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Integrated management of dry root rot of chilli caused by *S. rolfsii*

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Abstract
Chilli (*Capsicum annuum* L.), is an important solanaceous vegetable cum spice crop. The pot culture experiment was carried out during 2017-18 at Sanskriti Samvardhan Mandal. KVK, Sagroli under the project Maharashtra Gene Bank to evaluate three fungicides two bioagents and three organic amendments by seed treatment and soil application in pot culture using susceptible local culture against *S. rolfsii*. However, highest average mortality reductions were recorded in the treatments viz; cabotin 37.5% (55.96%), carboxin (53.47%) and mancozeb (53.27%). These were followed by the treatments NSKE @ 20% (52.79%), *T. harzianum* (50.52%), Neem seed cake (48.85%), *T. viride* (48.27%) and mustard seed cake (30.04%) whereas, comparatively minimum average mortality reductions was recorded in mustard seed cake (30.04%).

Keywords: Integrated management, dry root rot, Chilli, *S. Rolfsii*, mortality

Introduction
Chilli (*Capsicum annuum* L.), is an important solanaceous vegetable cum spice crop. *Capsicum* requires long and warm season for growth and development and its cultivation is mainly confined to the tropical regions of the world. In India, chillies are grown for domestic consumption and export. India is the largest producer of chillies in the world. The area, production and productivity of chilli were 774 ha, 1492 MT and 1.93MT / ha respectively (Anonymous, 2016). Chillies are grown in almost all the states of the country and the major growing states in terms of production share are Andhra Pradesh (49%), Karnataka (15%), Orissa (8%), Maharashtra (6%), West Bengal (5%), Rajasthan (4%) and Tamil Nadu (3%). In Maharashtra, chillies are grown on an area of 99.50 ha with the production of 45.60 tones and productivity 0.46 tones/ha (Anonymous, 2016). Chilli crop suffers from many fungal, bacterial, viral and nematode diseases resulting in huge yield losses (Kalmesh and Gurjar 2001) [11]. Major diseases of chilli are: damping off (*Pythium* spp.), anthracnose or fruit rot or dieback (*Colletotrichum capsici*), wilt (*Fusarium oxysporum* f.sp.*solani*), leaf spots (*Xanthomonas campestris* pv. *vesicatoria*) and powdery mildew (*Leveillula taurica*) and dry root rot (*Sclerotium rolfsii*). Among the fungal diseases, dry root rot that is caused by *Sclerotium rolfsii*. During recent years, the root rot disease has attained serious proportion causing economic losses in chilli (Kalmesh and Gurjar, 2001) [11]. Dry root rot (*S.rolfsii)* was reported to cause losses to the tune of 60-80% (Kalmesh and Gurjar, 2001; Madhavi *et al*. 2006; Muthukumar *et al*, 2010) [11, 15, 16]. The pathogens involved in the root rot of chilli are polyphagus, mostly soil borne and survive for longer duration in the soil. Hence, very difficult to manage with a single method of plant protection. Therefore, various methods have been suggested to manage the soil borne diseases. Cultural practices like management of soil moisture, soil temperature and soil solarisation showed promising performance (Dey, 2005) [7]. Application of fungicides for the control of soil borne pathogens may be effective but it is neither cost effective nor environment friendly. Some isolates of *Trichoderma harzianum* and *T. viride* were effective against these soil borne pathogens.
Therefore, keeping in view importance of the chilli crop and economic importance of the dry root rot of chilli, the present investigation was planned and conducted with the integrated management of dry root rot of chilli caused by *S. rolfsii* (Pot culture).

Materials and Methods
Those fungicides, bioagents and organic amendments found effective against *S. rolfsii* during present *in vitro* (plate and pot culture) studies were selected for integrated management of dry

root rot of chilli (pot culture). The earthen pots (30 cm dia.) disinfected with 5 per cent of copper sulphate solution were filled with the autoclaved potting mixture of soil: sand: FYM (2:1:1). The mass multiplied (sand: cornmeal) inoculum of *S. rolfsii* was inoculated (@ 50 g / kg potting mixture) separately to the potting mixture in pots, mixed thoroughly, watered adequately and incubated for two weeks in the screen house, to proliferate the pathogen and make the soil / potting mixture sick.

The pot culture experiment comprised of 11 treatments as described under treatment details. The test fungicides and talc based formulations of the bioagents were applied (alone and in combination) as pre- sowing seed treatment to the healthy seeds of susceptible Pusa Jwala chilli and sown (20 seeds / pot) in the earthen pots containing *S. rolfsii* sick soil.

The coarse powdered test amendments (each @ 50 g / kg potting mixture) and crude extracts of the test botanicals at 50% concentration (each @ 50 ml/kg potting mixture) were added/ drenched in the earthen pots containing *S. rolfsii* sick soil, mixed thoroughly, watered adequately and kept in screen house. After 96 hrs, these pre-amended pots were seeded (20 seeds / pot) with surface sterilized healthy seed of chilli Pusa Jwala.

The earthen pots containing sick soil / potting mixture of *S.rolfsii* and sown (20 seeds/pot) with surface sterilized (0.1% $HgCl_2$) healthy seeds of chilli cv. Pusa Jwala were maintained as untreated control. For each treatment, three pots / replication were maintained and all the treatments were replicated thrice. All these pots were watered regularly and maintained in the screen house for further studies.

Experimental details

Design: Completely Randomized Design (CRD), Crop/Variety: Pusa Jwala, Replications: Three, Treatments: Nine

Treatment details

T1: Carboxin 37.5% (75 WP), T2: Mancozeb 75 WP (ST), T3: (T1+ T2) (ST), T4: *T. harzianum* (5 X 106 cfu/g carrier) (ST), T5: *T. viride* (5 X 106 cfu/g carrier) (ST), T6: Neem seed cake (SA), T7: Mustard seed cake (SA), T8: NSKE (@ 20%) (SD), T9: Control (sick soil)

Result and Discussion

Integrated management of *S. rolfsii* (pot culture)

Effect on seed germination

Results (Table 1 and Fig 1) revealed that all the treatments exhibited improved seed germination, over untreated control and it was ranged from 68.28 to 75.25 per cent, as against 40.03 in untreated control. However, as compared to control significantly highest seed germination was recorded in treatment *viz.*, cabotin + mancozeb (75.25%) followed by cabotin (74.16%) mancozeb (73.81%). NSKE (@ 20% (73.77) and *T. harzianum* (72.32%), which were on day with each other followed by neem seed cake (69.37%), *T. viride* (69.34%*)* and mustard seed cake (68.28%), whereas, least seed germination was recorded in mustard seed cake (68.28%), but significantly more than that of untreated control (40.03%).

Effect on pre - and post-emergence mortalities

Results (Table 1 and Fig 2) revealed that all the treatments significantly influenced both pre-emergence seed rot (PESR) and post- emergence seedling mortality (PESM) caused by *S. rolfsii* in chilli. The per cent pre-emergence seed rot (PESR) recorded in all the treatment was ranged from 24.75 to 31.35 per cent, as against 59.54 per cent in untreated control. However, significantly least PESR was recorded in caboxin + mancozeb (24.75%), carboxin (25.64%). This was followed by NSKE (25.89%), Mancozeb (26.14%), *T. harzianum* (28.17%), neem seed cake (29.12%), *T. viride* (29.42%) and mustard seed cake (31.35%). The percentage post emergence seedling mortality (PESM) recorded with all the treatment was ranged from 29.22 to 45.24 per cent, as against 65.57 per cent in untreated control. However, the treatments found most effective with significantly least PESM was carboxin + mancozeb (31.66). It was followed by treatments carboxin (31.66%), mancozeb (31.72%), NSKE @ 20% (31.74%), *T. harzianum* (32.69%), neem seed cake (33.92%) and *T. viride* (34.34%).Whereas, comparatively maximum PESM was recorded in treatment mustard seed cake (45.24%).

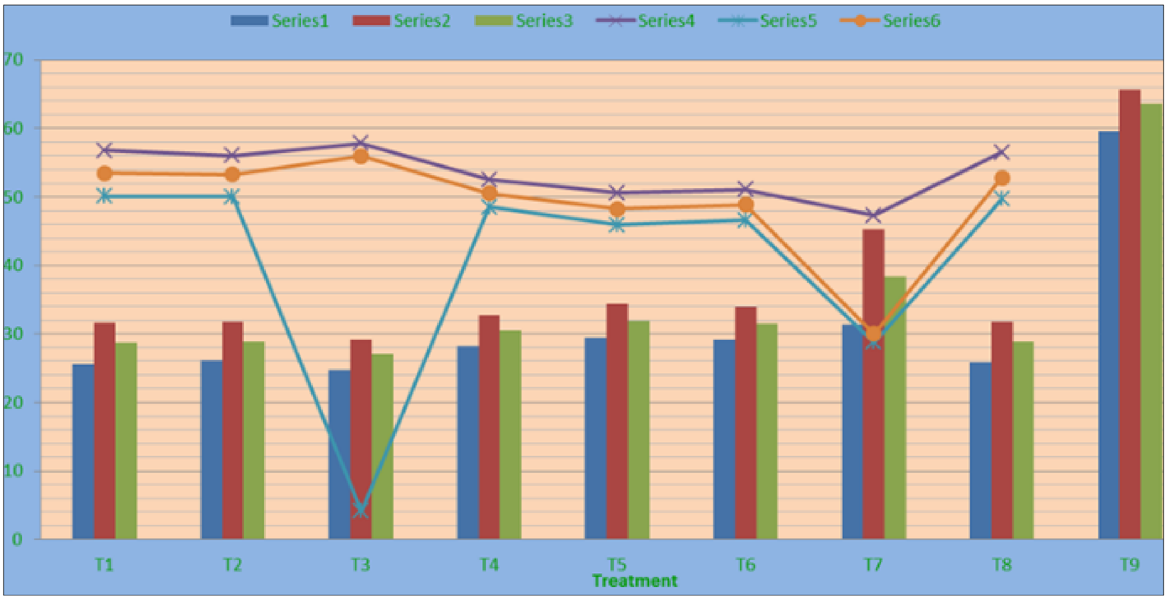
The average mortality recorded in all the treatments was ranged from 27.15 to 38.36 per cent, as against 63.56 per cent in untreated control (Table8). However, the treatments found most effective with least average mortality were *viz*, cabotin) + mancozeb (27.15%), caboxin (28.71%) and mancozeb ((28.89%). These were followed by the treatments *viz*., NSKE (28.92%), *T. harzianum* (30.51%), Neem seed cake (31.55%), *T. viride* (31.91%) and Mustard seed cake (38.36%), Whereas, comparatively higher average mortality was recorded in mustard seed cake (38.36%) but less than that of untreated. control.(63.56%)

Table 1: Efficacy of fungicides, bioagents, and organic amendments against *S. rolfsii,* causing dry root rot in chilli.

Tr. No.	Treatments	Rate	Germination (%)	Incidence (%)		Av. Mortality (%)	Reduction over control (%)		Av. Red. (%)
				PESR	PESM		PESR	PESM	
T_1	Cabotin 37.5% (75 WP)	(3 g/ kg seed)	74.16 (59.44)	25.64 (30.42)	31.66 (34.24)	28.71 (32.39)	56.82 (48.91)	50.13 (45.07)	53.47 (46.98)
T_2	Mancozeb 75 WP (ST)	(3 g/kg seed)	73.81 (59.21)	26.14 (30.74)	31.72 (34.27)	28.89 (32.51)	56.05 (48.47)	49.07 (44.82)	53.27 (46.87)
T_3	(T_1+ T_2) (ST)	(each 2 g/kg) seed	75.25 (60.16)	24.75 (29.83)	29.22 (32.72)	27.15 (31.40)	57.81 (49.49)	54.12 (47.36)	55.96 (48.42)
T_4	*T. harzianum* (5 X 10^6 cfu/g carrier) (ST)	(10g/kg seed)	72.32 (58.25)	28.17 (32.05)	32.69 (34.87)	30.51 (33.52)	52.54 (46.45)	48.51 (44.14)	50.52 (45.29)
T_5	*T. viride* (5 X 10^6 cfu/g carrier) (ST)	(10g/kg seed)	69.34 (56.37)	29.42 (32.84)	34.34 (35.87)	31.91 (34.37)	50.61 (45.34)	45.93 (42.66)	48.27 (44.00)
T_6	Neem seed cake (SA)	(50 g/kg soil)	69.37 (56.39)	29.12 (32.65)	33.92 (35.62)	31.55 (34.17)	51.1 (45.63)	46.61 (43.05)	48.85 (48.34)
T_7	Mustard seed cake (SA)	(50 g/kg soil)	68.28 (55.72)	31.35 (34.04)	45.24 (42.26)	38.36 (38.26)	47.31 (43.45)	28.78 (32.44)	30.04 (32.23)

T_8	NSKE (@ 20%) (SD)	(50 ml/kg soil)	73.77 (59.19)	25.89 (30.58)	31.74 (34.29)	28.92 (32.53)	56.51 (48.78)	50.05 (45.62)	52.79 (46.59)
T_9	Control (sick soil)	Untreated	40.03 (39.4)	59.54 (50.49)	65.57 (54.07)	63.56 (52.86)	-	-	-
		SE ±	0.81	0.20	0.09	0.28	0.19	0.18	
		CD (P=0.05)	2.20	0.54	0.26	0.77	0.55	0.50	

*Means of three replications, Figures in parentheses are angular transformed values. PESR=Post emergence seed rot, PESM= Pre emergence seedling mortality.



T_1: Carboxin 37.5% T_2: Mancozeb T_3: (T_1+ T_2) T_4: *T. harzianum*
T_5: *T. viride* T_6: Neem seed cake T_7: Mustard seed cake T_8: NSKE T_9: Control

Fig 1: Efficacy of the fungicides, bioagents and organic amendments against *S. rolfsii*, causing root rot in chilli

Reduction in mortality

The results (Table 1) revealed that all the treatments were effective against *S. rolfsii* and significantly reduced the mortalities (pre- and post-emergence), over untreated control. The reductions recorded in the treatments in pre-emergence seed rot (PESR) and post-emergence seedling mortality (PESM) was ranged from 57.81 to 47.31 per cent and 54.12 to 28.78 per cent, respectively. However, the treatments, found most effective with significantly reduced PESR and PESM were with cabotxin) + mancozeb (57.81% and 54.12%, respectively), carboxin (56.82 and 50.13%, respectively) and NSKE (56.51% and 50.05%, respectively). These were followed by the treatments *viz.*, Mancozeb (75 WP) (56.05 and 49.07%), *T. harzianum* (52.54 and 48.51%), Neem seed cake (51.08 and 46.61%), *T. viride* (50.61 and 45.93%), Mustard seed cake (47.31 and 28.78%), for PESR and PESM reductions, respectively.

The average mortality (PESR and PESM) reduction recorded in all the treatments was ranged 30.04 (Mustard seed cake) to 55.96 Per cent caboxin + mancozeb, as compared to untreated control. However, highest average mortality reductions were recorded in the treatments viz; cabotin 37.5% (55.96%), carboxin (53.47%) and mancozeb (53.27%). These were followed by the treatments NSKE @ 20% (52.79%), *T. harzianum* (50.52%), Neem seed cake (48.85%), *T. viride* (48.27%) and mustard seed cake (30.04%) whereas, comparatively minimum average mortality reductions was recorded in mustard seed cake (30.04%).

The results of the present study are in conformity with those reported earlier by several workers. Singh *et al.*, 2008 [20], Sultana *et al.*, 2012 [22], Borgaonkar 2013 [6], Anahosur, 2001 [3], Vanita and Suresh 2002 [24], Suryawanshi *et al.*, 2005 [23], Kathikeyan *et al.*, 2006, Rini and Sulochana, 2006 [18], Jadon *et al.*, 2007 [10], Okereke *et al.*, 2007 [17] Banyal *et al.* 2008 [4], Khodke and Raut 2010 [13], Begum *et al.*, 2011 [5], and Samsuzzaman *et al.*, 2012 [19].

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