MATERIAL AND METHODS and **RESULTS AND DISCUSSION** not mantion

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RESEARCH ARTICLE

Efficacy of various bio-control agents for the management of leaf spot of turmeric (*Curcuma longa* L.) caused by *Taphrina maculans*

■ **Shweta, R.K.S. Tiwari and Vinod Kumar Nirmalkar**

SUMMARY

A field experiment was conducted in the last week of June 2020, at Horticulture Research cum Instructional Farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Sarkanda, Bilaspur (C.G.), to test the efficacy of various bio-control agents for the management of leaf spot of turmeric caused by *Taphrina maculans.* Treatment include the bio-agents alone or different combinations viz. *Trichoderma harzianum, Pseudomonas fluorescens, Bacillus subtilis, Trichoderma harzianum + Pseudomonas fluorescens, Trichoderma harzianum + Bacillus subtilis, Pseudomonas fluorescens + Bacillus subtilis* and *Trichoderma harzianum + Pseudomonas+ Bacillus subtilis* and chemical fungicide mancozeb for foliar spray at 35 days after appearance of disease. Foliar spray of combination *Pseudomonas fluorescens* at 45 days after appearance of disease significantly reduced percent diseases index of taphrina leaf spot (PDI 43.57 %) and enhanced fresh rhizome yield (20.85 t ha^{-1}) compared to other bio-control agents applications.

Key Words : Crop phenology, Yield, Turmeric, *Taphrina maculans*

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Turmeric (*Curcuma longa* L.) is an important, sacred and ancient Indian spice. It is a common rhizomatous spice that is grown and exported in India. Turmeric (*Curcuma longa* L.) is a perennial herbaceous plant that belongs to the Zingiberaceae family. Turmeric (*Curcuma longa* L.) is known as the golden spice and the spice of existence. It is also recognised as National Heritage and is considered a valuable gift from nature (Maurya *et al*., 2011).

Turmeric (*Curcuma longa* L.) is an Asian and Indian spice tree. According to the Horticulture Statistics at a Glance database, India generated 1052000 MT of turmeric in 2018 from an acreage of 193000 ha. Andhra Pradesh, Tamil Nadu, Orissa, West Bengal, Maharashtra,

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Karnataka and Kerala are the major turmeric-producing states in India. Andhra

Pradesh has the most turmeric-growing land (71.61000 ha), with a high output of 371.64000 tonnes. In Bihar, the turmeric production is 2.60000 MT from 2.40000 ha area (Anonymous, 2017). The state's low crop productivity has been due to leaf spot disease caused by *Taphrina maculans*, as well as other factors that impede production.

Turmeric yield losses due to disease have been documented as high as 37.6 % to 52.9 % in some areas, rendering turmeric cultivation uneconomical, especially where susceptible varieties are grown (Panja *et al*.,2000 and Annon, 2011). Turmeric leaf spot of turmeric is, a severe disease caused by *Taphrina maculans* Butler, was first identified in 1911 in Gujarat, Saharanpur (UP), and Rangapur. Taphrina leaf spot appears late in the sesson, usually on the lower leaves in first week of October. Severe outbreak of this disease was reported from Rayaseema area of Andhta pradesh (Sarma and Dakshinsmurthy, 1962). Yield losses were 37.6 to 52.9% due to this fungus (Panja *et al,* 2000). Area under sussceptible cultivars of turmeric is increasing because of the cultivars high curcumin content. Babu *et al*. (2015) reported that two sprays of *Pseudomonas fluorescens* have been shown to help in reduces of *Taphrina* leaf spot disease in turmeric. Jagtap *et al*. (2013) reported that biocontrol agent *P. fluorescens* was found to be the most effective antagonist 53.33% against leaf spot of turmeric incited by *Colletotrichum capsici.* However, very limited effort was made to develop a management strategy with new bio-agents. Hence, the present field trial was conducted for managing taphrina leaf spot disease in turmeric using new bio-agents combinations.

Field experiment were conducted during the last week of June 2020, at Horticulture Research cum Instructional Farm of Barrister Thakur Chhedilal College of Agriculture and Research Station, Sarkanda, Bilaspur (C.G.), Field trials were laid out with nine treatments and three replications in Factorial Randomized Block Design. Rhizome were planted on raised beds of 2 mts × 3 mts size at a spacing of 50 cm × 25 cm. nitrogen. Phosphorus and potassium were applied @ 60, 50 and 120 kg NPK ha^{-1} in form of urea, single super phosphate and muriate of potash, respectively. Full dose of phosphorus and potash and half dose of Nitrogen were applied in two splits doses at 30 and 60 days after sowing of seedlings. The experimental plot was irrigated by total of 2 to 3 irrigations were given as and when required by flooding method at different interval. Five weeding operation were carried out in an experimental plot at an interval of 4 weeks after planting. At the time of manual weeding, plants were earth up. Bio-agents such as alone and combinations were applied foliar application at 35 and 45 days after appearance of disease.

Treatments details of foliar application are presented in Table 1. The first spray was applied at 35 days after appearance of disease and the second spray at 45 days after appearance of disease. Observation on percent disease index was recorded 10 days after the last spray. Observation recorded on 5 plants randomly selected in each replication following a 0 - 9 disease rating scale as suggested by Pawar and Ghurde (1989). Percent Disease Index (PDI) were worked out in each treatment using the following formulas:

$$\text{PDI} = \frac{\text{Rating of infected leaves on plant}}{\text{Number of leaves observed x Maximum disease score}} \text{x100}$$

The data on efficacy of bio-control agent for the management of Taphrina leaf spot of turmeric presented in Table 2. Results revealed that all the treatments were significantly effective reducing the taphrina leaf spot

Table 1 : Treatment details

Treatments	Bio-agent used	Formulations	CFU^{-1} ml	Dose ml/l water
T_1	*T. harzianum*	Liquid 10%	1×10^8	20ml/l
T_2	P. *fluorescens*	Liquid 10%	1×10^9	20ml/l
T_3	*Bacillus subtilis*	Liquid 10%	1×10^9	20ml/l
T_4	*T. harzianum.* + *P. fluorescens*	Liquid 10%	1×10^8	10+10ml/l
T_5	*T. harzianum.* + *B. subtilis*	Liquid 10%	1×10^8	10+10ml/l
T_6	*P. fluorescens* + *B. subtilis*	Liquid 10%	1×10^7	10+10ml/l
T_7	*T. harzianum* + *P. fluorescens* +*B. subtilis*	Liquid 10%	1×10^9	7+7+7ml/l
T_8	Mancozeb	80 WP	-	2.5gm/l
T_9	Control (untreated)		-	-

disease as compared to control. Amongst bio-control agents and their combinations, two sprays of *P. fluorescens* + *B. subtilis* (43.07%), *P. fluorescens* (47.57%) alone proved to be most effective treatments in controlling the Taphrina leaf spot disease of turmeric and as good as chemical fungicide Mancozeb (43.12%) other treatments *i.e. T. harzianum* + *P. fluorescens* (44.77%) and *T. harzianum* (45.75%) were also significantly more effective over control and can be used for the management of Taphrina leaf spot of turmeric. Amongst different bio-control agents the efficacy of *P. fluorescens* seems to be more effective than *T. harzianum* and *B. subtilis* it also clear from present study that combinations of bio-control agents is more effective than the combinations of 3 bio- control agents.

Amongst different bio-control agents, the efficacy of *P. fluorescens* seems to be more effective than *T. harzianum* and *B. subtilis*. It is also clear from present study that the consortia of two bio-control agents are more effective than the consortia of three bio-control agents. It is concluded from the present study that foliar application of bio-control agents either alone or in combinations can be used for the management of Taphrina leaf spot in place of chemical fungicide *i.e.* Dithiocarbamates (Mancozeb) and copper fungicides (COC). It may also be concluded from present study that use of bio-control agents should be intensified in those areas where turmeric cultivation is being done under organic forming mode.

Similar finding has also been reported by Babu *et al*. (2015) under which two sprays of *Pseudomonas fluorescens* along with rhizome therapy, has been found effective in reducing the *Taphrina* leaf spot disease in turmeric the antagonistic activity of P. *fluorescens* against *C. capsici*, that causes turmeric leaf spot reported by Chidanandswamy (2006). He also reported the most effective in preventing the fungus from growing.

The data presented Table 3 on per cent increase in disease severity indicate that the increase in per cent disease severity recorded after 10 days after the 1st spray was maximum in untreated plot of both of varieties *i.e.* B.S.R.- 2 (7.90) and Narendra haldi (535). Whereas, the least increase in per cent disease severity recorded from treatments *i.e. T. harzianum* + *P. fluorescens*

Table 2 : Efficacy of biocontrol agents on disease severity of taphrina leaf spot caused by *Taphrina maculans*

Treatments	Before spray			10 days after 1st spray			10 days after 2nd spray		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
T_1	19.23	21.85	20.54	28.89	27.41	28.15	44.76	46.74	45.75
T_2	21.46	20.22	20.84	27.71	23.03	25.39	43.48	43.65	43.57
T_3	22.79	24.45	23.62	29.39	29.19	29.29	45.99	46.00	46.00
T_4	25.55	23.47	24.51	30.71	25.36	28.04	41.47	48.07	44.77
T_5	29.25	26.27	27.76	36.93	31.08	34.00	46.53	49.15	47.84
T_6	22.09	21.10	21.59	31.56	23.37	27.46	42.33	43.81	43.07
T_7	23.94	22.74	23.34	32.15	25.41	28.78	46.11	47.52	46.81
T_8	22.83	21.41	22.12	30.37	30.37	29.18	41.54	44.71	43.12

Table 3: Efficacy of bio-control agents and fungicides on the severity of Taphrina leaf spot

Per cent increase in 10 days after 1st spray				Per cent increase in 10 days after 2nd spray		
	V1	V2	Mean	V1	V2	Mean
T_1	9.66	5.56	7.61	15.87	19.33	17.06
T_2	6.25	2.86	4.55	15.77	20.58	18.17
T_3	6.06	4.63	5.61	16.06	16.04	16.05
T_4	5.16	1.86	3.51	16.76	22.71	19.73
T_5	7.68	4.54	6.11	9.06	18.14	13.87
T_6	9.47	2.27	5.87	10.77	20.44	15.60
T_7	9.21	2.67	5.94	13.96	22.11	18.03
T_8	5.13	8.96	7.04	13.58	14.34	13.96
T_9	12.01	14.87	13.44	23.51	25.11	24.31
Mean	7.90	5.35	-	15.15	19.90	-

(3.51) which was followed by *P. fluorescens* (4.55), *B. subtilis* (5.61) and *T. harzianum* + *P. fluorescens* + *B. subtilis* (5.94). Other treatments *i.e. T. harzianum* (7.61) and Mancozeb (7.04) did also showed comparatively less increase of diseases severity compared to control (13.44). Data presented in Table 3 on per cent increase in disease severity indicate that, the increase in per cent disease severity recorded after 10 days of 2nd spray was maximum in untreated plot of both of varieties *i.e.* Narendra (19.90) and B.S.R-2 (15.15). Whereas, the least increase in per cent disease severity was recorded from treatments *i.e. T. harzianum* + *B. subtilis* (13.87) closely followed by Mancozeb (13.96). Other treatments *i.e. P. fluorescens* + *B. subtilis* (15.60), *B. subtilis* (16.05), *T. harzianum* (17.6), *T. harzianum* + *P. fluorescens* + *B. subtilis* (18.03), *T. harzianum* + *P. fluorescens* (18.03) did also showed comparatively less increase of disease of disease severity compared to control (24.31).

Data from Table 3 indicate that the per cent increase in disease 10 days after 1st spray was higher in variety B.S.R.-2 (7.92) then Narendra haldi. Whereas per cent increase in diseases severity 10 days after 2nd spray was higher in Narendra haldi (19.90) then B.S.R.-2 (15.15).

Similar finding has also been reported by Babu *et al*. (2015) under which two sprays of *Pseudomonas fluorescens* along with rhizome therapy, has been found effective in reducing the *Taphrina* leaf spot disease in turmeric.

Efficacy of bio-control agents on yield and yield components of taphrina leaf spot caused by *Taphrina maculans*:

Data presented in Table 4 and depicted showed in Fig. 1 indicate that the significantly higher rhizome yield was recorded from the plot treated with *P. fluorescens* (20.85 t ha^{-1}) which was at par with the rhizome yield recorded from Mancozeb treated plot (21.30 t ha^{-1}) rhizome yield recorded from different plot treated with bio-control agents and their combinations *i.e. T. harzianum*+ *P. fluorescens* (19.51 t ha^{-1}), *P. fluorescens* + *B. subtilis* (18.63 t ha^{-1}), *T. harzianum* (18.25 t ha^{-1}), B. *subtilis* (18.16 t ha^{-1}), *T. harzianum* + *B. subtilis*

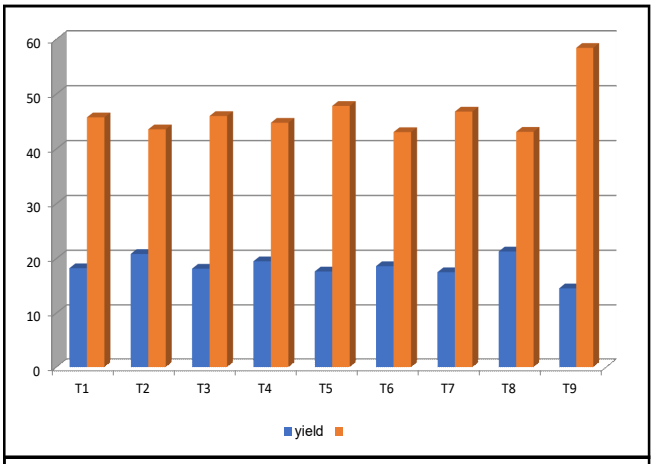

Fig. 1: Efficacy of bio-control agents on yield and yield components of turmeric

Table 4 : Efficacy of bio-control agents on yield and yield components of turmeric

Treatments	Yield per plant (g)			Yield per plot (kg)			(t ha^{-1})		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
T_1	210.06	246.26	228.16	10.08	11.82	10.95	16.80	19.70	18.25
T_2	258.53	262.93	260.06	12.41	12.62	12.51	20.68	21.03	20.85
T_3	220.86	233.33	227.10	10.60	11.20	10.90	17.66	18.66	18.16
T_4	247.73	240.23	243.98	11.89	11.53	11.71	19.81	19.21	19.51
T_5	221.20	220.46	220.83	10.61	10.58	10.60	17.69	17.63	17.66
T_6	273.60	192.33	232.96	13.13	09.23	11.71	21.88	15.38	18.63
T_7	215.13	222.86	219.00	10.32	10.69	10.51	17.44	17.82	17.52
T_8	268.00	264.66	266.33	12.86	12.70	12.78	21.44	21.17	21.30
T_9	183.46	181.13	182.30	8.80	8.69	8.74	14.67	14.49	14.58
Mean	233.17	229.35	-	11.19	11.00	-	18.65	18.34	-
SeM (±)									
Factor A (T)	2.79		-	0.13		-	0.22		-
Factor B (V)	1.31		-	0.06		-	**0.10**		-
Interaction (T×V)	3.95		-	0.19		-	**0.13**		-
C. D. (P=0.05									

(17.66 t ha^{-1}) and *T. harzianum* + *P. fluorescens* + *B. subtilis* (17.52 t ha^{-1}) was significantly higher than untreated control plot. However, the treatments compressing there combination which was at par with yield. Significant reduction in rhizome yield recorded in untreated plot confirms the economic importance of Taphrina leaf spot disease which is drastically effecting the rhizome yield of turmeric.

Results of present study confirm the finding of Srivastava and Gupta (1977), who reported that that Mancozeb provides best control of Taphrina leaf spot and leaf blotch diseases of turmeric. Ramkumar *et al*. (2012) reported that the *P. fluorescens* (2%) in the form of rhizome treatment and foliar spray (two times) was found to be the most effective antagonistic microbe in regulating *C. capsici* infecting *Curcuma longa*. The significant effect of bio-control agents *i.e. T. harzianum, P. fluorescens, B. subtilis* and their combination indicate the spraying of above treatments not only controls Taphrina leaf spot of turmeric but also effective in increasing the rhizome yield of turmeric. Present study indicate that foliar application of bio-control agents can be effective in the manage the taphrina leaf spot and would an be alternative for chemical fungicide. The significant interaction between biocontrol agents and varieties indicate that there may be different varietal response for biocontrol agents on plant growth promotion and rhizome yield.

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