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IN VIVO EVALUATION OF FUNGICIDES, BOTANICALS AND BIOAGENTS AGAINST C. *TRUNCATUM* CAUSING ANTHRACNOSE/ POD BLIGHT OF SOYBEAN

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ABSTRACT
Present field experiment was planned and undertaken during *Kharif* 2012 and *Kharif* 2013 to evaluate the bioefficacy of five effective fungicides *viz*., Propiconazole 25 EC, Carbendazim, Mancozeb 75 WP, Propineb, Carbendazim 12% + Mancozeb 63%, one fungal antagonist (*Trichodermaviride*) and one bacterial antagonist (*P. fluorescens*); two botanicals *viz*., garlic (*Allium sativum*) and onion (*Allium cepa*) as foliar sprayings against *C. truncatum*. In both experiments (*Kharif* 2012 and *Kharif* 2013) fungicides tested, Carbendazim (@ 0.1%) was found most effective with highest average reduction in the disease intensity and pod infection to the tune of 51.37 and 76.89 per cent (*Kharif* 2012) and 47.92 and 72.05 per cent (*Kharif* 2013), respectively and significantly highest yield of 2525 kg/ha (*Kharif* 2012) and 2513 kg/ha (*Kharif* 2013).

INTRODUCTION

Soybean (Glycine max L.) is important oil and protein crop,it contains about high quality protein (40-42%), oil (18-20%) and other nutrients like calcium, iron and glycine (Devi *et al.*, 2012). The annual soybean production in India was 12.21 million tonnes (2011-12) with its area under cultivation was 10.1 million hectares. Madhya Pradesh is known as the soybean bowl of India, contributing 59% of the country's soybean production, followed by Maharashtra with 29% contribution and Rajasthan with a 6% contribution. Andhra Pradesh, Karnataka, Chhattisgarh and other parts of India also produce the bean in small quantities (Anonymous, 2013).

Soybean is known to be affected by more than hundred plant pathogens of which very few cause tremendous losses. Among which *Colletotrichum truncatum* is the most common species recorded on soybean (Lenne, 1992) and soybean crop is susceptible to it at all stages of development particularly from bloom to pod fill stage.The pathogen, *Colletotrichum truncatum* has been reported as major constraint in the successfully cultivation of soybean, causing more than 30 per cent yield losses (Khan and Sinclair, 1992 and Mittal *et al.*, 1993). The pathogen cause considerable damage by reducing plant stand, seed quality, seed germination and yield (Vyas *et al.*, 1997, Kumar and Dubey, 2007). Although,Efficacy of the fungicides,botanicals and bioagents in controlling anthracnose disease and increasing the yields were reported earlier by several workers (Ekbote, 2005;Singh, 2010; Chauhan *et al.*, 2014; Choudhary *et al.*, 2013),the pathogen *Colletotrichum truncatum* causes maximum yield losses of 16-100 per cent (Sinclair, 1992; Anonymous, 1999) and soybean anthracnose is a common recurrence in India. So, it is necessary to conduct experiments to minimize the losses caused by pathogen with new chemicals ,bioagents, botanicals.

Therefore, concerning the increasing importance of soybean crop and most important constraint in the successfully cultivation of soybean, the present study was undertaken in two trials with an objective of integrated management of *Colletotrichum truncatum* causing anthracnose/pod blight of soybean by means of chemicals, bioagents and botanicals. With the present study farmers can be guided to implement integrated management practices to minimize the losses caused by the pathogen causing anthracnose/ pod blight of soybean.

MATERIALS AND METHODS

The field experiment was conducted on the research farm of Department of Agronomy, MarathwadaKrishiVidyapeeth, Parbhani during *Kharif* 2012 and *Kharif* 2013 to evaluate the bioefficacy of five effective fungicides *viz*., Propiconazole 25 EC, Carbendazim, Mancozeb 75 WP, Propineb, Carbendazim 12% + Mancozeb 63%, one fungal antagonist (*Trichodermaviride*) and one bacterial antagonist (*P. fluorescens*); two botanicals *viz*., garlic (*Allium sativum*) and

onion (*Allium cepa*) as foliar sprayings against *C. truncatum* with randomized block design in three replications.Anthracnose susceptible soybean variety, JS-335 was sown at 30x10 cm spacing. A total of three sprayings of all the treatments were undertaken at intervals of 15 days, starting first spraying at first appearance of the disease. One plot per replication was maintained as unsprayed control without receiving any fungicides.Observations on foliage anthracnose disease were recorded before and after each spraying and last observation on anthracnose were recorded at 15 days after last spraying. Observations on pod blight were also be recorded from its first appearance at 15 days interval and continued till 15 days before harvesting.Five plants per treatment, per replication were selected randomly and tagged for recording the observations. Three trifoliate leaves (bottom, middle and top) from main branch on each observation plant were selected for recording observations and per cent anthracnose disease intensity was worked out. Observations on anthracnose intensity were recorded onselected soybean plants, applying standard 0-9 grade disease rating scale (Mayee and Datar, 1986) as described below:

Standard disease rating (0-9 grade) scale

Rating scale	Description
0	No symptoms on the leaf.
1	Small, irregular brown spots covering 1 per cent or less of the leaf area.
3	Small, irregular, brown spots with concentric rings covering 1-10 per cent of the leaf area.
5	Lesions enlarging, irregular, brown with concentric rings covering 11-25 per cent of the leaf area.
7	Lesions coalescing to form irregular brown patches with concentric rings. Covering 26-50 per cent of the leaf area. Lesions also on stem and petioles.
9	Lesions coalescing to form irregular, dark brown patches with concentric rings covering 51 per cent or more of the leaf area. Lesions on stem and petioles.

Table 1: Effect of fungicides, botanicals and bioagents sprayings on per cent pod infection (PPI) and anthracnose intensity (PDI) in soybean cv. JS-335 (*Kharif*-2012)

Treatments	Conc. (%)	Mean PPI*	PDI* Before I spray	After I spray	After II spray	After III spray
Propiconazole (Tilt 25 EC)	0.1	21.82 (12.60)	28.10 (16.31)	29.80 (16.14)	22.48 (12.99)	17.50 (10.08)
Carbendazim (Bavistin 50WP)	0.1	8.94 (5.11)	26.60 (15.42)	27.40 (14.71)	14.40 (8.27)	9.00 (5.16)
Mancozeb (Indofil M-45 75 WP)	0.2	10.14 (5.81)	25.50 (14.7)	28.90 (15.60)	19.70 (11.37)	11.10 (6.37)
Propineb (Antracol 75 WP)	0.2	28.63 (16.63)	26.72 (16.53)	28.46 (15.49)	25.90 (15.00)	17.32 (9.97)
Carbendazim 12% + Mancozeb 63% (Saff 75WP)	0.1	15.93 (9.16)	24.80 (14.35)	28.57 (16.00)	23.23 (13.43)	17.96 (10.35)
T. viride	0.5	31.98 (18.64)	27.30 (15.84)	31.80 (17.33)	26.73 (15.50)	20.97 (12.10)
P. fluorescens	0.5	32.66 (19.06)	26.40 (15.30)	32.48 (17.74)	27.70 (16.08)	21.30 (12.29)
Garlic (*A.sativum*)	10	30.33 (17.65)	28.20 (16.37)	29.80 (16.14)	25.46 (14.74)	17.90 (10.31)
Onion (*A.cepa*)	10	31.82 (18.54)	27.12 (15.73)	30.30 (16.43)	26.60 (15.42)	19.18 (11.06)
Control		38.69 (22.76)	28.58 (16.60)	33.75 (16.70)	35.00 (17.45)	38.19 (20.61)
S.E. +		0.57	0.24	0.53	0.76	0.9
C.D. (P = 0.05)		1.7	0.73	1.57	2.28	2.68

Treatments	Mean	Per cent reduction over control PPI	PDI After I spray	PDI After II spray	PDI After III spray	Mean
Propiconazole (Tilt 25 EC)	23.97 (13.88)	43.60 (25.90)	11.56 (6.64)	35.80 (20.98)	54.05 (32.85)	33.80 (15.12)
Carbendazim (Bavistin 50WP)	18.85 (10.89)	76.89 (50.30)	18.81 (1.08)	58.89 (36.09)	76.41 (49.83)	51.37 (21.75)
Mancozeb (Indofil M-45 75 WP)	20.80 (12.01)	73.79 (47.63)	14.33 (8.23)	43.89 (26.26)	70.86 (45.50)	43.03 (20.00)
Propineb (Antracol 75 WP)	24.60 (14.25)	26.00 (14.99)	15.15 (8.73)	25.96 (15.05)	54.66 (33.13)	31.92 (14.23)
Carbendazim 12% + Mancozeb 63% (Saff 75WP)	23.39 (13.53)	58.82 (36.01)	14.93 (8.60)	33.68 (19.72)	52.83 (32.10)	33.81 (15.11)
T. viride	26.20 (15.19)	17.34 (9.94)	5.83 (3.34)	23.70 (13.72)	45.09 (26.83)	24.87 (10.97)
P. fluorescens	26.47 (15.35)	15.58 (8.89)	3.77 (2.16)	20.79 (12.02)	44.27 (26.290	22.94 (10.12)
Garlic (*A.sativum*)	24.84 (14.66)	21.60 (12.48)	11.91 (6.84)	27.29 (15.83)	53.11 (32.24)	30.77 (13.73)
Onion (*A.cepa*)	25.30 (17.84)	17.75 (10.14)	10.24 (5.87)	24.07 (13.93)	49.75 (29.91)	28.02 (12.43)
Control	33.88 (22.93)		-	-	-	-
S.E. +		1.67	1.38	2.19	2.42	
C.D. (P = 0.05)		4.96	4.15	6.56	7.25	

PDI :- Percent disease intensity ; PPI :- Percent pod infection

Based on numerical ratings or scale observed per cent disease intensity was worked out applying the formula given by Mc Kinney (1923).

$$\text{Per cent intensity(PDI)disease} = \frac{\text{Summation of numerical ratings}}{\text{Number of leaves/plants observed x maximum rating}} \times 100$$

Further, per cent disease control (PDC) was worked out by applying the formula.

$$\text{Per cent disease control(PDC)} = \frac{\text{PDI in control plot} - \text{PDI in treatment plot}}{\text{PDI in control plot}} \times 100$$

Per cent disease incidence/Per cent pod infection was calculated by using formula.

$$\text{Per cent disease incidence} = \frac{\text{Number of plant infected}}{\text{Total number of plant examined}} \times 100$$

At harvest of the crops, observations on total number of pods/ plants, number of infected and healthy pods, 100 seed weight and seed yield were recorded in all the treatments and yield data was present on hectare basis.

The data obtained in the experiment was subjected to statistical analysis (Panse and Sukhatme, 1978). The percentage values were transformed into arcsine values. The standard error (SE) and critical difference (C.D.) at level P = 0.05 were worked out and results obtained were compared statistically.

RESULTS AND DISCUSSION

Anthracnose intensity and pod infection (*Kharif* 2012 and *Kharif* 2013)

In both experiments (*Kharif* 2012 and *Kharif* 2013) (Table 1 and 2) fungicides were found effective than botanicals and bioagents. However, of the fungicides tested, Carbendazim (@ 0.1%) was found most effective with highest average reduction in the disease intensity and pod infection to the tune of 51.37 and 76.89 per cent (*Kharif* 2012) and 47.92 and 72.05 per cent (*Kharif* 2013), respectively. The other treatments found effective were the fungicides, Mancozeb (@ 0.2%), Carbendazim 12% + Mancozeb 63% (@ 0.1%) and Propiconazole (@ 0.1%), bioagent*T. viride* and the botanical *A. sativum*. The results are in agreement with Bhardwaj and Thakur (1991b), Shirshikar (1995), Satya and Patil (2007) and Gawande *et al.* (2009), who reported that the fungicide, Carbendazim (@ 0.1%) was found the most effective and economical in controlling the pod blight of soybean, followed by fungicide Mancozeb.The fungicide,Carbendazim found effective against *C. truncatum* in present studies were also reported effective against several *Colletotrichum* species causing anthracnose in other crop plants. Chauhan *et al.,* 2014; Choudhary *et al.*, 2013 reported that Carbendazim (@ 0.1%) was most effective against *Colletotrichum*

Table 2 : Effect of fungicides, botanicals and boiagents sprayings on per cent pod infection (PPI) and anthracnose intensity (PDI) in soybean cv. JS-335 (*Kharif*-2013)

Treatments	Conc. (%)	Mean PPI*	PDI* Before I spray	After I spray	After II spray	After III spray
Propiconazole	0.1	24.42 (14.13)	28.50 (16.56)	31.78 (18.53)	27.60 (16.02)	19.20 (11.07)
Carbendazim	0.1	11.54 (6.62)	28.30 (16.43)	31.00 (18.05)	16.80 (9.67)	12.50 (7.18)
Mancozeb 75 WP	0.2	12.70 (7.29)	27.83 (16.15)	29.47 (17.14)	22.20 (12.83)	14.90 (8.50)
Propineb	0.2	31.23 (18.19)	31.70 (18.48)	32.16 (18.76)	27.88 (16.19)	19.10 (11.02)
Carbendazim + Mancozeb	0.1	18.53 (10.67)	28.66 (16.65)	30.50 (17.76)	26.70 (15.48)	19.70 (11.36)
T. viride	0.5	34.58 (20.23)	31.65 (18.45)	32.61 (19.04)	29.07 (16.90)	23.75 (13.74)
P. fluorescens	0.5	35.26 (20.64)	31.20 (18.18)	34.20 (20.00)	29.10 (16.91)	22.78 (13.16)
Garlic	10	32.93 (19.22)	30.30 (17.64)	32.46 (18.96)	28.60 (16.62)	19.60 (11.31)
Onion	10	34.41 (20.13)	29.70 (17.27)	34.68 (20.29)	27.20 (15.78)	22.10 (12.77)
Control		41.29 (24.38)	30.78 (17.92)	37.50 (22.02)	38.70 (22.76)	41.38 (24.44)
S.E. +		0.64	0.71	0.65	0.95	1.2
C.D. (P=0.05)		1.9	2.12	1.94	2.82	3.56

Treatments	Mean	Per cent reduction over control PPI	PDI After I spray	PDI After II spray	PDI After III spray	Mean
Propiconazole	26.27 (15.54)	40.85 (24.09)	15.27 (8.78)	28.54 (16.59)	56.73 (34.96)	33.51 (20.11)
Carbendazim	21.15 (12.83)	72.05 (46.09)	17.25 (9.93)	56.59 (34.54)	69.92 (44.48)	47.92 (29.65)
Mancozeb 75 WP	23.10 (13.65)	69.24 (43.93)	21.67 (12.42)	42.73 (25.48)	63.82 (39.78)	42.74 (25.89)
Propineb	27.21 (16.11)	24.36 (16.11)	14.08 (8.10)	27.60 (16.09)	53.36 (32.59)	31.68 (18.93)
Carbendazim + Mancozeb	25.89 (15.31)	55.00 (33.42)	18.64 (10.74)	30.65 (17.93)	52.05 (31.54)	33.78 (20.07)
T. viride	28.77 (17.03)	16.25 (9.32)	13.14 (7.55)	24.87 (14.40)	42.47 (25.28)	26.83 (15.74)
P. fluorescens	28.82 (17.06)	14.60 (8.39)	8.79 (5.05)	24.78 (14.35)	45.08 (26.81)	26.22 (15.40)
Garlic	27.24 (16.13)	20.24 (11.68)	13.66 (7.86)	26.20 (15.19)	53.34 (32.40)	31.07 (18.48)
Onion	27.92 (16.52)	16.66 (9.53)	7.53 (4.31)	29.42 (17.15)	46.27 (27.68)	27.74 (16.38)
Control	37.09 (21.79)		-	-	-	-
S.E. +		1.63	1.74	2.73	3.59	
C.D. (P=0.05)		4.86	5.22	8.17	10.77	

PDI :- Percent disease intensity ; PPI :- Percent pod infection

Table 3: Effect of fungicides, botanicals and bioagents on per cent pod infection (PPI) and anthracnose intensity (PDI) on seed yield and test weight in soybean Cv. JS-335 (*Kharif* 2012)

Treatments	Conc. (%)	Mean PPI	Mean PDI	Seed yield* (kg/ha)	Test weight* (g)	Per cent increase over control Seed yield	Test weight
Propiconazole	0.1	21.82 (12.60)	23.97 (13.88)	2168	13.16	20.71	10.33
Carbendazim	0.1	8.94 (5.11)	18.85 (10.89)	2525	14.1	31.92	16.31
Mancozeb 75 WP	0.2	10.14 (5.81)	20.80 (12.01)	2425	14	29.11	15.71
Propineb	0.2	28.63 (16.63)	24.60 (14.25)	2074	13.1	17.11	9.92
Carbendazim + Mancozeb	0.1	15.93 (9.16)	23.39 (13.53)	2326	13.3	26.09	11.27
T. viride	0.5	31.98 (18.64)	26.20 (15.19)	1954	12.6	12.03	6.35
P. fluorescens	0.5	32.66 (19.06)	26.47 (15.35)	1899	12.11	9.47	2.56
Garlic	10	30.33 (17.65)	24.84 (14.66)	2050	13	16.14	9.23
Onion	10	31.82 (18.54)	25.30 (17.84)	1968	12.9	12.65	8.52
Control		38.69 (22.76)	33.88 (22.93)	1719	11.8	-	-
S.E. +		0.57		4.23	0.07	0.17	0.5
C.D. (P = 0.05)		1.7		12.56	0.21	0.52	1.4

* :- Average of three replication

Table 4: Effect of fungicides, botanicals and bioagents on per cent pod infection (PPI) and anthracnose intensity (PDI) on seed yield and test weight in soybean Cv. JS-335 (*Kharif* 2013)

Treatments	Mean PPI	Mean PDI	Seed yield* (kg/ha)	Test weight* (g)	Per cent increase over control Seed yield	Test weight
Propiconazole	24.42 (14.13)	26.27 (15.54)	2155	12.96	20.74	10.49
Carbendazim	11.54 (6.60)	21.15 (12.83)	2513	13.9	32.03	16.54
Mancozeb 75 WP	12.70 (7.20)	23.10 (13.65)	2414	13.8	29.25	15.94
Propineb	31.23 (18.19)	27.21 (16.11)	2063	12.9	17.21	10.07
Carbendazim + Mancozeb	18.53 (10.67)	25.89 (15.31)	2314	13.1	26.19	11.45
T. viride	34.58 (20.23)	28.77 (17.03)	1943	12.4	12.09	6.45
P. fluorescens	35.26 (20.64)	28.82 (17.06)	1887	11.91	9.48	2.6
Garlic	32.93 (19.22)	27.24 (16.13)	2048	12.87	16.6	9.86
Onion	34.41 (20.13)	27.92 (16.52)	1955	12.7	12.63	8.66
Control	41.29 (24.38)	37.09 (21.79)	1708	11.6		
S.E. +	0.64		2.16	0.02	0.09	0.16
C.D. (P = 0.05)	1.9		6.42	0.07	0.27	0.48

* :- Average of three replication

species.Efficacy of botanicals, garlic, onion and bioagents*T. viride* and *P. fluorescens* against *Colletotrichum* species reported earlier by several workers (Chandrasekaran *et al.*, 2000; Gupta *et al.*, 2005; Santra *et al.*, 2008; Gawande *et al.*, 2009; Vihol *et al.*, 2009 and Padder *et al.*, 2010).

Seed yield and test weight (*Kharif* 2012 and *Kharif* 2013)

The results (Table 3 and 4) obtained on the efficacy of fungicides, botanicals and bioagents in controlling anthracnose/pod blight disease and increasing the seed yield and test weight in soybean indicated that all the treatments effectively control the disease, increased the seed yield and test weight in soybean during *Kharif* 2012and *Kharif* 2013. Among the fungicides tested, Carbendazim (@ 0.1%) recorded highest seed yield of 2525 kg/ha (*Kharif* 2012) and 2513 kg/ha (*Kharif* 2013)and highest test weight and thereby increased the seed yield and test weight over unsprayed control with least mean anthracnose disease intensity and mean pod infection. The second best fungicide found was Mancozeb 75 WP (@ 0.2%) followed by fungicides, Carbendazim 12% + Mancozeb 63% (@ 0.1%), Propiconazole (@ 0.1%) and Propineb (@ 0.2%). Efficacy of these fungicides in controlling anthracnose disease and increasing the yields were reported earlier by several workers (Khare*et al.*, 1972; Chaudhary,1977; Kumar and Mukhopadhyay, 1990; Bharadwaj and Thakur, 1991; Mittal,2001;Dubey and Ekka,2003; Ekbote, 2005; Gawande*et al.*, 2009 and Singh, 2010). The botanicals and bioagents found effective against *C. truncatum* in present studies were also reported effective against *Colletotrichum* species earlier by several workers (Chandrasekharan*et al.*, 2000; Joshi and Tripathi, 2002; Chandrasekharan and Rajappan, 2002b; Rao and Narayana, 2005 and Kaur *et al.*, 2006).

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