RESEARCH ARTICLE

Integrated Disease Management for Pigeonpea Wilt Caused by *Fusarium udum*

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Abstract

Field experiments were conducted during Kharif seasons of 2013 and 2014 in the farmer's field of Gariyaband, Chhattisgarh, India to find out different integrated management levels of control schedule for pigeonpea wilt disease. All treatments had a significant effect on germination percent, disease incidence, seed yield and disease index in both the consecutive years of experimentation. T_4–Seed treatment with Thiram + Carbendazim+ *Trichoderma viride* + *Rhizobium* + Soil application of *Trichoderma viride*, resulted in higher germination percentage (96.8 and 97.2), wilt incidence percent at 60 DAS (2.97 and 3.15), wilt incidence per cent at 150 DAS (9.68 and 7.65) and seed yield (15.10 and 16.28 q ha^{-1}) during 2013 and 2014, respectively and was found superior over rest of the treatments. The loss in pigeonpea yield was up to the tune of 18.86 to 54.24% due to the incidence of wilt disease.

Keywords: Disease, Fusarium, Integrated, Pigeonpea, *Trichoderma*, Wilt.

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Introduction

Pigeon pea, commonly known as redgram or tur or arhar [*Cajanuscajan* (L.) Millsp.] is the second most important pulse crop after chickpea in India. It is one of the important legume crops of tropics and subtropics and cultivated since prehistoric times. Among the pulses, it is extensively used as an important source of protein in the human diet. Generally, pigeonpea is grown in almost all states of India, but it is cultivated extensively in Bihar, Uttar Pradesh, Maharashtra, Tamil Nadu, Andhra Pradesh, Karnataka, West Bengal, Gujarat, and Chhattisgarh. It finds an important place in the farming systems adopted by small and marginal farmers in a large number of developing countries as it restores the soil fertility by fixing atmospheric nitrogen. The heavy shedding of leaves adds considerable organic matter to the soil. Pigeon pea has multiple uses, besides its consumption in the form of dry split dhal the tender green seeds are used as vegetables and the stem and roots as fuelwood. In addition, it is also used for forage purpose and improves soil health through its deep strong rooting system, leaf drop at maturity and addition of nitrogen by symbiotic activities during the crop growth. The main constraints in boosting the yield of the crop are its susceptibility to diseases, insects and other physiological stresses. Pigeonpea is affected by more than a hundred pathogens (Nene *et al.,* 1981). Incidentally, only a few of them cause economic losses (Kannaiyan *et al.,* 1984) and the distribution of the most important diseases is geographically restricted, among which wilt caused by *Fusarium udum* is a serious problem in the production of pigeonpea. The incidence of infection ranges from 3–94% in the field. The disease can attack at any stage of the plant, but the highest mortality occurs at the flowering and podding stage.

The total geographical area of Chhattisgarh is 13.8 m ha, of which 5.9 m ha area is under gross cultivation. Pigeonpea occupies 52.82 thousand ha with a production of 29.48 000 MT and average productivity of 558 kg ha^{-1} (Agriculture Statistics, Government of Chhattisgarh, 2013). In the year 2015–2016 pigeon pea was cultivated in 5000 ha area in Gariyaband district of Chhattisgarh state with a production of 3.990 '000 MT. The average productivity of pigeonpea in the district is 798 kg ha^{-1}. There are several constraints affecting the productivity of pigeonpea; most important of them is diseases, which often pose a serious problem. The diseases of economic importance at present are *viz*., *Fusarium* wilt, sterility mosaic disease (SMD), *Phytophthora* blight (PB), Macrophomina root rot, stem canker, Alternaria blight, and pearly cyst nematode. Among these diseases, the wilt is one of the major constraints, followed by Phytophthora blight and Sterility mosaic in the district, which is affecting the productivity of this crop per unit area.

The wilt caused by *Fusarium udum* is one of the most serious and oldest known diseases (Butler, 1906) and is known to cause heavy losses every year in India (Kannaiyan *et al.,* 1981). *Fusarium* wilt (*Fusarium udum*) is a soil-borne disease. The genus *Fusarium* has wide host range and survives for a long time in the field in the absence of host plant. Therefore, chemical control is not satisfactory, adequate and economical as a long-term solution. Frequent application of fungicides to the soil has caused

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environmental hazards causing water and soil pollution in addition to killing the non-target beneficial microorganisms in the soil. Recently, the biocontrol approaches have been initiated by using antagonistic microorganisms to combat the wilt disease in pigeonpea. Considering, the crop health and economic losses, the alternative to this is to explore the integration of chemical and biological control, which can be successfully adopted in modern agriculture. Keeping this in view, the present investigation was envisaged to develop integrated management schedule for pigeonpea wilt disease.

Materials and Methods

The present study was conducted during consecutive Kharif season of the year 2013 and 2014 at farmers field of Mahulkot village of Gariyaband district. This experiment was laid out in randomized block design with six number of replications. The soil of the farmers' field was sandy loam in texture, neutral in reaction and had low nitrogen and medium phosphorus and potassium contents. Treatment combinations of chemical fungicide, bioagents, and culture both as seed and soil treatment were tested during experimentation. The treatment combinations consisted of two chemical fungicides, i.e., *Thiram* and *Carbendazim*, one biological agent, i.e., *Trichoderma viride* of which both seed treatment and soil application was done and one nitrogen-fixing culture *Rhizobium*. The combinations were framed out as T_1–Control, T_2–*Trichoderma viride* (seed treatment), T_3–*Thiram* + *Carbendazim* + *Trichoderma viride* + *Rhizobium* and T_4–*Thiram* + *Carbendazim*+ *Trichoderma viride* + *Rhizobium* + soil application of *Trichoderma viride*. Pigeonpea variety "Rajeevlochan" was grown as a test crop. The duration of variety Rajeevlochan is 180–190 days with a production potential of 18–20 q ha^{-1} and is a wilt-resistant variety. The crop was sown manually after the onset of monsoon with a spacing of 60 cm x 15 cm using a certified seed with a seed rate of 20 kg ha^{-1}. To prevent the crop from the soil and seed-borne diseases, the seeds were treated with a combination of different fungicide, bioagents, and culture as per the treatments. The crop was fertilized with 20, 60 and 30 kg N, P_2O_5 and K_2O ha^{-1}, respectively. The harvesting was done manually with the help of sickle when the crop attained full maturity. The produce of a square meter from four randomly selected of each plot was tied into a bundle and allowed to sun drying in respective plots. The harvested bundles were weighed with the help of balance and transported to the threshing floor. Threshing of the produce of each plot was done separately by beating with wooden sticks; the seeds were then cleaned manually and weighed.

Germination percent of each treatment was calculated at 15 DAS from four randomly selected area of each plot with the help of 1 m^2 quadrate.

Wilt incidence percent (WI %) is calculated at 60 DAS and 150 DAS, with the help of the following formulae:

$$\text{Wilt incidence (WI) \%} = \frac{\text{Number of plants infected by wilt disease}}{\text{Total number of plants observed}} \times 100$$

Seed yield of the net plot was noted down, after threshing, winnowing, and drying and calculated in q ha^{-1}.

Disease index indicates the reduction in yield of crop due to disease attack and is expressed in percent by using formulae:

$$\text{Disease index (\%)} = \frac{\text{Yield from best-treated plot-yield from the untreated plot}}{\text{Yield from best-treated plot}} \times 100$$

Results and Discussion

Different integrated management levels of control schedule for pigeonpea wilt disease had a significant effect on germination percent, disease incidence percent, seed yield, and disease index in both the consecutive year of experimentation (Tables 1 and 2).

Effect on Germination Percent

Among different integrated management levels of control schedule for pigeonpea wilt disease, a combination of fungicides with bioagents and culture, as seed and soil treatment have significantly improved germination (%) over control. Treatment T_4–Seed treatment with *Thiram* + *Carbendazim* + *Trichoderma viride* + *Rhizobium* + soil application of *Trichoderma viride*, resulted in higher germination percentage of 96.8 and 97.2 during 2013 and 2014, respectively with mean of 97.0 percent and was found significantly superior to other treatments, followed by T_3–Seed treatment with *Thiram* + *Carbendazim* + *Trichoderma viride* + *Rhizobium* (91.26 and 93.45), and T2–Seed treatment with *Trichoderma viride* alone (84.62 and 86.25) during 2013 and 2014 with mean percent of 92.36 and 85.44, respectively. Pawar *et al.* (2013) also reported almost the same results, indicating that all the fungicides, as well as biocontrol agents, have significantly improved germination (%) over untreated control. The results fall in line with the findings of Gholve and Kurundkar (2002). The lowest germination percent was observed in the control plot (80.35 and 81.17) during 2013 and 2014 with a mean of 80.76.

Effect on Wilt Incidence (%)

The data on wilt disease incidence percent under various treatments have been presented in Table 1. Results reveal that all the treatments significantly differ from each other. However, the lowest disease incidence percent (2.97 and 3.15) at 60 DAS in both the years 2013 and 2014, respectively was found with treatment T_4–Seed treatment with *Thiram* + *Carbendazim* + *Trichoderma viride* + *Rhizobium* + Soil application of *Trichoderma viride*, and was found significantly superior over rest of the treatments with mean percent of 3.06

Table 1: Effect of integrated management of pigeonpea wilt disease on germination percent and wilt disease incidence percent

Treatment	Germination (%)			Wilt disease incidence (%) at 60 DAS			Wilt disease incidence (%) at 150 DAS		
	2013	2014	Mean	2013	2014	Mean	2013	2014	Mean
T_1–Control	80.35	81.17	80.76	7.89	8.54	8.22	28.64	31.04	29.84
T2–Seed treatment with *Trichoderma viride* alone	84.62	86.25	85.44	4.45	5.28	4.87	18.01	15.58	16.80
T_3–Seed treatment with *Thiram* + *Carbendazim* + *Trichoderma viride* + *Rhizobium*	91.26	93.45	92.36	3.46	3.84	3.65	14.90	12.33	13.62
T_4–Seed treartment with *Thiram* + *Carbendazim*+ *Trichoderma viride* + *Rhizobium* + Soil application of *Trichoderma viride*	96.80	97.20	97.00	2.97	3.15	3.06	9.68	7.65	8.67
SEm±	0.37	0.34		0.15	0.12		0.38	1.71	
CD ($p = 0.05$)	1.11	1.04		0.46	0.36		1.15	5.15	

Table 2: Effect of Integrated management of pigeonpea wilt disease on germination percent and wilt disease incidence percent

	2013	2014		2013	2014	
T1–Control	8.50	7.45	7.98	43.71	54.24	48.97
T2–Seed treatment with *Trichoderma viride* alone	10.21	11.32	10.77	32.38	30.47	31.43
T3–Seed treatment with *Thiram* + *Carbendazim* + *Trichoderma viride* + *Rhizobium*	11.34	13.21	12.28	24.90	18.86	21.88
T4–Seed treartment with *Thiram* + *Carbendazim*+ *Trichoderma viride* + *Rhizobium* + Soil application of *Trichoderma viride*	15.10	16.28	15.69	–	–	–
SEm+	0.55	0.20	–	–	–	–
CD ($p = 0.05$)	1.64	0.60	–	–	–	–

followed by T_3–Seed treatment with *Thiram* + *Carbendazim* + *Trichoderma viride* + *Rhizobium* (3.46 and 3.48) and T_2–Seed treatment with *Trichoderma viride* alone (4.45 and 5.28) during 2013 and 2014 with mean disease incidence percent of 3.65 and 4.87, respectively. The highest wilt incidence was obtained with a control plot *i.e.*, 7.89 and 8.54, with mean percent of 8.22.

As far as wilt incidence percent at 150 DAS is concerned, similar results were obtained. Treatment T_4–Seed treatment with *Thiram* + *Carbendazim* + *Trichoderma viride* + *Rhizobium* + Soil application of *Trichoderma viride* recorded lowest wilt incidence per cent during both the years (9.68 and 7.65), followed by T_3–Seed treatment with *Thiram* + *Carbendazim* + *Trichoderma viride* + *Rhizobium* (14.90 and 12.33) and T_2–Seed Treatment with *Trichoderma viride* alone (18.01 and 15.58). The highest wilt incidence was obtained with the control plot (28.64 and 31.04). All the treatments were found statistically significant from each other.

These results confirm the findings of Verma and Rai (2008) in which he reported that seed treatment with 4 g *Trichoderma viride* formulation + 3 g thiram kg^{-1} seed and application of 2 kg T. viride formulation with 125 kg

farmyard manure ha^{-1} has also been reported to control the disease. This report was supported by Mandhare and Suryawanshi (2005) who recommended the application of Trichoderma as a seed treatment and soil application for managing Fusarium wilt of pigeonpea. Various reports have shown that supplementing the soils with fungal or bacterial antagonists reduces incidences of Fusarium wilt (Bapat and Shar, 2000; Singh *et al*., 2002; Anjaiah *et al*., 2003; Maisuria *et al*., 2008).

This also confirms the findings of Bapat and Shar (2000), Siddiqui *et al*. (2005), Siddiqui (2006) and Siddiqui and Shakeel (2007) in which they revealed that numerous rhizobacteria have been used as biocontrol agents. Soil amendment with Trichoderma *harzianuma* all pathogen levels has also been reported to give a disease control of 22–61.5% (Prasad *et al*. 2002).

Effect on Seed Yield

Under different integrated management levels of control schedule for pigeonpea wilt, treatment T_4–Seed treatment with *Thiram* + *Carbendazim* + *Trichoderma viride* + *Rhizobium* + Soil application of *Trichoderma viride* recorded statistically significant highest seed yield (15.10 and 16.28 q ha^{-1}) in both years with mean yield of 15.69 q ha^{-1}, and was found superior over the rest of the treatment combination. On the other hand, the minimum seed yield was recorded under a control plot.

Mahesh *et al*. (2010) also reported the similar findings in which they stated that combination of carbendazim seed treatment @ 2g kg^{-1} of seeds + soil application of *T. viride, B. subtilis* + *P. fluorescens* each @ 2.5 kg ha^{-1} in FYM @ 50 kg ha^{-1} recorded significantly lowest wilt incidence of 5.32 per cent with highest yield of 1437 kg ha^{-1}, followed by combination of carbendazim seed treatment @ 2g kg^{-1} of seeds + *T. viride* soil application @ 2.5 kg ha^{-1} in FYM @ 50 kg ha^{-1} recorded wilt incidence of 9.30 percent and yield of 1398 kg ha^{-1}.

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The capacity of plants to produce seed yield depends not only on the size of photosynthetic systems, it's efficiently and length of time for which it is active but also on translocation of dry matter into the economic sink. The final build-up of yield is the cumulative function of yield components.

Higher seed yield under these treatments was due to high germination, lower wilt incidence, causing a higher dry matter production resulting in the superiority of yield attributing characters and ultimately high yield.

Effect on Disease Index

Disease index indicates the reduction in yield of crop due to disease attack. The data presented in Table 2 reveals that the yield loss in pigeon pea crop ranged from 18.86–54.24 percent. Maximum loss or disease index was noticed under the control plot (43.71 and 54.24%), whereas the minimum disease index was registered under T_3–Seed treatment with *Thiram* + *Carbendazim* + *Trichoderma viride* + *Rhizobium* (24.90 and 18.16%) closely followed by T_2–Seed Treatment with *Trichoderma viride* alone (32.38 and 30.47 percent) in both the years, respectively.

Conclusion

The present investigation suggests that seed treatment with *Thiram* + *Carbendazim* + *Trichoderma viride* + *Rhizobium* and soil application of *Trichoderma viride* was found to be effective in controlling wilt in pigeonpea and reducing the yield loss.

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