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Kumar M
Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Kudada N
Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India

Srivastava JN
Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Saurabh A
Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Kumari A
Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Correspondence
Kumar M
Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Evaluation of Bio-control agents against Root rot disease of French bean caused by *Rhizoctonia solani* under field condition

Kumar M, Kudada N, Srivastava JN, Saurabh A and Kumari A

Abstract
Seed treatment with *Trichoderma viride* @ 5.0 g/kg seed showed maximum seed germination (85.82%) and minimum pre- emergence (13.93%) and post- emergence (17.00%) root rot incidence and The maximum yield (63.44 q/ha) was also recorded by seed treatment with *T. veride* @ 5.0 g/10^{-6} spores/ml followed by *Aspergillus niger* @ 5.0 g/10^{-6} spores/ml (62.33 q/ha). Correlation coefficient studies exhibited negative and highly significant association of pre- and post-emergence root rot disease incidence with green pod yield during both the years Rabi 2014-15 and 2015-16 cropping seasons.

Keywords: French bean, *Rhizoctonia solani*, Management, Bio-control agents

Introduction
French bean (*Phaseolus vulgaris* L.) is an important leguminous and vegetable crop grown in India. In India the fresh pod used as vegetables are called French bean and the dried pod for pulse is called Rajama. French bean is an annual and herbaceous plant, grown worldwide for its edible beans in India. The more fleshy tender pods of round padded types with less string are preferred for vegetable as compared to flat pods. They are rich source of protein and closely compared with meat. French bean is cultivated in a variety of environmental condition ranging from sea level to high- land in the temperature range of 20-25^0 C.

In India, vegetables occupy about an area of 9,068 lakh ha and with the production of about 1, 59,511 lakhs tonnes among which beans vegetable occupy an area of about 125 lakhs ha and with production of about 1292 lakh tonnes. This vegetable is largely grown in Andra Pradesh, Jharkhand, Maharashtra, Karnataka, Odisha, Uttarakhand, Tamil Nadu etc. (Anusuya *et al*. 2016).

French bean is affected by a no. of diseases viz., Leaf spot (*Alternaria alternata*), Collar rot (*Sclerotium rolfsii*), Anthracnose (*Colletotrichum lindemuthianum*), Powdery mildew (*Erysiphe polygoni*), Rust (*Uromyces phaseoli*), Root rot (*R. solani*), Fusarium root rot (*Fusarium solani* f. sp. *phaseoli*), Root knot nematode (*Meloidogyne sp.*), Bacterial brown spot (*Pseudomonas syringae* pv. *syringae*), Common blight (*Xanthomonas campestris* pv. *phaseoli*), Halo blight (*Pseudomonas syringae* pv. *phaseolicola)*, Bean yellow mosaic disease etc. Amongst these *Rhizoctonia* root rot is the prevalent disease in all growing areas.

Several reviews on the subject have been published (Back *et al.*, 2002; Shahzad and Ghaffar, 1992; Anwar and Khan, 2002; Bhagwati *et al.*, 2007). Most of these reports indicated that an important pathogen. *Rhizoctonia* root rot generally affects seedlings, but fungus can also infect mature plants and induce root rot leading to plant wilt and finally death
of infected plants. Affected plants show yellowing and drying of stem at soil level. Stunting may also occur. The crop may also show poor seedling establishment, uneven growth, chlorosis and premature defoliation of severely infected plants.

The yield losses from this disease have been reported 8.5 to 64.7 % from Bangalore (Sharma and Sohi, 1980&1981). The aims of present study was to determine the occurrence and incidence of root rot disease and also study was conducted to search for suitable antagonistic bio-control agents against *Rhizoctonia solani* under field condition.

Materials and Methods
To test the efficacy of four bio-agents viz., *Trichoderma viride*, *Trichoderma harzianum*, *Aspergillus niger* and *Pseudomonas fluorescence* @ 5 g/kg seed of each bio-agents as a seed treatment against root rot disease, a field trial was conducted within glass house. A trial was conducted in RBD during Rabi 2014-2015 and 2015-2016 cropping seasons using the variety, Pant Anupama. There were five treatments including control with four replications. The plot

The plot size was 3.0 m X 1.5 m with spacing of 20.0 cm X 30.0 cm recommended dose of fertilizers and Farm Yard Manure (FYM) were applied. Mass multiplied culture of *R. solani* were incorporated in plot to make it sick before 72 hrs of sowing. Control plots were maintained without seed treatment. Percent disease was recorded in all treatments by counting the number of infected healthy plants. The bio-agent viz., *Trichoderma viride* (P1), *Trichoderma harizanum* (P2), *Aspergillus niger* (P3) from Department of Microbiology, R.A.U. Pusa and *Pseudomonas fluorescence* (R) from Department of Soil science, B.A.U. Kanke, Ranchi were used in present investigation.

Observations seed germination, pre- and post- emergence root rot disease incidence of French bean plants were recorded periodically in each plot. Yield of green pods was also recorded.

The details of treatments were as follows

T_1 - Seed treatment with *Trichoderma viride* @ 5.0 g/kg seed

T_2 - Seed treatment with *Trichoderma harzianum* @ 5.0 g/kg seed

T_3 - Seed treatment with *Aspergillus niger* @ 5.0 g/kg seed

T_4 - Seed treatment with *Pseudomonas fluorescence* @ 5.0 g/kg seed

T_5 - Control – No treatment

Result and Discussion

Seed treatment with bio-control agents gives good result in management of root rot disease (Harman, 1996; El-Mohamedy, 2004.. El-Mohamedy, *et al.*, 2006). Four antagonists, i.e., three fungal and one bacterial antagonist were used as seed treatment against the pathogen (*R. solani*) in field condition for controlling the disease. A field trial was conducted during Rabi 2014-15 and 2015-16 cropping seasons and the results have been presented in Table -1, Fig.-1 and Fig.-2.

In pooled analysis Table- 1 revealed that all the antagonists proved to be significantly superior over control in respect of seed germination, pre- and post-emergence root rot incidence and recorded that all the treatments were significantly superior over the control. Post-emergence root rot incidence and yield were also significantly superior over the control. Maximum seed germination (85.82%) was observed in T1 (*Trichoderma viride*) followed by T2- (*T. harzianum*) (84.27%). Minimum seed germination was found in T4- (*Pseudomonas fluorescens*) (82.32%) as compared to control (70.96%).

Minimum pre-emergence (13.93%) and post-emergence (17.00%) root rot disease incidence was recorded in T1 (seed treatment with *T. viride*). This treatment was followed by T2 (seed treatment with *T. harzianum*). Maximum pre-emergence (26.04 percent) and post- emergence (31.50 percent) root rot incidence were recorded in T5 (control).

The maximum yield (63.44%) was also recorded in T1 (seed treatment with *T. viride*) followed by T3 (seed treatment with *A. niger*) (62.33%). Minimum yield was recorded in control (32.37%). Green pod yield was significantly higher in bio-agents treated plots except *Aspergillus niger* during Rabi 2014-15 and 2015-16.

As an alternative to fungicides biological control can offer an alternative effective and environmentally safe management of root rot of French bean. Never the less, a notable feature of biological control has been its freedom from harmful effects on mankind. In the present study, seed treatment with *Trichoderma viride* gave maximum seed germination (85.82%) followed by *T. harzianum* (84.27%). Seed treatment with *Trichoderma viride* @ 5.0 g/kg gave best result in reducing pre-emergence (13.93 percent) and post- emergence (17.0 percent) root rot as compared to control. The maximum yield (63.44 q/ha) was also recorded by seed treatment with *T. veride* @ 5.0 g/10^{-6} spores/ml followed by *Aspergillus niger* @ 5.0 g/10^{-6} spores/ml (62.33 q/ha). These results are in accordance with Rajeswari, B. and Kumari Meena, K V S (2009), Khodke and Raut (2010) who observed increased seed germination and reducing pre - and post- emergence root rot and collar rot disease caused by *Rhizoctonia bataticola* and *Sclerotium rolfsii* of soybean. Rani *et al.* (2011) reported on banded leaf and sheath blight of maize, Panwar and Gaur (2012) on chickpea, Matloob and Juber (2013) on all been cultivated areas of Babylon city-Iraq and El - Mohamedy *et al.* (2015) on root rot disease on green bean.

Seed germination and pre-emergence showed negative and highly significant association with green pod yield in both the years 2014-15 and 2015-16. However, in both the years post-emergence positive and highly significant correlation with green pod yield.

The correlation coefficient studies revealed that green pod yield was significantly positively correlated with post-emergence (r=o.896) but seed germination (r=- 0.996) and pre-emergence (r= -0.986) showed negative and highly significant association with green pod yield (Table-2).

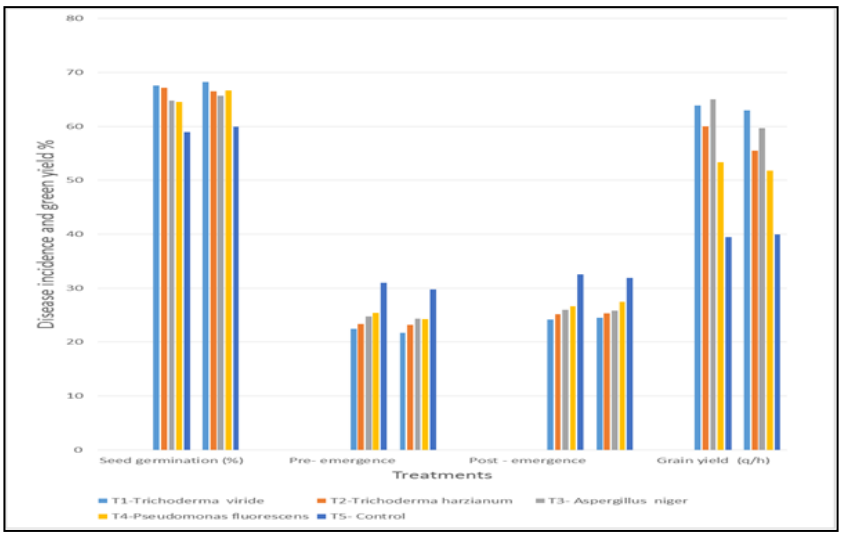

Fig 2: Effect of seed treatment with bio- agents against root rot disease incidence and green pod yield of French bean

Table 1: Effect of seed treatment with different bio- agents against on root rot disease incidence of French bean

Treatments	Dose (g/kg)	Seed germination (%)			Root rot disease incidence (%) **						Green pod yield (q/ha)			Percent Yield over control
					Pre- emergence			Post - emergence						
		2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	
T_1-*Trichoderma viride*	5.0	85.39 (67.55)	86.25 (68.26)	85.82 (67.90)	14.61 (22.47)	13.75 (21.74)	13.93 (22.10)*	16.75 (24.14)	17.25 (24.52)	17.00 (24.33)	63.88	63.00	63.44	59.71
T_2-*Trichoderma harzianum*	5.0	84.27 (67.17)	84.32 (66.52)	84.30 (66.67)	15.73 (23.36)	15.68 (23.21)	15.71 (23.33)	18.33 (25.17)	19.25. (25.32)	18.79 (25.65)	60.00	55.50	57.75	45.39
T_3- *Aspergillus niger*	5.0	82.40 (64.81)	83.25 (65.70)	82.83 (65.55)	17.60 (24.78)	16.75 (24.34)	17.18 (24.47)	19.31 (25.97)	18.75 (25.82)	19.03 (25.84)	65.00	59.66	62.33	56.92
T_4-*Pseudomonas fluorescence*	5.0	81.53 (64.56)	83.10 (66.70)	82.32 (65.17)	18.47 (25.42)	16.90 (24.26)	17.69 (24.84)	20.39 (26.68)	22.25 (27.50)	21.32 (27.47)	53.33	51.83	52.58	32.37
T_5- Control	-	73.30 (58.89)	68.63 (55.93)	70.96 (57.37)	26.70 (30.98)	31.37 (34.06)	29.03 (32.59)	29.25 (32.57)	33.75 (35.52)	31.50 (34.14)	39.44	40.00	39.72	-
SEm±		0.632	0.631	0.596	0.637	0.652	0.607	0.309	0.440	0.400	0.244	0.322	0.267	-
CD at 5%		1.936	1.936	1.726	1.966	2.010	1.759	0.951	1.358	1.159	0.754	0.993	0.775	-
C.V. %		1.946	1.946	1.946	5.018	5.274	5.144	2.286	3.224	2.799	14.47	19.87	17.28	-

*Figures in parentheses are arcsine-transformed values
**Average on four Replications

Table 2: Correlation coefficient between root rot disease incidence and green pod yield of fench bean Year, 2014

Correlation Matrix	Green pod Yield (Y_1)	Seed germination (X_1)	Pre-emergence (X_2)	Post- emergence (X_3)
Green pod Yield (Y_1)	1.000			
Seed germination (X_1)	-0.996**	1.000		
Pre-emergence (X_2)	-0.986**	0.997**	1.000	
Post- emergence (X_3)	0.896*	-0.927*	-0.941*	1.000

*Significant at 5%, ** significant at 1%, − Non Significant

The multiple regression equation

$Y=66.849-0.652\ X_1-0.981\ X_2+0.134\ X_3$, $R^2=0.9434$

Where,

Y= Green pod yield

X_1= Seed germination, X_2= Pre-emergence, X_3= Post-emergence

Regression analysis showed positive effect of post-emergence but negative effect of seed germination and pre- emergence on green pod yield.

The multiple regression equation

$Y=66.849-0.652\ X_1-0.981\ X_2+0.134\ X_3$, $R^2=0.9434$

Where,

Y= Green pod yield

X_1= Seed germination, X_2= Pre-emergence, X_3= Post-emergence

Regression analysis showed positive effect of post-emergence but negative effect of seed germination and pre- emergence on green pod yield.

The correlation among seed germination, pre-emergence and post- emergence with green pod yield were established and found that green pod yield was positive and significantly correlated with post-emergence (r=0.902) root rot incidence. But it showed negative and highly significant association with seed germination (r=-0.988) and pre-emergence (r= -0.941) (Table-3)

Table 3: Correlation coefficient between root rot disease incidence and green pod yield of French bean Year, 2015

Correlation Matrix	Green pod Yield (Y_1)	Seed germination (X_1)	Pre-emergence (X_2)	Post- emergence (X_3)
Green pod Yield (Y_1)	1.000			
Seed germination (X_1)	-0.988**	1.000		
Pre-emergence (X_2)	-0.941*	0.975**	1.000	
Post- emergence (X_3)	0.902*	-0.933*	-0.967**	1.000

*Significant at 5%, ** significant at 1%, − Non Significant

The multiple regression equation is

$Y=1.599+0.072\ X_1+0.144\ X_2-0.244\ X_3$, $R^2=0.9405$

Where,

Y= Green pod yield

X_1= Seed germination, X_2= Pre-emergence, X_3= Post-emergence

Regression analysis showed positive effect of seed germination and pre-emergence but negative effect of post-emergence on green pod yield.

Fig 1: Field view of experimental Plots

The multiple regression equation is

$Y=1.599+0.072\ X_1+0.144\ X_2-0.244\ X_3$, $R^2=0.9405$

Where,

Y= Green pod yield

X_1= Seed germination, X_2= Pre-emergence, $X_{3=}$ Post-emergence

Regression analysis showed positive effect of seed germination and pre-emergence but negative effect of post-emergence on green pod yield.

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