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Biological Management of Root Rot (*Rhizoctonia solani*) of Clusterbean in Rajasthan

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ABSTRACT

Background: Clusterbean is an important legume crop in arid and semi-arid regions of Rajasthan. It provides livelihood security to arid zone farmers. Bacterial leaf blight (BLB) and root rot are two important diseases of clusterbean which limits its production and productivity. Although, management of these diseases are possible through fungicides. However, in present study focus on use of bio-agents which are friendly to the environment.

Methods: Field experiment was conducted at ARS, SKRAU, Bikaner, Rajasthan during three consecutive *kharif* seasons of 2017 to 2019. The experiment was conducted on *cv*. RGC-1033 with six different combination of *Trichoderma harzianum* and *Pseudomonas fluorescens* bio- agents *viz*, seed treatment, soil treatment and their combinations against the root rot disease and compared with an untreated control.

Conclusion: Seed treatment with a combination of *T. harzianum* + *P. fluorescens* (4+4 g/kg seed) along with soil application of *T. harzianum* + *P. fluorescens* (1.25 +1.25 kg in 50 kg FYM for each/ha) was an effective treatment which reduced root rot incidence and increased seed yield under field conditions. It can be recommended to the cultivators of clusterbean for enhancing yield.

Key words: Bio-agents, Biological management, Clusterbean, Root rot, *Rhizoctonia solani,* Seed treatment, Soil application.

INTRODUCTION

Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.], is commonly known as *Guar*, is a drought and high temperature tolerant deep rooted summer annual legume of high social and economic significance. The qualities of the crop like high adaptation towards erratic rainfall, multiple industrial uses and its importance in cropping system for factors such as soil enrichment properties, low input requirement, etc have made the *guar* one of the most significant crops for farmers in arid and semi-arid area in India. Its deep penetrating root enables plant to utilize available moisture more efficiently and thus find better scope for rain fed cropping. The crop requires less input and restricted after care, matching with the arid farmer's livelihood conditions. Clusterbean is grown for grain, vegetable, fodder, cattle feed and green manure purposes. This crop has an important place in national economy because the gum extracted from seed has many industrial applications and great export value and is thus an important foreign exchange earner for the country. It has extensive use in paper, textile, food, mining, cosmetic, pharmaceutical, explosives and oil industries. About 80-85% clusterbean gum produced in India is exported to other countries and rest is used for domestic commercial demand. India exports over 0.17 million tons of clusterbean and its derivatives worth Rs. 500 crores (Baldodiya and Awasthi, 2018).

India is the most important clusterbean producer in the world and contributes almost 75-82% global clusterbean seed production followed by Pakistan (15%). Annually almost 75-80% of clusterbean gum is exported from India. Rajasthan, Gujarat and Haryana are major clusterbean producing states in India and amongst the states, Rajasthan is leading producer having 70-75% of total area and 60-62% of total production of the country. In Rajasthan state, the clusterbean is cultivated on about 3.5 million ha and produce about 1.4 million ton seed with average yield of 0.39 t/ha (Anonymous, 2018). The cultivation of clusterbean in is Rajasthan mainly confined to north-western hot arid region "Bikaner, Churu, Barmer, Jaisalmer, Hanumangarh and Jodhpur" districts which occupy about 60 % of total area of clusterbean of the state. The area under clusterbean cultivation has been increasing due to its high demand in the industry. Hence, clusterbean is now considered as a source for providing livelihood security to arid zone farmers.

Clusterbean is prone to many diseases including root rot caused by *Rhizoctonia solani*,which is considered as one

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of the factors for low productivity. The pathogen attacks roots causing damping-off and root rot diseases. The disease causes substantial loss to clusterbean crop. *Rhizoctonia solani* Kuhn [teleomorph–*Thanatephorus cucumeris* (Fr.) Donk] is a destructive soil-borne plant pathogen (Saksena and Dwivedi, 1973) infecting a wide range of agricultural and horticultural crops, including legumes and world wide causing several diseases (‘Kataria and Grover’, 1977; Gonzalez *et al.,* 2006). The pathogen also causes considerable yield loss inmungbean and urdbean in India (Dubey, 2003). Yield loss up to 57% in mungbean wasreported from Iran (Kaiser, 1970). Control of *R. solani* is difficult because of wide host range and its abilit to survive through sclerotia under adverse environmental conditions. In practice,control of diseases caused by *R. solani* relies mainly on fungicides (Kataria and Gisi, 1996). There is a rising demand for intervention of ecologically safe and sound, environmentally compatible techniques in crop production which will provide global food security and improved agricultural produces. To accomplish this goal, application of agriculturally beneficial microorganisms is a potential alternative to traditional agricultural techniques which have severely damaged the agro-ecosystem (Abhilash *et al*., 2016). Beneficial microorganisms including biological control agents (BCAs), plant growth promoting rhizobacteria (‘PGPR’s), fungi (PGPFs) and endophytes play a crucial role in sustainable crop production. These microorganisms provide growth promotion, crop protection and abiotic stress mitigation by the direct application. Considering the economic significance of clusterbean, the present investigation was under taken to identify different combinations of bio-control agents against root rot disease.

MATERIALS AND METHODS

Field experiment was under taken at Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan during three consecutive *kharif* seasons of 2017 to 2019. A most popular clusterbean cultivar RGC-1033 was used in the experiment and six different combination treatments of bio-agents were evaluated. These were T_1: *Trichoderma harzianum* seed treatment (8 g/kg seed),T_2: *T. harzianum* seed treatment (8 g/kg seed) + soil application of *T. harzianum* (2.5 kg in 100 kg FYM/ha), T_3: *T. harzianum* + *Pseudomonas fluorescens* seed treatment (4+4g/kg seed), T_4: *T. harzianum* + *P. fluorescens* seed treatment (4+4 g/kg seed) + soil application of *T. harzianum* + *P. fluorescens* (1.25 +1.25 kg in 50 kg FYM for each/ha),T_5: *P. fluorescens* seed treatment (8 g/kg seed), T_6: *P. fluorescens* seed treatment (8 g/kg seed) + soil application of *P. fluorescens* (2.5 kg in 100 kg FYM/ha) and T_7: untreated control. For application *T. harzianum* and *P. fluorescens*, the pre-sowing seed dressing treatments were done with the help of hand rotary seed dresser. The treatments were applied immediately before planting of the seed in field. The bio-agents were mixed in moist FYM 15 days before sowing every year and kept in shade and after multiplication, applied in the field through broad casting and mix in the soil by use of cultivator. The treated seeds were sown by drilling method @ 15 kg seed /ha. The experiment was conducted in randomized block design (RBD) and replicated three times. The crop was planted at 45 cm row to row and 10 cm plant to plant spacing. The gross plot size was 3.0 × 2.7m^2. All other recommended practices required for cultivation of the crop were followed. Bio formulations *T. harzianum* and *P. fluorescens* contained 1 x 10^7 and 2 x10^{6}c.f.u./g, respectively. The data for disease incidence (%) of clusterbean from each treatment were recorded. Seed yield (q/ha) and economics of each treatment were computed**.** The statistical analysis of data was done as per procedure suggested by Panse and Sukhatme (1967).

Bio- agents (*Trichoderma harzianum* and *Pseudomonas fluorescens*) were received from bio-agent lab, Department of Plant Pathology, College of Agriculture, SKRAU, Bikaner to conduct the experiment.

RESULTS AND DISCUSSION

The application of bio-agents caused significant reduction in root rot incidence in all the years (Table 1). However, amongst the different bio-agents tested, treatment combination of *T. harzianum* + *P. fluorescens* seed treatment (4+4 g/kg seed) + soil application of *T.harzianum* + *P. fluorescens* (1.25 +1.25 kg in 50 kg FYM for each/ha) was found most effective in controlling root rot in all the years and had 7.67, 4.67 and 5.33 per cent root rot incidence during 2017, 2018 and 2019, respectively. Averaged across the years, this treatment had lowest incidence (5.89 %) among all the treatments. This treatment caused 63.93 per cent reduction in root rot incidence as compared to untreated control plots**.** Treatment $T_{2,}$ *i.e. T. harzianum* seed treatment 8 g/kg seed + soil application of *T.harzianum* 2.5 kg in 100 kg FYM/ha was found next best option. It has reduced 46.23 per cent root rot incidence as compared to untreated control plots**.** Treatment T_5 *i.e.* seed treatment with *P*. *fluorescens* @ 8 g/kg seed found least effective against root rot in all the years. The maximum root rot incidence of 16.00 per cent, 15.67 per cent and 17.33 per cent were recorded in control plot of respective consecutive years.

The application of bio-agent treatments had significant effects on seed yield (Table 1) and all the treatments were found effective in enhancing seed yield than control. The highest seed yield of 15.67 q/ha was recorded in the treatment T_4 i.e., treatment combination of *T. harzianum* + *P. fluorescens* seed treatment (4+4 g/kg seed) + soil application of *T.harzianum* + *P. fluorescens* (1.25 +1.25 kg in 50 kg FYM for each/ha), which had significantly higher seed yield (15.67 q/ha) compared to all other treatments, followed by T_2 *i.e. T.harzianum* seed treatment 8 g/kg seed + soil application of *T. harzianum* 2.5 kg in 100 kg FYM/ha (14.61 q/ha). This treatment had 5.18 q/ha higher seed yield than control. This treatment increased the seed yield by

Table 1: Management of root rot of clusterbean through bio-agents at Bikaner during *Kharif* 2017, 18 and 19.

Treatment	Root rot incidence (%)				% Root rot decreased	Seed yield (q/ha)				Yield increased (q/ha)	% Yield increased
	2017	2018	2019	Pooled		2017	2018	2019	Pooled		
T_1: *Trichoderma harzianum* seed treatment (8 g/kg seed)	13.33 (21.41)*	11.00 (19.37)*	10.33 (18.71)*	11.55 (19.83)	29.27	14.45	11.90	10.69	12.34	1.85	14.99
T_2: *T. harzianum* seed treatment (8 g/kg seed) +soil application of *T. harzianum* (2.5 kg in 100 kg FYM/ha)	9.67 (18.11)	7.67 (16.08)	9.00 (17.43)	8.78 (17.21)	46.23	16.23	14.66	12.96	14.61	4.12	28.19
T_3: *T. harzianum* + *Pseudomonas fluorescens* seed treatment (4+4 g/kg seed)	12.00 (20.26)	10.33 (18.75)	11.00 (19.35)	11.11 (19.45)	31.96	15.04	12.14	11.43	12.87	2.38	18.49
T_4: *T. harzianum* + *P. fluorescens* seed treatment (4+4 g/kg seed) + soil application of *T. harzianum* + *P. fluorescens* (1.25 +1.25 kg in 50 kg FYM for each/ha)	7.67 (16.05)	4.67 (12.48)	5.33 (13.33)	5.89 (13.96)	63.93	17.41	15.63	13.98	15.67	5.18	33.06
T_5: *P. fluorescens* seed treatment (8 g/kg seed)	13.67 (21.68)	11.33 (19.67)	12.00 (20.25)	12.33 (20.53)	24.49	13.66	11.83	9.48	11.65	1.16	9.96
T_6: *P. fluorescens* seed treatment (8g/kg seed) + seed + soil application of *P. fluorescens* (2.5 kg in 100 kg FYM/ha)	11.00 (19.36)	9.66 (18.11)	8.33 (16.77)	9.66 (18.07)	40.84	15.94	13.37	10.61	13.30	2.81	21.13
T_7:Control	16.00 (23.57)	15.67 (23.32)	17.33 (24.58)	16.33 (23.82)	-	12.51	10.61	8.35	10.49	-	-
S. Em. ±	0.56	0.73	0.55	0.46		0.45	0.76	1.11	0.26		
C.D. (P=0.05)	1.72	2.26	1.71	1.45		1.39	2.35	3.46	0.81		
C.V. %	4.82	12.63	5.11	4.27		5.20	10.25	12.41	3.4		

*Data in parentheses indicate angular transformed values; ST: Seed treatment; SA: Soil treatment.

Table 2: Economics of different treatments of clusterbean.

Treatment	Quantity of treatment (kg/ha)	Cost of treatment (Rs/ha)	Labour cost (Rs/ha)	Total cost of treatment (Rs/ha)	Seed Yield (q/ha)	Gross realization (Rs/ha)	Net realization over control (Rs/ha.)	Net Gain (Rs/ha)
T_1: *Trichoderma harzianum* seed treatment (8 g/kg seed)	0.12	24	100	124	12.34	49,360	7,400	7,276
T_2: *T. harzianum* seed treatment (8 g/kg seed) + soil application of *T. harzianum* (2.5 kg in 100 kg FYM/ha)	2.62	674	150	824	14.61	58,440	16,480	15,656
T_3: *T. harzianum* + *Pseudomonas fluorescens* seed treatment (4+4 g/kg seed)	0.06 0.06	12 12	100	124	12.87	51,480	9,520	9,396
T_4: *T. harzianum* + *P. fluorescens* seed treatment (4+4 g/kg seed) + soil application of *T. harzianum* + *P. fluorescens* (1.25 +1.25 kg in 50 kg FYM for each/ha)	1.31 1.31	337 337	150	824	15.67	62,680	20,720	19,896
T_5: *P. fluorescens* seed treatment(8 g/kg seed)	0.12	24	100	124	11.65	46,600	4,640	4,516
T_6: *P. fluorescens* seed treatment (8g/kg seed) + soil application of *P. fluorescens* (2.5 kg in 100 kg FYM/ha)	2.62	674	150	824	13.30	53,200	11,240	10,416
T_7: Control	-	-	-	-	10.49	41,960	-	-

Clusterbean price Rs. 4000/q., *T. harzianum* = Rs 200 /kg, *P. fluorescens* = Rs 200 /kg, Labour cost of seed treatment = Rs.100/ha.

33.06 per cent as compared to untreated control plots. The minimum seed yield was obtained in treatment T_5 *i.e.* seed treatment with *P. fluorescens* @ 8 g/kg seed (11.65 q/ha).

The economics computed on various treatments revealed that the treatment combination of *T.harzianum* + *P. fluorescens* seed treatment (4+4 g/kg seed) + soil application of *T. harzianum* + *P. fluorescens* (1.25+1.25 kg in 50 kg FYM for each/ha) gave highest gross return Rs 62,680/ha when treatment cost was Rs 824/ha as compared to control (Rs 41,960/ha) which gave an additional income of Rs. 20,720/ha and net gain of Rs 19,896/ha (Table 2). Seed treatment is an attractive delivery system of fungal bioprotectants (Wright *et al*. 2003). Bioprotectants applied to seeds may not only protect seeds (Sivan and Chet 1986) but also may colonies and protect roots and may increase plant growth. It is evident that the antagonistic bio-agent can affect the plant's resistance to a pathogen either by inducing the basal level of defense reactions immediately after treatment or by enhancing a capacity for rapid and effective activation of cellular defence responses (Conrath *et al*., 2002). Lorito *et al*. (1996) reported that fungal pathogens are killed by the release of toxic compounds i.e. antibiotics gliotoxin, gliovirin and peptabiols and a battery of lytic enzymes, mainly chitinases, glucanases and proteases produced by species of *Trichoderma.* These enzymes facilitate penetration intothe host and utilization of host nutrients. Antibiotic production, mycoparasitism, the production of cell wall degrading enzymes and competition for nutrient or space are considered as the action involved in biocontrol of pathogens during mycoparasitic interaction between *Trichoderma* and fungal pathogens (Zeilinger and Omann, 2007 and Vinale *et al*., 2008). Similarly, Benhamou and Chet (1993) illustrated many interactions of *Trichoderma* with pathogens *Rhizoctonia* and *Pythium*. Various species of bacteriaincluding *Pseudomonas*, *Bacillus*, *Azospirillum*, etc. have been reported as potential bio-control agents, bio-fertilizers and bio stimulants (Keswani *et al*., 2014, 2015a). They suppress plant pathogens in soil through production of antibiotics and siderophores and suppress plant diseases through induction of defense response (Bisen *et al*., 2015; Keswani *et al*., 2015b; Singh, 2014). Earlier workers also reported that the genus *Trichoderma* is highly effective against several phytopathogenic fungi including *R.solani* causing seed and soil- borne diseases of several economically important crops (Howell 2003). The potential of *Trichoderma* species in managing diseases caused by *R.solani* has been demonstrated in soybean ('Raguchander' *et al*., 1998), mungbean (Dubey and 'Patel' 2001, Singh and Chand 2006), potato (Ishtiaq and Raziq 2006), fababean (El-Mougy and Abdel-Kader 2008),tomato (Montealegre *et al*. 2010), bean (Abd-El-Khair *et al*., 2010) and chickpea (Dubey *et al*.2012).

CONCLUSION

In clusterbean *cv*. RGC-1033, seed biopriming with a combination of *T. harzianum* + *P. fluorescens* seed treatment (4+4 g/kg seed) along with soil application of *T. harzianum* + *P. fluorescens* (1.25 +1.25 kg in 50 kg FYM for each/ha) was observed to be an effective treatment which reduced root rot incidence and increased seed yield as compared to other treatments as well as untreated control under field conditions.

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