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Effect of novel fungicides and biocontrol agents on yield and yield attributing characters onion tested against onion twister disease incited by involvement of *Colletotrichum gloeosporioides* and *Fusarium oxysporum* f. sp. *cepae* in North Karnataka

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Abstract
This study was conducted under natural epiphytotic conditions at Mangapura (14^{o} 68' N, 76^{o} 33' E) village of Kotturu taluk in Ballari district. The experiment site was selected having previous season onion crop with heavy twister incidence. The objectives were to know the efficacy of novel fungicides, biocontrol agents against onion twister disease development and yield and yield attributing characteristics of onion. The results indicated that treatment T_9 carbendazim 12% + mancozeb 63% 75 WP was significantly superior with least disease severity (16.59%) over the control (72.11%). Yield and yield attributing characteristics significantly superior in treatment application, T_9 carbendazim 12% + mancozeb 63% 75 WP, the maximum neck length, bulb diameter, bulb weight, total bulb yield per plot, total bulb yield per hectare recorded as 74.60 mm, 60.05 mm, 77.22 g, 56.56 kg/plot, 28.28 t/ha respectively with highest benefit cost ratio (5.74) over the control (54.73 mm, 29.14 mm, 31.72 g, 29.39 kg/plot, 14.70 t/ha and 3.03).

Keywords: Onion twister, carbendazim, disease severity, efficacy, biocontrol agents

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 (Kyofa-Boamah *et al*., 2000) [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 (Griffiths *et al*., 2002) [5]. Onion is known for its flavor and pungency due to chief chemical constituent "Allylpropyl disulfide" (Ly *et al*., 2005) [13].

According to the global onion production data China emerged as the leading producer, accounting for 24.92 percent of the total production. India followed closely behind with 22.83 percent of the production, while the USA secured the third position with 3.17 percent of the production. Onion ranked second in terms of cultivation area and third in productivity. In India, onion is cultivated in an area approximately 1.91 million hectares, resulting in a production of 31.27 million tones and a productivity rate of 16.30MTper hectare, in Karnataka area under cultivation 0.23 million hectares, production 2.77 million tones and productivity 11.99 MT during the 2021-22 period (Anon., 2022) [1]. 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, The current research was initiated with an objective to know the effect of fungicides, bio agents on disease development and yield and yield attributing characteristics of onion during *Rabi* 2020-21.

Materials and Methods

The field experiment to test the efficacy of novel fungicides, biocontrol agents against onion twister disease development and yield and yield attributing characteristics of onion was conducted during *Rabi* 2020-2021. Experiment site was selected having previous season onion crop with heavy twister incidence 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 treatments comprising best-performing fungicides and the bio-control agent from *in vitro* studies. Each plot measured 5×4 m and seeds of Panchaganga brand (*var*. NIFAD Selection) were sown following the broadcasting method of sowing (on 30-10-2020) uniformly across each plot.

Recording of observations on yield and yield attributing characters

Neck Length (mm): Randomly selected twenty-five onion plants from a harvested stack of each treatment were measured for their neck length and then the mean value was calculated for further analysis.

Diameter of the bulb (mm): Twenty-five randomly selected bulbs harvested from each treatment and diameter were measured individually and the mean of all three replications were calculated for statistical analysis.

Average bulb weight (g): Average bulb weight was measured on electronic balance by taking the mean weight of 25 bulbs randomly selected in each treatment.

Total bulb yield per plot (kg): Total bulb obtained from the individual plot was weighed after curing and weighed to record the plot yield of each treatment in kilograms per plot.

Total bulb yield per hectare (t ha^{-1}): Total bulb yield obtained from the individual plot was used to calculate bulb yield per unit hectare and expressed in tons.

$$\text{Total bulb yield} = \frac{\text{Area of 1ha x bulb yield kg/plot}}{\text{Plot size}} \times 1000$$

Statistical analysis

The data obtained from the experiments were statistically analyzed following standard procedures advocated by Gomez and Gomez (1984) [4], Panse and Sukhathme (1985) [17] and Sheoran (2010) [19]. The filed data were converted to arcsine values for analysis as described by Snedecor and Cochran (1967) [21].

Economical analysis

The cost of cultivation of each treatment was derived by taking into account each input, unit price and total inputs consumed including labor wages until harvesting of the crop. Based on the total yield obtained and sold, gross returns and net returns were calculated to arrive at the benefit-cost ratio using the following formula.

Gross returns (Rs. ha^{-1}) = Total values of the produce

= (bulb yield × bulb price)

Net returns (Rs. ha^{-1}) = Gross returns (Rs. ha^{-1}) – Cost of cultivation (Rs. ha^{-1})

Benefit-cost ratio (B: C ratio)

To know the rate of return per rupee invested, the benefit-cost ratio was calculated using the below formula.

$$\text{BCR} = \frac{\text{Gross returns (Rs. Ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. Ha}^{-1}\text{)}}$$

Results and Discussion

Effect of different novel fungicides, bioagents against onion twister disease significantly superior in reduction of disease development results indicated that treatment T_9 carbendazim 12% + mancozeb 63% 75 WP was found effective with least disease severity and maximum disease reduction over control 16.59 and 77 percent respectively (Table 1)

The yield and yield attributing characters were measured in each treatment imposed against the management of onion twister disease caused by *C. gloeosporioides* and *F. oxysporum*. The crop was harvested by observing maturity indices. Plants were uprooted from the net area of each treatment separately; soil particles adhering to the bulbs were removed and cured separately. Twenty-five onion bulbs were randomly selected from each treatment in all the replications, yield and yield attributing characters *viz*., neck length, bulb diameter and bulb weight were recorded for each sample and analyzed statistically (Table 2).

Neck length (mm): Statistically, significant variation was recorded in terms of neck length (mm) influenced by different fungicides and bioagents against onion twister disease (Table 2). The maximum neck length (74.60 mm) was recorded in treatment T_9 which was statistically identical with T_2, T_{10} and T_{13} with neck lengths of 72.80, 69.90 and 69.70 mm respectively. On the other hand, minimum neck length (54.73 mm) was recorded in T_{15} (control) which was followed by T_7 (55.37 mm).

Bulb diameter (mm): The results showed that there was a considerable variation in yield and yield-related parameters between the different fungicide and bio-control agents spray against onion twister disease. The results revealed that treatment T_9 had maximum bulb diameter (60.05 mm) followed by T_{13} and T_{10} with bulb diameters of 57.21 and 55.82 mm respectively, which were statistically on par with each other. The least bulb diameter of 29.14 mm was recorded in the T_{15} (control).

Bulb weight (g): Yield enhancement certainly has an improvement in yield attributing characters. Different fungicides and bio-control agents tested against onion twister had varying effects on bulb weight respectively. Statistically, significant variation was recorded in bulb weight (g) of onion in (Table 2). The highest bulb weight was recorded in the treatment T_9 (77.22 g) which was statistically identical with T_{13} and T_{10} with bulb weights of 74.56 and 72.56 grams respectively. The lowest bulb weight (31.72 g) was recorded in T_{15} (control) preceded by T_8 (41.89 g).

Yield (kg/plot): Statistically, significant variation was recorded in onion (kg/plot) yield among the different fungicide and bio-control agents treated plots (Table 2). The highest yield was recorded in the treatment T_9 (56.56 kg/plot), which was statistically on par with T_{10} (54.89 kg/plot) and T_{13} (53.78 kg/plot) and the lowest yield (29.39 kg/plot) was recorded in T_{15} (control) followed by T_8 (36.56 kg/plot).

Present findings *viz*, maximum neck length, bulb diameter, bulb weight, yield and lesser percent of bulb rotting was recorded in the foliar application of carbendazim + mancozeb followed by propiconazole and *T. viride* + *P. fluorescens* spray. The combi fungicide involving carbendazim + mancozeb had shown the highest fungicidal activity against onion twister pathogens *in vitro* and proved similar efficacy against the disease *in vivo* also at low concentration (0.20%). These results indicated that, these two fungicides might have synergism and compatibility and hence exercised a high degree of inhibitory activity against both the pathogens *F. oxysporum* and *C. gloeosporioides*. Carbendazim is a systemic fungicide and mancozeb is a contact fungicide with different modes of action and hence their combined formulation could have acted in both ways resulting in enhanced crop performance by increasing the yield and yield attributing parameters.

A similar result was obtained by Singh (2002) [20], who recorded a significant reduction in *Alternaria* blight of sunflower by foliar application of carbendazim + mancozeb at 1:1 (v/v) with enhanced grain yield.

Propiconazole also showed a significant reduction in disease severity and improvement concerning yield and yield-related parameters. This may be attributed to the effectiveness of triazole fungicides, they are known to interfere with the biosynthesis of fungal sterols and inhibition of ergosterol biosynthesis primarily by blocking the action of 14-α-sterol demethylase (Zhang, 2021) [23].

Combined usage of *T. viride* + *P. fluorescens* talc-based antagonistic formulation as foliage treatment was found most effective in reducing the twister disease and increasing yield like neck length, bulb diameter, and bulb weight under field conditions. This is mainly due to the fast growth of *Trichoderma* competing with disease-causing fungi for food and space, as well as producing mycotoxin substances against the soil or foliar pathogens (Barbosa *et al*., 2001) [2] as enhancing growth and vigor of seedlings. It is also well documented that the interaction of *Trichoderma* with the plant enhances disease resistance (Harman *et al*., 2004; Gajera *et al*., 2013) [8, 3].

The improvement in bulb diameter, size index and yield attributes were mainly due to the ability of *P. fluorescens* to trigger defense in the host and enhance the uptake of insoluble or fixed phosphorus from the soil (Gupta and Gupta, 2013; Gupta, 2009; Verma and Mathur, 1989) [7, 6, 22].

The present findings are following Naguleswaran *et al*. (2014) [16] who reported the bulb treatment together with foliar application of *T. viride*, performed very well by enhancing bulb diameter (29.64 mm), circumference of the bulb (76.06 mm), mean number of bulbs per bunch (6.95) and yield (130.7 Mt/ha). The combined effect of *Trichoderma* and *Pseudomonas* was reported by Gupta and Gupta (2013) [7] who noticed 100 percent control of white rot and basal rot of onion was by soil application of *P. fluorescens* at 5 kg ha^{-1} followed by *T. viride* at 5 kg ha^{-1} as well as seedling root dip has effectively controlled the soil-borne fungal disease of onion.

Total bulb yield per hectare (t/ha): The effect of different fungicides and bioagents on reducing onion twister showed its impact on bulb yield with similar variation among the treatments. The treatment T_9 carbendazim 12% + mancozeb 63% 75 WP recorded the highest yield of 28.28 t/ha followed by T_{10} propiconazole 25 SC and T_{13} *T. viride* + *P. fluorescens*, which recorded 27.45 t/ha and 26.89 t/ha respectively. The next best yield was noticed in T_{12} mancozeb 75 WP (0.25%) with a bulb yield of 25.50 t/ha. The lowest yield was observed in T_8 flusilazole 12.5% + carbendazim 25% 37.5 SE (18.28 t/ha) followed by T_7 of tebuconazole 25.9 SC (18.84 t/ha) which were on par with each other. The untreated control recorded bulb yield of 14.70 t/ha (Table 2).

Benefit-cost ratio (BCR): A benefit to cost ratio of various fungicides and bioagents imposed was calculated. They ranged from 3.03 to 5.74. Highest BCR was recorded in treatment T_9 carbendazim 12% + mancozeb 25% 75 WP (5.74) followed by T_{10} propiconazole 25 EC (5.59) and T_{13} *T. viride* + *P. fluorescens* (5.46). In the control plot, it was 3.03 (Table 2). The results of the experiments on the management of onion twister disease conclude that spraying with carbendazim 12% + mancozeb 25% 75 WP or propiconazole 25 EC or a mixture of *T. viride* + *P. fluorescens* (1%) will reduce the onion twister disease with the highest cost-benefit ratio (Table 2). These fungicides and bioagents can be recommended for the management of onion twister disease in farmer's fields.

The present study revealed that maximum yield, benefit-cost ratio, and lesser disease severity were recorded in the carbendazim 12% + mancozeb 63% 75 WP followed by propiconazole 25 SC and *T. viride* + *P. fluorescens* spray.

The combination of carbendazim and mancozeb was found to be more effective than when sprayed alone. Carbendazim is a systemic fungicide and mancozeb is a contact fungicide with different modes of action. The benefit-cost ratio result was slightly in agreement with Jagtap *et al*. (2014), who reported that the combined application of carbendazim + mancozeb found a C: B ratio (1:8.92) in the management of *Colletotrichum truncatum* causing anthracnose/pod blight of soybean. Konjengbam and Devi (2020) [11] also reported the application of carbendazim had the highest gross return, the net return, and cost-benefit ratio of 1:3.25 in the management of white rot of onion caused by *Sclerotium rolfsii* Sacc. Whereas, Mathivanan and Prabavathy (2007) [14] reported that the combined application of carbendazim + mancozeb at 2 g/L increased sunflower yield by 2293 (kg/ha) with a benefit-cost ratio of 1:7.1 with the lesser sunflower leaf blight.

Along with carbendazim + mancozeb, propiconazole 25 EC was also found best at controlling the disease as well as increasing the yield and B: C ratio, which belongs to the triazole class of fungicides. An *in vitro* study revealed that triazole fungicides significantly showed typical fungicidal activity against onion twister pathogens even at lower concentrations (0.10%). These results indicate that triazoles, a class of fungicides, are becoming increasingly important in the control of plant diseases under their mode of action. The triazole fungicides inhibit one specific enzyme, C14-demethylase, which plays a role in sterol production. These sterols are needed for membrane structure and the development of functional cell walls of fungi. Thus triazole fungicides result in abnormal fungal growth and eventually death of fungi (Mueller, 2006) [15].

The combined application of *Trichoderma* + *Pseudomonas* (1%) was the new intervention included in this study and was found effective in terms of reduced disease severity, enhanced yield, yield-related parameters, net returns, and B: C ratio. These findings are slightly consistent with those of Hinduja *et al.* (2021) [9], who recorded the highest yield of 15.30 q/acre, B: C ratio of 2.11, and lesser disease intensity (27.8%) in combined application *Pseudomonas fluorescens* + *Trichoderma viride* + silkworm excreta for the management of purple blotch of onion.

Naguleswaran *et al.* (2014) [16] in a field trial showed that bulb treatment combined with foliar spray of *T. viride* increased onion production up to 130.7 Mt/ha with a negligible disease incidence (1.08%) against onion leaf twisting disease. Thus, it is evident beyond doubt that application of combi fungicides and combined bio-control agents' mixture both were promising in reducing the onion twister disease incidence and shall form the recommendations against the disease for adoption by the farmers.

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

Tr. No.	Treatments	Concentration (%)	PDI* at 10 days after first spray	Percent Reduction over control	PDI* at 10 days after second spray	Percent Reduction over control	PDI at 10 days after third spray	Percent Reduction over control	PDI Before harvesting	Percent 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% + carbendazim 25% 37.5 SE	0.05	11.06 (19.38)	42.93	12.86 (21.00)	59.30	21.83 (27.82)	59.95	28.93 (32.52)	59.88
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 viride* +*Pseudomonas fluorescens*	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 ($p \leq 0.05$)			2.92		3.19		3.67		4.64	
CV			9.59		9.43		8.58		8.75	

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

Table 2: Effect of fungicides and bioagents on yield and yield attributing characters in onion twister disease management

Sl. No.	Treatments	Concentration (%)	Neck length in (mm)*	Bulb diameter (mm)	Bulb weight (gram)*
T_1	Tebuconazole 50% + trifloxystrobin 25% 75 WG	0.05	59.90	51.71	67.66
T_2	Fluopyram 17.7% + tebuconazole 17.7% 400 SC	0.025	72.80	51.11	65.69
T_3	Hexaconazole 5 EC	0.1	63.73	53.54	68.69
T_4	Kitazin 48 SC	0.1	69.33	45.41	51.72
T_5	Myclobutanil 10 WP	0.1	69.40	49.86	52.89
T_6	Azoxystrobin 23 SC	0.1	62.63	43.36	57.22
T_7	Tebuconazole 25.9 EC	0.1	55.37	40.52	52.56
T_8	Flusilazole 12.5% + carbendazim 25% 37.5 SE	0.05	65.77	37.84	41.89
T_9	Carbendazim 12% + mancozeb 63% 75 WP	0.25	74.60	60.05	77.22
T_{10}	Propiconazole 25 EC	0.1	69.90	55.82	72.56
T_{11}	Carbendazim 50 WP	0.1	62.90	32.54	46.56
T_{12}	Mancozeb 75 WP	0.25	69.53	50.59	61.92
T_{13}	*Trichoderma viride +Pseudomonas fluorescens*	1	69.70	57.21	74.56
T_{14}	Copper oxychloride 50 WP	0.25	61.70	46.10	55.72
T_{15}	Untreated Control/check	-	54.73	29.14	31.72
SEm±			7.09	4.08	5.36
CD ($p \leq 0.05$)			14.52	8.66	10.96

* Average of 25 bulbs ** Figures in parenthesis are arc transformed value

Table 3: Economic analysis of fungicides and bioagents used for management of onion twister disease

Sl. No	Treatments	Yield (kg/plot)	Yield (t/ha)	B:C
T_1	Tebuconazole 50% + trifloxystrobin 25% 75 WG	43.22	21.61	4.36
T_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 viride +Pseudomonas fluorescens*	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

Conclusion

The outcomes of the study advocate spray of carbendazim12% + mancozeb 63% (0.25%) for three times at 15 day interval schedule shall help inminimizing the incidence of twister disease effectively and increase the yield and yield attributing characteristics of onion. Since plant growth parameters contributes towards bulb formation and quill the yield losses.

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References

1. Anonymous; c2022. www.nhrdf.org
2. Barbosa MAG, Rehn KG, Menezes M, Mariano RDLR. Antagonism of Trichoderma species on *Cladosporium herbarum* and their enzimatic characterization. Brazilian J. Microbiol. 2001;32:98-104.
3. Gajera H, Domadiya R, Patel S, Kapopara M, Golakiya B. Molecular mechanism of *Trichoderma* as bio-control agents against phytopathogen system-a review. Curr. Res. Microbiol. Biotechnol. 2013;1(4):133-142.
4. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. 2nd edition, John wiley Sons, Singapore; c1984. p. 683.
5. Griffiths G, Trueman L, Crowther T, Thomas B, Smith B. Onions a global benefit to health. Phytother. Res. 2002;16(7):603-615.
6. Gupta PK. Soil, plant, water and fertilizer analysis. 2nd Edi. Agrobios (India) Agro house, behind Nasrani Cinema, Chopasani Road, Jodhpur; c2009. p. 152-204.
7. Gupta RC, Gupta RP. Effect of integrated disease management packages on diseases incidence and bulb yield of onion (*Allium cepa* L.). SAARC J Agric. 2013;11(2):49-59.
8. Harman GE, Howell CR, Viterbo A, Chet I, Lorito M. *Trichoderma* species-opportunistic, avirulent plant symbionts. Nat. Rev. Microbiol. 2004;2(1):43-56.
9. Hinduja N, Simon S, Lal AA. Effect of selected bio-resources on purple blotch disease of onion (*Allium cepa* L.). The Pharma Inno. J. 2021;10(10):366-370.
10. Jagtap GP, Gavate DS, Dey U. Control of *Colletotrichum truncatum* causing anthracnose/pod blight of soybean by aqueous leaf extracts and biocontrol agents. Legume Res. Int. J. 2014;37(3):329-334.
11. Konjengbam R, Devi RT. Cost benefit ratio of bio-control agents, botanicals and fungicide in the

management of white rot of onion caused by *Sclerotium rolfsii* Sacc. in Manipur. J Agric. Ecol. 2020;10:83-89.
12. Kyofa-Boamah M, Blay E, Braum M, Kuehn A. Good agricultural practices and crop protection recommendations for selected vegetables. Handbook of Crop Prot. Ghana. 2000;5:95-108.
13. Ly TN, Hazama C, Shimoyamada M, Ando H, Kato K, Yamauchi R. Antioxidative compounds from the outer scales of onion. J Agric. Food. Chem. 2005;53:8183-8189.
14. Mathivanan N, Prabavathy VR. Effect of carbendazim and mancozeb combination on Alternaria leaf blight and seed yield in sunflower (*Helianthus annus* L.). Arch. Phytopathol. Pl. Prot. 2007;40(2):90-96.
15. Mueller DS. Fungicides: Triazoles. Integrated Crop Manag. News; c2006, 1274.
16. Naguleswaran V, Pakeerathan K, Mikunthan G. Biological control: A promising tool for bulb-rot and leaf twisting fungal diseases in red onion (*Allium cepa* L.) in Jaffna district. World Appl. Sci. J. 2014;31(6):1090-1095.
17. Panse VG, Sukhathme PV. Statistical methods for agricultural workers. 4th edition, Indian Council of Agricultural Research Publication, New Delhi; c1985. p. 87-89.
18. Patil S, Nargund VB, Hariprasad K, Hegde G, Lingaraju S, Benagi VI. Etiology of twister disease complex in onion. Int. J Curr. Microbiol. Appl. Sci. 2018;7(12):3644-3657.
19. Sheoron OP. Online statistical analysis tool. Chaudhary Charan Singh Haryana Agricultural University; c2010.
20. Singh SN. Effect of sowing dates and fungicidal spray on Alternaria blight and yield of sunflower. Indian Phytopathol. 2002;55:104-106.
21. Snedecor VG, Cochran WG. Statistical methods. 6th Edn., Oxford and IBH Publishing company, Calcutta; c1967, 67.
22. Verma S, Mathur RS. Biological association between nitrogen fixing and phosphate solubilizing micro organisms. Curr. Sci. 1989;58:1099-1100.
23. Zhang J, Zhang B, Zhu F, Fu Y. Baseline sensitivity and fungicidal action of propiconazole against *Penicillium digitatum*. Pestic. Biochem. Physiol. 2021;172:104752.