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Influence of fungicides, nutrients and bioagents on leaf twisting disease and yield of onion (*Allium cepa* L.)

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ABSTRACT: Influence of fungicides, nutrients and bioagents on yield, quality enhancement and management leaf twisting in onion was studied at Regional Agricultural Station, Vijayapur, Karnataka, during *kharif* and *rabi* 2021-22. The variety of 'Bhima Super' seeds collected from two sources (normal and twisting affected seeds) with nine treatments combination of polymer (3 ml kg^{-1}), chemicals, captan (2 g/kg), carboxin 37.5 % + thiram 37.5 % (3 g kg^{-1}), captan 70 % + hexaconazole 5 % (3 g kg^{-1}) and bioagents of *Trichoderma harzianum*, *Pseudomonas fluorescens*, and *Bacillus subtilis* each @ 5 g kg^{-1}. The results obtained from combination of all three bioagents recorded significantly higher bulb yield (23.82 t ha^{-1}) followed by all three bioagents along with fungicides carboxin 37.5 % + thiram 37.5 % (3 g kg^{-1}) (23.15 t ha^{-1}) as compared to control (15.22 t ha^{-1}) due to significant increase in the yield attributes. *Kharif* harvested bulbs treated with nine different treatment combinations and planted during *Rabi* season to know the effect of nutrients, fungicides and bioagents on field performance and management of leaf twisting. Among treatments application of N: P: K @ 125: 50: 125 kg ha^{-1} + Mg @ 30 kg ha^{-1} + S @ 45 kg ha^{-1} + B @ 3 kg ha^{-1} + Zn @ 4 kg ha^{-1} + foliar spray of hexaconazole 0.05 % at 30 and 60 days after planting recorded significantly higher plant growth parameters, lesser leaf twisting (17.44 %) and higher seed yield (504.49 kg ha^{-1}) as compared to control (34.99 % and 312.47 kg ha^{-1} respectively).

Keywords: Nutrients, fungicides, bioagents, leaf twisting, seed yield

INTRODUCTION

Onion (*Allium cepa* L.) belonging to the family Amaryllidaceae, is said to be native to Central Asia and Mediterranean region (McCollum, 1976). Indian onions are famous for their pungency due to the presence of a volatile compound 'Allyl propyl disulphide' ($C_6H_{12}S_2$). India is the second largest onion bulb producer in the world after China and occupies an area of 1.62 m ha with a production of 26.64 mt and 16400 kg ha^{-1} of productivity. This crop is affected by various diseases and pests. Some of the diseases like purple blotch, downy mildew, *Stemphylium* blight, basal rot, storage rots and now recently twisting disease. Prior to 1997, leaf twisting disease was not an important disease in onion crop, but in the recent years this is one of major diseases not only in low land areas, but also in highlands. In Karnataka, leaf twisting disease complex severity has varied from 7.9 to 52.4 per cent (Anon., 2005). Patil *et al*. (2017) reported twisting of leaves, stem and bulbs of onion which has caused serious threat to cultivation and loss was estimated to extent of 40-60 per cent. At present, onion is extensively cultivated in all the parts of Karnataka. Both seed and bulb crops are infected with disease severity of 20-30 per cent and 50-70 per cent respectively (Anon., 2011).

The seed treatments help in protecting seedlings against pests and diseases. Also, the treated seeds could improve root development, seedling emergence, inducing the structural and ultrastructural modifications for water to imbibe, decreasing the stress at the germination stage, establishment rates and enhancing the activity of enzymes which convert macromolecules to materials needed and applied for the embryo's growth and development (Bewley and Black, 2012 and Galhaut *et al*., 2014). Along with seed treatment a new formulation technology for treating the seeds called polymer coating, has been developed. Polymer coating provides growers with high quality, seed treatments that are safer to use, offer additional protection from pathogens and improve flow ability of seeds. Application of micronutrients along with macronutrients to the soil or foliar spray showed remarkable increase in yield of several crops. Nutrients play an active role in the plant metabolic process from cell wall development to respiration, photosynthesis, chlorophyll formation, enzyme activity and nitrogen fixation *etc.* In addition they play an essential role in improving better plant growth, quality and crop yield (Ballabh *et al.,* 2013).

The higher yield and better quality bulb or seed can be produced by treating with fungicides, nutrients and bioagents. As the detailed information on these aspects in onion is lacking, present study was conducted with special reference to leaf twisting in onion.

MATERIALS AND METHODS

A field experiment was carried out at Regional Agricultural Research Station, Vijayapur during *kharif* and *rabi* 2021-2022 to study the effect of chemicals, nutrients and bioagents on yield and management of leaf twisting in onion. The experimental site was located at latitude of 16˚ 77' North, longitude of 75˚ 74' East and an altitude of 516.29 meters above mean sea level in Northern Dry Zone of Karnataka (Zone 3). Two source of onion seeds, seed collected from normal plant (M_1) and seed collected from affected plant showing twisting symptoms (M_2) were treated with different combination of fungicides, nutrients and bioagents along with polymer coat before sowing. The harvested *Kharif* bulbs of 'Bhima Super' variety were treated with micro nutrients, fungicides and bioagents prior to planting. The seeds or bulbs were directly mixed with the micro nutrients, fungicides and bioagents as per the treatment and dosage and were thoroughly mixed for 10 to 15 min to ensure the uniform application of nutrients, fungicides and bioagents.

The experiment was laid out in a by simple factorial randomized block design with three replications during *kharif* (seed to bulb) and randomized complete block design with three replications during *rabi* (bulb to seed). The experiment consisted of nine treatments involving different combination of nutrients, fungicides and bioagents. The land was brought to a fine tilth by once deep ploughing and two times repeated harrowing followed by puddling. The treated onion seeds were sown by line sowing at the congenial field condition. Planting of treated bulbs of onion was done as per the treatment details with one bulb per hill by hand dibbling on one side of the ridge at a spacing of 45 cm × 15 cm.

The flowering parameters, yield attributes, per cent incidence of leaf twisting and economics of bulb production were recorded from the net plots and yield was converted to hectare basis in kilograms. The data collected from the experiment at different growth stages and at harvest were subjected to statistical analysis as described by Sundarrajan *et al.* (1972). The level of significance used for 'F' and 't' tests was P=0.05. Critical Difference (CD) values were calculated at 5 per cent probability level if the F test was found to be significant.

RESULTS AND DISCUSSION

Influence of fungicides, nutrients and bioagents on flowering parameters, yield attributing characters, management of leaf twisting and economics of bulb production

The yield attributes (Table 1) of onion were greatly influenced by chemicals and bioagents. differences with respect to different sources of seeds *i.e.,* seeds from normal plant (M_1) and seeds from plant showing twisting (M_2). Normal seeds (M_1) recorded maximum weight of bulb (88.68 g) as compared to seeds collected from affected plant showing twisting symptoms (M_2) (84.85 g). A significant difference was noticed on weight of bulb due to different seed treatments. Among the seed treatments, T_7 (*T. harzianum* + *P. fluorescens* + *B. subtilis* each @ 5 g kg^{-1} of seeds) recorded maximum weight of bulb (96.68 g) which was on par with T_8 (*T. harzianum* + *P. fluorescens* + *B. subtilis* each @ 5 g kg^{-1} of seeds + carboxin 37.5 % + thiram 37.5 % @ 3 g kg^{-1} seeds) as (95.00 g), T_3 (Captan 70 % + hexaconazole 5 % WP @ 3 g kg^{-1} of seeds + Polymercoat @ 3 ml kg^{-1} seeds) as (91.76 g) and T_2 (Carboxin 37.5 % + thiram 37.5 % @ 3 g kg^{-1} seeds + Polymercoat @ 3 ml kg^{-1} of seeds) as (90.56 g), whereas lowest weight of bulb (72.98 g) was recorded in T_9 (control). Results on interaction effects due to different sources of seeds and seed treatment with polymercoat, chemicals and bioagents were non-significant for weight of bulb.

Similar results were noticed on bulb yield per hectare, M_1 recorded significantly higher bulb yield (21.30 t ha^{-1}) per hectare as compared to M_2 (19.97 t ha^{-1}). Among the treatments, T_7 recorded significantly higher bulb yield per ha^{-1} (23.82 t) and was on par with T_8, T_3, and T_2 as (23.15 t ha^{-1}, 22.28 t ha^{-1} and 21.98 t ha^{-1} respectively while minimum bulb yield 15.22 t ha^{-1}) was found in T_9 (control). Interaction between the different source of seeds and seed treatment with polymercoat, chemicals and bioagents did not differ significantly in terms of bulb yield per hectare. However, numerically higher bulb yield (24.80 t) per hectare was found in M_1T_7 followed by M_1T_8 (23.92 t), M_1T_3 (23.28 t) and lower bulb yield was found in the M_2T_9 (14.37 t) combination due to difference in the quality of seeds which were free from pathogens and enhanced better growth habit and yielding ability helps in growth habit and yielding ability. These results are in conformity with the observations of Pramodkumar and Palakshappa (2010), Prakasam and Sharma (2012), Yadagir and Gupta (2017) and Manthesha *et al*., (2022) in onion.

On similar lines: the flowering parameters and yield attributes of onion (Table 2) were greatly influenced by nutrients, fungicides and bioagents treatments. The observations on number of umbel per plant and diameter

Table 1. Effect of fungicides and bioagents treatment on yield parameters of onion bulb

Treatment	Weight of bulb (g)			Bulb yield (t ha^{-1})		
	M_1	M_2	Mean	M_1	M_2	Mean
T_1 : Captan @ 2 g kg^{-1} of seeds + Polymercoat @ 3 ml kg^{-1} of seeds	90.80	88.00	89.40	21.20	20.43	20.82
T_2 : Carboxin 37.5 % + thiram 37.5 % @ 3 g kg^{-1} seeds + Polymercoat @ 3 ml kg^{-1} of seeds	91.70	89.42	90.56	22.81	21.15	21.98
T_3 : Captan 70 % + hexaconazole 5 % WP @ 3 g kg^{-1} of seeds + Polymercoat @ 3 ml kg^{-1} seeds	93.52	90.00	91.76	23.28	21.27	22.28
T_4 : *Trichoderma harzianum* @ 5 g kg^{-1} of seeds	89.64	86.20	87.92	20.30	19.30	19.80
T_5 : *Pseudomonas fluorescens* @ 5 g kg^{-1} of seeds	84.50	75.50	80.00	19.97	19.20	19.58
T_6 : *Bacillus subtilis* @ 5 g kg^{-1} of seeds	78.80	74.35	76.58	19.30	18.77	19.03
T_7 : T_4 + T_5 + T_6 (*T. harzianum* + *P. fluorescens* + *B. subtilis* each @ 5 g kg^{-1} of seeds)	97.30	96.07	96.68	24.80	22.83	23.82
T_8 : T_7 + carboxin 37.5 % + thiram 37.5 % @3 g kg^{-1} seeds	96.80	93.20	95.00	23.92	22.37	23.15
T_9 : Control	75.05	70.90	72.98	16.07	14.37	15.22
	S.Em ±	**CD @ 5 %**		**S.Em ±**	**CD @ 5 %**	
M	1.27	3.67		0.44	1.27	
T	2.71	7.79		0.94	2.70	
M× T	3.83	NS		1.32	NS	

NOTE: *NS - Non significant

M_1 Seed collected from normal plant

M_2 Seed collected from affected plant showing twisting symptoms

of umbel differed significantly due to different bulb treatments. T_6 (T_5 + foliar spray of hexaconazole 0.05 % at 30 and 60 days after planting) recorded significantly higher number of umbel per plant (2.47) and diameter of umbel (70.40 mm) which was on par with T_4 (bulb treatment with carboxin 37.5 % + thiram 37.5 % @ 2 g kg^{-1} bulb + foliar spray of hexaconazole 0.05 % at 30 and 60 days after planting) with 2.33 and 69.53 mm, and T_8 (T_7 + foliar spray of propiconazole 0.1 % at 45 and 60 days after planting) with 2.27 and 68.13 mm and T_7 (foliar spray of Zn @ 0.05 % + B @ 0.1 % + 19:19:19 @ 3 g L^{-1} at 45 days after planting) with 2.20 and 67.60 mm per plant and umbel diameter respectively. However, lower number of umbel per plant (1.60) and minimum diameter 58.73 mm was noticed in T_9 (control). These treatments indicated probable beneficial impact of boron in pollen tube growth, pollen viability, stigma receptivity and pollination (Pandey and Gupta, 2012) and biosynthesis of endogenous hormones responsible for better development of reproductive organs (Battal, 2004 and Hansch and Mendel, 2009). Thangasamy *et al*., (2010) and Kumar *et al*., (2018) also supported the results which revealed that B deficiency affects the reproductive yield than biomass yield, even in the absence of any visible symptoms of deficiency. Foliar spray of hexaconazole after 30 and 60 days of planting was found effective in management of pathogens and increase flowering parameters. These findings were similar to Selim *et al*., (2018).

The data on number of seeds per umbel as influenced by bulb treatments was found to differ significantly. Among Treatments, T_6 recorded significantly more number of seeds per umbel (994.6) which was on par with T_4, T_8 and T_7 as (957.6, 933.6 and 907.3 respectively) when compared to T_9 (control) as (685.6). Similarly the significant difference was recorded on seed yield per hectare. While, T_6 recorded significantly higher seed yield as (504.4 kg) per hectare which was on par with T_4, T_8, T_7 and T_5 as (443.8 kg, 439.7 kg, 438.6 kg and 428.2 kg per hectare respectively), minimum seed yield (312.4 kg) per hectare was found in the T_9 (control). The highest number of seeds per umbel and seed yield per hectare can be attributed to positive effects of these elements in activation of metabolic enzymes for photosynthates, translocation, carbohydrate metabolism, synthesis of

Table 2. Effect of chemicals, nutrients and bioagents treatment on flowering and seed yield parameters

Treatment	No. of umbels/ plant	Diameter of umbel (mm)	No. of seeds/ umbel	Seed yield (kg/ ha	B:C ratio
T_1: Bulb treatment with Zn @ 0.05 % + B @ 0.1 % + *Pseudomonas fluorescens* @ 10 g L^{-1}	1.87	63.17	792.33	365.47	3.21
T_2: Bulb treatment with carboxin 37.5 % + thiram 37.5 % @ 2 g kg^{-1} bulb + soil application of *Trichoderma harzianum* @ 2 kg ha^{-1} + *Pseudomonas fluorescens* @ 2 kg ha^{-1}	1.93	65.33	863.67	392.50	3.39
T_3: Bulb treatment with carbendazim @ 2 g L^{-1}	1.73	62.47	766.33	357.55	3.44
T_4: Bulb treatment with carboxin 37.5 % + thiram 37.5 % @ 2 g kg^{-1} bulb + foliar spray of hexaconazole 0.05 % at 30 and 60 days after planting	2.33	69.53	957.67	443.89	3.06
T_5: N: P: K @ 125: 50: 125 kg ha^{-1} + Mg @ 30 kg ha^{-1} + S @ 45 kg ha^{-1} + B @ 3 kg ha^{-1} + Zn @ 4 kg ha^{-1}	2.13	67.60	875.00	428.28	3.02
T_6: T_5 + foliar spray of hexaconazole 0.05 % at 30 and 60 days after planting	2.47	70.40	994.67	504.49	2.94
T_7: Foliar spray of Zn @ 0.05 % + B @ 0.1 % + 19:19:19 @ 3 g L^{-1} at 45 days after planting	2.20	66.50	907.33	438.68	3.68
T_8: T_7 + foliar spray of propiconazole 0.1 % at 45 and 60 days after planting	2.27	68.13	933.67	439.70	3.57
T_9: Control	1.60	58.73	685.67	312.47	2.35
S.Em ±	0.16	2.11	152.49	26.97	
CD @ 5 %	0.48	6.32	152.49	80.86	

proteins and activation of oxidation process resulting into better vegetative growth and accumulation of higher food materials which finally converted into higher seed yield. Habib (2009), Rafique *et al*., (2011), Yaseen *et al.,* (2013) and Thangasamy *et al*., (2010) also reported similar results for application of mineral nutrients on yield attributing traits.

There were significant differences in per cent incidence of leaf twisting (Table 3) observed during 40 DAP, 80 DAP and at harvest stage as influenced by bulb treatments. Lesser incidence of disease was observed in T_6 as (14.58 %, 17.44 % and 20.30 % at 40 DAP, 80 DAP and at harvest stage respectively) which was on par with T_4 and T_8 (17.73 %, 18.20 % and 21.06 % at 40 DAP, 80 DAP and at harvest stage respectively) and (24.89 %, 19.14 % and 22.00 % at 40 DAP, 80 DAP and at harvest stage respectively). While maximum per cent incidence of disease was observed in T_9 (Control) as (32.13 %, 34.99 % and 37.85 %) at 40, 80 DAP and at harvest. The reduction in disease incidence and severity as compared to control could be due to antifungal property of Zn and vital role of other minerals in development of disease resistance in plants, synthesis of tryptophan, which is a precursor of growth promoting substance (indole acetic acid). Similar results have been reported by Kumar *et al*., (2018) in onion. Spray of hexaconazole after 30 and 60 days of planting was found effective in management of pathogens and increase growth parameters. These findings were similar to Nargund *et al*., (2013), Patil (2013)

Table 3. Effect of chemicals, nutrients and bioagents treatment on per cent incidence of leaf twisting of onion bulbs

Treatment	Leaf twisting (%)		
	40 DAP	80 DAP	At harvest
T_1: Bulb treatment with Zn @ 0.05 % + B @ 0.1 % + *Pseudomonas fluorescens* @ 10 g L^{-1}	20.25	27.75	30.61
T_2: Bulb treatment with carboxin 37.5 % + thiram 37.5 % @ 2 g kg^{-1} bulb + soil application of *Trichoderma harzianum* @ 2 kg ha^{-1} + *Pseudomonas fluorescens* @ 2 kg ha^{-1}	16.28	23.11	25.97
T_3: Bulb treatment with carbendazim @ 2 g L^{-1}	19.04	30.67	33.53
T_4: Bulb treatment with carboxin 37.5 % + thiram 37.5 % @ 2 g kg^{-1} bulb + foliar spray of hexaconazole 0.05 % at 30 and 60 days after planting	17.73	18.20	21.06
T_5: N: P: K @ 125: 50: 125 kg ha^{-1} + Mg @ 30 kg ha^{-1} + S @ 45 kg ha^{-1} + B @ 3 kg ha^{-1} + Zn @ 4 kg ha^{-1}	15.34	21.90	24.76
T_6: T_5 + foliar spray of hexaconazole 0.05 % at 30 and 60 days after planting	14.58	17.44	20.30
T_7: Foliar spray of Zn @ 0.05 % + B @ 0.1 % + 19:19:19 @ 3 g L^{-1} at 45 days after planting	27.81	20.59	23.45
T_8: T_7 + foliar spray of propiconazole 0.1 % at 45 and 60 days after planting	24.89	19.14	22.00
T_9: Control	32.13	34.99	37.85
S. Em.±	1.05	0.84	1.03
CD @ 5 %	3.015	2.53	3.08

Note: DAP – Days after plant

Effect of seed treatment on economics of bulb production

The results pertaining to net returns and B: C ratio were found significantly higher in the normal plant seeds (M_1) as (₹ 2,96,323 ha^{-1} and 3.29) when compared to seeds collected from affected plant (M_2) *i.e.,* (₹ 2,69,723 ha^{-1} and 3.08). The highest B:C ratio (3.68) was recorded from T_7 which in turn was statistically on par with T_8, T_3 and T_2 compared to other treatments (Table 2).

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