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Efficacy of different fungicides and bio-control agents for the management of Chickpea Wilt (*Fusarium oxysporum* f.sp. *ciceri*)

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Chickpea Wilt caused by *Fusarium oxysporum* f.sp. *ciceri* is one of the most serious diseases in West Bengal. If the inoculums pressure is high in the soil, results in the death of infected plant and that depends on the crop variety and stage of the crop. In field study, two antagonists and five fungicides alone or in combinations were studied against wilt disease of chickpea. The field studies found that seed treatment of Carbendazim (@ 2g/Kg seed) and soil application of *Trichoderma viridae* (7.5kg/ha) gave less wilt incidence (7.5%) and maximum yield (1325.0 kg/ha) followed by seed treatment of *Trichoderma viridae* (@ 5g/Kg seed) with soil drenching of Carbendazim (1.5 kg/ha) were also significant treatment that in reducing the wilt incidence (10.0%) and gave maximum yield (951.4 kg/ha) as compared to control and also observed that increased the disease reduction and seed yield percentage on over control with maximum net return obtained in both the treatments.

Key words: Chickpea wilt, *Fusarium oxysporum* f.sp.*ciceri*, fungicides, bio-control agents

INTRODUCTION

Chickpea or Bengal gram (*Cicer arietinum* L.) is the most important pulse crop in India as well as in West Bengal, it is affected by large number of diseases but among them wilt disease caused by *Fusarium oxysporum* f.sp. *ciceri* (Padw.) Snyd. & Hans. is a major constraints of Chickpea production in India as well as in the world. The pathogen cause chickpea wilt is a seed borne as well as soil borne and colonizing the xylem vessels and blocking them completely to cause wilting and losses drastically upto 100% depending on the crop variety, stage of the crop and inoculums pressure in the soil (Pande *et al*, 2007; Jimenez-Fernandez *et al*, 2011).Combination of bio- control agents and chemical fungicides has been considered a possible option to overcome the diseases caused by soil borne fungi. The present study was conducted to observe the efficacy of different fungicides and bio- control agents for the economical management of wilt disease of chickpea.

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MATERIALS AND METHODS

Layout and design of the experimental plot

The experiment was laid out in the permanent wilt sick plot of Pulses and Oilseeds Research Station, Berhampore, Murshidabad, West Bengal, and the sick plot was further fortified by putting laboratory-prepared Fusarium culture, during *rabi* (dry) season for three consecutive year of 2012-13, 2013-14 and 2014-15. There were eight treatments (T1-T8) and a control (Untreated seed + untreated soil) (T9) with a randomized block design by using the var. Anuradha, a moderately susceptible variety against the wilt pathogen (*Fusarium oxysporum* f.sp.*ciceri*) of Chickpea. Seeds were sown on third week of November during the testing years with standard dosage of NPK fertilizer. The plot size was 4m. X 2 m with row to row spacing of 30 cm and plant to plant distance was 10 cm.

The treatments were T1: ST (Soil treatment) with *Trichoderma viride* (Bio-Cure-F) @ 5g/kg of

seed + Soil Spraying @ 5g/lt of water, T2: ST with *Pseudomonas fluorescence* (Bio-Cure-B) @ 10 g/kg seed + Soil Spraying @ 10g/lt of water, T3: ST with Carbendazim 25%+Mancozeb50% WP @ 2.5 g/ kg + Soil Spraying @ 2.5g/lt of water, T4: ST with Carboxin 37.5% +Thiram 37.5% @ 2.0 g/ kg of seed + Soil Spraying @ 2.0 g/lt of water, T5: ST with Carbendazim @ 2g/ kg of seed + Soil Application with *Trichoderma viride* @ 7.5 kg/ha mixed with well decomposed F.Y.M @ 50 kg/ha as 7 days before sowing, T6: ST with Hexaconazole 4% + Zineb 68% WP @ 2 g/kg seed+ Soil Spraying @ 2.0 g/lt of water, T7: ST with *Trichoderma viride* @ 5g/kg seed+ Soil Spraying with Carbendazim @ 2.0 g/lt of water or 1.5 kg/ha, T8: ST with Metalaxyl 8% +Mancozeb 64% WP @ 2.5g/ kg of seed + Soil Spraying @ 2.5 g/lt of water, T9= Control (Untreated seed + untreated soil), for this treatment, seed served as untreated as well as soil not treated with any fungicides or bio-agents or any soil amendments. Initial plant population was recorded 20 DAS i.e. seedling stage and final plant population was recorded at the time reach maximum disease infestation i.e. before maturity stage. All general agronomic practices were made for this experiment such as weeding and control of insect pest, by foliar spray with on systemic insecticide (i.e. Imidachloprid 17.8 SL @ 4ml/10 liter of water).

Assessment of wilt disease

The wilt incidence of chickpea was recorded at 60 DAS and finally 90 DAS i.e. by using the formula- Percentage of disease incidence= Number of total infected plants/Number of total germinated plants observed X 100. The percentage of wilt disease reduction over control was calculated by using the formula as below:Value of the Untreated (Control) plot – treated plot/ Untreated (Control) plot X 100.

RESULTS AND DISCUSSION

In the present study, it was observed that all the treatments were significantly superior over control (untreated seeds+ untreated soil drenching). Generally Chickpea wilt incidence was appeared 19th days after sowing in control treatments. It showed that the mortality of wilt incidence (%) of Chickpea varied due to application of different doses of bio-control agents as well as various concentrations of fungicides or its combinations that were selected as seed treatment followed by first soil drenching as described above after 15 days of sowing and second one at 40-45 DAS (Table 1). Treatment T5 showed lowest wilt incidence (7.5%) and proved to best significant reduction of the disease with mean 84.3% in the three consecutive years 2012-13, 2013-14 and 2014-15 followed by the treatment T7 (wilt incidence =10.0%), T3 (wilt incidence =13.7%) and T4 (wilt incidence =15.9%) with 79.1%, 71.4% and 66.7% mean reduction of the disease over control were recorded and also proved to second, third and fourth best treatment during the investigation period. In case of treatment T1 (wilt incidence = 21.0%) and T8 (wilt incidence = 21.0%) both the treatment showed mean 56.2% and 56.1% disease reduction on over control along with their yield performance were statistically at par followed by rest treatment T2 and T6. Maximum wilt disease incidence (47.9 %) was recorded in control (untreated seed + untreated soil) plot.

The three years yield data of each treatment were pooled and compared with each other. Highest pooled seed yield of 1325.0 kg ha^{-1} was recorded with treatment T5 followed by T7 (951.4 kg ha^{-1}), T3 (867.1 kg ha^{-1}), T4 (822.3 kg ha^{-1}), T1 (697.5 kg ha^{-1}), T8 (688.0 kg ha^{-1}), T6 (644.4 kg ha^{-1}) and T2 (580.6 kg ha-1) respectively. Minimum yield (386.5 kg ha^{-1}) was obtained in control plot. So yield performance in critically difference of each treatment were statistically significant except treatment T1 and T8, where yield differences of both the treatments showed statistically at par (Table 1). Combined evaluation of bio-control agents and fungicides could be revealed that seed treatment with Carbendazim + Soil drenching with *Trichoderma viride* was proved to be most effective on all the other treatments regarding disease reduction, increased yield on over control as well as ecofriendly are similar to the results obtained by Poddar *et al,* (2004). Similarly seed treatment with *Trichoderma viride* + Soil drenching with Carbendazim was also recorded second best treatments against the *Fusarium* wilt disease incidence of chickpea. Similar observation was also reported by Poddar *et al,* (2004) where he observed that Chickpea seed treated with *Trichoderma* and then infected soil was drenched with Carbendazim, this practice proved to be very effective against chickpea wilt disease incidence.

As compare the efficacy of bio-agents (except fungicides), two bio-agents i.e. *Trichoderma*

Table 1: Effect of different treatments on wilt disease of chickpea under sick plot conditions of West Bengal (Pooled Mean)

Treatments	Disease incidence (%)				% Disease reduction over control	Yield (Kg/ha)				% Seed yield increase over Control
	2012-13	2013-14	2014-15	Mean		2012-13	2013-14	2014-15	Mean	
T_1	22.9 (28.2)	19.6 (25.9)	20.4 (26.5)	21.0 (26.9)	56.2	667.8	690.6	734.2	697.5	80.5
T_2	25.6 (30.1)	23.9 (28.9)	22.9 (28.2)	24.1 (29.1)	49.7	576.9	584.4	580.6	580.6	50.2
T_3	13.0 (20.7)	15.6 (22.9)	12.4 (20.2)	13.7 (21.3)	71.4	861.7	846.5	893.2	867.1	124.3
T_4	17.6 (24.4)	15.9 (23.1)	14.3 (21.8)	15.9 (23.1)	66.7	796.0	819.4	851.4	822.3	112.7
T_5	8.5 (16.4)	7.9 (15.8)	6.2 (13.8)	7.5 (15.3)	84.3	1315.4	1325.6	1334.0	1325.0	242.8
T_6	25.9 (30.3)	26.2 (30.5)	22.5 (28.0)	24.9 (29.6)	48.1	626.0	639.4	667.8	644.4	66.7
T_7	12.2 (20.0)	9.5 (17.5)	8.3 (16.2)	10.0 (18.0)	79.1	951.3	890.4	1012.6	951.4	146.1
T_8	22.1 (27.7)	21.2 (27.1)	19.8 (26.1)	21.0 (26.9)	56.1	646.3	705.4	712.2	688.0	78.0
$T_{9(Control)}$	52.7 (46.3)	46.5 (42.7)	44.4 (41.5)	47.9 (43.5)	0.0	380.1	395.3	384.2	386.5	0.0
SEm(±)	0.5200	0.5874	0.8429	0.824	--	10.3962	10.9863	31.4435	13.55	--
CV (%)	4.0	5.0	7.7	6.9	--	2.4	2.5	6.8	3.0	--
CD (0.05)	1.559	1.761	2.527	2.463	--	44.401	46.921	134.291	40.617	--

Figures in parentheses are angular transformed value

Table 2: Economical evaluation under different treatments for management of wilt disease in Chickpea (Pooled data of 2012-13, 2013-14 and 2014-15)

Treatments	Total cost of insecticides and labour (P)	Yield (Kg/ha)	Avoidable losses (%)	Gross realization (Rs./ha)	Net realization over control (Rs./ha)(A)	Net Profit (Rs/ha) (A-P)	ICBR (A/P)	NICBR (A-P)/P
T_1	4730	697.5	44.6	41850.0	18660.0	13930.0	3.9	2.9
T_2	8240	580.6	33.4	34836.0	11646.0	3406.0	1.4	0.4
T_3	5400	867.1	55.4	52026.0	28836.0	23436.0	5.3	4.3
T_4	6212	822.3	53.0	49338.0	26148.0	19936.0	3.3	2.3
T_5	7595	1325.0	70.8	79500.0	56310.0	48715.6	7.4	6.4
T_6	5276	644.4	40.0	38664.0	15474.0	10198.0	2.9	1.9
T_7	4735	951.4	59.4	57084.0	33894.0	29159.8	7.2	6.2
T_8	5822	688.0	43.8	41280.0	18090.0	12268.0	3.1	2.1
$T_{9(Control)}$		386.5		23190.0				

Cost of fungicides and Bio-Control agents- Carbendazim 50% WP: Rs. 500/kg, Hexaconazole 4% + Zineb 68% WP- Rs. 1050 /kg, Carbendazim 25% + Mancozeb 50% WP -Rs. 850/kg, Carboxin 37.5% + Thiram 37.5% WS-Rs. 1350/kg; *Trichoderma viridae*- Rs. 350/ kg, *Pseudomonas fluresence* - Rs. 400/kg, Metalaxyl 8% + Mancozeb 64% WP-Rs.980/kg. Efficacy of sprayer: 1 ha/day, Rent for sprayer : Rs. 50/day, For spraying one hectare area 5 man days @ Rs. 200 were considered for fungicide spray, Chickpea seed @ Rs.60 per kg, Water necessary for spray 750 lt. ha^{-1}, ICBR- Incremental cost benefit ratio, NICBR- Net incremental cost benefit ratio.

viride and *Pseudomonas fluorescence* were use as seed treatment as well as soil drenching to manage against the disease during the investigation period but ST and Soil drenching by *Trichoderma viride* prove to be more significant effective management against the disease than the *Pseudomonas fluorescence*.

Table 2 shows that the bio-control agents along with different type of fungicides treatments were evaluated for net profits of various amounts as well as different incremental cost benefit ratio (ICBR) and Net incremental cost benefit ratio (NICBR). The profit or net monetary return varied from Rs. 3406.0 ha-1 to Rs. 48715.6 ha^{-1} in different treatments. The highest net profit was obtained from the T5 (Rs. 48715.6 ha^{-1}), followed by T7 (Rs. 29159.8 ha^{-1}), T3 (Rs. 23436.0 ha^{-1}) and T4 (Rs. 19936.0 ha^{-1}) respectively whereas economics of various bio-control agents as well as fungicides revealed that the highest net realization over control was obtained from the treatment T5, followed by T7, T3, T4, T1 and T8 respectively. In contrast to the net profits, a different trend was observed with ICBR and NICBR. ICBR was worked out for each treatment during 2012-13, 2013-14 and 2014-15 by calculating prevailing market prices of fungicides, bio-control agents and Chickpea seed along with

minimum cost of F.Y.M (Table 2). The best NICBR was determined from the treatment T5 (1: 6.4), followed by T7 (1: 6.2), T3 (1: 4.3), T1 (1: 2.9) and T4 (1: 2.3) whereas poor NICBR was recorded in T2 (1: 0.4) treatment. The difference between the net profit and NICBR can perhaps be attributed to the cost of the fungicides along with labour cost involved. The similar results also reported on mustard (Das, 2015). From this calculation it was found that the treatment T5 i.e. seed treatment with Carbendazim + soil treatment with *Trichoderma viride* along with F.Y.M was the most effective economic and useful treatment along with low cost and highest benefit ratio followed by T7, T3 and T4 respectively (Table 2).

Overall and individual effect of all treatments may be concluded that seed treatment of fungicide and soil application of bio-control agents along with F.Y.M and vice versa were proved to be more effective management and higher yield than individual one i.e. either fungicide alone or bio-control alone in other words i.e. approaches of either seed treatment only or soil treatment. So the management of *Fusarium* wilt of chickpea disease by single approaches of chemical fungicide will be difficult and not ecofriendly along with economically not viable it was determined by NICBR as well as net profit.

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