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Evaluation of fungicides against Root rot (*Rhizoconia solani*) incidence of French bean under field conditions

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Abstract
Among seed treatment with different fungicides i.e. Bavistin (Carbendazim) @ 0.1%,Vitavix (Carboxin + Thiram (37.5%) @ 0.2%, Tilt (Propiconazole) @ 0.1%,Contaf (Hexaconazole) @ 0.1%, Ridomil- MZ (Metalaxyl M 4% + Mancozeb 64%) @ 0.15%,Topsin- M (Thiophanate methyle) @ 0.1%, Nativo (Tebuconazole 50% + Trifloxystrobin 25%) @ 0.05%, maximum seed germination (89.89%), maximum green pod yield (72.16 q/ha), minimum mean pre(10.11%) and post (11.92%) - emergence root rot incidence was observed by seed treatment with Carbendazim. Multiple correlation coefficient showed positive and highly significant association with plant height, number of branches/plant, number of green pods/plant, pod length and green pod weight/plant and with green pod yield.

Keywords: fungicides, French bean, green pod

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) [1].

Several reviews on the subject have been published (Back *et al.*, 2002; Shahzad and Ghaffar, 1992; Anwar and Khan, 2002; Bhagwati *et al*., 2007) [3, 12, 2]. 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

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of infected plants. 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 Jharkhand. The yield losses from this disease have been reported 8.5 to 64.7 % from Bangalore

(Sharma and Sohi, 1980) [14]. The aims of present investigation was to determine the occurrence and incidence of root rot disease on French bean in the field of different villages of Ranchi, Ramgarh and Gumla districts of Jharkhand.

Materials and Methods

To test the efficacy of fungicides as a seed treatment a field trial was conducted inside glass house compound of Department of Plant Pathology, B.A.U., Kanke. A field trial was conducted in RBD during Rabi 2014-15 and 2015-16 cropping seasons using the variety, Pant Anupma. There were eight treatments including control with four replications. 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 plants.

Germination percentage and pre- and post- emergence root rot disease incidence per cent were recorded in each plot. Yield of green pods were also recorded. Observations on seed germination, pre- and post-emergence were recorded at 10 to 20 days after sowing and yield attributing phenotypic characters (plant height, no. of branches/ plant, no. of pods/plant, pod length and pod weights/plant) recorded from randomly selected 10 plants in each replication of each treatment at maturity stage. Green pod yield harvested periodically was also recorded for both the years and correlate with yield attributing phenotypic characters of French bean for each year.

Cost- benefit ratio for various treatments was worked out as follows

$$\text{Cost- benefit ratio} = \frac{\text{Gross return (Rs ha}^{-1}\text{)}}{\text{Total variable cost (Rs ha}^{-1}\text{)}}$$

Result and Discussion

Effect of fungicides on root rot disease incidence and green pod yield of French bean

The results of pooled analysis (Table-1) revealed that the all the fungicides proved to be significantly superior to the control in respect of seed germination. Pre-emergence root rot disease incidence recorded in all the treatments was significantly superior over the control. Post-emergence root rot disease incidence and yield were also significantly superior over the control. Maximum seed germination (89.89 percent) was observed in T_1 (seed treatment with Bavistin @ 0.1%) followed by T_2 (Vitavax @ 0.2%) (88.46 percent), T_7 (Nativo @ 0.05%) (87.10 percent) and T_3 (Tilt @ 0.1%) (85.97percent). Minimum seed germination was observed in control (64.61 percent).

Minimum pre- and post- emergence root rot disease incidence were observed in T_{1-} (seed treatment with Bavistin @ 0.1%) which recorded to the extent of 10.11 and 11.92 percent followed by T_{2-} (Vitavax @ 0.2%) 11.55 and 14.18 percent, T_{7-} (Nativo @ 0.05%) 12.91and 14.97 percent and T_{3-} (Tilt @ 0.25%) 14.03 and 16.72 percent, respectively. These treatments were at par with each other. Maximum pre- and post-emergence root rot disease incidences were recorded 33.39 and 35.37 percent, respectively in control.

The maximum green pod yield (72.16 q/ha) was also recorded in T_1 (seed treatment with Bavistin @ 2.0%) followed by T_7 (Nativo) (69.33 q/ha), T_2 (Vitavax) (65.83 q/ha) and T_3 (Tilt) (62.67 q/ha). Higher yield was recorded in T_5 (Ridomil-MZ) (57.50 q/ha), T_6 (Topsin-M) (60.39 q/ha) and T_4 (Contaf) (60.83 q/ha) as compared to control (39.17 q/ha). This treatment (T_1) also recorded increase yield over control of 84.22 percent. This treatment T_1 was followed by T_7 which recorded 68.05 percent increase yield over control

Observations recorded on the effect of fungicides on yield and yield attributing characters have been presented in Table-2. Maximum plant height (27.72 cm) was recorded in T_1 (seed tratment with Bavistin @ 0.1%) followed by T_2 (Vitavax @ 0.2%) (27.10 cm), T_7 (Nativo @ 0.05 %) (26.30 cm) and T_6 (Topsin-M) (26.25%). Minimum plant height was recorded in control (21.08 cm). Maximum number of branches/plant, number of green pods/plant and green pod weight were also recorded in T_1 (seed treatment with Bavistin @ 0.1%) (6.73, 10.96 and 37.0 g) followed by T_2 (Vitavax @ 0.2%) (6.37, 8.96 and 34.0 g).

Minimum numbers of branches/plant (3.76), number of green pods/plant (5.58), pod length (8.74 cm), green pod weight were recorded in control (T_8). The maximum pod length was also observed in T_1 (seed treatment with Bavistin @ 0.1 %) (14.95 cm) followed by T_7 (Nativo @ 0.05%) (13.18 cm) and other treatments in order of superiority were Vitavax, Topsin-M and Contaf. Minimum pod length was recorded in control (8.74 cm) (Table-2).

In the present studies, effect of seed treatment with different fungicides on incidence of root rot and yield of green pod was investigated. Of these, seed treatment with Bavistin @ 2.0% gave maximum germination (89.89 %) followed by Vitavax @ 0.2% (88.46%). Minimum pre- emergence (10.11%) and post-emergence (11.92%) root rot were observed by seed treatment with Bavistin followed by Vitavax (11.55% and 14.18%), Nativo (12.91%, 14.97%). Highest yield (72.16 q/ha) was also recorded by seed treatment with Bavistin @ 2.0%) followed by Nativo @ 0.05 percent (69.33 q/ha).

Maximum mean plant height (27.72 cm) was recorded by seed treatment with Nativo @ 0.05% followed by seed treatment with Vitavax @ 0.2% (27.10 cm). But number of branches/plant (6.73), number of green pods/plant (10.96) and green pod weight (37.0 g) were recorded by seed treatment with Bavistin @ 0.1% followed by seed treatment with Vitavax (6.37, 8.96 and 34.0 g) and pod length was observed by seed treatment with Nativo @ 0.05% (14.95 cm) followed by Bavistin @ 0.2% (13.18 cm). Multiple correlation coefficient exihibited positive and highly significant association of plant height, number of branches/plant, number of green pods/plant, pod length and green pod weight/plant with green pod yield during both the 2014-15 and 2015-16 cropping seasons.

Regression equation of green pod yield between number of green pods/plant and pod length exhibited negative significant during the year 2014-15. The co- efficient of multiple determinants (R^2) indicated that the number of green pods/plant and pod length (cm) favoured the green pod yield. These results were the similarity with findings of other workers. Sharma and Sohi (1981) [7] reported that the systemic fungicides were more effective than non-systemic fungicides against the root rot/web blight disease of frenchbean for first time in 1980. Upmanyu *et al*. (2002) [16] reported that seed treatment with Carbendazim (0.2%) in combination with foliar sprays were found effective in reducing the root rot incidence and web blight severity of *R. solani* as well as increased the yield of French bean. Tiwari and Singh (2004) [15]; Rajeswari and Meena (2009) [9]; Khodke

and Raut (2010) [8] studied on management of root rot and collar rot of soybean. They reported that maximum germination due to seed treatment with Thiram + Carbendazim + *Trichoderma* @ (4.0 g/kg) i.e., 89.15, 81.33 and 83.14% in consecutive three years followed by seed treatment with *Trichoderma* + Carbendazim @ 1.0 g/kg. Highest pre-emergence mortality (50.15%) and post-emergence mortality (20.22%) was obtained in control.

Considering the cost-benefit ratio, T_5 (seed treatment with Ridomil-MZ @ 0.15%) gave the highest cost- benefit ratio of 1:28.78 followed by T_1 (Bavistin @ 0.1%) (1:24.10) and T_4 (Contaf @ 0.1%) (1:23.13) in Table-3.

The correlation coefficient studies exhibited negative and highly significant association of Pre-emergence (r= -0.933) and post-emergence (r= -0.982) root rot disease incidence with green pod yield. However, seed germination (r= 0.932) was found to be highly significant positive association with green pod yield during the year 2014-15 in (Table-4).

Table 1: Effect of seed treatment with different fungicides on root rot incidence and green pod yield of French bean

Treatments	Dose (%)	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	
T1- Bavistin	0.1	90.32 (71.93)	89.46 (71.07)	89.89 (71.49)*	09.68 (18.12)	10.54 (18.90)	10.11 (18.51)	11.18 (19.49)	12.66 (20.77)	11.92 (20.13)	72.66	71.66	72.16	84.22
T2- Vitavax	0.2	89.40 (71.05)	87.51 (69.34)	88.46 (70.19)	10.60 (18.96)	12.49 (20.65)	11.55 (19.81)	15.33 (23.02)	14.18 (22.10)	14.76 (22.55)	65.00	66.66	65.83	68.06
T3- Tilt	0.1	85.38 (67.56)	86.56 (68.53)	85.97 (68.05)	14.62 (22.45)	13.44 (21.47)	14.03 (21.96)	17.22 (24.50)	16.22 (23.73)	16.72 (24.12)	62.00	63.33	62.67	59.99
T4- Contaf	0.1	83.46 (66.03)	84.63 (66.96)	84.05 (66.49)	16.54 (23.97)	15.37 (23.06)	15.96 (23.52)	19.22 (25.98)	18.64 (25.55)	18.93 (25.76)	61.66	60.00	60.83	55.29
T5- Ridomil MZ	0.15	81.48 (64.53)	80.28 (63.66)	80.88 (64.09)	18.52 (25.47)	19.72 (26.34)	19.12 (25.91)	20.22 (26.70)	22.26 (28.31)	21.24 (27.51)	58.33	56.66	57.50	46.79
T6- Topsin M	0.1	84.56 (66.89)	85.50 (67.65)	85.03 (67.27)	15.44 (23.11)	14.50 (22.35)	14.97 (22.73)	18.27 (25.29)	19.21 (25.98)	18.74 (25.64)	61.11	59.66	60.39	54.17
T7- Nativo	0.05	87.53 (69.36)	86.66 (68.60)	87.10 (68.98)	12.47 (20.64)	13.34 (21.39)	12.91 (21.02)	14.52 (22.37)	15.42 (23.09)	14.97 (22.73)	70.00	68.33	69.17	76.58
T8-Control	-	65.56 (60.38)	67.66 (55.34)	64.61 (53.49)	34.44 (36.02)	32.34 (34.70)	33.39 (35.14)	34.55 (36.12)	36.20 (36.74)	35.37 (36.56)	40.00	38.33	39.17	-
SEm±		0.981	0.900	1.63	0.915	0.802	1.491	0.510	0.825	1.188	0.296	0.793	0.498	
CD at 5%		2.97	2.73	4.72	2.77	2.43	4.31	1.54	2.51	3.44	0.89	0.84	1.44	
C.V. %		2.52	2.33	2.43	6.95	6.01	6.49	3.53	5.69	4.74	13.66	13.31	13.51	

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

Table 2: Effect of seed treatment of different fungicides on phenotypic characters of French bean

Treatments	Dose (%)	Plant height (cm)			No. of Branches/plant			No. of green pods/plant			Pod length (cm)			Green pod weight (g/plant)		
		2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
T1- Bavistin	0.1	27.60	27.83	27.72	5.16	7.06	6.73	10.46	11.46	10.96	15.44	14.46	14.95	35.20	39.0	37.10
T2- Vitavax	0.2	26.53	27.66	27.10	5.66	7.00	6.37	08.60	09.33	8.96	12.49	13.34	12.91	33.30	34.80	34.10
T3- Tilt	0.1	25.40	26.46	25.93	5.43	6.13	5.78	08.20	08.86	8.53	12.38	12.05	12.21	29.00	28.60	29.00
T4- Contaf	0.1	24.40	26.06	25.23	5.40	5.30	5.35	08.06	08.20	8.13	12.12	12.02	12.07	28.00	27.30	27.70
T5- Ridomil- MZ	0.15	23.43	24.73	24.08	4.70	4.40	4.55	06.96	07.06	7.01	11.84	11.86	11.85	25.10	24.90	25.00
T6- Topsin- M	0.1	25.90	26.60	26.25	5.06	5.70	5.38	07.86	08.26	8.06	12.58	14.16	12.45	29.30	31.30	30.30
T7- Nativo	0.05	25.93	26.66	26.30	5.16	5.73	5.44	08.20	08.53	8.36	13.82	12.55	13.18	31.70	32.30	32.00
T8-Control	-	20.73	21.43	21.08	3.63	3.90	3.76	05.43	05.73	5.58	09.00	08.49	8.74	19.30	19.0	19.15
SEm±		1.13	1.28	2.09	0.652	0.58	1.07	0.574	0.326	0.808	0.926	0.926	1.528	0.023	0.021	0.038
CD at 5%		3.44	3.89	6.08	1.97	1.76	3.10	1.74	0.98	2.34	2.53	2.81	4.42	0.07	0.66	0.112
C.V. %		7.87	8.57	6.76	21.27	17.60	19.42	12.26	6.59	9.70	11.60	13.22	11.95	13.96	13.22	13.58

**Average on three Replications

Table 3: Cost- Benefit ratio of seed treatment with fungicides

Treatments	Dose (g/kg seed)	Green pod yield q/ha	Additional yield q/ha	Cost of additional yield q/ha	Cost of application of inputs	Net return	C.B ratio
T_1 – Bavistin	0.1	72.16	31.00	62000	2470	59530	1:24.10
T_2 – Vitavax	0.2	65.83	24.67	49340	4502	44838	1:10.95
T_3 – Tilt	0.1	62.67	21.51	43020	7590	35430	1:5.66
T_4 – Contaf	0.1	60.83	19.33	38640	1670	36970	1:23.13
T_5 – Ridomil - MZ	0.15	52.50	11.34	22680	3894	18786	1:28.78
T_6 – Topsin- M	0.1	60.39	19.23	38640	1690	12950	1:5.82
T_7 – Nativo	0.05	67.16	26.00	52000	3294	51175	1:15.78
T8- Control	-	41.16	-	-		-	-

Price of French bean - Rs – 2000/q, Cot of inputs – Price of fungicides Rs/q,
Bavistin–Rs.-1200/kg, Vitavax - Rs. 1900/kg, Tilt– RS. 1100/kg, Contaf – Rs.700/kg,
Ridomil -MZ- RS 1900/kg, Topsin-M– Rs. 1000/kg, Nativo – Rs. 490/100 g
Labour required for application of fungicides – 2 Man days/ha, One labour charge- Rs. 225/day, Miscellaneous - Rs. 100/ha.

Table 4: Correlation coefficient between green pod yield and seed germination, pre and Post-emergence of root rot incidence of French bean Year-2014

Description	Green pod yield (q/ha)	Seed germination (%)	Root rot disease incidence (%)	
			Pre-emergence	Post-emergence
Green pod yield (q/ha) Y				
Seed germination (%) X_1	0.932**			
Pre-emergence X_2	-0.933**	-1.000**		
Post-emergence X_3	-0.982**	-0.970**	0.969**	

** Significant at 1 % leval

The multiple regression equations

$Y= 2,221.06 - 23.289X_1 - 22.416 X_2 -3.331 X_3$, $R^2 = 0.9759$

Where,

Y=green pod yield, X_1= seed germination, X_2= Pre-emergence, X_3= Post-emergence

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

The multiple correlation coefficient showed positive and highly significant association of plant height (r=0.940 and r=0.970), no. of branches/plant (r=0.736 and r=0.843), number of pods/plant (r= 0.831 and r=0.896), pod length/pod (r=0.963 and r=0.900), green pod weight/plant (r=0.949 and r=0.994) with green pod yield and seed germination, respectively. All the phenotypic characters showed highly significant negative association with pre- and post-emergence root rot disease incidence (Table-5).

Multiple regression equation among pre-emergence, post-emergence, seed germination and green pod yield exhibited strongly relationship among different phenotypic characters during the year of study 2014-15. Phenotypic characters viz., number of pods/plant showed significant positive effect on pre- and post-emergence and accounted for 95.43 and 98.91 percent variation, respectively. Plant height, number of branches/plant, pod weight/plant showed significant positive effect on seed germination and accounted for 95.45 percent variation. Phenotypic characters viz., plant height, number of branches/plant, pod length/pod, pod weight/plant showed significant positive effect on green pod yield (Table-6).

The correlation coefficient studies exhibited negative and highly significant association of pre-emergence (r= -0.931) and post-emergence (r= -0.980) root rot disease incidence with green pod yield. However, seed germination (r= 0.929) was found to be highly significant positive association with green pod yield during the year 2015-16 in (Table-7).

Table 5: Multiple correlation- coefficient of phenotypic characters of French bean with green pod yield, seed germination, Pre-emergence, Post-emergence Year-2014

Phenotypic characters	Green pod yield (q/ha)	Seed germination (%)	Pre-emergence (%)	Post-emergence (%)
Plant height (cm) (X_1)	0.940**	0.970**	-0.970**	-0.966**
No. of branches/plant (X_2)	0.736**	0.843**	-0.841**	-0.818**
No. of pod/plant (X_3)	0.831**	0.896**	-0.894**	-0.900**
Pod length (cm)/plant (X_4)	0.963**	0.900**	-0.899**	-0.973**
Pod weight /plant (X_5)	0.949**	0.994**	-0.994**	-0.978**

****** Significant at 1 %

Table 6: Multiple regression equation of pre-and post-emergence, green pod yield and eed germination in to relation to phenotypic characters Year- 2014

Description	Multiple regression equation	R^2
	Root rot disease incidence (%)	
Pre-emergence	$Y=71.35- 1.462X_1-4.810 X_2 + 2.473X_3 -0.524 X_4 -0.625 X_5$	0.9543
Post-emergence	$Y=72.13- 0.798 X_1 -6.726 X_2 +4.295 X_3-2.106 X_4 -0.1.112 X_5$	0.9891
Seed germination	$Y=18.71+1.456X_1+4.759 X_2 -2.419X_3 +0.517X_4+0.462 X_5$	0.9545
Green pod yield	$Y= - 74.41+1.965 X_1+28.738 X_2 - 20.915X_3+8.310 X_4+6.251 X_5$	0.9899

Where,

Y= Pre-emergence, Y=Post-emergence, Y=Seed germination, Y=Green pod yield

X_1 = Plant height, X_2 =Number of branches/plant,

X_3 = Number of pods/plant

X_4 = Pod length /plant,

X_5 = Pod weight/plant

Table 7: Correlation coefficient between green pod yield and seed germination, pre and post- emergence of root rot incidence of French bean Year- 2015

Description	Green pod yield (q/ha)	Seed germination (%)	Root rot disease incidence (%)	
			Pre-emergence	Post-emergence
Green pod yield (q/ha) (Y)				
Seed germination (%) (X_1)	0.929**			
Pre-emergence (X_2)	-0.931**	-0.980**		
Post-emergence (X_3)	-0.980**	-0.970**	0.972**	

** Significant at 1 %

The multiple regression equations

$Y= 231.56 – 1.727X_1- 4.164 X_2 -3.321 X_3$, $R^2 = 0.9659$

Where,

Y= Green pod yield, X_1= Seed germination, X_2= Pre-emergence, X_3= Post-emergence

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

The multiple correlation coefficient showed positive and highly significant association of plant height (r=0.966 and r=0.984), no. of branches/plant (r=0.784 and r=0.872), number of pods/plant (r= 0.805 and r=0.859), pod length/pod (r=0.961 and r=0.939) and green pod weight/plant (r=0.927 and r=0.947) with green pod yield and seed germination, respectively. All the phenotypic characters showed highly significant negative association with pre- and post-emergence root rot disease incidence (Table-8).

Multiple regression equation among pre-emergence, post-emergence, seed germination and green pod yield exhibited strongly relationship among different phenotypic characters during the year of study 2015-16. Phenotypic characters viz., number of branches/plant, pod length/plant showed significant positive effect on pre- emergence and accounted for 99.5 percent variation. Pod length/plant showed significant positive effect on post-emergence and accounted for 95.67 percent variation. Plant height, number of pods/plant, pod weight/plant showed significant positive effect on seed germination and accounted for 99.53 percent variation. Phenotypic characters viz., plant height, number of pods/plant, pod length/pod, pod weight/plant showed significant positive effect on green pod yield and accounted for 95.32 percent variation (Table-9).

Table 8: Multiple correlation coefficient of phynotypic characters of French bean with green pod yield, seed germination, Pre-emergence, Post-emergence Year-2015

Phenotypic characters	Green pod yield (q/ha)	Seed germination (%)	Pre-emergence (%)	Post-emergence (%)
Plant height (cm) (X_1)	0.966**	0.984**	-0.984**	-0.943**
No. of branches/plant (X_2)	0.784*	0.872**	-0.873**	-0.918**
No. of pod/plant (X_3)	0.805*	0.859**	-0.861**	-0.900**
Pod length /plant (X_4)	0.961**	0.939**	-0.940**	-0.917**
Pod weight/plant (X_5)	0.927**	0.947**	-0.948**	-0.948**

** Significant at 1%

Table 9: Multiple regression equation of pre-and post-emergence, green pod yield and seed germination in relation to phenotypic characters Year- 2015

Description	Multiple regression equation	R^2
Root rot disease incidence (%)		
Pre-emergence	$Y=76.74 -2.436X_1+1.000 X_2 - 1.267X_3 +1.301 X_4 - 0.039 X_5$	0.9951
Post-emergence	$Y=61.45- 1.162 X_1 - 0.549 X_2 - 0.772 X_3+0.311 X_4 -0.008 X_5$	0.9567
Seed germination	$Y=13.04+2.456X_1- 1.008 X_2 +1.268X_3 - 1.312X_4+0.035 X_5$	0.9953
Green pod yield	$Y= - 54.06+3.981 X_1- 3.013 X_2 +1.533X_3+0.727 X_4+0.229 X_5$	0.9532

Where,

Y= Pre-emergence, Y=Post-emergence, Y=Seed germination, Y=Green pod yield

X_1 = Plant height, X_2 =Number of branches/plant, X_3 = Number of pods/plant

X_4 = Pod length /plant, X_5 = Pod weight/plant

Field view of experimental plots

Plate–21. A **Plate-21B**

Effect of seed treatment of with fungicides on root rot incidence (*R. solani*)

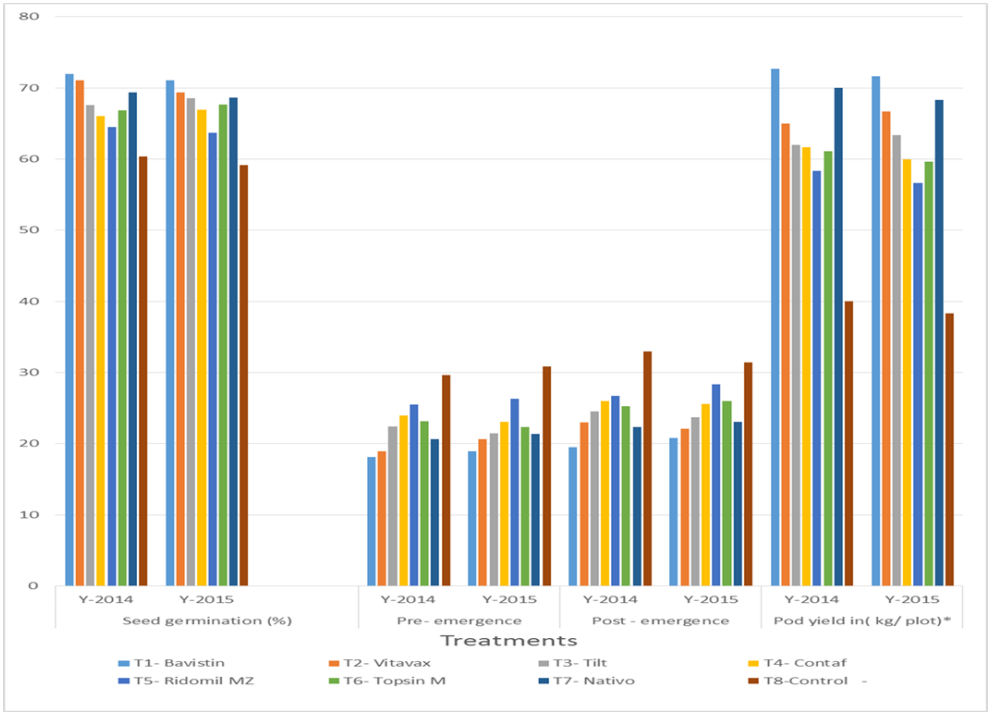

Fig 16: Effect of seed treatment with fungicides on root rot incidence and green pod yield of French bean

Summary

Seed treatment with Carbendazim @ 0.1% was found to be most efficacious in increasing seed germination in reducing pre- and post-emergence and increasing green pod yield during both Rabi 2014-15 and 2015-16 cropping seasons.

Maximum mean plant height, number of branches/plant, number of green pods/plant and green pod weight were recorded by seed treatment of Carbendazim @ 0.1 percent followed by Vtavax and Nativo. Considering the cost- benefit ratio the seed treatment with Carbendazim was found to be most favorable and economical with returns of Rs.24.10 per rupee. Plant height, number of branches/plant, number of green pods/plant, pod length (cm) and green pod weight/plant with green pod yield were positive and highly significant correlation. Regression equation between number of Green pods/plant, pod length (cm) and green pod yield exhibited positive significant during the year 2014 study. The co-efficient of multiple determinants (R^2) indicated that the number of green pods/plant, pod length (cm) favored the green pod yield.

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