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Management of leaf spot of turmeric caused by *Colletotrichum capsici* through different Fungitoxicants

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Abstract
Turmeric (*Curcuma longa* L.) is an important spices crop India is the leading country in respect to area production, export consumption of turmeric in the world. Leaf spot disease of turmeric caused by *Colletotrichum capsici* is a very serious disease causes huge yield losses in various turmeric growing regions of the world. Hence an experiment was conducted at MES, vegetable science, Anaduat, Kumarganj, Ayodhya to evaluate different fungi toxicants for there efficacy in effective management of the disease under field conditions. The present investigation carried out of nine different fungi toxicants including bioagents and botanicals tested under field conditions, Propiconazole @ 0.1% concentration was found most effective in minimizing the disease intensity with PDI 25.57% and providing the higher yield 343.44 q/ha followed by Hexaconazole with disease intensity (PDI 28.84% and yield 332.89 q/ha). Although both the fungi toxicant are statistically at par with each other. The next best fungicides in reducing the disease intensity and enhancing the yield were recorded as (Azoxystrobin) with PDI 35.37% and yield 326.72 q/ha, (Copper oxychloride) with PDI 35.34% and yield 322.94 q/ha, and Kasugamycin with PDI 36.00% and yield 302.22q/ha, above three fungi toxicants were not significantly different with one another. The other remaining fungi toxicants in order of superiority were *Trichoderma harzianum* with PDI 38.64% and yield 291.17 q/ha, Jeevamruth with PDI 40.96% and yield 283.78q/ha, and NSKE with PDI 43.27% and yield 291.17 q/ha.

Keywords: Turmeric, leaf spot, *Trichoderma harzianum*, Jeevamruth and yield

Introduction
Turmeric (*Curcuma longa* L.) is one of the most important ancient sacred rhizomatous spices of India belongs to the family Zingiberaceae, grown in India for its culinary, medicinal, religious, cosmetics and industrial purposes. Turmeric has strong associations with the socio cultural life of the people of the Indian subcontinent. This "earthy herb of the Sun" with the orange-yellow rhizome was regarded as the "herb of the Sun" by the people of the Vedic period. No wonder the ancients regarded turmeric as the *"Oushadhi"*, the healing herb, the most outstanding herb, the one herb above all others (Jager, 1997) [3]. India ranks first in respect of production, consumption and export of turmeric, its total production during the year 2021-2022 was 1334 thousand MT with an area of 349 thousand hectare (Agricultural Statistics at a Glance 2022) [1].

Major turmeric producing states in India are Telangana, Andhra Pradesh, Tamil Nadu, Karnataka, Orissa, West Bengal and Maharashtra. In Uttar Pradesh, during the year 2021 - 2022 the area and the production of turmeric was 1.76 thousand ha and 3.64 MT respectively. It is highly prone to several fungal diseases such as leaf spot, leaf blotch, rhizome rot, etc. due to which its quantitative and quantitative production decreases significantly. Among these diseases leaf spot is the most important disease which losses yield up to 62.12 per cent in various major turmeric growing regions in India (Jagtap *et al*. 2013) [2]. McRae was the first who reported the disease from Coimbatore district of Tamil Nadu in 1917. Now the disease became more prevalent and destructive in all the turmeric growing regions of India. The disease usually appear in the field during August and September and become more aggressive during November and December, when average temperature around 20 ºC to 25 ºC and high relative humidity in the atmosphere. Typically, the months of August and September are when the sickness manifests itself due to high and persistent atmospheric humidity. Additionally, it was noted in November and October.

The pathogen usually targets leaves. The illness primarily affects leaf blades, though it can infrequently spread to the leaf sheaths. Variously sized elliptic or oblong patches are the disease's primary symptom. When they first appear, they are small, measuring 1.0 to 1.5 inches in width and 1.5 to 2.0 inches in length. However, a large number of them quickly grow in size. Two or more of these spots combine to form uneven patches that frequently cover a significant area of the leaf and finally dry up. Each individual spot has a distinct appearance. The center is narrow, greyish white, and covered in numerous black acervuli-like dots that are grouped in concentric rings on both surfaces (Kumawat *et al*., 2022) [7]. A brown border surrounds the area of spot all around beyond the greyish white section. A faint yellowish area surrounds the area outside, making a halo. Despite being visible on both surfaces, the spots are more obvious in fresh leaves on the upper surface. Most of the leaves dry up and the field gives a parched appearance when disease prevalence is high. Keeping in the view importance of this economically spice crop and seriousness of the disease, the present experiment was carried out to evaluate the efficacy of fungicides, bio-agents, botanicals against the leaf spot disease of turmeric under field conditions to find out efficient management of the disease.

Materials and Methods

The present experiment was conducted at Main Experimental Station (MES) Vegetable Science, Acharya Narendra Deva University of Agriculture & Technology Kumarganj, Ayodhya, during 2020-2021 and 2022-23. Field trials were laid out in ten fungitoxicant with in three replications in a randomized block. A total number of nine different fungitoxicants was selected for testing their efficacy including bio-agents and botanicals, such as, copper oxychloride, propiconazole, hexaconazole, azoxystrobin, kasugamycin, neem seed kernel extract (NSKE), jeevamrutha, *Trichoderma harizianum*, and garlic leaf extract along with a control. The turmeric rhizome were planted in a prepared bed of 3 M x 1 M, size at a spacing of 30 cm between the row and 20cm between the plants. Thus, 50 plants per beds were raised by adopting recommended packages and practice same among all the treatments except the fungicidal application of treatments. The disease intensity was recorded by adopting 0 to 9 disease rating scale as developed by Mayee and Datar, 1986 [8]. The collected data were analyzed statistically using analysis of variance (ANOVA). Percent disease intensity (PDI) and percent disease control (PDC) was recorded by using following formula;

$$\text{PDI} = \frac{\text{sum of total numerical rating}}{\text{Total number of leaves examined} \times \text{maximum rating}} \times 100$$

$$\text{PDC} = \frac{\text{PDI in control plot} - \text{PDI in treatment plot}}{\text{PDI in control plot}} \times 100$$

Results and Discussion

The results presented in table 1 reveal that all the tested treatments were significantly superior in reducing the disease intensity and increasing the yield over control .The best fungitoxicant was T_2 (Propiconazole) which reduces maximum disease intensity (PDI 25.57%) and higher yield (343.44q/ha in 2021-2022 & 2022-2023) followed by T_3 (Hexaconazole) with PDI 28.84 and yield 332.89q/ha. Although both the treatments are statistically at par with each other. The next best fungicides in reducing the disease intensity and enhancing the yield were recorded as T_4 (Azoxystrobin) with PDI 35.37% and yield 326.72 q/ha, T_1 (Copper oxychloride) with PDI 35.34% and yield 322.94 q/ha, and T_5 (Kasugamycin) with PDI 36.00% and yield 302.22 q/ha. The above three fungitoxicants were not significantly different with one another. The other remaining fungitoxicants in order of superiority are T_8 (*Trichoderma harzianum*) with PDI 38.64% and yield 291.17q/ha, T_7 (Jeevamruth) with PDI 40.96% and yield 283.78q/ha, T_6 (NSKE) with PDI 43.27% and yield 291.17q/ha, and T_9 Garlic leaf extract with PDI 45.33% and yield 267.89q/ha. Among the four eco-friendly fungitoxicant tested the maximum percent disease control (28%) was found in T_8 (*Trichoderma harzianum*) followed by T_7 (Jeevamrutha) with 23.51%, T_6 (NSKE) with 19.38% and maximum percent disease control (PDC) was found in T_9 (Garlic Leaf Extract) 15.54% on the basis of pooled data of both the years conducted trials 2021-22 and 2022-2023.

Table 1: Effect of different fungicides & botanicals against *Colletotrichum capsici* causing leaf spot disease of turmeric during second trial in 2021-22 and 2022-23.

		2021-2022			2022-2023		
Treatments	**Concentration**	**PDI**	**PDC**	**Fresh Rhizome Yield q/ha**	**PDI**	**PDC**	**Fresh Rhizome Yield q/ha**
T_1- Copper oxychloride	0.3%	37.00	33.37	318.00	33.67	34.83	327.89
T_2 - Propiconazole	0.1%	26.62	52.11	339.33	24.52	52.66	347.56
T_3 - Hexaconazole	0.1%	29.47	46.84	329.11	28.21	45.26	336.67
T_4 - Azoxystrobin	0.2%	36.09	35.07	323.56	34.64	33.11	326.39
T_5- Kasugamycin	0.3%	37.24	32.90	297.22	34.76	32.49	307.22
T_6 - NSKE	5%	45.19	18.62	271.44	41.35	20.14	280.44
T_7- Jeevamrutha	5%	43.42	21.72	281.00	38.50	25.30	286.56
T_8- *Trichoderma harzianum*	0.5%	40.75	26.65	289.22	36.53	29.35	293.11
T_9- Garlic leaf extract	5%	47.00	15.49	264.22	43.67	15.60	271.56
T_{10} - Control		55.60	0.00	252.11	51.78	0.00	258.00
SEm ±		1.22	2.29	4.66	1.45	2.83	5.55
C.D. at 5%		3.66	6.86	13.98	4.36	8.49	16.62
C.V.		5.31	13.77	2.72	6.86	17.26	3.16

Table 2: Efficacy of various fungitoxins on disease incidence of leaf spot disease of turmeric caused by *C. capsici* in field condition Pooled data (2021-2022 & 2022-2023).

Treatment Name	Concentration	PDI	PDC	Fresh Rhizome yield kg/plot	Fresh Rhizome Yield q/ha
T_1- Copper oxychloride	0.3%	35.34	34.10	9.69	322.94
T_2 - Propiconazole	0.1%	25.57	52.39	10.30	343.44
T_3 - Hexaconazole	0.1%	28.84	46.05	9.99	332.89
T_4 - Azoxystrobin	0.2%	35.37	34.09	9.80	326.72
T_5- Kasugamycin	0.3%	36.00	32.70	9.07	302.22
T_6 - NSKE	5%	43.27	19.38	8.40	275.94
T_7- Jeevamrutha	5%	40.96	23.51	8.51	283.78
T_8- *Trichoderma harzianum*	0.5%	38.64	28.00	8.60	291.17
T_9- Garlic leaf extract	5%	45.33	15.54	8.04	267.89
T_{1O}- Control		53.69	0.00	7.65	255.06
SEm ±		1.26	2.43	0.14	4.06
C.D. at 5%		3.8	7.30	0.44	12.15
C.V.		5.73	14.74	2.83	2.34

Percent disease control

From the perusal of the data presented in table 2 further apparently seems that the treatment T_2 (Propiconazole) is highly effective fungicides which recorded maximum percent disease control (52.11% and 52.66%) followed by treatment T_3 (Hexaconazole) with PDC (46.48% and 45.26%), T_4 (Azoxystrobin) with PDC (35.07% and 33.11%), T_1 (Copper oxychloride) PDC (33.37% and 34.83%) and T_5 Kasugamycin PDC (32.90% and 32.49%). Among the four ecofriendly fungitoxicant tested the maximum per cent disease control (26.65% and 29.35%) was found in T_8 (*Trichoderma harzianum*) followed by T_7 (Jeevamrutha) PDC (21.72% and 25.30%), T_6 (NSKE) PDC (18.62% and 20.14%) and minimum percent disease control was found in T_9 (Garlic leaf extract) PDC (15.49% and 15.60%) on the basis of pooled data of both the years conducted trials 2021-22 and 2022-23.

Yield

From the perusal of data presented on the table 1 obtained further reveals that the highest yield were obtained both the years from foliar spray with Propiconazole 333.33 q/h and 347.56 q/h are lower yield. 264.22q/hec in 2021-22 and 2071.56 q/hec 2022-23 were recorded from garlic leaf extract application.

However in the control plot least yield only 252.11q/h in 2021-22 and 258.00 q/h 2022-23 were recorded.

Mishra *et al.* (2015) [10] tested various fungicides against leaf spot of turmeric and found carbendazim + Mancozeb 0.1% best fungicide followed by Propiconazole and Hexaconazole.

Koche *et al.* (2009) [6] tested efficacy of five fungicides along with three botanicals against foliar diseases of turmeric.

The findings of these workers are increadence with the present finding. It is also noticeable that chemical fungicides are more effective in reducing the disease intensity as increasing rhizome yield than bio-agents and botanicals but tested bio-agents and botanicals can be promoted among the turmeric growing farmers those interested to produce organically qualitative organic rhizomes of turmeric.

Conclusion

The protecting action of different fungicides & botanicals against *Colletotrichum capsici* causing leaf spot disease of turmeric was observed in field experiment. In the present study low percent disease intensity (PDI), high percent disease control (PDC) and fresh rhizome yield t/ha was considerably increased by different treatments. All the fungicides and botanicals were tested *in vivo* in various concentrations, significantly inhibited the growth of *Colletotrichum capsici*. However, garlic leaf extract was found most effective among the botanicals followed by Jeevamrutha, NSKE, *and Trichoderma harzianum*. The effect is due to the bio-chemicals present in garlic, which helps in the eradication of plant disease.

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