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Management of onion twister disease under field condition

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Abstract
Onion (*Allium cepa* L) cultivation has been hampered by many pests and diseases. In recent times onion twister has become most serious and threatening since two years. The severity of disease witnessed drastic decline in production and shortage in domestic supply across the country. Its management was studied using different fungicides along with bio-control agents *Trichoderma* and *Pseudomonas* in combined mixture form during *Rabi* 2021. The experiment was conducted on a site previously cultivated with onion and infested by sever twister disease. Among the different treatments, folair application of carbendazim 12% + mancozeb 63% 75 WP at 2.5g/l (T_9), *Trichoderma* + *Pseudomonas* mixture at 10 g/l concentration (T_{13}) and propiconazole 25 EC at 1 ml/l (T_{10}) recorded less PDI of 16.59, 17.26 and 18.54 respectively. Maximum PDI of 72.11 was observed in control plot. The yield was also significantly superior in T_9 with yield of 28.28 t/ha and B:C value of 5.74 followed by T_{10} which had yield of 27.45 t/ha and B:C ratio of 5.59 and T_{13} with an yield of 26.89 t/ha and B:C ratio of 5.46. Lowest yield (14.70 t/ha) was recorded in control which had B:C ratio of 3.03. It was necessary that among these best fungicides or bio-control agents' mixture, any one shall be adopted but spraying of three times at an interval of 15 days in essential once the symptoms are first observed for effective control of the disease.

Keywords: Onion, twister, *trichoderma*, *pseudomonas*, disease, management

Introduction
Onion is the most commonly cultivated vegetable around the world, (*Allium cepa* L. 2n=16) belongs to the *Alliaceae* family and genus *Allium*. It is an important commercial vegetable crop (Sinnadurai, 1970; Kyofa-Boamah *et al*., 2000) [24, 12]. It is commonly known as "Queen of the kitchen" due to its high frequent use in one or the other culinary items, valued flavor, aroma, unique taste and medicinal properties (Selvaraj, 1976; Griffiths *et al*., 2002) [21, 9]. Onion is known for its flavor and pungency due to chief chemical constituent "Allylpropyl disulfide" (Ly *et al*., 2005) [13]. According to Vavilov it has two centers of origin, primary and secondary, i.e., Central Asia and the Near East and the Mediterranean region, respectively (McCollum, 1976) [15]. India is next to China in onion production from an area of 14.34 lakh hectares with the production of 26.74 million tonnes and productivity of 18.64 MT/ha. Maharashtra alone contributes 40.94 per cent of the total area under onion cultivation in the country. Madhya Pradesh is the second-largest in terms of production (16.36%), followed by Karnataka (8.71%) and Gujarat (5.45%) (Anon, 2020a) [2]. In Karnataka, north and interior districts *viz*., Dharwad, Chitradurga, Gadag, Chamarajnagara, Vijayapur, Bagalkot, Koppal, Belagavi, Kalaburagi, Yadgir, Chikkaballapura and Haveri (Baraker *et al*., 2020) [3] are major districts contributing to onion production. However, the onion demand has never been constant due to various hurdles in its production such as diseases and pests. Among the diseases, onion twister has become most threatening in the last two years. The disease was earlier considered caused by co-infection of *Colletotrichum gloeosporioides*, *Fusarium oxysporum* f. sp. *cepae* and *Meloidogyne* spp. (Patil *et al*., 2018) [18]. However, its etiology studied in detail and found to be caused by *Colletotrichum gloeosporioides* and *Fusarium oxysporum* f. sp. *cepae*. The disease caused huge shortage in onion supply across the country due to severe twister disease outbreak both in Karnataka and Maharashtra during *Kharif* 2019 and 2020. This resulted in sudden decline in onion supply and acute shortage of seeds also due to failure of seed crops. In view of significant negative impact of onion twister disease on its production and supply, its management was on priority in Karnataka for successive onion cultivation. The current research was initiated with an objective to identify suitable and economical strategies for management of onion twister disease in field conditions.

Materials and Methods

The field experiment on onion twister was conducted during *Rabi* 2020-21 on a plot having previously onion with heavy twister disease severity under natural epiphytotic conditions at Mangapura (14º 68' N, 76º 33' E) village of Kotturu taluk in Ballari district.

The experiment was laid out following Randomized Block Design (RBD) with three replications and 15 different treatments that includes, fungicides sole systemic, contact fungicides and their combined formulations and a control plot without any interventions. Bio control agents *viz*., *Trichoderma* and *Pseudomonas* were also part of the treatments in combined form. Onion seedlings of Nasik Red N-53 were raised on nursery beds following recommended practices. Well grown 30 days old seedlings were transplanted on ridges and irrigated for establishment. Agronomical, irrigation and plant protection except for twister disease were followed as per recommended package of practices. The crop was under flood irrigation system during the experiment period. Treatments were imposed immediately after observing first symptoms of twister disease on onion plants. Foliar applications of fungicides and biocontrol agents in each treatment were implemented for four times respectively at an interval of 15 days. Observations on disease incidence and severity were recorded at 10 days after each treatment and 7 days before harvesting the crop. The crop was harvested at its physiological maturity each treatment wise separately. Yield obtained in each treatment for all the three replications was recorded and subjected to statistical analysis. Cost benefit analysis was also carried out to identify best performing and economical recommendation for recommending among farmers on large scale. The disease incidence, per cent disease index and per cent disease reduction were calculated following the below mentioned formulae

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

$$\text{Per cent disease index (\%)} = \frac{\text{Sum of all disease ratings}}{\text{Total no. of plants observed X maximum disease grade}} \text{ X } 100$$

$$\text{Disease reduction (\%)} = \frac{C - T}{C} \text{ X } 100$$

Where C – Per cent disease severity in control plot
T – Per cent disease severity in treated plot

The disease rating followed in onion twister

Grades	Twisting (%)	Description
0	No disease	No symptoms
1	Up to 10%	Curling and chlorosis of leaves
2	11 to 20%	Abnormal elongation of leaves and neck
3	21 to 40%	Leaf-sheath showing cluster of acervuli concentric rings along with shallow, sunken necrotic spots and root galling
4	41 to 60%	Elongated neck, slender bulb leaves show dieback symptoms
5	>60%	Severe dieback, rotten bulbs, root system underdeveloped with discolored roots.

(Bhangale and Joi, 1985) [4]

Different fungicides and bio-control agent's employed against onion twister disease management

Tr. No.	Name of the treatment	Trade name	Concentration (%)
T_1	Tebuconazole 50% + trifloxystrobin 25% 75 WG	Nativo	0.05
T_2	Fluopyram 17.7% + tebuconazole 17.7% 400 SC	Luna experience	0.025
T_3	Hexaconazole 5 EC	Contaf	0.1
T_4	Kitazin 48 SC	Kitazin	0.1
T_5	Myclobutanil 10 WP	Systhane	0.1
T_6	Azoxystrobin 23 SC	Amister	0.1
T_7	Tebuconazole 29.5 SC	Folicur	0.1
T_8	Flusilzole 12.5% + carbendazim 25% 37.5 SE	Lustre	0.05
T_9	Carbendazim 12% + mancozeb 63% 75 WP	SAAF	0.25
T_{10}	Propiconazole 25 EC	Tilt	0.1
T_{11}	Carbendazim 50 WP	Bavistin	0.1
T_{12}	Mancozeb 75 WP	DM-45	0.25
T_{13}	*Trichoderma* + *Pseudomonas*	-	1
T_{14}	Copper oxychloride 50 WP	Blitox	0.25
T_{15}	Untreated check/control		

The economic analysis of the experiment conducted was done by calculating the cost of imposing the individual treatments using following formula

$$\text{Benefit cost ratio} = \frac{\text{Gross returns (Rs.ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs.ha}^{-1}\text{)}}$$

Results and Discussion

The management of onion twister by different chemical fungicides and combined use of bio-control agents showed varying and significant positive response over the control. The disease severity recorded at each stage is presented in Table 1. Among the different treatments imposed, until the last observation recorded on 7 days before harvesting the crop least disease incidence of 16.59 per cent was recorded in treatment T_9 followed by 17.26 per cent in T_{13} though statistically both are on par. The treatments T_{10}, T_{12} and T_1 recorded 18.54, 19.60 and 20.19 per cent disease severity respectively. Disease severity in untreated control plot stood at 72.11 per cent. A similar trend was observed for per cent disease reduction over control. The maximum disease reduction over control 77.00 per cent was observed in T_9 followed by T_{13} (76.06%) and T_{10} (74.29%).

The results indicate that, the application of carbendazim + mancozeb combined product was highly effective mainly because of its combination of both systemic (Carbendazim 12%) and contact fungicide (Mancozeb 63%) with different modes of action could greatly reduce the twister disease

severity in onion. This combination used by Singh (2002) [23] in sunflower against *Alternaria* blight significantly increased the sunflower grain yield compared to control plot. Whereas, Mathivanan and Prabavathy (2007) [14] also reported successful control of *Alternaria* leaf blight in sunflower by carbendazim + mancozeb at 2.0 g/l.

Combined application of *Trichoderma* + *Pseudomonas* (1%) of talc formulation as foliar spray was found next best treatment in reducing the twister disease severity. This reduction in disease is mainly due to their different modes of action *viz*., competition for nutrients (O'Sullivan and O'Gara, 1992), production of cell wall lytic enzymes (Singh *et al*. 1999) and induced systemic resistance (Nandakumar *et al*. 2001) [16], the salicylic acid and lipopolysaccharide produced by *P. fluorescens* may act as local and systemic signal molecules in inducing resistance in plants (Van Peer and Schippers, 1992) [25]. The diversity of mechanisms available to *Trichoderma* spp. for pathogen suppression (e.g. production of a wide range of broad-spectrum antifungal metabolites, mycoparasitism, competition with the pathogen for nutrient and occupation of the infection court, induced resistance, protease and fungal cell wall degrading enzyme) makes this fungus an efficient biocontrol agent (Dennis and Webster 1971; Elad, 2000; Perello *et al*. 2003) [5, 6, 20] hence the mixture of both the bioagents is largely responsible for the onion twister disease suppression and plant growth promotion. It is well documented that the interaction of *Trichoderma* strains with the plant may promote growth, improve crop yield, increase nutrient availability and enhance disease resistance (Harman *et al*., 2004; Gajera *et al*., 2013) [10, 7].

At final observation, third best treatment T_{10} involving propiconazole 25 EC at 0.1 per cent concentration as foliar spray was also found most promising in reducing the twister disease. Though it stood second third but had no significant difference with second most superior treatment and eventually it stood second best under cost benefit analysis. Propiconazole has been effective against many foliar and soil borne diseases like *Fusarium* head blight (Paul *et al*., 2008) [19]. Application of propiconazole at 0.1% caused a dramatic reduction in anthracnose of chilli incidence by (70%) when compared to difenoconazole at 0.05% (58%) and carbendazim at 0.1% (44%). Additionally the fruit yield increased in the range of 86, 63 and 60 per cent for propiconazole, difenoconazole and carbendazim, respectively, when compared to unsprayed controls (Gopinath *et al*., 2006) [8]. Propiconazole belongs to triazoles, a new class of fungicides, belong to Group 3 fungicide family, involved in ergosterol biosynthesis inhibition (EBI) that prevents the formation of a key fungal cell membrane component (Anon, 2013) [1]. Thus, its use improved the plant disease resistance and played an essential role in maximizing benefits.

During the entire course of experiment, among the treatments, up to 10 days after the third spray (85 DAT) treatment T_{13} had the lowest disease severity of 11.60 per cent, followed by T_9 (11.87%) and T_{12} (12.88%), which were statistically on par with each other (Table 1).

Among the different fungicides and biocontrol agents treated plots, bulb yield varied as a result of decline in onion twister severity. The treatment T_9 recorded the highest yield of 28.28 t/ha followed by T_{10} and T_{13} which recorded 27.45 t/ha and 26.89 t/ha respectively. The next best yield was noticed in T_{12} with a bulb yield of 25.50 t/ha, whereas in untreated control plot bulb yield was 14.70 t/ha (Table 2).

Cost benefit ratio of various fungicides and bio-control agents treated ranged from 3.03 to 5.74. Highest BCR was recorded in treatment T_9 (5.74) followed by T_{10} (5.59) and T_{13} (5.46). In the control plot, it was 3.03 (Table 2). The highest returns over other treatments by carbendazim + mancozeb against *Colletotrichum truncatum* causing anthracnose/pod blight of soybean was earlier also observed by Jagtap *et al*. (2014) who recorded B:C ratio of 1:8.92 against *Colletotrichum truncatum* causing anthracnose/pod blight of soybean. Similarly, Mathivanan and Prabavathy (2007) [14] also reported that combined application of carbendazim + mancozeb at 2 g/L recorded highest benefit-cost ratio of 1:7.1 with the lesser *Alteranria* leaf blight disease of sunflower. The combined application of *Trichoderma* + *Pseudomonas* (1%) was also found effective in terms of reduced disease severity, enhanced yield, net returns and B: C ratio. These findings are similar to the observations of Hinduja *et al*. (2021) [11], who recorded the highest yield of 15.30 q/acre, B: C ratio of 2.11 and lesser disease intensity (27.80%) in combined application *Pseudomonas fluorescens* + *Trichoderma viride* + silkworm excreta for the management of purple blotch of onion.

Table 1: Field efficacy of chemical fungicides and bioagents against onion twister disease

Tr. NO.	Treatments	Concentration (%)	PDI* at 10 days after first spray	Per cent Reduction over control	PDI* at 10 days after second spray	Per cent Reduction over control	PDI at 10 days after third spray	Per cent Reduction over control	PDI 7 days Before harvesting	Per cent Reduction over control
T_1	Tebuconazole 50% + trifloxystrobin 25% 75 WG	0.05	7.54 (15.92) **	61.09	9.35 (17.78)	70.41	13.65 (21.64)	74.96	20.19 (26.64)	72.00
T_2	Fluopyram 17.7% + tebuconazole 17.7% 400 SC	0.025	8.70 (17.12)	55.10	9.21 (17.65)	70.85	13.91 (21.88)	74.48	22.78 (28.48)	68.41
T_3	Hexaconazole 5 EC	0.1	9.48 (17.91)	51.08	11.30 (19.62)	64.24	15.55 (23.13)	71.46	23.75 (29.13)	67.06
T_4	Kitazin 48 SC	0.1	12.76 (20.87)	34.15	14.46 (22.29)	54.24	19.17 (25.90)	64.82	29.05 (32.61)	59.71
T_5	Myclobutanil 10 WP	0.1	11.48 (19.77)	40.76	12.98 (21.08)	58.92	26.83 (31.14)	50.77	35.38 (36.47)	50.94
T_6	Azoxystrobin 23 SC	0.1	9.44 (17.87)	51.28	11.45 (19.77)	63.76	16.91 (24.22)	68.98	27.78 (31.80)	61.47
T_7	Tebuconazole 25.9 EC	0.1	9.13 (17.53)	52.88	11.47 (19.73)	63.70	15.27 (22.98)	71.98	26.69 (31.06)	62.99
T_8	Flusilazole 12.5% +	0.05	11.06	42.93	12.86	59.30	21.83	59.95	28.93	59.88

	carbendazim 25% 37.5 SE		(19.38)		(21.00)		(27.82)		(32.52)	
T_9	Carbendazim 12% + mancozeb 63% 75 WP	0.25	7.31 (15.61)	62.28	8.86 (17.20)	71.96	11.87 (20.12)	78.22	16.59 (23.93)	77.00
T_{10}	Propiconazole 25 EC	0.1	9.25 (17.68)	52.27	10.21 (18.61)	67.68	14.06 (21.98)	74.21	18.54 (25.46)	74.29
T_{11}	Carbendazim 50 WP	0.1	8.52 (16.95)	56.03	12.60 (20.68)	60.12	16.39 (23.79)	69.93	26.48 (30.93)	63.28
T_{12}	Mancozeb 75 WP	0.25	7.00 (15.28)	63.88	8.11 (16.52)	74.33	12.88 (20.98)	76.37	19.60 (26.15)	72.82
T_{13}	*Trichoderma+Pseudmonas*	1	6.36 (14.56)	67.18	7.29 (15.65)	76.93	11.60 (19.91)	78.71	17.26 (24.44)	76.06
T_{14}	Copper oxychloride 50 WP	0.25	11.00 (19.30)	43.24	12.08 (20.28)	61.77	22.67 (28.39)	58.40	34.43 (35.90)	52.26
T_{15}	Untreated control/ Check	-	19.38 (26.05)	-	31.60 (34.16)	-	54.50 (47.59)	-	72.11 (58.22)	-
Sem±			1.00		1.10		1.26		1.60	
CD (P ≤0.05)			2.92		3.19		3.67		4.64	

*****PDI- per cent disease index ** Figures in parenthesis are arc transformed value

Table 2: Economic analysis of fungicides and bioagents used for management of onion twister disease

Tr. No	Treatments	Yield (kg/plot)	Yield (t/ha)	B:C
T_1	Tebuconazole 50% + trifloxystrobin 25% 75 WG	43.22	21.61	4.36
ST_2	Fluopyram 17.7% + tebuconazol17.7% 400 SC	49.33	24.67	5.00
T_3	Hexaconazole 5 EC	45.00	22.50	4.58
T_4	Kitazin 48 SC	44.22	22.11	4.51
T_5	Myclobutanil 10 WP	44.89	22.45	4.55
T_6	Azoxystrobin 23 SC	44.89	22.45	4.49
T_7	Tebuconazole 25.9 EC	37.67	18.84	3.82
T_8	Flusilazole 12.5% + carbendazim 25% 37.5 SE	36.56	18.28	3.72
T_9	Carbendazim 12% + mancozeb 63% 75 WP	56.56	28.28	5.74
T_{10}	Propiconazole 25 EC	54.89	27.45	5.59
T_{11}	Carbendazim 50 WP	40.45	20.23	4.12
T_{12}	Mancozeb 75 WP	51.00	25.50	5.19
T_{13}	*Trichoderma + Pseudmonas*	53.78	26.89	5.46
T_{14}	Copper oxychloride 50 WP	41.28	20.64	4.19
T_{15}	Untreated control/check	29.39	14.70	3.03
	SEm±	4.50	-	-
	CD (P ≤0.05)	9.23	-	-

Conclusion

The outcomes of the study advocate spray of carbendazim 12% + mancozeb 63% (0.25%) or, propiconazole 25 EC (0.1%) or mixture of *Trichoderma* + *Pseudomonas* (1%) for three times at 15 day interval schedule shall help in minimizing the incidence of twister disease effectively and avoid the yield loss due to infection of foliage and bulb by *Colletotrichum* and *Fusarium* respectively. Since foliage contributes towards bulb formation and bulb is the economical part of onion, protection of both is crucial in management of twister disease and quill the yield losses.

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