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Research Article

Management of pigeonpea wilt caused by *Fusarium udum* Butler through integrated approaches

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ABSTRACT: Integrated Disease Management (IDM) approach was carried out to combat pigeonpea wilt with a combination of fungicides, bio agents, organic amendments and different cropping systems in *kharif* seasons of four years *viz*., 2006, 2007, 2008 and 2009. Based on the performance, four treatments were identified as best practices for the management of pigeonpea wilt *viz*., carbendazim seed treatment @ 2 g/kg of seeds + *Trichoderma viride* @ 2.5 kg/ha in FYM @ 50 kg / ha recorded lowest mean wilt incidence of 11.38 per cent with highest mean yield of 969.18 kg/ha, followed by carbendazim seed treatment @ 2g/Kg of seeds + $ZnSo_4$ @ 25 kg/ha which recorded mean wilt incidence of 11.75 per cent with mean yield 951.25 kg/ha. However, *Trichoderma viride* seed treatment @ 5g/kg of seeds + *Trichoderma viride* @ 2.5 kg/ha in FYM @ 50 kg/ha which recorded mean wilt incidence of 11.97 per cent and yield of 929.63 kg/ha and pigeonpea intercrop with sorghum @ 1:1 recorded mean wilt incidence of 17.62 per cent and yield of 632.18 kg/ha were also found effective in controlling wilt incidence and increasing yield compared to untreated control which recorded highest wilt incidence of 53.04 per cent and lowest yield (314.95 kg/ha).

KEY WORDS: Pigeonpea, wilt, *Fusarium udum,* fungicide, bio-agent

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INTRODUCTION

Pigeonpea *(Cajanus cajan* (L. Mill) is one of the most important pulse crops in the semi-arid tropics. The largest producer of pigeonpea in the world is India, where it is widely cultivated with minima1 input of nutrients and pest management measures. The main constraints in boosting the yield of the crop, are susceptibility to diseases and insects. Pigeonpea is known to be affected by more than hundred pathogens (Nene *et al*., 1989a). *Fusarium* wilt (*Fusarium udum* Butler) is an important soil borne disease, which causes significant yield losses in susceptible cultivars throughout the pigeonpea growing areas. (Reddy *et al.,* 1990). The pathogen is primarily a soil inhabitant; hence controlling the disease is very difficult. Application of carbendazim has been successful in controlling the disease, but to a limited extent and also it is not economical. Bio-control approaches have been initiated by using antagonistic microorganisms to combat the wilt disease in pigeonpea. Many control measures have been suggested (Sharma and Nene, 1990; Mishra, 1992; Whitehead, 1998; Chaudhary and Kumar, 1999), but, cost-effective options for the management of these pests, especially under rain-fed conditions, have not been developed. Therefore, an attempt was made to provide inexpensive and effective control measures. Studies were conducted to evaluate bio-pesticides, bio-agents, resistant varieties and chemicals as seed treatments. Keeping this in view, present investigations were envisaged with the development of integrated management approaches for pigeonpea wilt disease.

MATERIAL AND METHODS

Field experimental details

Field experiment was conducted at AICRP on pigeonpea, ZARS, GKVK, Bangalore under *Fusarium* wilt sick plot, during *Kharif* 2006, 2007, 2008 and 2009 with a combination of fungicides, bio agents, organic amendments and different cropping systems (Table 1, 2, 3 and 4).

Experimental details

Location	:	AICRP on pigeonpea, ZARS,GKVK, Bangalore
Season	:	*Kharif,* 2006, 2007, 2008 and 2009
Variety	:	TTB-7
Plot size	:	3.5 x 3 sq.m
Treatments	:	15
Replications	:	3

Periodically observations were recorded and mean wilt incidence was calculated as year wise treatments.

$$\text{Wilt incidence (\%)} = \frac{\text{Number of plants wilted}}{\text{Total number of plants examined}} \times 100$$

Mass multiplication of *Trichoderma viride*

Present investigation was undertaken for mass multiplication of *T. viride*. Giant culture of antagonist was prepared in the proportion of 95:5 w/w sand, maize meal mixture and moistened with sterile water to 20 per cent of volume in order to get maximum inoculants. The mixture was filled to autoclavable poly propylene bags and the bags were sealed by using rubber band and autoclaved at 15 lbs pressure at 121.6°C for 20 minutes for two consecutive days. After autoclaving, 8–10 mycelial discs of 5 mm were cut from the margin of actively growing fungal antagonist and transferred aseptically to the polypropylene bags and were incubated at 28 ± 1°C for 15 days. The bags were carefully shaken periodically in order to obtain uniform growth mycelia.

Mass multiplication of bacterial antagonists

Bacterial antagonists such as *Bacillus subtilis* and *Pseudomonas fluorescens* were multiplied on nutrient broth as per the procedure given by Sivamani and Gnanamanickam, (1988).

RESULTS AND DISCUSSION

Integrated approaches for wilt management during *Kharif* 2006

Results of integrated disease management of pigeonpea wilt were recorded during *Kharif* season, 2006 by employing twenty treatments (Table 1). Among the treatments employed, combination of seed treatment of carbendazim @ 2 g/kg of seeds + soil application of *T. viride, B. subtilis* + *P. fluorescens* each @ 2.5 kg/ha in FYM @ 50 kg/ha recorded significantly lowest wilt incidence of 5.32 per cent with highest yield of 1473 kg/ha, followed by combination of carbendazim seed treatment @ 2 g/kg of seeds + soil application of *T. viride* @ 2.5 kg/ha in FYM @ 50 kg/ha recorded wilt incidence of 9.30 per cent and yield of 1398 kg/ha, seed treatment of carbendazim @ 2 g/kg of seeds + soil application of $ZnSO_4$ @ 25 kg/ha., recorded wilt incidence of 9.37 per cent and yield of 1376 kg/ha. Among, the intercrops, pigeonpea intercropped with sorghum @ 1:1 recorded significantly less wilt incidence of 9.44 per cent and yield of 1213 kg/ha; followed by pigeonpea intercropped with marigold @ 1:1, which recorded wilt incidence of 9.55 per cent with yield of 1173 kg/ha; while the untreated control showed highest wilt incidence of 62.20 per cent with lowest yield of 554 kg/ha.

Integrated approaches for wilt management during *Kharif,* 2007

During *Kharif* season 2007, 15 treatments were imposed along with the effective treatments of the previous year (Kharif, 2006) (Table 2). Among the 15 treatments employed for the disease management, combination carbendazim seed treatment @ 2 g/kg of seeds + soil application of *P. fluorescens* (2.5 kg/ha) + *T. viride* @ 2.5 kg/ha in FYM @ 50 kg/ha., recorded lowest wilt incidence of 9.18 per cent with highest yield of 933.33 kg/ha, followed by carbendazim seed treatment @ 2 g/kg of seeds + *T. viride* soil application @ 2.5 kg/ha in FYM @ 50 kg/ha., recorded wilt incidence of 10.27 per cent with yield of 910.80 kg/ha, seed treatment of Carbendazim 2 g/kg of seeds + $ZnSO_4$ @ 25 kg/ha soil application recorded wilt incidence of 10.45 per cent with a seed yield of 796.19 kg/ha and seed treatment of *T. viride* @ 5 g/kg of seeds + *T. viride* @ 2.5 kg/ha in FYM @ 50 kg/ha soil application recorded wilt incidence of 10.84 per cent with yield of 928.89 kg/ha. Among, the intercrops, pigeonpea mixed crop with sorghum @ 3:1 recorded significantly less wilt incidence of 10.66 per cent and yield of 360.64 kg/ha, whereas untreated control showed wilt incidence of 64.86 per cent with lowest yield of 171.43 kg/ha.

Integrated approaches for wilt management during *Kharif,* 2008

Results of integrated pigeonpea wilt disease management conducted during *kharif* season 2009 by imposing 15 treatments are presented in the Table 3. Seed treatment of *T. viride* @ 5 g/kg seeds + *T. viride* @ 2.5 kg/ha in 50 kg FYM / ha recorded lowest wilt incidence of 10.13 per cent and highest yield of 978 kg/ha, followed by *T. viride* seed treatment 5 g/kg of seeds, pigeonpea intercrop with maize @ 1:1 recorded wilt incidence of

Table 1: Treatments impact under integrated approaches for wilt management during *Kharif* 2006

Sl. No.	Treatments	Wilt Incidence (%)	Yield (kg/ha)
1	T-1: Carbendazim seed treatment @ 2 g/kg of seeds + carbendazim soil application @ 1g/liter 60 days after sowing	12.08*	1086
2	T-2: Carbendazim seed treatment @ 2 g/kg of seeds + hexaconazole soil application @ 2ml/liter 60 days after sowing	22.80	860
3	T-3: Carbendazim seed treatment @ 2 g/kg of seeds + *T. viride* soil application @ 2.5 kg/ha in FYM @ 50 kg/ha	9.30 *	1398**
4	T-4: Carbendazim seed treatment @ 2 g/kg of seeds + *T. viride* soil application @ 2.5 kg/ha in sheep drops @ 50 kg/ha	11.51*	1120
5	T-5: Carbendazim seed treatment @ 2 g/kg of seeds + *T. viride* soil application @ 2.5 kg/ha in poultry manure @ 50 kg/ha	21.97	868
6	T-6: Carbendazim seed treatment @ 2 g/kg of seeds + *P. fluorescens* soil application	19.09	937
7	T-7: Carbendazim seed treatment @ 2 g /kg of seeds + soil application of *T. viride, Bacillus subtilis* + *Pseudomonas fluorescens* each @ 2.5 kg/ha in FYM @ 50 kg/ha	5.32 *	1473**
8	T-8: Carbendazim seed treatment @ 2 g/kg of seeds + soil application of *Rhizobium* @ 5 kg/ha + *B. subtilis, P. fluorescens* each @ 2.5 kg/ha in FYM @ 50 kg/ha	14.24	1060
9	T-9: Carbendazim seed treatment @ 2 g/Kg of seeds + *Mycorhiza* soil application @ 5 kg/ha	27.20	846
10	T-10: Carbendazim seed treatment @ 2 g/kg of seeds + soil application of Zn SO_4 @ 25 kg/ha	9.37 *	1376**
11	T-11: Carbendazim seed treatment @ 2 g/kg of seeds + thiophanate methyl soil application @ 1g/liter 60 days after sowing	30.41	710
12	T-12: *T. viride* seed treatment @ 5 g/kg of seeds + *T. viride* soil application @ 2.5 kg/ha in FYM @ 50 kg/ha	11.77*	1088
13	T-13: *T. viride* seed treatment @ 5 g/kg of seeds +*B. subtilis* soil application @ 2.5 kg/ha in FYM @ 50 kg/ha	19.35	910
14	T-14: *B. subtilis* seed treatment @ 5 g/kg of seeds + *B. subtilis* soil application @ 2.5 kg/ha in FYM @ 50 kg/ha	21.24	929
15	T-15: Zn SO_4 soil application @ 25 kg/ha	20.28	982
16	T-16: Pigeonpea inter crop with sorghum @ 1:1	9.44 *	1213**
17	T-17: Pigeonpea inter crop with marigold @ 1:1	9.55 *	1173
18	T-18: Pigeonpea intercrop with *Citronella* grass @ 1:1	18.10	977
19	T-19: Vitavax seed treatment @ 2 g/kg of seeds + vitavax soil application @1g/liter 60 days after sowing	15.16	1003
20	T-20: Control	62.20	554
	S.Em $\pm$	2.99	94.62
	CD ($p = 0.05$)	8.56	270.84

Note: * T2, T3, T6, T7, T10, and T14 are on par for wilt.

** T1, T2, T3, T4, T5, T6, T7, T13 and T14 are on par for yield.

Table 2: Treatments impact under integrated approaches for wilt management during *Kharif* 2007

Sl. No.	Treatments	Wilt Incidence (%)	Yield (kg/ha)
1	T1: *Trichoderma viride* seed treatment @ 5g/kg of seeds	16.88	715.55**
2	T2: Carbendazim seed treatment @ 2 g/kg of seeds + *T. viride* soil application @ 2.5 kg/ha in FYM @ 50 kg/ha	10.27*	910.80**
3	T3: Carbendazim seed treatment 2 g/kg of seeds+ soil application of *Pseudomonas fluorescens* + *T. viride* @ 2.5 kg/ha in FYM @ 50 kg/ha.	9.18*	933.33**
4	T4: Carbendazim seed treatment 2 g/kg of seeds+$ZnSO_4$ @ 15 kg/ha soil application.	14.80	705.08**
5	T5: Carbendazim seed treatment 2 g / kg of seeds+$ZnSO_4$ @ 20 kg/ha soil application.	13.25	765.08**
6	T6: Carbendazim seed treatment 2 g / kg of seeds+$ZnSO_4$ @ 25 kg/ha soil application.	10.45*	796.19**
7	T7: *T. viride* seed treatment @ 5 g/kg of seeds + *T. viride* @ 2.5 kg/ha in FYM @ 50 kg/ha soil application.	10.84*	928.89**
8	T8: Pigeonpea intercrop with sorghum @ 1:1.	18.58	435.24
9	T9: Pigeonpea intercrop with sorghum @ 1:2.	14.37	212.07
10	T10: Pigeonpea mixed crop with sorghum @ 3:1.	10.66*	360.64
11	T11: Pigeonpea intercrop with ragi @ 1:1.	14.63	549.52
12	T12: Pigeonpea intercrop with maize @ 1:1	12.81	342.86
13	T13: Soil application of neem cake @ 20 kg /3 guntas (667 kg/ha).	28.39	706.67**
14	T14: *T. viride* soil application @ 2.5 kg/ha in FYM 50 kg /ha.	11.39*	752.38**
15	T15: Control.	64.86	171.43
	S.Em ±	1.18	91.03

Note: * T2, T3, T6, T7, T10, and T14 are on par for wilt.

** T1, T2, T3, T4, T5, T6, T7, T13 and T14 are on par for yield.

10.47 per cent with 813, 462 kg/ha, respectively. Carbendazim seed treatment 2g/Kg of seeds + *T. viride* @ 2.5 kg /ha in 50 kg FYM / ha recorded wilt incidence of 12.73 per cent with yield of 818 kg/ha, whereas control treatment showed wilt incidence of 32.44 per cent with lowest yield of 356 kg/ha.

Integrated approaches for wilt management during *Kharif,* 2009

Results of integrated pigeonpea wilt disease management conducted during *kharif* 2009 by imposing 15 treatments, along with the effective treatments during previous year revealed that (Table 4), seed treatment of carbendazim @ 2g/Kg of seed + soil application of *T. viride* @ 2.5 kg /ha in FYM @ 50 kg / ha recorded significantly lowest wilt incidence of 13.20 per cent and highest yield of 748.70 kg/ha, followed by seed treatment of *T. viride* @ 5g/kg of seed + soil application of *T. viride* @ 2.5 kg /ha in FYM @ 50 kg / ha as recorded wilt incidence of 15.17 per cent with yield of 722.50 kg/ha. Among the intercrops tested, pigeonpea intercroped with sorghum @1:2 recorded significantly lesser wilt incidence of 15.77 per cent and yield of 228.60 kg/ha; followed by pigeonpea mixed crop with sorghum @ 3:1 which recorded wilt incidence of 18.61 per cent with yield of 362.60 kg/ha. While, untreated control showed highest wilt incidence of 52.66 per cent with lowest yield of 178.80 kg/ha.

Pooled data of effective treatments for management of pigeonpea wilt

Four effective treatments along with untreated control from four seasons of integrated disease management were analyzed statistically in order to identify best treatments

Table 3: Treatments impact under integrated approaches for wilt management during *Kharif* 2008

Sl. No.	Treatments	Wilt Incidence (%)	Yield (kg/ha)
1	T-1: *Trichoderma viride* seed treatment 5 g/kg of seeds	10.47	813
2	T-2: Carbendazim seed treatment 2 g/kg of seeds + *T. viride* @ 2.5 kg/ha in 50 kg FYM / ha soil application	12.73	818
3	T-3: Carbendazim seed treatment 2 g/kg of seeds + *Pseudomonas fluroscens* + *T. viride* @ 2.5 kg/ha in 50 kg FYM / ha soil application	18.09	516
4	T-4: Carbendazim seed treatment 2 g/kg of seeds + $ZnSO_4$ @ 15 kg/ha soil application	19.99	540
5	T-5: Carbendazim seed treatment 2 g/kg of seeds + $ZnSO_4$ @ 20 kg/ha soil application	16.52	869
6	T-6: Carbendazim seed treatment 2 g/kg of seeds + $ZnSO_4$ @ 25 kg/ha soil application	13.15	882
7	T-7: *T. viride* seed treatment @5 g/kg seeds + *T. viride* @ 2.5 kg/ha in 50 kg FYM / ha soil application	10.13	978
8	T-8: Pigeonpea intercrop with sorghum @ 1:1	20.30	405
9	T-9: Pigeonpea intercrop with sorghum @ 1:2	19.62	450
10	T-10: Pigeonpea mixed crop with sorghum @ 3:1	14.40	180
11	T-11: Pigeonpea intercrop with ragi @ 2:1.	15.66	570
12	T-12: Pigeonpea intercrop with maize @ 1:1	10.74	462
13	T-13: *P. f.* seed treatment @ 5 g/kg seed+ *P.f* @2.5 kg in 50 kg FYM / ha soil application	22.71	640
14	T-14: *T. viride* soil application 2.5 kg/ha in FYM 50 kg/ha.	18.20	716
15	T-15: Control	32.44	356
	S.Em ±	3.17	41
	CD ($p = 0.05$)	5.41	116

for the management of pigeonpea wilt and their yield performance (Table 5). Among the four treatments, Carbendazim seed treatment @ 2 g/kg of seeds + *T. viride* @ 2.5 kg/ha in FYM @ 50 kg/ha recorded lowest mean wilt incidence of 11.38 per cent with highest mean yield of 969.18 kg/ha. Followed by carbendazim seed treatment @ 2 g/kg of seeds + $ZnSO_4$ @ 25 kg/ha which recorded mean wilt incidence of 11.75 per cent with mean yield of 951.25 kg/ha. However, seed treatment of *T. viride* @ 5 g/kg of seeds + *T. viride* @ 2.5 kg/ha in FYM @ 50 kg / ha with mean wilt incidence of 11.97 per cent and yield 929.63 kg/ha and pigeonpea intercrop with sorghum @ 1:1 with mean wilt incidence 17.62 per cent and yield of 632.18 kg/ha were also effective in controlling wilt incidence and increasing yield compared to untreated control which recorded highest mean wilt incidence of 53.04 per cent and lowest yield 314.95 kg/ha. In the present study, systemic fungicide; bio-control agent and FYM application was found the most effective treatment which may be recommended on large scale management of pigeonpea wilt disease.

The results of the present study are in agreement with Ingole *et al.* (2005) who observed a combination of carbendazim + thiophanate (0.15 + 0.10%) was found effective in reducing the *Fusarium* wilt disease. The results of present study received support from Somashekhara *et. al.* (2000), who recorded reduced pathogen population and with 13.3% wilt incidence in *T. viride* amended soil. Similarly, Naik *et al.* (1997) observed a significant reduction in wilt incidence at ICRISAT when sorghum (cv. CSH 9) was intercropped with pigeonpea compared with sole pigeonpea. The reduced wilt incidence in sorghum intercropped with pigeonpea was attributed to fungi-toxic exudates secreted by sorghum roots. Rangaswami and Balasubramanian (1963) observed secretion of hydrocyanic acid by sorghum roots, when spores of *Fusarium*

Table 4: Treatments impact under integrated approaches for wilt management during *Kharif* 2009

Sl. No.	Treatments	Wilt Incidence (%)	Yield (kg/ha)
1	T-1: *Trichoderma viride* seed treatment 5 g/kg of seeds.	20.16	602.30
2	T-2: Carbendazim seed treatment 2 g/kg of seeds + *T. viride* soil application 2.5 kg/ha in FYM 50 kg/ha	13.20	748.70
3	T-3: *T. viride* seed treatment 5 g/kg of seed + *T. viride* 2.5 kg /ha in FYM 50 kg/ha soil application.	15.17	722.50
4	T-4: Carbendazim seed treatment 2 g/kg of seeds + $ZnSO_4$ 15 kg/ha soil application.	18.60	654.20
5	T-5: Carbendazim seed treatment 2 g/kg of seeds + $ZnSO_4$ 20 kg/ha soil application.	18.31	685.80
6	T-6: Carbendazim seed treatment 2 g/kg of seeds + $ZnSO_4$ 25 kg/ha soil application.	13.88	704.00
7	T-7: Pigeonpea intercrop with groundnut @ 1:1	26.20	538.60
8	T-8: Pigeonpea intercrop with sorghum @ 1:1	22.19	474.70
9	T-9: Pigeonpea intercrop with sorghum @ 1:2	15.77	228.60
10	T-10: Pigeonpea mixed crop with sorghum @ 3:1	18.61	362.60
11	T-11: Pigeonpea intercrop with castor @ 1:1.	20.86	286.90
12	T-12: Pigeonpea intercrop with maize @ 1:1	25.60	263.60
13	T-13: Pigeonpea intercrop with avare @ 1:1	31.78	308.40
14	T-14: *T. viride* soil application 2.5 kg/ha in FYM 50 kg/ha.	18.19	639.60
15	T-15: Control	52.66	178.80
	S. Em ±	3.25	44.06
	CD ($p = 0.05$)	9.47	127.30

Table 5: Pooled data of wilt incidence and yield in the best treatments in integrated pigeonpea wilt disease management

Treatment	% wilt incidence					Yield (kg/ ha)				
	2006	2007	2008	2009	Mean	2006	2007	2008	2009	Mean
T1 – Carbendazim ST @ 2 g/kg of seeds + *T. v* @ 2.5 kg/ha in FYM @ 50 kg/ha SA	9.3	10.3	12.7	13.20	11.38	1399	911	818	748.70	969.18
T2 – Carbendazim ST @ 2 g/kg of seeds + $ZnSO_4$ @ 25 kg/ha SA	9.4	10.5	13.2	13.88	11.75	1423	796	882	704.00	951.25
T3 – Pigeonpea intercorp with sorghum @ 1:1	9.4	18.6	20.3	22.19	17.62	1214	435	405	474.70	632.18
T4 – *T. v* ST @ 5 g/kg of seeds +*T. v* @ 2.5 kg/ha in FYM @ 50 kg/ha SA	11.8	10.8	10.1	15.17	11.97	1089	929	978	722.50	929.63
T5 – Control	62.2	64.9	32.4	52.66	53.04	554	171	356	178.80	314.95

moniliforme treated with sorghum root exudates showed delayed germination. Similar results were obtained by Goudar and Srikant Kulkarni (1998) the observed that seed pelleting with *T. viride* either alone or in combination with carbendazim reduced the plant infection besides enhancing the growth. Effective disease management control by integrated method could be due to the synergistic effect of the fungicide and biocontrol agents on the pathogens (Haider *et al*., 1979). Mahesh *et al*. (2010) showed that based on two years performance of different treatments, four effective treatments were identified as pooled analysis for the management of pigeonpea wilt.

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