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EVALUATION OF FUNGICIDES AND HERBICIDES AGAINST THE ROOT ROT OF OKRA

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ABSTRACT
Okra (*Abelmoschus esculentus* L.) is an important vegetable crop, severely attacked by root rot (*Fusarium solani*) in Junagadh district, Gujarat state (India). Therefore affords were made to screen the different systemic, contact and combination of fungicides and herbicides *in vitro* condition against test fungus. Among systemic fungicides, tebuconazole 25.9% EC gave cent per cent growth inhibition of test fungus followed by epoxyconazole 5% WP (92.69%) whereas contact fungicides, copper hydroxide 77% WP and thiram 75% WP were found effective and gave 91.94 and 78.04 per cent growth inhibition of test fungus. The combination of fungicides cymoxanil 8% WP + mancozeb 64% WP, metiram 55% WG + pyraclostrobin 5% WG and carbendazim 12% WP + mancozeb 63% WP gave cent per cent growth inhibition of test fungus. While in herbicides, oxadiargyl was proved to be most effective and gave cent per cent growth inhibition of test fungus followed by quizalophop-p-ethyle with mean per cent inhibition of 94.72 per cent.

INTRODUCTION

Okra [*Abelmoschus esculentus* (Linnaeus) Moench], belongs to the family *Malvaceae* is one of the most important vegetable crops grown extensively throughout the India during the summer and *kharif* seasons. Due to intensive cultivation practices the crop has been found to suffer from many diseases of which, root rot caused by *Fusarium solani* has been contributing significantly for low yield in Gujarat which cause wilting of leaves, tips, loss of turgidity followed by yellowing and drooping of leaves and underground stem become dry, brown and peeling of epidermis. Roots become soft, watery and browning of vascular bundle was also observed (Gangopadhyay, 1984). *Fusarium solani* (Mart.) Sacc., a soil inhabiting pathogen, attacks a large number of host plants including oilseeds, pulses, vegetables and ornamentals (Mani and Sethi, 1968; Bazalar and Delgadi, 1981; Kumar *et al.,* 1983 and Kore and Mane, 1992). The affords were made in other region to manage the root rot (*Fusarium* spp.) through systemic (Baird and Herzog, 1995; Bhat and Srivastava, 2003; Rawal and Thakore, 2003; and Soni and Verma, 2010), contact (Patil *et al.,* 2001) and combination (Manica *et al.*, 2008; Chavan *et al.,* 2009) of fungicides in various crops. The suppressive effect of herbicides on root rot (*Fusarium* spp.) also recorded by Macedo *et al*. (1984) and Kelaiya (1998). However, information is lacking in Gujarat for management of root rot in okra. Hence the present investigation was under taken to screen various fungicides and herbicides *in vitro* condition to manage the root rot.

MATERIALS AND METHODS

In vitro evaluation of fungicides and herbicides

Eight systemic fungicides viz. carbendazim 50%WP, epoxyconazole 7.5% EC, picoxystrobilurin 25% EC, metiram 70% WG, dimethomorph 50% WP, hexaconazole 5% SC, tebuconazole 25.9% EC and kitazin 48% EC were tested at concentration of 50, 100, 250, 500 ppm. Seven non-systemic fungicides viz. mancozeb 75% WP, copper hydroxide 77% WP, thiram 75%WP, chlorothalonil 75% WP, zineb 75 %WP, wett.sulphur 80%WDG and dinocap 48% EC were tested at concentration of 500, 1000, 1500, 2000ppm. The six combination products of fungicides viz. zineb 60% WP + hexaconazole 4%WP, iprodine 25% WP + carbendazim 25% WP, cymoxanil 8% WP + mancozeb 64% WP, carbendazim 12% WP + mancozeb 63% WP, metiram 55% WG + pyraclostrobin 5% WG and pyraclostrobin 13.3% WP + epoxyconazole 5%WP were tested at concentration of 250, 500, 1000, 2000ppm whereas in herbicides, nine herbicides used viz. propaquizafop 10%EC, quizalophop-p-ethyle 5%EC, pendimethalin 30%EC, metasulfuron methyl 20%WG, glyphosate 41%EC, paraquate dichloride 24%SL, oxadiargyl 6%EC, oxyfluorfen 23.5%EC and fenoxaprop-p-ethyle 10%EC were tested at concentration of 500, 1000, 1500, 2000ppm against *F. solani* using growth inhibition technique (Nene and Thapliyal, 1993). Potato dextrose agar (PDA) medium amended with test concentration of fungicides and herbicides were poured in Petri plates and inoculated in center with mycelia disc (4mm) from 7d old culture of *F. solani*. The inoculated Petri plates were incubated at 27 $\pm$ 1^0 C for 7d. Each treatment was replicated thrice. The per cent inhibition in mycelia growth was worked out from average colony diameter in each treatment and control using following formula (Sinclair and Dhingra, 1985).

Table 1: Growth inhibition of *F. solani* at different concentrations of various systemic fungicides after seven days of incubation at 27 ± 1ºC

Fungicide	Concentration (ppm)/per cent inhibition*				Mean	Toxicity Index#
	50	100	250	500		
Tebuconazole	100	100	100	100	100	400
Epoxyconazole	84.36	86.39	100	100	92.69	370.75
Metiram	59.00	74.33	77.94	81.03	73.08	292.30
Carbendazim	61.50	66.78	73.64	76.44	69.59	278.36
Picoxystrobilurin	56.14	56.94	60.75	73.06	61.72	246.89
Kitazin	54.14	62.00	64.14	64.61	61.22	244.89
Hexaconazole	53.08	53.83	54.64	54.89	54.11	216.44
Dimethomorph	6.01	16.92	34.08	38.47	23.87	95.48
Control	0.00	0.00	0.00	0.00	0.00	0.00
	Fungicide (F)		Concentration (C)			F×C
S.Em.±	0.46		0.33			0.91
C.D. at 5%	1.28		0.90			2.56

* Mean of four replications; # Maximum toxicity index = 400.00

Table 2: Growth inhibition of *F. solani* at different concentrations of various non-systemic fungicides after seven days of incubation at 27 ± 1ºC

Fungicide	Concentration (ppm)/per cent inhibition*				Mean	Toxicity Index#
	500	1000	1500	2000		
Copper hydroxide	91.03	92.08	92.31	92.33	91.94	367.75
Thiram	57.72	78.72	80.53	95.19	78.04	312.16
Chlorothalonil	61.28	63.86	66.92	72.03	66.02	264.09
Wett.sulphur	35.92	51.03	53.14	59.25	49.83	199.34
Dinocap	33.08	42.58	50.00	59.72	46.53	185.38
Mancozeb	28.22	32.58	42.06	50.77	38.41	153.63
Zineb	16.69	26.69	34.64	36.44	28.62	114.46
Control	0.00	0.00	0.00	0.00	0.00	0.00
	Fungicide (F)		Concentration (C)			F×C
S.Em.±	0.34		0.26			0.68
C.D. at 5%	0.96		0.73			1.93

* Mean of four replications; # Maximum toxicity index = 400.00

Table 3: Growth inhibition of *F. solani* at different concentrations of various combinations of fungicides after seven days of incubation at 27 ± 1ºC

Fungicide	Concentration (ppm)/per cent inhibition*				Mean	Toxicity Index#
	250	500	1000	2000		
Cymoxanil + Mancozeb	100	100	100	100	100	400
Metiram + Pyraclostrobin	100	100	100	100	100	400
Carbendazim + Mancozeb	100	100	100	100	100	400
Iprodine + Carbendazim	78.31	91.41	93.03	100	90.69	362.75
Pyraclostrobin + Epoxyconazole	61.90	62.37	63.20	75.55	65.75	263.02
Zineb + Hexaconazole	48.69	50.05	79.91	83.31	65.49	261.96
Control	0.00	0.00	0.00	0.00	0.00	0.00
	Fungicide (F)		Concentration (C)			F×C
S.Em.±	0.34		0.28			0.68
C.D. at 5%	0.96		0.79			1.93

* Mean of four replications; # Maximum toxicity index = 400.00

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

Where,

PGI = per cent growth inhibition index

C = area of test fungus in control (mm^2)

T = area of test fungus in respective treatment (mm^2)

RESULTS AND DISCUSSION

The growth inhibition of *Fusariun solani* causing root rot in okra has been tested at various concentration of systemic, non-systemic, combination of fungicides and herbicides *in vitro* recorded in Table 1-4. The perusal of results showed that (Table 1) all the systemic fungicides were effective and gave more than 53 per cent inhibition growth of test fungus at 50 ppm concentration as compared to control except dimethomorph which gave only 6.01 per cent inhibition. Tebuconazole gave cent per cent growth inhibition at all concentration (50 to 500ppm) tested in present investigation. This results is in agreement with finding of Baird and Herzog (1995), they found good mycelial growth inhibition of *F. solani* by tebuconazole. Bhat and Srivastava (2003) also found triazole group of fungicides highly inhibitory to *F. solani*. The epoxyconazole gave 100 per cent inhibition at 250 and 500ppm concentration but act as fungistatic indicating that it only restrict the growth of fungus but do not kill the pathogen.

Table 4: Growth inhibition of *F. solani* at different concentrations of various herbicides after seven days of incubation at 27 ± 1ºC

Herbicide	Concentration (ppm)/per cent inhibition*				Mean	Toxicity Index#
	500	1000	1500	2000		
Oxadiargyl	100	100	100	100	100	400
Quizalophop-p-ethyle	87.73	91.14	100	100	94.72	378.87
Fenoxaprop-p-ethyle	61.28	72.71	86.46	88.72	77.29	309.17
Pendimethalin	76.78	76.79	77.69	77.72	77.25	308.98
Oxyfluorfen	60.50	76.66	78.47	85.39	75.25	301.02
Propaquizafop	62.40	74.99	76.80	78.22	73.10	292.41
Paraquate dichloride	56.14	60.25	63.34	65.11	61.21	244.84
Metasulfuron methyl	53.11	55.11	56.80	79.56	61.14	244.58
Glyphosate	44.36	61.81	66.63	67.48	60.07	240.28
Control	0.00	0.00	0.00	0.00	0.00	0.00
	Herbicide (H)		Concentration (C)			H × C
S.Em. ±	0.50		0.33			1.00
C.D. at 5%	1.41		0.94			2.82

* Mean of four replications; # Maximum toxicity index = 400.00

Metiram and carbendazim were performed well against test fungus and gave 73.08 and 69.59 per cent mean growth inhibition respectively, in present investigation. The effectiveness of carbendazim towards *F. solani* has been recorded by Rawal and Thakore (2003) and Soni and Verma (2010).

Similarly, non systemic fungicides, copper hydroxide and thiram were found effective and gave 91.94 and 78.04 per cent mean growth inhibition of test pathogen, respectively (Table 2). However, thiram was found quite effective at 2000ppm and gave 95.19 per cent growth inhibition. Patil *et al*. (2001) also achieved effective control of *Fusarium solani* using thiram.

The results of combination of fungicides presented in Table 3 revealed that cymoxanil 8% WP + mancozeb 64% WP, metiram 55% WG + pyraclostrobin 5% WG and carbendazim 12% WP + mancozeb 63% WP were proved the most effective and gave cent per cent growth inhibition of test fungus at lowest concentration of 250ppm. The effectiveness of carbendazim + mancozeb against *F. solani* has been reported by Chavan *et al*. (2009). Iprodine 25% WP + carbendazim 25% WP also gave cent per cent inhibition of fungus at 2000ppm concentration with mean inhibition of 90.69 per cent. Similar result was recorded by Manica *et al*. (2008) working with *F. solani* causing root rot of acacia.

The herbicides oxadiargyl was proved to be most effective and gave cent per cent growth inhibition at lowest concentration of 500ppm in present experiment. It was followed by quizalophop-p-ethyle and gave cent per cent inhibition at 1500 and 2000ppm concentration. Pendimethalin and oxyfluorfen were found moderately effective with mean growth inhibition of 77.25 and 75.25 per cent respectively in present finding (Table 4). The effectiveness of pendimethalin against *F. oxysporum* f. sp. *vesinfectum* and oxyfluorfen against *F. solani* has been reported by Macedo *et al*. (1984) and Kelaiya (1998), respectively.

The present results indicates that tebuconazole 25.9% EC, thiram 75% WP and combination of fungicides viz. cymoxanil 8% WP + mancozeb 64% WP, metiram 55% WG + pyraclostrobin 5% WG and carbendazim 12% WP + mancozeb 63% WP were quite effective in controlling pathogen. The herbicides oxadiargyl was also proved to be most effective. The alternate application of these chemicals reduced the risk of development of resistant in pathogen. Such information will be helpful in formulation of schedule for management of disease.

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