Journal of Entomology and Zoology Studies
Available online at www.entomoljournal.com
Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(2): 80-83

Received: 19-01-2020
Accepted: 21-02-2020

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Management of wilt complex involving *Heterodera cajani* Koshy, 1967 and *Fusarium udum* Butler on pigeonpea

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Abstract
A pot culture experiment was carried out for the management of cyst nematode and wilt disease complex of pigeonpea. Sick pots were prepared by adding 1000 J_2 of *H. cajani* and *F. udum* culture 25 g/pot (6×10^6 cfu/g). Studies were conducted by using bio-agents, botanicals and chemicals. Among all treatments tested, seed treatment with carbosulfan 25 EC @ 2 ml/ kg seed + soil drenching of carbendazim 50 WP @ 2 g/ l was recorded maximum plant growth parameters, less number of cysts (3), less number of nematodes (706.67) and less disease incidence followed by NSKE powder.

Keywords: Pigeonpea, *Heterodera cajani*, *Fusarium udum*, wilt complex, bio-agents, botanicals and chemicals

Introduction
Pigeonpea (*Cajanus cajan* (L.) Millsp.) is a major pulse crop of India providing for much of the protein supplement to vegetarian population [1]. In India, it is one of the very important grain legumes and occupies second position in area and production next to chickpea. There are several constraints for the production of pulses, among them plant parasitic nematodes associated with wilt causing fungi is one of the major factors affecting the productivity of pulses. The crop suffers 13.2 per cent worldwide loss due to plant parasitic nematodes [2]. Among the diseases, wilt caused by *F. udum* is the most important soil borne disease. The disease appears on young seedlings but the highest mortality occurs during flowering and podding stage [3].

Many effective pesticides have been used against soil borne pathogens but not considered as long term solution because of concerns about exposure risks, health and environmental hazards, expensiveness, residue persistence, development of resistance to pesticides and elimination of natural enemies. The non availability of efficient appliances and pesticides (fungicides, bactericides and nematicides) and lack of resistant varieties also aggravate the problem. Therefore, need for alternative methods of control of soil borne pathogens have become vital. Unfortunately, there are no effective ecologically sound multiple disease management practices especially for nematodes. Development of resistant varieties and biological control for soil borne disease is acceptable as a durable and eco friendly alternative for agro chemicals.

Materials and Methods
A pot culture experiment was carried out for the management of cyst nematode and wilt disease complex of pigeonpea in the glasshouse of Department of Plant Pathology, College of Agriculture, Raichur.

a. Experimental layout
The experiment was conducted with CRD (Completely Randomized Design) and it was replicated three times with nine treatments. Sick pots were prepared by adding 1000 J_2 of *H. cajani* and *F. udum* culture 25 g/pot (6×10^6 cfu/g). Pigeonpea seeds were treated just before sowing by pouring/dusting the treatment material in plastic vessels and soil application of the bio-agents, botanicals and chemicals were done before sowing of seeds.

b. Treatment details

Table 1: Treatment details are as follows:

Treatments	Treatment details
T1	Seed treatment with Neem Seed Kernel Extract (NSKE) powder @ 50 g/kg (w/w) + Soil application of NSKE powder @ 50 kg/ha at sowing
T2	Seed treatment with *Trichoderma harzianum* @ 5 g/kg (v/w) + Soil application of FYM enriched *T. harzianum* @ 2.5 kg/ha at sowing
T3	Seed treatment with *Pseudomonas fluorescens* @ 5 g/kg (v/w) + Soil application of FYM enriched *P. fluorescens* @ 2.5 kg/ha at sowing
T4	Seed treatment with *Paecilomyces lilacinus* @ 20 g/kg (v/w) + Soil application of *P. lilacinus* @ 2 kg/ha at sowing
T5	Seed treatment with *Pochonia chlamydosporia* @ 2 g/kg (v/w) + Soil application of *P. chlamydosporia* @ 2 kg/ha at sowing
T6	Seed treatment with carbosulfan 25 EC @ 2 ml/kg + Soil application of carbosulfan 25 EC @ 2 l/ha at sowing
T7	Seed treatment with carbendazim 50 WP @ 2 g/kg + Soil drenching of carbendazim 50 WP @ 2 g/l
T8	Seed treatment with carbosulfan 25 EC @ 2 ml/kg + Soil drenching of carbendazim 50 WP @ 2 g/l
T9	Control

c. Observations

Observations were recorded at end of the experiment. The experiment was completed 135 days after inoculation of pathogen and observations on growth parameters of pigeonpea plants were recorded. The population of nematode in soil and cysts on root was estimated and disease incidence was recorded.

Results and Discussion

Management of *H. cajani* and *F. udum* in pigeonpea by using bioagents, organic amendments and chemicals as seed treatment and soil application at the time of sowing with a control for comparison with respect to plant growth parameters and multiplication of pigeonpea cyst nematode, per cent wilt incidence under glasshouse condition were taken up and presented in the Table 2.

Table 2: Management of pigeonpea cyst nematode and wilt complex in pigeonpea by using bioagents, organic amendments and chemicals

Treatment	Shoot			Root			No. of cysts/ plant	Cyst Index	wilt incidence	No. of nematodes/ 250 g of soil
	Length (cm)	Fresh weight (g)	Dry weight (g)	Length (cm)	Fresh weight (g)	Dry weight (g)				
T1	80.07	14.5	4.8	18.5	1.93	0.96	28.33	4	++	816.67
T2	75.17	12.63	3.9	14.6	1.65	0.76	35.67	4	++	1210.0
T3	71.37	10.87	3.43	12.43	1.51	0.71	32.33	4	++	1170.0
T4	57.07	6.67	2.77	10.2	1.09	0.55	19.67	3	+++	1070.0
T5	52.73	5.57	1.97	8.87	0.92	0.37	15.0	3	+++	996.67
T6	61.7	9.3	3.17	11.3	1.33	0.66	1.67	2	++	703.33
T7	66.33	10.5	3.3	12.03	1.48	0.74	50.67	5	-	1316.67
T8	82.33	15.87	5.63	19.43	2.09	1.12	3.0	2	-	706.67
T9	43.9	7.33	1.63	6.53	0.6	0.25	52.67	5	++++	1303.33
S.Em. ±	0.89	0.25	0.09	0.16	0.04	0.02	0.78			15.28
C.D. at 1%	3.63	1.03	0.38	0.66	0.16	0.07	3.17			62.18

+ : 0-10 per cent wilt, ++ : 10-20 per cent wilt, +++ : 20-40 per cent wilt, ++++ : >40 per cent wilt, - : no wilt
T1- Seed treatment with NSKE powder @ 50 g/kg (w/w) + Soil application of NSKE powder at 50 kg/ha at sowing
T2- Seed treatment with *T. harzianum* @ 5 g/kg (v/w) + Soil application of FYM enriched *T. harzianum* at 2.5 kg/ha at sowing
T3- Seed treatment with *P. fluorescens* @ 5 g/kg (v/w) + Soil application of FYM enriched *P. fluorescens* at 2.5 kg/ha at sowing
T4- Seed treatment with *Paecilomyces lilacinus* @ 20 g/kg (v/w) + Soil application of *P. lilacinus* at 2 kg/ha at sowing
T5- Seed treatment with *Pochonia chlamydosporia* @ 2 g/kg (v/w) + Soil application of *P. chlamydosporia* at 2 kg/ha at sowing
T6- Seed treatment with carbosulfan 25 EC @ 2 ml/kg + Soil application of carbosulfan 25 EC at 2 l a.i./ha at sowing
T7- Seed treatment with carbendazim 50 WP @ 2 g/kg + Soil drenching of carbendazim 50 WP at 2 g/l
T8- Seed treatment with carbosulfan 25 EC @ 2 ml/kg + Soil drenching of carbendazim 50 WP at 2 g/l
T9- Control.

The maximum shoot length (82.33 cm), fresh shoot weight (15.87 g), dry shoot weight (5.63 g), root length (19.43 cm), fresh root weight (2.09 g) and dry root weight (1.12 g) was observed in seed treatment with carbosulfan 25 EC + soil drenching of carbendazim 50 WP (T8) followed by (T1) seed treatment with NSKE (Neem Seed Kernel Extract) powder @ 50 g/kg (w/w) + soil application of NSKE powder @ 50 kg/ha at sowing, (T2) seed treatment with *Trichoderma harzianum* @ 5 g/kg (v/w) + soil application of FYM enriched *T. harzianum* @ 2.5 kg/ha at sowing. However, the least shoot length was recorded in the control (T9).

The treatments recorded less number of cysts per plant as compared to control. Carbosulfan 25 EC (T6) and seed treatment with carbosulfan 25 EC + soil drenching of carbendazim 50 WP (T8) were found to be best among all other treatments recorded lowest number of cysts per plant (1.67 and 3.00 respectively) having cyst index (2) followed by (T5) *P. chlamydosporia* (15.00) and (T4) *P. lilacinus* (19.67) which were having cyst index (3) as compared to control (T9) which recorded highest number of cyst per plant *i.e.* 52.67 and cyst index (5).

Among all treatments carbosulfan 25 EC (T6) and (T8) seed treatment with carbosulfan 25 EC + soil drenching of carbendazim 50 WP recorded least nematode population *i.e.*, 703.33 and 706.67 respectively followed by (T1) NSKE powder (816.67), (T5) *Pochonia chlamydosporia* (996.67). The highest number nematode population was recorded in (T7) carbendazim 50 WP (1316.67) and control (1303.33).

The present investigation clearly indicated that seed treatment with carbosulfan 25 EC + soil drenching of carbendazim 50 WP was found effective in enhancing the plant growth parameters like shoot (82.33 cm) and root length (19.43 cm), fresh (15.87 g) and dry shoot weight (5.63 g) and fresh (2.09 g) and dry (1.12 g) root weight. It also reduced number of cysts per plant (3.0), nematode population (706.67) and wilt incidence.

The results indicated that carbosulfan was most effective among the treatments in improving plant growth and reducing *H. cajani* population densities in soil. Carbosulfan impairs nematode neuromuscular activity by inhibiting the function of the enzyme acetyl cholinesterase resulting in reduced movement and ability of invasion and multiplication [4, 5]. The nematodes may also be killed while feeding on root tissues by the systemic action of these nematicides when they are absorbed by the plant roots and translocated in the plant system [6].

Carbendazim was found most effective in controlling root colonization by fungus. It inhibits the nuclear division of fungi by inactivating the spindle, which is composed of microtubules. Various scientists have also been reported that carbendazim as an important control measure against *F. udum* [7-11]. To maintain a low inoculum load by continuous application of systemic fungicide alone is not practical for the control of wilt disease. It was clear from the results that besides chemicals NSKE seed powder was sufficiently effective against both the pathogens, this may be due to presence of active principles and toxic chemicals in NSKE powder [12- 14].

Results showed significant suppression of both *H. cajani* and *F. udum* by *T. harzianum*. The possible mechanism involved in *Trichoderma* antagonism had been studied intensively in terms of antibiotic and enzyme production as hyphal interactions [15, 16]. The extracellular proteases of mycoparasitic fungi have been shown to have important roles during the biocontrol process against nematodes and fungi. Production of chitinases may have direct significance in the parasitism of *Trichoderma* on *F. udum* as these enzymes function by breaking down the polysaccharides, chitin and β-glucan that are responsible for the rigidity of fungal cell walls thereby destroying cell wall integrity [17]. Significant suppression of nematode multiplication by *P. fluorescens* was due to its capability of altering root exudates, which could alter nematode behavior and suppress nematode population in root system [18]. *Pseudomonas fluorescens* was found not only effective against *H. cajani* but also against wilt causing fungi. Results showed that the *H. cajani* and *F. udum* wilt complex can cause severe yield losses in pigeonpea as in other crops. Although chemicals *viz*. carbosulfan and carbendazim showed a significant effect in suppression of the disease complex, these can be replaced to some extent by NSKE seed powder and microbial antagonists *viz*. *T. harzianum* and *P. fluorescens* to avoid the hazards of chemicals. The results are in conformity with Akhtar *et al*. (2007) [19], Sobita and Anamika (2011) [20] and Syed (2012) [21], who worked on management of *M. incognita* and *F. oxysporum* wilt complex.

Conclusion

Finally, it could be concluded that application of bioagents, organic amendment and chemicals suppressed the development of pigeonpea cyst nematode, *H. cajani* and *F. udum* in pigeonpea and increased plant growth parameters. Chemicals affected the penetration and development of *H. cajani* into pigeonpea roots and avoided infection and growth of *Fusarium*, bioagents colonized around the plant root zone which provided protection against *H. cajani* infection and application of organic amendment released plant nutrients which accelerates root development and overall plant growth, thereby helping plants to escape from nematode and fungus attack and provided food for harmful nematophagous microorganisms in rhizosphere region which affected the multiplication of nematodes.

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