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Integrated Management of Collar Rot of Chilli Caused by *Sclerotium rolfsii* Sacc

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A B S T R A C T

Collar rot (*Sclerotium rolfsii* Sacc.) of chilli (*Capsicum annuum* L.) is one of the devastating soil-borne diseases of fungal origin, due to which 16–80% yield loss is recorded annually according to the severity of the disease. An integrated disease management approach was developed for the management of collar rot of chilli using fungicide, biocontrol agents and an organic amendment. The results of the experiments from the two years pooled data and cost-benefit ratio indicated that chilli seedling dip treatment with Carbendazim 12 % + Mancozeb 63 % (75 WP) @ 2.5 g/l + *Trichoderma viride* @ 10 g/l + soil application with Neem seed cake @ 5 q/ha significantly reduced the collar rot disease incidence (8.33 %) with higher B:C ratio (3.73:1). The reduction in disease incidence over control in this treatment was 77.06 %. Consequently, the green fruit yield in chilli was 128.11 q/ha, recording a percent increase of 68.72 % over control. The integrated management of chilli collar rot by using fungicide, biocontrol agents and an organic amendment is safe and ecologically sound and appears to be a healthy approach to the disease management.

Introduction

Chilli (*Capsicum annuum* L.) is one of the most important constituents of the foods of tropical and subtropical countries and the fourth major crop cultivated worldwide. Their characteristics such as pungency, colour, aroma, and flavour are desirable in a variety of culinary dishes around the world, which make them widely appreciated. Chilli is susceptible to many diseases, some of them are widespread and some are localized. Among the diseases, collar rot or root rot of chilli caused by *Sclerotium rolfsii* Sacc. occurs in almost all chilli growing areas of India.

It causes up to 16- 80 % reduction in yield (Singh and Dhancholia, 1991; Mathur and Gurjar, 2001). *S. rolfsii* is a soil borne facultative pathogen which has wide host range of more than 500 species of cultivated and wild plants in tropical and sub-tropical regions (Punja, 1985; Xu, 2009).

Management of collar rot/root rot diseases is difficult because of soil borne nature and the chemical methods are very expensive and will not be that good effect against the pathogen and also have a wide host range. Because of unsatisfactory control of soil borne pathogen by chemicals, considerable attention has been given on the other non-chemical means of plant disease control. This can be effectively managed by the integration of biological and conventional methods, which include the use of eco-friendly biocontrol agents.

The application of biocontrol agents to the soil is an alternative to suppress soil borne plant pathogens through parasitism, production of antagonistic chemicals, competition for the host and nutrients, and induction of resistance in plants against disease-causing pathogens (Shafique, 2016).Biological control of soil borne pathogens offersan environmentally safe, durable and cost-effective alternative to chemicals (Sharma, 2011). Many species of fungi and bacteria are reported to be effective as bio-control agents against soil borne plant pathogens (Papavizas, 1985; Baker, 1987).

Integration of biological seed protectant with fungicidal, insecticidal treatment involves, the reduced amounts of pesticides can stress and weaken the pathogen and render its propagules more susceptible to subsequent attack by the antagonist and provides better control of seeds and seedlings diseases than either used separately (Lorito *et al.,* 1996; Mahato *et al.,* 2017). Hence, the integrated approach plays an important role in the effective management of collar rot of chilli.

Integrated Pest Management strategy is comparatively safe, environment friendly and durable. Keeping these in view an experiment was undertaken to evaluate the effectiveness of integrated disease management strategies involved of fungicide, bio-control agent and organic amendment to manage collar rot (*S. rolfsii*) disease of chilli.

Materials and Methods

The experiment was conducted at Horticulture Research Scheme (Vegetable), Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India during the year 2016-17 to 2017-18 in *Kharif* seasons using chilli cv. Pusa Jwala for the management of collar rot of chilli caused by *Sclerotium rolfsii* Sacc. The soil of the experimental field was black cotton soil. The experiment was laid out in a randomized block design with three replications. The plot size was 2.4 x 3.15 m. Thirty-five days old seedlings raised in the nursery were transplanted at a distance of 60 x 45 cm spacing. Efficacies of twelve treatments as shown in Table 1 were compared with untreated control. The seedlings of chilli were dipped in the suspension of bioagents and fungicides for 15 minutes just before transplanting in the field. All recommended horticultural practices were followed. Observations on the incidence of collar rot disease were recorded and statistically analysed. Per cent disease incidence was calculated by using the following formula.

$$\text{Disease incidence (\%)} = \frac{\text{Number of diseased plants}}{\text{Total number of plants observed}} \times 100$$

Results and Discussion

Effect of various treatments on the disease incidence of collar rot of chilli

The data on disease incidence presented in Table 2 showed that all the treatments reduced the disease incidence significantly as compared to untreated control. It is revealed from the data that there was significant difference in percent disease incidence during 2016-17 and 2017-18 and pooled also.

In pooled data, the minimum disease incidence was noticed in treatment T_9 (Carboxin 37.5 % + Thiram 37.5 % (75 WP) + *Trichoderma harzianum* + Neem seed cake) (4.17 %) followed by T_{10} (Carbendazim 12 % + Mancozeb 63 % (75 WP) + *T. viride* + Neem seed cake) (8.33 %), T_7 (Carbendazim 50 WP+ *Trichoderma harzianum* + Neem seed cake) (10.71 %), T_8 (Carbendazim 50 WP + *T. viride* + Neem seed cake) (11.91 %), T_3 (Carboxin 37.5 % + Thiram 37.5 % (75 WP) (13.10 %),T_{11} (Bioagents consortia) (16.67 %), T_2 (Carbendazim 12 % + Mancozeb 63 % (75 WP) (20.84 %), T_2 (Carbendazim 50 WP (22.62 %), T_1 (Captan 50 WP) (24.41 %), T_5 (*T. harzianum*) (25.60 %) and T_6 (*T. viride*) (27.98 %).

Effect of various treatments on the yield of collar rot of chilli

Effect of different treatments on chilli yield was found significant during all the years andpooled also (Table 3). The data on chili green fruit yield showed that all the treatments recorded significantly higher yield as compared to untreated control. In pooled data, significantly highest yield of 148.15 q/ha was recorded by treatment T_9 (Carboxin 37.5 % + Thiram 37.5 % (75 WP) + *Trichoderma harzianum* + Neem seed cake). This was followed by the treatment *viz*., T_{10} (Carbendazim 12 % + Mancozeb 63 % (75 WP) + *T. viride* + Neem seed cake) (128.11 q/ha), T_8 (Carbendazim 50 WP + *T. viride* + Neem seed cake) (126.46 q/ha), T_7 (Carbendazim 50 WP+ *Trichoderma harzianum* + Neem seed cake) (125.22 q/ha),T_2 (Carbendazim 12 % + Mancozeb 63 % (75 WP)(118.12 q/ha), T_{11} (Bioagents consortia) (115.82 q/ha), T_3 (Carboxin 37.5 % + Thiram 37.5 % (75 WP) (115.00 q/ha), T_2 (Carbendazim 50 WP(111.87 q/ha), T_1 (Captan 50 WP) (107.35 q/ha), T_5 (*T. harzianum*) (97.35 q/ha) and T_6 (*T. viride*) (95.17 q/ha).

Economics of integrated management practices on collar rot of chilli

The economic evaluation of the experiments was done to evaluate the best treatment in terms of monitory units. The economics of benefit: cost ratio was worked out and presented in Table 4 revealed that, treatment T_{10} (Carbendazim 12 % + Mancozeb 63 % (75 WP) + *T. viride* + Neem seed cake) obtained highest gross income (Rs. 4,44,444/ha), net profit (Rs.3,50,573/ha) and B:C ratio (3.73:1).

The second best treatment T_9 (Carboxin 37.5 % + Thiram 37.5 % (75 WP) + *Trichoderma harzianum* + Neem seed cake) which was superior concerning yield (148.15 q/ha) and recorded less B:C ratio (3.15:1), mainly because of the increased cost of chemicals.

Rest of the treatments found economical with better B:C ratio were *viz*., T_7 (Carbendazim 50 WP+ *Trichoderma harzianum* + Neem seed cake), T_8 (Carbendazim 50 WP + *T. viride* + Neem seed cake), T_3 (Carboxin 37.5 % + Thiram 37.5 % (75 WP)), T_{11} (Bioagents consortia), T_2 (Carbendazim 12 % + Mancozeb 63 % (75 WP), T_2 (Carbendazim 50 WP, T_1 (Captan 50 WP)), T_5 (*T. harzianum*) and T_6 (*T. viride*).

The results of the experiments from the two years data clearly indicated that chilli seedling dip treatment with Carbendazim 12 % + Mancozeb 63 % (75 WP) @ 2.5 g/l + *Trichoderma viride* @ 10 g/l + soil application with Neem seed cake @ 5 q/ha significantly reduced the collar rot disease incidence (8.33 %).

The reduction in disease incidence over control in this treatment was 77.06 %. Consequently, the fruit yield in chilli was 128.11 q/ha, recording a per cent increase of 68.72 % over control. The possible reason for such finding may be that Carbendazim +

Mancozeb would have affected the spore germination and mycelial development, antagonistic effect of *Trichoderma viride* and neem seed cake plays an important role in reducing the incidence of soil borne diseases which may have resulted in the inhibition of disease producing activity of pathogen in the plant and induced resistance in the plant. Kowsari, 2014 stated that Trichoderma species are known to produce large quantities of fungi-toxic metabolites. They are the active mycoparasites which have been used as effective biocontrol agents against foliar and soil borne disease. This resulted in better overall growth and good health of chilli plants. This may be the reason for minimum disease incidence and maximum yield as compared to other treatments.

Similar views were put forth by several other workers (Dutta and Das, 2002; Vanitha and Suresh, 2002; Bhoraniya *et al.*, 2003; Gogoi *et al.*, 2004; Islam and Bhuiyan, 2006; Okereke *et al.*, 2007; Banyal *et al.*, 2008; Jadon, 2009; Begum *et al.*, 2011; Madhavi and Bhattiprolu, 2011; Sultana *et al.*, 2012; Bhattacharjee *et al.*, 2015; Suryawanshi *et al.*, 2015; Kuldhar and Suryawanshi, 2017).

Table.1 Details of various treatments used for the management of chilli collar rot

Treatment No.	Treatments	Doses (g/l of water or q/ha of soil)
T_1	Captan 50 WP	3.0 g
T_2	Carbendazim 50 WP	1.0 g
T_3	Carboxin 37.5 % + Thiram 37.5 % (75 WP)	3.0 g
T_4	Carbendazim 12 % + Mancozeb 63 % (75 WP)	2.5 g
T_5	*Trichoderma harzianum* (5x10^7 cfu/g carrier)	10 g
T_6	*Trichoderma viride* (5x10^7 cfu/g carrier)	10 g
T_7	Carbendazim 50 WP + *T. harzianum* + Neem seed cake	1.0 g + 10 g + 5 q
T_8	Carbendazim 50 WP + *T. viride* + Neem seed cake	1.0 g + 10 g + 5 q
T_9	Carboxin 37.5 % + Thiram 37.5 % (75 WP) + *T. harzianum* + Neem seed cake	3.0 g + 10 g + 5 q
T_{10}	Carbendazim 12 % + Mancozeb 63 % (75 WP) + *T. viride* + Neem seed cake	2.5 g + 10 g + 5 q
T_{11}	Bioagents consortia	10 g
T_{12}	Control	-

Table.2 Effect of integrated use of fungicide, bio-control agent and organic amendment on collar rot of chilli (Pooled)

Tr. No.	Treatments	Doses (g/l of water or q/ha of soil)	Per cent Incidence			Yield (q/ha)			Per cent increase over control
			2016-17	2017-18	Mean	2016-17	2017-18	Mean	
T_1	Captan 50 WP	3.0 g	25.00 (30.00)*	23.81 (29.11)	24.41	110.60	104.10	107.35	41.38
T_2	Carbendazim 50 WP	1.0 g	23.81 (29.19)	21.43 (27.58)	22.62	111.81	106.22	109.01	43.57
T_3	Carboxin 37.5 % + Thiram 37.5 % (75 WP)	3.0 g	14.29 (22.10)	11.91 (20.14)	13.10	121.03	115.21	118.12	55.56
T_4	Carbendazim 12 % + Mancozeb 63 % (75 WP)	2.5 g	22.62 (28.38)	19.05 (25.86)	20.84	115.00	108.73	111.87	47.33
T_5	*Trichoderma harzianum* ($5x10^7$ cfu/g carrier)	10 g	26.19 (30.77)	25.00 (29.96)	25.60	100.40	94.31	97.35	28.21
T_6	*Trichodermaviride* ($5x10^7$ cfu/g carrier)	10 g	27.38 (31.54)	28.57 (32.31)	27.98	99.47	90.87	95.17	25.34
T_7	Carbendazim 50 WP + *T. harzianum*+ Neem seed cake	1.0 g + 10 g + 5 q	11.90 (20.14)	9.52 (17.90)	10.71	129.63	123.28	126.46	66.55
T_8	Carbendazim 50 WP + *T. viride*+ Neem seed cake	1.0 g + 10 g + 5 q	13.10 (21.18)	10.71 (19.10)	11.91	128.21	122.22	125.22	64.92
T_9	Carboxin 37.5 % + Thiram 37.5 % (75 WP) + *T. harzianum* + Neem seed cake	3.0 g + 10 g + 5 q	4.76 (17.90)	3.57 (15.50)	4.17	151.06	145.24	148.15	95.11
T_{10}	Carbendazim 12 % + Mancozeb 63 % (75 WP) + *T. viride* + Neem seed cake	2.5 g + 10 g + 5 q	9.52 (12.43)	7.14 (10.89)	8.33	131.48	124.74	128.11	68.72
T_{11}	Bioagents consortia	10 g	19.05 (25.86)	14.28 (22.11)	16.67	119.00	112.70	115.85	52.57
T_{12}	Control	-	35.71 (36.70)	36.90 (37.40)	36.31	79.37	72.49	75.93	0.00
	S.E.m±		**1.03**	**0.89**		**6.35**	**6.02**	**3.84**	**-**
	C.D. (P = 0.05)		**3.04**	**2.63**		**18.78**	**17.75**	**11.11**	**-**

* Figures in parenthesis are angular transformed values

Table.3 Economics of integrated management treatments on collar rot of chilli

Tr. No.	Treatments	Yield (q/ha)	Total cost of treatment (Rs./ha)	Cost of production (Rs./ha)	Gross Income (Rs./ha)	Net profit (Rs./ha)	B:C ratio	
T_1	Captan 50 WP	107.35	700	85935	322051	236116	2.75	:1
T_2	Carbendazim 50 WP	109.02	920	86313	327040	240727	2.79	:1
T_3	Carboxin 37.5 % + Thiram 37.5 % (75 WP)	118.12	1100	87358	354360	267002	3.06	:1
T_4	Carbendazim 12 % + Mancozeb 63 % (75 WP)	111.87	560	86225	335610	249385	2.89	:1
T_5	*Trichoderma harzianum* (5x10^7 cfu/g carrier)	97.36	2000	86286	292063	205778	2.38	:1
T_6	*Trichoderma viride* (5x10^7 cfu/g carrier)	95.17	2000	86078	285516	199438	2.32	:1
T_7	Carbendazim 50 WP + *T. harzianum* + Neem seed cake	126.46	5120	92170	379365	287195	3.12	:1
T_8	Carbendazim 50 WP + *T. viride* + Neem seed cake	125.22	5120	92053	375648	283596	3.08	:1
T_9	Carboxin 37.5 % + Thiram 37.5 % (75 WP) + *T. harzianum* + Neem seed cake	148.15	5300	92507	384325	291818	3.15	:1
T_{10}	Carbendazim 12 % + Mancozeb 63 % (75 WP) + *T. viride* + Neem seed cake	128.11	4760	93871	444444	350573	3.73	:1
T_{11}	Bioagents consortia	115.85	2200	88243	347548	259305	2.94	:1
T_{12}	Control	75.93	0	82250	227778	145528	1.77	:1
Average market price Rate Rs/q: 3000								

The results obtained in this study revealed that based on cost-benefit ratio chilli seedling dip treatment with Carbendazim 12 % + Mancozeb 63 % (75 WP) @ 2.5 g/l + *Trichoderma viride* @ 10 g/l + soil application with Neem seed cake @ 5 q/ha for fifteen minutes before transplanting is very effective in reducing the collar rot of chilli disease incidence, thereby increasing fruit yield. This may be an effective module for the integrated management of chilli collar rot.

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