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Original Research Article

On - farm demonstrations of *Trichoderma harzianum* in pulse crops under rainfed conditions of Bundelkhand - A case study

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A B S T R A C T

On- farm demonstrations on *Trichoderma harzianum* were undertaken to empower farmers and show the potential against root rot complex and wilt disease in major pulse crops. Accordingly, a project was implemented during 2008-2011 in six villages with 620 farmers under rainfed conditions of Sumerpur Block, Hamirpur district in Bundelkhand of Uttar Pradesh. The identified native strain of *Trichoderma harzianum* (IPT 31) was multiplied and supplied to farmers for seed treatment in chickpea, lentil and pigeonpea crops. The results showed that the overall reduction in plant mortality due to root rot complex over control was 32.1% and 14.3% in chickpea and lentil, respectively. However, the reduction in wilt incidence was observed 26.7% in chickpea and 25.9% of lentil. Further, the percent increase in yield over the control was 16.6% and 12.6% in chickpea and lentil, respectively. The additional yield in chickpea and lentil from *T. harzianum* application was received 1.30 q/ha and 0.93 q/ha with economic gain of ₹ 2600 and ₹ 2800/ha. The impact of *T. harzianum* in pigeonpea was observed to a lesser extent. The availability of soil moisture played an important role in effectiveness of *Trichoderma*. The increase in awareness and knowledge on nature, role and benefits of *T. harzianum;* methods of application, source of availability and market price was observed between 20 to 70 percent.

Keywords

On- farm demonstration, Pulses, Rainfed, Root rot and *Fusarium* wilt, *Trichoderma harzianum*

Introduction

Pulses are rich source of vegetative protein and play an important role in nutritional security of a substantially vegetarian population of India. The pulse crops are invariably grown under risk-prone rainfed environments. The comprehensive assessment demonstrated that current yield under rainfed farming is 2-5 folds lower than the achievable potential yield due to low rain-water use efficiency (35–45%) in most rainfed areas (Dar *et al.* 2009). Bundelkhand region consisting of 7 districts of Uttar Pradesh and 6 districts of Madhaya Pradesh comes under rainfed farming. The region is considered to be the pulse bowl of Uttar Pradesh as it shares about 50% area and 45% of total pulse production in the state (Anonymous 2007). However, several

constraints cause low productivity in pulses in this region. Soil borne fungal diseases such as *Fusarium* wilt and root rot complex (*Fusarium solani, Sclerotium rolfsii, Rhizoctonia solani, R. bataticola* etc) are causing 10-50% yield losses in farmers' field of Bundelkhand region. It was reported that low yield of chickpea due to wilt was the major problem in district Mahoba of Bundelkhand (Singh *et al.* 2009). Majority of farmers are practicing crop rotations and mixed cropping of linseed and sorghum as a measure against wilt disease. In addition, there is a major shift from lentil and chickpea to fieldpea in many locations as fieldpea is relatively less affected by wilt and root rot. Although the recommended practice of deep summer ploughing minimizes insects and diseases, yet it is sometimes not feasible in clay soils. Moreover, sudden variations in weather conditions such as temperature, humidity and frost caused higher aggravation of the diseases. Therefore, there is a need for an aggressive extension campaigns against the major pulse diseases in different seasons for their effective management.

Use of bio-agents such as *Trichoderma* spp. is helpful in managing fungal diseases in chickpea, lentil and pigeonpea and also enhances the growth of plants. Several isolates of *Trichoderma* spp. were characterized and evaluated against different fungal pathogens of pulse crops (Dubey *et al*., 2007). The inoculation of seeds with antagonists helps in managing externally seed and soil borne pathogens. Talc based formulation of *Trichoderma* spp. has been used to coat seeds (Harman, 1991, Mukhopadhaya and Mukherjee, 1991; Chaudhary and Kumar, 1990). Further, *Trichoderma harzianum* (wheat bran powder granules) has been used for management of pigeonpea and chickpea diseases (Prasad and Rangeshwaran, 1999).

It was reported that *Trichoderma* was not under use in chickpea, lentil and pigeonpea at village level in Hamirpur district of Uttar Pradesh (Purushottam *et al*. 2012). Since pulses are mainly grown by small and marginal farmers, therefore, cost effective and eco-friendly technologies i.e. *Trichoderma* spp. need to be popularized among farmers. In fact, availability of good quality native *Trichoderma* spp. is a great concern to farmers. Efficiency of native *Trichoderma* strains is reported to be more effective than from other ecosystems. Further, *Trichoderma* promotion will not only empower and motivate farmers for adoption and diffusion of technology but also hastens production and productivity of pulses and gain higher farm income. Therefore, keeping in view of the above facts, on- farm demonstrations were undertaken by supplying native *Trichoderma harzianum* strain (IPT-31) under the project to empower and show potential of technology among farmers for the management of wilt and root rot complex in major pulse crops.

Materials and Methods

The study was carried out in Hamirpur district of Uttar Pradesh. Out of seven community development blocks in district, Bharuwa Sumerpur block was selected. Six villages namely, Baank, Baanki, Bilhari, Soukhar, Narayanpur and Nadehra were adopted from this block. The land use pattern of selected villages revealed a total cultivable area of 3297 ha (nearly 88%) out of the total geographical area of 3766 ha. Acreage of crop sown during *rabi* (2551 ha) was higher over *kharif* (1211 ha). The characteristics of soil indicated the existence of both light soil (popularly known as *Parua* and *Rankar*) and heavy type of soil (also called as *Mar, Kabar*). The sowing time for chickpea and lentil were first and second

fortnight of October and for pigeonpea second fortnight of July. Besides the sowing of chickpea and lentil in line these pulses are also mixed with linseed and mustard.

The isolate IPT 31 (*T. harzianum*) is native to Bundelkhand region of Uttar Pradesh was identified at IIPR, Kanpur. Its multiplication activity was started well in advance at a laboratory so that same could be supplied at opportune time for *rabi* and *kharif* pulses under demonstrations where the idea was to supply a fresh quantity of *T. harzianum* for better results. The isolate IPT 31 was inoculated on sterilized broken sorghum grain in conical flask using grain and water in 1:1 ratio (W/V) and incubated at 28 ± 1^0C for 10 days. The *T. harzianum* grown sorghum grain was taken out from the flasks and dried at 30 ^{0}C temp for a week in a laminar hood. The grains were grinded to a fine powder and sieved through 200 mesh sieves. A total of 40g *T. harzianum* inoculum was mixed with per kg of talc powder (400 mesh) and 10 g Carboxy Methyl Cellulose (CMC) was also added for improving the binding ability of the formulation. The population of propagules was adjusted 10^9 CFU/g formulations. Thus, total 278 kg quality formulation of *T. harzianum* was prepared and supplied to farmers in packets (500, 250, 100 gm) as per their requirement for chickpea, lentil and pigeonpea, respectively.

Trainings and demonstrations were conducted for generating awareness and enhancing the farmers' knowledge and skills. Accordingly, one institutional training cum exposure visit and 26 field trainings were organized in coordination of state agriculture department and para extension agents. The trainings were participatory in nature where lecture and group discussions were mainly used for transferring the scientific knowledge to the farmers.

The pulse crops chickpea, lentil and pigeonpea were sown in 650 field level demonstrations covering 260 hectares and 620 farmers under adopted villages (Table 1) during 2008-11.

Results and Discussion

Reduction in root rot: The mean incidence of root rot in chickpea at 30 DAS in *Trichoderma* treated seeds was 9.5% against 14.0% in untreated plots. Total percent reduction due to root rot over control was 32.1 in chickpea. Similarly, the mean incidence of root rot complex caused by *Rhizoctonia solani, Sclerotium rolfsii* and *Fusarium solani* in lentil at 30 DAS was 15.5% against the untreated plots of 18.1%. Thus, overall reduction over control was 14.3% in lentil. Plant mortality due to root rot complex was lower in the *Trichoderma* inoculated seed of chickpea and lentil (Table 2). It is reported that *Trichoderma harzianum* and *Trichoderma virens* based seed dressing formulation Pusa 5SD and soil application formulations Pusa Bio pellet 16G and Pusa Bio granule 6 were used for management of dry root rot and wet root rot of chickpea respectively (Dubey *et. al.* 2011: Dubey *et al.* 2012).

Root rots caused plant mortality in chickpea and lentil at an early (seedling) stage. The lentil is grown in distant fields from the village boundary caused poor monitoring might results in more disease infestation. The root rot complex causes lower plant population in fields and to overcome the problem, farmers often use higher seed rate in lentil and chickpea causing higher cost of cultivation. Farmers perceived that light rains help in reduction of disease incidences and they were also aware that repetition of pulse based cropping systems also causes infestations.

Reduction in wilt: The mean incidence of wilt in chickpea observed at 80 DAS in *Trichoderma* treated plot was 8.8% whereas; it was 12.0% in control plots. Similarly, the incidence of wilt in lentil was 10.3% in *Trichoderma* seed treated plots whereas, incidence of disease in control plot was 13.9%. The overall reduction over control was 26.7% and 25.9% under chickpea and lentil, respectively (Table 3). It is also reported that both in dry and wet seed treatments isolates IPT 2, 4, 6, 8, 11, 19, and 31 effectively reduced the wilt incidence by 23.0 to 53.5% compared to control (Trivedi S. *et al*., 2013). Hasan *et al.* (2013) observed a total of 64% reduction in plant mortality by soil inoculation of *Trichoderma hamatum* in sick field.

The farmers had lesser knowledge to differentiate between the wilt and dry root rot and generally referred to as wilt (*Chatka/Uktha*). The rainfed sites were more prone to wilt. Mostly, lentil is grown as rainfed crop while chickpea cultivated under limited or life saving irrigation. Also, to derive maximum benefit out of residual moisture, lentil is usually sown in heavy soils (*Mar)* where as chickpea is grown in soil ranging from heavy to sandy loam (*Parua/Kachar*). The farmers believed that applying one irrigation at flowering stage in chickpea lower incidences of wilt.

The level of moisture in soil has a relationship with the wilt incidences as the higher level of moisture is usually associated with low level of wilt incidences. The soil moisture level is also determined by field leveling, depth of ploughing, summer ploughing, bunding, fallow/rotational crop, weed intensity, mixed/inter cropping, broadcast or line sowing etc. Further, the delayed sowing in *Rabi* season due to local festival like *Dashara* etc and social factors aggravated wilt incidence as low moisture profile in February and March.

It was also observed with participating farmers that the inoculated field had higher plant height, better root growth, dark leaf colour, higher nodulation and more plant vigour in chickpea before flowering which clearly established the role of *T. harzianum* in plant growth promotion. In addition, the healthy plants had offered more resistance to diseases and thereby lowering the plant mortality due to diseases. The successive application of *Trichoderma* increases population load in field causing better crop performance.

Thus, the losses from root rot and wilt diseases in chickpea and lentil could successfully be minimized by application of *T. harzianum* seed inoculation. As referred that seed treatment with *T. harzianum* caused reduction in chickpea and lentil plant mortality 25 and 28%, respectively in Hamirpur district of Bundelkhand (Singh S.K. *et al*., 2009). Also, Rawat *et al*. (2012) reported that *Trichoderma* found effective against *Sclerotium rolfsii* and *Fusarium oxysporum* f.sp. *ciceri* in lentil and chickpea. Further, Sunil C. Dubey *et al*. (2007) found that integration of *T. harzianum* (10^6 spores/ml/10 g seed) and carboxin (2 g kg^{-1} seed) for seed treatment was the best which reduced wilt incidence (44.1–60.3%) during experimentations in chickpea.

Increased seed yield: The chickpea and lentil were harvested in first fortnight of March and second fortnight of February, respectively. The seed yield was estimated through crop cutting followed by farmers' information. Mean seed yield in chickpea was 9.1 q/ha under the seed treated plots in comparison to untreated one 7.8 q/ha (Fig 3) resulting in overall 16.6% increase in chickpea yield.

Similarly, mean seed yield in lentil was 8.0 q/ha in comparison to control 7.1 q/ha. The total percent increase in yield compare to

control was 12.6% (Fig 4). It was reported that seed treatment with *Trichoderma harzianum* caused average yield increase in chickpea and lentil 11 and 5.6%, respectively in Hamirpur district of Bundelkhand (Singh S.K. *et al.* 2009).

The wide variation was found in yield levels among chickpea as well as lentil fields especially due to nature of soil, input use, crop management and socio-personal factors of the farmers. The observations showed that seed yield of lentil and chickpea was low due to prolonged frost followed by rains in the December-January during 2009-10 and 2010-11. The heavy rains caused more vegetative growth and flowers drop. Further, the soil moisture also played an important role in yield and effectiveness of *Trichoderma*. In fact, there were continuously 4 drought years since 2004-05 in Bundelkhand region. A rainfall deficit was recorded as 25, 33, 45 and 56% in 2004-05, 2005-06, 2006-07 and 2007-08, respectively. Paradoxically, when there was drought in several parts of Uttar Pradesh in 2008-09, there was good rainfall in Bundelkhand region. Good rains in 2008 after several years of drought caused adequate soil moisture retention, lower incidences of diseases and better yield in pulses. Further, percent deviation in rainfall in 2008 and 2009 was -20.35 and -40.0 in the region. Again, total rainfall between April 2010 – March 2011 was 626.5 mm but it was 516 mm during July-Sept 2010. The rain fall distribution pattern during 2010-11 showed that number of rainy days was 16 in July and August but just only 4 in Sept. Maximum rainfall of 60 mm in just a day was also received in month of Sept. Lack of rains in December and almost nil in January and February caused heavy water stress on crop resulting in poor yield.

Effect on kharif pulses (pigeonpea): Pigeonpea was sown as mix crop with sorghum under poor/refuge soils. High plant population and heavy weed affected crop performance. The unleveled fields also caused more moisture variations during *kharif* season. The impact of *T. harzianum* in pigeonpea was observed to a lesser extent due to long duration of the crop. The average incidence of wilt was observed less than 5% in pigeonpea. Trivedi N. *et al.* (2013) tested different species of *Trichoderma* against *F. udam in* laboratory. They found that 85.7-96.4% reduction in spore production of *F. udam* over control.

Increase in income and other impacts: The average additional seed yield from *T. harzianum* was 1.30 q/ha and 0.93 q/ha thus economic gain of ₹ 2600/- ₹ 2800/- per ha (chickpea and lentil) were realized (Table 4). Further, the environmental and social gains of bio-agent's use are largely over looked while considering the economics. The adverse effects of pesticides in terms of soil, water and air pollution, detrimental effects on other beneficial organisms and creatures, health hazards to human being and domestic animals and the development of pesticide resistant pest population are the established and known facts.

The increase in awareness and knowledge on nature, role and benefits of *T. harzianum;* methods of application, source of availability and market price was observed 20 to 70 percent. Rate of purchase of *T. harzianum* in adopted villages had increased in open market and at Block Development Office. The awareness and confidence level in district agriculture personnel was also increased. The present study has demonstrated that *T. harzianum* can be used for controlling root rot complex and wilt disease in chickpea and lentil as low-cost input for sustainable agriculture under rainfed.

Table 1 *Trichoderma* demonstrations in chickpea, lentil and pigeonpea

Crop	Number of demonstrations	Number of farmers	Area covered (ha)
Chickpea	300	290	120
Lentil	250	230	100
Pigeonpea	100	100	40
Total	650	620	260

Table 2 Plant mortality (%) in chickpea and lentil due to root rot

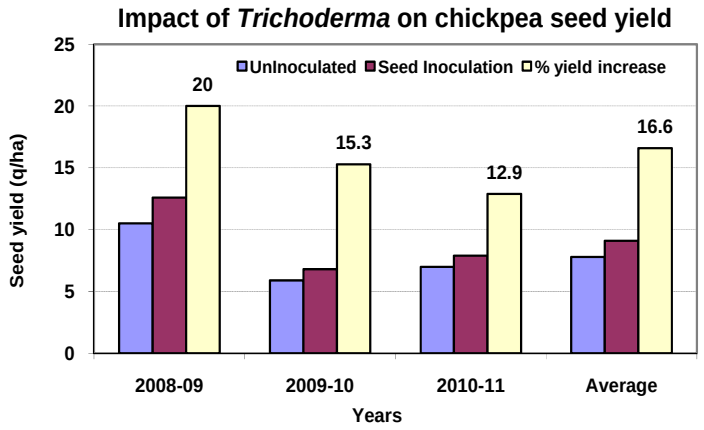
Period	DAS	Chickpea		Lentil	
		Uninoculated (control)	Seed inoculated	Uninoculated (control)	Seed inoculated
2008-09	30	15.3	8.6 (43.7)	21.9	16.6 (24.2)
2009-10	30	13.2	10.1 (23.5)	17.2	15.2 (11.6)
2010-11	30	13.5	9.7 (28.1)	15.7	13.6 (13.4)
Mean	-	14.0	9.5 (32.1)	18.1	15.5 (14.3)

Data in parenthesis indicates % reduction over uninoculated (control)

Table 3 Plant mortality (%) in chickpea and lentil due to wilt

Period	DAS	Chickpea		Lentil	
		Uninoculated (control)	Seed inoculated	Uninoculated (control)	Seed inoculated
2008-09	80	13.1	7.4 (43.5)	16.0	10.9 (31.9)
2009-10	80	11.3	9.3 (17.7)	13.3	10.4 (21.8)
2010-11	80	11.7	9.7 (17.1)	12.5	9.7 (22.4)
Mean	-	12.0	8.8 (26.7)	13.9	10.3 (25.9)

Data in parenthesis indicates % reduction over uninoculated (control)



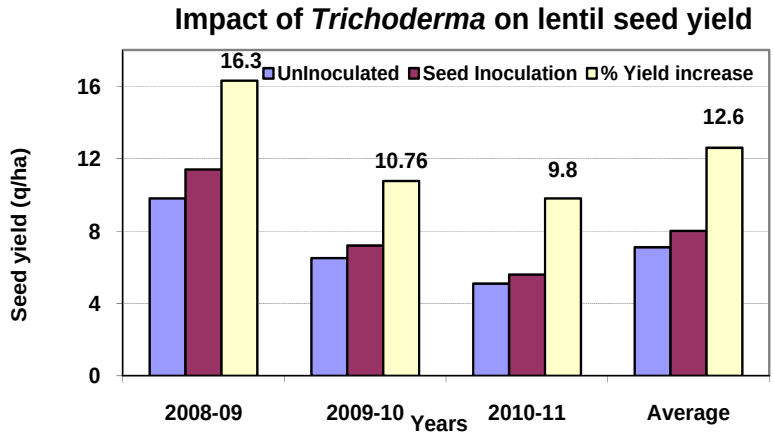


Table 4 Economic gain (₹/ha) of *Trichoderma* application

Crop	***Trichoderma* (g/ha)**	**Additional yield (q/ha)**	**Economic gain (₹)/ha)**
Chickpea	500	1.30	2600
Lentil	300	0.93	2800

Based on price of seed = chickpea@₹ 2000/q and lentil@₹3000/q

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