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Integrated Disease Management of Pigeonpea Wilt (*Fusarium udum* Butler)

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Integrated Disease Management (IDM) approach was carried out to combat pigeonpea wilt a combination of best fungicides, bio agents, organic amendments and different cropping systems. Carbendazim seed treatment @ 2g/kg + *Trichoderma viride* soil application @ 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 *T. viride* seed treatment @ 5g/kg + *T. viride* soil application @ 2.5kg /ha in FYM @ 50 kg / ha with wilt incidence of 15.17 per cent with yield of 722.50kg/ha. Pigeonpea intercropped with sorghum @1:2 recorded significantly lesser wilt incidence of 15.77 per cent and yield of 228.60 kg/ha, followed by pigeonpea with sorghum @ 3:1 which recorded wilt incidence of 18.61 per cent with yield of 362.60 kg/ha.

Key words: Pigeonpea, wilt, *Fusarium udum, IDM*

Pigeonpea (*Cajanus cajan* (L) Millsp.) is one of the major grain legume crops and finds an important place in farming systems, as it restores the soil fertility by fixing atmospheric nitrogen. (Reddy *et al.,*1990). Pigeonpea is affected by more than hundred pathogens (Nene *et al*., 1989).Pigeonpea is affected by the wilt disease caused by *Fusarium udum* butler. 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 lmited extent and also it is not economical. Biocontrol approaches have been initiated by using antagonistic microorganisms to combat the wilt disease in pigeonpea. Secondly, the development of resistant varieties and combined application of bioagents and fungicides is more practicable. Keeping this in view, present investigations were envisaged with the development of integrated management schedule for pigeonpea wilt disease.

Materials and Methods

In vitro evaluation of bioagents against Fusarium udum

The fungal and bacterial bioagents were evaluated *in vitro* for their antagonistic effect against *F. udum* by dual culture method (Dennis and Webster, 1971) on PDA medium. Twenty ml of PDA medium was poured into sterile petriplate and allowed for solidification. Seven days old 5 mm disc of *F. udum* was cut with a sterile cork borer and placed near the periphery on one side of PDA plate. Similarly antagonistic organisms were placed on opposite side. A plate without antagonist was maintained as control. The inoculated plates were incubated at 28 ± 1^{o}C for seven days. Each treatment was replicated thrice. Per cent inhibition of the colony over control was calculated by using following formula given by Vincent (1947) and data were statistically analyzed.

In vitro evaluation of fungicides against Fusarium udum

Three systemic fungicides *viz*., carbendazim (Bavistin 50 WP), combination product of carbendazim 12% +mancozeb 63% (SAAF 75 WP) and thiophanate methyl (Topsin M 70 WP) and three non systemic fungicides *viz*., mancozeb (Indofil M-45 75 WP), captan (Captaf-75SD) and chlorothalonil (Kavach 75 WP) were evaluated against *F. udum* under laboratory conditions by poisoned food technique. *F. udum* was grown on PDA medium in Petri-plates for eight days prior to the setting of the experiments. Fungicidal suspension was prepared by adding required quantity of fungicides in PDA medium to obtain the desired concentration on the basis of active ingredients present in the chemical. Twenty ml of poisoned medium was poured in each sterilized Petriplate, suitable checks were maintained without addition of fungicides. Five mm of eight days old fungal disc was taken from the periphery of the culture and was placed at the center of the poisoned medium and incubated at 28 ± 1^{o}C for seven days. Three replications were maintained for each treatment. The diameter of the colony was recorded, per cent inhibition was calculated as per Vincent (1947).

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Management of Fusarium udum through integrated approaches

The field experiment on integrated pigeonpea wilt disease management was conducted during *Kharif,* 2009 by employing best the bio agents, fungicides and inter cropping, by imposing 15 treatments (Table 3).

Mass multiplication of Trichoderma viride native isolate

Present investigation was undertaken for mass multiplication of *T. viride* native isolate and giant culture of antagonist was prepared (Mahesh *et al*., 2010).

Field experimental details

Field experiment was conducted at ZARS, GKVK, Bangalore under *Fusarium* wilt sick soil conditions during *Kharif,* 2009-10.

Estimation of F. udum population

Estimation of *F. udum* population density from infected soil was carried out by dilution plate technique. Selective *Fusarium* Agar (SFA) medium is a modified Czapek's dox agar medium developed for the selective isolation of *F. udum* from soil (John Leslie and Brett Summerell, 2006).

Numbers of colony forming units (cfu) were calculated per gram of soil by employing the following formula.

$$\text{C.f.u/g of dry weight of soil} = \frac{\text{No. of colonies x dilution factor x volume of stock solution}}{\text{Dry weight of soil}}$$

Results and Discussion

Among bioagents, maximum inhibition of 91.13 per cent growth was observed in *Trichoderma viride* native isolate followed by *T. viride* isolate Tv 23 PDBC (76.70 %). In bacterial bioagents, *Bacillus subtilis* isolate Bs GKVK inhibited growth of the fungus to the extent of 88.33 per cent*,* which was followed by *Pseudomonas fluorescens* isolate Pf-2 GKVK with 71.30 per cent (Table 1). The results of the present study was supported by the previous reports by Gaur and Sharma (1991) . *Trichoderma* spp. recognized and attached to the pathogenic fungus and began to excrete extra cellular lytic enzymes like β1, 3-glucanase, chitinases, protease and lipase. (Cook and Baker, 1983; Hardar *et al.,* 1984). *T. harzianum* and *T. viride* both suppressed the growth of *F. udum* and this is due to coiling and disintegration of hyphae of the test fungus resulting in the loss of competitive saprophytic ability.

Table 1. *In vitro* evaluation of bioagents against *Fusarium udum*

Bio agent	Name of the isolates	Colony diameter (mm)	Per cent inhibition over control
Trichoderma viride	Native isolate (GKVK)	8.00	91.13
Trichoderma viride	Tv-23-PDBC	21.00	76.70
Trichoderma viride	Tv-PDBC	25.50	71.66
Trichoderma virens	Tvs-12-PDBC	26.00	76.11
Trichoderma harzianum	ThB9-PDBC	27.16	69.81
Trichoderma hamatum	Tha10-PDBC	34.00	62.22
Bacillus subtilis	Bs-GKVK	10.50	88.33
Bacillus subtilis	B-7-PDBC	29.00	67.77
Pseudomonas fluorescens	Pf-2-GKVK	25.83	71.29
Pseudomonas aeroginosa	Pa-PDBC	50.83	43.50
Control (*Fusarium udum)*		90.00	0.00
S.Em ±		0.42	0.49
C.D at 1 %		1.68	1.96

Among systemic fungicides, carbendazim and combination product of carbendazim 12 % + mancozeb 63% recorded maximum inhibition of mycelial growth of 100 % at all the concentrations tested. Non systemic fungicide chlorothalonil inhibited mycelial growth to 75.73, 77.03, 77.29, 77.03 and 77.58 per cent at 250, 500, 750, 1000 and 1500 ppm concentrations (Table 2). Whereas, captan inhibited mycelial growth to 48.14, 43.70, 43.51, 43.33 and 39.62 % at 1500, 1000, 750, 500 and 250 ppm concentrations respectively. Ghosh and Sinha (1981); Jadav and Jani (2003) and Mahesh and Muhammad Saifulla (2006) have observed carbendazim as the most effective in inhibiting the growth of *F. udum.*

Table 2. *In vitro* evaluation of fungicides against *Fusarium udum*

Fungicides	Systemic fungicides					
	Fungicidal concentration					
	Per cent inhibition of mycelial growth					
	50 ppm	100 ppm	250 ppm	500 ppm	750 ppm	Mean
Carbendazim	100.00	100.00	100.00	100.00	100.00	100.00
Carbendazim 12% + Mancozeb 63%	100.00	100.00	100.00	100.00	100.00	100.00
Thiophanate methyl	88.14	100.00	100.00	100.00	100.00	97.62

Fungicides	Non Systemic fungicides					
	Fungicidal concentration					
	Per cent inhibition of mycelial growth					
	250 ppm	500 ppm	750 ppm	1000 ppm	1500 ppm	Mean
Mancozeb	33.14	35.73	42.40	47.03	50.18	41.70
Captan	39.62	43.33	43.70	43.51	48.14	43.66
Chlorothalonil	75.73	77.03	77.29	77.03	77.58	76.73

	Fungicides	Concentration	Fungicides X Concentration
S. Em ±	0.15	0.14	0.35
CD at 1%	0.58	0.53	1.30

Results of field experiment revealed that, carbendazim seed treatment @ 2g/Kg of seed + *T. viride* soil application @ 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 *T. viride* seed treatment@ 5g/kg of seed + *T. viride* soil application @ 2.5kg /ha in FYM @ 50 kg / ha as recorded wilt incidence of 15.17 per cent with yield of 722.50kg/ha (Table 3). Among the intercrops, 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 the highest wilt incidence of 52.66 per cent with the lowest yield of 178.80 kg/ha.

Table 3. Integrated pigeonpea wilt disease management

Treatment	Per cent Wilt incidence	Yield (kg/ha)
Trichoderma viride seed treatment 5g/kg of seeds.	20.16	602.30
Carbendazim seed treatment 2g/Kg of seeds + *T. viride* soil application 2.5 kg /ha in FYM 50 kg / ha	13.20	748.70
T. viride seed treatment 5g/kg of seed + *T. viride* 2.5kg /ha in FYM 50 kg / ha soil application.	15.17	722.50
Carbendazim seed treatment 2g / kg of seeds + $ZnSO_4$ 15kg/ha soil application.	18.60	654.20
Carbendazim seed treatment 2g / kg of seeds + $ZnSO_4$ 20kg/ha soil application.	18.31	685.80
Carbendazim seed treatment 2g / kg of seeds + $ZnSO_4$ 25kg/ha soil application.	13.88	704.00
Pigeonpea intercrop with groundnut 1:1	26.20	538.60
Pigeonpea intercrop with sorghum 1:1	22.19	474.70
Pigeonpea intercrop with sorghum 1:2	15.77	228.60
Pigeonpea mixed crop with sorghum	18.61	362.60
Pigeonpea intercrop with castor 1:1.	20.86	286.90
Pigeonpea intercrop with maize 1:1	25.60	263.60
Pigeonpea intercrop with Dolichos 1:1	31.78	308.40
T. viride soil application 2.5 kg/ ha in FYM 50 kg /ha.	18.19	639.60
Control	52.66	178.80
S. Em ±	3.25	44.06
CD at 5 %	9.47	127.30

Somashekhara *et al.* (2000) recorded reduced pathogen population 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 to sole pigeonpea. Natarajan *et al*. (1985) reported 24 per cent wilt in susceptible pigeonpea genotypes intercropped with sorghum compared to 85 per cent in the sole pigeonpea crop. The reduced wilt incidence in sorghum intercropped with pigeonpea has been attributed to fungitoxic exudates secreted by sorghum roots. Rangaswami and Balasubramanian (1963) observed secretion of hydrocyanic acid by sorghum roots, when spores of *Fusarium moniliforme* treated with sorghum root exudates showed delayed germination.

Table 4. Population density of *Fusarium udum*

Treatment	*Fusarium udum* population (cfu/g of soil x 10^{-6})		
	Pre treatment	Post treatment (After harvest)	Per cent reduction
Trichoderma viride seed treatment 5g/kg of seeds.	219.70	181.00	17.62
Carbendazim seed treatment 2g/Kg of seeds + *T. viride* soil application 2.5 kg /ha in FYM 50 kg / ha	209.00	162.70	22.15
T. viride seed treatment 5g/kg of seed + *T. viride* soil application 2.5kg /ha in FYM 50 kg / ha	220.70	186.70	15.41
Carbendazim seed treatment 2g / kg of seeds + $ZnSO_4$ 15kg/ha soil application	217.00	161.30	25.66
Carbendazim seed treatment 2g / kg of seeds + $ZnSO_4$ 20kg/ha soil application	216.00	156.30	27.64
Carbendazim seed treatment 2g / kg of seeds + $ZnSO_4$ 25kg/ha soil application	205.30	153.70	25.13
Pigeonpea intercrop with groundnut 1:1	204.30	169.00	17.28
Pigeonpea intercrop with sorghum 1:1	205.30	149.70	27.08
Pigeonpea intercrop with sorghum 1:2.	210.00	160.70	23.48
Pigeonpea mixed crop with sorghum	217.30	156.30	28.07
Pigeonpea intercrop with castor 1:1	203.00	166.00	18.23
Pigeonpea intercrop with maize 1:1	207.70	188.70	09.15
Pigeonpea intercrop with Dolichos1:1	204.00	188.30	07.70
T. viride soil application 2.5 kg/ ha in FYM 50 kg /ha	219.30	172.30	21.43
Control.	223.30	238.30	-06.72
Mean	212.00	173.00	-
S. Em ±	1.33	0.48	-
CD at 5 %	3.75	12.35	-

Fusarium udum population density showed that the highest per cent population reduction of 27.64 was observed in the carbendazim seed treatment 2g /kg of seed + $ZnSO_4$ @ 20kg /ha soil application, followed by per cent population reduction of 25.66, was recorded in carbendazim seed treatment 2g / kg of seed + ZnSO4 @ 15kg/ha soil application (Table 4). Among the intercrops, pigeonpea with sorghum @ 3:1 recorded the per cent population reduction of 28.07 followed by pigeonpea intercroped with sorghum @ 1:1 with per cent population reduction of 27.08, whereas in untreated control the, *F. udum* population in soil was increased by 6.72. There was drastic reduction in population in the soil corresponding to the effective treatments as reported by Somashekhara *et al.* (2000)

The study concluded that carbendazim seed treatment @ 2g/kg of seed + *T. viride* soil application @ 2.5 kg/ha in FYM @ 50 kg/ha recorded significantly lowest wilt incidence and give the highest yield.

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