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Comparative Study of Fungicides, Bio-Agents and Organic Amendments for Management of Black Scurf of Potato

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ABSTRACT

Potato (*Solanum tuberosum* L.) is an important staple food crop of the world. India rank 2nd after China producing 52588.98 thousand metric tons potato per year. In India, among all the states Uttar Pradesh stands first with the production of 15812.62 thousand metric tones followed by West Bengal with the production of 12782.00 thousand metric tons in the year 2018-19. Potato is infected by a number of soil and tuber borne diseases and pest. Among all, black scurf (*Rhizoctonia solani* Kuhn.) is a destructive disease of potato. The most common phase of this disease is formation of sclerotial masses on the tuber resulting in black scurf which considerably reduces market value of edible tubers. In present investigation different bio-agents and chemicals were tested for management of the disease were used under field conditions. Among the bio-agents, *Trichoderma harzianum*, *Chaetomium globosum*, *Bacillus subtilis,* with vermicompost. Fungicides, Boric acid @ 3%, Carbendazim 50% WP @ 1%, Mencozeb @ (0.2%) and Pencycuron @ (0.2%) concentration. In field experiment the result revealed that the minimum disease incidence was recorded (12.00%) in Mancozeb @ 0.25% foliar spray compared to untreated check 60.00% and minimum disease severity (18.96%) and maximum yield 275.00 q/ha was recorded in Boric acid @ 3% tuber treatment compared to untreated control.

Keywords Potato, Bio-agents, *Rhizoctonia solani*, Vermicompost, Fungicides.

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INTRODUCTION

Potato (*Solarium tuberosum* L., Family Solanaceae) is an important non-grain food crop in the world, with a total production of over 365 million tones per year (FAOSTAT 2013), Potato occupies largest area under any single vegetable in the world it is also known as king of vegetable. Management of *Rhizoctonia solani* Kühn. (teleomorph *Thanatephorus cucumeris* (Frank, Donk)), the cause of potato black scurf, is complex due to its soil-borne nature and high level of survival. Potato is infected by a number of soil and tuber borne diseases such as common scab (*Streptomyces scabies*), powdery scab

(*Spongospora–subterranean*), brown rot (*Ralstonia solanacearum*), black leg (*Erwinia carotovora* sp.), sclerotium wilt (*Sclerotium rolfsii* Sacc.), *VerticiIlium* wilt (*VerticiIliumalbo-atrum*, Reinke and Berth), black scurf (*Rhizoctonia solani* Kuhn.), sclerotinia stem rot (*Sclerotinia sclerotiorum* L.). Among these, black scarf caused by *Rhizoctonia solani* appears in severe proportions in the Uttar Pradesh, causing considerable yield losses. The pathogen attacks young sprouts through epidermis and produces dark brown lesions, thereby killing the sprout before emergence which results in gappy germination. Emergence of canker on stem results in poor downward flow of carbohydrates, resulting the development of aerial tubers as well as top rosette due to accumulation of carbohydrates in the aerial parts. The most common phase of the disease is formation of sclerotial masses on the tuber resulting in black scurf which considerably reduces market value of edible tubers.

The disease can be managed through seed treatment with fungicides such as organo mercurials, benomyl, thiabendazole, carboxin, pencycuron, azoxystrobin and fenpiclonil (Virgen-Callerus *et al.* 2000). Among different fungicides Pencycuron–based fungicide is known to exhibit high and specific activity against *Rhizoctonia solani* and has been reported to be very effective for control of black scurf (Thind *et al.* 2002). The two compounds that Indian farmers use most commonly to control black scurf are boric acid and pencycuron (Khurana *et al.* 2001). Before sprouting, typically before cold storage, boric acid should be administered to seed tubers (Singh *et al.* 2002, Arora *et al.* 2006), but pencycuron can be treated to sprouted tubers during planting time (Thind *et al.* 2002). Since many farmers apply seed treatment to the sprouted tubers after its removal from cold stores prior to their planting in field, a comparison of efficacy and cost of seed treatment with boric acid and pencycuron applied by different methods at planting, was carried out in the current study.

Control of soil-borne plant pathogens is usually done by cultural, physical, mechanical, biological and last one chemical method. There are no really good control measures for *Rhizoctonia solani*. The crop rotation may have some beneficial effect, but the fungus has such a wide host range and is easily re-introduced as sclerotia on seed potatoes that it is not very effective to control. Control of the disease by conventional methods is inadequate and not eco-friendly. Therefore, biological control appears to be a good alternative either alone or in IPM system for management of black scurf disease. The use of beneficial, naturally occurring fungi, bacteria as biocontrol agents of plant diseases has been studied for at least two decades.

MATERIALS AND METHODS

The phytopathogenic fungus (*Rhizoctonia solani*) was multiplied using wheat grains (*Triticum aestivum*). Wheat grains taken and washed with water to remove the dirt particles then the grain soaked in water containing 2% sucrose for 6 hrs. Drain excess water and dry under shade for reducing the moisture up to 60–70%. 250 g of wheat grain filled in 500 ml conical flasks. Flasks containing wheat grains were sterilized at 121°C and incubated with one-week old fungal culture grown on PDA medium. Flasks were incubated at room temperature (26±2°C) for fifteen days and stirred once in three days. Colonized wheat grains were used as fungal inoculum of *R. solani* @ 75 g wet weight/m^2 of field three days prior to sowing in all treatments challenge the potato tuber/seedlings with black scurf disease except control (Paulitz and Schroeder 2005).

Field trials were carried out during 2019-20 at Crop Research Center (CRC) of the Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (UP). The seed potato tuber of var Kufri Chipsona-1 susceptible surface covered with black scurf sclerotia were used in these experiments. The experiments were conducted in plots where the incidence of black scurf in the previous crop season was below one per cent hence the infected seed used in these experiments were the main source of disease inoculum.

The fungicides used in this experiment were Pencycuron 250 SC @ 0.25%, boric acid @ 3% and Mencozeb 75% WP @ 0.25%. Calculated amount of fungicides added in water and was used as foliar spray. However, potato tubers dip in the carbendazim 50% WP solution @ 1 g/kg and bioagent, *Tricho-*

Table 1. Comparative study of fungicides, bio-agents and organic amendments against the black scurf of potato under field condition.

	Treatment detail	Germination (%)	Plant height (cm) 30 DAS	Plant height (cm) 60 DAS	Disease incidence (%)	Disease severity (%)	Yield q/ha
T_1	Soil application of *Chaetomium globosum* @ 5 kg/ha with vermicompost @ 500 kg/ha	**80.33**	26.33	**40.00**	**38.67**	**46.96**	**175.00**
T_2	Soil application of *Trichoderma harzianum* @ 5 kg/ha with vermicompost @ 500 kg/ha	83.00	28.33	41.33	36.00	41.78	194.44
T_3	Soil application of *Bacillus subtilis* @ 5 kg/ha with vermicompost @ 500 kg/ha	80.33	**25.00**	40.00	33.33	38.37	180.56
T_4	Soil application of vermicompost @ 500 kg/ha alone	84.00	29.67	41.00	26.67	31.40	211.11
T_5	Tuber treatment with *Trichoderma harzianum* @10 g/kg seed	85.00	30.00	41.00	34.66	40.00	197.22
T_6	Tuber treatment with *Chaetomium globosum* @ 10 g/kg seed	85.00	30.33	41.00	26.67	30.22	205.56
T_7	Tuber treatment with *Bacillus subtilis* @ 10g/kg seed	88.33	30.67	41.67	18.67	24.29	216.67
T_8	Tuber seed treatment with Carbendazim 50 % WP @ 1g/kg	**89.67**	30.00	42.00	17.33	22.074	244.44
T_9	Pencycuron (250 SC) @ 0.25% foliar spray	89.67	**31.67**	41.67	14.67	20.74	269.44
T_{10}	Boric acid @ 3% tuber treatment	89.00	31.67	41.33	13.33	**18.96**	**275.00**
T_{11}	Mancozeb 75% WP @ 0.25% foliar spray	89.67	31.67	**42.67**	**12.00**	20.00	263.89
T_{12}	Control	75.00	22.67	35.00	60.00	68.29	116.67
CD at 5%		**3.03**	**2.205**	**2.334**	**8.328**	**5.260**	**4.430**
SE(m)		**1.02**	**0.747**	**0.791**	**2.821**	**1.782**	**1.501**
CV		**2.09**	**4.462**	**3.364**	**17.662**	**9.189**	**10.194**

derma harzianum (grain based) @ 10 g/ kg seed, *C. globosum* @ 10 g/kg seed *Bacillus subtillis* @ 2.5 g/kg with vermicompost @ 500 kg/ha it has soil application were also evaluated for control of black scurf during 2019-20. The germination per cent, Plant height/length of shoot (cm), per cent disease incidence (PDI), per cent disease severity (PDS), Yield q/ha were recorded.

$$DI\ (\%) = \frac{\text{No. of tuber black scurf of potato}}{\text{Total no. of plants observed}} \times 100$$

$$DS\ (\%) = \frac{\text{Sum of all numerical ratings}}{\text{Total no. of tubers counted} \times \text{maximum rating}} \times 100$$

RESULTS AND DISCUSSION

A combination of management practices such as addition of organic amendments (e.g. FYM and vermicompost), biological control agents (e.g., *Trichoderma harzianum*, *Chaetomium globosum*, *Bacillus subtilis*), mixing in soil and seed treatments at the sowing time. Seed treatment and foliar spray of fungicides viz., Carbendazim, Pencycuron, Mancozeb and Boric acid were applied. The results revealed that all treatments significantly reduced the percentage of disease incidence, disease severity and increased the germination, plant height and yield data in Table 1 and Fig. 1 indicate.

Germination percentage

The germination percentage was varied between 75.00 to 89.67%. Maximum germination 89.67% was recorded in (T_8, T_9 and T_{11}) tuber seed treatment with Carbendazim 50% WP @ 1 g/kg, Pencycuron (250 SC) @ 0.25% foliar spray, Mancozeb 75% WP @ 0.25% foliar spray respectively followed by 89.00% in T_{10} Boric acid @ 3% concentration, tuber treatment. Average 85.00% tuber seed germination was recorded in (T_5 and T_6) seed treatment with *Trichoderma harzianum* @ 10 g/kg seed and seed treatment

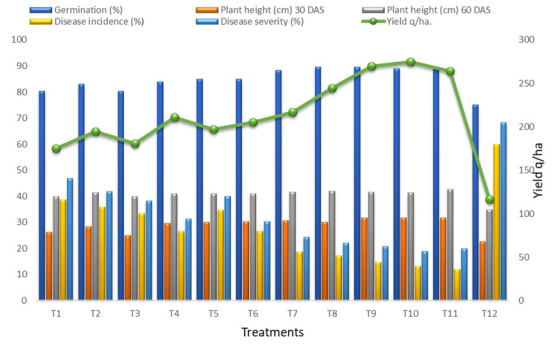

Fig. 1. Comparative study of fungicides, bio-agents and organic amendments against the black scurf of potato under field condition.

with *Chaetomium globosum* @ 10 g/kg seed respectively followed by 84.00% in (T_4) soil application of vermicompost @ 500 kg/ha alone. The minimum germination 80.33% was recorded in (T_1 and T_3) soil application of *Chaetomium globosum* @ 5 kg/ha with vermicompost @ 500 kg/ha and soil application of *Bacillus subtilis* @ 5 kg/ha with vermicompost @ 500 kg/ha respectively compared to 75.00% in untreated control significantly discussion with Sultana *et al.* (2001) observed growth and storability of *Trichoderma harzianum* and its effect on germination of egg plant seeds. They found that *Trichoderma* treated seed resulted up to 48.62% higher germination than control. Pandey and Pandey (2005) observed that tomato seeds coated with *T. viride* was found effective against *F. solani* and *Sclerotium rolfsii* with 56.7% and 80.8% seed germination, respectively. Whereas, *T. virens* was the best antagonist against *Rhizoctonia solani* (71.7%).

Plant height

Plant height in cm, varied between 22.67cm to 31.67cm at 30 DAS and 40.00 cm to 42.67cm at 60 DAS. Maximum plant height 31.67cm was recorded at 30 DAS in (T_9, T_{10} and T_{11}) Pencycuron (250 SC) @ 0.25% foliar spray, Boric acid @ 3% tuber treatment, Mancozeb 75% WP @ 0.25% foliar spray respectively and 42.67 cm was recorded 60 DAS in (T_8 and T_{11}), Tuber seed treatment with Carbendazim 50 % WP @ 1 g/kg and Mancozeb 75% WP @ 0.25% foliar spray. The minimum plant height 25.00 cm was recorded at 30 DAS in (T_3) soil application of *Bacillus subtilis* @ 5 kg/ha with vermicompost @ 500 kg/ha and 40.00 cm was recorded at 60 DAS in (T_1 and T_3), Soil application of *Chaetomium globosum* @ 5 kg/ha with vermicompost @ 500 kg/ha and soil application of *Bacillus subtilis* @ 5 kg/ha with vermicompost @ 500 kg/ha compared to 22.67 cm was recorded at 30 DAS and 35.00 cm was recorded at 60 DAS in (T_{12}) untreated control significantly discussion with Lal *et al*. (2014) evaluated penflufen fungicide at different concentration viz., 0.062%, 0.083%, 0.166% and 0.332% against black scurf of potato and found that penflufen 240 FS @ 0.083% was highly effective and reduced disease incidence 89.93% during 2010-11 and 92.49% during 2011-12 and disease severity 82.79% in 2010-11 and 95.04% in 2011-12 with higher yield followed by Penflufen 240 FS @ 0.062%. Germination % was recorded more than 93% at tested doses and no adverse effect on germination %, plant stand % and plant height (cm).

Disease incidence and severity

The disease incidence percentage was varied between 12.00 to 38.67%. Maximum disease incidence 38.67% was recorded in (T_1) soil application of *Chaetomium globosum* @ 5 kg/ha with vermicompost @ 500 kg/ha followed by 36.00% in (T_2) soil application of *Trichoderma harzianum* @ 5 kg/ha with vermicompost @ 500 kg/ha. Average 26.67% disease incidence was recorded in (T_4 and T_6) soil application of vermicompost @ 500 kg/ha alone and seed treatment with *Chaetomium globosum* @ 10 g/kg seed respectively followed by 18.67% in (T_7) seed treatment with *Bacillus subtilis* @ 10 gm/kg seed. The minimum disease incidence percent was recorded 12.00% in (T_{11}) Mancozeb 75% WP @ 0.25% foliar spray compared to 60.00% in (T_{12}) untreated control significantly. The disease severity percentage was varied between 18.96 to 46.96%. The maximum disease severity 46.96% was recorded in (T_1) soil application of *Chaetomium globosum* @ 5 kg/ha with vermicompost @ 500 kg/ha followed by 41.78% in (T_2) soil application of *Trichoderma harzianum* @ 5 kg/ha with vermicompost @ 500 kg/ha. Average 31.40% disease severity was recorded in (T_4) soil application of vermicompost @ 500 kg/ha alone followed by 30.22% in (T_6) seed treatment with *Chaetomium globosum* @ 10 g/kg seed. The mini-

mum disease severity percent was recorded 18.96% in (T_{10}) Boric acid @ 3% tuber treatment compared to 68.29% in (T_{12}) untreated control significantly discussion with Penflufen 240 FS @ 0.083% was highly effective and reduced disease incidence by 89.93% in 2010–11 and by 92.49% in 2011–12, as well as disease severity by 82.79% in 2010–11. Lal *et al.* (2014) evaluated penflufen fungicide at different concentrations, including 0.062%, 0.083%, 0.166%, and 0.332% against black scurf of potato and 95.04% in 2011-12 with higher yield followed by Penflufen 240 FS @ 0.062%. Germination % was recorded more than 93% at tested doses and no adverse effect on germination %, plant stand % and plant height (cm). Goswami *et al.* (2018) tested efficacy of Pencycuron 250 SC (soluble concentration) and Amistar 25 SC (soluble concentration) fungicides control the disease completely. Luster 37.5% SE (Flusilazole 12.5% + Carbendazim 25%), UPF-106 and Quental 50 WP treated plots produced 4.8%, 4.0% and 4.4% disease severity respectively as compared to 17.7% in control. While, Boric acid, Indofil M-45, Emisan-6, Tilt 25 EC, Score 25 EC and Hexadhan 5 EC treated plots produced disease severity in the range of 1.0% to 6.2%.

Yield quintal per hectare

The yield per hectare was varied between 175.00 to 275.00 q/ha. The maximum yield 275.00 q/ha was recorded in (T_{10}) Boric acid @ 3% tuber treatment followed by 269.44 q/ha in (T_9) Pencycuron (250 SC) @ 0.25% foliar spray. Average 216.67 q/ha yield was recorded in (T_7) seed treatment with *Bacillus subtilis* @ 10 g/kg seed followed by 211.11 q/ha in (T_4) soil application of vermicompost @ 500 kg/ha alone. The minimum yield was recorded 175.00 q/ha in (T_1) soil application of *Chaetomium globosum* @ 5 kg/ha with vermicompost @ 500 kg/ha compared to 116.67 q/ha in (T_{12}) untreated control significantly discussion with Singh *et al*. (2014) found that *T. viride* and *Tharzianum* effectively reduced the incidence of black scurf in infested soil and gave significant increase in yield. Khanna and Sharma (1996) reported significant reduction in seed and soil borne inoculum of *R. solani* and increase in population of antagonistic actinomycetes and bacteria by 3% Boric acid tuber treatment. According to (Jalali *et al.* 1994), controlling black scurf and improving tuber production might be accomplished by dipping tubers in a suspension of 3% boric acid for 30 minutes or by spraying them with 4% boric acid prior to planting. In order to successfully manage the disease without damaging crop emergence, Pencycuron @ 0.057% a.i. or Boric acid (3%) as a spray on the seed tubers prior to planting were found to be effective treatments (Arora 2013). Bagri *et al.* (2017) conducted an experiment to find out more effective management of black scurf diseases of potato through chemicals with five treatments involving chemicals i.e. Penflufen 240 FS and Boric acid, application before planting. Minimum disease incidence, disease severity and maximum tuber yield (27.69 t/ha) was noticed in tuber dip treatment with Penflufen @ 0.083% for 10 min before planting followed by tuber dip treatment with 3% Boric acid for 10 min. before planting. Tsror *et al.* (2001) reported that furrow application of *T. harzianum*, non-pathogenic *Rhizoctonia* and cattle manure compost reduced black scurf incidence under field conditions.

CONCLUSION

In field experiment, Boric acid @ 3% concentration as tuber treatment was found most effective for reduction of disease severity and enhance the yield and quality of potato thereby suggest that farmers may use Boric acid @ 3% as tuber treatment for the management of black scurf disease and enhance the yield and quality of potato while alternative of chemical, farmers may also use bio-agent *Bacillus subtilis* for the management of black scurf disease. Seed borne infection of *Rhizoctonia solani* causing black scurf of potato can be controlled in an efficient and economical manner by a spray of Pencycuron (250 SC) @ 0.25% concentration.

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