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RESEARCH ARTICLE :

Fungicidal management of okra powdery mildew, caused by *Erysiphe cichoracearum* DC.

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SUMMARY : Powdery mildew caused by *Erysiphe cichoracearum* DC. of okra (*Abelmoschus esculentus* L.) has been found to affect okra crop severely causing yield losses ranging in between 17 to 86.6% (Sridhar and Sinha, 1989). Present field study was planned and conducted to manage okra powdery mildew disease with newer chemical molecules, at the Department of Plant Pathology, College of Agriculture, Latur, during *Summer*-2016. All the eight fungicides and water spray evaluated under field condition were found effective against *Erysiphe cichoracearum* over untreated control. However, among the fungicides hexaconazole (0.1%) recorded the least mean disease incidence (16.11%) and severity (8.25%) with the corresponding high yield 6.88(t/ha) and thereby highest per cent disease control (78.02%). This was followed by propiconazole (0.1%) and difenconazole (0.05%). Hexaconazole was the most economical treatment, which recorded the highest cost: benefit ratio (1:28.74).

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KEY WORDS :
Erysiphe cichoracearum, Powdery mildew, Okra, Fungicide management, Incidence, Severity, Fruit yield

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BACKGROUND AND OBJECTIVES

Okra/ ladies finger/ bhindi (*Hibiscus esculentus* L.) is one of the most popularly cultivated fruit vegetable crops, which belong to the family *Malvaceae*. The crop was supposed to be originated from tropical Africa and cultivated in most of the countries including India and Pakistan (Anonymous, 2013 and Akanbi *et al*., 2010).

In India, area, production and productivity of okra were 530.79 thousand hectares, 6350.26 thousand tones and 12.00 mt/ha, respectively (Anonymous, 2013). In Maharashtra, the okra crop is grown throughout the year, providing continuous and good source of income to the farmers. The crop is succumb to many fungal, bacterial, viral and nematode diseases, resulting in accountable quantitative as well as qualitative losses. Among the fungal diseases, powdery mildew caused by *Erysiphe cichoracearum* DC.is of common occurrence round the year, but most severe during *Summer* season.The disease initiates as white minute patches on upper surface of the lower older leaves and then gradually spreads to younger ones. Simultaneously, grayish powdery coating is visible on severely affected leaves, which

finally get necrotized, leading to foliage withering, drying, defoliation and ultimately fruit yield losses of about 17 to 86.6 per cent (Sridhar and Sinha, 1989).

Therefore, present field study was planned and conducted to manage okra powdery mildew disease with newer chemical molecules, at the Department of Plant Pathology, College of Agriculture, Latur, during Summer-2016.

RESOURCES AND METHODS

The field experiment was laid out in Randomized Block Design (RBD) with nine fungicidal spray treatments, replicated thrice. Okra cv. PARBHANI OK susceptible to powdery mildew was sown (30 cm x 20 cm) on 23.01.2016 and all recommended package of practices were applied. Ten days after sowing, thinning and gap fillings were completed to maintain uniform plant population per unit area.

Three sprayings of the test fungicides were undertaken at ten days interval,starting first spraying immediately after first appearance of powdery mildew disease symptomsand subsequent second and third sprayings at an interval of 10 days.

Observations on disease incidence were recorded at first appearance of the disease, subsequent three observations were recorded one day before each spraying and per cent incidence was calculated by applying following formula :

$$\text{Per cent disease incidence} = \frac{\text{No. of plants affected}}{\text{Total number of plants observed}}$$

Observations on powdery mildew disease severity were recorded on five randomly selected plants per treatment per replication. Initial observation was recorded at first appearance of the disease; subsequent three observations were recorded as that of incidence. The powdery mildew disease severity on foliage was graded by applying 0-5 disease rating scale (McKineey, 1923), as detailed below:

Score	Description	Disease rating
0	No symptoms	Immune
1	1-10 per cent leaf area affected	Resistant
2	11-25 per cent leaf area affected	Moderately resistant
3	26-50 per cent leaf area affected	Moderately susceptible
4	51-75 per cent leaf area affected	Susceptible
5	Above 76 per cent leaf area affected	Highly susceptible

Based on numerical ratings observed, per cent disease severity was calculated by applying the formula given below:

$$\text{PDS} = \frac{\text{Summation of numerical ratings}}{\text{Number of leaves observed x Maximum rating}} \times 100$$

Further, per cent disease control (PDC) was worked out by applying following formula:

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

Okra fruits were harvested in 3-4 pickings, finally cumulative fruit yield per treatment replicated was computed and final fruit yield data was presented on hectare basis (tons / ha). Also, incremental cost: benefit ratio (ICBR) was worked out, to find most economical treatment.

OBSERVATIONS AND ANALYSIS

Results obtained on the effect of test fungicidal spray treatments on okra powdery mildew incidence and severity, per cent disease control, fruit yield and ICBR are being interpreted herein under following sub-heads.

Powdery mildew incidence:

The results (Table 1) revealed that the test fungicides were found effective against powdery mildew of okra.

The powdery mildew incidence from its first appearance was found to increased steadily upto first spraying, which thereafter decreased slowly. The disease incidence after second and third sprayings was ranged from 18.89- 33.89 and 13.33- 22.22 per cent, respectively, as against highest incidence (30.00- 68.89%) in untreated control.

After third spraying, powdery mildew incidence was reduced drastically and it was significantly least with Propiconazole and Hexaconazole (each 13.33%), compared to Mancozeb and Water spray (each 22.22%) and untreated control (68.89%).Rest of the fungicides, were on par to each other.

Powdery mildew severity :

Similar trend as that of incidence was observed in respect of powdery mildew severity (Table 2). The diseasese verity among the spray treatment after first, second and third sprayings ranged from 9.50-22.33, 8.17-21.33 and 6.67-17.33 per cent, respectively, as against

28.00-59.33 per cent in untreated control.After second spraying, significantly least disease severity was recorded with Hexaconazole (8.17%) which was at par with Propiconazole (8.67%),Difeneconazole (9.33%), Dinocap(10.17%) and Benomyl (11.33%).These were followed by Carbendazim(12.09%), Sulphur (12.33%), Mancozeb (15.33%) and Water spray (21.33%), as against 39.33 per cent in untreated control.

After third spraying, significantly least powdery mildew severity was with Hexaconazole (6.67%), which was on par with Propiconazole (7.33%), Difeneconazole (8.00%) and Dinocap (8.67%). These were followed by Benomyl (10.08%), Sulphur (11.17%), Carbendazim (10.70%), Mancozeb (10.67%) and Water spray (17.33), as against59.33 per cent in untreated control.

Average powdery mildew severity in all the treatments ranged from 8.25 to 33.99 per cent. However, it was least with Hexaconazole (8.25%), which was on par with Propiconazole (8.42%), Difenconazole (8.67%), Dinocap (9.54%) Benomyl(9.77%), Carbendazim (10.38%), Sulphur (11.21%), Mancozeb (13.42%) and Water spray(17.29%), as against 33.99 per cent in untreated control.

Table 1: Effect of fungicides on powdery mildew incidence in okra

Treatments	Conc.	PDIAt 1st Appr.	% Disease incidence* After spraying			Av. PDI
			First	Second	Third	
T_1 – Wettable sulphur 80% WP	0.3%	10.56 (18.96)	28.89 (32.51)	26.11(30.73)	15.56 (23.23)	20.28 (26.76)
T_2 - Hexaconazole 5% EC	0.1%	11.11 (19.47)	20.00 (26.57)	18.89 (25.76)	14.44 (22.34)	16.11 (23.66)
T_3 - Difenconazole 25% EC	0.05%	10.56 (18.96)	25.56 (30.37)	23.33 (28.88)	15.56 (23.23)	18.75 (25.66)
T_4 - Propiconazole 25% EC	0.1%	11.67 (19.97)	22.22 (28.13)	21.11 (27.35)	13.33 (21.42)	17.08 (24.41)
T_5 - Mancozeb 75% EC	0.25%	8.89 (17.35)	37.22 (37.60)	30.00 (33.21)	22.22 (28.13)	24.58 (29.72)
T_6 - Dinocap 48% EC	0.15%	12.22 (20.46)	26.67 (31.09)	24.44 (29.63)	14.44 (22.34)	19.44 (26.17)
T_7 - Carbendazim 50% WP	0.1%	10.56 (18.96)	30.56 (33.56)	27.22 (31.45)	16.67 (24.09)	21.25 (27.45)
T_8 - Benomyl 50% WP	0.1%	11.11 (19.47)	27.78 (31.81)	26.11 (30.73)	13.33 (21.42)	19.58 26.27
T_9 - Water spray	-	8.89 (17.35)	41.11 (39.88)	33.89 (35.60)	22.22 (28.13)	26.53 (31.00)
T_{10}- Control (untreated)	-	10.56 (18.96)	30.00 (33.21)	42.22 (40.53)	68.89 (56.10)	37.91 (38.00)
S.E.±		0.78	1.38	1.24	0.65	-
C.D. (P=0.05)		2.30	4.10	3.68	1.92	-

* Mean of three replications; PDI –Per cent disease incidence Figures in parenthesis are arcsine transformed values

Table 2 : Effect of fungicides on powdery mildew severity in okra

Treatments	Conc.	PDS at 1st Appr.	% Disease severity* After spraying			Av. PDS
			First	Second	Third	
T_1 – Wettable Sulphur 80% WP	0.3%	9.33 (17.79)	12.00 (20.27)	12.33 (20.56)	11.17 (19.52)	11.21 (19.56)
T_2 - Hexaconazole 5% EC	0.1%	8.67 (17.12)	9.50 (17.95)	8.17 (16.61)	6.67 (14.96)	8.25 (16.69)
T_3 - Difenconazole 25% EC	0.05%	7.33 (15.71)	10.00 (18.43)	9.33 (17.79)	8.00 (16.43)	8.67 (17.12)
T_4 - Propiconazole 25% EC	0.1%	8.00 (16.43)	9.67 (18.11)	8.67 (17.12)	7.33 (15.71)	8.42 (16.86)
T_5 - Mancozeb 75% EC	0.25%	8.17 (16.61)	17.00 (24.35)	15.33 (23.05)	10.67 (19.06)	12.79 (20.95)
T_6 - Dinocap 48% EC	0.15%	8.67 (17.12)	10.67 (19.06)	10.17 (18.59)	8.67 (17.12)	9.54 (17.99)
T_7 - Carbendazim 50% WP	0.1%	5.33 (13.35)	13.42 (21.48)	12.09 (20.34)	10.70 (19.09)	10.38 (18.79)
T_8 - Benomyl 50% WP	0.1%	6.33 (14.58)	11.33 (19.67)	11.33 (19.67)	10.08 (18.51)	9.77 (18.21)
T_9 - Water spray	-	9.33 (17.79)	22.33 (28.19)	21.33 (27.50)	17.33 (24.60)	17.58 (24.78)
T_{10}- Control (untreated)	-	10.67 (19.06)	28.00 (31.94)	39.33 (38.34)	59.33 (50.38)	33.99 (35.66)
S.E.±		1.50	1.08	2.25	1.03	-
C.D (P=0.05)		4.47	3.22	6.70	3.08	-

* Mean of three replications; PDS– Per cent disease severity Figures in parenthesis are arcsine transformed values

Reduction in powdery mildew severity:

Results (Table 3) indicated that all the treatments significantly reduced powdery mildew disease severity, over untreated control. Per cent reduction in disease severity after first, second and third spray treatments were ranged from 20.25 - 66.07%, 45.76 - 79.24% and 70.79 - 88.76%, respectively and per cent reduction in disease severity was increased with subsequent sprayings.

Among the fungicides tested, Hexaconazole resulted with highest disease severity reduction of 66.07, 79.24 and 88.76 per cent, respectively after first, second and third spraying, followed by Propiconazole (65.46, 77.97 and 87.64%, respectively) and Difenconazole (64.28, 76.27 and 86.52%, respectively), after first, second and third sprayings. Rest of the fungicides tested also reduced the disease severity.

Average disease reduction over untreated control was ranged from 45.60 - 78.02%. However, it was highest with Hexaconazole (78.02%), followed by Propiconazole (77.02%), Difenconazole (75.69), Dinocap (73.80%), Benomyl (71.24%), Carbendazim (67.76), Sulphur (68.98%), Mancozeb (63.51 %) and Water spray (45.6%).

Fruit yield and ICBR :

The results (Table 4) revealed that all of the fungicidal spray treatments resulted with better fruit yield (range: 4.20 - 6.88 t/ha.), considerably increase in fruit yield (range: 43.28 - 65.38 %), over untreated control and were also economical with higher ICBR (range: 12.62 – 27.91). In respect of fruit yield, fungicides *viz*.,

Table 3 : Efficacy of fungicides in reduction of okra powdery mildew severity

Treatments	Conc.	PDC after spraying			Av. PDC
		First	Second	Third	
T_1 – Wettable Sulphur 80% WP	0.3%	57.14	68.64	81.18	68.98
T_2 - Hexaconazole 5% EC	0.1%	66.07	79.24	88.76	78.02
T_3 - Difenconazole 25% EC	0.05%	64.28	76.27	86.52	75.69
T_4 - Propiconazole 25% EC	0.1%	65.46	77.97	87.64	77.02
T_5 - Mancozeb 75% EC	0.25%	39.28	69.26	82.01	63.51
T_6 - Dinocap 48% EC	0.15%	61.89	74.14	85.39	73.80
T_7 - Carbendazim 50% WP	0.1%	52.07	69.26	81.96	67.76
T_8 - Benomyl 50% WP	0.1%	59.53	71.19	83.01	71.24
T_9 - Water spray	-	20.25	45.76	70.79	45.6
T_{10} - Control (untreated)	-	0	0	0	0

PDC- Per cent disease control

Table 4 : Effect of fungicides on powdery mildew meanincidence, severity and fruit yield of okra

Treatments	Conc.	PDC	Fruit yield* (tons / ha)	% Increase over control	ICBR
T_1 – Wettable Sulphur 80% WP	0.3%	68.98	5.47	56.45	19.42
T_2 - Hexaconazole 5% EC	0.1%	78.02	6.88	65.38	27.91
T_3 - Difenconazole 25% EC	0.05%	75.69	6.35	62.50	19.02
T_4 - Propiconazole 25% EC	0.1%	77.02	6.43	62.96	20.85
T_5 - Mancozeb 75% EC	0.25%	63.51	4.76	50.00	12.82
T_6 - Dinocap 48% EC	0.15%	73.80	5.93	59.82	13.90
T_7 - Carbendazim 50% WP	0.1%	67.76	5.53	56.94	20.35
T_8 - Benomyl 50% WP	0.1%	71.24	5.91	59.70	17.63
T_9 - Water spray		45.6	4.20	43.28	12.62
T_{10} - Control (untreated)	-	-	2.38	-	-
S.E.±	-	-	0.16	-	-
C.D. (P=0.05)	-	-	0.48	-	-

* Mean of three replications

Hexaconazole (6.88 t/ha), Propiconazole (6.43 t/ha) and Difenconazole (6.35 t/ha) were on par and significantly superior over rest of the treatments. These were followed by Dinocap (5.93 t/ha), which was on par with Benomyl (5.91 t/ha), Carbendanzim (5.53 t/ha) and Wettable sulphur (5.47 t/ha), as against 2.38 t/ha in untreated control.

All the treatments significantly increased the fruit yield over untreated control. Highest increase in fruit yield was resulted with Hexaconazole (65.38%), followed by Propiconazole (62.96%), Difenconazole (62.50%), Dinocap (59.82%), Benomyl (59.70%), Carbendazim (56.94%), Wettable Sulphur (56.45%), Mancozeb (50.00%) and water spray (43.28%).

Based on ICBR, the most economical fungicide found was Hexaconazole (27.91), followed by Propiconazole (20.85), Carbendazim (20.35), Wettable sulphur (19.42) and Difenconazole (19.02). Rests of the fungicide were also found economical for management of the okra powdery mildew.

Thus, among all the treatments, Hexaconazole, followed by Propiconazole, Carbendazim, Sulphur, and Difenconazole were found most effective and economical to manage okra powdery mildew disease.

Result of the present study on fungicidal management of okra powdery mildew are in consonance with the report of several earlier workers (Khunti *et al*., 2002; Banniyal and Rana, 2003; Singh 2007; Surwase *et al*. 2009 and Kachhot *et al.*, 2011). Effectiveness of Propiconazole against green gram powdery mildew was reported by Nargund *et al*. (2012) and Hiramath *et al*. (2013) in pea crop. Effectiveness of Difeneconazole, Dinocap, Benomyl and Carbendazim was reported earlier against many powdery mildews by Choudhary (1975) and Singh *et al*. (1998) in okra; Banniyal and Rana (2003) and Khodke and Kakde (2004) in mustard and Rahman and Bhattiprolu (2005) in okra.

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