Biological Forum – An International Journal 15(9): 623-630(2023)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Bio Efficacy of Fungicides against *Alternaria porri* causing the Purple Blotch Disease of Onion

Chandan M.J.[1], Sadanand K. Mushrif [2*], Devappa, V.[3], Manjunatha Reddy T. B.[4], Meenakshi Sood[5] and Premalatha B.R.[6]

[1]Department of Plant Pathology, College of Horticulture, Bengaluru (Karnataka), India.
[2]Krishi Vigyan Kendra Kolar, College of Horticulture, Kolar Campus (Karnataka), India.
[3]Assoc. Director of Research and Extension, UHS, Bagalkot (Karnataka), India.
[4]Department of Plant Pathology, College of Horticulture, Kolar (Karnataka), India.
[5]Department of Vegetable Science, College of Horticulture, Bengaluru (Karnataka), India.
[6]Department of NRM, College of Horticulture, Bengaluru (Karnataka), India.

(Corresponding author: Sadanand K. Mushrif)*
(Received: 01 July2023; Revised: 26 July 2023; Accepted: 31 August 2023; Published: 15 September 2023)
(Published by Research Trend)

ABSTRACT: Purple blotch disease of onion caused by *Alternaria porri* (Ellis) Cif. is one of the most destructive diseases of onion and thus has become a major constraint in onion cultivation. Among the various management practices, management through fungicide is the best option. The present investigations involving the bio efficacy of various new generation fungicides and efficacy of sequential sprays were undertaken. The bio efficacy studies involved *in vitro* efficacy of ten fungicides at various concentration levels and later field evaluation of promising fungicides against *Alternaria porri*, the causal agent of purple blotch of onion. Among the fungicides, azoxystrobin + tebuconazole was found to be the most effective chemical as it inhibited the growth of the mycelium completely at all levels of concentrations this was followed by the fungicides hexaconazole and difenoconazole. A study on the field evaluation of the fungicides that were found most effective against *A. porri* under *in vitro* conditions was carried out. A significant difference in per cent disease index among the treatments was noticed. The fungicide azoxystrobin + tebuconazole at 0.1 per cent concentration recorded the least disease severity (PDI 28.76) followed by hexaconazole (PDI 34.59) at 0.1 per cent. The treatment involving combi product pyraclostrobin + epoxiconazole at 0.1 per cent was least effective (PDI 41.25). The outcome on the management of purple blotch disease of onion using sequential sprays using the combination of 3 fungicides revealed that treatment involving spray of propiconazole followed by hexaconazole and then mancozeb at 15 days interval) was most effective in controlling the purple blotch of onion with least disease severity (PDI 32.08) and followed by the treatment involving spray of hexaconazole followed by propiconazole and then mancozeb at 15 days interval) with PDI of 36.25 per cent. The findings of this study might be useful in exploring new fungicides and also sequential spray pattern for the management of the purple blotch disease of onion.

Keywords: Onion, *Alternaria porri*, fungicides and sequential spray.

INTRODUCTION

Onion is one of India's most essential and oldest known vegetable crops often regarded as the "Queen of the Kitchen" and "Princess of Vegetables". It is classified into the family *Alliaceae* with chromosome number 2n (2x) = 16. It is known for its medicinal properties since ancient times and is used in medicine, rituals and food in 600 B.C. India is the second largest onion producer next to China in the world scenario. Onion is grown over 1638.58 thousand ha with production and productivity of 26830.27 thousand tones and 16.37 tonnes ha^{-1} respectively (Anon., 2022). About 5 to 6 lakh tonnes of onion are exported from India. The major onion-growing states in India are Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Punjab and Haryana. In Karnataka, onion occupies an area of 230 thousand ha and production is 2660 thousand tonnes with productivity of 11.50 tones ha^{-1} (Anon., 2022). Compared to other countries, India's onion productivity is very low (< 10 tones. ha^{-1}). Onion diseases play a significant role in low productivity including foliar, bulb and root pathogens that reduce not only the yield but also deteriorate the quality (Cramer, 2000). The crop is vulnerable to destructive diseases like Stemphyllium blight, purple blotch, basal rot, downy mildew, Botrytis leaf blight, blast and storage rots and key insect pests like thrips. Of all the foliar diseases, purple blotch caused by *Alternaria porri* is the most destructive disease in most of the onion growing regions of the world.

The name "Purple blotch" to this disease was proposed by Nolla (1927) and he also named the causal organism as *Alternaria alli* that was later changed to *Alternaria porri*. In Karnataka the purple blotch of onion was discovered by Ponnappa (1970) which caused the severe damage to the onion crop especially the local white variety extensively grown in Dharwad region. Verma and Joshi (2002) described the symptoms of the onion purple blotch; at early stages, it is observed as small water-soaked lesions on leaves of about 2-3 mm in diameter. As the disease advances, these lesions enlarge, coalesce, become zonate and turn brown to purple that extends upward and downwards. In humid conditions, the lesions may appear black, covered with fruiting bodies of the fungus. Purple blotch is the most destructive disease in almost all onion growing pockets except in extremely cool production areas worldwide (Chethana *et al.*, 2018). In this view three studies *viz.*, *in vitro* evaluation of fungicides, *in vivo* evaluation of fungicides and efficacy of sequential sprays of different fungicides against purple blotch were conducted in understanding the efficacy of the fungicides against this disease.

MATERIAL AND METHODS

Isolation. Onion leaves exhibiting typical leaf symptoms of purple were collected from COH, Bangalore experimental farm and these leaves were used for the isolation of the pathogen. The isolation was done according to tissue segment methodology of Rangaswami (1958). The pathogen was purified using single spore isolation method (Riker and Riker 1936). The identification was done through colony colour, morphology and spore characters. The pure culture of the pathogen was maintained on PDA slants at 27±1 C.

In vitro* evaluation of fungicides against *Alternaria porri. Ten fungicides (Table 1) were evaluated *in vitro* for their efficacy against *Alternaria porri*, the causal agent of purple blotch disease of onion, The poisoned food technique (Nene and Thapliyal 1993) was employed to study the efficacy of these fungicides on the radial growth of the pathogen at different levels of concentrations *viz*., 10, 25, 50, 100, 250 and 500 ppm of their active ingredient. The experiment was carried out using a Completely Randomized statistical design with 3 replications for each fungicide and for each concentration.

Table 1: List of the fungicides used in the *in vitro* experiment.

Chemical name	Chemical group code	Mode of action	FRAC
Systemic fungicides			
Hexaconazole	Triazoles	Sterol biosynthesis in membranes	3
Difenoconazole	Triazoles	Sterol biosynthesis in membranes	3
Azoxystrobin	Methoxy-acrylates	Quinone outside Inhibitors	11
Contact fungicides			
Mancozeb	Dithio-carbamates and relatives	Multi-site activity	M03
Metiram	Dithio-carbamates and relatives	Multi-site activity	M03
Zineb	Dithio-carbamates and relatives	Multi-site activity	M03
Combi products			
Azoxystrobin+ Tebuconazole			
Metiram + Pyraclostrobin			
Pyraclostrobin +Epoxiconazole			
Zineb+Hexaconzaole			
Source: Frac code list 2022			

The fungus was grown on Potato dextrose agar (PDA) medium for nine days prior to setting up the experiment. The requisite quantity of each fungicide based on the active ingredient was calculated and mixed thoroughly with autoclaved and cooled (40°C) PDA medium in conical flasks to obtain the desired concentration. PDA medium without fungicide served as control. 20 mL of fungicide amended PDA medium was then poured aseptically in Petri plates (90 mm dia.). After solidification of the medium, all the plates were inoculated aseptically with 5 mm culture disc of the test fungus obtained from a nine-day old actively growing pure culture of *A. porri*. The disc was placed on PDA in inverted position in the center of the Petri plate and plates were incubated at 24 ± 2°C. Each treatment was replicated thrice. Radial growth of the fungus was measured when the fungus attained maximum growth in control plates. The per cent inhibition of mycelial growth in treated plates was calculated by applying the formula given by Vincent (1947).

$$I = \frac{C - T}{C} \times 100$$

Where,
I=Per cent inhibition.
C =Radial growth in control.
T =Radial growth in treatment (fungicide).

Field evaluation of fungicides against purple blotch disease of onion. A field experiment was conducted in the farmer's field in Chillahalli village of Hiriyur taluk in Chithradurga district to evaluate the efficacy of fungicides that were found most effective against *A. porri* during *in vitro* studies. Totally five fungicides were evaluated under field conditions. The experiment was laid outin Randomized Block Design (RBD) with four replications. A plot size of 1.0 × 1.0 m was maintained for each plot with the spacing of 10 ×10 cm. The susceptible onion variety Arka Niketan was used for the study. All the required recommended cultivation practices were carried out as per the package of practices of UHS, Bagalkot.

Totally three sprays of each fungicide were given. First spray was administered immediately after the first appearance of the disease and then remaining two sprays were given at an interval of 15 days. The control plot was maintained without receiving any fungicide. Observations on disease incidence and severity were recorded soon after each spraying. The disease severity was assessed on randomly selected ten plants in each field using a 0 to 5 scale (Datar and Mayee 1986) and finally the Per cent disease index (PDI) was calculated using the formula proposed by Wheeler (1969).

Per cent Disease Index (PDI)

$$= \frac{\text{Sum of all numerical ratings} \times 100}{\text{Total number of observations} \times \text{maximum grade}}$$

Efficacy of sequential sprays of different fungicides on purple blotch disease of onion. The field investigations on the efficacy of the sequential sprays of different fungicides against purple blotch disease caused by *A. porri* on onion were conducted at the College of Horticulture, Kolar. The experiment was laid out using randomized block statistical design with 6 treatments and 4 replications. The susceptible onion variety Arka Niketan was planted in well-drained soil at a spacing of 10 cm × 10 cm spacing. A plot size of 1.0 × 1.0 m was maintained for each plot. All the required recommended cultivation practices were carried out as per the package of practices of UHS, Bagalkot.

The study was carried out with 6 treatments of different fungicides and control with 4 replications. Totally, three sprays of each fungicide were given. The first spray was given immediately after the first appearance of the disease and then the remaining two sprays were taken up at an interval of 15 days. The control plot was maintained without receiving any fungicide. Observations on disease incidence and severity were recorded soon after each spraying. The disease severity was recorded 10 days after each spray. The treatments were imposed using hand operated Knapsack sprayer. The details of the spray taken are given below,

Treatment details:

T_1: first spray of propiconazole, second spray of hexaconazole and third spray of mancozeb

T_2: first spray of hexaconazole, second spray of propiconazole and third spray of mancozeb

T_3: first spray of mancozeb, second spray of hexaconazole and third spray of mancozeb

T_4: first spray of mancozeb, second spray of propiconazole and third spray of mancozeb

T_5: all three sprays of mancozeb

T_6: control (without any spray).

The disease severity was assessed on randomly selected ten plants in each field using a 0-5 scale (Datar and Mayee, 1986). Per cent Disease Index was calculated using the formula given by Wheeler (1969) as mentioned above.

Yield. Crop was harvested at maturity stage and yield of the bulbs in each plot was recorded and yield per hectare was computed by using net plot yield data and then converted to tones per hectare and the data were statistically analyzed.

RESULTS AND DISCUSSION

In vitro* evaluation of fungicides against *Alternaria porri. The data collected in the study conducted is presented in Table 2, Fig. 1, Plate 1a, 1b and 1c. The results revealed that there was a significant difference among the fungicides evaluated in inhibition of the mycelial growth at different concentrations. The inhibition increased as the concentration of fungicide was increased from 10 ppm to 500 ppm. Among the fungicides the combi product azoxystrobin + tebuconazole showed complete inhibition (100.00 %) of radial mycelial growth in all levels of concentrations. Though, the fungicide hexaconazole inhibited the mycelial growth completely (100 % inhibition) at 250 and 500 ppm, the inhibition by this fungicide was equally good at all levels of concentrations. A similar trend was noticed with the fungicide difenoconazole. The fungicides azoxystrobin + tebuconazole, pyraclostrobin + epoxiconazole, zineb + hexaconzaole, the combi products and hexaconazole were on par with each other at 500 ppm. The fungicide difenoconazole showed 97.93 per cent inhibition at 500 ppm followed by metiram (89.19 %), mancozeb (71.27 %) and azoxystrobin (68.28 %). The least inhibition (62.81 %) was obtained from zineb at 500 ppm. Thus, from the present *in vitro* studies, it was concluded that the combi product azoxystrobin + tebuconazole was very promising as it could inhibit the growth of the mycelium at all levels of concentrations followed by the fungicide hexaconazole which was effective at 250 and 500 ppm. The least effective fungicide was zineb which was not effective even at 500 ppm. In a similar experiment, Aujla *et al.* (2010) evaluated nine fungicides under *in vitro* conditions against *Alternaria porri* and found that the fungicide difenoconazole and the combi product trifloxystrobin 25 % + tebuconazole 50 % were found most effective. The present studies are in accordance with the earlier work on *in vitro* studies of the fungicides against *Alternaria porri* (Kareem *et al.*, 2012; Yadav *et al.*, 2013; Arunakumara *et al.*, 2016; Savitha and Ajithkumar 2016; Yadav *et al.*, 2017).

Field evaluation of fungicides against purple blotch disease of onion. The data from *in vivo* studies of fungicides (Table 3 and in Fig. 2) revealed the significant variation among different fungicides with respect to their efficacy in managing the purple blotch disease of onion caused by *Alternaria porri*. At 70 days after transplanting (DAT), the combi product azoxystrobin + tebuconazole recorded the least disease severity (PDI 15.67) followed by the fungicide hexaconazole with a PDI of 16.25 which was statistically on par with the former treatment and these treatments were statistically significant over other treatments. The combi product pyraclostrobin + epoxiconazole was found to be the least effective (PDI 23.32). Maximum disease severity (PDI 26.25) was noticed in the control plot. At 85 days after transplanting (DAT), the least disease severity (PDI 20.41) was found in the combi product treatment of azoxystrobin + tebuconazole followed by hexaconazole (PDI 22.25) which were on par with each other and statistically significant in reducing the disease severity over other treatments. This was followed by difenoconazole with and 24.50 per cent. The treatments involving combi products *viz*., zineb + hexaconzaole and pyraclostrobin + epoxiconazole with PDI of 27.71 and 28.50 respectively were found to be statistically on par with each other. The highest severity of the disease was found in control plot with PDI of 42.08. At 100 DAT, the least disease severity (PDI 24.00) was found in the treatment involving the combi product azoxystrobin + tebuconazole and was statistically superior over other treatment. The treatment involving spray of hexaconazole was next best with PDI of 27.25. However, difenoconazole (PDI 29.50) was statistically on par with hexaconazole. The maximum PDI was noticed in untreated control plot with PDI of 54.53. From the mean data, it was observed that the treatment involving the combi product azoxystrobin + tebuconazole was a promising fungicide with a mean PDI of 20.03 followed by the treatment involving hexaconazole (PDI 21.92). Among all the treatments, the treatment involving the combi product pyraclostrobin + epoxiconazole was found to be the least effective with mean PDI of 29.51. Similar outcomes were found from the findings of Ruth and Naik (2016) who conducted field trials of azoxystrobin 11% + tebuconazole 18.3% SC on onion in Andhra Pradesh. The results suggested that the combi product azoxystrobin +tebuconazole @ 750 & 1000 ml/ha was superior recording lowest disease incidence (17.15 & 18.05 respectively) and gave the highest yield @ 1000 ml/ha which was on par with azoxystrobin + tebuconazole @ 750ml/ha with the highest cost-benefit ratio of 1:2.16. The outcomes of the study are in the nature of the results from earlier works by Aujla *et al.* (2010); Arunakumara *et al.* (2016); Savitha and Ajithkumar (2016); Bachkar *et al*. (2018); Dar *et al*. (2020); Mandi *et al.* (2020).

Efficacy of sequential sprays of different fungicides against purple blotch disease of onion. The efficacy of sequential sprays of fungicides with different combinations of three sprays was studied during the *kharif* 2019 for the management of purple blotch disease of onion at College of Horticulture, Kolar. The fungicide combinations were used as mentioned in the material methods.
The spray of fungicides was applied at 15 days interval. The disease severity was recorded 10 days after each spray and it was expressed in Per cent Disease Index (PDI). At 70 days after transplanting (DAT), it was observed that treatment T_1 was significantly superior (PDI 21.58) in controlling the purple blotch disease of onion but was statistically on par with treatment T_2 (PDI 22.66) followed by treatment T_3 (PDI 25.83). At 85 DAT, it was noticed that treatment T_1registered least disease severity (PDI 24.92) and was statistically superior over other treatments followed by treatment T_2 (PDI 28.67). The treatments T_3 and T_4 were found to be statistically on par with each other with PDI of 30.00 and 31.58 per cent respectively. At 100 DAT, it was observed that the treatment T_1 was most effective in controlling the purple blotch disease of onion (PDI 32.08). Treatment T_2 was the next best with PDI of 36.25 per cent which was statistically on par with treatment T_3 (PDI 38.33). However, treatment T_3 was statistically on par with treatment T_4 (PDI 41.08). The maximum disease severity (PDI 66.50) was observed in the control treatment. The data are presented in Table 4 and Figure 3.

From the study, it was concluded that the treatment T_1 (First spray of propiconazole followed by a spray of hexaconazole and then by mancozeb spray) was significant in controlling the purple blotch disease (Plate 12) followed by treatment T_2 (First spray of hexaconazole followed by propiconazole spray and then mancozeb spray). Treatment T_3 (First spray of mancozeb followed by hexaconazole and then mancozeb) was found to be the next best combination. The treatment T_5 involving all three sprays of mancozeb gave the least control of the disease. The maximum yield (13.73 t/ha) was obtained in the treatment T_1 which was statistically on par with the treatment T_2 (13.28 t/ha). The least yield (6.87 t/ha) yield was obtained from the control treatment. The benefit: cost (B:C) ratio significantly increased for all fungicidal treatments. The highest benefit-cost ratio was recorded in treatment T_1 (3.25) in the followed by the treatment T_2 (3.14) while the lowest benefit-cost ratio (1.36) was found in the control treatment. The results obtained in the study were found to be in agreement with Deshmukh *et al.* (2007) who conducted a study on the chemical control of purple blotch disease caused by *A. porri*. The different combination of chemicals was tested in net house conditions and the results revealed that maximum disease control (79.58 %) was recorded in the foliar application of a mixture of hexaconazole (0.05 %) + mancozeb (0.3 %) followed by difenoconazole (0.02 %) + mancozeb (0.3 %) and chlorothalonil (0.2 %) + hexaconazole (0.05 %) resulting in 70.72 and 66.61 per cent reduction in disease intensity. The results obtained in the study were comparable with the works of Bansode *et al.* (2018); Kumar and Rathi (2018); Selim *et al.* (2018).

Table 2: *In vitro* evaluation of fungicides against *Alternaria porri*, the causal agent of purple blotch disease of onion.

Sr. No.	Fungicides	Per cent inhibition of mycelial growth (mm)						Mean percentage inhibition
		Concentrations						
		10 ppm	**25 ppm**	**50 ppm**	**100 ppm**	**250 ppm**	**500 ppm**	
1.	Azoxystrobin + Tebuconazole	100.00 (89.50)	100.00 (89.50)	100.00 (89.50)	100.00 (89.50)	100.00 (89.50)	100.00 (89.50)	100.00
2.	Metiram + Pyraclostrobin	31.11 (33.88)	39.63 (39.01)	50.74 (45.42)	57.78 (49.48)	65.56 (54.07)	80.00 (63.49)	54.14
3.	Pyraclostrobin +Epoxiconazole	29.61 (32.96)	72.17 (58.16)	95.43 (77.68)	97.11 (80.28)	97.94 (81.78)	100 (89.50)	82.04
4.	Zineb + Hexaconazole	23.11 (28.73)	43.44 (41.23)	66.39 (54.57)	71.78 (57.92)	98.50 (83.03)	100.00 (89.50)	67.20
5.	Hexaconazole	86.72 (68.63)	98.07 (82.09)	98.94 (84.37)	99.55 (86.25)	100.00 (89.50)	100.00 (89.50)	97.21
6.	Difenoconazole	77.17 (61.46)	83.83 (66.31)	94.44 (76.38)	95.52 (77.79)	95.83 (78.25)	97.93 (81.74)	90.79
7.	Azoxystrobin	0.00 (0.49)	8.58 (17.02)	11.67 (19.94)	30.70 (33.64)	41.03 (39.83)	68.28 (55.73)	26.71
8.	Mancozeb	0.00 (0.49)	9.63 (18.06)	12.59 (20.76)	32.29 (34.62)	46.45 (42.96)	71.27 (57.59)	28.70
9.	Metiram	0.00 (0.49)	22.74 (28.47)	27.51 (31.63)	73.43 (58.97)	83.05 (65.71)	89.19 (70.86)	49.32
10.	Zineb	0.00 (0.49)	10.86 (19.23)	16.00 (23.58)	41.42 (40.06)	54.47 (47.57)	62.81 (52.43)	30.93
11.	Control	0.00 (0.49)	0.00 (0.49)	0.00 (0.49)	0.00 (0.49)	0.00 (0.49)	0.00 (0.49)	0.00
	SEm±	0.66	0.69	0.73	0.64	0.66	0.78	
	C.D. (P=0.01)	1.94	2.034	2.165	1.88	1.947	2.31	
	CV(%)	3.60	2.68	2.43	1.74	1.61	1.72	

Note: Figures in parenthesis are *arc sine* transformed values

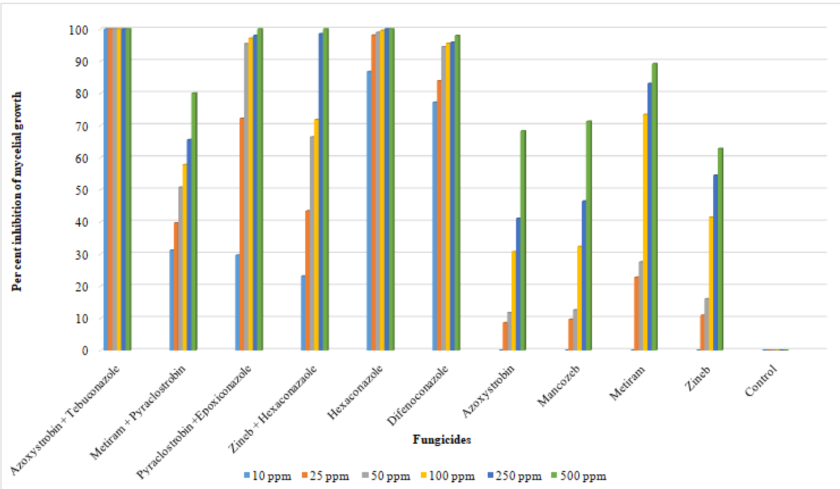
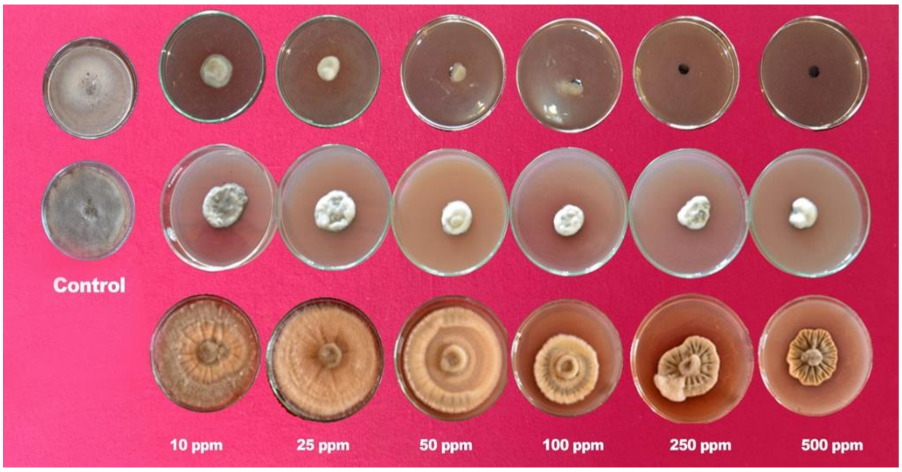


Fig. 1. *In vitro* evaluation of fungicides against *Alternaria porri*, the causal agent of purple blotch disease of onion.



Hexaconazole

Difenoconazole

Azoxystrobin

Plate 1a: *In vitro* evaluation of systemic fungicides against *Alternaria porri*.

Plate 1b: *In vitro* evaluation of contact fungicides against *Alternaria porri*.

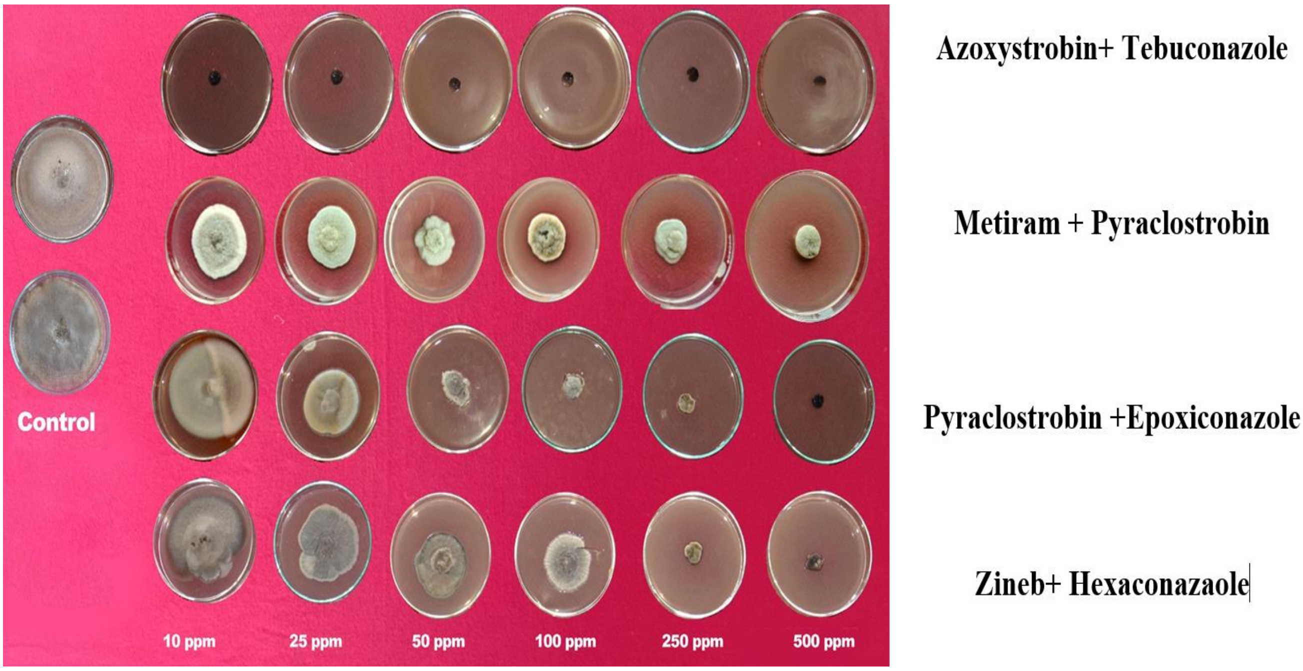


Plate 1c: *In vitro* evaluation of combi fungicides against *Alternaria porri*.

Table 3: Field evaluation of promising fungicides against purple blotch of onion caused by *Alternaria porri*.

Sr. No.	Treatments	Trade name	Per cent Disease Index (PDI)			Mean
			70 DAT	85 DAT	100 DAT	
1.	Azoxystrobin + Tebuconazole	Custodia	15.67 (23.30)	20.41 (26.86)	24.00 (29.31)	20.03
2.	Difenoconazole	Score	21.16 (27.38)	24.50 (29.66)	29.50 (32.89)	25.05
3.	Hexaconazole	Contaf	16.25 (23.76)	22.25 (28.14)	27.25 (31.46)	21.92
4.	Pyraclostrobin + Epoxiconazole	Opera	23.32 (28.87)	28.50 (32.26)	36.71 (37.29)	29.51
5.	Zineb + Hexaconazaole	Avtar	21.72 (27.77)	27.71 (31.75)	31.50 (34.13)	26.98
6.	Control	--	26.25 (30.81)	42.08 (40.44)	54.43 (47.54)	40.92
SEm±			0.67	0.67	0.83	
CD (P=0.05)			2.01	2.01	2.49	
CV(%)			6.48	4.87	4.57	

Note: Figures in parenthesis are *arc sine* transformed values; *DAT: Days after transplanting.

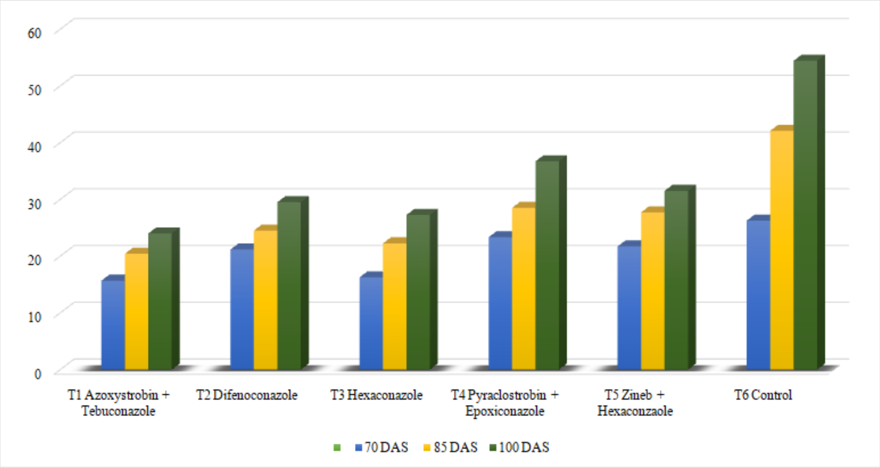


Fig. 2. Field evaluation of fungicides against purple blotch disease of onion caused by *Alternaria porri*.

Table 4: Efficacy of sequential sprays of different fungicides against purple blotch disease of onion caused by *Alternaria porri*.

Sr. No.	Treatments	Percent disease index (PDI)			Yield (tones/ ha)
		70 DAT	85 DAT	100 DAT	
1.	T_1 (Spray of propiconazole@1ml/liter of water followed hexaconazole@ 1 ml /liter of water and then mancozeb@ 2.5 gm/liter of water at 15 days intervals.)	21.58 (27.67)	24.92 (29.94)	32.08 (34.50)	17.73
2.	T_2 (Spray of hexaconazole@1ml/liter of water followed propiconazole @ 1 ml /liter of water and then mancozeb@ 2.5 gm/liter of water at 15 days intervals.)	22.66 (28.42)	28.67 (32.37)	36.25 (37.01)	17.28
3.	T_3 (Spray of mancozeb@ 2.5 gm/liter of water followed hexaconazole@ 1 ml /liter of water and then mancozeb@ 2.5 gm/liter of water at 15days intervals.)	25.83 (30.54)	30.00 (33.20)	38.33 (38.25)	16.69
4.	T_4 (Spray of mancozeb@ 2.5 gm/liter of water followed by propiconazole@ 1 ml /liter of water and then mancozeb@ 2.5 gm/liter of water at 15 days intervals.)	26.75 (31.14)	31.58 (34.19)	41.08 (39.86)	14.62
5.	T_5 (Three sprays of mancozeb75WP (0.25%) @ 2.5 gm/liter of water at 15 days interval)	26.67 (31.09)	35.83 (36.76)	43.75 (41.40)	13.00
6.	T_6 control	32.16 (34.54)	44.67 (41.94)	66.50 (54.64)	9.44
	SEm±	0.75	0.84	0.98	0.37
	CD (P=0.05)	2.26	2.25	2.95	1.13
	CV(%)	5.79	5.13	4.55	5.02

Note: Figures in parenthesis are *arc sine* transformed values; *DAT: Days after transplanting

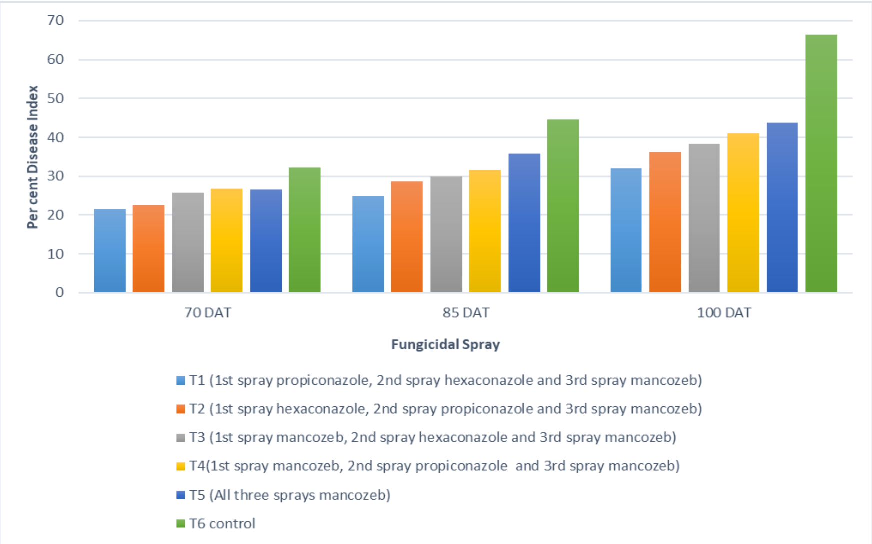


Fig. 3. Efficacy of sequential sprays of different fungicides against purple blotch disease of onion caused by *Alternaria porri*.

CONCLUSIONS

The purple blotch caused by *Alternaria porri* (Ellis) Cif. is the most destructive disease that causes severe damage to both bulb and seed production of the onion. Currently, the best management practice available is use of fungicides. Our studies involving use of fungicides and sequential sprays of fungicides revealed that combi product fungicide azoxystrobin + tebuconazole and other fungicide hexaconazole were found to be highly effective both under *in vitro* and *in vivo* conditions. The sequential spray comprising of the fungicides propiconazole followed by hexaconazole and then by mancozeb was not only effective in reducing disease severity but also contributed to high yield of onion bulbs.

FUTURE SCOPE

As the farmers rely mainly on the fungicides to manage the purple blotch disease, the present study provides immense scope for the use of the fungicides with less residue and pre harvest interval (PHI). Management of the diseases using fungicides in sequence is another area that can be explored for minimizing the repetition of fungicides and to find out optimum regime in reduction of the purple blotch disease of onion.

Acknowledgement. The authors are grateful to the University of Horticultural Sciences, Bagalkot, Karnataka for providing financial assistance to carry out this research.

REFERENCES

Anonymous (2022). *Agricultural statistics at a glance*. (2021). Ministry of Agriculture and Farmers Welfare, Directorate of Economics and Statistics, 431 p

Arunakumara, K., Satyanarayana, C. and Anand Kumar, V. (2016). Varietal reaction of onion cultivars against *Alternaria porri* causing purple blotch and its management. *The Bioscan*, *11*(4), 2925-2929.

Aujla, I. S., Amrate, P. K., Kumar, P. and Thind, T. S. (2010). Efficacy of some new fungicides in controlling purple blotch of onion under Punjab conditions. *Pl. Dis. Res.*, *28*, 171-173.

Bachkar, C. B., Bhalekar, M. N. and Pawar, S. A. (2018). Control of *Alternaria porri* causing purple blotch of onion during *kharif* season. *Journal of Allium Research*, *1*(1), 57-59.

Bansode, G. M., More, S. A., Deshmukh, M. R. and Supe, V. S. (2018). Efficacy of sequential sprays of different fungicides against early blight *Alternaria solani* (Ellis and Martin) in potato (*Solanum tubrosum* L). *International Journal of Pharmacy and Biological Sciences*, *8*(1), 11-15.

Chethana, B. S., Girija, G., Rao A. S. and Bellishree, K. (2018). Morphological and molecular characterization of *Alternaria* isolates causing purple blotch disease of onion. *International Journal of Current Microbiology and Applied Sciences*, *7*(4), 3478-3493.

Cramer, C. S. (2000). Breeding and genetics of *Fusarium* basal rot resistance in onion. *Euphytica, 115*, 159-166.

Dar, A. A., Sharma, S., Mahajan, R., Mushtaq, M., Salathia, A., Ahamad, S. and Sharma, J. P. (2020). Overview of purple blotch disease and understanding its management through chemical, biological and genetic approaches. *Journal of Integrated Agriculture*, *19*(12), 3013-3024.

Datar, V. V. and Mayee, C. D. (1986). *Phytopathometry*, Marathwada Agricultural University, Parabhani, 95-102.

Deshmukh, V. S., Dhruj, I. U. and Chavan, R. V. (2007). Efficacy of fungicides *in vitro* against *Alternari porri* (Ellisi) Cif. causing purple blotch of onion. *Journal of Plant Disease Sciences*, *3*(1), 127-128.

Kareem, M. A., Murthy, K. V. M., Waseem, M. A., Pasha, M. A. and Nadaf, H. A. (2012). Effect of fungicides on spore germination and growth of *Alternaria porri*. *BIOINFOLET-A Quarterly Journal of Life Sciences*, *9*(3), 292-294.

Kumar, R. A. and Rathi, A. S. (2018). Management of *Alternaria* blight in Indian mustard through fungicides under field conditions. *International Journal of Chemical Studies*, *6*(2), 2042-2044.

Mandi, N., Nayak, B. S., Sahoo, B. B., Prasad, G. and Khanda, C. (2020). Efficacy of Novel Fungicides against Purple Blotch in Onion (*Allium cepa* L.) in the Western Undulating Zone of Odisha, India. *International Journal of Current Microbiology and Applied Sciences*, *9*(4), 1970-1976.

Nene, Y. and Thapliyal, P. N. (1993). *Fungicides in Plant Disease Control*. Oxford and IBH. Publication Company. New Delhi. 507 p.

Nolla, J. A. B. (1927). A new *Alternaria* disease of onions (*Allium cepa* L.). *Phytopathology*, *17*, 115-132.

Ponnappa, K. M. (1970). Leaf blight of onion *(Allium cepa* L.) caused by *Alternaria cepulae* Ponnappa and Deshpande NOVI. Comparative Morphology and Physiology. *Nova Hedwigia*, *47*, 547-564. *M. Sc (Agri.) Thesis* University of Agricultural Sciences, Bangalore.

Rangaswami G. (1958). An agar block technique for isolating soil microorganisms with special reference to the Pythiaceous fungi. *Science and Culture*,*24*, 85.

Riker, A. J. and Riker, R. S. (1936). *Introduction to research on plant diseases*. John Swift Co., St. Louis, Chicago, p. 117.

Ruth, C. and Naik, M. T. (2016). Bio efficacy of azoxystrobin 11% + tebuconazole 18.3% SC on onion in Andhra Pradesh. *Journal of Plant Development. Sciences, 8*(8), 401-404.

Savitha, A. S. and Ajithkumar, K. (2016). Evaluation of newer combination of azoxystrobin and tebuconazole for the management of purple blotch of onion. *Madras Agriculture. Journal*, *103*(7-9), 233-236.

Selim, A., Quddus, R. A. F. M., Kamrozzaman, M. M., Rumpa, S. and Uddin, M. M. (2018). Integrated approaches for controlling purple blotch of onion for true seed production in Faridpur of Bangladesh. *Fundamentals of Applied Agriculture*, *3*(1), 390-397.

Verma, L. R. and Joshi, V. K. (2002). Diseases of Horticultural Crops: Vegetables, Ornamentals and Mushrooms. *Indus Publishing Company*, New Delhi, 353-356.

Vincent, J. M. (1947). Distortion of fungal hyphae in the presence of certain inhibitors, *Nature*., *159*, 850.

Wheeler, B. E. J. (1969). *An Introduction to Plant Diseases*. John Wiley and Sons Ltd., London, UK, pp 301-307.

Yadav, P. M., Rakholiya, K. B. Pawar, D. M. (2013). Evaluation of different systemic fungicides against *Alternaria* from *in vitro. Trends in Biosciences*, *6*(4), 382-383.

Yadav, R. K., Singh, A., Jain, S. and Dhatt, A. S. (2017). Management of purple blotch complex of onion in India Punjab. *International Journal of Applied Sciences and Biotechnology*, *5*(4), 454-465.

How to cite this article: Chandan M.J., Mushrif S. K., Devappa, V., Manjunatha Reddy T.B., Meenakshi Sood and Premalatha B.R. (2023). Bio Efficacy of Fungicides against *Alternaria porri* causing the Purple Blotch Disease of Onion. *Biological Forum – An International Journal, 15*(9): 623-630.