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Management of powdery mildew (*Erysiphe cichoracearum*) of okra by using low profile chemicals

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Abstract
Okra (*Abelmoschus esculentus* (L.) Moench is one of the most popular vegetable belonging to the family Malvaceae and has its special place in Indian food habit. The field experiment was carried out to study the efficacy of different low profile chemicals against powdery mildew (*Erysiphe cichoracearum*) of okra in Randomized Block Design (RBD) with nine treatments (Seven low profile chemicals, one standard check and one control) and three replications were adopted.
The disease management studies showed that all the low profile chemicals evaluated in field condition against powdery mildew significantly reduced disease intensity over water sprayed control. Chlorine dioxide @ 0.2 per cent gave significant reduction in powdery mildew disease incidence on okra with PDI in the range of (6.90 to 21.27%) and maximum disease control (PDC) about 59.09 to 66.43 per cent followed by hexaconazole (0.1%) and *Ampelomyces quisqualis* (0.3%). Chlorine dioxide (0.2%) gave significantly highest yield (22.65 t/ha) in comparison to check (14.39 t/ha). Minimum infection rate 'r' of 0.29 and lowest AUDPC value (410.7) were observed in chlorine dioxide (0.2%).

Keywords: Okra, powdery mildew, low profile chemicals, per cent disease intensity and yield

Introduction
Okra is among the most important vegetable crop due to its nutritional, industrial and medicinal values. It is rich in vitamin A and C, calcium, potassium. phosphorous and iron. Mainly fruits and stems are used for cleaning the sugarcane juice while preparing jaggery from it (Chavan *et al*. 2007) [1]. This crop is affected by many fungal as well as viral diseases such as Damping off, Leaf spot, Leaf blight, Powdery mildew, Yellow vein mosaic, Bhendi enation mosaic, Enation leaf curl (Diwakar *et al*., 1986) [4]. The crops have also suffered from root knot nematode disease. Among all the fungal diseases, powdery mildew is one of the most important diseases. It is generally seen in July to September every year and first appears with onset of monsoon (Choudhary, 1975) [2]. For the control of powdery mildew disease several systemic and non-systemic fungicides have reported and are available in market. However the phyto-toxicity of such fungicides coupled with prolonged persistence in tissues and huge residue accumulation in soil have resulted in dreadful consequences with respect to environment and human health. In such cases, low profile chemicals are important in disease management. Among the most promising low profile chemicals like Chlorine dioxide, Hydrogen peroxide, Ozonated water, Nano silver, Potassium salt of phosphoric acid, *Ampelomyces quisqualis* and bioactive oligosaccharides CHI (Chitosan) which have attracted attention because of their unique biological properties, including inhibitory effect on the growth ofvarious pathogenic fungi and its ability to be a potent elicitor of plant defence reactions. The present study was undertaken to study the effect of low profile chemicals on powdery mildew of okra.

Materials and Methods
The present study was conducted in *kharif*, 2018 at Div-16 of National Agricultural Research Project, Ganeshkhind, Pune- 67 (MS). The field experiment was carried out to study the efficacy of different low profile chemicals against powdery mildew of okra (*Erysiphe cichoracearum*). Randomized Block Design (RBD) with nine treatments (Seven low profile chemicals, one standard check and one control) and three replications were adopted. Powdery

mildew susceptible okra variety Pusa Sawani was obtained from Seed Processing Unit, Mahatma Phule Krishi Vidyapeeth, Rahuri (MS). Total seven low profile chemicals, one standard check and one untreated control water spray were undertaken during application. The low profile chemicals such as Hexaconazole @ 0.1%, Chitosan @ 0.2%**,** *Ampelomyces quisqualis* @ 0.3%, Potassium salt of phosphoric acid @ 0.5%**,** Chlorine dioxide @ 0.2%, Hydrogen peroxide @ 0.2%, Ozonated water @ 0.2%, Nano silver @ 0.2%, water spray were used for experiment. Spray suspension solution made separately by adding desired quantity in specified amount of water resulting into concentration normally recommended for spraying. Symptoms of the disease on the host plants were observed and studied directly from the experimental plot. The symptoms of the disease were periodically observed and described.

For recording observations, five plants from each plot were randomly selected and tagged before the incidence of the disease. The total numbers of leaves were counted and each leaf was examined individually. The disease was graded on the basis of intensity of powdery mildew on the leaves given by Mayee and Datar (1986) [6]. The per cent disease intensity (PDI) and per cent disease control (PDC) calculated on the basis of observations recorded and method adopted by Mayee and Datar (1986) [6]. Based on mean PDI, the genotypes were rated as: Highly resistant (0 PDI), Resistant (1 to 10 PDI), Moderately resistant (11 to 25 PDI), Moderately susceptible (26 to 50 PDI),

Susceptible (51 to 75 PDI) and Highly susceptible (76 to 100 PDI).

$$\text{PDI} = \frac{\text{Sum of observed numerical ratings}}{\text{Number of leaves/plant observed x 5}} \text{ x } 100$$

Per cent Disease Control (PDC) =

$$\frac{\text{PDI in control plot} - \text{PDI in treatment plot}}{\text{PDI in control plot}} \text{ x } 100$$

The per cent increase in fruit yield in each treatment over the control was worked by using following formula.

Per cent increase in yield=

$$\frac{\text{Yield in treatment plot} - \text{Yield in control plot}}{\text{Yield in treatment plot}} \text{ x } 100$$

Apparent Infection Rate

It is an estimate of the rate of progress of a disease, based on proportional measures of the extent of infection at different times.

$$r = \frac{1}{t_2 - t_1} \log_e \frac{x_2\,(1-x_1)}{x_1\,(1-x_2)}$$

Where,

r = Apparent infection rate

t1 = Time of the first measurement

t2 = Time of second measurement

x_1 = Proportion of infection measured at time t_1 x_2 = Proportion of infection measured at time t_2

Area under Disease Progress Curve (AUDPC)

$$A = \sum_{t=1}^{N-1} \left(\frac{Xi+1+Xi}{2}\right) (t_1 + 1 - t_2)$$

Where,

Xi = Disease index expressed as a proportion at the i^{th} observation

t = Time (days after planting) at the i^{th} observations

n = Total number of observations.

Results and Discussion

The PDI calculated before spraying was in the range of 1.12 to 2.11 per cent and it was statistically non-significant among the treatments. The chlorine dioxide (0.2%) spray was statistically significant in controlling per cent disease intensity of powdery mildew of okra with PDI

6.90 per cent in comparison to check followed by hydrogen peroxide (0.2%) with PDI 8.67 per cent in post spray (PDI-I) observations. The effectiveness of chlorine dioxide (0.2%) was found to be rather consistent in controlling per cent disease incidence with PDI 10.31 per cent in comparison to check followed by *Ampelomyces quisqualis* (0.3%) with PDI 12.17 per cent in post spray (PDI-II) observations. Among the low profile chemicals tested, chlorine dioxide (0.2%) gave significant reduction in incidence of powdery mildew of okra under field condition with PDI 18.33 per cent and it was at par with hexaconazole (0.1%) with PDI 19.17 per cent, *Ampelomyces quisqualis* (0.3%) with PDI 20.67 per cent in comparison to check followed by chitosan (0.2%) with PDI

22.87 per cent and nano silver particle (0.2%) with PDI 23.63 per cent in the post spray (PDI-III) observations. During field studies, per cent disease control was also calculated at different intervals. It showed that chlorine dioxide (0.2%) consistently gave maximum per cent disease control over untreated check. The per cent disease control (PDC) due to chlorine dioxide (0.2%) was ranged from 59.09 to 66.43 per cent followed by hexaconzole (0.2%) in the range of 27.08 to 64.89 per cent over unsprayed check.

Rate of infection

The result of rate of infection is presented in (Table 2). It was observed that rate of infection (units day^{-1}) varied from 0.25 to 0.37 within intervals. On comparison among treatments overall mean as well as between each interval 'r' values were always high in T_9 (Untreated control). Mean 'r' value was noticed as the lowest 0.29 in T_5 (Chlorine dioxide @ 0.2per cent),

Area Under Disease Progress Curve (AUDPC)

The result of effect of low profile chemicals on area under disease progress curve is presented in table 3. It was observed that progress of powdery mildew disease was higher due to favourable environmental conditions. The AUDPC values of powdery mildew disease were ranged from 410.7 to 1166.82. The maximum disease progress was observed in treatment T_9 (Untreated control) with value 1166.82. The lowest AUDPC was observed in treatment T_5 (Chlorine dioxide @

0.2 per cent) compared to any other treatment with value 410.7.

The result of effect of low profile chemicals on yield of okra is presented in table 4. It was observed that all treatments effectively controlled the powdery mildew severity over water sprayed control. The results on fruit yield were statistically significant. Fruit yield was ranged from 14.39 t/ha to 22.65

t/ha. The maximum yield of 22.65 t/ha was obtained from the plot treated with T_5 (Chlorine dioxide @ 0.2 per cent) with 57.40 per cent increase in yield over control, followed by treatment T_1 (Hexaconazole @ 0.1 per cent) with 21.39 t/ha and 48.64 per cent increase in yield over control. The minimum okra fruits were harvested from T_9 (Untreated control) with 14.39 t/ha. The spraying of low profile chemicals showed either decrease or less effective performance to control disease severity. Various researchers like Khunti *et al*., (2002) [7], Singh and Sirohi (2003) [10], Naik and Nagarja (2003) [8], Suryawanshi *et al*. (2009) [11], Dhutraj and Dadke (2012) [2] have worked on it and gave similar results.

Table 1: Effect of low profile chemicals on powdery mildew disease of okra (Summarized) (*Kharif*, 2018)

Tr. No.	Treatment	conc. (%)	Mean PDI and PDC at intervals						
			Pre spray	PDI I	PDC	PDI II	PDC	PDI III	PDC
T_1	Hexaconazole	0.1	0.76 (5.00)	12.30 (20.52)	27.08	15.43 (23.12)	47.69	19.17 (25.96)	64.89
T_2	Chitosan	0.2	1.71 (7.51)	9.63 (18.07)	42.91	14.32 (22.23)	51.45	22.87 (28.56)	58.12
T_3	*Ampelomyces quisqualis*	0.3	1.97 (8.07)	10.70 (19.09)	36.57	12.17 (20.41)	58.74	20.67 (27.03)	62.14
T_4	Potassium salt of phosphoric acid	0.5	1.66 (7.40)	9.07 (17.52)	46.23	16.33 (23.83)	44.64	25.83 (30.53)	52.70
T_5	Chlorine dioxide	0.2	1.34 (6.64)	6.90 (15.22)	59.09	10.31 (18.72)	65.05	18.33 (25.34)	66.43
T_6	Hydrogen peroxide	0.2	2.11 (8.35)	8.67 (17.12)	48.60	13.33 (21.41)	54.81	21.27 (27.45)	61.05
T_7	Ozonated Water	0.2	1.45 (6.91)	13.20 (21.38)	21.75	17.83 (24.97)	39.55	25.17 (30.10)	53.90
T_8	Nano silver	0.2	0.87 (5.35)	11.45 (19.77)	32.12	16.53 (23.98)	43.96	23.63 (29.07)	56.72
T_9	Untreated Control (Water Spray)		1.89 (7.90)	16.87 (24.24)	0.00	29.50 (32.88)	0.00	54.61 (47.63)	0.00
	S. Em. ±		0.24	0.64	-	0.58	-	1.37	
	CD at 5%		NS	1.95	-	1.77	-	4.16	

values in bracket are arcsine transformed value.

Table 2: Progress of powdery mildew disease of okra over period of time under influence of different spray treatments

Treatment No.	Treatment	Rate of infection (units day^{-1}) at ith interval			
		r_1	r_2	r_3	R mean
T_1	Hexaconazole	0.28	0.33	0.35	0.32
T_2	Chitosan	0.28	0.32	0.36	0.32
T_3	*Ampelomyces*	0.29	0.30	0.35	0.31
T_4	Potassium salt of phosphoric acid	0.27	0.33	0.37	0.32
T_5	Chlorine dioxide	0.25	0.29	0.34	0.29
T_6	Hydrogen peroxide	0.27	0.31	0.35	0.31
T_7	Ozonated Water	0.30	0.34	0.37	0.33
T_8	Nano silver	0.28	0.33	0.36	0.32
T_9	Untreated Control (Water Spray)	0.33	0.38	0.45	0.38

r = Rate of infection at ith interval

Table 3: Effect of low profile chemicals on AUDPC value of powdery mildew on okra

Tr. No.	Treatment	Conc. (%)	AUDPC values
1	Hexaconazole	0.1	528.18
2	Chitosan	0.2	538.08
3	*Ampelomyces quiqualis*	0.3	496.33
4	Potassium salt of phosphoric acid	0.5	592.53
5	Chlorine dioxide	0.2	410.7
6	Hydrogen peroxide	0.2	499.56
7	Ozonated Water	0.2	639.15
8	Nano silver	0.2	587.58
9	Untreated Control (Water Spray)	-	1166.82

Table 4: Effect of low profile chemicals on yield of okra (*Kharif*, 2018)

Tr. No.	Treatment	conc. (%)	Fruit Yield (t/ha)	Per cent increase over control
T_1	Hexaconazole	0.1	21.39	48.64
T_2	Chitosan	0.2	17.83	23.21
T_3	*Ampelomyces*	0.3	19.91	38.35
T_4	Potassium salt of phosphoric acid	0.5	15.89	10.42
T_5	Chlorine dioxide	0.2	22.65	57.40
T_6	Hydrogen peroxide	0.2	18.12	25.92

T_7	Ozonated Water	0.2	16.57	15.14
T_8	Nano silver	0.2	17.20	19.52
T_9	Untreated Control(Water Spray)	--	14.39	
S. E.±				0.89
CD at 5%				2.17

Conclusion

Chlorine dioxide (0.2%) gave significant reduction in powdery mildew disease incidence on okra with PDI in the range of (6.90 to 21.27%) in comparison to check and maximum per cent disease control ranging from 59.09 to 66.43 per cent over unsprayed check. Chlorine dioxide (0.2%) produced significantly highest yield (22.65 t/ha) in comparison to check (14.39 t/ha).Among all the treatments mean infection rate 'r' values were always high in untreated check (0.38) and minimum 'r' value (0.29) was noticed in chlorine dioxide (0.2%). The maximum area under disease progress curve of 1166.82 was noticed in untreated check control and the lowest AUDPC value (410.7) was observed in chlorine dioxide (0.2%).

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