Indian Journal of Agricultural Sciences **87** (10): 1283–7, October 2017/Article
https://doi.org/10.56093/ijas.v87i10.74794

Management of wilt and root rots of chickpea (*Cicer arietinum*) using *Trichoderma harzianum* in India

S C DUBEY[1], BIRENDRA SINGH[2], O M GUPTA[3], D R SAXENA[4], O P SHARMA[5], O D KOHIRE[6], V P ANADANI[7], R K SINGH[8], S K SINGH [9] and ARADHIKA TRIPATHI[10]

ICAR-Indian Agricultural Research Institute, New Delhi 110 012

Received: 14 April 2017; Accepted: 19 June 2017

ABSTRACT

Wilt (*Fusarium oxysporum* f. sp. *ciceris*), dry root rot (*Rhizoctonia bataticola*) and collar rot (*Sclerotium rolfsii*) are the major soil-borne diseases of chickpea (*Cicer arietinum*) prevalent across the country and causing substantial yield losses. Field experiments were conducted at eight different hot spot locations of these diseases belonging to six states namely, New Delhi (Delhi), Indore, Sehore and Jabalpur (Madhya Pradesh), Badnapur (Maharashtra), Junagadh (Gujarat), Samba (Jammu and Kashmir) and Durgapura (Rajasthan) to evaluate and validate the performance of Pusa 5SD (a novel seed dressing formulation developed from *Trichoderma harzianum)* alone and in combination with fungicide along with recommended fungicidal seed treatment against wilt and root rots of chickpea under AICRP-Chickpea during 2010 to 2013 crop seasons. Seed treatment with Pusa 5SD (*T. harzianum*) alone and in combination with Vitavax power (carboxin + thiram) proved to be effective for the management of wilt and root rots at different locations. A combination of seed treatment with Pusa 5SD and Vitavax power (carboxin + thiram) provided the lowest disease incidence (12.2%) along with the highest grain yield (1053.3 kg/ha). Cardendazim (Bavistin) + Tetra methyl thiuram disulphide (thiram) and Vitavax power also reduced the diseases incidence (13.0%) and enhanced the grain yield (998.2 kg/ha) of chickpea. The bio-formulation Pusa 5SD showed effectiveness across the locations and varieties against wilt, dry root rot and collar rot of chickpea.

Key words: Biological management, Chickpea, Pusa 5SD, Root rots, *Trichoderma harzianum,* Wilt

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops of Indian subcontinent and ranks third in the world. It is one of the first grain legumes domesticated by humans. Biotic factors are the major cause of low yield of chickpea. Among the biotic factors, diseases namely, wilt (*Fusarium oxysporum* f. sp. *ciceris* (Padwick) Matuo and K. Sato); dry root-rot (*Rhizoctonia bataticola* (Taub.) Butler) and collar rot (*Sclerotium rolfsii* Sacc.) are considered the main cause for its low productivity. These diseases are widely distributed in all chickpea growing areas of the world including India (Dubey *et al*. 2015). The losses caused by wilt varied according to the stages of the crop affected, i.e. at seedling stage causes 77-94% while at flowering or late wilting causes 24-65% yield loss (Haware and Nene 1980). In India, an extensive survey were conducted in the major chickpea growing states and the incidence of wilt varied from 14.1 to 32% (Dubey *et al.* 2010) whereas, the incidence of dry root-rot ranged from 5-35% (Anonymous 2010). The collar rot of chickpea reduced production in warmer and high soil moisture area of Madhya Pradesh, Uttar Pradesh and Rajasthan (Dubey and Singh 2016).

Presently there is worldwide concern on the use of bio-agents in combination with reduced doses of chemical fungicide for sustainable agriculture (Someya *et al.* 2007, Dubey *et al*. 2015). Cultural methods of disease management are not sufficiently effective for the pathogens like *Fusarium*, *Rhizoctonia* and *Sclerotium* due to their longer saprophytic survival capability. Cultivation of resistant cultivars is one of the most potential and cost efficient strategies for management of these diseases. However, the availability of

[1]Principal Scientist and Head (e mail: scdube2002@yahoo.co.in), Division of Plant Quarantine, ICAR-National Bureau of Plant Genetic Resources, New Delhi. [2]Chief Technical Officer (e mail: birendra0057@gmail.com), [10]Research Associate (e mail: tripathi.aradhika@gmail.com), Division of Plant Pathology, ICAR-Indian Agricultural Research Institute, New Delhi. [3]Dean (e mail: omgupta_jnkvv@ rediffmail.com), College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh. [4]Principal Scientist (e mail: saxenadr@rediffmail.com), Department of Plant Pathology, RAK College of Agriculture, Sehore, Madhya Pradesh. [5]Chickpea Pathologist (e mail: sharmaom57@yahoo.co), Agricultural Research Station, Durgapura, Jaipur, Rajasthan. [6]Scientist (e mail: o.d.kohire@gmail.com), Plant Pathology, ARS, Badnapur, Maharashtra. [7]Associate Research Scientist (Plant Pathology) (e mail: vpandani@jau.in), Gujarat Agricultural University, Junagadh, Gujarat. [8]Scientist Plant Pathology (e mail: rakesh0429@gmail.com), College of Agriculture, Indore, Madhya Pradesh. [9]Junior Scientist (e mail: sksingh.patho@gmail.com), Plant pathology, PRSS, Samba, SKUAST, Samba Jammu and Kashmir.

durable resistant varieties due to high level of variability in the pathogens is the major bottleneck. Under such conditions, use of biological agents for management of the diseases proved promising. *Trichoderma* species are considered as efficient bio-agents due to their effectiveness against various plant pathogens (Harman *et al*. 2004). *Trichoderma* species have been evaluated against the wilt (Dubey *et al*. 2007), dry root rot (Dubey *et al*. 2011) and collar rot (Lahre *et al*. 2012) of chickpea under field conditions. *Trichoderma harzianum* was found to be most effective in reducing the mycelia growth and sclerotial formation of *R. batoticola* (Khan and Gupta 1998). A novel bio-formulation Pusa 5SD developed from a potential strain of *T. harzianum* (Dubey *et al*. 2009) was effective against wilt (Dubey *et al*. 2007, 2013, 2015) and dry root-rot of chickpea (Dubey *et al.* 2011). The Indian patent for the product (Pusa 5SD) is under the process (2032/DEL/2008).

The present study was aimed to determine or validate the efficacy of Pusa 5SD alone and along with reduced dose of fungicide for the management of root diseases of chickpea in different ecological zones belonging to six states of India under AICRP-chickpea programme.

MATERIALS AND METHODS

Field experiments were conducted during winter season of 2010-11, 2011-12 and 2012-13 in randomized block design (RBD) with six treatment in three replications in the fields infested with *F. oxysporum* f. sp. *ciceris* at seven locations, *R. bataticola* at two locations and *Sclerotium rolfsii* at one location. Across the eight locations belonging to six states of India, the treatment were evaluated against wilt, dry root and collar rots at Jabalpur (Madhya Pradesh), against wilt at New Delhi (Delhi), Indore and Sehore (Madhya Pradesh), Badnapur (Maharashtra), Junagadh (Gujarat) and Samba (Jammu and Kashmir) and against dry root-rot at Durgapura (Rajasthan) depending on the hot spot locations for these diseases.

The treatment consisted of Pusa 5SD (*T. harzianum),* Vitavax power (carboxin + thiram), Pusa 5SD + Vitavax power, Vitavax (carboxin), carbendazim (Bavistin) + Tetramethyl thiuram disulphide (TMTD - thiram) and control (untreated seeds). The local and popular cultivars namely, JG74 at Sehore and Jabalpur, JG62 at New Delhi, L550 at Durgapur, GG1 at Junagarh, GNG469 at Samba, JG130 at Indore and BDN- 9-3 at Badnapur were sown at 30 × 10 cm spacing in 3 × 1.8 m^2 plot size for each replication of a treatment. Pusa 5SD (10^8 cfu/g) was used at 4 g/kg of seed. The fungicides Vitavax, Vitavax power and the mixture of Bavistin + Thiram (1:1 ratio) were used at 2 g/kg of seed. However, the Vitavax power was used at 1 g/kg of seed when combined with bio-formulation Pusa 5SD. Seeds were treated with various treatments prior to sowing. Depending on the sowing times at different locations, the crop was sown during November and harvested during March in each year of experimentations. Seed germination was counted at 15 days after sowing. Wilt, dry root-rot and collar rot at respected locations were recorded at 20 day intervals up to the maturity of the crop and incidence of the diseases were calculated based on the total number of plants wilted/dried. Grain yield per plot was recorded after the harvesting of the crop.

For statistical analysis, the data recorded in percentages were transformed into angular values before the analysis. The data pertaining to all the observations were subjected to ANOVA using the SAS Software (SAS Institute, version 9.1, Cary, NC, USA). The data were analyzed as per the procedure of a randomized block design for the test of significance. The mean data of three years data are presented in the paper. Fisher's protected least significant differences (LSD) was computed only when ANOVA showed significant differences for any particular effect.

RESULTS AND DISCUSSION

Wilt, dry root rot and collar rot are the major yield limiting factors of chickpea across the world. In India, annually 8-10% produce is lost due to diseases in chickpea (Vishwadhar and Chaudhary 2001). Chemical control of these soil borne diseases is barely effective. Use of bio-agents is the best strategy for these diseases. The bio-agent has limitation for area and pathogen specificity. A seed dressing bio-formulation Pusa 5SD was developed from the potential isolates of *T. harzianum* (Dubey 1998, Kumar and Dubey 2001, Dubey 2002, 2003; Dubey *et al*. 2007, 2009) and evaluated against wilt (Dubey *et al*. 2013, 2015) and dry root rot (Dubey *et al*. 2011) at IARI, New Delhi. But the efficacy of Pusa 5SD has not been evaluated against the diseases at different locations across the country which is a prerequisite for wide scale adoptability, registration and commercial production of any bio-formulation.

The results of present study (Table 1) indicated that except dry root rot incidence recorded at Jabalpur, all the treatments were found significantly superior over the control in respect of reducing the disease incidence at all the centers. At Jabalpur, the dry root rot incidence recorded in carboxin treated plot was statistically similar with that of the control. The plots sown with the seeds treated with a combination of *Trichoderma harzianum* based seed dressing formulation Pusa 5SD and Vitavax power (carboxin + thiram) provided the lowest wilt incidence at New Delhi, Indore, Samba and Junagadh with statistically superior from other treatments at the first three centers. At Badnapur, the seeds treated with *T. harzianum* based seed dressing formulation Pusa 5SD provided the lowest wilt incidence followed by Pusa 5SD + Vitavax power (carboxin + thiram), Bavistin + Thiram and Vitavax power alone with statistically similar wilt incidences. At Sehore, the wilt incidences recorded in all the treatments were statistically similar, whereas at Jabalpur, the lowest wilt was in Bavistin + Thiram followed by Vitavax, Pusa 5SD + Vitavax power and Pusa 5SD alone with statistically similar performance. The lowest dry root rot incidence recorded in the plots sown with the seeds treated with Bavistin + Thiram followed by Pusa 5SD + Vitavax power were statistical similar. Bavistin + Thiram and Pusa 5SD treated seeds provided statistically similar

Table 1 Effect of different seed treatments on diseases (wilt and root rots) of chickpea at different locations in India (mean of 2010-11, 2011-12 and 2012-13)

Treatment	Dose (g/kg seed)	Disease incidence (%) at different places										Mean
		Wilt							Dry root rot		Collar rot	
		New Delhi	Indore	Badnapur	Sehore	Jabalpur	Samba	Junagadh	Durgapura	Jabalpur	Jabalpur	
Pusa SD (*Trichoderma harzianum*)	4	9.7^{bc}	10.8^{c}	4.2^{a}	23.7^{a}	33.7^{ab}	16.8^{c}	3.5^{ab}	33.9^{b}	9.1^{a}	6.3^{a}	15.2^{a}
Vitavax power (carboxin + thiram)	2	9.2^{b}	7.2^{bc}	6.4^{ab}	17.3^{a}	37.1^{b}	13.0^{b}	3.7^{bc}	29.6^{b}	20.4^{bc}	3.7^{a}	14.8^{a}
Pusa SD (*Trichoderma harzianum*) + Vitavax power (carboxin + thiram)	4+1	6.3^{a}	4.6^{a}	5.1^{a}	19.2^{a}	31.2^{ab}	9.2^{a}	3.4^{a}	21.5^{a}	17.0^{b}	4.8^{a}	12.2^{a}
Vitavax (carboxin)	2	14.1^{d}	17.0^{d}	8.3^{b}	24.0^{a}	25.9^{ab}	15.9^{bc}	3.9^{c}	30.4^{b}	24.2^{cd}	6.9 ^{a}	17.1^{a}
Bavistin (carbendazim) + thiram (TMTD)	1+1	11.1^{c}	10.6^{c}	5.3^{a}	26.9^{a}	21.8^{a}	15.4^{bc}	3.9^{c}	19.7^{a}	9.7^{a}	5.8 ^{a}	13.0^{a}
Control (untreated seeds)		19.2^{e}	24.4^{e}	18.6^{c}	37.8^{b}	44.6^{c}	42.1^{d}	8.5^{d}	62.2^{c}	28.2^{d}	20.5^{b}	30.6^{b}

The values within a column with different letters are significantly different at 5% level by using Fisher's least significance difference test.

dry root rot incidence at Jabalpur. Collar rot was observed only at Jabalpur and all the treatments provided statistically similar collar rot incidence and they were significantly superior over the control.

Over all, considering all three diseases and the centers together, Pusa 5SD + Vitavax power provided the lowest disease incidence followed by Bavistin + Thiram, Vitavax power, Pusa 5SD and Vitavax with statistically similar performances. Thus, it is clear that the combined application of Pusa 5SD and fungicide Vitavax power showed superiority over any one treatment alone due to combined effect of bio-agent and fungicide and differences in their mode of action at the site of application. The pathogen were weakened by the chemical and are therefore, better controlled by *Trichoderma* (Dubey *et al*. 2007). The present findings are supported by the observations made by Jyotsna *et al*. (2008) and Dubey *et al*. (2011) that application of *T. harzianum* suppressed the disease caused by *R. bataticola* in chickpea. *Trichoderma viride* and *Pseudomonas fluorescens* proved potential against dry root rot of chickpea and soil application of bio-agent enriched farm yard manure (FYM) along with seed treated with the bio-control agent proved highly effective in managing the disease (Manjunatha *et al*. 2013). Pandey *et al*. (2017) reported that seed biopriming and soil application of *Trichoderma* enriched FYM significantly reduced the wilt and dry root rot incidence in the range of 46-78% and increased the grain yield by 13-27% in chickpea. Seed biopriming with *T. viride* or *T. harzianum* alone reduced wilt and root rot incidence by 45-60%, and increased the yield of chickpea by 10-20%. In the present findings, the seed treatment with a combination of *T. harzianum* based seed dressing formulation Pusa 5SD and Vitavax power (carboxin + thiram) reduced 60.1% disease incidence and increased 74.4% grain yield.

The seeds treated with a combination of *T. harzianum* based seed dressing formulation Pusa 5SD and Vitavax power (carboxin + thiram) provided the highest mean grain yield followed by Bavistin + Thiram and the grain yield recorded in these two treatments were statistically similar. The next treatment in order of superiority was Vitavax power followed by Pusa 5SD with statistically similar grain yield (Table 2). The seeds treated with Pusa 5SD + Vitavax power provided the highest grain yield at New Delhi, Indore, Badnapur, Samba and Junagadh, whereas at other centers, the grain yield recorded in this treatment was statistically similar with those treatments provided the highest grain yield. At Sehore, the highest and statistically similar grain yield was recorded in Vitavax power, Bavistin + Thiram, Vitavax and Pusa 5SD + Vitavax power. At Jabalpur and Durgapura, Bavistin + Thiram provided the highest grain yield followed by Pusa 5SD + Vitavax power and they were statistically similar only at Durgapura.

Trichoderma species are well recognized for the management of plant diseases and for their ability to increase the plant growth and yield (Dubey *et al*. 2007, 2011, 2013, 2015). The combination of commercial formulations of *Bacillus subtilis* and *T. harzianum* effectively controlled the wilt in chickpea but their individual effect did not differ significantly (Moradi *et al*. 2012). A combination of soil application of *T. harzianum* based Pusa biopellet 10G and seed treatment with Pusa 5SD + carboxin was found to be the best by providing the highest seed germination, shoot

Table 2 Effect of different seed treatments on grain yield of chickpea at different locations in India (mean of 2010-11, 2011-12 and 2012-13)

Treatment	Dose (g/kg seed)	Grain yield (kg/ha) at different locations								Mean
		New Delhi	Indore	Badnapur	Sehore	Jabalpur	Samba	Junagadh	Durgapura	
Pusa SD (*Trichoderma harzianum*)	4	1102.0^{b}	615.6^{c}	1003.0^{b}	802.1^{b}	530.0^{c}	292.8^{e}	1656.0^{a}	811.0^{b}	851.6^{cd}
Vitavax power (carboxin + thiram)	2	1150.0^{b}	757.9^{b}	1087.3^{a}	859.2^{a}	576.9b^{c}	493.6^{c}	1733.5^{a}	874.5^{b}	941.6^{bc}
Pusa SD (*Trichoderma harzianum*) + Vitavax power (carboxin + thiram)	4+1	1280.0^{a}	905.0^{a}	1147.5^{a}	840.1^{ab}	649.6^{b}	695.3^{a}	1754.0^{a}	1155.0^{a}	1053.3^{a}
Vitavax (carboxin)	2	898.0^{c}	527.8^{d}	721.3^{c}	840.4^{ab}	553.6b^{c}	397.6^{d}	1744.5^{a}	971.0^{b}	831.8^{d}
Bavistin (carbendazim) + thiram (TMTD)	1+1	1078.5^{b}	681.0^{c}	1110.0^{a}	858.3^{a}	800.7^{a}	605.3^{b}	1660.0^{a}	1191.5^{a}	998.2^{ab}
Control (untreated seeds)		814.9^{c}	407.2^{e}	603.7^{d}	605.9^{c}	292.1^{d}	252.2^{e}	1318.5^{b}	538.0^{c}	604.1^{e}

The values within a column with different letters are significantly different at 5% level by using Fisher's least significance difference test.

and root lengths grain yield and the lowest wilt (Dubey *et al.* 2013) and dry root rot (Dubey *et al*. 2011) incidence in chickpea. Seed treatment with Pusa 5SD (*T. harzianum*) along with bacterial bio-agent and Vitavax power proved effective in reducing wilt and increasing grain yield of chickpea at Delhi conditions (Dubey *et al*. 2015), but through this findings its efficacy has been validated across the county not only against wilt but also against dry root rot and collar rot. The present study, clearly indicated that application of Pusa 5SD (*T. harzianum*) alone and in combination with Vitavax power reduced the root diseases and enhanced the grain yield of chickpea at different locations and hence it may be recommended for the management of the diseases across the country.

ACKNOWLEDGMENTS

Authors are thankful to Dr N P Singh, Director, IIPR, Kanpur and the then Project Coordinator, Chickpea for supporting the programme at different AICRP centers.

REFERENCES

Anonymous. 2010. Project Coordinator Report 2009-10, All India Coordinated Research Project on Chickpea, Kanpur, 45 p.

Dubey S C. 1998. Evaluation of fungal antagonists of *Thanatephorus cucumeris* causing web light of horsegram. *Journal of Mycology and Plant Pathology* **28**: 15–7.

Dubey S C. 2002. Bioagent based integrated management of collar rot of french bean. *Indian Phypathology* **55**: 230–1.

Dubey S C. 2003. Integrated management of web blight of urd/ mung bean by bio-seed treatment. *Indian Phytopathology* **56**: 34–8.

Dubey S C, Bhavani R and Singh B. 2009. Development of Pusa 5SD for seed dressing and Pusa Biopellet 10G for soil application formulations of *Trichoderma harzianum* and their evaluation for integrated management of dry root rot of mungbean (*Vigna radiata*). *Biological Control* **50**: 231–42.

Dubey S C and Singh B. 2016. Diseases of Pulse Crops. *Diseases of Field Crops and their Management*, pp 373–444. Dubey S C, Aggarwal R, Patro T S S K and Sharma P (Eds), Today and Tomorrow's Printers and Publishers, Daryaganj, New Delhi.

Dubey S C, Singh S R and Singh B. 2010. Morphological and pathogenic variability of Indian isolates of *Fusarium oxysporum* f. sp. *ciceris* causing chickpea wilt. *Archives of Phytopathology and Plant Protection* **43**: 174–89.

Dubey S C, Suresh M and Singh B. 2007. Evaluation of *Trichoderma* species against *Fusarium oxysporum*. f. sp. *ciceris* for integrated management of chickpea wilt. *Biological Control* **40**: 118–27.

Dubey S C, Tripathi Aradhika, Bhavani R and Singh B. 2011. Evaluation of seed dressing and soil application formulations of *Trichoderma* species for integrated management of dry root rot of chickpea. *Biocontrol Science and Technology* **21**: 93–100.

Dubey S C, Tripathi Aradhika and Singh B. 2013. Integrated management of Fusarium wilt by combined application of soil and seed dressing formulations of *Trichoderma* species to increase grain yield of chickpea. *International Journal of Pest Management* **59**: 47–54.

Dubey S C, Singh Vivek, Priyanka Kumari, Upadhyay B K and Singh B. 2015. Combined application of fungal and bacterial bio-agents, together with fungicide and *Mesorhizobium* for integrated management of Fusarium wilt of chickpea. *Bio Control* **60**: 413–24.

Harman G E, Howell C R, Viterbo A, Chet I and Lorito M. 2004. *Trichoderma* species – opportunistic, avirulent plant symbionts. *Nature Reviews* **2**: 43–56.

Haware M P and Nene Y L. 1980. Influence of wilt at different stages on the yield loss in chickpea. *Tropical Grain Legume Bulletin* **19**: 38–40.

Jyotsna S A, Singh R, Srivastava A, Saxena A and Arora D. 2008. Growth promotion and charcoal rot management in chickpea by *Trichoderma harzianum*. *Journal of Plant Protection Research* **48:** 81–92.

Khan M R and Gupta J. 1998. Antagonistic efficacy of *Trichoderma* species against *Macrophomina phaseolina* on egg plant. *Journal of Plant Diseases and Protection* **105**: 387–93.

Kumar D and Dubey S C. 2001. Management of collar rot of pea

by the integration of biological and chemical methods. *Indian Phytopathology* **54**: 62–6.

Lahre S K, Khare N, Lakpale N and Chaliganjewar S D. 2012. Efficacy of bio-agents and organic amendments against *Sclerotium rolfsii* in chickpea. *Journal of Plant Disease Science* **7**: 32–4.

Manjunatha S V, Naik M K, Khan M F R and Goswami R S. 2013. Evaluation of bio-control agents for management of dry root rot of chickpea caused by *Macrophomina phaseolina. Crop Protection* **45**: 147–50.

Moradi H, Bahramnejad B, Amini J, Siosemardeh A, Allahverdipoor K. 2012. Suppression of chickpea (*Cicer arietinum* L.) Fusarium wilt by *Bacillus subtillis* and *Trichoderma harzianum*. *Plant Omics Journal* **5**: 68–74.

Pandey R N, Gohel N M and Jaisani P. 2017. Management of wilt and root rot of chickpea caused by *Fusarium oxysporum* f. sp. *ciceri* and *Macrophomina phaseolina* through seed biopriming and soil application of bio-agents. *International Journal of Current Microbiology and Applied* **6**: 2516–22.

Someya N, Tsuchiya K, Yoshida T, Tsujimoto-noguchi M and Sawada H. 2007. Combined application of *Pseudomonas fluorescens* strain LRB3W1 with a low dosage of benomyl for control of cabbage yellows caused by *Fusarium oxysporum* f. sp. *conglutinans*. *Biocontrol Science and Technology* **17**: 21–31.

Vishwadhar and Chaudhary R G. 2001. The role of resistance in intensive agriculture. *Disease Resistance in Pulse Crop-Current Status and Future Approaches*, pp 144–57. Nagarajan S and Singh D P (Eds). Kalyani Publisher, New Delhi.