RESEARCH ARTICLE

INTEGRATED MANAGEMENT OF ROOT ROT OF PEA

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Abstract: In present investigation the fungicides, phytoextracts, oil cakes and biocontrol agents found effective *in vitro*, were further evaluated in field for two consecutive seasons as seed treatment individually as well as in different combinations for suppression of root rot of pea. It was found that combined treatments were superior in terms of better germination, lower mortality and higher yield as compared to individual treatments. The most effective treatment with ST Bavistin + Neem oil + *T. harzianum*+ SA Neem cake followed by seed treatment with Bavistin + Neem oil + *T. harzianum* as compared to control as well as other treatments. *T. harzianum* applied as seed treatment effectively established in pea rhizosphere and reached high population densities, at 90 DAS while the population of the pathogen was low in the rhizosphere as significant disease suppression was recorded.

Keywords: *F.* solanif.sp. *pisi*, Pea, Root root, Neem oil, Bavistin, *T. harzianum*

INTRODUCTION

Among the soil borne diseases root rot of pea is a major soil borne disease in pea growing areas worldwide and is often considered to be the limiting factor in pea production (Shehata*et al*., 1983). Root rot may start when the plant is in the pre or post emergence seedling stage. Death soon follows as early infections, resulting in a poor crop stand. Root decay generally begins on the finer feeder roots and progresses gradually to the main tap root of the plant. In some cases all roots are destroyed, leaving only remnants below the attachment of the seed. Root rot of pea is characterized by the cortical decay and a brilliant red discoloration of vascular tissues in the root (Lin *et al*., 1984).

The underground part of pea plant is damaged by the fungus. On underground stem reddish brown sunken lesions are formed. The root system may be completely decayed and the plant has poor standing. Vascular reddish discoloration is commonly observed in diseased plants. Symptoms consist of poor growth, yellowing and finally wilting of leaves (Singh, 1999).

Among the fungal diseases, the root rot caused by *Fusariumsolani*f.sp.*pisi*remains to be challenging task in terms of management. Therefore, integrated management strategy is the better solution to maintain plant health. These strategies include minimum use of chemical for checking the pathogen population, encouragement of beneficial biological agent to reduce pathogen inoculums, modification of cultural practices and use of resistant varieties (Bendre and Barhate, 1998).In sustainable agriculture, diseases of grain legume need to be managed by integrated disease management (IDM) strategies that involve the use of additive or synergistic combinations of biotic, cultural and chemical control measures (Conway, 1996; Jimenez-Diaz *et al*., 1998).

MATERIAL AND METHOD

Field trials on integrated disease management of the disease were conducted during *rabi*season 2010 and 2011 at field, Department of Plant Pathology, Rajasthan college of Agriculture, Udaipur. Field experiments were laid down in Randomized block design. Plot size taking in 3x2 m plot with spacing of 30x10 cm and replicated thrice. Following treatment were laid out in IDM trial. On the basis of *in vitro* studies, one promising fungicide, one oil extract, one organic amendment and one bio control agent *viz*., Bavistin 50 WP, Neem oil, Neem cake and *T. harzianum* respectively were evaluated alone or in combination with each other to observe their individual as well as combined effects on root rot of pea. Local Pea variety was used for the study under irrigated condition.

T1- Seed treatment with fungicide (Bavistin 50 WP 0.1%)
T2- Seed treatment with botanical (Neem oil @ 3%)
T3- Seed treatment with bio-agent (*T. harzianum*10 gm/ kg)
T4- Seed treatment with fungicide +botanical (Bavistin 50 WP 0.1% + Neem oil @ 3%)
T5- Seed treatment with fungicide + bio-agent (Bavistin 50 WP 0.1% + *T.harzianum*10 gm/ kg)
T6- Seed treatment with botanical + bio-agent (Neem oil @ 3% + *T.harzianum*10 gm/ kg)
T7- Seed treatment with fungicide + botanical + bio-agent (Bavistin 50 WP 0.1% + Neem oil @ 3% +*T. harzianum*10 gm/ kg)
T8- Soil application with organic amendment (Neem cake 100 gm/ sqm)

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T9- Combined treatment with organic amendment + Seed treatment with fungicide, botanical and bio-agent respectively (Bavistin 50 WP 0.1%+ Neem oil @ 3% + *T. harzianum*10 gm/ kg seed + Neem cake 100 gm/ sqm)

T10 - Untreated control

Required quantity of Bavistin (0.1%), Neem oil and *T. harzianum*alone or in combination of each were used as seed treatment at the time of sowing and Neem cake used as soil treatment.The organic soil amendments (cakes) were added in to the soil two weeks before seed sowing and then soil infested with addition of inoculums @ 25 gm/sqm at 5-8 cm depth in the soil for increase the disease pressure.For seed treatment, cultures of the bio-control agents were individually grown on PDA. The sporulating colonies so developed were harvested by suspending in 20 ml water in each petri plates and mixed with sterilized fine clay (talc powder) 10 gm to make a slurry. This formulation of *T. harzianum* was used for seed treatments at 10 gm/kg seed in plots inoculated in combination of *F. solani*f.sp. *pisi*@ 25gm/ sqm. The coated seeds were kept overnight in moist chamber so as to enable the antagonists to establish on seeds.For chemical and oil extract seed treatment small quantity of each fungicide bavistin 0.1 % seed treatment and oil extract Neem oil (3%) separately for 30 minutes, air dried in shade and then sown.

Observations

- Per cent germination of pea seeds in different treatment
- Root rot incidence in different treatments
- Population density of pathogen and biocontrol agents in different treatments
- Green pod yield in different treatments

The seed germination was recorded 15 days after sowing and plant mortality was recorded upto 90 days after sowing. Green pod yield was recorded for each plot after harvesting of pods. To determine the population of biocontrol agent and their possible effect on *F.solani*f.sp.*pisi*, soil samples from pea rhizosphere and around from both diseased and healthy plants were collected from each plot carefully by uprooting the plants lightly shaking these to remove the extra soil. The rhizosphere soil was collected by lightly scrapping with a hard brush. Samples of all the three replications of each treatment were pooled and placed in polythene bags, labeled and brought to the laboratory. Sub-samples from these pooled samples were used for determining population densities of biocontrol agents and the pathogen.

RESULT AND DISCUSSION

The fungicides, phytoextracts , oil cakes and bio-agents which were found most effective in single experiment, further tested in combinations in Random Block Designed in the field during *rabi*season (2010-11) and (2011-12). The seed germination was recorded 15 days after sowing and plant mortality was recorded 90 days after sowing.

The plot size was 3x2 meter, total 10 treatments were taken including control and each treatment with 3 replications, following randomised block design (RBD). Culture of *F. solani*f.sp.*pisi*was multiplied on corn meal sand (2:1) medium filled in flasks at 28 ± 1^0C for 15 days till good growth occurred. These cultures were then properly mixed together and applied in soil @ 25 g/ sqm. All the plots were lightly irrigated immediately after inoculation and to allow establishment of the pathogen before sowing.

At the time of sowing, soil samples were taken from a depth of 15 cm to determine initial population of pathogens. Seeds of pea were treated with fungicide Bavistin @ 0.1%, Neem oil @ 3% and the most effective bioconrol agent *T. harzianum* talc based formulation as seed treatment and most effective oil cake Neem cake was used for soil treatment @ 100 g/sqm two week before sowing. A light irrigation was given immediately after sowing. Observations on germination percentage, per cent plant mortality and Green pod yield in different treatments were recorded. The results thus obtained are presented in Table 1, Plate 1, Fig. 1. After 30, 60 and 90 days of sowing, soil samples were collected from rhizosphere of pea for determination of population density of the respective biocontrol agent and the pathogen.

Pooled data of two seasons reveals that the inoculated untreated control plots (T_{10}) had 80.27% germination. Among individual treatments, seed treated with Neem cake (T_8) showed the highest (88.24%) germination, as compared to control as well as other treatments. Seed treated with Bavistin (T_1) had 86.98% germination, 85.92 % germination was observed in seed treated with *T. harzianum*(T_3) and the lowest germination (82.68%) was observed with Neem oil (T_2). In plots with treatments in combination, higher germination (92.31%) was recorded in plots having treatment with Bavistin + Neem oil + *T. harzianum* + Neem cake (T_9), those with Bavistin + Neem oil + *T. harzianum*(T_7) showed 91.02% germination. This was followed by treatment with Bavistin + *T. harzianum*(T_5) showed 90.74% germination and treatment with Bavistin + Neem oil (T_4) showed 89.44% germination. The lowest germination (89.04%) was recorded in plots with seed treatment of Neem oil + *T. harzianum*(T_6).

The pooled data of two season showed lowest mortality (23.42%) with individual treatment, Neem cake (T_8), followed by treatment with Bavistin (T_1) showed 25.53% mortality. Seed treatment with *T. harzianum*(T_3) resulted in 27.37% mortality and the highest mortality (37.95%) among the individual treatments was recorded in seed treatment with Neem oil (T_2). The inoculated untreated control (T_{10}) showed 42.69% mortality. In plot with treatments in combination, the lowest mortality (13.75%) was recorded in treatment with Bavistin + Neem oil +*T.*

harzianum + Neem cake (T_9) as compared to 42.69% mortality in inoculated untreated control plots. This was followed by 14.75% mortality in plots with Bavistin + Neem oil + *T. harzianum*(T_7) treated seeds. Plots treated with Bavistin + *T. harzianum*(T_5) showed 16.74% mortality while 19.55% mortality was observed with Bavistin + Neem oil (T_4). The seed treatment with Neem oil + *T. harzianum*(T_6) resulted the highest mortality 22.32% among the combined treatments.

The inoculated untreated control (T_{10}) plots gave 3.15kg/plot green pod yield, while among the individual treatments highest green pod yield (4.51 kg/plot) was recorded in plots treated with Neem cake (T_8), followed by 4.11 kg/plot green pod yield with Bavistin (T_1), 3.97 kg/plot green pod yield with *T.harzianum*(T_3) and the lowest green pod yield (3.74 kg/plot) was recorded in treatment with Neem oil (T_2). In plots with the treatments in combination, the highest green pod yield (5.26 kg/plot) was recorded in treatment with Bavistin + Neem oil + *T. harzianum* + Neem cake (T_9), followed by 5.08 kg/plot green pod yield in treatment with Bavistin + Neem oil + *T. harzianum*(T_7), 4.90 kg/plot green pod yield with Bavistin + *T. harzianum*(T_5) and 4.70 kg/plot green pod yield with Bavistin + Neem oil (T_4). The lowest green pod yield (4.64 kg/plot) among the combined treatments was recorded with Neem oil + *T. harzianum*(T_6).

The present findings are supported by other workers that integration of biocontrol agent with fungicides gave significantly higher disease control in several crops than that obtained by either biocontrol agent or fungicide (Henis*et al.,* 1978; Upadhyay and Mukhopadhyay, 1983; Mukhopadhyay and Kaur, 1990; Sawant and Mukhopadhyay 1990; Vyas, 1994; Dubey*et al., 1996;*Dubey, 1997). Neelamegam and Govindarajalu (2002) demonstrated better results of plant stand and other growth parameters with biocontrol agents and farm yard manure (FYM) integration.

Table 1. Effect of different Integrated management module on per cent seed germination, per cent plant mortality and green pod yield in inoculated field of root rot pathogen on pea local cultivar during *rabi* season 2010-11 and 2011-12

S. No.	Treatments	Seed Germination* (%)			Plant mortality* (%)			Green pod yield* Kg/ plot		
		2010-11	2011-12	pooled	2010-11	2011-12	pooled	2010-11	2011-12	pooled
1.	Bavistin 50 WP @ 0.1% ST	87.96 (69.74)	86.00 (68.04)	86.98 (68.89)	25.66 (30.43)	25.30 (30.25)	25.53 (30.34)	4.30	3.92	4.11
2.	Neem oil @ 3% ST	83.14 (65.79)	82.21 (65.08)	82.68 (65.44)	38.18 (38.15)	37.71 (37.88)	37.95 (38.02)	3.87	3.60	3.74
3.	*T. harzianum* @ 10 gm/kg ST	86.29 (68.29)	85.55 (67.66)	85.92 (67.98)	27.03 (31.28)	27.71 (31.76)	27.37 (31.52)	4.02	3.91	3.97
4.	Bavistin @ 0.1% ST + Neem oil @ 3% ST	89.62 (71.25)	89.25 (70.88)	89.44 (71.07)	19.39 (26.11)	19.69 (26.33)	19.55 (26.22)	4.81	4.58	4.70
5.	Bavistin @ 0.1% ST + *T. harzianum* @ 10 gm/kg ST	91.11 (72.67)	90.36 (71.94)	90.74 (72.31)	16.47 (23.90)	17.00 (24.34)	16.74 (24.12)	5.11	4.69	4.90
6.	Neem oil @ 3% ST + *T. harzianum* @ 10 gm/kg ST	89.07 (70.74)	89.00 (70.65)	89.04 (70.70)	22.20 (28.09)	22.43 (28.26)	22.32 (28.17)	4.75	4.52	4.64
7.	Bavistin @ 0.1% + Neem oil @ 3% ST + *T. harzianum* @ 10 gm/kg ST	91.29 (72.86)	90.73 (72.31)	91.02 (72.59)	14.39 (22.28)	15.10 (22.86)	14.75 (22.57)	5.23	4.92	5.08
8.	Neem cake 100 gm/ sqm (soil application)	88.33 (70.05)	88.14 (69.87)	88.24 (69.96)	23.29 (28.84)	23.54 (29.01)	23.42 (28.92)	4.59	4.42	4.51
9.	Bavistin @ 0.1% ST + Neem oil @ 3% ST + *T. harzianum* @ 10 gm/kg ST + Neem cake 100 gm/ sqm (soil appli.)	92.58 (74.24)	92.03 (73.63)	92.31 (73.94)	13.40 (21.45)	14.09 (22.03)	13.75 (21.74)	5.40	5.10	5.26
10.	Untreated control	79.99 (63.44)	80.55 (64.23)	80.27 (63.84)	43.00 (40.98)	42.37 (40.61)	42.69 (40.79)	3.27	3.02	3.15
	SEm ±	0.74	1.20	0.70	0.82	0.65	0.52	0.18	0.17	0.12
	CD at 5%	2.20	3.55	0.02	2.42	1.92	1.49	0.54	0.50	0.35
	CV%	2.12	3.44	2.86	5.60	4.42	5.04	8.05	7.80	7.94

* Mean of three replications

Figures in parenthese arearcsine √ per cent angular transformed values

c.f.u of inoculum prepared in lab is 3×10^6

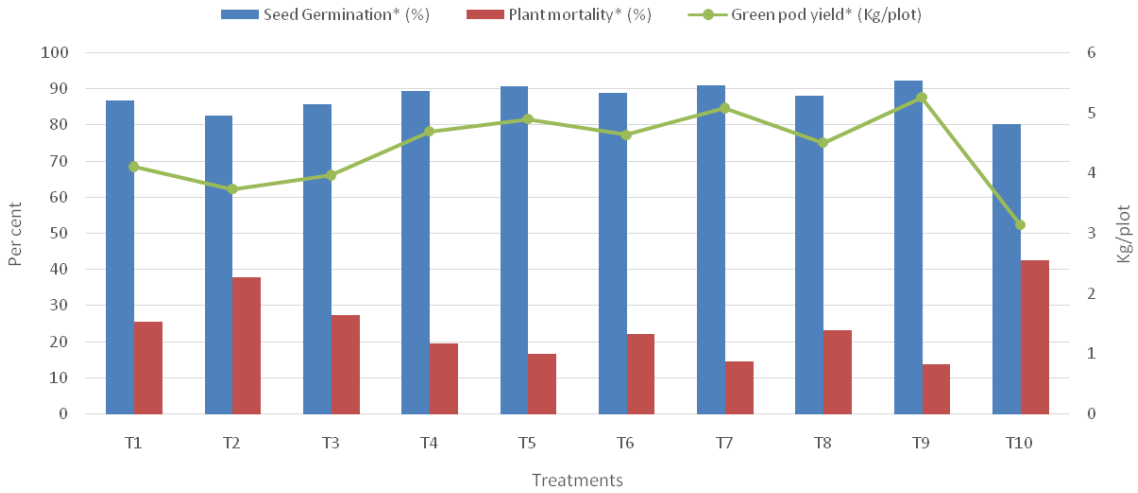

Fig 1. Effect of integrated management modules on per cent seed germination, per cent plant mortality and green pod yield in inoculated field against root rot of Pea

T_1 = Bavistin 50 WP @ 0.1% ST
T_2 = Neem oil @ 3% ST
T_3 = *T. harzianum* @ 10 gm/kg ST
T_4 = Bavistin @ 0.1% ST + Neem oil @ 3% ST
T_5 = Bavistin @ 0.1% ST + *T. harzianum* @ 10 gm/kg ST
T_6 = Neem oil @ 3% ST + *T. harzianum* @ 10 gm/kg ST
T_7 = Bavistin @ 0.1% + Neem oil @ 3% ST + *T. harzianum* @ 10 gm/kg ST
T_8 = Neem cake 100 gm/ sqm (soil application)
T_9 = Bavistin @ 0.1% ST + Neem oil @ 3% ST + *T. harzianum* @ 10 gm/kg ST + Neem cake 100 gm/ sqm S.A.
T_{10} = Untreated control

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