Integrated Crop Management of chickpea in Nepal: Past, present and future

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Abstract

Chickpea until recently was a major winter pulse crop in Nepal normally grown on residual moisture after harvest of rice. A severe botrytis gray mold disease (BGM) epidemic in 1997/98 devastated the crop in Nepal and the damage was two-fold. Not only did farmers lose their crop, they did not cultivate chickpea in the following season due to lack of seed and disillusionment with the crop. A collaborative program between the Nepal Agricultural Research Council (NARC), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and Natural Resources Institute (NRI) was launched on the Integrated Crop Management (ICM). The focus was on Integrated Pest Management (IPM) to fight diseases (BGM and wilt) and insect-pests (pod borer) to rehabilitate chickpea in the rainfed rice and maize based cropping systems in Nepal. The components of ICM technology included high yielding chickpea variety, Avarodhi (tolerant to BGM), treating seed with fungicide (Bavistin), wider row spacing, and applying need-based sprays of fungicide (Bavistin) to control BGM, and need based application of insecticide, Monocrotophos® or Endosulfan® (Thiodan) and biocide (Nuclear Polyhedrosis Virus NPV) for the management of pod borer. In the 1998/99 seasons, ICM technology was evaluated in 110 farmers' fields, and large yield responses were obtained. The following season saw a five-fold increase in adoption of chickpea using the ICM package. This number multiplied to 1100 farmers in 2000/01, 7000 farmers in 2001/02, 15,000 farmers in 2002/03 and 21,000 farmers in 2003/04. The overall mean grain yield obtained by adopting ICM (2.5 t/ha) was

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124.5% greater than yield from non-ICM farmers. The increase in net income for chickpea cultivation attributable to ICM was two to six-fold. Further on-farm ICM of chickpea resulted in: 1) increase in family income by 80-100%, 2) increase in protein consumption by 40%, 3) increase in brick and mortar houses by 22%, 4) increase in labor use by 20%, 5) increase in household expenditures by 45%, and 6) increase in livestock ownership by 30%. Chickpea performance for profit and wealth was $216 per farmer that resulted in increase in overall wealth of 3500 project farmers by $750,000. In addition to these contributions, a farmer-friendly BGM disease forecasting system was developed and village level farmer-owned seed systems and IPM schools were initiated to sustain chickpea in Nepal. The ICM technology used so successfully in Nepal also holds great potential for chickpea in BGM-prone areas in India and Bangladesh.

Introduction

Chickpea (C*icer arietinum* L.) is the most important leguminous crop for vegetarian diets in Nepal, as it is a rich source of proteins and essential amino-acids. It is remunerative and has high water use efficiency. It fixes atmospheric nitrogen, improves soil fertility and maintains the sustainability of cropping systems. During the past three decades, average yields of chickpea have declined or remained static (600-700 kg/ha); the crop has been virtually eliminated from rice- and maize-based cropping systems in the country. Biotic, abiotic and socioeconomic constraints are responsible for low yields of chickpea (Pandey et al. 2000). The major biotic constraints are seed/soil-borne diseases [wilt caused by *Fusarium oxysporum* and root rots caused by *Rhizoctonia solani* and *R. bataticola*], foliar diseases [botrytis gray mold (BGM) caused by *Botrytis cinerea*] and pod borer (*Helicoverpa armigera*). Drought, poor soil fertility and mineral deficiency are among the location-specific abiotic constraints. Together these biotic and abiotic stresses cause losses to the chickpea crop. Inadequate incentives by the government along with the poor minimum support price (MSP) system are the main socioeconomic constraints to chickpea production.

In this paper, we discuss past initiatives on collaborative research and development on chickpea in Nepal; processes and approaches in establishing on-farm farmers' participatory research (FPR) on Integrated Crop Management (ICM), quantification and prioritization of constraints for economical chickpea production, the present status of ICM, and future research needs.

The specific objectives of ICM of chickpea in Nepal were to:

- Identify constraints and opportunities for chickpea production by using participatory rural appraisal (PRA).

- Develop and validate ICM packages including IPM components that are appropriate and affordable to poor farmers.
- Scale-up and rehabilitate chickpea through ICM in rice- and maize-based cropping systems especially in rainfed fallow lands.

Past initiatives: Research and development on chickpea, 1978-1997

Technical collaboration on chickpea research and development (R&D) between ICRISAT and NARC was started in late 1970 with the exchange of germplasm and trait specific trials/nurseries. These included germplasm such as international chickpea screening nursery-desi-duration long (ICSN-DL); international chickpea screening nursery desi-duration medium (ICSN-DM); international botrytis gray mold nursery (IGMN) and international wilt and root-rot screening nurseries (IWRRN) and breeding lines selected by NARC scientists during their visits and participation in the annual chickpea scientists meet at ICRISAT. Further, some emphasis was laid on transfer of technology in the early 1990s and the Asian Grain Legumes On-Farm Research (AGLOR) was initiated in 1991 with support from the United Nations Development Programme (UNDP/ICRISAT). Technical collaboration with ICRISAT continued through the Cereals and Legumes Asia Network (CLAN). In addition to CLAN activities from 1994 to 1997, ICRISAT further expanded R&D activities on chickpea through the ADB project, *Legumes-based technologies for enhanced productivity of rice-wheat system in the Indo-Gangetic Plains*. The present DFID-funded project on *IPM of chickpea in Nepal* was linked with the ADB project in 1997 and this is presently ongoing.

In general, in the past three decades, attempts to overcome biotic constraints of chickpea production in Asia and in Nepal mainly focused on the use of chemical pesticides and/or host-plant resistance. These single factor management strategies to combat biotic and/or abiotic constraints were studied in isolation to each other. As a result, the yield losses caused by pest/disease epidemics along with poor agronomy, remained alarming and significant.

There is a greater opportunity to combine best-bet technologies that combat insect-pests and diseases with improved agronomical practices and emerge with an ICM package. The ICM of chickpea provides greater scope and need for its validation, scale-up and scale-out with the involvement of farmers for farmers.

Present successes: Processes and approaches of FPR and ICM, 1998-2004

Participatory rural appraisal (PRA)

Before on-farm FPR on ICM was established, and constraints for economical chickpea production quantified and prioritized, informal and formal surveys, and group meetings were organized in 20 villages across the country to be acquainted with the farmers' experiences on chickpea production and marketing.

During the formal survey intended to diagnose production constraints of chickpea, a multi-stage stratified random sampling technique was employed to select chickpea producers. At the first stage, five eco-regions of the Terai – Eastern, Central, Western, Mid-Western and Far-Western – were stratified based on administrative boundaries. At the second stage, 16 districts were randomly selected depending upon the extent of chickpea area across all five regions. In the third stage, villages were selected randomly from the selected districts. Finally, chickpea producers were selected randomly from each village amounting to 500 producers. The distribution of the selection was based on the probability proportionate criteria.

The target villages in the districts of Banke, Bardia, Rupendehi, Nawalparasi, Sarlahi, Mohottari, Bara, Parsa, Sirha, Saptari, Sunsari Morang and Jhapa were selected by formal and informal visits, and meetings with village heads and farmers. In each selected village, a meeting was held with farmers and IPM was explained. Participation was then solicited on a voluntary basis. Additionally, IPM orientation camps and schools were held thrice during the crop season (Pande et al. 2001).

Collection of data: Data was collected in a questionnaire that was specifically structured in Nepali, through personal interviews with producers. Questions were raised on general information about producing chickpea, land use patterns, enterprise choices, economics and benefits of chickpea vis-a vis other competitive crops, and constraints of chickpea production. Information was also sought on marketing and consumption of chickpea. Data was analyzed in different modules: the status of chickpea in sample farms, the economics of its production, the benefits of its production and its constraints.

Formation of Integrated Crop Management trials

Integrated Crop Management is a holistic approach that coordinates available crop and pest management technologies in an economically and ecologically sound manner. One major component of ICM is a high yielding, disease-tolerant (especially BGM/wilt) chickpea cultivar. High levels of disease resistance to these diseases, however, are yet to be identified. Other major components include seed treatment with fungicide (carbendazim), improved agronomical practices such as seed treatment with *Rhizobium*, seed priming (soaking the seeds for 8 hours in water before sowing), wider row spacing, and applying need-based sprays of carbendazim/chlorthalonil for BGM management and need-based insecticides such as Monocrotophos®/Endosulfan® (Thiodan) and biocide, Nuclear Polyhedrosis Virus (NPV).

On-farm trials consisted of two treatments: ICM and non-ICM. The non-ICM package consisted of a local cultivar with none of the inputs given to the ICM package.

For pest management, the trial consisted of two treatments: IPM and non-IPM. The IPM package included improved cultivar Avarodhi; seed treatment (2 g/kg seed) with a mixture of commercial fungicides; Thiarm + Bavistin in 1:1 ratio; application of Rhizobium inoculum (210 g/ha); di-ammonium phosphate (100 kg/ha), boron (whenever needed @ 500 g/ha) and need- or weather-based foliar spray with chemical pesticides (fungicide and insecticides) to control BGM and *Helicoverpa* pod borer. The non-IPM package consisted of a local cultivar with none of the IPM inputs. Fungicide, Bavistin (Carbendazim) 1 g/liter of water and 250 liter fungicide solution/ha to control BGM and insecticide, Thiodan (Endosulfan) 3 ml/liter of water and 250 liters insecticide solution/ha were used to manage pod borer.

Results

Findings from participatory rural appraisal (PRA)

Chickpea yields are very low (<0.5 t/ha) in Nepal. Diseases and pests are the main reasons for poor yields. The five Bs, ie, Boron deficiency, Bhilt (wilt), Botrytis gray mold (BGM), Borer and Bruchids, are the major constraints for its production. Of these, BGM [*Botrytis cinerea* (Pers. ex Fr.)], Fusarium wilt [*Fusarium oxysporum* f. sp. *ciceri* (Schlecht.)] among diseases, and pod borer [*Helicoverpa armigera* (Hub.)] among insects are economically significant. Weather conditions usually favor BGM development during the vegetative and reproductive growth stages of the crop and this can cause severe damage, and even result in total crop failure (Pande et al. 1998).

The salient findings from PRA can be summarized as follows:

- Chickpea can be grown more efficiently in Nepal because of the availability of large area of rice fallow lands (390,000 ha), demand and market.
- IPM is a new concept and about 75% farmers have no knowledge of its components, while 25% are aware of pest control by a thumb rule judgment.

- Chickpea in Nepal is declining at a very alarming rate because of the severe incidence of diseases and insect pests. Other contributing factors are:
  - Non-availability of quality seed
  - Non-availability of suitable pest-resistant varieties
  - Inadequate improved agronomical practices
  - Adulterated pesticides and bio-pesticides
  - Poor promotion of IPM packages
  - Seed loss in storage
  - Insufficient training and incentives

Findings from ICM trials

The results of on-farm ICM trials over several years with emphasis on IPM were:

- The incidence of wilt and root rot was less than 10% in ICM plots while it was about 70% in non-ICM plots.
- BGM was substantially controlled in ICM plots while the disease aborted upto 100% flowers and killed upto 80% plants in non-ICM plots.
- Pod borer damage was significantly less (≥ 5% damaged pods) in ICM plots than in non-ICM plots (30-50%).
- Two- to six-fold increase in grain yield (upto 4 t/ha) was obtained in ICM plots over the non-ICM plots (Fig. 1).
- Two- to five-fold increase in net income (Fig. 2).

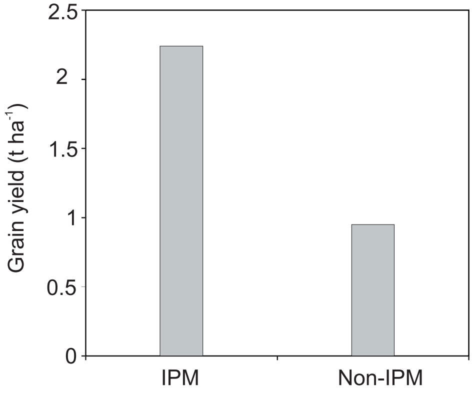

Fig. 1. ***Grain yield of chickpea in ICM and non-ICM on-farm trials, Nepal.***

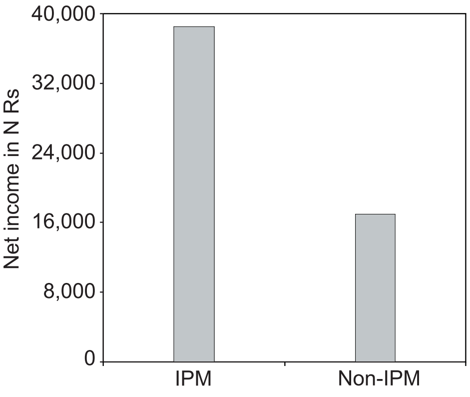

Fig. 2. Net income from ICM and non-ICM on-farm trials, Nepal.

Adoption and impact of ICM

In the 1998/99 season, the new chickpea line Avarodhi bred by ICAR was sown in the fields of 110 farmers. The following season saw a five-fold increase in chickpea adoption. The good news kept spreading, and by 2000/01, 1100 farmers were sowing chickpea. The best news was that IPM technology was firmly adopted by 21000 farmers during 2003/2004 season (Fig. 3). The Nepali farmers are happy that their chickpea fields are flourishing once more. The adoption of ICM has had a measurable impact on the livelihood of resource-poor farmers and has resulted in increase in the overall wealth of 3500 project farmers by $750,000. A summary:

- Increase in family income by 80-100%
- Increase in protein consumption by 40%
- Increase in brick and mortar houses by 22%
- Increase in labor use by 20%
- Increase in household expenditures by 45%
- Increase in livestock ownership by 30%
- Chickpea's total contribution to profit and wealth was $216 per farmer

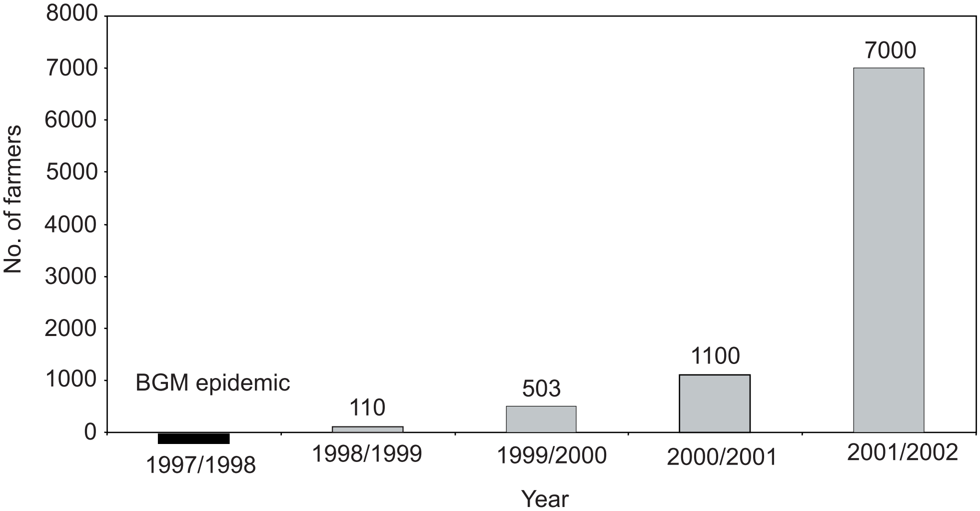

Fig. 3. Adoption and expansion of ICM of chickpea in Nepal, 1997/98 to 2001/02.

Future needs

In spite of the rational combination of the various management options available, the severity of disease/pest outbreaks remains significantly high. Therefore, effective, economical and eco-friendly components of IPM still need to be developed. Among promising approaches are broad-spectrum antagonistic biocontrol agents and the introduction of antifungal or insecticidal genes into commonly cultivated chickpea. These are being vigorously investigated in national as well as international research institutions. *Trichoderma* and *Pseudomonas* spp. proved effective in the control of BGM and wilt. A combination of fungicide tolerant *T. viride* and reduced fungicide was found effective in the management of BGM.

Transgenic crops offer hope to combat diseases wherein genetic resistance does not occur. The introduction of polygalacturonase inhibiting proteins (PGIP) and chitinase into chickpea can provide resistance against BGM/AB; this research is in progress at ICRISAT and its collaborating Institute, Scottish Crops Research Institute (SCRI), UK. Research efforts to identify molecular markers associated with resistance to BGM, AB and pod borer are in progress, which rapidly enhance resistance screening in breeding programs. Additionally, disease/pest resistance was identified in few wild accessions of C. *bigujum*, C. *judaicum* and C. *reticulatum*. Since adequate levels of resistance to AB, BGM and pod borer have not been identified in the cultivated C*icer* spp., attempts are on to transfer the resistance from wild C*icer* spp. into cultivated varieties through wide hybridization and embryo rescue techniques. Meanwhile, ICM technologies with available management options remain the best alternative currently available for higher production and economically sustainable yields.

Conclusion

All participating farmers expressly preferred the IPM package. IPM technologies included sowing of an improved BGM tolerant variety, treating seed with fungicide, wider row spacing and need-based sprays of fungicide and insecticide. The seed yield increase attributable to IPM was two- to six-fold and resulted in higher net incomes. IPM technologies, used so successfully in Nepal, also hold great potential for India and Bangladesh, which face similar problems.

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