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RESEARCH ARTICLE

Efficacy of fungicides and Phyto-extracts for suppression on leaf spot of cotton caused by *Alternaria* spp.

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ABSTRACT

The principal part affected is the leaf on which small, dull to dark brown, circular or irregularly shaped spots appear, the spots varying in diameter from 0.5 to 10 mm. When these spots mature they have dry, grey centres which may crack and even drop. The spots may coalesce and occupy large area of the leaf. Fungal pathogens were isolated, purified and identified as *Alternaria alternata, Alternaria macrospora* and *Alternaria gossypina* and pathogencity was confirmed on Bt and non Bt cotton in potted plants. In potted plants, minimum disease severity were obtained in Mancozeb and Hexaconazole followed by Copper oxychloride and Tilt. All fungicides as foliar sprays were able to reduce disease severity over untreated control at 0.2% followed by 0.1% concentration. Mancozeb and Hexaconazole were found most effective in management of Alternaria leaf spot of cotton.

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INTRODUCTION

Alternaria leaf spot of cotton is an important disease and widely prevalent in all the cotton growing areas. It has been observed that it initiates severe to moderate form at seedling to young stage in cotton plant. In USA, Alternaria leaf spot was first reported in 1918 by Faulwetter. This disease was for the first time reported from India by Rane and Patel, (1956) from Bombay area.

The earliest symptoms of the disease may be the appearance of spot on the cotyledons of the newly emerged seedling. Under continuous cotton cultivation, the disease can also be found affecting the young cotyledons, beginning as small, brown, circular spots, bordered by a purple margin. Under favourable condition for disease development, the spot can enlarge to 10 mm. in diameter. Large numbers of spots, coalescing together, may develop on susceptible cultivars, causing the cotyledons to be shed. Cotyledons and, to a certain extent, the first formed leaves are more susceptible than the later leaves.

According to Sciumbato and Pinckard (1974) on older plants lesions were at first small and brown with reddish purple borders, later coalescing and causing considerable defoliation. Observations indicate that stressed plants tend to contract more disease. Alternaria leaf spot caused by *A. macrospora* and *A. alternata* are common in cotton crops around the world.

According to Padaganur *et al*. (1989) yield losses in cotton cv. Jayadhar due to infection by *A. macrospora* in Karnataka, ranged from 16.6 to 60.1 per cent with an average loss of 35.6 per cent.

MATERIAL AND METHODS

For any quantitative assessment of disease, it is important to know the severity of the disease in a population. Since, all the individuals in a population may differ in grade of severity, frequency of such grade will have to be determined to know exactly the intensity of disease in the population.

On the basis of performance of antifungal effect fungicides were assessed against three *Alternaria* spp.

fungicides were used as foliar sprays. The experiment was conducted in pots with Completely Randomized Design with three replications. For comparison, control plants were maintained without application of any treatment. One month old potted cotton plants were spray inoculated twice at 24h interval. After the appearance of first visible symptoms, two foliar sprays of fungicides were given at 10 days interval. The final observations were taken after 10 days of second spray.

Data recording:

The disease severity of Alternaria leaf spot of cotton was recorded on standard 0 to 5 disease rating scale. (Grades 0, 1, 2, 3, 4, 5 for 0, 1–10%, 11–20%, 21–35%, 36-60 and more than 61 per cent leaf area, stem and bolls severely infected, defoliation common)

The per cent infection index (Chester, 1959 and Wheeler, 1969) was calculated by using following formula:

$$\text{Per cent Disease Index} = \frac{\text{Sum of all numercial rating}}{\text{Number of plants assessed} \times \text{Maximum disease rating}} \times 100$$

The per cent efficacy of disease control (PEDC) was determined by using following formula:

$$\text{PEDC} = \frac{\text{Per cent infection index in control} - \text{Per cent infection index in treatment}}{\text{Per cent infection index in control}} \times 100$$

RESULTS AND DISCUSSION

Eight fungicides *viz.,* Copper oxychloride, Mancozeb, Captafol, Saaf, Tebuconazole, Carbendazim, Tilt and Hexaconazole, were tested at 0.1 and 0.2 per cent concentrations for their comparative efficacy as foliar spray for controlling the Alternaria leaf spot in cotton. All the fungicides were tested on *Alternaria alternata*, *A. macrospora* and *A. gossypina* pathogens infected Bt and non-Bt cotton in potted plant separately.

In case of *Alternaria alternata* on non-Bt cotton all the fungicides were able to reduce disease severity in both (0.1 and 0.2%) concentrations. Mancozeb performed the best and gave (70.14 and 72.23%) per cent efficiency of disease control followed by Hexaconazole (62.60 and 66.28%), Copper oxychloride (58.72 and 64.12%). Wherever, Tilt gave (38.77 and 56.48%), Tebuconazole (35.42 and 49.83%), Captafol (32.75 and 48.14%) and Saaf (26.76 and 46.89%). Further, Carbendazim (22.54 and 44.81%) was noticed less effective in reducing Alternaria leaf spot on non-Bt cotton (Table 1).

While in case of Bt cotton, all the fungicides were able to reduce disease severity in both (0.1 and 0.2%) concentrations. Mancozeb performed the best and gave (76.04 and 77.55%) per cent efficiency of disease control followed by Hexaconazole (67.75 and 72.59%), Copper oxychloride (64.06 and 71.25%). Wherever, Tilt gave (59.45 and 66.63%), Tebuconazole (54.85 and 64.22%), Captafol (50.15 and 63.36%) and Saaf (41.61 and 56.67%). Further, Carbendazim (32.28 and 52.27%) was noticed less effective in reducing the Alternaria leaf spot on Bt cotton. (Table 1 and Fig. 1).

In case of *Alternaria macrospora* on non-Bt cotton, all the fungicides were able to reduce disease severity in both (0.1 and 0.2%) concentrations. Mancozeb performed the best and gave (71.88 and 77.51%) per cent efficiency of disease control followed by Hexaconazole (66.68 and 70.52%), Copper oxychloride (61.09 and 64.94%). Wherever, Tilt (55.91 and 59.20%), Captafol (50.33 and 56.92%), Tebuconazole (47.42 and 52.92%) and Saaf (33.42 and 48.66%) were found to be less effective than the previous fungicides. Further, Carbendazim (24.00 and 44.43%) was noticed less effective in reducing Alternaria leaf spot on non-Bt cotton.

Table 1 : Relative efficacy of promising fungicides on *Alternaria alternata* on non-Bt and Bt cotton in potted plants

Treatments	PDI of non-Bt cotton		PEDC of non-Bt cotton		PDI of Bt cotton		PEDC of Bt cotton	
	0.1% conc.	0.2% conc.	0.1% conc.	0.2% conc.	0.1% conc.	0.2% conc.	0.1% conc.	0.2% conc.
Copper oxychloride	29.80(33.08)	25.90(30.59)	58.72(50.03)	64.12(53.21)	21.50(27.62)	17.20(24.50)	64.06(53.18)	71.25(57.58)
Mancozeb	21.50(27.60)	20.00(26.54)	70.14(56.92)	72.23(58.24)	14.30(22.20)	13.40(21.45)	76.04(60.73)	77.55(61.76)
Captafol	48.50(44.14)	37.40(37.69)	32.75(34.84)	48.14(43.93)	29.80(33.08)	21.90(27.89)	50.15(45.08)	63.36(52.77)
Saaf	52.82(46.62)	38.30(38.23)	26.76(31.06)	46.89(43.21)	34.90(36.21)	25.90(30.59)	41.61(40.16)	56.67(48.84)
Tebuconazole	46.60(43.05)	36.20(36.99)	35.42(36.50)	49.83(44.90)	27.00(31.31)	21.40(27.55)	54.85(47.79)	64.22(53.27)
Carbendazim	56.00(48.45)	39.90(39.17)	22.54(28.34)	44.81(42.02)	40.58(39.57)	28.60(32.32)	32.28(34.62)	52.27(46.30)
Tilt	44.27(41.71)	31.47(34.12)	38.77(38.51)	56.48(48.72)	24.30(29.53)	20.00(26.56)	59.45(50.45)	66.63(54.71)
Hexaconazole	27.00(31.31)	24.30(29.52)	62.60(52.30)	66.28(54.53)	19.30(26.06)	16.40(23.88)	67.75(55.40)	72.59(58.44)
Control	72.27(58.24)	72.27(58.24)	–	–	59.90(50.71)	59.90(50.71)	–	–
SEm±	0.833	0.770	1.3471	1.1214	0.5973	0.5270	1.003	0.816
CD 5%	2.475	2.289	4.0042	3.3320	1.7746	1.5659	2.979	2.425
CD 1%	3.391	3.136	5.4861	4.5651	2.4314	2.1454	4.081	3.322

* Average of three replications

** Figures in parentheses are arcsine $\sqrt{}$ per cent angular transformed values

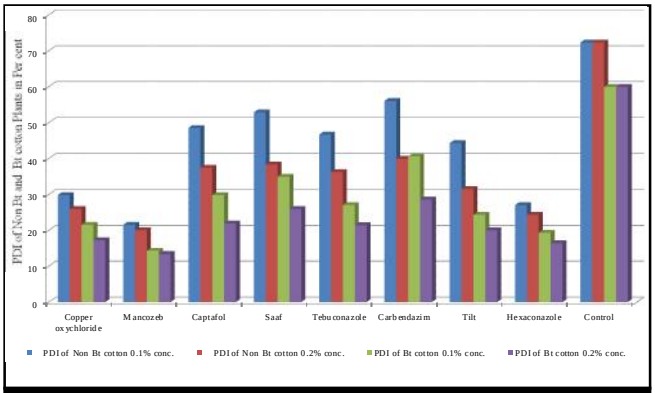

Fig. 1 : Relative efficacy of promising fungicides on *Alternaria alternate* on non-Bt cotton and Bt cotton in potted plants

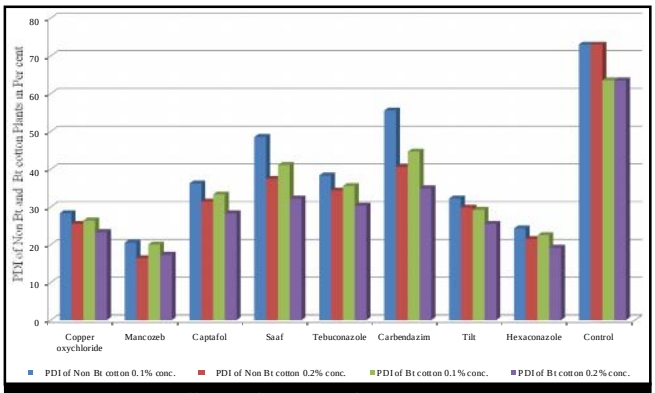

Fig. 2 : Relative efficacy of promising fungicides on *Alternaria macrospora* on non-Bt cotton and Bt cotton in potted plants

Moreover, in case of Bt cotton all fungicides were able to reduce disease severity in both the (0.1 and 0.2%) concentrations. Mancozeb performed the best and gave (68.45 and 72.71%) per cent efficiency of disease control followed by Hexaconazole (64.51 and 69.72%), Copper oxychloride (58.26 and 63.16%). Further, Tilt gave (54.02 and 59.84%), Captafol (47.45 and 55.34%), Tebuconazole (43.95 and 52.16%) and Saaf (35.15 and 49.16%) were found to be less or moderately effective. whereas, Carbendazim (29.75 and 45.03%) was observed to be very less effective in reducing Alternaria leaf spot on Bt cotton. All data presented in (Table 2 and Fig. 2).

On non-Bt cotton, leaf spot caused by *Alternaria gossypina* was effectively controlled by all the fungicides by reducing disease severity in both (0.1 and 0.2%) concentrations. Mancozeb was found to the best fungicide by giving (72.92 and 75.60%) per cent efficiency of disease control followed by Hexaconazole (65.74 and 71.80%), Copper oxychloride (63.49 and 69.83%), respectively.

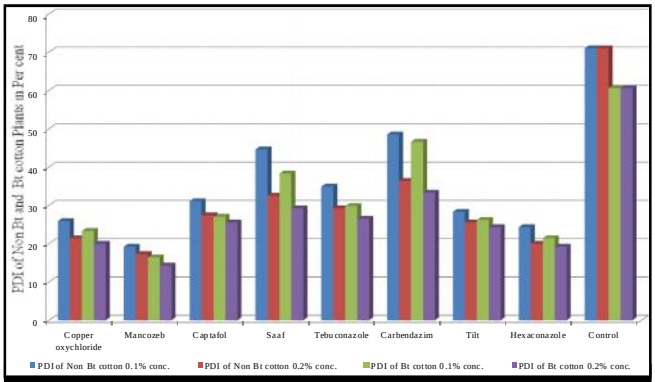

Fig. 3 : Relative efficacy of promising fungicides on *Alternaria gossypina* on non-Bt cotton and Bt cotton in potted plants

Table 2 : Relative efficacy of promising fungicides on *Alternaria macrospora* on non-Bt and Bt cotton in potted plants

Treatments	PDI of non-Bt cotton		PEDC of non-Bt cotton		PDI of Bt cotton		PEDC of Bt cotton	
	0.1% conc.	0.2% conc.	0.1% conc.	0.2% conc.	0.1% conc.	0.2% conc.	0.1% conc.	0.2% conc.
Copper oxychloride	28.30 (32.12)	25.50 (30.31)	61.09 (51.44)	64.94 (53.73)	26.40 (30.90)	23.30 (28.84)	58.26 (49.78)	63.16 (52.66)
Mancozeb	20.50 (26.92)	16.40 (23.88)	71.88 (57.99)	77.51 (61.70)	20.00 (26.56)	17.30 (24.57)	68.45 (55.84)	72.71 (58.52)
Captafol	36.20 (36.99)	31.40 (34.08)	50.33 (45.19)	56.92 (48.98)	33.30 (35.24)	28.30 (32.14)	47.45 (43.54)	55.34 (48.07)
Saaf	48.50 (44.14)	37.40 (37.70)	33.42 (35.27)	48.66 (44.23)	41.10 (39.87)	32.20 (34.57)	35.15 (36.34)	49.16 (44.52)
Tebuconazole	38.30 (38.23)	34.30 (35.84)	47.42 (43.52)	52.92 (46.68)	35.50 (36.56)	30.30 (33.39)	43.95 (41.51)	52.16 (46.24)
Carbendazim	55.50 (48.16)	40.58 (39.57)	24.00 (29.33)	44.43 (41.80)	44.60 (41.90)	34.90 (36.21)	29.75 (33.06)	45.03 (42.15)
Tilt	32.20 (34.57)	29.80 (33.08)	55.91 (48.40)	59.20 (50.30)	29.20 (32.70)	25.50 (30.32)	54.02 (47.30)	59.84 (50.68)
Hexaconazole	24.30 (29.53)	21.50 (27.62)	66.68 (54.75)	70.52 (57.12)	22.50 (28.32)	19.20 (25.99)	64.51 (53.44)	69.72 (56.62)
Control	73.00 (58.72)	73.00 (58.72)	–	–	63.47 (52.82)	63.47 (52.82)	–	–
SEm±	0.788	0.709	1.163	0.991	0.673	0.631	1.121	1.015
CD 5%	2.340	2.108	3.456	2.945	1.999	1.876	3.330	3.017
CD 1%	3.207	2.889	4.736	4.036	2.738	2.570	4.562	4.133

* Average of three replications

** Figures in parentheses are arcsine √ per cent angular transformed values

Table 3 : Relative efficacy of promising fungicides on *Alternaria gossypina* on non-Bt and Bt cotton in potted plants

Treatments	PDI of non-Bt cotton		PEDC of non-Bt cotton		PDI of Bt cotton		PEDC of Bt cotton	
	0.1% conc.	0.2% conc.	0.1% conc.	0.2% conc.	0.1% conc.	0.2% conc.	0.1% conc.	0.2% conc.
Copper oxychloride	25.90 (30.59)	21.40 (27.55)	63.49 (52.83)	69.83 (56.69)	23.30 (28.86)	20.00 (26.56)	61.54 (51.67)	66.96 (54.92)
Mancozeb	19.20 (25.99)	17.30 (24.58)	72.92 (58.65)	75.60 (60.40)	16.40 (23.89)	14.30 (22.22)	72.91 (58.64)	76.37 (60.92)
Captafol	31.10 (33.89)	27.40 (31.56)	56.22 (48.58)	61.43 (51.61)	27.00 (31.30)	25.50 (30.32)	55.46 (48.14)	57.94 (49.57)
Saaf	44.60 (41.90)	32.50 (34.75)	37.06 (37.47)	54.13 (47.38)	38.30 (38.23)	29.20 (32.71)	36.71 (37.27)	51.71 (45.98)
Tebuconazole	34.90 (36.20)	29.20 (32.70)	50.75 (45.43)	58.79 (50.08)	29.80 (33.08)	26.50 (30.97)	50.79 (45.45)	56.18 (48.56)
Carbendazim	48.50 (44.14)	36.40 (37.10)	31.70 (34.26)	48.76 (44.29)	46.60 (43.05)	33.30 (35.24)	23.14 (28.74)	45.07 (42.17)
Tilt	28.30 (32.12)	25.50 (30.31)	60.00 (50.80)	63.96 (53.14)	26.20 (30.77)	24.30 (29.51)	56.68 (48.86)	59.76 (50.66)
Hexaconazole	24.30 (29.53)	20.00 (26.56)	65.74 (54.18)	71.80 (57.93)	21.40 (27.55)	19.20 (25.98)	64.68 (53.54)	68.28 (55.73)
Control	71.01 (57.44)	71.01 (57.44)	-	-	60.60 (51.12)	60.60 (51.13)	-	-
SEm±	0.723	0.673	1.107	0.931	0.645	0.613	1.041	0.994
CD 5%	2.149	1.999	3.289	2.765	1.916	1.821	3.094	2.954
CD 1%	2.945	2.739	4.506	3.788	2.625	2.495	4.239	4.048

* Average of three replications

** Figures in parentheses are arcsine √ per cent angular transformed values

Moreover, Tilt gave (60.00 and 63.96%), Captafol (56.22 and 61.43%), Tebuconazole (50.75 and 58.79%) and Saaf (37.06 and 54.13%) and were found to be less effective by giving disease severity in the range of 50-63%. Further, Carbendazim (31.70 and 48.76%) was noticed very less effective in reducing the Alternaria leaf spot on non-Bt cotton (Table 3).

However, in case of Bt cotton all the fungicides were able to reduce disease severity in both the (0.1 and 0.2%) concentrations. Mancozeb performed the best and gave (72.91 and 76.37%) per cent efficiency of disease control followed by Hexaconazole (64.68 and 68.28%), Copper oxychloride (61.54 and 66.96%). Tilt gave (56.68 and 59.76%), Captafol (55.46 and 57.94%), Tebuconazole (50.79 and 56.18%) and Saaf (36.71 and 51.71%) efficacy. Further, Carbendazim (23.14 and 45.07%) was noticed very less effective in reducing Alternaria leaf spot on Bt cotton (Table 3 and Fig. 3).

All the fungicides were able to reduce disease severity. Mancozeb was found most effective followed by Hexaconazole and Copper oxychloride to reduce the disease severity in potted plant of Bt and non-Bt cotton. The higher concentration (0.2%) of each fungicide was superior to low concentration (0.1%). These results are in accordance with Ramegowda *et al*. (2007), Alagarsamy *et al*. (1989) and Rao and Rao (2002).

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