



Efficacy of Fungicides and Commercially Available Organic Products against Blight of Cotton Caused by *Alternaria macrospora*

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An attempt was made to test available formulation of fungicides and commercially available organic products for their efficacy under laboratory condition, an experiment was carried out at Department of Plant pathology, Raichur, Karnataka, India by using poison food technique. Among the commercially available organic products tested, fatty alcohol and diluents has recorded significantly higher mycelial inhibition of 100 per cent at the concentration of 5 and 10 per cent. In case of contact fungicides propineb 70% WP, metiram 70% WP and mancozeb 75 % WP recorded 100 per cent mycelial inhibition, with respect to systemic fungicides hexaconazole 5% EC, propiconazole 25% EC and difenoconazole 25% WP and among the combi fungicides azoxystrobin 8.3% +

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mancozeb 66.7% WG were most effective in 100 per cent inhibition of mycelial growth of *Alternaria macrospora* over the control. The commercially available organic product fatty alcohol and diluents, propineb 70% WP, hexaconazole 5% EC, propiconazole 25% EC and azoxystrobin 8.3% + mancozeb 66.7 % WG were found to be effective against inhibition of mycelial growth of *Alternaria macrospora*.

Keywords: *Alternaria macrospora*; commercially available organic product; fungicides; in vitro.

1. INTRODUCTION

Cotton (*Gossypium* spp.) is the most important commercial crops of the world providing fibre for clothing for the mankind, which belongs to the botanical family Malvaceae. Cotton is referred to as "King of Fibres" and also known as "White Gold". India accounts for 33 per cent (10.7 mha) of world cotton area and 22 per cent (5.4 million tonnes) of world cotton production. In India, about 70 per cent area is covered by hybrids, 20 per cent by upland varieties and 10 per cent by diploid cultivars. The Egyptian cotton is cultivated in a very little area (2%) in few pockets of Tamil Nadu and Andhra Pradesh. The *G. herbaceum* is confined to two states, Gujarat and Karnataka. Two species viz., *G. hirsutum* and *G. arboreum* are cultivated in all the nine cotton growing states in India [1]. *Bt* (*Bacillus thuringiensis*) cotton was first genetically modified (GM) crop approved in India during 2002 for commercial cultivation. The area under *Bt* cotton has increased from 50,000 ha in 2002 to 12.35 million ha in 2021-22. *Bt* cotton has contributed to increase the production of cotton by almost three times from 13 million bales to 34.06 million bales during 2002 to 2021-22. *Bt* cotton is gaining popularity with farmers because of effective control of bollworm complex besides higher productivity and ultimately resulted an expansion of area under *Bt* cotton in India from 38,000 ha in 2002 to 12.35 million ha in 2021-22 [2].

Among the various diseases, *Alternaria* blight caused by *Alternaria macrospora* Zimm. is a major foliar disease of cotton which results in heavy defoliation and reduced seed cotton yield [3]. The resistant cultivars may not reach the maximum cultivable area as that of susceptible but high yielding cultivars. Perhaps use of fungicides and commercially available organic product may be the only suitable option when risk of outbreak of epidemics arises under field conditions. Hence, as a management strategy, bioassay of fungicides helps to know the efficacy of these fungicides against pathogens which would serve as a guide in order to test them in field.

2. MATERIALS AND METHODS

The present investigation was carried out to evaluate different fungicides and commercially available organic products their fungitoxicant properties against *A. macrospora* by poisoned food technique. Eight contact fungicides (Propineb 70 % WP, Copper oxychloride 50 % WP, Chlorothalonil 75 % WP, Mancozeb 75 % WP, Copper hydroxide 77 % WP, Metiram 70 % WP, Mandipropamid 23.4 % SC and Cyazafamid 34.5 % SC) were tested against *A. macrospora* at 0.1,0.2 and 0.3 per cent concentrations. Nine systemic fungicides (Azoxystrobin 23 % SC, Hexaconazole 5 % EC, Propiconazole 25 %EC, Tebuconazole 25 % EC, Thiophanate methyl 50 % SC, Difenconazole 25 % WP, Triadimefon 25 % WP, Pyraclostrobin 5 % WP and Isoprothiolane 40 % EC) at 0.05,0.1 and 0.15 per cent concentrations, and eight combination fungicides (Azoxystrobin 11 % + Tebuconazole 18.3 % SC, Metiram 55 % + Pyraclostrobin 5 % WG, Azoxystrobin 18.2 % +Difenconazole 11.4 % SC, Penflufen 13.28 % + Trifloxystrobin 13.28 % SC, Carbendazim 12 % + Mancozeb 63 % WP, Hexaconazole 4 % + Zineb 68 % WG, Azoxystrobin 8.3 % + Mancozeb 66.7 % WG and Azoxystrobin 4.8 % + Chlorothalonil 40 % SC) at 0.1,0.15 and 0.20 per cent concentration were tested. The commercially available organic products (Neem peptide, Sea weed extract, Lantana camara plant extract, Humic acid + fulvic acid, Amino acid and peptide derivatives, Fatty alcohol and diluents, Activated P. fluorescens+ karanja extract + natural Bi-carbonates, P. fluorescens 0.5% WP and Eugenol 0.10 % w/w+ potassium salt of fatty acids 2 % w/w+ sodium salt 97.90 % w/w) were tested at 5 and 10 per cent, required quantities of individual commercially available organic products and fungicides were added separately into molten and cooled potato dextrose agar media. Later 20 ml of such poisoned medium was poured into sterile Petri plates. Actively growing 7 to 8 days cultures of *Alternaria macrospora* maintained at the Department of Plant Pathology, Raichur. Mycelial discs of 5 mm size from the culters of *A. macrospora* was cut

out by a sterile cork borer and one such disc was placed at the centre of each agar plate. Control was maintained without adding any fungicides and commercially available organic products into the medium and each treatment was replicated thrice. Then such plates were incubated at room temperature for 15 days and diameter colony growth (mm) was measured and data is subjected to statistical analysis by using R software. Per cent inhibition of mycelial growth in treated plates was calculated by using the formula given by Vincent [4].

$$I = C - T / C \times 100$$

Where,

- I= Per cent mycelial inhibition of test pathogen (%)
- C= Mycelial growth of the pathogen in control
- T= Mycelial growth of the pathogen in treatment

3. RESULTS AND DISCUSSION

The commercially available organic products are cost effective means of management, an effort was made to know the efficacy of different plant extracts against *A. macrospora*. The results revealed that, (Table 1) among the commercially

available organic products tested at 5 and 10 per cent concentrations, fatty alcohol and diluents (Green miracle) was found most effective which has completely inhibited the growth of fungus by 100 per cent. Whereas, at 10 per cent concentration, Amino acid and peptide derivatives (Isobian) and Activated *P. fluorescens* + Karanja extract+ natural Bi-carbonates (Organic fungicide) both the products inhibited mycelial growth of 100 and 100 per cent, respectively. other commercially available organic products such as, *P. fluorescens* 0.5 % WP (Spot) did not show mycelial inhibition at the concentration of 5 and 10 per cent, respectively. The quantities, interactions, and differences across various commercially available organic products were quite varying. The organic products at 10 per cent were notably better than at 5 per cent concentration. According to literature, the phenolic compound eugenol, in addition to other chemical compounds such as β-caryophyllene, αhumulene, caryophyllene oxide and eugenyl acetate were effective at lower concentrations [5] fungitoxicity of eugenol and other compounds has been reported in some studies [6]. The mechanism of action associated with its hydrophobicity, which provides interaction with the wall and lipids of the cell membrane and mitochondria, altering cellular permeability and causing disturbances in fungal cell structures.

Table 1. Efficacy of commercially available organic products against *Alternaria macrospora*

Sl. No.	Organic product	Per cent inhibition of mycelial growth over control		
		Concentration (%)		
		5	10	Mean
1	Neem peptide (Azardictin)	28.88(32.51)	44.44(41.81)	36.66(37.26)
2	Sea weed extract (Biozyme)	20.00(26.57)	33.33(35.26)	26.67(31.09)
3	<i>Lantana camara</i> plant extract (BI-OVIS)	40.00(39.23)	82.22(65.06)	61.11(51.42)
4	Humic acid + fulvic acid (Humicil)	4.44(12.17)	73.33(58.91)	38.89(38.58)
5	Amino acid and peptide derivatives (Isobian)	97.00(80.03)	100.00(90.00)	98.50(82.97)
6	Fatty alcohol and diluents (Green miracle)	100.00(90.00)	100.00(90.00)	100.00(90.00)
7	Activated <i>P. fluorescens</i> + Karanja extract + natural Bi-carbonates (Organic fungicides)	82.22(65.06)	100.00(90.00)	91.11(72.65)
8	<i>P. fluorescens</i> 0.5% WP (Spot)	0.00(0.00)	0.00(0.00)	0.00(0.00)
9	Eugenol 0.10 % W/W+ potassium salt of fatty acids 2 % W/W+ sodium salt 97.90 % W/W (Ecofit)	0.00(0.00)	28.88(32.51)	14.44(22.33)
	Mean	41.39(40.04)	62.46(52.22)	
		SEm±	CD at 1%	
	Organic product (O)	0.77	2.94	
	Concentrations (C)	0.36	1.39	
	OxC	1.09	4.16	

* Original value **Arc sine transformed value

The efficacy of eight contact fungicides were tested against *A. macrospora*, out of which propineb 70 % WP, metiram 70 % WP and mancozeb 75 % WP showed complete inhibition of *A. macrospora* at all the three concentrations (0.1, 0.2 and 0.3 %) followed by chlorothalonil 75 % WP showed 87.04 per cent inhibition at 0.3 per cent concentration, cyazafamid 34.5 % SC (55.93 %) recorded least per cent mycelial inhibition of *A. macrospora*. Increase in inhibition of mycelial growth of the fungus was observed with increase in concentration (Table 2). Among nine systemic fungicides evaluated, triazole group of fungicides like, difenoconazole 25 % EC, hexaconazole 5 % SC, propiconazole 25 % EC and tebuconazole 25 % EC and triadimefon 25 % EC recorded complete mycelial inhibition of *A. macrospora* at all the three concentrations (0.05, 0.1 and 0.15 %), least effective was thiophanate methyl 50 % SC with 47.40 per cent inhibition at 0.15 per cent concentration (Table 3). Development of resistance in many pathogens to fungicides with single point of action has led way to the development of new fungicides where chemicals with two different mode of action, which showed synergistic effect for the control of pathogens. So, evaluation of such fungicides for their efficacy to control the disease was important. Out of eight tested combi fungicide, azoxystrobin 8.3% + mancozeb 66.7 % WG inhibited 100 per cent mycelial growth at

all the three concentration (0.1, 0.15 and 0.2 %), followed by azoxystrobin 18.2 % + difenoconazole 11.4 % SC, azoxystrobin 4.8 % + chlorothalonil 40 % SC, azoxystrobin 8.3 % + mancozeb 66.7 % WG and hexaconazole 4 % + zineb 68 % WG also inhibited 100 per cent growth at 0.3 per cent concentration, least per cent inhibition was recorded by penflufen 13.28 % + trifloxystrobin 13.28 % SC (68.52 %) at 0.1 per cent concentration. Increase in inhibition of mycelial growth of the fungus was observed with increase in concentration (Table 4).

Mancozeb reacts and inactivates the sulfhydryl groups of amino acids and enzymes within fungal cells resulting in disruption of lipid metabolism, respiration and production of adenosine phosphate. Tebuconazole is demethylase inhibitor interferes in process of building the structure of cell wall, finally inhibits the reproduction and further growth of fungus and trifloxystrobin interferes with respiration in plant pathogenic fungi. Azoxystrobin inhibit mitochondrial respiration by blocking electron transport and difenoconazole fungicides interfere with biosynthesis of sterols. The results are also in agreement with findings of several workers such as [7,8,9,10] who evaluated eight fungicides against *Alternaria macrospora*, out of which propiconazole, hexaconazole and tebuconazole at 500 and 1000 ppm recorded

Table 2. Efficacy of contact fungicides against *Alternaria macrospora*

Sl. No.	Fungicides	Per cent inhibition of mycelial growth over control			
		Concentration (%)			
		0.1	0.2	0.3	Mean
1.	Propineb 70 % WP (Antracol)	100*(90.00)**	100(90.0)	100(90.00)	100(90.00)
2.	Chlorothalonil 75% WP (Kavach)	74.81(59.80)	79.63(63.17)	87.04(68.9)	80.49(63.79)
3.	Copper oxychloride 50% WP (Blitox 50)	63.70(52.95)	69.63(56.56)	77.41(61.62)	70.24(56.94)
4.	Mancozeb 75 % WP (Dhanuka M 45)	100(90.00)	100(90.0)	100(90.00)	100(90.00)
5.	Copper hydroxide 77% WP (Kocide)	60.00(50.77)	74.81(59.88)	83.70(66.19)	72.84(58.59)
6.	Metiram 70% WP (Sanit)	100(90.00)	100(90.0)	100(90.00)	100(90.00)
7.	Cyazafamid 34.5 % SC (Ranman)	55.93(48.40)	66.67(54.74)	75.93(60.62)	66.17(54.44)
8.	Mandipropamid 23.4 % SC (Revus)	57.04(49.05)	76.30(60.87)	86.67(68.58)	73.33(58.91)
	Mean	85.14(67.33)	83.38(65.94)	99.26(85.07)	
				SEm±	CD at 1%
	Fungicide (F)			0.36	1.37
	Concentration (C)			0.22	0.84
	FxC			0.63	2.38

* Original value **Arc sine transformed value

Table 3. Efficacy of systemic fungicides against *Alternaria macrospora*

Sl. No.	Fungicides	Per cent inhibition of mycelial growth over control			
		Concentration (%)			
		0.05	0.10	0.15	Mean
1	Azoxystrobin 23 % SC (Amistar)	53.33*(46.91)**	67.54(55.27)	89.62(71.21)	70.16(56.89)
2	Hexaconazole 5 % EC (Contaf)	100.00 (90.00)	100.00(90.00)	100.00(90.00)	100.00(90.00)
3	Propiconazole 25 %EC (Tilt)	100.00(90.00)	100.00(90.00)	100.00(90.00)	100.00(90.00)
4	Tebuconazole 25 % EC (Folicure)	100.00(90.00)	100.00(90.00)	100.00(90.00)	100.00(90.00)
5	Thiophanate methyl 50 % SC (Topsin M)	22.96(28.63)	35.55(36.60)	47.40(43.51)	35.30(36.45)
6	Difenoconazole 25 % WP (Score)	100.00(90.00)	100.00(90.00)	100.00(90.00)	100.00(90.00)
7	Triadimefon 25 % WP (Clash)	100.00(90.00)	100.00(90.00)	100.00(90.00)	100.00(90.00)
8	Pyraclostrobin 5 % WP (Headline)	91.11(72.65)	96.29(78.89)	100.00(90.00)	95.80(78.17)
9	Isoprothiolane 40 % EC (Blaster)	84.44(66.77)	94.81(76.83)	100.00(90.00)	93.08(74.75)
	Mean	83.53 (66.06)	88.24(69.94)	92.00(74.66)	
				SEm±	CD at 1%
	Fungicide (F)			0.88	3.31
	Concentration (C)			0.51	1.91
	FxC			1.52	5.73

Table 4. Efficacy of combi fungicides against *Alternaria macrospora*

Sl. No.	Fungicides	Per cent inhibition of mycelial growth over control			
		Concentration (%)			
		0.1	0.15	0.2	Mean
1.	Azoxystrobin 18.2 % + Difenoconazole 11.4 % SC (Amistar)	94.81*(76.84)**	96.67(79.48)	100(90.00)	97.16(80.30)
2.	Carbendazim 12 % + Mancozeb 63 % WP (SAAF)	89.26(70.87)	94.07(75.91)	100(90.00)	94.44(76.37)
3.	Azoxystrobin 8.3 % + Mancozeb 66.7 % WG (Logic (100(90.00)	100(90.0)	100(90.00)	100(90.00)
4.	Metiram 55 % + Pyraclostrobin 5% WG (Cariotop)	88.52(70.19)	92.96(74.62)	96.30(78.90)	92.59(74.21)
5.	Tebuconazole 18.3 % + Azoxystrobin 11 % SC (Custodia)	88.15(69.86)	91.11(72.65)	94.81(76.84)	91.36(72.90)
6.	Hexaconazole 4 % + Zineb 68 % WG (Avitar)	88.89(70.53)	95.96(77.83)	100(90.00)	94.81(76.84)
7.	Azoxystrobin 4.8 % + Chlorothalonil 40 % SC (Azostar)	92.59(74.21)	95.53(78.36)	100(90.00)	96.17(78.72)
8.	Penflufen 13.28 % + Trifloxystrobin 13.28 % SC (Ever Gol Xtend)	68.52 (55.87)	82.59 (65.34)	92.96 (74.62)	81.36 (64.42)
	Mean	88.78(70.43)	84.36(66.71)	98.01(81.89)	
				SEm±	CD at 1%
	Fungicide (F)			0.34	1.29
	Concentration (C)			0.21	0.79
	FxC			0.59	2.23

* Original value **Arc sine transformed value

maximum inhibition with 100 per cent inhibition and no radial growth of mycelium was observed. Pyraclostrobin and azoxystrobin at 1000 ppm showed 91.0 and 87.2 per cent inhibition respectively. Carbendazim + mancozeb (SAAF) at 1500 ppm and 2000 ppm showed 96.1 and 96.9 per cent inhibition, respectively.

4. CONCLUSION

The commercially available organic product, fatty alcohol and diluents resulted as best to inhibit the mycelia growth of *A. macrospora*. Likewise, contact fungicides propineb 70 % WP, metiram 70 % WP and mancozeb 75 % WP and systemic fungicides hexaconazole 5 % EC, propiconazole 25 % EC and difenoconazole 25 % WP, among the combi fungicides azoxystrobin 8.3 % + mancozeb 66.7 % WG were most effective in complete inhibition of mycelial growth of *A. macrospora*.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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