigera* larvae in leaf dip bioassays on chickpea (n = 3).

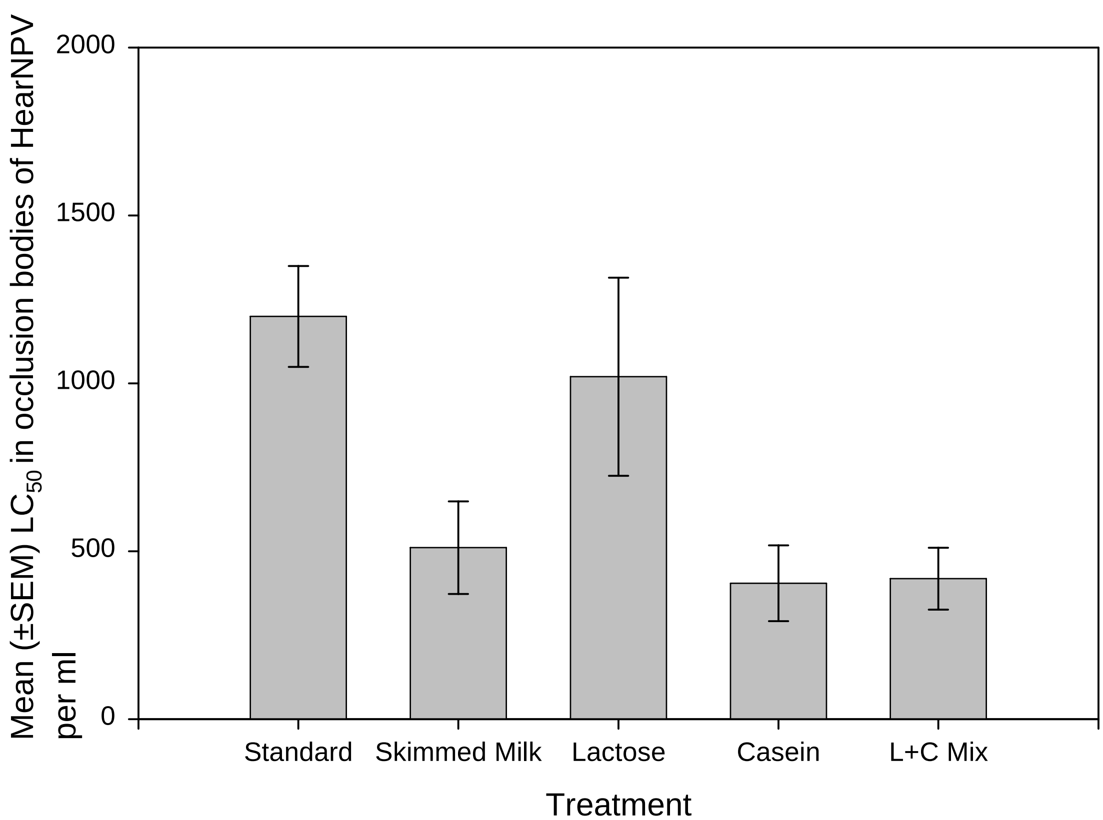


All four of the different formulations produced LC_{50} values in first instar larvae that were significantly different at the 5% level from the standard *Hear*NPV treatment (2 way ANOVAR P= 0.003, DF= 4 & 24, F= 9.86). The mean LC_{50} values ranged from $2.92x10^2$ PIB/ml for the best performing formulations (skimmed milk and Amino Green) to $1.15x10^3$ PIB/ml for the standard treatment (Figure 4).

The reductions in LC_{50} value observed indicated a mean increase in efficacy of the formulated virus over the standard of between 1.88 for molasses to 4.1 times for skimmed milk powder. However there were no significant differences in potency between the different formulations probably related to the variability of the bioassay and the limited number of replicates (n = 3) (Figure 4). While molasses had an effect on LC_{50} the milk powder additives seemed to give a greater increase in potency. There was no greater increase in potency from using artificial powdered milks such as Amino-green over using simple skimmed milk powder that is commonly available in Nepal.

In considering the mechanism by which milk powder enhances the potency of *Hear*NPV on chickpea it was decided to take this study further by testing the different constituents of milk powder to determine if the effect was associated with any particular constituent.

Fig 5 Effect of different milk constituents on potency of HearNPV on chickpea in leaf dip bioassays (n =3)



A 2 way ANOVAR of the LC50 data (randomised block bioassay design) showed treatment to be highly significant (P=0.0041, df = 4 & 24. F= 6.88). A multiple comparison procedures (Student-Newman-Keuls Method) showed that skimmed milk powder, casein and lactose/casein mix all were significantly lower LC_{50} (P <0.05) than standard.

From this work it would seem that the effect of milk powder in increasing the potency of *Hear*NPV on chickpea is primarily associated with the casein (protein) fraction. At this stage the findings are insufficient to determine how this effect is mediated and whether other casein analogues might be as effective. How it relates to the earlier finding that application of *Hear*NPV to chickpea foliage induces the production of specific isoflavonoids is also as yet unclear. It may be that the casein acts as an alternate binding site for this factor thus competing to reduce its impact on NPV.

It is known that many crops produce a range of biocidal or biostatic compounds as part of their defenses against predators or disease and these can include antiviral compounds active against NPV (Ali *et al*., 1999). The surface exudates of chickpea contain a wide range of organic compounds (Reed *et al*., 1987). It is most probable that the chemical factor responsible for the reduced efficacy of *Hear*NPV on chickpea is produced in the leaf exudate as part of a general host defense mechanism and its action against *Hear*NPV is a side effect. However, finding a formulation that can block this effect on the *Hear*NPV would potentially increase the efficacy of *Hear*NPV by a factor of x3-4 at least. This in turn would enable application rates of active ingredient to be reduced with a major improvement in the cost effectiveness of *Hear*NPV on chickpea. Work on the chickpea *Hear*NPV inactivating factor is being pursued as part of an ongoing University of Greenwich funded Ph.D. study.

2.3.3 The value of formulation ingredients on the efficacy of HearNPV in chickpea - On station IPM demonstration plots.

Trials validating the use of the new varieties of chickpea and evaluating them in comparison to traditional varieties were conducted on station and on farm in the target areas. On station field trials of selected *HearNPV* formulations at provisional field use rates were also carried out to validate the pod-borer control recommendations and used for demonstration to farmers. The *Hear*NPV stock from two commercial sources (Pest Control India & Vermigreen Biofertilizers) and ICRISAT's own production were microscopically examined and counted for *Hear*NPV content. The PCI stock was excellent and 0.95 $x10^9$ viral occlusion bodies (OB) ml^{-1} was within acceptable limits of its nominal 1 $x10^9$ OB ml^{-1}. All other products had unacceptably low NPV counts. The Vermigreen product at 1.5 $x10^7$ OB ml^{-1} was 1.5% of nominal content while the ICRISAT product instead of a stated 6 $x10^9$ OB ml^{-1} was found to be 3.2 $x10^8$ OB ml^{-1} (5% of nominal). Only the PCI product was selected for use on the field trials.

The sites selected for the trials were the NARC Oilseeds Research Programme Research Station (ORP) at Nawalpur outside Lalbandi in Sarlahi District A 1) and the NARC grain legumes research station at Rampur in Chitwan District in Central Terai. There was a four-treatment randomised plot replicated trial carried out on two different chickpea varieties the new high yielding Avarodhi and traditional local variety Tara. Plant condition and stand were excellent. The treatments were

1. NPV at standard dose 1.5 $x10^{12}$ OB ml^{-1}.
2. NPV (1.5 x $x10^{12}$ OB ml^{-1}) with 1% milk powder additive
3. Thiodan (endosulfan 35% EC) used at 3 ml L^{-1} of water
4. No treatment control.

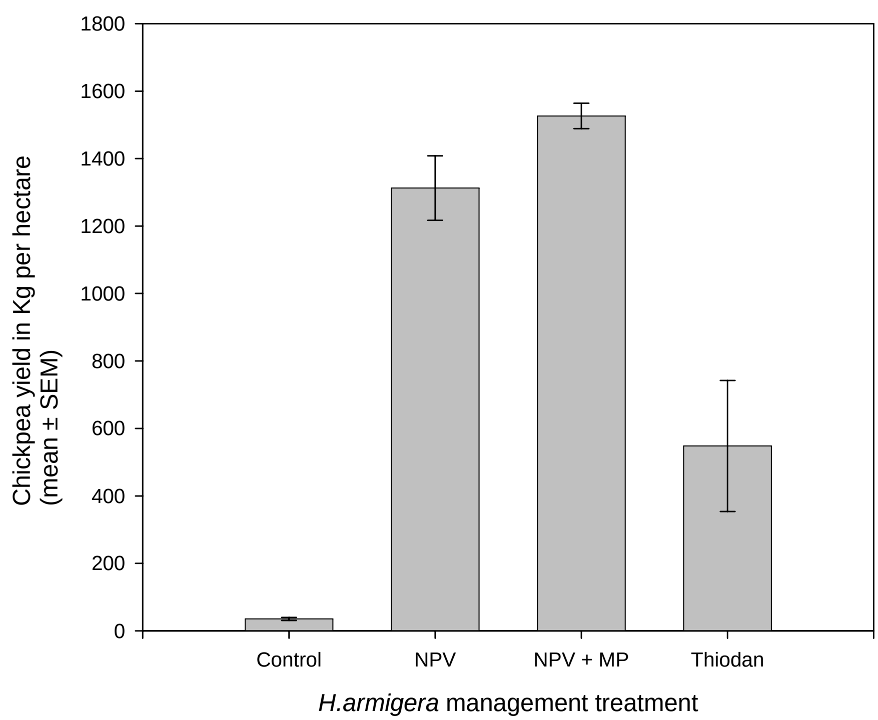
The plots were 16m^2 with three replicates each. The plants were in the flowering stage and *H. armigera* counts showed insect numbers to be low at <0.2 per plant. It was intended that these studies would form the basis of recommendations to farmers for the most appropriate IPM package combining all the best pest management practices.

Data from trials was analysed using "Sigmastat" statistical package using analysis of variance procedure with Student-Newman-Keuls multiple comparison method where data were appropriate (normally distributed and with equal variance for all treatment groups). Where data was either non-normal or failed equal variance tests an appropriate ranking significance test (Kruskal Wallis one way analysis on ranks) was used.

It had been intended to carryout field trials in both 2002 and 2003 as part of this project. However an upsurge of fighting as part of the ongoing major guerrilla insurgency in Nepal in early 2002, including a guerrilla attack that wiped out a police post only 5 km from the field station at Nawalpur the week the field trials were due to start in February made it impossible for project staff to conduct effective station trials in 2002. In 2003 the chickpea season coincided with a cease-fire in the civil war and IPM trials were successfully conducted at Rampur, and Nawalpur. The on station trials looked at the effect of different IPM packages including NPV on the improved varieties Avarhodi and Tara variety.

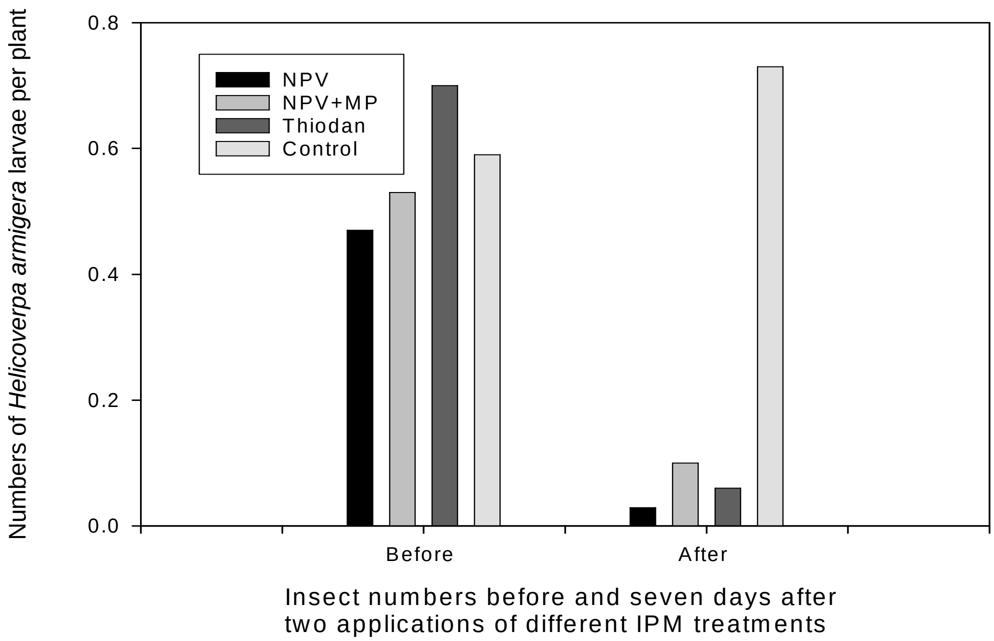
The on station trial (Fig.6) showed that significantly higher yields ($P = 0.0002$, $F = 31.1$, df = 3 &10) were achieved with the use of all 3 IPM treatments to control *H.armigera*. There was no significant difference between the *Hear*NPV used alone or with the milk powder though the latter gave a higher mean yield of 1536 as compared to 1312 Kg ha. Both *Hear*NPV treatments gave a significantly higher yield than the Thiodan at the 0.05% significance level.

Figure 6 Yield results from on-station trials of Hear NPV with Avarodhi variety of chickpea Ramphur 2003



The data on *H.armigera* numbers before and after application showed that all three control treatments produced a major reduction in larval numbers after treatment.

Figure 7 Mean number of *H.armigera* larvae per plant before & after IPM treatments were applied in IPM on station trials on avarohdi variety of chickpea at Ramphur 2003



However the differences in yield between the two *Hear*NPV treatments and the Thiodan seem much greater than would be explained by the immediate reduction in pest numbers alone. It is possible that the capacity of *Hear*NPV to replicate in the insects it kills means that in spite of the NPV inactivating factor *Hear*NPV has a much longer lasting effect than chemical pesticides.

The IPM trials with Tara show a rather different picture. Here yields are much lower than with Avarodhi but the highest yield is found in the Thiodan treatment.

Both NPV treatments give lower means yields than the Thiodan though the NPV + MP is not significantly different from Thiodan. Here there are no significant differences between NPV, NPV + MP and Thiodan. This absence of significant differences between treatments reflects the much higher variability in yields seen in the Thiodan and NPV + MP treatments in this trial on the Tara variety of chickpea.

Figure 8 Yield results from on station trials of different IPM packages with Tara variety of chickpea Ramphur 2003

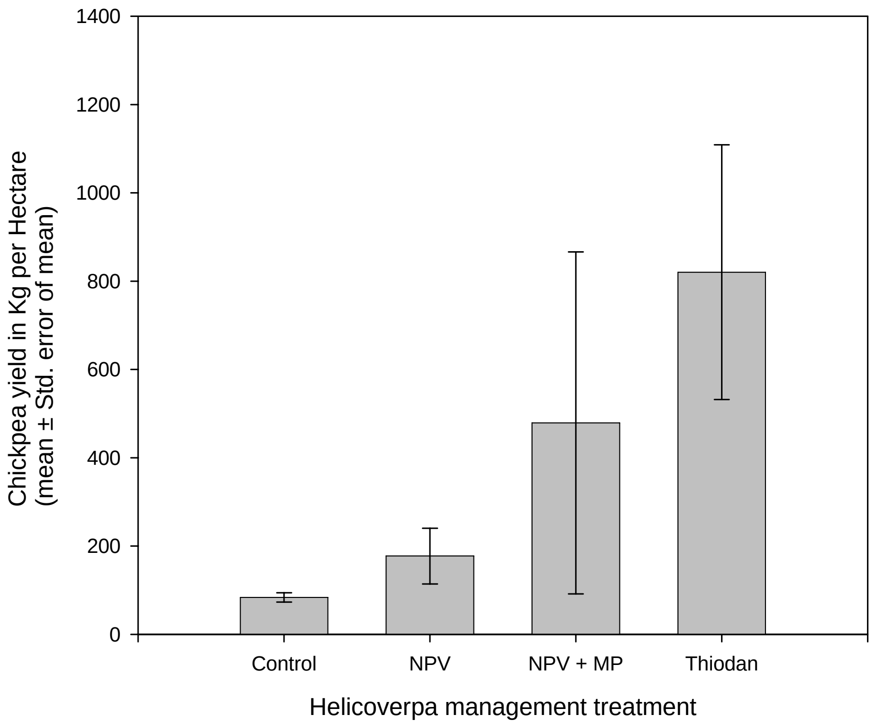
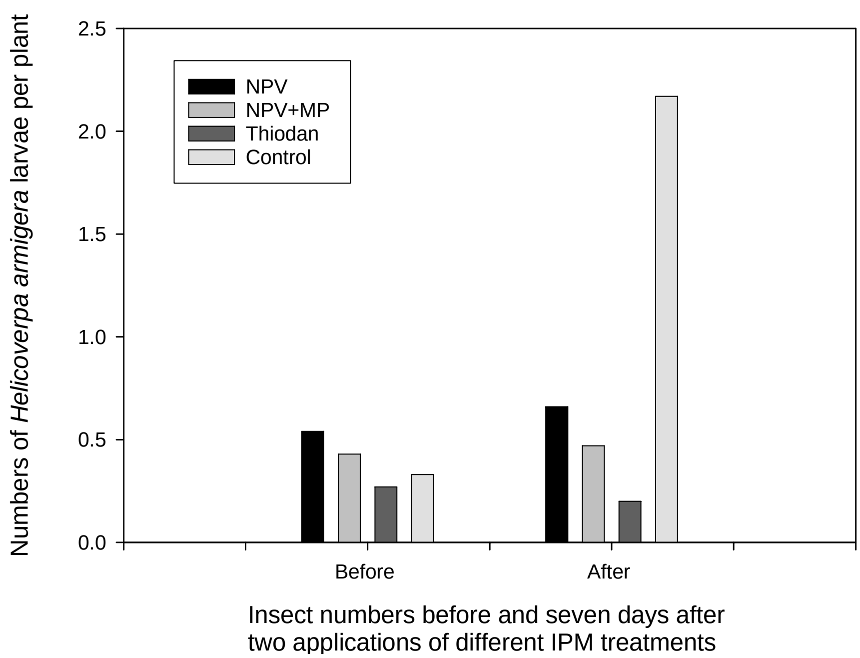


Figure 9 Mean number of *H. armigera* larvae per plant before and after IPM treatments were applied in on station trials on chickpea variety Tara in IPM trials Rampur 2003



The insect data taken immediately before and seven days after application shows that the NPV and Thiodan treatments successfully prevented a serious outbreak of *H.armigera* that occurred on the control plots. Here pest numbers were lowest in the Thiodan plot after treatment and numbers of pests in the two NPV treatments at around 0.5 larvae per plant are about five-ten times higher than in the Avarodhi trials reported above. This may indicate that NPV is much less effective on Tara than on Avarodhi that in turn may be related to differences in surface chemistry.

The IPM trials at Lalbandi show in figures 10 and 11 produced a similar result to those at Rampur in assessing the different IPM packages. Once again on the new Avarodhi variety NPV +MP gave the highest yield of 2070 Kg ha with the yields from NPV and the Thiodan treatments being about equal. Here the control also gave a better yield than the very low one recorded at Rampur. This is associated with a much lower occurrence of podborer larvae (generally less than 0.2 per plant in all treatments) and percentage pod damage was also much lower never exceeding 3% in any treatment. In the trials on Tara variety again all yields were much higher than at Rampur with very little difference seen between any of the IPM treatments. Even in the control here pod damage was recorded as 0.9% and pest incidence less than 0.1 per plant indicating no significant pest attack. Given the very low incidence of podborer in these trials the yield results must be considered of very limited utility in demonstrating the effectiveness of podborer control options. The yield data from these trials was available only as a mean yield for the three plots used for each treatment so no SEM is shown.

Figure 10 Mean yield results from on station trials of IPM packages with Avarodhi variety of chickpea in on station trials at Lalbandi 2003

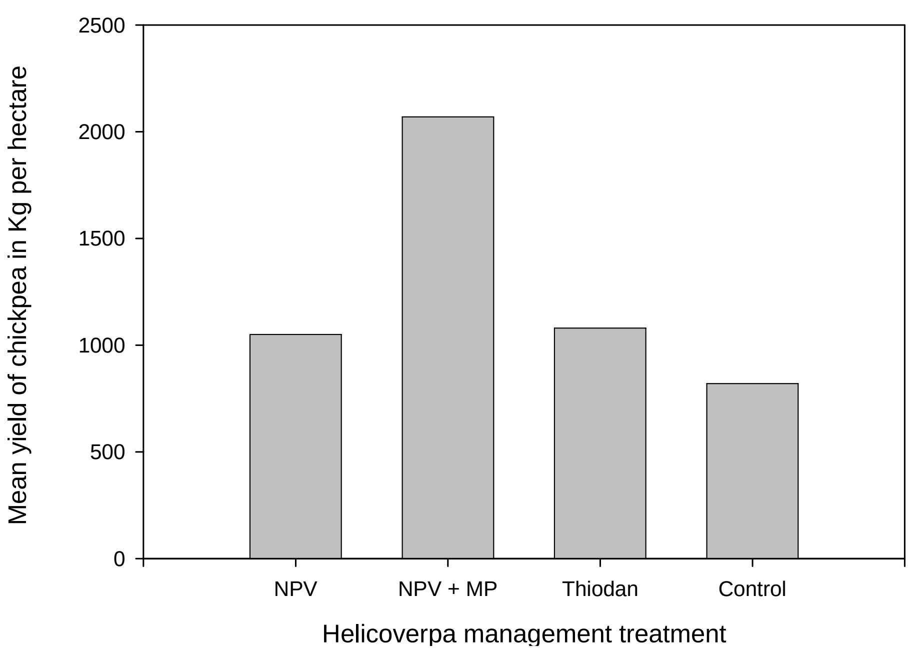
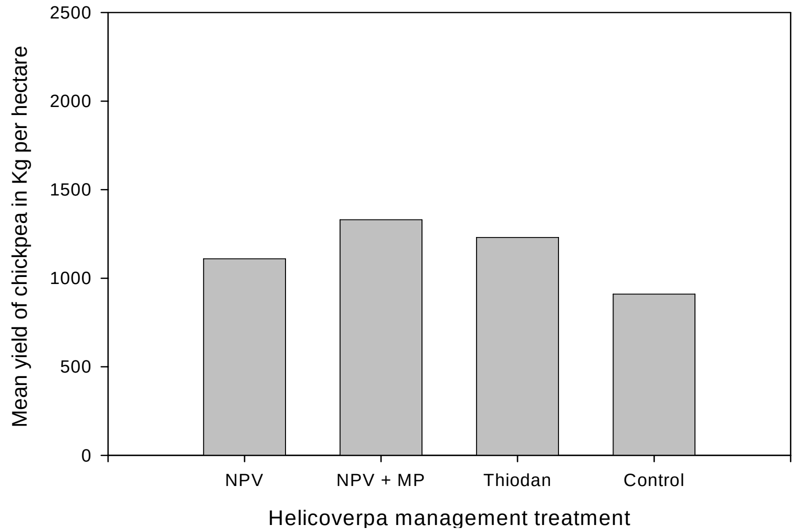


Figure 11 Yield results from on station trials of IPM packages with Tara variety of chickpea at Lalbandi 2003



On farm trials of NPV formulations

Farmer trials were carried out at Bardiya supervised by the staff from the Lalbundi station to compare the different IPM options of NPV, NPV + MP and Thiodan on both the new Avarodhi and Tara chickpea varieties. The results (Fig 12 & Fig 13) produced the finding that yields were significantly higher in the NPV plots than in the Thiodan, NPV plus MP or control (Kruskal Wallis one way ANOVAR $P = 0.0034$ $H = 13.7$ $df = 3$) for Avarodhi and for Tara (Kruskal Wallis one way ANOVAR $p = 0.0048$ $H = 12.9$, $df = 3$) varieties of chickpea.

Figure 12 Yield results from on farm trials of IPM packages with Avarodhi variety of chickpea Bardiya 2003

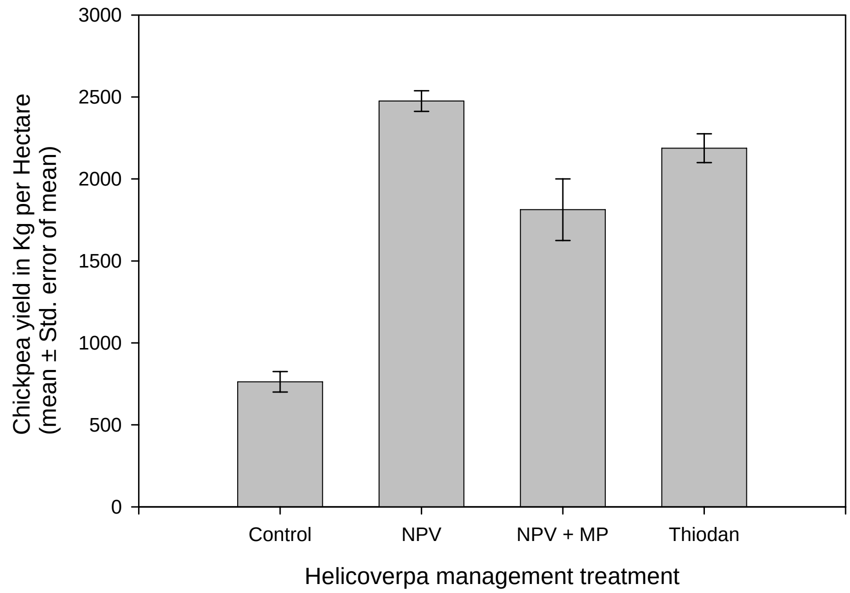
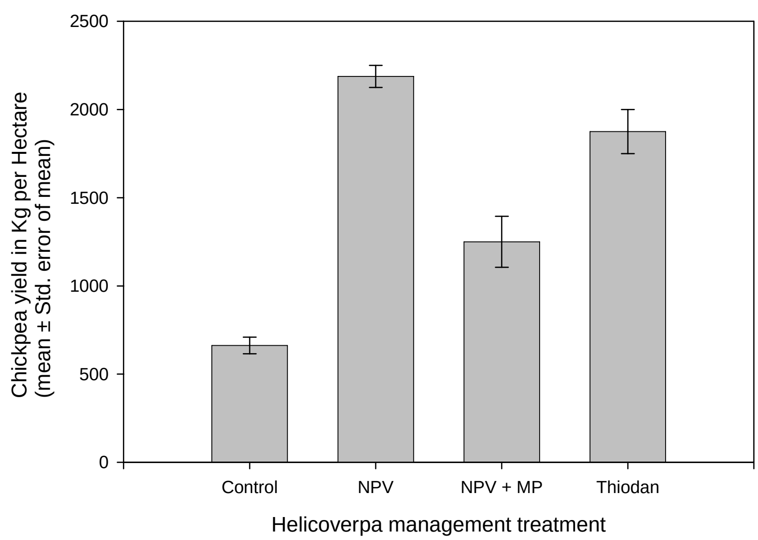


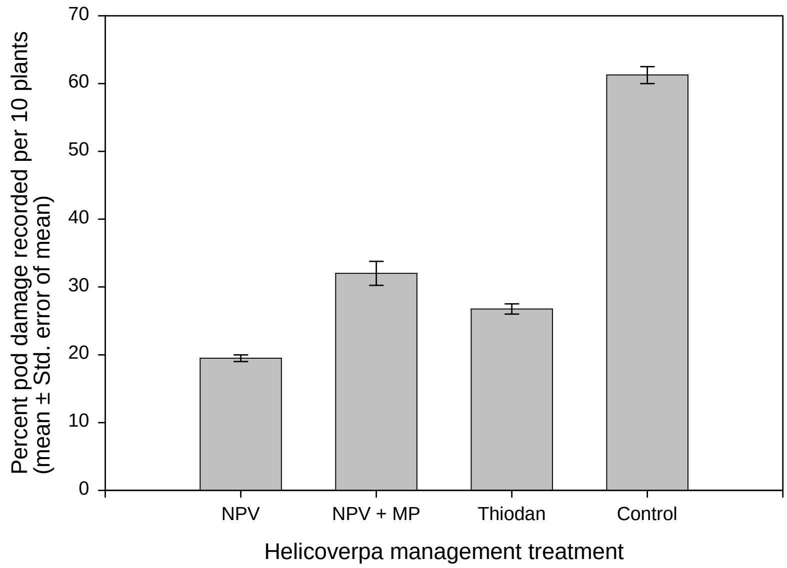
Figure 13 Yield results from on farm trials of IPM packages with Tara variety of chickpea Bardiya 2003



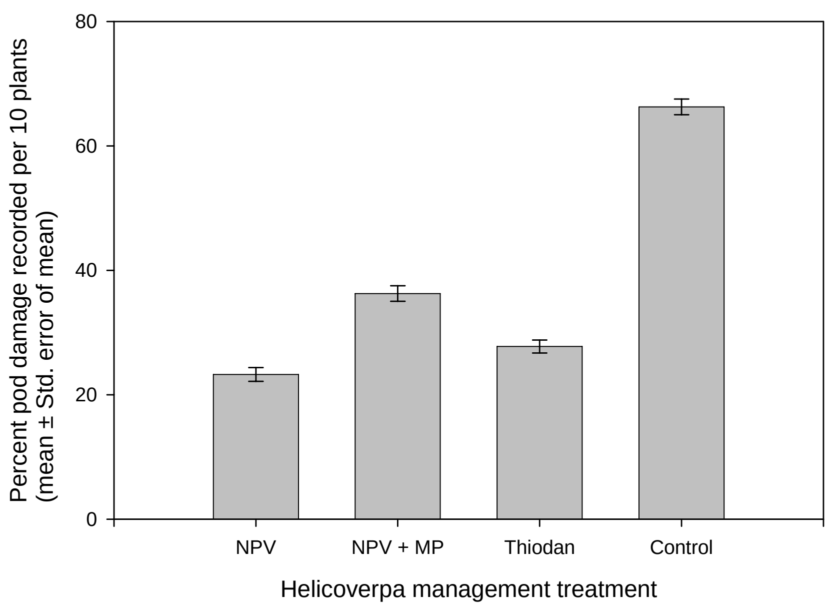
If we look at the corresponding data on pod damage there is the pattern of responses strongly suggesting the yield differences are related to the effectiveness of controlling podborer damage (Fig 14)

Fig 14 Pod damage in on farm IPM trials on Chickpea Bardiya 2003

Effect of different Helicoverpa management treatment on pod damage of Chickpea (variety Avarodhi) in on farm IPM trials Baridya 2003



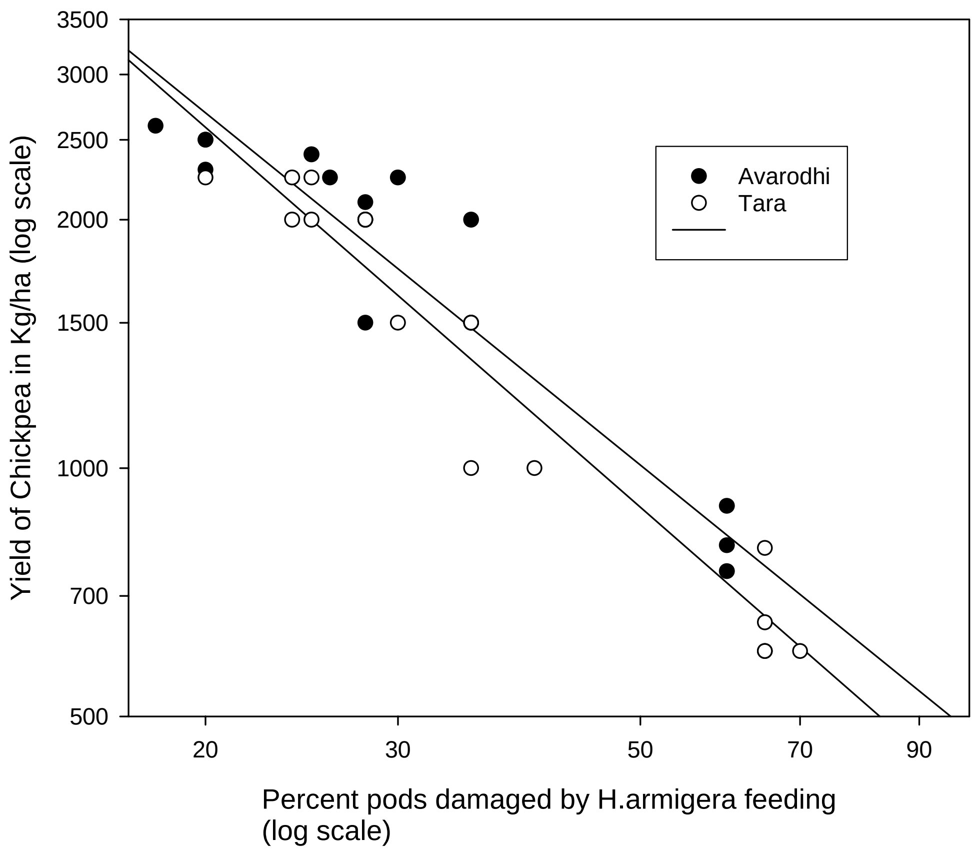
Effect of different *Helicoverpa* management treatment on pod damage of Chickpea (variety tara) in on farm IPM trials Baridya 2003



These differences in pod damage are statistically significant both for the trials on Avarodhi (P = 0.0028 H = 14.1, df = 3) and Tara (P = <0.0001 F = 276.5, df = 3 & 12).

Fig 15 shows that log yield is linearly related with log *H.armigera* pod damage (Slopes = -1.1571 & -1.07, r2 = 0.929 & 0.8963 for Tara and Avarodhi regressions respectively).

Fig 15 Regression plot of log yield against log *H.armigera* pod damage in on farm IPM trials for Avarodhi and Tara varieties of chickpea Bardiya 2003



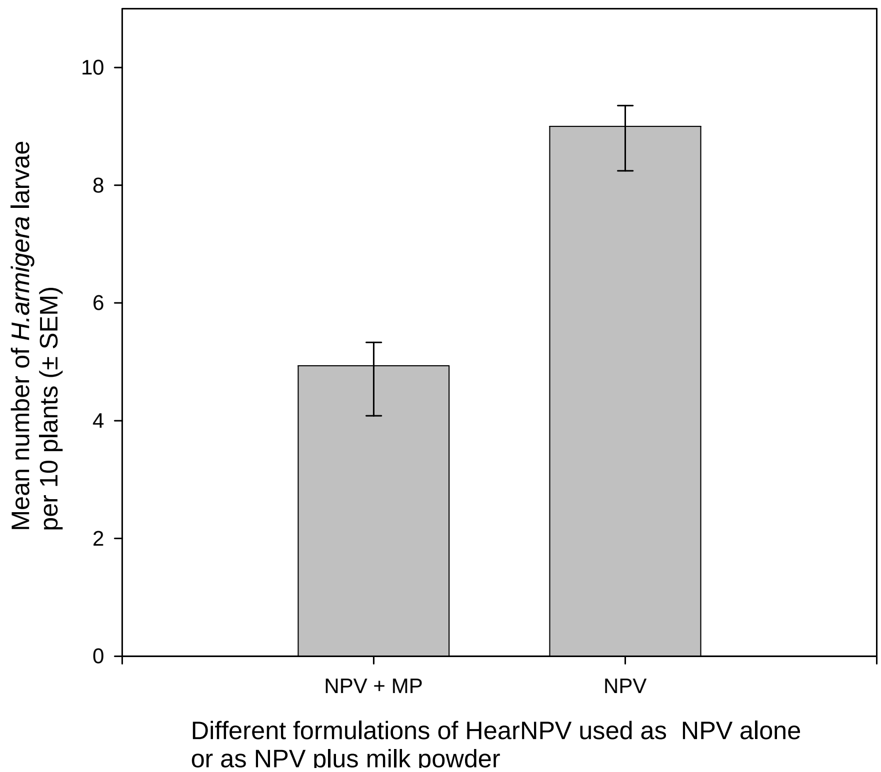
A number of trials comparing the NPV alone and NPB plus MP were carried out on farm at Rampur and Nepalgunj. These involved treatment groups of 10-25 either NPV alone or NPV plus MP as controls for *H.armigera*.

In the Rampur trial the finding was that the NPV + MP gave yields that were higher than for the NPV but not significantly so. Overall yields were lower than for the station trials with the Avarodhi variety. That could indicate a high level of *H.armigera* attack though damage scores from these trials showed 9% of pods were damaged prior to the application of treatments indicating a significant though not major outbreak of *H.armigera*.

At Nepalgunj farmer trials used groups of 25 farmers to test NPV with or without milk powder. Here however application occurred when the crop already had damage to 56% of pods far too late for effective podborer control. The application of NPV did result in a significant reduction in pest numbers in the NPV +MP over the NPV alone P= 0.0384 (Mann-Witney rank test T = 413.5

n = 25 & 25, see fig. X). Pod damage did not increase significantly in either treatment after NPV application, which may indicate effective control, was established.

Fig 16 Effect of different NPV formulations on pest numbers



Thus it does appear that NPV + MP is significantly better at reducing *H.armigera* numbers on farm than NPV alone although in this trial this did not result in improved yields as application was too late to prevent serious yield loss that had already occurred.

Conclusions of NPV work on chickpea

The NPV work both in the laboratory, on farm and on station when brought together can be said to show.

1. *Hear*NPV is as good as or better in preventing *H.armigera* damage on chickpea than chemical insecticides such as Thiodan.

2. The *Hear*NPV does not perform to its full potential on chickpea as there is a leaf surface chemical factor in chickpea that inactivates the *Hear*NPV much faster than on other crops.

3. The use of simple low cost additives such as casein or milk powder can increase *Hear*NPV activity on chickpea in the laboratory.

4. In field and farm trials milk powder additive can significant improve *Hear*NPV performance on high yielding disease resistant varieties being promoted as part of this project in Nepal but seems not as effective on traditional varieties.

2.3.4 Integrated IPM package initiated and validated on farm.

Participatory on-farm trials of an IPM package that had been developed as part of an earlier ADB project (RETA 5711) were conducted across the Terai and adjacent foothill areas of Nepal during the 2000/2001 season with 500 farmers evaluating the total package of improved variety and optimum agronomy.

The selected villages were representative of the districts concerned in topography and farming practice and were relatively closer to research stations to allow trials to be monitored with reasonable travel times for collaborators. In most cases farms could be reached and evaluated within a day. The target villages were D-Gaon, Bankatwa (district Banke), Munalbasti, Maina Pokhar (district Bardia), Rajahar (district Nawalparasi) Lalbandi (district Sarlahi), Bardibas (district Mohattari), Dhangadhi-Hanuman Nagar-Kuruwa (district Sirha), Kusuha (district Saptari) and Simariya/Tarahara (district Sunsari) (Appendix 1). The villages were selected by formal and informal visits and meetings with village heads and farmers.

The characteristics of farm sites chosen for farmer trials:

- Areas where chickpea was grown traditionally in rice-based cropping systems and their production constraints (biotic and abiotic) were important with a high degree of uniformity.
- Areas where, it was possible to group the participating farmers into units who had similar management practices and had been cultivating chickpea traditionally.
- Areas where, numbers of small farmers or farmers-groups were greater than required number per replicate or block and where it was possible for each participating farmer to provide 1m $\times$ 1m plot or multiples for yield analysis.
- Sites, that were accessible and near to motorable roads.
- Farmer communities that were cohesive and communicative according to local NARC staff information.

Participating farmers broadly possessed the following characteristics:

- Willing to accept innovations and were concerned about biotic constraints to chickpea crop.
- Traditional chickpea farmers using normal practices and were ready and willing to contribute labour.
- Willing to be guided by research staff and carry out operations as indicated.
- Agreed to co-operate without any financial incentives other than free seed and plant protection material

It was not necessary to involve women specifically in trials since in many places they were already heads of household and principal decision makers for farms especially in rabi when men often migrate for seasonal labour such as construction.

The main improved agronomic practices included

- improved cultivar Avarodhi or Tara which are both resistant to Fusarium wilt
- Seed priming
- BGM control (Bavistin @ 1gL^{-1} water 17 L. $katha^{-1}$)
- pod borer control with Thiodan @ 3 ml L^{-1} of water (17 L. of water $katha^{-1}$),
- fungicidal treatment of seed (thirum + Bavistin (1:1 ratio) @ 2 g kg^{-1} seed)
- boron application in areas shown to be boron deficient (restricted to Some farms in central region).

- application of Rhizobium inoculum @ 3 g Kg^{-1} seed (where not previously applied)
- seed treatment with a mixture of
- di-ammonium phosphate @100 Kg ha^{-1}
- maintenance of an open canopy by avoiding irrigation or excessive fertilizer.

A prophylactic spray of the fungicide was given at flowering/pod formation stage (70–80 days after sowing). Subsequent fungicide sprays were scheduled based on weather (cool temperatures, length of foggy hrs, humidity and cloudiness) for BGM development. In general, spray schedules coincided with vegetative/flowering, pod formation and pod development stages of the crop. Insecticide was sprayed by farmers once at flowering and the other at pod filling and development stage.

The non-IPM package consisted of a local cultivar with none of the IPM inputs (farmer's practice)

Ten IPM and 10 non-IPM trials were selected at random from each village for more detailed observations at the start of the cropping season. Periodic observations from sowing to harvest on weather, crop, diseases, and insect pests of selected fields were as follows:

- Weather data sets available at Nepalgunj, Rampur, and Tarahara.
- Plant stand on 1–9 rating scale, where 1 = >90%, and 9 = <10% emergence.
- Wilt and root rot incidence on 1–9 rating scale, where 1 = no plant mortality and 9 = 80-100% plants killed by Fusarium wilt and or root rots.
- BGM incidence and severity on 1–9 rating scale at vegetative (seedlings), flowering and pod filling and near maturity growth stages of the crop.
- Periodical pod borer infestation and progress by counting number of larvae $plant^{-1}$, at vegetative, flowering, pod filling and near maturity growth stages of the crop.
- Pod borer damage (%) by counting damaged pods and total pods on 5 random plants in each treatment at harvest.
- Nodulation score on 1–5 visual rating scale (after Rupela, 1991).
- Total number of plants m^{-2} (three quadrates of 1 m^2 size) at harvest.
- Total pods $plant^{-1}$ at harvest (based on 15 plants).
- Grain yield t ha^{-1} (based on three quadrates).

Visual scorings of the rest of the IPM trials (other than selected trials) in each village were also recorded on plant stand, wilt and root rots, BGM, pod borer damage and grain yield tonnes ha^{-1}. In addition to the above data sets, farmers' perceptions of the IPM practice were also recorded following a simple questionnaire, where farmers registered their response in 'yes' and 'no'. (details of 1–9 rating scale is given in Appendix-9).

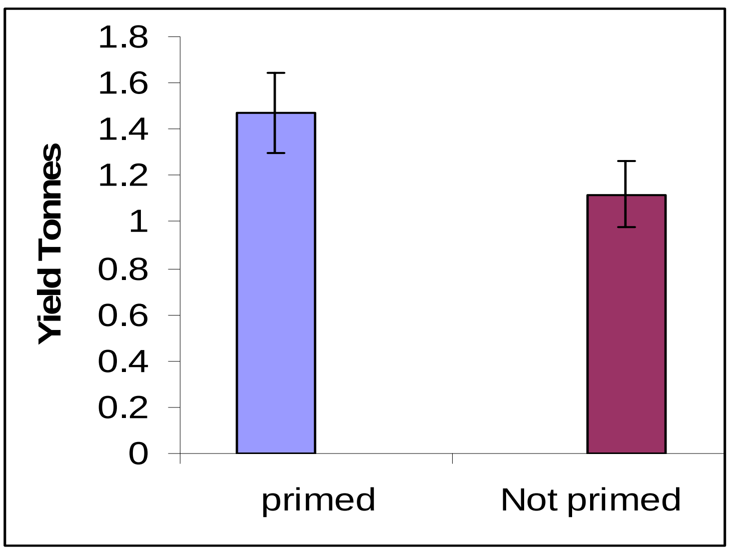
The results of this output are extensive and have been published as a FULL report: Pande, S. & Narayan Rao, J. (2001) that has already been submitted to CPP. key results are described below. The sowing period was from Nov 2-Dec 8 2000 and the harvest period was from 27 March – April 13 2001.

Of the 883 trials sown 7% did not emerge satisfactorily due to soil conditions and low moisture content in the soil with a mean plant stand across locations of 1.7 (1-9 scale where 1 > 90% see appendix 9). This indicated an important role for seed priming in improving chickpea production. For example plant emergence can be improved dramatically by soaking seed in water overnight before sowing (Musa *et al*., 1999). A small trial during this season indicated that plots where seed priming had been used gained a mean yield of 1.41 t Ha^{-1} but where seed had not been primed; farmers only obtained a yield of 1. 21 t Ha^{-1} (Fig 17).

Of the 883 trials sown 647 were harvested so the percent success of farmers' participatory on-farm trials on integrated pest (diseases and insects) management (IPM) in Nepal during 2000/2001 post-rainy season was 73.3.

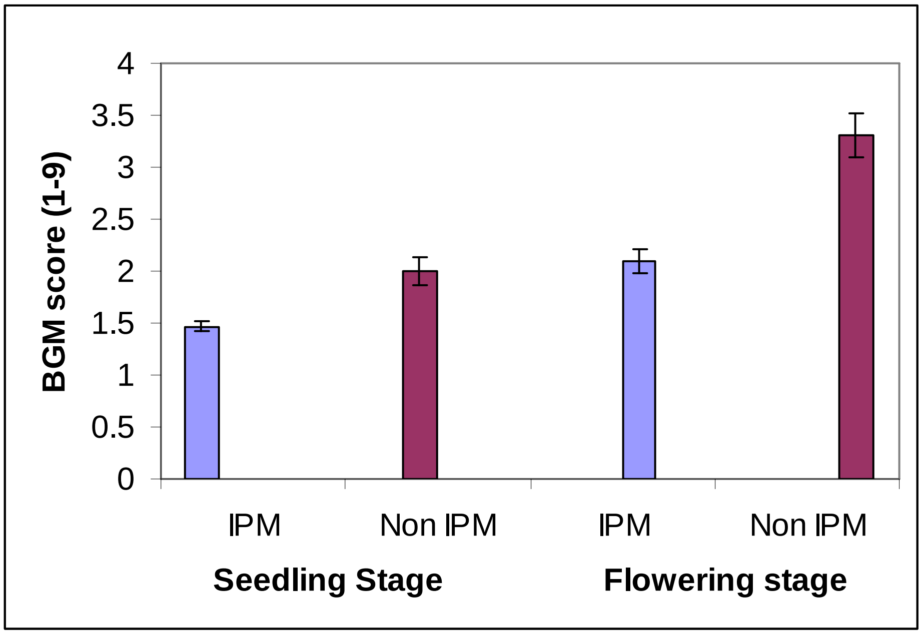
Approximately 13% of the trials failed because of moisture stress resulting in poor stand; 7% due to poor alkaline soil, 4% because of mixed cropping with mustard/linseed, 2% though had optimum crop stand but either detopped/grazed or harvested for green pods and 1% were harvested earlier.

Fig 17 Yield in Tonnes Ha^{-1} (SEM) in plots sown with either primed or unprimed seed



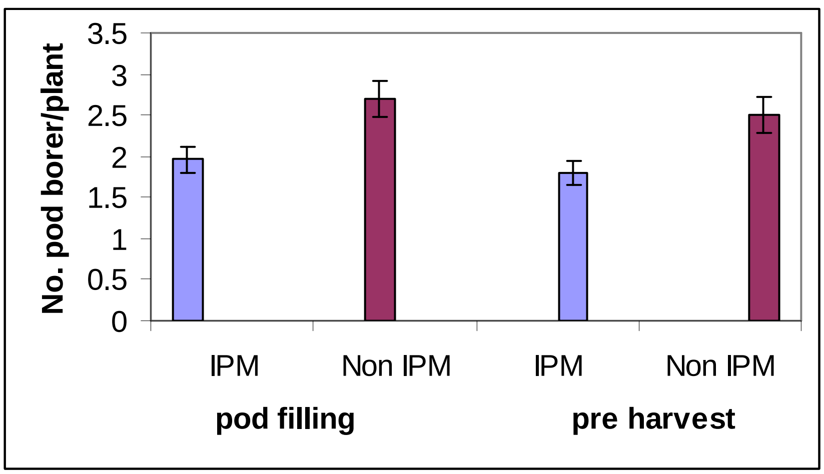
Overall the incidence of root rots and wilt disease across districts was low with a score of 2.0 in IPM plots and 3.1 in non-IPM plots. The reduced incidence in IPM plots was due to seed treatment with fungicide and Avarodhi being a wilt tolerant variety. BGM occurrence was also overall mild even in non-IPM plots although the range of occurrence was wide so in some places considerable losses were reported by farmers. Overall where fungicide was used by farmers to control the disease BGM was successfully managed and the score on the 1-9 scale was lower at seedling and flowering than in non-IPM plots (Fig 18).

Fig 18 BGM severity as a mean of BGM score (SEM) at seedling and flowering stages in IPM and non-IPM plots



IPM = Improved cultivar Avarodhi chemical control of BGM (Bavistin @ 1g L^{-1} water)

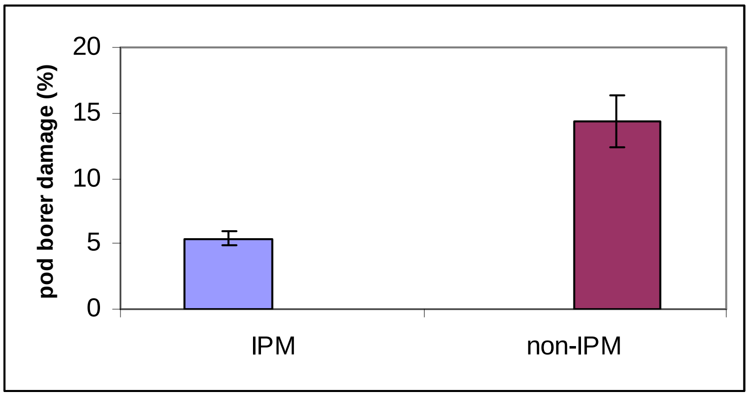
Fig 19. Larval population (number $plant^{-1}$ ±SEM) of *Helicoverpa armigera* at pod filling and pre harvest in IPM and non-IPM treatments field



IPM = Improved cultivar Avarodhi with Thiodan 3 ml L^{-1} water.
Non-IPM = Local cultivar with none of the IPM inputs

The population of pod borer on IPM plots was considerably lower than on non-IPM plots across the districts showing that the judicial use of Thiodan provided farmers with a technology for protecting the crop from this potentially devastating insect pest. However during this year the overall numbers of pod borer were low so the result may not necessarily reflect what might happen during a year with very large numbers. It is worth noting that farmers frequently reported that insecticides did not work, especially around Nepalgunj in Bardia and Banke district. It is possible that this was due to either local products being of low quality or that being so close to the cotton growing regions that numbers of insecticide resistant pod borer were invading chickpea in those districts. The damage caused by podborer was based on total numbers of pods damaged on five plants. Two applications of insecticide were given at the flowering and podding stage with a 15 day interval. Across the districts the mean damage (%) was 5.4 in IPM plots and 15.4 in non-IPM plots (Fig 20). So even in this year with relatively low incidence the use of only a few sprays with Thiodan had positive effect on yield.

Fig 20 Pod borer damage on Avarodhi treated with Thiodan (IPM) and unsprayed (non-IPM)



IPM = Improved cultivar Avarodhi with Thiodon 3 ml L^{-1} water.
Non-IPM = Local cultivar with none of the IPM inputs (n=10)

Nodulation in legumes is a symptom of the unique process by which the plants establish symbiotic relationships with Rhizobia or nitrogen fixing bacteria which can convert atmospheric nitrogen into nitrates that are useable by the plant. This allows the plants to gain nitrogen from depleted soil and ultimately help to add nitrogen to soil for relay crops. This is especially relevant to rice which has high nitrogen requirements. Consequently the rotation of chickpea with rice is an essential process for maintaining a healthy nutrient balance in soil. The process can be established where there are no soil Rhizobia by inoculating seeds before sowing. This became a component of the IPM package and overall had a considerable impact on plant growth and the need and therefore cost of fertilizer. Across the district the overall level of nodulation on IPM plants was 3.4 on a 1-5 ranking system whereas level for non-IPM plots was 1.8.

After threshing, the grains from sample plots of all the selected trials were dried, weighed and yield ha^{-1} was calculated. IPM plots gave higher grain yields than non-IPM plots in all the trials in all districts. The mean grain yield across locations was 2.06 t ha^{-1} in IPM plots and 0.90 t ha^{-1} in non-IPM plots (Fig 21). A maximum grain yield of 5 t ha^{-1} was obtained in three trials in the village Munalbasti and as much as 3.5 t ha^{-1} to 4.25 t ha^{-1} were obtained by the most successful farmers in most of the trials in IPM treatment in the rest of the villages. Two farmers in Munalbasti also obtained 5 t ha^{-1} during 1999-2000 season from IPM treatment. A close observation of the yield data revealed, that there was a considerable variation in yield levels obtained by participating farmers between both treatments in all villages. In general, these yield levels (1.6 to 5 t ha^{-1}) suggested that chickpea established with optimum plant population density in the majority of IPM plots and yielded two to four times more grain than non-IPM plots.

Fig. 21 Grain yield t ha^{-1} in integrated pest management (IPM) and non-integrated pest management (non-IPM) treatments in farmers' participatory on-farm trials in Nepal during 2000/2001 post-rainy season.

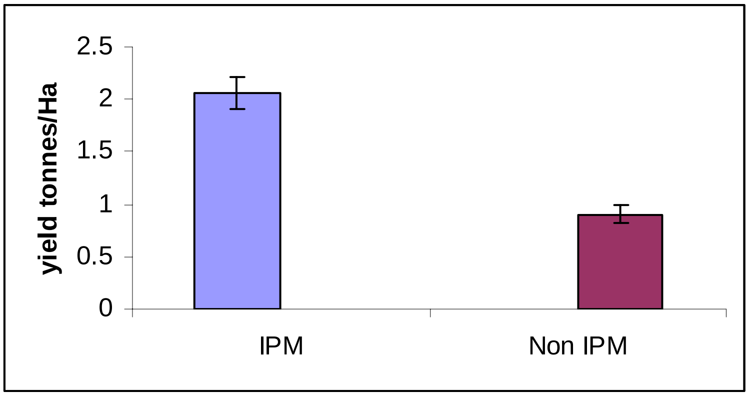
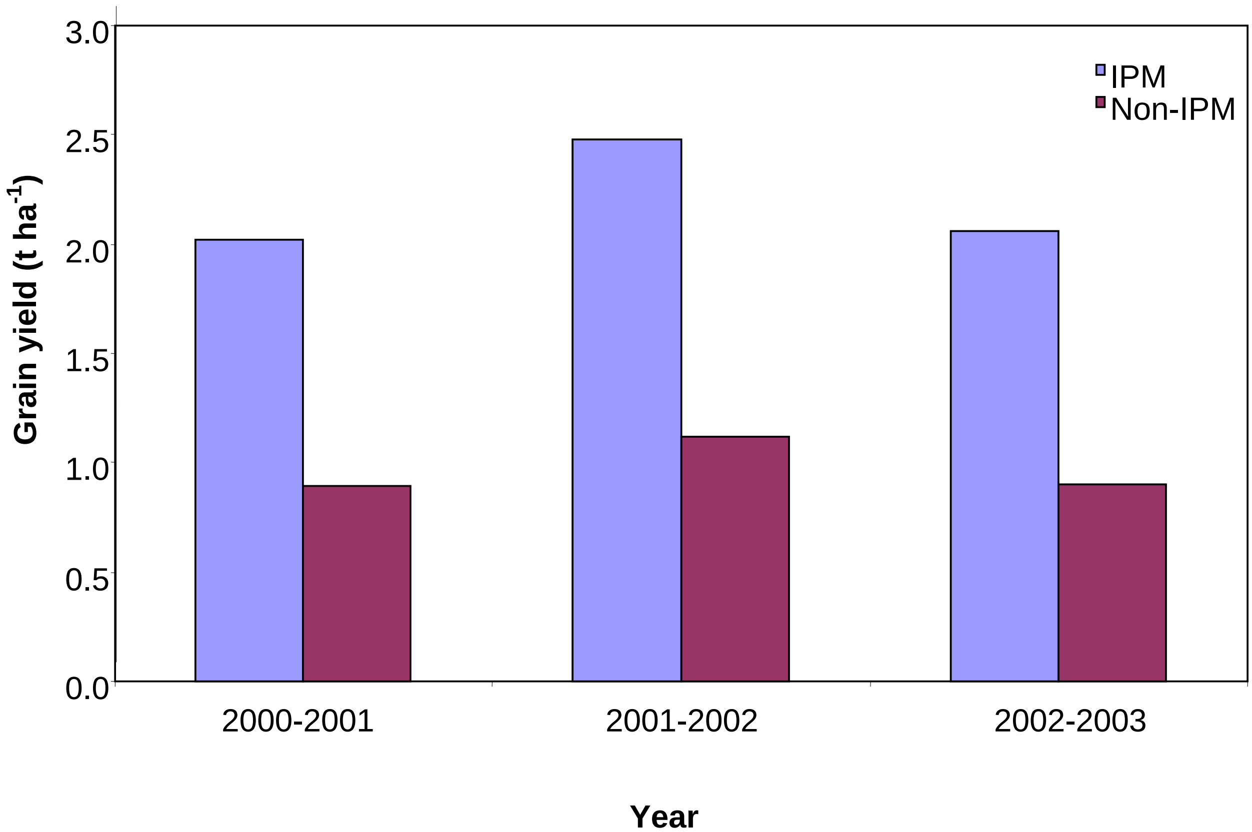


Fig 22 On farm grain yields achieved by farmers throughout project IPM vs Non-IPM



2.4 OUTPUT 4.

Promotion tools produced and disseminated to chickpea farmers in Nepal.

The IPM package was promoted through farmer schools, NARC extension services and NGO links established under the previous ICRISAT led crop diversification project, funded by the Asian Development Bank (ADB). A central facet of the project was to use the farmer participatory techniques previously developed by ICRISAT/NARS under previous legume grain projects and that farmers themselves should conduct all on-farm trials. The performance of the package based upon grain yields was monitored as described above but simple tools were needed to provide farmers with a guide to IPM along with farmer schools described later in this report.

Using data from the farmer surveys and from the previous ADB project the NARS/NGO/ICRISAT team developed promotion tools for the new chickpea IPM system. As well as posters and materials for showing farmers at field schools the team produced information cards in Nepalese detailing all stages of chickpea growth, when they are affected by the principal target constraints of the project and how best to manage them (Plates 1 and 2). During the 2000-2001 season promotion tools for new integrated technologies were distributed. These sheets were produced and used during the main promotion phases in years 2 and 3. They were disseminated to at least 2000 farmers in the target areas in year 3.

Improvements in the content of the sheets have been recorded with the following changes

- More information on storage and its importance for sustainability needed generally.
- Info leaflet would benefit from some information on economics – cost of inputs and expected rewards with indications of the importance of forward planning.
- Important to keep sheet on two sides but with less on soil diseases and more on BGM and insect pests.
- Needs to be very specific about the importance of the stage of insect that is susceptible to insecticides/NPV
- There is a tendency for farmers to mislay them because there are long periods between events, so leaflets should be made into a calendar so farmers are more likely to keep them and even stick them on wall.
- Posters of the hand out should be made for public places in villages
- Malathion recommended for use in storing seed. Clearly ill-advised for grain being kept for food. Needs clarifying.

Plate1

चना विषयमा केही महत्वपूर्ण जानकारी - रोग र कीराहरूको रोकथाम

चना नेपालको एउटा बहुपयोगी हिउँदे बाली हो। विशेषगरि तराई र भित्री मधेसमा धान पछि चनाको खेती गरिन्छ। हाम्रो दैनिक जीवनको खानपीनमा निकै महत्व राख्ने चना बालीको उत्पादन नेपालमा त्यतिको संतोषजनक रहेको छैन। अहिले हामीहरूले उन्नत प्रविधिको प्रयोग गर्‍यौं भने निकै फाइदा हुनेछ र प्रत्येक वर्षनै राम्रो उपजनी हुनेछ। चनाको खेतीले जमीनको उर्वरक शक्ति, बढाउनमा पनि मद्दत गर्दछ। यसको निम्ति हाम्रा किसान दाज्यू-भाईहरू र दीदी-बहिनीहरूले अलिकति कुराहरू ख्याल राख्नु पर्ने छ। हवापानी, मलखाद, जमीनको तयारी, रोप्ने विधि र विशेषगरि बोट तथा जरामा लाग्ने रोग र कीराहरू विषयमा हामी तपाईहरूलाई केही संक्षिप्त जानकारी दिंदै छौं।

हावापानी कस्तो हुनु पर्ने: बोट फस्टाउन र बढ़ी उपजनीका लागि चिसो र सुख्खा मौसम उत्तम हुन्छ।

जमीनको तयारी: एक अथवा दुई पटक जोती चिस्यान कायमै रहन दिएर पाटा लगाउनु पर्दछ। झारपात र पहिलो बालीका ठुटाहरू निकाल्नु पर्दछ। जमीन सुख्खा भएमा अलि पानीले सिंचाई पनि गर्नु पर्दछ।

मलखाद कस्तो हुनु पर्ने: पहिलो पटक बाली लाउँदा, बीऊलाई १०% चीनी पानीको घोलले भिजाई जीवाणु मलले उपचार गरे राम्रो हुनेछ। रासायनिक मलको हकमा, डाई-अमोनियम फोस्फेट (डी ए पी) १०० कि.ग्रा./हेक्टेयर (लगभग ३ कि.ग्रा. प्रति कठ्ठा डी.ए.पी.) प्रयोग गर्नु पर्दछ।

रोप्ने समय र विधि: मध्य र पूर्वी तराई, भित्री मधेशमा कार्तिकको तेस्रो देखि चौथो हफ्ता र पश्चिमी क्षेत्रमा कार्तिकको पहिलो देखि दोस्रो हफ्तामा रोप्नु पर्दछ। हलोको सियो पछाडि, एक लाइनमा झण्डै १० सेण्टीमीटरको फरक राखी बीउ खसाले पछि पाटा लगाउनु पर्दछ। धान बाली न काटुनजेल, बीउ छर्न पनि सकिन्छ।

रोग र कीराहरू देखि बालीको बचाउ

बीऊ र माटो देखि उपजने रोग: जरा, डाँठ र फेद कुहिने रोग, ओइलाउने रोग र खैरे रोग

लक्षण:

- पातहरू औल्याएर पहेंलो हुंदै जान्छ अनि पछि ती बोटहरू खेतमा मर्दछन् र बेर्नाहरूको रंग फिक्का हुन्छ (चित्र नं. १)।
- फेद कुहिने रोग-माटोको सतहमा सेतो ढुसी (चित्र नं. २)।
- डाँठको भित्री भाग कालो हुन्छ र जरा सुख्छ अनि मसीना जराहरू झर्दछन (चित्र नं. ३)।

रोकथाम:

- सर्वप्रथम रोगरोधी जातहरू जस्तै ''अवरोधी'' प्रयोग गर्नु पर्दछ नत्रभए बीऊको उपचार अनिवार्य रूपमा निम्न तरिकाले गर्नु नै पर्दछ :

  वेभिष्टिन (कार्बेनडाजीम) ३ ग्रा. अथवा बेनलेट-T (बेनोमाईल+थायरम्) ३ ग्रा. अथवा थीराम+क्याप्टान २.५ ग्रा. प्रति कि.ग्रा. बीऊको दरले उपचार गर्नु पर्दछ।


चित्र नं. १


चित्र नं. २

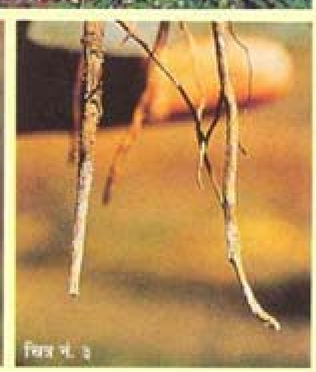

चित्र नं. ३

Plate2

बोट्राईटिस खैरे वा फुस्रे रोग

लक्षण:

- जाडोमा धेरै दिन कुहिरो लाग्दा र तापमान घट्दा यो रोगले च्याप्दछ।
- कोशाहरू न लाग्ने (चित्र नं. ४) र फूलहरू मर्ने (चित्र नं. ५)।
- डाँठमा खैरो ढुसी (चित्र नं. ६) र हांगाहरू कुहेको (चित्र नं. ७)।

रोकथाम:

- यो रोग बीऊबाट पनि जन्मिन्छ अनि यसको निम्ति पहिले बताइएको बीऊ उपचार विधि अथवा डाएथेन एम ४५ (मानेब) बाट पनि २.५ ग्रा. प्रति कि.ग्रा. बीऊको उपचार गर्न सकिन्छ।
- यसको अतिरिक्त धेरै चिस्यानको अवस्थामा प्रति कठ्ठा ८ लिटर पानीमा १६ ग्रा. बेभिष्टिन मिसायर १ देखि २ पाली सम्म छर्नु पर्दछ। पहिलो पटक फूल फुल्ने बेलामा छर्कनु पर्दछ। बेभेष्टिन न पाएको खंडमा गोलभेडा र आलूको बोटमा छर्किने ढुसी-नाशक औषधिको (प्रति कठ्ठा ८ लिटर पानीमा २४ ग्रा. डायथेन एम ४५) प्रयोग गर्न पनि सकिन्छ।


चित्र नं. ४


चित्र नं. ५


चित्र नं. ६


चित्र नं. ७

कीरा

पडबोरर अर्थात् बहादुरे कीरा

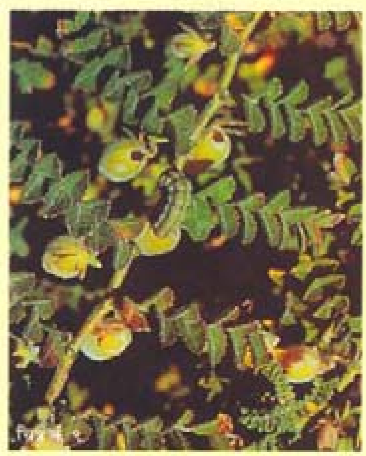
लक्षण:

- कोशामा प्वाल पार्ने र भित्र गुदी खाई खोक्रो पारेर पात र कोपिला समेत खान्छ (चित्र नं. ८ र ९)।

रोकथाम:

- यसको निदानका लागि थायोडन (३५ ई.सी.) अथवा डेसिस प्रति कठ्ठा २४ मि.लि. ८ लिटर पानीमा घोली फुल फुलेको बेला (१ व २ पटक) छरिदिनु पर्दछ। यो औषधिहरू न पाएको खंडमा निर्देश अनुसार साइपरमेथ्रिन पनि प्रयोग गर्न सकिन्छ। न्यूक्लियर पालि-हायड्रोसिस भायरस (एन पी भी) निश्चित मात्रामा थायोडन छरे पछि छरेमा लाभकारी हुन्छ।


चित्र नं. ८


चित्र नं. ९


चित्र नं. १०

खपटे

लक्षण: खपटे खेत-बारीमा लाग्दैन, तर पाकेको कोशा धेरै दिनसम्म खेतमा छाडि राख्यो भने लाग्छ। यसबाट चनामा लाम्चा प्वालहरू देखिन्छन (चित्र नं. १०)।

रोकथाम: यसको रोकथामको निम्ति सञ्चित चनाका पाकेका कोशाहरूलाई राम्ररी सफ्फा गरी, कीरा न लाग्ने भांडामा राख्नु पर्दछ।

धुंवाउने बिषादीले वा मेलाथायन जस्ता रासायनिक उपचार गरेको खंडमा पनि खपटे लाग्दैन् वा कपुरका चक्की वा वनस्पति तेल वा नीमका पात अथवा बीऊको धुलोले पनि उपचार गर्न सकिन्छ।

अधिक जानकारीका लागि सम्पर्क गर्नुहोस: नेपाल कृषि अनुसन्धान परिषद, खुमलटार, ललितपुर, काठमांडौ, नेपाल, फोन: ९७७-०१-५२५७०३ एवं इक्रिसैट, पाटनचेरु, आन्ध्रप्रदेश-५०२ ३२४, भारत, फोन: ०४०-३२९६१६१; अन्तराष्ट्रिय विकास विभाग (DFID), यु.के. बाट उपलब्ध कोष द्वारा प्रचारित।

2.5 OUTPUT 5
New IPM technologies for chickpea production promoted to farmers in principal chickpea growing districts of Nepal.

In order to start the promotion process, farmer field schools were conducted with all farmers prior to the chickpea-growing seasons in years 2 and 3 to inform participants and distribute promotional tools and technologies. In the 2001-2002 cropping season the validated package from output 3 was promoted to the target farmers. In the first season the aim was to involve an initial target group of 500 representative farmers from the main target areas for validation (see above) but in subsequent years the aim was to scale up promotion of the package. Trials expanded dramatically in subsequent years. In 2001/2002 1100 similar trials were set up with farmers, many in new districts and in 2002/2003 more than 2000 farmers' received the IPM package ingredients to try (Fig 23). Furthermore, local scouts and farm leaders indicated that many elements of the IPM practice had been adopted by an estimated additional 5000 farmers, who had assimilated knowledge by various local processes of communication.

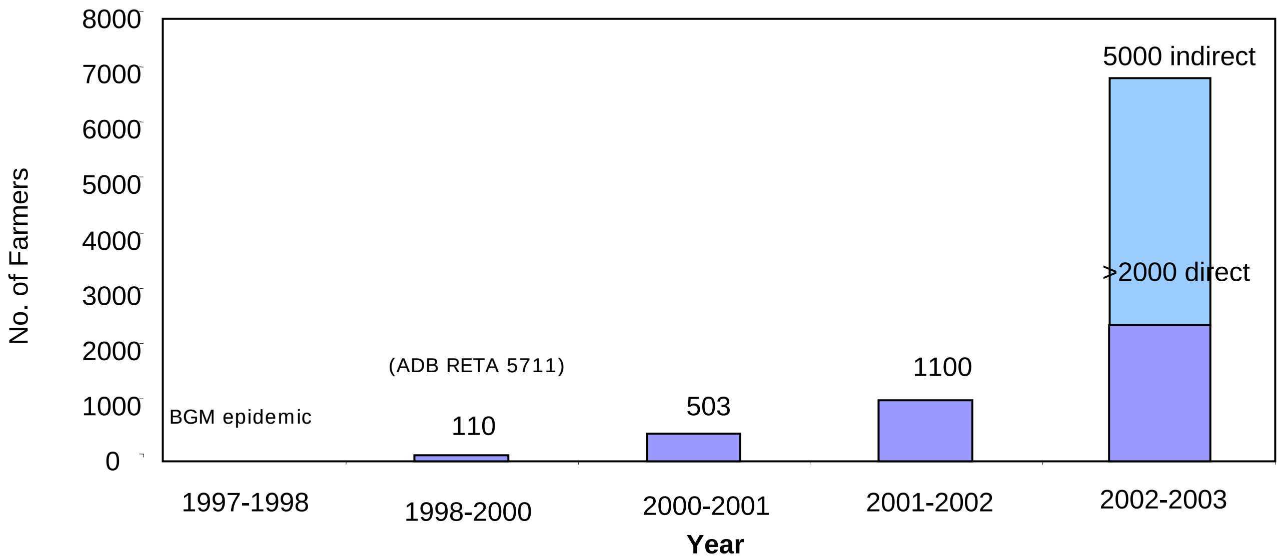


Fig 23 Adoption of IPM of chickpea in Nepal, from ADB forerunner project through to 1998- 2003

Farmer schools consisted of small groups of no more than 50 farmers from the same village who knew each other and were able to discuss IPM in the same language and with relevance to particular farming approaches peculiar to their village or district.

The area expansion by district is shown in Appendices 5, 6, 7 & 8 increasing from 4 under the ADB project to 12 in the third year of this project. This was only possible with the cooperation and close collaboration of the Regional Agricultural Research Station (RARS) Khajura, Nepalgunj in Western Nepal; Grain Legumes Research Program (GLRP) Rampur, Chitwan, National Oil Seeds Research Program (ORP) Nawalpur, in Central Nepal; and Regional Agricultural Research Station (RARS) Tarahara, in Eastern Nepal (See Appendix 1 for administrative divisions in Nepal). Banke and Bardia are the largest chickpea growing districts in Western Nepal and are command districts of RARS, Khajura and Nepalgunj. Nawalparasi, Sarlahi and Mohattari are potential legume growing districts in central Terai region of Nepal. Nawalparasi is the outreach site of GLRP Rampur; Sarlahi and Mohattari are the outreach sites of ORP, Nawalpur. Sirha, Saptari and Sunsari districts are important sites in Eastern Nepal for chickpea cultivation and are the command districts of RARS, Tarahara.

2.6 OUTPUT 6.
Socio-economic survey to determine the impact of improved chickpea IPM on rural livelihoods, poverty alleviation and nutrition in target districts.

2.6.2 Productivity and unit cost of production for chickpea with and without IPM

An impact evaluation on IPM uptake was the last field based project activity and took place in May 2003 after the harvest of chickpea. Surveys of farmers involved in the project quantified the economic implications and gains from uptake of the new technology. Many of the factors relevant to this analysis were determined during a mid-term impact evaluation commissioned by CPP in addition to this study and were also determined through discussion with NGOs, NARC staff and farmers and their representatives at the pre-project workshop and through discussions with farmers and NGOs during the course of the project. The mid term impact report on the impact assessment has been completed and will be published this year as an ICRISAT publication (Pande, S., *et al*., 2003 b & see also 2.7)

The farmer study groups in the present impact evaluation were:
1. Contact farmers of ICRISAT / NARC/ NRI (IPM farmers)
2. Non-contact farmers (non-IPM farmers)

Table 5. Number and location of sample households in Nepal.

Eco-regions	Districts	Villages	Contact farmers	Non contact farmers
Midwest Region	Bardia	Munal Basti	40	10
		Kurvinpur	18	---
		Kamalpur	---	10
	Banke	Betehni	6	---
		Dhaulaeri	---	10
		E-Gaon	2	---
		D-Gaon	32	---
Central region	Sarlahi	Lal Bandi	52	---
		Jabdik	---	10
	Mohatari	Bardibas	50	10
Total			200	50

Farmers were interviewed from a questionnaire on a one to one basis so that the impact of IPM on the farmers' livelihoods could be quantified. The full results are published in ICRISAT bulletins (Pande, *et al*., 2003 c & See also 2.7) but the salient findings of the study are described below. It is worth noting that some uneven distribution of knowledge may be apparent among farmers in Nepal and this may affect the outcome of surveys. The distances between villages and research stations were only 2-35km. This is because it is impractical to involve farmers from more distant locations where the majority of farmers live and where the non-motorable roads mean it may take several days travelling by foot to reach them. It is therefore possible that farmers involved in this study are more likely to have benefited directly or indirectly from previous contact with research and extension services and are likely to be more in tune with the goals of research stations. They are more likely to be better educated in modern farming techniques because of more contact over many years. In support of this supposition, based on land holding, farmers were divided in to three economic classes: deficit, non-deficit and surplus for the purposes of defining overall wealth. In both the mid-western and central regions, of the farmers that were considered contact farmers (i.e., targets for extension in this project) 16% were deficit and about 76% were non-deficit. However, in non-contact groups 50% were deficit farmers and about 47% were non-deficit suggesting that contact farmers were benefiting from this regular contact or some other economic variable prior to the introduction of our IPM technologies.

Agriculture is the mainstay of employment in villages. More than 95% of farmers have agriculture as the principal source of employment and income. A large number migrate for casual labour to towns in Nepal and India especially in the *Rabi*. This causes scarcity of labour in the sowing period but also increases the level of involvement of women both in physical labour but also in decision making and responsibility for food security. The outputs of this project therefore have a direct relevance to the poorest women farmers in Asia.

For farmers who own land the average holding was between 0.98 Ha in the central region (CR) and 1.86 Ha in the mid-western region (MWR) whereas for farmers who rented land this varied between 0.88 and 0.64 Ha (Fig 24). The data suggests that farmers in the mid western region are wealthier with respect to land ownership than farmers in the central region but more importantly perhaps is the consequence in terms of livelihoods since the rent on land in Nepal is almost invariably 50% of its output. Thus a farmer who owns land will reap double the profit of a farmer who rents from a landlord.

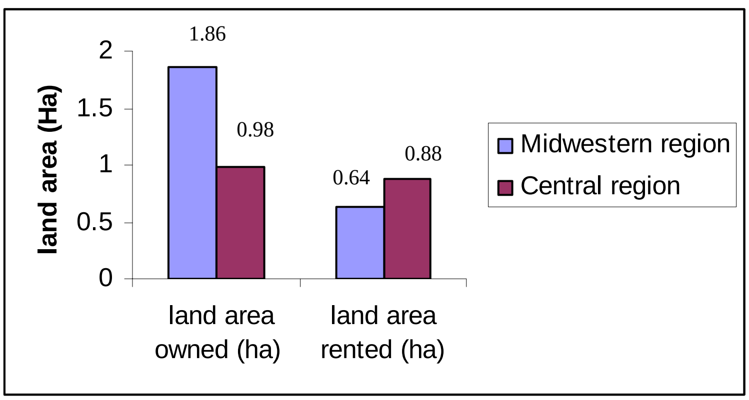


Fig 24. Average area of land owned and rented by farmers in Mid-Western and Central Region (Pande *et al*., 2003)

Expenditure priorities for contact farmers were reportedly the following in order of importance: food, clothes, education, fertilizers and chemicals. Most farmers reported that the crops they grew were insufficient alone to feed them and their families. Thus an excessive production of one crop was important for buying and selling other food and most farmers earned additional money through farm and building labour especially in the *rabi* season.

The pest management package was provided free to participating farmers. However, the economics of its cost and subsequent return was evaluated incorporating accurate cost factors for farmers as if they had paid for it themselves. The unit cost of chickpea grown using the IPM practice promoted by this project was 9 Rs kg^{-1} whereas non-IPM was 17.5 Rs kg^{-1} indicating that local production was less than half as profitable as IPM chickpea production. This closely reflects the differences in productivity and profit determined earlier in the validation phase (2.3). This is all the more impressive when one considers that the investment cost is only 10% greater with IPM (Table 6). Thus the outlay for farmers should not be dissuasive provided the package is well promoted.

Table 6. Economics of chickpea production across Nepal with and without IPM (NRs/ha)

	Without IPM	With IPM	Difference between IPM and non-IPM (%)
Material cost	4252.00	4332.00	1.88
Operational cost	10540.00	11950.00	13.38
Interest paid on working capital	170.00	172.00	1.18
Total cost	14962.00	16454.00	9.97
Gross income	24120.00	35440.00	46.93
Net income	9158.00	18986.00	107.00
Unit cost of production (NR/kg)	17.53	9.26	-47.18

2.6.2 Family income, domestic expenditure and housing

The use of IPM to grow chickpea had a positive effect on family income in both mid-western (MWR) and central regions (CR). Eighteen percent of respondents were on the lower level of income from agriculture (0-20%) but through increase in overall wealth after using IPM this decreased to only 9% (Table 7) indicating that wealth status had risen. This trend was observed throughout the income brackets such that between 41and 48% of IPM users reported that their family income was in the highest bracket compared with between 17 and 18% for non-IPM users (Table 7). In all areas the coefficient of variation was lower for IPM users indicating a greater uniformity and consistency in income and the data suggests shows that CR felt the impact of IPM more than the MWR.

Table 7. Family income from agriculture (%)

Income bracket	Midwest region		Central region	
	Before IPM	After IPM	Before IPM	After IPM
0 – 20	18	09	12	---
20 – 40	20	16	24	9
40 – 60	18	18	33	7
60 – 80	26	16	14	36
80 - 100	18	41	17	48
Coefficient of variation	51.65	43.17	56.74	32.42

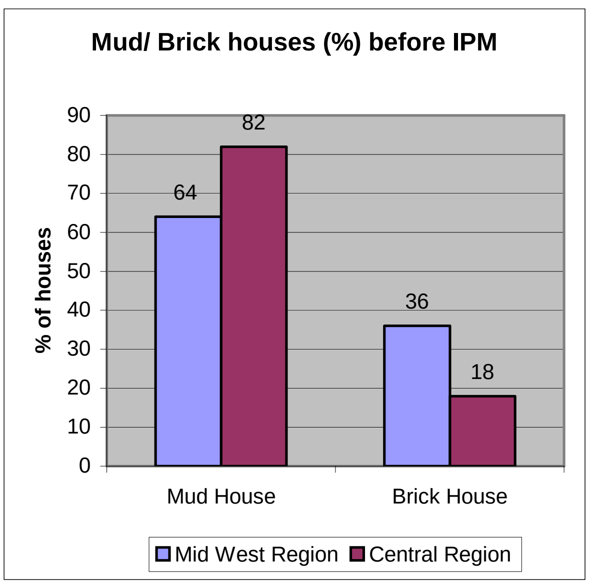
More specifically 70% of farmers said that their income from chickpea before IPM use was in the 0-20% bracket in MWR but this changed to 36% after IPM was introduced as their income from chickpea increased (Table 8). The coefficient of variation of chickpea income in mid-west region was 83.35% before IPM and after IPM it was 68.33%. This shows that chickpea increased the income level of farmers. Furthermore, after the introduction of IPM into the farming systems for chickpea, 80% of participating farmers said that their intake of chickpeas had increased. This addresses another key factor regarding nutrient deficiency identified in the introduction and at the workshop at the project outset describe earlier (2.1 Output 1)

Table 8. Family income from Chickpea (%)

	Midwest region		Central region	
Income bracket	Before IPM	After IPM	Before IPM	After IPM
0 – 20	70	37	63	12
20 – 40	16	35	24	25
40 – 60	11	15	8	30
60 – 80	3	9	5	18
80 – 100	---	4	---	15
Coefficient of variation	83.4	68.3	80.9	50.0

The cultivation of chickpea had a major impact on housing. In MWR 64% households had thatched mud houses (Kaccha houses). But after IPM this reduced to 44% as farmers reported building new houses. The percentage of brick and mortar (Pukka) houses before IPM was 36% but after IPM had been introduced it increased to 60%. In the central region fewer people lived in brick houses but a similar change was recorded between families before and after IPM had been introduced (Fig 25 A, B).

A



B

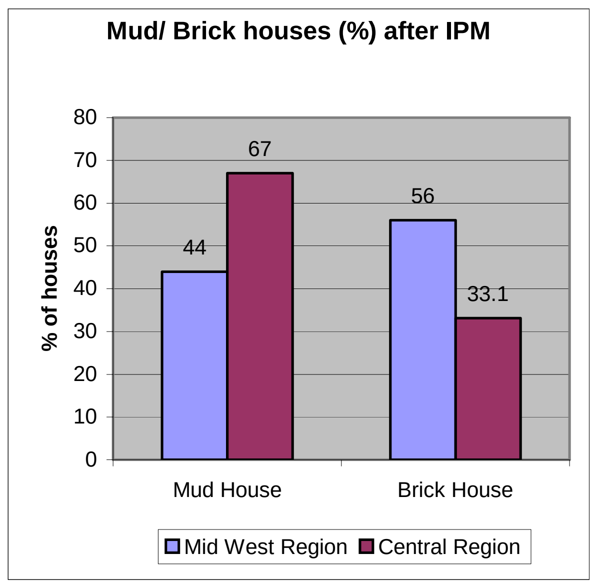


Figure 25. Mud/brick houses in study area (%).

While farmers reportedly supplement their income with other skills such as carpentry, engineering, plumbing and construction work, the changes in chickpea productivity did not affect this livelihood factor despite an increase in family income. The increase in income was used largely for household expenses (56% in MWR and 26% in CR) and on health care. Notably in CR farmers reported that they used 22% of their increased wealth to pay off debts whereas farmers reported only using 4% for a similar use in MWR (Fig 26)

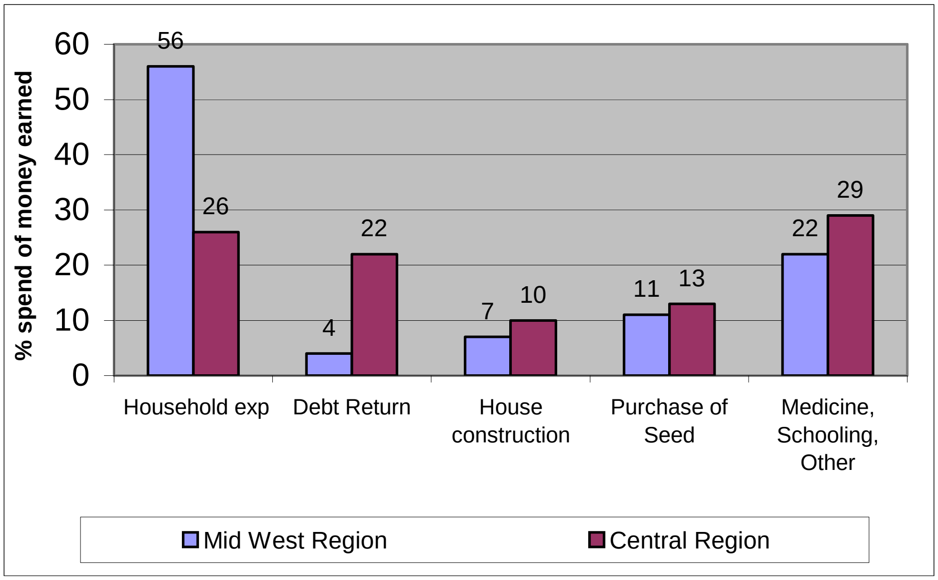


Figure 26. Spending of additional earnings from chickpea reported by farmers as a % of the money earned

2.6.3 Increase in household expenditure after IPM employed for production of chickpea.

The successes achieved by farmers using IPM technologies have made major changes in the expenditure pattern of the farmers. Of particular note, in both CR & MWR, there has been a major increase in expenditure on children's education and weddings. Expenditure on clothes increased dramatically in the CR and on social/family expenses in MWR. (Table 9).

Table 9. Increase in household expenditure after IPM used for production of chickpea.

Expenditures	% Change in amounts spent after IPM	
	Central region	Midwest region
School education	80	51
Wedding expenses	59	57
Clothes expenditure	49	25
Social/ family expenditures	33	66
Agriculture technology	27	23
Medicines	20	30

2.6.4 *Impact of chickpea on wealth generation*

The economic benefits for farmers of using IPM over non-IPM production can be evaluated by using the following criteria:

- Seed transaction benefits
- Sale of surplus product
- Consumption of chickpea grain
- Decrease in fertilizer application
- Increase in yield due to restoration of soil fertility

In village D-Gaon of MWR the average household seed transaction is about 127 Kg chickpea in a season. Farmers sold seed to other farmers but also to national NGOs working for the rice fallow land in eastern and far eastern parts of Nepal @NRs 27 kg^{-1} (the lowest price for chickpea at harvest time). Typically only 10% of the chickpea farmers involved in the project sold all their seed (equivalent to 127Kg). With 200 households in the village this would generate NRs 68,580.00 (= US$1000) from the 20 farmers selling chickpea for seed. With seed spreading rapidly to other villages, chickpea cultivation has the potential to change the local economy and increase wealth generation.

Over 3 years the mean output of chickpea was 50 kg $katha^{-1}$ $annum^{-1}$ (1.6 t Ha^{-1} $annum^{-1}$). On a mean land holding of 10 katha (0.3 Ha) this translates to 500 kg $farmer^{-1}$ $annum^{-1}$. If only 10% of farmers (=20) sell half of their produce at NRs 27/kg, then 5000 kg chickpea generates additional 135,000 rupees (US$2000) in the village economy $annum^{-1}$.

An average grower retains 50 kg of chickpea for family consumption. It is equivalent to a saving of NRs 1500/family. If only 10% families are taken into account then they can save NRs 30,000 $annum^{-1}$ for the village.
After chickpea harvesting, 24 man-days of labour ha^{-1} is saved on FYM input in the next paddy crop. This is as a direct result of the ability of chickpea to fix atmospheric nitrogen, which leads to a savings of NR 1200/household. The total FYM saving in the village is equal to NRs 8000, on urea it is NRs 3133 and on DAP it is NRs 2286. The total fertilizers savings is equal to NRs 13,419 (Table 10).
The crop rotation with chickpea increases yield of paddy by 7.71quintal/ha. This fetches additional income of NRs 5397/household. For 20 families (ie, 10%), it is NRs 107,940 of additional income.

Table. 10 Total benefits for village D-Gaon) $annum^{-1}$ for 20 farmers/families.

	(NRs)	**US$[a]**
Seed transaction benefits	68,580	979.71
Sale of surplus product	135,000	1928.57
Consumption of Chickpea	30,000	428.57
Reduced burden of fertilizers	13,419	191.70
Increase in yield due to restoration of soil fertility	35,980	514.00
Total	**282,979**	**4042.56**

[a] US$ 1 = NRs 70

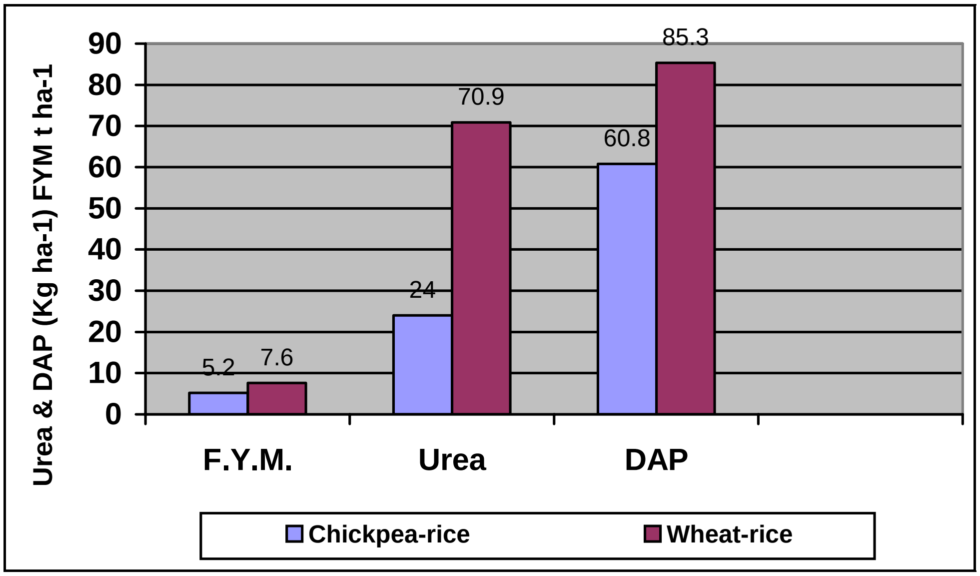


Figure 27. Consumption of fertilizers in rice under different rotations annum^{-1}.

The income of an average chickpea farmer has increased by NRs 14,148 (US$ 202) as calculated from a low profile village D-Gaon (Table 10) in the MWR to make sober estimates but the impact in the CR is potentially greater still. If we consider that overall the project has reached directly a total of 500 (yr 1), 1100 (yr 2) and 2000 (yr 3) = 3600 with mean increase in wealth of US$202 this equates to an over all increase in wealth of US$727,200. This overall wealth increase as a direct result of this project would be even greater still if one considers that a further 5000 farmers took on IPM practise through local dissemination processes during year 3.

The project has also generated more than 900 days of seasonal employment in the study villages (Fig 28) which is 370 more days than were available from farming the same land area at the project outset.

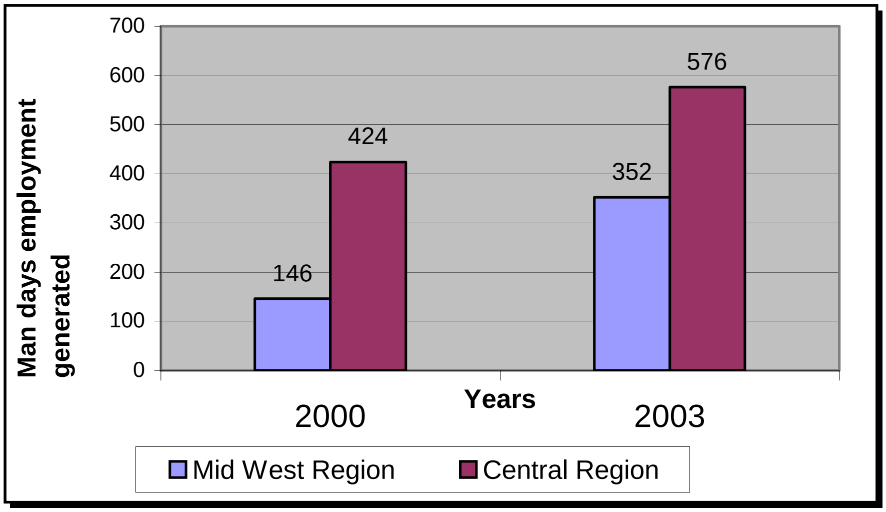


Figure 28. Employment generation in study area.

In addition the utilization of fallow lands is likely to generate substantial income and employment opportunities for thousands of small holders in the region in future where chickpea cultivation can be projected to generate an additional NR 8000/ha^{-1} (Pande *et al*., 2002).

An estimate indicates that chickpea cultivation on rice fallows generates almost 50 days of employment per hectare (Pandey et al., 2000). If at any point of time 10% of the *rabi* rice fallow land is brought under cultivation, it would generate approximately 1.29 million days of employment per annum. Similarly, 30% of the *rabi* rice fallow would add another 3.88 million man-days of employment.

2.6.5 *Impact of IPM of chickpea on seed transaction, fertilizer and employment.*

Bardibas (CR) was identified as a chickpea seed village. Here farmers reported a number of seed transactions with relatives, friends, NGOs, NARC and traders. The seed has been transacted far and wide in villages like Sitapur (10km), Sarlahi (45km), Sabila (40 Km), Onkar (35 km), Jaleshwar (37 km) and Dhalkewar (15 km) (Fig 29). In all these villages, *Avrodhi* has been the seed of choice owing to its superior agronomic characters such as seed quality, tolerance to wilt, high yield and response to available IPM technology.

Lalbandi is another very important seed village from where self-generated demand of *Avrodhi* is spreading in the villages such as Sisna (3 km) and another unnamed village (1 km) and to the local market (1km). Seed distribution is of course a key factor of the sustainability of the project outputs. The average amount of seed transaction is 127 kg/household/annum in MWR and 279 kg/household/annum in CR. In both these regions, its price is @ NR27 and NR 33/kg respectively (Table 11).

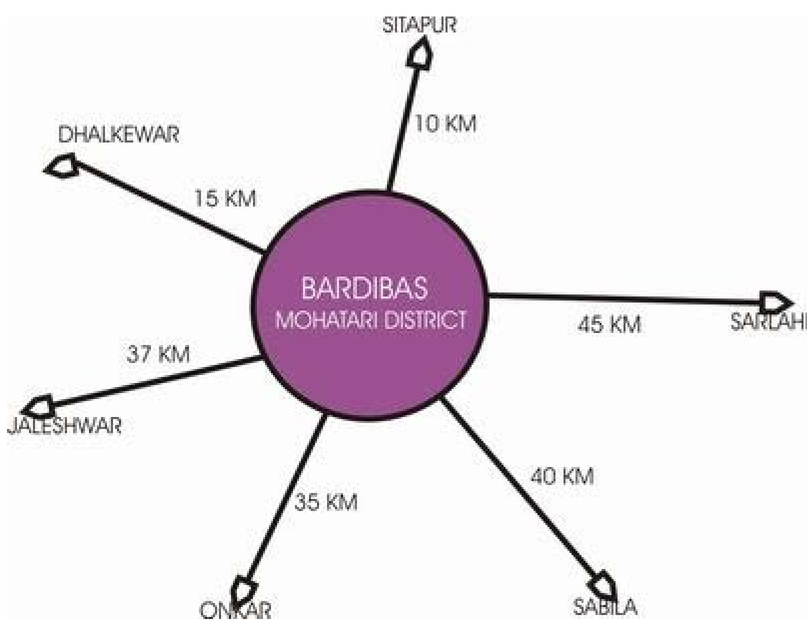


Figure 29. Seed Spread from the seed villages (arrows not to scale).

It is worth noting that in the CR farmers also sold seed to private sector seed distributors with whom pre-harvest guarantees were established for farmers and also to the NGO FORWARD who then distributed the seed with the promotion sheets from this project (output 4) to target farmers of the Plant Sciences Research Program (PSRP); a project promoting seed-priming across the Indo-gangetic plain.

Table 11. Mean yield sold as seed in 2003 and market price (NRs/Kg) of seed grain in transaction per farmer.

	Midwest region	**Central region**
Average amount (in Kg)	127	279
Average price per Kg (in NRs.)	27	33

(nb. seed grain is sold for the purpose of sowing not food)

2.6.6 Demand and supply estimates

In Nepal, pulses are in short supply. This offers opportunities to increase pulse production by bringing fallow land under cultivation. Table 12 shows chickpea demand projections for 2010 (Joshi *et al*., 2001). The short supply of chickpea is attributed to its shift in production from favorable to marginal areas. In favorable regions, coverage of wheat and rice has increased at the cost of coarse cereals, pulses and oil-seeds. Lack of technology to improve pulses yield and thereby less profitability has paved the way for cultivation of less risky and comparatively profitable rice and wheat crops. In the immediate future, the possibilities that pulses will regain lost ground are slim. The hope to raise pulse production lies in marginal areas like rice and maize fallow lands. In these fallows, chickpea is the most suitable crop and can double the income of the resource-poor farmers.

Table 12. Chickpea production projections in 2010 in Nepal.

Items	Estimates
Present consumption ('000t)	13.8
Population growth rate (%)	2.2
Income growth rate (%)	2.4
Demand growth rate (%)	3.2
Income elasticity	0.4
Projected demand for chickpea seed ('000t)	20.9

Source: Joshi *et al.* (2001)

Further, if IPM technology is disseminated to 5% of marginal and sub-marginal farmers in the same way then the estimated supply of chickpea in Nepal in 2010 will be 3,99,000 tons. Nepal could become self sufficient in chickpea production, which would will lead to

- higher yields of paddy
- restoration of soil health and fertility
- increase in human nutrition
- reduced consumption of fertilizers
- import substitution & export promotion
- reduction in poverty
- equitable distribution of wealth and social justice, through empowerment of the poor
- sustainable development for farmers in Nepal.

The technological intervention is required to achieve sustainable development without problems of market mechanism up to 2009 but overall the output income projections are good (Table 13).

Table 13. Output income projections based on 50kg / katha (1.65 t/ha)

Years	Average Chickpea Land area (ha)	Average Chickpea output/katha	Average total Chickpea output (kg)	Actual total output (t)	Chickpea price (million NR)
2000	.18	50	277	5.55	1.66
2001	.20	50	307	6.15	1.89
2002	.26	50	385	7.70	2.31
2003	.36	50	535	10.71	3.21
2004	.53	50	784	15.69	4.70
2005	.80	50	1157	23.15	6.94
2006	1.14	50	1680	32.60	9.78
2007	1.62	50	2377	47.55	14.20
2008	2.23	50	3275	65.51	19.65
2009	3	50	4399	87.99	26.39
2010	3.90	50	5775	115.50	34.65

Following are the assumptions for supply estimates:

- .26 million ha rice fallow land is suitable for chickpea production (0.4 million estimated by Subba Rao, 2001)
- The extension of chickpea will occur and be implemented in rice & maize winter fallow
- The extrapolation of land use is calculated on the basis of land area increase per year of chickpea coverage
- The margin of profit will remain the same up to 2010.

In future, chickpea production should not be threatened because IPM technology has shown that the crop can be grown efficiently with minimal labour cost in Nepal despite the various biotic and abiotic constraint identified by this project. The model can be applied else where in the world in similar agro-ecological regions such as India and Bangladesh.

2.7 OUTPUT 7
Project Dissemination

The results of the project were disseminated to the Nepali farming community, international scientific community and development organisations using the most appropriate media for each target community.

The dissemination to the Nepali farming community was carried out directly through project promotion activities and through established NARC network and activities. In addition local media were also targeted for press releases and articles. Appendix 12 shows 3 articles published in the Rising Nepal – the principal English Language Daily newspaper – that describes the project objectives. All three articles were published in Nepali language newspapers as well including the Gorkhapatra.

To inform the scientific community in South Asia articles andf information bulletin s have been produced and published or submitted. These include:

Pande S Johhansen, C. Stevenson, P.C. and Grzywacz, D (Ed.s) *On farm IPM of chickpea in Nepal: Proceedings of the International Workshop on Planning implementation of On-Farm Chickpea IPM in Nepal*. 6-7 September 2000, Kathmandu, Nepal. Patancheru 502 324 Andrha Pradesh, India: International Crops research Institute for the Semi-Arid Tropics and Chatham ME4 4TB, UK.,Natural Resources Institute. 125 pp. ISBN 92-9066-438-X.

Bourai V A, Pande S, Joshi P K and Neupane R K. 2003. Chickpea production constraints and promotion of integrated pest management in Nepal. On-farm IPM of Chickpea in Nepal -1. Information bulletin no. 64. Patancheru 502324,Andhra Pradesh, India: International Crops Research Institute for the Semi Arid Tropics. ISBN 92-9066-462-2. Order code IBE064..pp.

In addition several handouts and posters have been produced including

IPM Chickpea Poster 1.pdf (On CD)

And several Presentations were also given including the presentation below given at the Science museum to the public and the other posters on the CD notably D'Cunha R., Stevenson P C., and Grzywacz D., (2003) Differential activity of *Helicoverpa armigera* nucleopolyhedrovirus on cotton, chickpea and tomato. Proceedings Society of Invertebrate Pathology Annual meeting Burlington USA 25-30th July 2003.

A 12 minute film was also made that described the activities of the project and was shown at seminars and presentations – notably on loop for several hours at the Science Museum in London. This has been distributed to project partners and a copy has been burned on to the FTR CD.

The results of the field and laboratory data on the successes of NPV in farmers field is presently in preparation for submission to the journal *Crop Science*. It was not possible to publish this before the end of the project since the final field data was returned only in August 2003. Another paper has also been submitted:
Pande, S., Stevenson, P.C., Grzywacz, D., Narayana Rao, J., and Neupane, R.K. (2003) The Adoption of integrated crop management of chickpea for poverty alleviation in the Nepal Terai. *Plant Disease*. (submitted).

3.0 CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

The present study successfully promoted the adoption of crop protection technologies for improving the productivity and reliability of chickpea in small holder farms in Nepal.

The following factors were hypothesized to influence uptake and adoption.

- The institutional set-up for research and dissemination.
- Available crop protection strategies or technologies.
- Dissemination methods employed.
- Farmer circumstances.

It is evident that the institutional set-up for research and dissemination does exist. In the majority of cases, inadequate resources appear to be a constraint for both research and extension. There is therefore a need to form partnerships in order to make the technology generation and dissemination process more responsive to farmers needs. The public, private and NGO sectors, working as service providers together with the farmers, ought to be involved in the research and dissemination process. This would appear to be a feasible arrangement given the dwindling resources for agricultural research and extension.

It is also evident from the present study that the key attribute of any given crop protection technology is demonstrable efficacy and availability of technologies. For that reason, the majority of chickpea producers in Nepal should continue to employ chemical control methods since the *Hear*NPV alternative is not presently available. Given the quality associated with chemical control strategy and increasing reports of insecticide resistance, there is an even greater need for establishing *Hear*NPV as a widely available alternative.

The present study revealed an array of pathways for disseminating crop protection outputs. NARC appears to have adequate and functional extension system but Department of Agriculture (DoA) were conspicuous in their absence from collaborations with NARC. We are led to believe that relations between NARC and DoA are poor and since DoA is the principal extension service in country it is essential to break this barrier down and promote the knowledge from this project through that government department for nationwide adoption.

3.2 Recommendations to all stakeholders

A Promotion and uptake

1. The NARC and DoA should cooperate to expand the successes of this project throughout the country.
2. Private sector: seed sellers and agrochemicals distributors need to be encouraged to ensure sustainability.

B. Technology generation

1. A nationally co-ordinated stakeholders group should be set up in Nepal. This body should:

- Provide for regular interaction among stakeholders.
- Ensure more involvement of stakeholders in technology generation and evaluation.
- Ensure involvement of farmers in influencing research priorities.

2. Alternative sources of financing for promotion should be sought. It is also recommended that research should be funded by those who need it e.g. seed sellers and the agro-industry.

3. To ensure sharing of information among stakeholders, a data bank of available agrochemical Companies giving information on success and quality.

4. A committee comprised of stakeholders should be set up to ensure constant monitoring of pests, diseases and related problems.

5. Farmer – extension – adoption of IPM should be improved by training more key farmers (farm leaders) in pest problem identification and application of technologies.

6. Extension workers should be given the necessary resources and motivation to enable them do their work in a way that matches the needs of farmers.

C. Technology dissemination

1. Public sector extension should be strengthened through:
   - Provision of resources such as means of transport.
   - Routine training of staff to enable them keep up with the changing technologies.
2. Coordination between disseminators should be improved so that they can work closely especially linkages between NARC and DoA and NARC and NGOs.
3. More resources should be allocated to research institutions and AIC to enable them disseminate information/technologies to all stakeholders and farmers.
4. Effective communication methods, which employ demonstration techniques such as field days and FFS, should be used more often for disseminating technologies.
5. Optimum communication networks should be identified and stimulated
6. Food security and storage should be addressed
7. The information disseminated to farmers should be simplified with out losing the principal activities
8. Innovative approaches to the existing extension strategy should be adopted. These include:
   - Farmer field schools
   - Village/Community approaches
   - Training of stockists/other input providers countrywide
   - Commercialising of certain activities (e.g. extension activities in seed distribution)
9. Technologies should target the right groups in extension e.g. the youth, women, etc.
10. Determine the feasibility of NPV production and distribution in Nepal with strict quality control.

11. Distribution of Mini kits is one way of investing small amounts of national capital to demonstrate the opportunities farmers can reap with chickpea. The following is a breakdown of the cost of technologies for a farmer to sow and manage 1 Katha (0.033Ha) of land.

Inputs listed below with cost breakdown for 1 katha (336sqm)

- Seed – 1.5kg NRs 45
- Seed treatment components including Rhizobium NRs 10
- Fertilizer (DAP) NRs 40

• Fungicide for BGM	NRs 25
• Insecticide for Pod borer	NRs 35
• Plastic bag (for dry storage of seed for next year)	NRs 10
• Information leaflet	NRs 15
TOTAL =	NRs 180

Return for 1 katha = 25 – 40 kg @ NRs 30/kg = NRs 750 - 1200

This is an overestimate of investment cost but returns are still excellent and should be enough to convince a significant proportion of farmers to continue practise without financial help. Department of Agriculture will not pay for this mini-kit at present owing to lack of money but would be willing to distribute if money is provided by a large scale funding body. So for 5000 farmers the additional cost would be approximately US$ 17,000. With an estimate of 25-50% farmer take up this seems the best way to have long-term impact. The only thing not included in the cost above is sprayer use/hire but some aspects of the practise should be left to farmers and there are very simple sprayers available that cost as little as NRs 200 (see opposite).

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Appendix 1. Administrative divisions of Nepal.

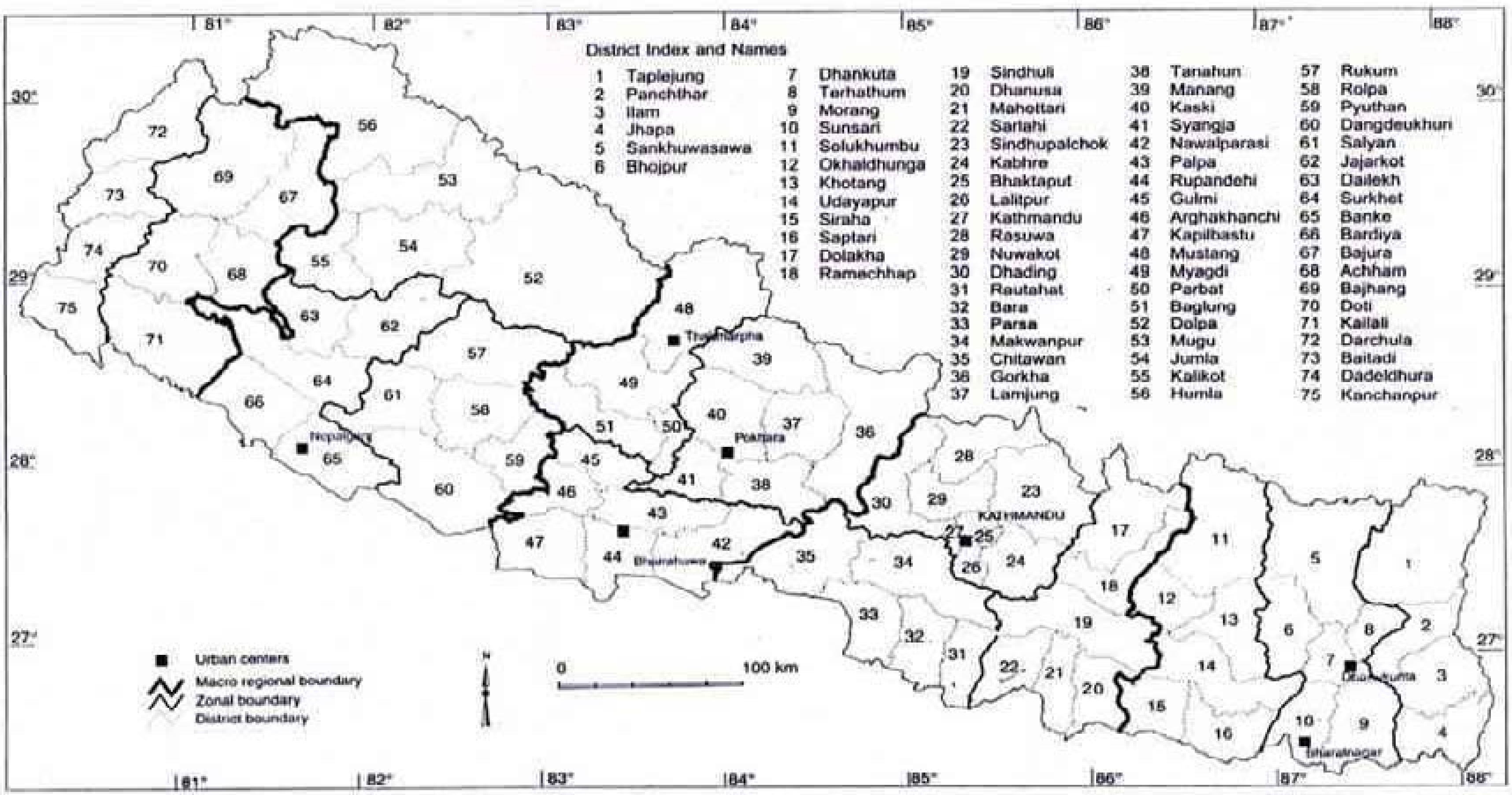


Figure .1. Administrative divisions (districts) and major urban centers in legume-growing areas of Nepal.

Appendix 2. Physiographic Map of Nepal

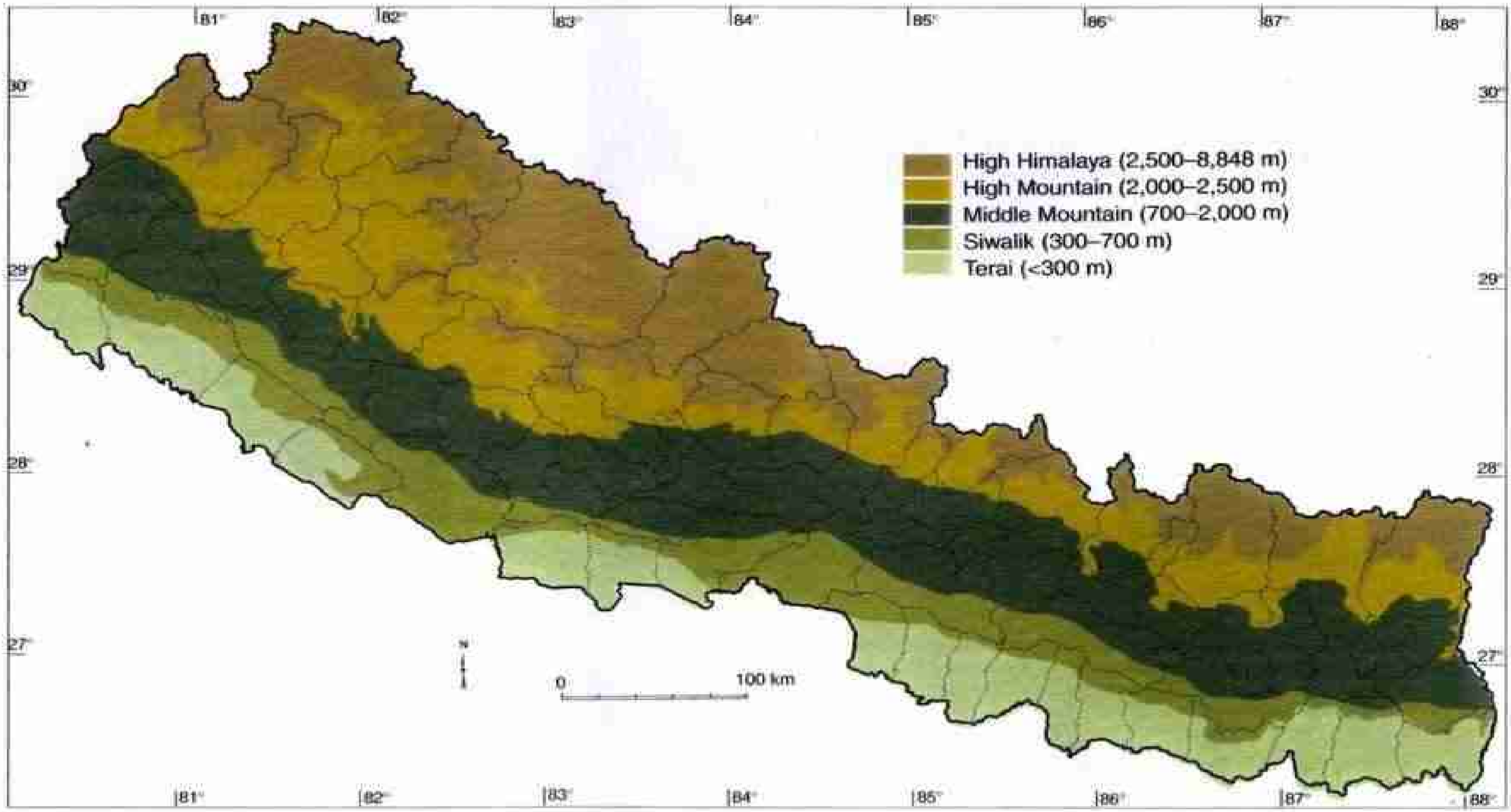
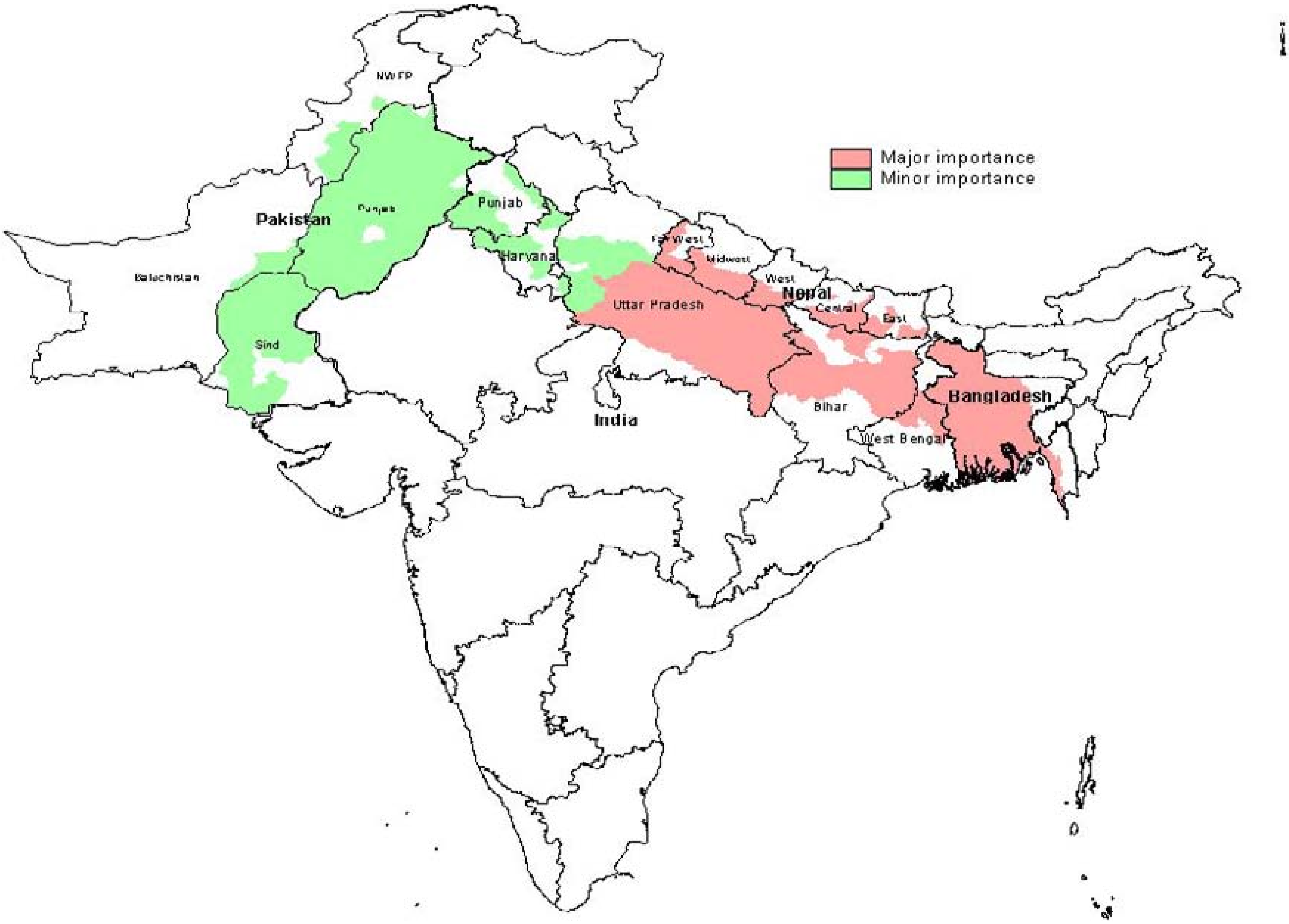
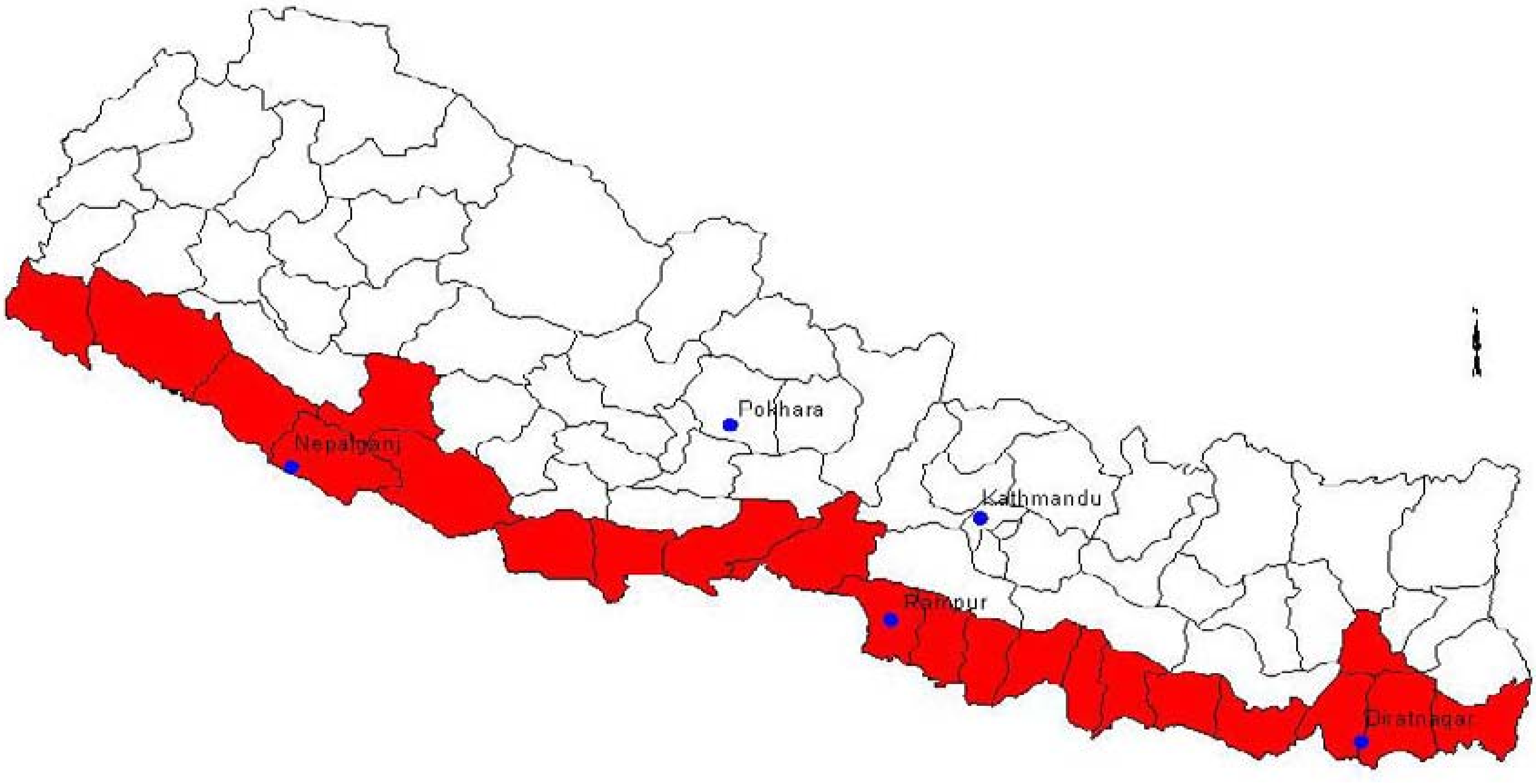


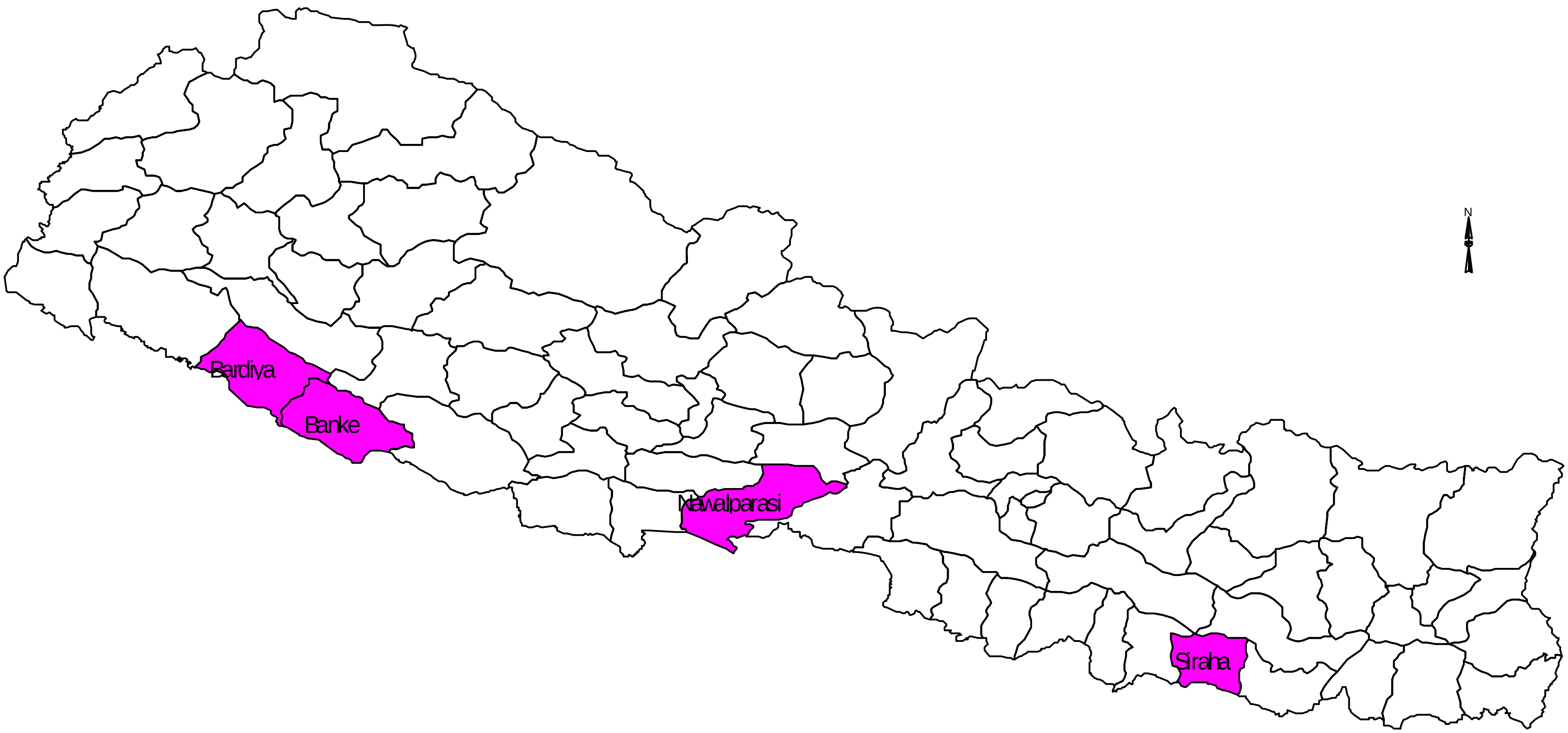
Figure 2. Physiographic regions of Nepal (Source: Topographic Survey Branch, Department of Survey, His Majesty's Government, Nepal, 1983).

Appendix 3. BGM of Chickpea in the Indo-Gangetic

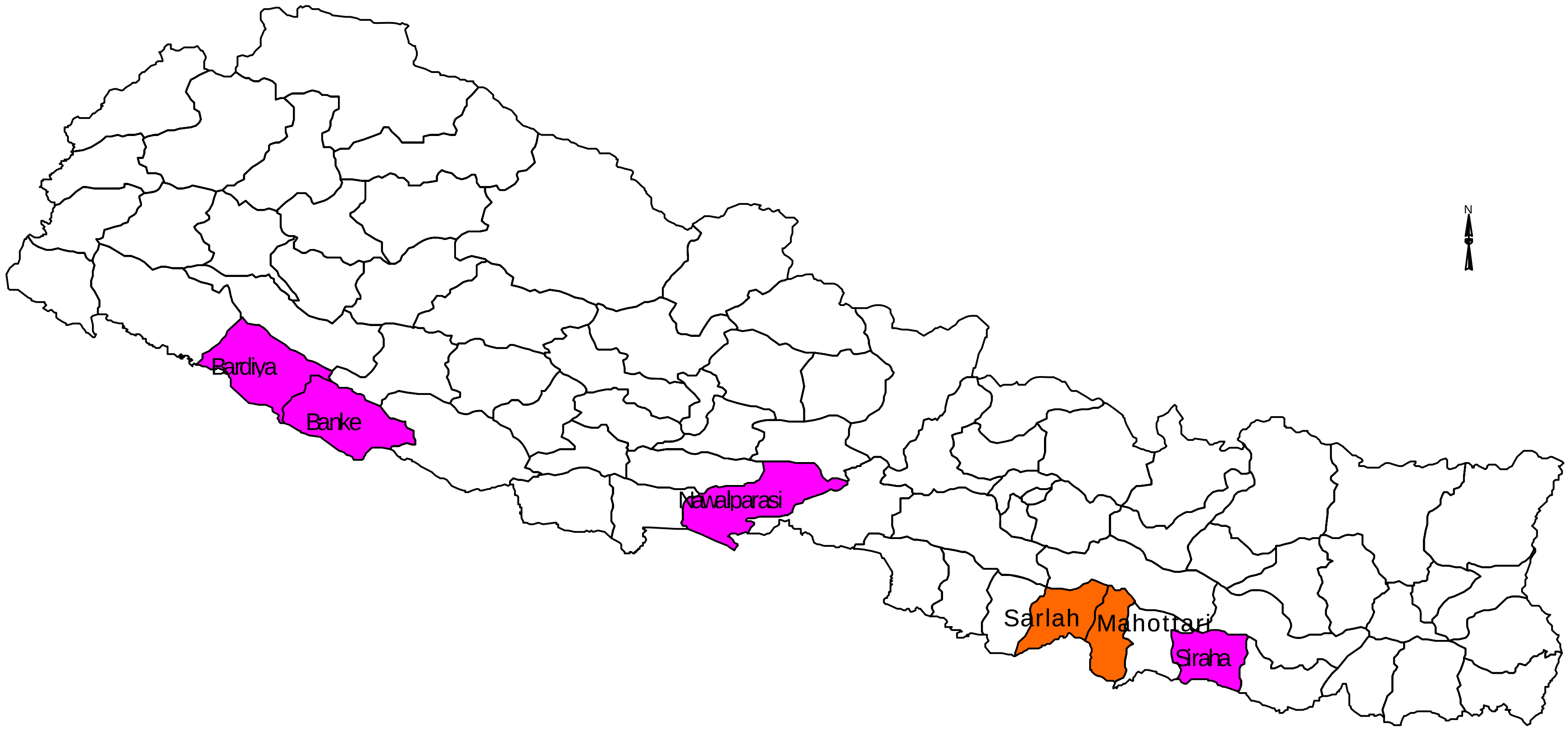


Appendix 4. Botrytis Gray Mold (BGM) epidemic of Chickpea/Lentil-1997-98

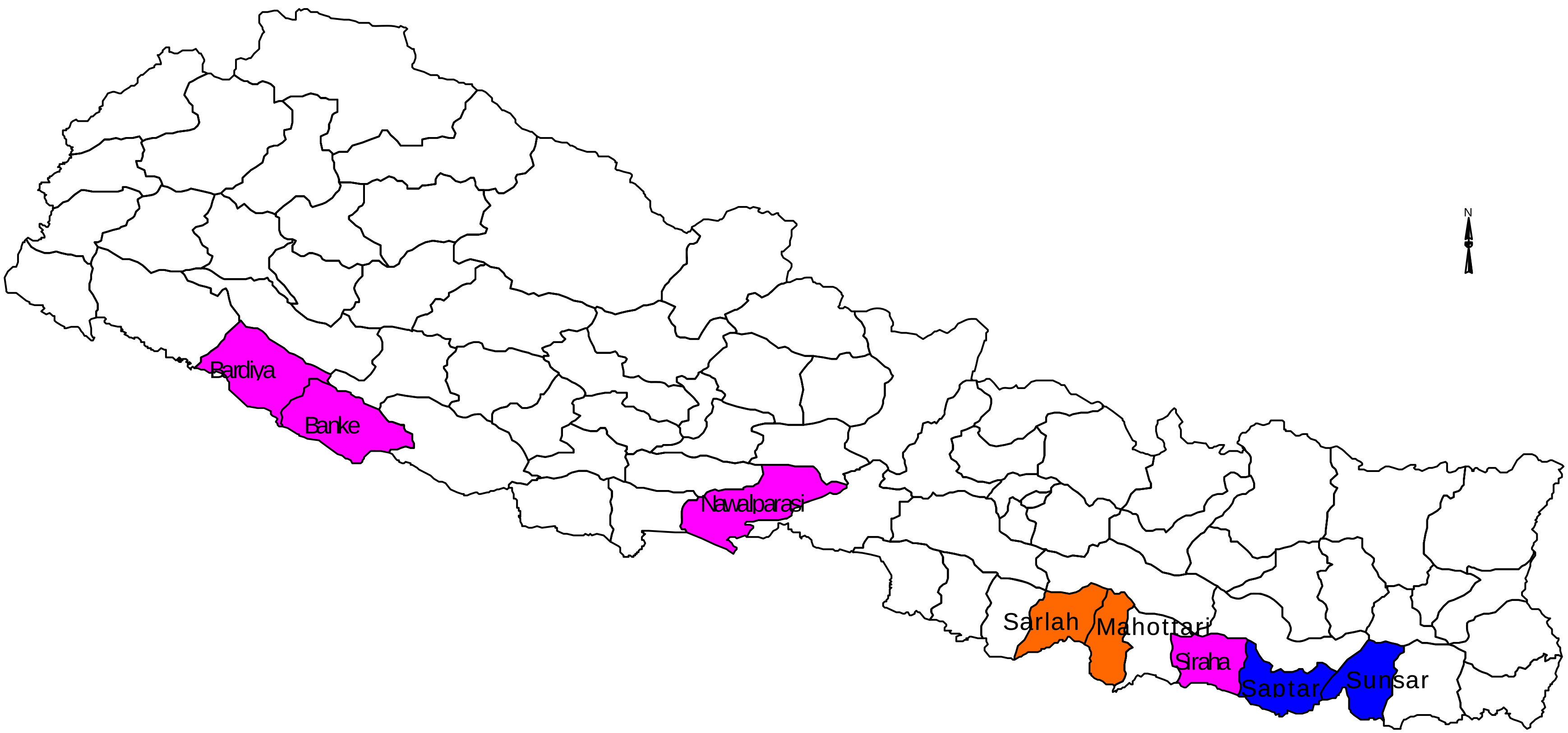




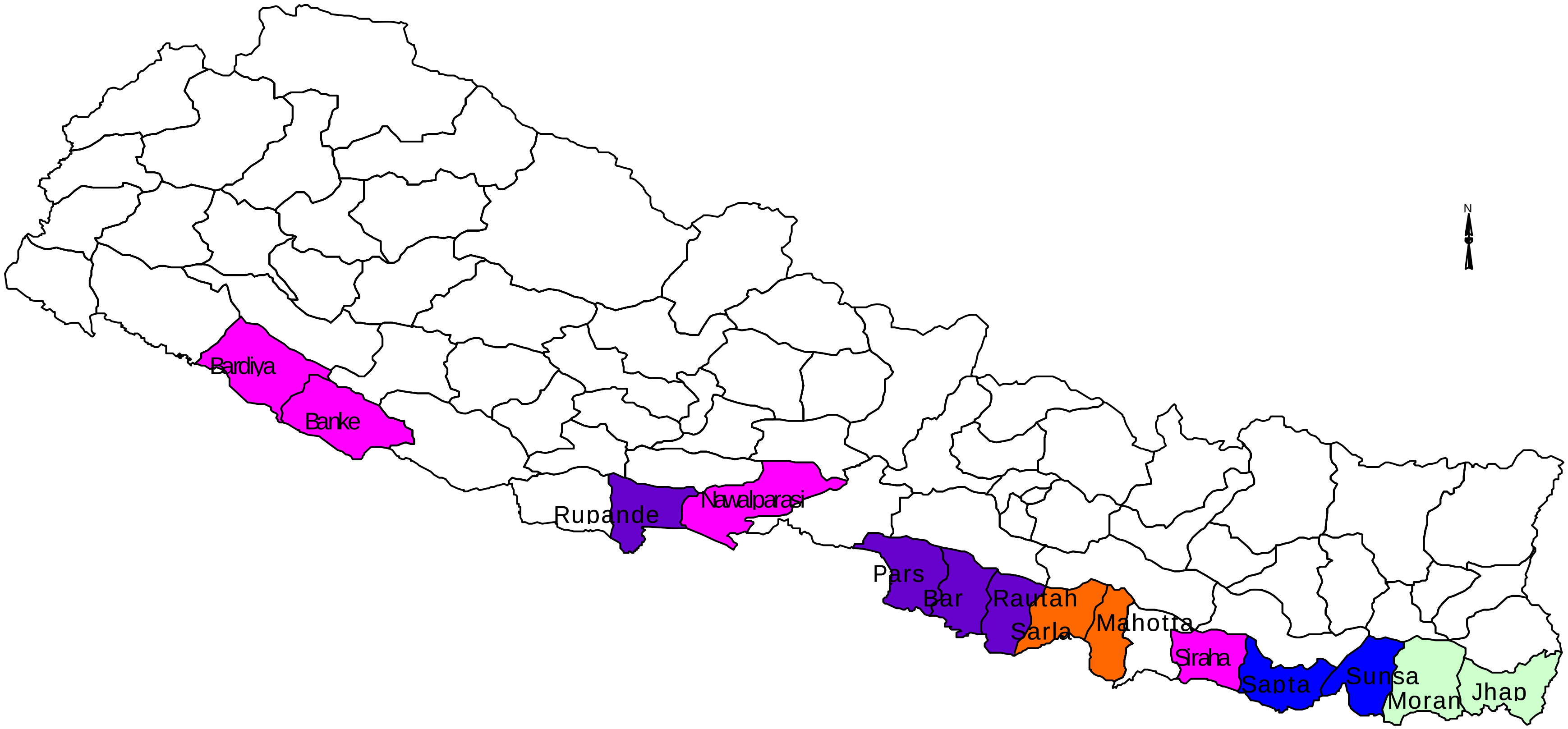
Appendix 5. Previous project : 1999-2000 Rehabilitation of chickpea through IPM
ADB RETA 5711 No. of farmers – 110 (4 Districts)



Appendix 6. Year 1 : 2000-2001 Rehabilitation and further expansion of chickpea through IPM CPP R7885 & ADB RETA 5711. 503 farmers in 6 Districts



Appendix 7. Year 2 :2001-02 Expansion of chickpea IPM in Nepal
ADB RETA 5945 & DFID/NRI R7885 – 1100 farmers in 8 Districts)



Appendix 8. Year 3:2002-03 Expansion of chickpea IPM in Nepal
ADB RETA 5945 & DFID/NRI R7885 – 7000 farmers in 14 Districts)

Appendix 9

Description of the modified 1–9 point scale for Wilt and Root rots, BGM and plant stand

Description

1–9 Scale	Wilt and root rots	BGM	Plant stand
1	No mortality	No disease	Emergence ≥ 90%
2	Mortality 0–5% of the plants	Lesions on some plants; usually not visible.	Emergence ≥ 71–80%
3	Mortality 6–10% of the plants	Few scattered lesions; usually se after careful examination	Emergence ≥ 61–70%
4	Mortality 11–20% of the plants	Lesions and defoliation on some plants; not damaging	Emergence ≥ 51–60%
5	Mortality 21–40% of the plants	Lesions common and easily observed on all plants but damage is not great.	Emergence ≥ 41–50%
6	Mortality 41–60% of the plants	Lesions and defoliation common; few plants killed.	Emergence ≥ 31–40%
7	Mortality 61–70% of the plants	Lesions and defoliation common; 25% plants killed.	Emergence ≥ 21–30%
8	Mortality 71–80% of the plants	All plants with extensive lesions and causing defoliation and drying of branches; 50% plants killed.	Emergence ≥ 10–20%
9	Mortality 81–100% of the plants	Lesions extensive on all plants; defoliation and drying of branches; more than 75% plants killed.	Emergence ≥ 10%

Appendix 10 Survey questionnaire for mid term impact assessment.

Quick PRA/RRA of Livelihood in Nepal
(Instruction for the investigators kindly asks all the questions from the group. Let the group decides preferences etc. The investigators should not be suggestive to the farmers. The preferences should be in strong ordering only.)
Village Name:-
Block:-
District:-
Region:-

1. Group Name
   No. of Participant:-
   No of Male: -
   No of female: -
2. Decision making regarding new crop/varieties
   Male ☐ Female ☐ Both ☐ other ☐
3. Assets per family/farmer
   a. Livestock
   : Cow ☐ Ox ☐ Buffalo ☐ Horse ☐
   Goat ☐

   b. House:
   No. of houses ☐ No. of kuccha house ☐ No. of *Pucca* house ☐

   c. Agricultural Infrastructure:
   Plough ☐ Spray pump ☐ Improved seed ☐ Pump set ☐
   Tractor ☐ Other ☐

4. Most important expenditure priority of the group
   Food ☐ Cloth ☐ Education ☐
   Medicine ☐ Fertilizer ☐ Chemical ☐
5. Land details (Area in local unit per katha)

   Landless ☐ 0-5 ☐ 5-10 ☐
   10-15 ☐ 15-20 ☐ 20 & above ☐
6. a. Consumption preference out of all type food:
   I. ______________________________.
   II. ______________________________.
   III. ______________________________.

   b. Consumption preference out of pulses:
   I. ______________________________.
   II. ______________________________.
   III. ______________________________.

7. a. Production preference out of all type food:
   I. ______________________________.

II. ______________________________.
III. ______________________________.

b. Production out of all pulses:
I. ______________________________.
II. ______________________________.
III ______________________________.

8. Why preference in food consumption and production:
______________________________.
______________________________.
______________________________.
______________________________.

9. What is your main source of profit earning?
______________________________.
______________________________.
______________________________.

10. Is area of chickpea increasing, decreasing or constant
Increasing ☐ Decreasing ☐ Constant ☐

11. What type of land quality used for growing chickpea
____.

12. After using improved seed by how much did production of chickpea increase
____.

13. How do you spend profit of chickpea production?
____.

14. How much chickpea seed is stored
____.

15. From where do you buy seed, if not from project?
____.

16. If there is increase in work out of chickpea production, specify
____.

17. Why do you grow chickpea specify
____.

18. Why don’t you grow chickpea specify
____.

Appendix 11. Newspaper articles published about the project.

KATHMANDU, SEPTEMBER 10, 2000, SUNDAY

Chickpea Production: To Reduce Poverty

NEPAL is a country where rural poverty in pervasive and in which agriculture plays a dominant role in the economy. Pulse legumes are an essential component of the Nepalese diet. WHO recommend a daily intake of protein of 36g per person but the actual intake in Nepal is 9g/person/day and most of this comes from grain legumes rather than meat. Chickpea is one of the major grain legumes but in recent years there has been a decline in its production.

Secondary Crop

Chickpea is an essential secondary crop for resource-poor hillside farmers; these legumes are traditionally planted after the harvest of cereals (predominantly rice) in Nepal. Chickpea planted immediately after the rice harvest in November can utilise the residual moisture in rice fields and produce a successful winter crop. These legumes represent an important protein contribution in the diet in Nepal and also provide domestic animal food from crop residue.

However, in recent years a combination of fungal disease (BGM) and pod borer (*Helicoverpa armigera)* damage have caused high losses (up to 100per cent) in these cropping systems. As a result the area under chickpea production has now dropped from more than 25,000 ha. in 1994 to less than 17,000 ha. in 1998. This cultivated area now represents less than 6 per cent of the grain legume production in Nepal. Despite the reduction in domestic production chickpea is still very popular in Nepal owing to its taste and versatility so there is an increasing dependence upon imported chickpea from India and eslewhere, a costly alternative to domestic production. In fact, 90 per cent of chickpea consumed in Nepal is imported yet more than 300,000 hectares of rice paddy lies fallow during the winter.

A forerunner project between ICRISAT and NARC, funded by the Asian Development Bank, showed that BGM losses can be overcome and podborer damage conrolled through judicious use of chemical persticides and dramatic improvements in chickpea yield (up to 300 per cent) and therefore increased farm incomes, can be attained.

The long term ambitions of the project are: to increase the nutritional and financial security of the rural poor; to increase production of chickpea in Nepal and thus; overcome the production-consumption deficit and reduce foreign exchange costs to Nepal; improve urban consumption through lower market costs resulting from lower production costs and overall increased national production; to benefit rural women-enhancing family incomes and food security during the winter and to reduce the negative impact on Nepal's environment by promoting the adoption of ecologically sound pest control methods.

Over 500 farmers in the west and centre of Nepal (Nepalgunj areas and Chitwan) who had previously stopped growing chickpea because of the disease and insect problems are now growing it with renewed enthusiasm—confident that the major biological constraints to production can be managed with pesticides because harvests are profitable.

However, the current pest management practice is based upon the use of chemical pesticides. While initially effective, these approaches have negative environmental impact and evidence from India and elsewhere has shown that repeated use induces the development of resistance in the pests to the chemicals (the insects evolve ways of coping with the insecticides and are no longer affected by them). Consequently farmers may need to spray many times a season. Not only is this increasingly expensive for the farmers but the health, safety and ecological problems associated with the excessive use of chemical pesticides along with their decreasing effectiveness in managing pests mean that more sustainable alternatives need to be sought and promoted.

This project seeks, by developing new alternative, bio-rational technologies, to reduce farmer's dependence on environmentally damaging chemical fungicides and insecticides and replace them with environmentally acceptable and sustainable alternatives.

One alternative is natural resistance where plants defend themselves against attack but no chickpea varieties acceptable to consumers have suitable natural resistance to pod borers. The only current ecologically appropriate alternative to chemical insecticides is the use of bio-insecticides using nuclear polyhedrosis virus (NPV). NPV is a natural virus of the insect and has many advantages over conventional insecticides. The primary benefit is that it is as effective at controlling the insect as chemicals and the huge increase in its use in India, Australia and USA is testimony to this. It does have many other advantages over chemical pesticides as well.

For instance it is a naturally occurring virus that occurs globally wherever the pod borer is found thus has no negative ecological or environmental impact. It usually takes a few days to kill the insect and so the insect spreads the virus as it dies so needs to be sprayed less frequently than chemicals. It is non-toxic to humans and other animals and is highly specific to the pest insect and so unlike chemicals does not kill beneficial insects, the predator insects that feed upon crop pests in the field and help control the problem.

The use of HaNPV as a biological insecticide on chickpea has been developed by Natural Resources Institute under previous DFID funding in India where it has been successfully promoted to farmers by ICRISAT. The present project seeks to use the experience of this success to promote the use of this control strategy in Nepal and help increase chickpea production in the winter rice fallows.

Some natural resistance in chickpeas to BGM has been identified in some cultivars including Nepal varieties. These new varieties will be tested on station and on farm during the course of this project and will be promoted to farmers as an alternative strategy to dependence upon chemical fungicides.

Other appropriate technologies include seed priming, a basic technology where seeds are soaked in water for several hours before being planted. This practise increase the likelihood of successful seed germination and plant growth resulting in up to 50 per cent yield increases.

The combination of these efficient, environmentally safe and relatively low cost strategies will be promoted to farmers in Nepalgunj, Tarahara and Chirtwan through NGOs and NARC extension workers via farmer participatory schools and via promotion tools include information bulletins frequent meetings with farmer representatives.

Analysis

Economic analysis will ensure that adoption of these new technologies is appropriate bearing in mind farming systems local farmer group needs and gender issues particularly relevant to farms where men migrate for winter work such as tourism and building. Furthermore the economic analysis will address the possibility that policy obstacles may affect the adoption of the improved farming practices on the large scale but more importantly will ensure that the infrastructure obstacles such as processing and distribution facilities are brought to attention of government through NARC so they can be improved.

NATIONAL DAILY
THE RISING NEPAL
GORKHAPATRA ROLLS A CENTURY INFORMING THE PUBLIC
KATHMANDU, SEPTEMBER 8, 2000 (BHADRA 23, 2057) FRIDAY

Nepal can cash in on chickpea cultivation

BY A STAFF REPORTER

Kathmandu, Sept 7:

The workshop on 'Planning And Implementation of On-Farm Chickpea IPM in Nepal concluded today emphasising the need to promote seed multiplication and to popularise the crop among the farmers through successful on-farm demonstrations.

The workshop called upon the NGOs and the scientists working at the research stations in different parts of the Nepal to join hands in changing the outlook of the farmers towards chickpea cultivation.

"Efforts need to be directed towards converting Chickpea into a cash crop from its present status of subsistence crop," Dhruva Joshi, Executive Director of the National Agricultural Research Council (NARC) told the concluding session of the workshop.

He said that the multiplication of seeds needs to be given due consideration in order to expand Chickpea cultivation.

"The deliberations at the workshop have provided additional inputs to chart out a future action plan on Chickpea cultivation," Joshi said.

Nepalese scientists associated with the promotion of legume crops working at research stations in different parts of the country presented the working plans they had formulated in their respective command districts.

All the scientists emphasised the dissemination of training and orientation to the farmers before sowing the crop in their fields.

P.C. Stevenson working with the Natural Resource Institute based in the UK said that the workshop had been instrumental to assess the problems being faced by the scientists in their respective research stations.

He said that the workshop had also given a feedback on how the three year project on On-Farm Chickpea IPM in Nepal could be launched effectively to exploit the 300 thousands hectares of land and remains fallow during the winter season.

"The promotion of Chickpea cultivation holds a significant potential for Nepal whereby the income levels of the families can be increased and the food security of Nepal can be enhanced," Stevenson said.

NARC came up with a pragmatism strategy of involving the farmers in the workshop to assess their needs and problems.

The partners of the three-year project are Natural Resource Institute (UK), International Crops Research Institute for the Semi Arid Tropics (ICRISAT), NARC, Department of Agricultural of HMG and the farmers of the targeted areas in Nepal.

NATIONAL DAILY

THE RISING NEPAL

GORKHAPATRA ROLLS A CENTURY INFORMING THE PUBLIC

KATHMANDU, SEPTEMBER 7, 2000 THURSDAY

IPM could double *Chana* output

BY A STAFF REPORTER

Kathmandu, Sept 6:

Research carried out in the past two years has revealed that the annual production of Chickpea (Chana), which stands at 12,798 metric tonnes/hectare can be doubled through the integrated application of improved farming practices.

"Production of Chickpea can be doubled after the implementation of the Integrated Pest Management Programme (IPM)," Ram Krishna Neupane, co-ordinator of the Legume Crop Cultivation Programme based in Parwanipur said.

Botrytis Gray Mould a plant disease very rampant in misty weather and the pod borer, an insect that attacks the pods destroyed 90 per cent of the Chickpea crop in the year 1997/98, Neupane said.

A workshop on 'Planning And Implementation of On-Farm Chickpea IPM In Nepal, which is to chalk out a three year (2001-2003) comprehensive package for enhancing Chickpea cultivation started today.

The partners of the three-year project are Natural Resource Institute (UK), International Crops Research Institute for the Semi Arid Tropics (ICRISAT), National Agricultural Research Council (NARC), Department of Agriculture of HMG and the farmers of the targeted areas in Nepal.

Funding for the project has been extended by the Department for International Development (UK) through the Natural Resource Institute based also in UK and ICRISAT centred in India.

"Despite high rates of return demonstrated on investment in agricultural research, the resources for agriculture research have been severely constrained nationally as well as globally," NARC Executive Director Dhruva Joshi said.

Joshi pointing at the constraints said all the plannng workshops therefore must assess the contribution the research has done and the benefits farmers and the society have received in relation to particular commodity.

"A fundamental problem to overcome in increasing Chickpea production is to change the prevailing perceptions of its status as subsistence crop and accept it as commercial crop," Joshi said.

ICRISAT Director General William D Dar said, "We have developed and implemented collaborative workplans with Nepal, the most recent on on-farm IPM of Chickpea was implemented during 1998-99 and 1999-2000 soon after the Botrytis Gray Mold disease epidemic in Chickpea in 1997-98."

This farmers participatory IPM was a part of the Crop Diversification Project commonly know as S4 Project which was funded by the Asian Development Bank, Dar said.

He said that more than 56 Nepalese scientists and technicians had participated in various training programmes at ICRISAT and germplasm exchange had been a major activity. ICRISAT has supplied Nepal with a total germplasm 1025 accessions and breeding lines and advanced generation lines of Chickpea, he added.

P.C. Stevenson from NRI, UK said that emphasis would be given to move away from using insecticides and pesticides. "Use of resistant variety of Chickpea will be given priority to overcome the diseases," he said.

Stevenson said he had observed that 3,000 hectares of land in the terai region of Nepal was being left fallow in winter.

"Planting of Chickpea by adopting improved farming practices and resistant varieties would contribute significantly towards increasing the food security in Nepal," he said.