

Farmers' Participatory Integrated Crop Management with Special Reference to Fungal Diseases of Vegetable Chickpea

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Abstract

Chickpea (*Cicer arietinum* L.) is grown both as a vegetable and a grain legume in the rice and/or wheat cropping systems (RWCS) of the Indian subcontinent. Its green grains are a rich source of protein in the vegetarian diets of poor. However, the profitable cultivation of chickpea is constrained by fungal diseases, [Fusarium wilt (FW), Ascochyta blight (AB) and Botrytis gray mold (BGM)] and pod borer. We reintroduced chickpea in RWCS following integrated crop management (ICM) technology in collaboration with farmers in India, Nepal, and Bangladesh. The ICM included wilt resistant chickpea cultivars, seed priming, *Rhizobium* inoculations, seed treatment with fungicides, reduced seed rate, and need-based fungicide and insecticide sprays. Following ICM several thousand farmers have reestablished chickpea cultivation for vegetable and grain purposes in the RWCS.

INTRODUCTION

Green leaves and pods of chickpea (*Cicer arietinum* L.) are consumed as vegetable throughout India, Nepal and Bangladesh. Though the dry grain yield potential of chickpea cultivars is up to 4 t/ha but actual yields are only about 0.79 t/ha. Chickpea production is constrained by fusarium wilt [FW, *Fusarium oxysporum* Schlechtend Synd. and Hans. f. sp. *ciceris* (Padwick) Synd. and Hans.], botrytis gray mold [BGM, *Botrytis cinerea* (Pers. ex Fr.)], ascochyta blight, [(AB, *Ascochyta rabiei* (Pass.) Labr.), and pod borer [*Helicoverpa armigera* Hubner]. Growing resistant cultivars is most economical to combat diseases and pests. High levels of resistance to FW are available in chickpea varieties but not to AB, BGM and pod borer (Pande et al., 2000). Fungicides have been identified to minimize losses caused by AB (Pande et al., 2005) and BGM (Pande et al., 2006). However, these single-factor disease and insect management measures have rarely been integrated in a chickpea production package. We initiated the process of identifying, refining and repackaging of available components of chickpea production and protection as an integrated crop management (ICM) technology and promoted in participation with farmers in Nepal, Bangladesh and India.

MATERIALS AND METHODS

Farmers' Participatory Rural Appraisal (PRA)

Structured PRAs were conducted in India, Nepal and Bangladesh to identify the constraints and opportunities of chickpea production. Data was analyzed to quantify the status of chickpea crop and used to select districts, villages, and farmers willing to grow chickpea following ICM technology with out any financial and input assistance.

Identification of Components of Integrated Crop Management (ICM)

Identification of individual components of ICM was done in on-station and on-farm experiments. Since AB and BGM were major constraints of vegetable chickpea production and high levels of resistance to manage these diseases was not available, deployment of available moderate levels of resistance in good agronomic background and judicious application of fungicides for AB (Pande et al., 2005) and BGM (Pande et al., 2006) control were selected as components of ICM. Cultivars selected had high levels of resistance to FW. Need based application of insecticide (Shahzad and Shah, 2003) was included to control pod borer. Seed treatment (Pande et al., 2005) was included to control seed born FW. Since the epidemics of both AB and BGM are favored by microclimate, 60-cm wider-row-spacing was included. Soil application of peat formulation of *Rhizobium* (210 g/ha) at the time of planting in Nepal, and 5 g/kg seed as seed inoculants in Bangladesh and India was included to improve nodulation of chickpea crop. Location specific application of boric acid at 500 g/ha was added in the ICM package to alleviate flower and pod drop, and need based fertilizer were included in the ICM package (Pande et al., 2006). Crop establishment was enhanced by seed priming wherever needed (Harris et al., 2005).

Integration of Components of Integrated Crop Management (ICM)

The ICM technology was a combination of the single-factor options for the management of FW, AB, BGM, pod-borer, poor nodulation and nutrient deficiency (boron). Avarodhi (ICC 14344), Vaibhav, ICCV 10 (for India), Tara (ICC X 840508-36) (for Nepal), and BARI- Chola 5 (for Bangladesh) were found highly resistant to FW. These five lines were found high yielding and adapted to local growing environment in these countries, and hence were selected as components of location specific ICM (Table 1). Fungicide sprays schedules were coincided with the vegetative-flowering and pod-formation to pod-development stages of the crop. To manage pod borer, insecticide Thiodon was sprayed once during flowering and twice during pod-filling stages (Pande et al., 2006).

Farmers' Participatory Validation and Expansion of ICM

Farmers' participatory ICM was conducted in collaboration between the Nepal Agriculture Research Council (NARC), Kathmandu, Nepal; Bangladesh Agricultural Research Institute (BARI), Joydebpur, Bangladesh; National Institute for Integrated Pest Management (NCIPM), New Delhi, India, Indira Gandhi Agricultural University (IGAU), Raipur, Chhattisgarh, and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India. In each selected village, meetings were held with farmers and the objectives of the on-farm ICM trials of chickpea were discussed. Along with ICM, a control (non-ICM) treatment was included for comparison (Table 2).

RESULTS

Findings from Participatory Rural Appraisal (PRA)

The PRA indicated that chickpea production has drastically declined due to diseases, insect damage, and non-availability of seeds of improved and high yielding varieties, and lack of improved production technologies and their extension. Chickpea can be grown more efficiently in rainfed rice fallow lands of Bangladesh, Nepal and India because of demand and market.

Findings from Participatory Validation and Expansion of ICM

Between 1998 and 2002 the ICM of chickpea was firmly established in more than 20,000 farm holdings in Nepal and in > 1200 small holders in Bangladesh and >1500 in India (Table 1). Country wise progress of ICM of chickpea is as follows:

1. **Nepal.** During 1998/99 the ICM trials were demonstrated in 110 farmers and in the following season there was five fold increase in the number of farmers adopting ICM. It

kept on spreading and 1100 farmers were sowing chickpea following ICM by 2000/01. The ICM was adopted by 7000 farmers during 2001/02 and 11000 during 2002/03 seasons. Effect of seed priming was superior in ICM-plots than non-ICM plots. Nodulation was significantly more in the ICM than in the non-ICM. Wilt was significantly ($P < 0.005$) low (up to 2%) in all ICM-plots than non-ICM plots across all locations. ICM plots had significantly ($P < 0.005$) lower severities of BGM and pod borer damage than non-ICM plots. Significantly ($P < 0.005$) higher grain yields were recorded in ICM (2.2 t/ha) than non-ICM (1.0 t/ha) across location in all the years (Table 2).

2. Bangladesh. Plant stand was more in the ICM-plots than in the non-ICM plots and nodulation was near two folds in the ICM than the non-ICM across locations. Local varieties in Bangladesh with dense canopies were highly prone to diseases and pests and gave poor yields (0.4-0.5 t/ha) in non-ICM. Response of the ICM package on yield was 300% more than the farmers' practice. On an average grain yield was > 2 t/ha (Table 2).

3. India. On-farm ICM validation trials were conducted in RWCS in Uttar Pradesh and Rajasthan while they were in the rice fallows in Chhattisgarh. Seed priming enhanced the plant stand in the ICM in rice fallows than the non-ICM. Rhizobium inoculation improved the nodulation significantly. There was a significant reduction in the incidence of pod borer and wilt at all the locations in India. The grain yield was more than two folds in the ICM-plots than the non-ICM plots (Table 2). Among foliar diseases only Ascochyta blight was noticed in traces in Rajasthan and Uttar Pradesh, and its severity was significantly less in the ICM plots.

DISCUSSION

Since high level of resistance to AB, BGM and pod borer was not available in chickpea varieties, agronomic management in conjunction with the best available FW resistant varieties was used to minimize the damage by AB, BGM and pod borer. The extent of nodulation, scored on a 1 to 5 rating scale was 3.7 in *Rhizobium*-treated plots in contrast to 2.0 in untreated plots across locations. Seed priming was found useful where chickpea germination and emergence was constrained due to drying of soil in the seed zone specifically in the upland rainfed rice fallow lands. A single management strategy for foliar diseases will not be adequate to limit the development of AB (Pande et al., 2005) and/or BGM (Pande et al., 2006). Our results also indicated that ICM that includes minimal application of fungicides, manipulation of sowing date, wider row spacing and growing of tall and erect genotypes could increase yield of chickpea in BGM and AB disease-prone areas in India, Bangladesh and Nepal. A number of management options to limit the fungal disease of chickpea have been identified, which need to be refined through farmer participatory trials. The ICM technology developed at ICRISAT was successful in rehabilitating chickpea in Nepal (Pande et al., 2006), Bangladesh (Bakr et al., 2002) and India. Introduction of similar ICM technology in the upland rice fallow lands of central, eastern, and western India and parts of Pakistan is desirable. All participating farmers expressed their preference for ICM package as increase in green pod and seed yield attributable to it was two to six- folds, and resulted in higher net incomes. The demonstration and limited expansion of ICM technologies used so successfully at selected locations in Nepal, India and Bangladesh, also hold great potential for its expansion to other areas which face similar problems

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Tables

Table 1. Major components of integrated crop management in India, Nepal and Bangladesh.

Components	Nepal ¹ (1998-2005)	Bangladesh ² (2000-2005)	India ³ (2000-2005)
Cultivar	Avarodhi, Tara	BARI Chola 5	ICCV 10, Vaibhav
Seed treatment	Thiram + Bavistin	Vitavax 200	Thiram + Bavistin
Rhizobium	5 g/kg seed	5 g/kg seed	210 g / kg seed
Seed priming	+	+	+
Boron	+	- ⁵	- ⁵
Seed rate	40 kg/ha	37.5 kg/ha	60 kg/ha
Fertilizer	DAP 100 kg/ha	TSP 100 kg/ha	DAP 100 kg/ha
Fungicide ⁶	Bavistin: BGM	Bavistin: BGM	Bavistin: BGM
			Chlorothalonil : AB
Insecticide ⁷	Thiodon	Thiodon	Thiodon

¹Nepal: The ICM trials with emphasis on the management of wilt and BGM were established in 22,000 farmers in 12 districts (Banke, Bardia, Rupandehi, Nawalparasi, Parsa, Bara, Rautahat, Sarlahi, Mohattari, Siraha, Saptari, and Sunsari).

Seed treatment was at 3 g (1:1) Thiram + Bavistin /kg after Rhizobium + Cow dung and coating.

²Bangladesh: The ICM trials with emphasis on the management of wilt and BGM were established in 1250 farmers in 7 districts (Pabna, Kushtia, Rajbari, Jhenaidah, Faridpur, Magura, and Jessore).

Seed treatment was at 3 g Vitavax/g of seed after Rhizobium seed inoculation.

³India: The ICM trials with emphasis on the management of wilt, BGM and AB were established in 1500 farmers in 7 districts (Raipur, Hazaribagh, Bhagpat, Meerut, Gaziabad, Karnal, and Jaipur)

Seed treatment was at 3 g (1:1) Thiram + Bavistin/kg after Rhizobium

⁴Approximately 8 hrs before sowing

⁵Not applied in India and Bangladesh

⁶Fungicide for foliar application to control BGM and AB

⁷Insecticide application to control *Helicoverpa* pod borer

Table 2. Effect of integrated crop management on different parameters from 1998 to 2006¹.

Observation ²	Nepal (1998-2001)		Bangladesh (2002-06)		India (2002-06)	
	ICM	Non-ICM	ICM	Non-ICM	ICM	Non-ICM
Plant stand ³	2.3	3.0	2.6	3.1	2.0	3.5
Fusarium wilt and root rots severity ⁴	2.0	5.1	2.2	5.4	2.0	4.0
Botrytis gray mold severity ⁵	2.7	8.0	2.2	7.5	3.0	7.7
Ascochyta blight ⁵	- ⁶	-	-	-	2.0	4.0
Pod borer damage ⁷	4.0	46.6	3.7	45.4	4.5	52.5
Nodulation ⁸	3.5	2.1	3.7	2.0	3.5	2.2
Total plants at harvest (/M ²)	28.1	22.3	31.2	20.4	25.0	19.0
Number of pods per plant	72.3	37.7	85.6	30.8	75.4	29.6
Grain yield (t/ha)	2.2	1.0	2.5	0.75	2.2	0.78

¹Mean values were based on 180 ICM and non-ICM trials in 18 villages of 11 districts in Nepal, 15 ICM and non-ICM trials in 12 villages in 7 districts in Bangladesh and 12 ICM and non-ICM trials in 7 villages in 7 districts in India. All mean values in ICM treatment differ significantly ($P < 0.01$) from non-ICM in all 3 years.

²Plant stand an indication of seed priming was recorded 30 days after sowing; all other observation presented was recorded at harvest.

³Plant stand was recorded on a 1 to 9 rating scale, where 1 = >90% emergence and 9 = <10% emergence.

⁴Severity of Fusarium wilt and root rots was recorded on a 1 to 9 rating scale, where 1 = no plant mortality and 9 = 80 to 100% plants killed by Fusarium wilt and/or root rots.

⁵Botrytis gray mold and Ascochyta blight severity was recorded on a 1 to 9 rating scale, where 1 = no infection and 9 = 81 to 100% defoliation of leaves, flower and pod infection, and complete drying of stem.

⁶- Not observed

⁷Pod borer damage was measured as percentage of damaged pods compared with total pods on five randomly selected plants.

⁸Nodulation was recorded at harvest on a 1 to 5 visual rating scale, where 1= poor nodulation < 5% root mass covered with nodulation and 5= profuse nodulation > 80% of the root mass covered with nodulation (Pande et al., 2006).