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Screening the Efficacy of different Fungicides against *Fusarium oxysporum* f. sp. *ricini* in Castor

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A B S T R A C T

Castor (*Ricinus communis* L.) is one of the major oilseed crops grown all over India. The castor crop is majorly affected by the castor wilt disease caused by *Fusarium oxysporum* f.sp. *ricini*, which cause severe crop yield loses. Understanding the importance of the castor wilt disease, we conducted an *in-vitro* bioassay to test the commercially available fungicides inhibition effect on the castor wilt fungus *F.oxysporum* f.sp. *ricini*. The fungicides tested include carbendazim, carboxin, thiram, metalaxyl and blitox at recommended and half-recommended dosage against castor wilt fungus. Among the five fungicides tested by poisoned food technique, carbendazim was found superior at both recommended and half-recommended doses with 100 percent inhibition of the test pathogen.

Keywords

Castor, F. oxysporum f.sp. ricini, in-vitro bioassay, fungicides, inhibition

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Introduction

Castor (*Ricinus communis* L.) is an ancient crop of family Euphorbiaceae, cultivated across the world in arid and semi-arid zones (Weiss, 2000; Castor Outlook, October 2019)in almost thirty different countries. The global castor production is noted to be 15.4 lakh million tones(FAO, 2008; Yerukala *et al.*, 2017; Shalini, 2014). The major castor seed growing countries includes India, Brazil, Philippines, China, Russia, Ethiopia, and Thailand accounting almost 88 percent of the world's production (Castor Outlook, October 2019).

Castor plays an important role in Indian vegetable oil economy. The India ranks first in area with 10.96 lakh ha and production with 11.43 lakh toneof castor in the world, which includes major castor producing states Gujarat, Rajasthan, and Andhra Pradesh etc. Andhra Pradesh accounts for about area 2.22 lakh ha with yield of 675 kgha^{-1}**(**Indiastat, 2013; Shalini *et al.,* 2014). Moreover, in the year 2019, in India the castor oil seed area harvested was 751320 ha; yield 15928 hg(hectogram)/ha; while crop production was 1196680 tones(FAO, 2019). The major castor producing states in India include Gujarat (7.02 lakh ha) followed by Rajasthan (1.54 lakh ha), Andhra Pradesh (0.33 lakh ha), Telangana (0.22 lakh ha) and Odisha (0.04 lakh ha) (Castor Outlook, October 2019). While in Telangana state, the major castor growing districts include Narayanpet (6973 ha) followed by Wanaparthy (5567 ha), Mahabubnagar (5104 ha) and Gadwal (2163 ha) (Castor Outlook, October 2019).

The castor crop is affected majorly by castor fusarium wilt disease caused by the pathogen *Fusarium oxysporum* f.sp. *ricini*, which belongs to the kingdom fungi: phylum ascomycota; subphylum pezizomycotina (EPPO, 2021). Further, castor fusarium wilt is found to cause huge crop losses almost up to eighty five percent depending on pathogen inoculum and prevailing environmental conditions (Dange, 2003).

Additionally, castor fusarium wilt being a soil and seed borne pathogen (Prasad *et al.,* 2019; Dange, 2003), colonizes the plant xylem vessels and block them completely causing plant wilting (Dange, 2003). Generally, for the control of this disease fungicides are used (Maitlo *et al.,* 2014). Further many varieties of chemicals are available in the market for the control of this disease. Despite, there exists a research gap with respect to the necessity to evaluate the efficacy of the chemicals, and dosage applied against the target pathogen before usage. The present study investigated on finding the effectiveness and optimum fungicide recommended dose and half recommended dosage of popularly available fungicides used in fusarium wilt disease control by an *in-vitro* bioassay.

Therefore, the present study was carried out to fill the gaps. And compare the efficiency of various fungicides available commercially in market against *Fusarium oxysporum* f. sp. *ricini*, the fusarium wilt of castor disease by an *in-vitro* bioassay. The best fungicide performed against fusarium wilt pathogen in the *in-vitro* bioassay, is further used for green house and open environment pot experiment studies in testing the castor fusarium wilt management.

Materials and Methods

All the experiments were performed at the Department of Plant Pathology, College of Agriculture, Hyderabad, India. The efficacy of different commercially available fungicides (Table 1) was tested by poisoned food technique (Nene and Thapliyal, 1993; Yerukala *et al.,* 2018) against *F. oxysporum* f. sp. *ricini* by measuring the radial growth of the fungal colony. For each treatment, potato dextrose agar (PDA) medium (100 ml) was taken in conical flask (250 ml) and autoclaved. To this medium, specified concentration of fungicide was added to the medium at lukewarm temperature and mixed thoroughly by shaking the flask. The poisoned medium was equally distributed into four petri dishes, which were treated as four replications and the medium was kept for solidification. Simultaneously, from periphery of actively growing fungal colony of target pathogen (*F. oxysporum* f.sp. *ricini*), a 5 mm fungal discs was cut with sterilized corn borer. A fungal disc was transferred to the center of each petri dish containing poisoned medium. For control treatment, the petri dish containing untreated (not poisoned) medium was maintained by placing fungal disc. The inoculated petri dish was incubated at 25 ± 2^{o}C in BOD (Bio-Oxygen Demand). The diameter of the fungal colony was measured in two directions and mean was recorded when the fungal growth in control petri dish was full.

Percent inhibition over control was calculated using the formula mentioned below.

$$R = (X - Y) / X \times 100$$

Where, R = Per cent growth reduction of test pathogen,

X = Radial growth of test pathogen in control (mm)

Y = Radial growth of test pathogen in treatment (mm)

The research data results obtained was transformed by angular transformations and statistically analyzed by CRD Completely Randomized Design (Snedecor and Cochran, 1967). Both actual percentage values and their corresponding transformed values are presented in Table 2.

Results and Discussion

The present research results on evaluating different fungicides against *F. oxysporum* f. sp. *ricini in-vitro* condition are presented in Table 2 and Figures 1 and 2. In our research, we found that all the fungicides tested were significantly superior over control in inhibiting the fungal growth of *F. oxysporum* f.sp. *ricini*. However, high inhibition (100 percent) of radial growth of test pathogen *F. oxysporum* f.sp. *ricini* was recorded by the fungicide carbendazim at both the recommended and half the recommended doses, while minimum inhibition was recorded by metalaxyl at the recommended (82.86 percent) and half the recommended doses (77.86 percent). At recommended dose carbendazim and vitavax recorded maximum (100 percent) fungal growth inhibition of test pathogen significantly followed by blitox (93.70 percent), thiram (91.94 percent) and metalaxyl (82.86 percent) and all the treatments were found statistically significant.

At half recommended dose carbendazim recorded maximum (100 percent) fungal growth inhibition of test pathogen significantly followed by vitavax (98.88 percent), thiram (89.80 percent), blitox (88.33 percent) and metalaxyl (77.86 percent). All the treatments were found statistically significant.

Similar research results showing fungicide carbendazim, high effectiveness on fungal growth inhibition on fusarium pathogen was reported by various research includes Raju *et al.*, 2008 reported against *F. oxysporum* f. sp. *udum*; while against *F. solani* and *R. solani* by Mallesh *et al.*, 2008; *F.oxysporum* f. sp. *pini* (Dar *et al.*, 2013)*; F. oxysporum* f. sp. *lentis* (Dahal and Shrestha, 2018); *F. pallidospermum* (Jamil and Kumar, 2010); *F. oxysporum* f. sp. *capsica* (Bashir *et al.*, 2018); *F. avenaceum* (Kopacki and Wagner, 2006); *F. oxysporum* f. sp. *lycopersici* (Deo, 2013; Harshita *et al.*, 2019); *F. solani* (Bhaliya and Jadeja, 2014). Some of the studies are detailed below which agree with our research results includes Dahal and Shrestha, 2018 tested different fungicides efficiency against *F.oxysporum* f. sp. *lentis* by an *in-vitro* bioassay using poisoned food technique. The authors used fungicides include carbendazim (50% WP), chlorothalonil (75% WP) and dithane M-45 (75% WP) at three different concentrations (100 ppm, 150 ppm and 200 ppm).

All the tested fungicides showed significant inhibition of fungal growth of the test pathogen, however carbendazim recorded high effectiveness in inhibition of fungal growth in all the concentrations tested by reducing the mycelial growth by 100 percent compared to others; followed by chlorothalonil, and least recorded inhibition was with Dithane M-45 (26.62 percent) at 200 ppm. Further authors noted that, with the increased fungicides concentration, increased inhibition of target pathogen.

Table.1 List of fungicides used against *Fusarium oxysporum* f. sp. *ricini*

S.No	Common Name	Trade Name	Formulation	Chemical name
1.	Carbendazim	Bavistin	50 WP	2-(methoxy carbomyl)-benzimidazole
2.	Carboxin	Vitavax	75 WP	5,6-dihydro-2-methyl-1,4-oxathiin-3-carboxamide
3.	Thiram	Thirasan Thirame, Thiuramin	75 WP	tetramethylthiuram disulfide
4.	Metalaxyl	Apron, Ridomil	50 WP	N-(2,6-dimethylphenyl)-N-(methyoxyacetyl)-alanine methyl ester
5.	Blitox	Blitox	50 WP	Copper oxychloride

Table.2 *In vitro* evaluation of fungicides against *Fusarium oxysporum* f. sp.*ricini*

S.No	Fungicides	*Per cent growth inhibition		
		Concentration		
		Recommended	Half recommended	Mean
1.	Carbendazim	100.00 (85.94)	100.00 (85.94)	**100.00**
2.	Vitavax	100.00 (85.94)	98.88 (83.93)	**99.44**
3.	Thiram	91.94 (73.51)	89.80 (71.48)	**90.87**
4.	Metalaxyl	82.86 (65.55)	77.86 (61.94)	**80.36**
5.	Blitox	93.70 (75.63)	88.33 (70.02)	**91.01**
6.	Control	0.00 (4.05)	0.00 (4.05)	**0.00**
	Mean	78.08	75.81	**76.94**
CD at 5%		2.13	2.04	**2.08**
S.Ed±		0.97	0.93	**0.95**
S.Em±		**0.69**	**0.66**	**0.67**

*Mean of four replications, figures in the parentheses are angular transformed values

Fig.1 Efficacy of fungicides on *Fusarium oxysporum* f.sp. *ricini*

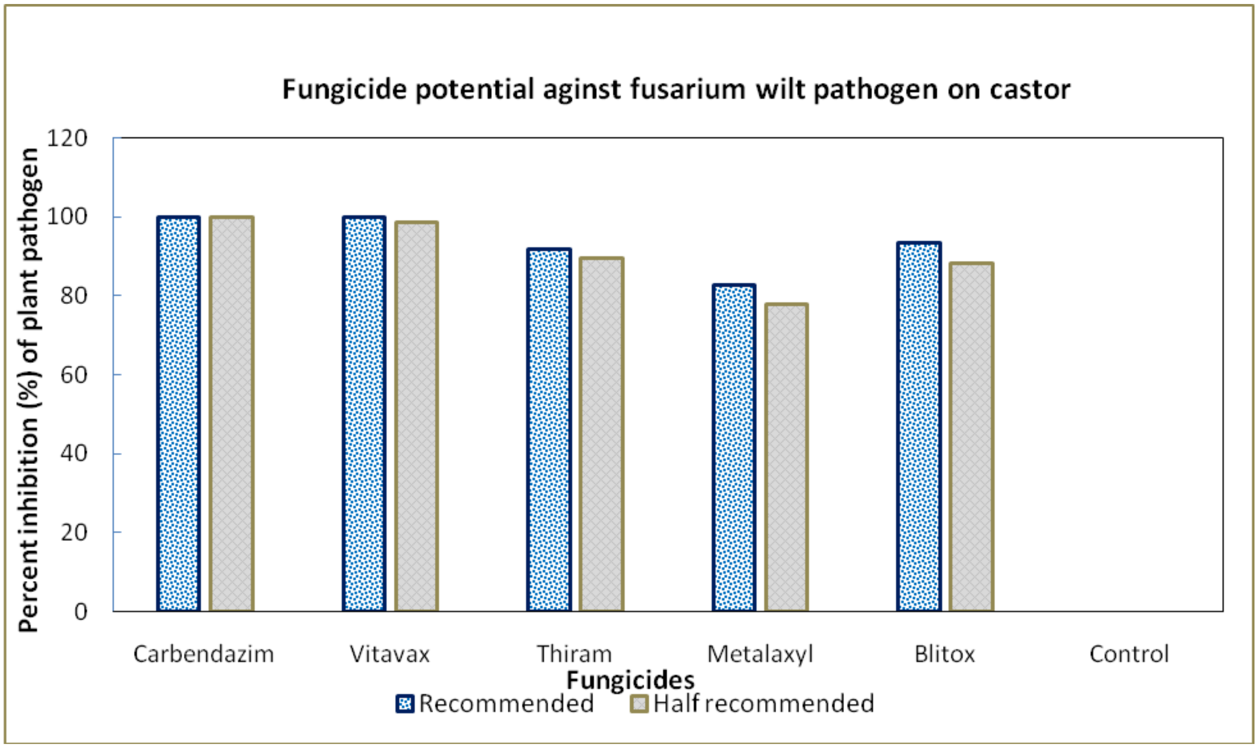
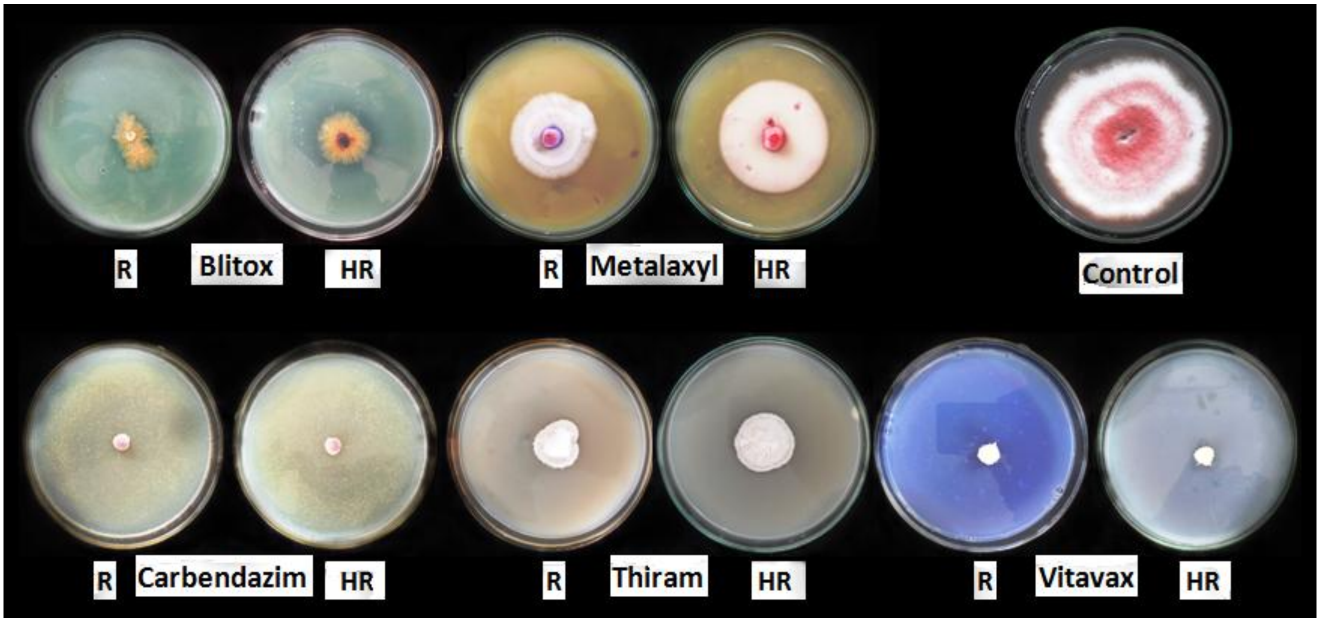


Fig.2 Efficacy of fungicides on *Fusarium oxysporum* f.sp. *ricini*



*R=Full recommendation, HR-Half recommended

Dar *et al.*, 2013 reported *F. oxysporum* f. sp. *pini* sensitivity to the fungicides carbendazim, thiaphonate methyl, hexaconazole, triadimefon, mancozeb, metalaxyl, captan, copper oxychloride and chlorothalonil.

The authors tested different fungicides efficiency against *F.oxysporum* f. sp. *pini*by *in-vitro* bioassay using poisoned food technique. The authors used systemic fungicides include hexaconazole, triadimefan, carbendazim, thiophonate methyl, metalaxyl evaluated at 5 different concentrations (10, 20, 30, 40, 50 ppm); non-systemic fungicides include copper oxychloride, mancozeb, chlorothalonil and captan evaluated at 5 different concentrations (100, 200, 300, 400 and 500 ppm.

Among fungicides tested, carbendazim was most effective with maximum inhibition of target pathogen (*F.oxysporum* f. sp. *pini*) compared to the other chemicals tested. In similar Jamil and Kumar (2010) evaluated fungicides carbendazim, mancozeb, maneb, thiram and ziram against *F.pallidospermum*, the research found that carbendazim was most effective, additionally carbendazim showed broad spectrum fungitoxic activity against four species of *Fusarium* (*F. equseti; F. moniliformae; F. pallidospermum; F. solani)*. Dilip (1989), who reported that carbendazim at 1000 ppm showed maximum fungal growth inhibition of pathogen *F. oxysporum* f. sp. *nicotianae* (tobacco wilt).

Bashir *et al.*, 2018, tested efficacy of different fungicides *in-vitro* against *F. oxysporum* f. sp. *capsica* (chilli pepper wilt) by poisoned food technique. Among 6 treatments tested include carbendazim, benomyl, topsin-m, difenoconazole, nativo, alliete and control at various concentrations, and days, and their interactions. Among all treatments tested, carbendazim at 700 ppm recorded significant reduction of pathogen growth. Similarly, Khadse *et al.,* 2015. tested efficacy of different fungicides against *Neocosmospora vasinfecta* (pigeon pea wilt) *in-vitro* by poisoned food technique. The different fungicides tested include thiram, carbendazim, chlorothalonil, metalaxyl, combinations treatments include thiram + cabendazim(2:1), carbendazim + mancozeb, tricyclazole+ mancozeb, zineb+hexaconazole was evaluated against the target pathogen.

Among all treatments tested, carbendazim (0.1%), combination treatments carbendazim+ mancozeb (0.2 %) and thiram+carbendazim 2:1 (0.3%) recorded high (100 per cent) inhibition of *N. vasinfecta*, other fungicides also recorded significant pathogen inhibition over control.

In the present studies we found that carbendazim showed high effectiveness against *F. oxysporum* f. sp. *ricini* with high percent inhibition (100 percent) at both recommended and half-recommended doses in comparison with other fungicides tested.

Susceptibility of the *F. oxysporum* f. sp. *ricini* to all the fungicides tested was recorded. Our study provide knowledge on better fungicide dosage evaluation for specific purposes. Further research needed to better understand the susceptibility index and application in field experiments.

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