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RESEARCH ARTICLE

Management of Radopholus similis and Fusarium wilt Complex in Banana

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Abstract

The pot culture experiment was carried out to check the efficacy of three bioagents and two organic amendments as individual and combined application for the management of Panama wilt of banana.Among these, the combined application of *T. viride* (15g/plant), *P. fluorescens* (15g/plant) and*P. lilacinus* (15g/plant) or combined application of carbofuran (15g/plant) and carbendazim (0.2%) provided the maximumplant height, root length, pseudostem girth, number of leaves, total leaf area, shoot weight, fresh root weight and dry root weight in Nanjanagud Rasabale infected with *R. similis* and *Fusarium oxysporum* f.sp. *cubense*. The lowest disease incidence was noticed when mixtures of biocontrol agents were used against *R. similis* and *Fusarium* wilt complex with a minimum number of nematodes in soil (24.00), number of lesions (4.67/plant), lesion index, wilt incidence (22.22%), wilt severity (13.33%).

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Introduction

Banana is one of the most important fruit crops and is intensively cultivated in India. It is the second most important fruit crop next to mango, with an annual production of 28.46 mt in 0.78mha and productivity of 35.7 tonnes per hectare, covering one third (34.22 %) of total fruit production (Anon., 2014a).In Karnataka during 2010-11 banana was grown in an area of 0.11 mha with a production of 2.28 mt with a productivity of 20.40 tonnes per hectare (Anon., 2014b).

Fusarium wilt (Panama disease) is a destructive fungal disease of banana caused by the soil borne fungus *Fusarium oxysporum* f.sp. *cubense*(Smith) Snyder and Hansen (Stover, 1962) (*Foc*) and itis a most destructive disease on many cultivars grown in different banana growing regions of the world (Ploetz *et al*., 1990). It causes an annual yield loss of 60 to 90 per cent in many countries (Bhuvanendra, 2010). In India, the yield loss by this disease was estimated to be 30 to 40 per cent and in South India alone ranging from 2 to 90 per cent (Thangavelu, 1999).Burrowing nematode (*Radopholus similis* (Cobb) Thorne) is the most serious pathogen on banana causing heavy economic losses (Krishnappa and Reddy, 1993).Crop losses caused by nematodes to bananas are very high, with average annual yield loss of about 20 per cent worldwide (Sasser and Freckman, 1987). Significant economic losses resulting from *R. similis* infestation ranging from 31 to 41 per cent have been reported (Reddy *et al*., 1992).

Disease complex situations in agricultural crop systems are very common in nature. It has long been shown that fungal pathogens of crop plants interact with plant parasitic nematodes leading to increased disease severity (Atkinson, 1892).Presently, most of the banana are grown with nematicides. In this present organic era, new and effective management tools, that actually achieve control without environmental side effects, are needed. Successful nematode management strategies have to take a holistic approach and integrate all resources available, be they chemical, biological or cultural. In recent years there has been much success in obtaining effective control of plant pathogens by using beneficial bio control agents. Here we attempted to develop a management strategy against nematode fungal wilt complex by using bioagents and organic products.

Material and methods

A pot culture experiment was carried out for the management of *R. similis* and *Fusarium* wilt disease complex of banana in the greenhouse of AICRP (Nematodes), ZARS, Department of Plant Pathology, Bangalore. Tissue cultured *Nanjanagud Rasabale* plants were grown in the 12″ plastic pots, the commercially available plant products like neem cake, farm yard manure, bioagents (*Trichoderma viride, Pseudomonas fluorescens, Paecilomyces lilacinus*)and chemicals (carbofuran and carbendazim) were used individually and in combination.

Sterilized pot mixture was filled in 12″ pots and tissue culture banana plants were potted separately. After proper establishment of plants, commercially available plant products *viz*., Neem cake, farm yard manure, bioagents like *T. viride, P. fluorescens, P.lilacinus* wereapplied to the soil and chemicals like carbofuran and carbendazim at their respective dosages were applied individually as well as in combinations into the respective sets of pots. Simultaneously *R. similis* and *Foc* were inoculated @ 1000 J2 per kg and 200 g of giant culture per pot, respectively around the roots of banana plants. The treatments were replicated thrice in completely randomized design. The experimental details are as follows.

Treatments	Treatment Details
T_1	*Trichoderma viride* @ 15 g/plant
T_2	*Pseudomonas fluorescens* @ 15 g/plant
T_3	*Paecilomyces lilacinus* @ 15 g/plant
T_4	Neem cake @ 200 g/plant
T_5	Farm Yard Manure (FYM) @ 5000 g/plant
T_6	*T. viride* @ 15 g/plant + *P. fluorescens* @ 15 g/plant
T_7	*T. viride* @ 15 g/plant + *P. lilacinus* @ 15 g/plant
T_8	*P. fluorescens* @ 15 g/plant + *P. lilacinus*@ 15 g/plant
T_9	*T. viride* @ 15 g/plant + *P. fluorescens* @ 15 g/plant + *P. lilacinus* @ 15 g/plant
T_{10}	Carbofuran 3G @ 15 g/plant
T_{11}	Carbendazim 50 % WP @ 0.2% as drenching
T_{12}	Carbofuran 3G @ 15 g/plant + Carbendazim 50 % WP @ 0.2% as drenching
T_{13}	Untreated Control

Nematode suspension containing 10000 juveniles of *R. similis* was inoculated per pot. Gaint culture of *Foc* and bioagents inoculation was done by removing top layer of soil in each pot and placing bioagents in the root zone of the banana plant and covering it with the soil. All the experiments were conducted under greenhouse conditions at temperature range of 26 °C to 32 °C.

For the purpose of inoculating nematodes to the plants.Four holes were made in the soil around the plant. Known quantity of nematode suspension containing minimum of 1000 larvae was pipetted and distributing equally into all the holes. Later, the holes were closed by gently pressing the soil around the plant and watered regularly so as to keep the soil moist.

Results and Discussion

All the treatments were significantly found superior in increasing the plant growth over control. At 90 days, the maximum plant height of 77.33 cm was recorded in T_{12} (carbofuran + carbendazim) and it was on par with T_9 (*T. viride* + *P. fluorescens* + *P. lilacinus*) and T_8 (*P. fluorescens* + *P. lilacinus*) with a plant height of 71.67 and 68.67 cm respectively. The lowest plant height was recorded in control (33.33 cm), it was on par with T_{10}- carbofuran (35.67 cm). At harvest, T_9 (*T. viride* + *P. fluorescens* + *P. lilacinus*) recorded maximum plant height of 85.67 cm. It was on par with T_{12} (carbofuran + carbendazim) with 82.33 cm plant height. The lowest plant height was recorded in control (38.67 cm), it was on par with T_{10} (carbofuran) (41.67 cm) (Table 1).

All the treatments recorded significantly better root length over control. Maximum root length was observed in T_9 (*T. viride* + *P. fluorescens* + *P. lilacinus*) (41.00 cm). It was on par with T_{12} (carbofuran + carbendazim) (40.67 cm), T_6 (*T. viride* + *P. fluorescens*) (38.33 cm) and T_8 (*P. fluorescens* + *P. lilacinus*) (35.67 cm). The lowest root length was recorded in control (26.00 cm), it was on par with T_{10}- carbofuran (31.67 cm) (Table 1).The treatments T_9 (*T. viride* + *P. fluorescens* + *P. lilacinus*) (11.67 cm, 14.67 cm), T_{12} (carbofuran + carbendazim) (11.67 cm, 14.00 cm) and T_{11} (carbendazim)(10.67 cm, 12.67 cm) recorded superior pseudostem girth compared to control (4.67 cm, 5.67 cm) at 90 days after inoculation and at harvest respectively (Table 1).

The number of functional leaves was maximum in T_9 (*T. viride* + *P. fluorescens* + *P. lilacinus*) (8.00 and 6.33). It was on par with T_{12} (carbofuran + carbendazim) (7.00, 5.33) and the minimum number of functional leaves was observed in control (3.00, 1.33) followed by carbofuran treatment (5.00, 3.00) during 90 days after inoculation and harvest respectively. The maximum leaf area at 90 days after inoculation and during harvest was recorded in T_{12} (carbofuran + carbendazim) (13233.98 and 9138.91 cm^2) and T_9 (*T. viride* + *P. fluorescens* + *P. lilacinus*) (13003.37 and 8237.57 cm^2) and the lowest leaf area was observed in control (831.39 and 741.76 cm^2) (Table 2).

The plants treated with treatment, T_9 (*T. viride* + *P. fluorescens* + *P. lilacinus*) recorded the maximum shoot weight (416.67 g), fresh root weight (166.67 g) and dry root weight (53.00 g) compared to control with a shoot weight of 70.00 g, fresh root weight of 71.67 g and dry root weight of 22.33 g. The next best treatment was T_{12} (carbofuran + carbendazim) with maximum shoot weight (341.67 g), fresh root weight (131.67 g) and dry root weight (41.67 g) compared to control (Table 2).

Finally, it was concluded that, the combined application of all the three bioagents *i.e.T. viride*, *P. fluorescens* and *P. lilacinus* was superior in improving the plant growth parameters of banana infected with *R. similis* and *Foc* compared to control. The next best treatment was combination of carbofuran and carbendazim. The application of only two bioagents in combination also had positive effect in improving the plant growth. Among them *T. viride* + *P. fluorescens* and *P. fluorescens* + *P. lilacinus* had tremendous effect in improving the growth of banana infected with *R. similis* and *Foc*. The application of carbendazim was as good as combined application of only two bioagents. The application of carbofuran alone had least effect and it was on par with control.

Observations on the effect of different treatments on population of *R. similis* per 200 cc soil was recorded at monthly intervals *viz*., 30, 60, 90 days after inoculation and at harvest and the number of lesions per plant and lesion index was recorded at the time of harvest. The data is presented in Table 3.All the treatments were effective in suppressing the nematode population and all the treatments differed significantly compared to the control for the number of nematodes/200cc of soil.The treatment T_9 (*T. viride* + *P. fluorescens* + *P. lilacinus*) recorded very low nematodes population 30 DAI (49.33), 60 DAI (24.00), 90 DAI (17.33) and at harvest (24.00). It was on par with T_8 (*P. fluorescens* + *P. lilacinus*) with a population of 61.33, 33.33, 28.00 and 33.33 at 30, 60, 90 days after inoculation and at harvest respectively.

The maximum *R. similis* population was observed in carbendazim alone treated plants with a population of 388.00, 453.33, 602.67 and 805.33 at 30, 60, 90 days after inoculation and at harvest respectively. This was followed by control with a population of 298.67, 353.33, 452.00 and 413.33 at 30, 60, 90 days after inoculation and at harvest respectively. All the treatments were significant in reducing the soil population of *R. similis* and lesions in the root compared to control. The plants treated with carbofuran had lowest number of lesions (2.33) and lesion index (0.67) and it was on par with T_9 (*T. viride* + *P. fluorescens* + *P. lilacinus*) (4.67, 1.00), T_{12} (carbofuran +

carbendazim) (7.67, 1.00) and T_8 (*P. fluorescens* + *P. lilacinus*) (11.33, 1.00).The maximum number of lesions and lesion index was observed in control (88.67, 3.00) and it was on par with T_{11} (carbendazim) (84.33, 3.00) (Table 3).

Among the various treatments tested, carbendazim alone and T_{12} (carbofuran + carbendazim) had given good results where disease was completely absent. This was followed by T_9 (*T. viride* + *P. fluorescens* + *P. lilacinus*) with wilt incidence of 22.22 % and T_8 (*P. fluorescens* + *P. lilacinus*) with wilt incidence of 55.56 %. The highest wilt incidence was noticed in *T. viride* (100.00 %), *P. lilacinus* (100.00 %), neem cake (100.00 %), FYM (100.00 %), carbofuran (100.00 %), *P. fluorescens* (100.00 %) and control (100.00 %). Based on the leaf severity index (LSI), the less severe wilt was observed in T_9 (*T. viride* + *P. fluorescens* + *P. lilacinus*) with 13.07 % severity and it was on par with (*P. fluorescens* + *P. lilacinus*) (26.14 %). The maximum wilt severity was noticed in control followed by FYM (66.67 %), *T. viride* (60.00 %), *P. lilacinus* (60.00 %), neem cake (60.00 %) and carbofuran (53.33 %). There was no rhizome discolouration in T_{12} (carbofuran + carbendazim) and T_9 (*T. viride* + *P. fluorescens* + *P. lilacinus*) with a rhizome discolouration index of 1.00. It was on par with carbendazim (1.33) followed by T_6 (*T. viride* + *P. fluorescens*) (1.67) and T_8 (*P. fluorescens* + *P. lilacinus*) (2.33).The rhizome was completely discoloured in control (7.00) and it was followed by carbofuran (5.67) treated plants (Table 4).

The combinations of *T. viride*, *P. fluorescens* and *P. lilacinus* or combined application of carbofuran and carbendazim provide the maximum growth of banana cultivar Nanjanagud Rasabale infected with *R. similis* and *Foc* in pot conditions. The present findings are in confirmation with findings of Senthil Kumar *et al.* (2008a;b) they reported maximum plant growth on treatment with *P. fluorescens B13* isolate. The soil application of *P. fluorescens* @ 10 g/plant recorded increased plant growth and yield, further, Jonathan *et al.* (2009) observed significantly enhanced the growth and fruit yield with combined application of *P. fluorescens* (Pfbv22) and *B. subtilis* (Bbv57).

The efficacy of *T. viride* in managing the *R. similis* and improving the growth is in confirmation with the findings of Ravi *et al.* (2000); Harish and Nanje Gowda (2001). They found that, neem cake + *T. viride* + carbofuran was the most effective in increasing plant growth and fruit yield of banana with least *R. similis* population in soil and roots.

T. viride was also found effective against wilt. The improved plant growth by this bioagent is in confirmation with findings of Thangavelu and Mustaffa (2010) they found that soil application of *T. viride* significantly reduced the external (up to 78%) and internal symptoms (up to 80%) of *Fusarium* wilt of banana and increased the plant growth significantly under pot culture and field conditions.

The effect of *P. lilacinus* in managing the *R. similis* and improving the growth of banana is in confirmation with findings of Kilama*et al.* (2007); Mendoza *et al.* (2007); Marimuthu and Murugesan (2008). Kilama*et al.* (2007) showed paralytic effect of *P. lilacinus* against *R. similis*.This outstanding performance of fungal bioagents in our study might be attributed to their strong fungicidal and nematicidal property against both pathogens and provided maximum defence with improved plant growth.

These bioagents had individual and synergistic effect in managing these pathogens thereby showed the improved plant growth. Apart from this, these bioagents also acts a PGPR. The various phytohormones produced by PGPR play a major role in growth promotion and many bacteria have the ability to produce auxins, gibberellins, cytokinins and ethylene. Some PGPR possesses ACC deaminase which lowers the ethylene level and thus indirectly promotes the growth of the plant (Saravanakumar*et al*., 2007). Similarly *T. harzianum* is potential biocontrol agent which poses growth hormone and all these combinations resulted in improved growth parameters. The *T. viride* has been reported to be a natural source of enzymes and plant hormones, provide additional support to plants for its better growth, development and immunity.

The results obtained in current investigation uphold the results observed by, Shreenivasa*et al.* (2005); Shanthi and Rajendran (2006); Senthil Kumar *et al.* (2008a); Jonathan *et al.* (2009); and Shanthi and Sivakumar (2011).The reduction in nematode population might be due to parasitic activity of *P. lilacinus* on eggs and all stages of nematodes. Spores of the *P. lilacinus* also adhere to the cuticle of vermiform stages of the nematodes as they migrate through the soil. The spore germinate, penetrate the cuticle and engulfs the nematode. The hyphae of the *P. lilacinus* can also enter the nematode through body openings, such as the anus and vulva. The developing *P. lilacinus* kills the nematode by feeding on its body contents. *P. lilacinus* has been reported to produce peptidal antibiotic *viz.*, lilacin, paecilo toxin which has direct nematicidal effect.

Thangavelu (2002) and Bastasa and Baliad (2005) reported that application of *T. harzianum Th*-10 and *T. viride* effectively reduced the wilt disease under both glass house and field conditions. The reasons for the reduced wilt incidence and severity and increased yield may attributed to the *Trichoderma* spp. involved in the reduction of *Fusarium* wilt severity by mycoparasitism, spatial and nutrient competition, antibiosis by enzymes and secondary metabolites, and induction of plant defence system. The fluorescent *pseudomonads* produced secondary metabolites like phenazine, 2,4-diacetylphloroglucinol, pyocyanine, pyoluteorin and pyrrolnitrin which were involved in suppression of root diseases causing pathogens (Ayyaduraiet *al*., 2006) and the developing *P. lilacinus* kills the

nematode by feeding on its body contents. In effect, the *P. lilacinus* acts as a parasite on all the stages of nematode.
The pre-colonization with *P. fluorescens* reduced *Foc* colonization. Massive depositions of unusual structures at sites of fungal entry clearly indicated that bacterized root cells were signalled to mobilize a number of defense structures for preventing the spread of pathogen in the tissue (Sukhada*et al.,* 2004).Besides microbial competition structural changes in host, induction of resistance of the host plant by biocontrol agents is another mode of action that can suppress *Fusarium* wilt (Van Loon *et al*., 1997). In this study, systemic induced resistance could not be excluded, because of *P. fluorescens* involvement in the suppression of vascular discolouration.
The combined action of these three bioagents against *R. similis* and *Foc* helped tremendously for the management of wilt complex in banana under *in vitro* and *in vivo*. The amount of disease suppression obtained with a biological control agent depends on the density of the agent, the density of the pathogen, and how efficiently individual units of the agents render units of the pathogen ineffective. In our study, an inoculum dose of 10 g of talc formulation per plant was optimum.
In the present study, the individual application of *T. viride* was not found effective in reducing the wilt incidence and this finding is in confirmation with the findings of Wibowo*et al.* (2013). They found that *T. harzianum* isolates *Th* UH and *Th* 13 could inhibit the growth of tropical race 4 of the *Foc* and did not show any reduced disease intensity under *in vitro* and *in vivo*.
Finally, it may be concluded that, soil borne pathogens like *Foc*and *R. similis* are cannot be kept under control with just a single management strategy. In the present study an integrated approach was attempted to manage this disease, with mixtures of biocontrol formulations which showed significant reduction in the disease incidence. The application of *T. viride*, *P. fluorescens* and *P. lilacinus* in combination is highly useful in managing the *R. similis* - *Fusarium* wilt complex in banana.

Table 1: Effect of different treatments on plant height, root length and pseudostem girth of banana cv. Nanjanagud Rasabale infected with *R. similis* and *Foc* under pot conditions

Sl. No.	Treatments	Plant Height (cm)		Root Length (cm)	Pseudostem Girth (cm)	
		90 DAI	At harvest		90 DAI	At harvest
1	T_1 - *T. viride*	55.00^{c}	63.33^{de}	30.33^{def}	5.00^{fg}	7.33^{fg}
2	T_2 - *P. fluorescens*	53.00^{c}	65.33^{cde}	31.33^{def}	7.33^{cde}	8.00^{ef}
3	T_3 - *P. lilacinus*	51.00^{c}	60.00^{e}	28.67^{ef}	6.33^{def}	6.67^{fg}
4	T_4 - Neem cake	54.67^{c}	61.67^{de}	31.00^{def}	6.00^{efg}	9.33^{e}
5	T_5 - FYM	57.33^{c}	67.33^{cde}	32.33^{cde}	8.33^{bc}	9.67^{de}
6	T_6 –*Tv+Pf*	61.33^{bc}	77.00^{abc}	38.33^{abc}	9.00^{b}	12.33^{bc}
7	T_7 –*Tv+Pl*	60.67^{bc}	73.67^{abcd}	34.67^{bcde}	8.67^{bc}	11.67^{c}
8	T_8 –*Pf+Pl*	68.67^{ab}	79.67^{ab}	35.67^{abcd}	7.67^{bcd}	11.33^{cd}
9	T_9 –*Tv+Pf+Pl*	71.67^{ab}	85.67^{a}	41.00^{a}	11.67^{a}	14.67^{a}
10	T_{10} - Carbofuran	35.67^{d}	41.67^{f}	31.67^{def}	6.33^{def}	8.00^{ef}
11	T_{11} - Carbendazim	62.33^{bc}	71.33^{bcde}	39.33^{ab}	10.67^{a}	12.67^{bc}
12	T_{12} – Carbofuran+Carbendazim	77.33^{a}	82.33^{ab}	40.67^{ab}	11.67^{a}	14.00^{ab}
13	T_{13} - Control	33.33^{d}	38.67^{f}	26.00^{f}	4.67^{g}	5.67^{g}
S. Em ±		2.63	2.77	1.43	0.36	0.43
CD @ 5%		7.62	8.02	4.16	1.05	1.23

DAI- Days After Inoculation;

Table 2: Effect of different treatments on number of leaves, leaf area, shoot and root weight of banana cv. Nanjanagud Rasabale infected with *R. similis* and *Foc* under pot conditions

Sl. No.	Treatments	Number of Leaves		Total Leaf Area (cm^2)		Fresh Shoot Weight (g)	Root Weight (g)	
		90 DAI	At harvest	90 DAI	At harvest		Fresh	Dry
1	T_1 - *T. viride*	4.00^{e}	3.00^{d}	4058.87^{e}	2582.92^{e}	253.33^{e}	111.67^{cd}	35.33^{cd}
2	T_2 - *P. fluorescens*	4.00^{e}	4.00^{c}	4900.44^{de}	5242.37^{cd}	271.67^{de}	121.67^{cd}	38.33^{cd}
3	T_3 - *P. lilacinus*	4.33^{e}	3.00^{d}	4441.24^{e}	3950.33^{de}	241.67^{e}	101.67^{d}	32.00^{d}
4	T_4 - Neem cake	4.00^{e}	3.00^{d}	5478.08^{de}	4375.19^{cd}	348.33^{bc}	151.67^{ab}	48.33^{ab}
5	T_5 - FYM	4.33^{e}	4.00^{c}	6475.04^{cd}	5744.34^{c}	376.67^{ab}	158.33^{ab}	50.33^{ab}
6	T_6 –*Tv+Pf*	4.00^{e}	5.00^{b}	5075.33^{de}	5466.73^{c}	311.67^{cd}	136.67^{bc}	43.33^{bc}
7	T_7 –*Tv+Pl*	5.00^{d}	4.00^{c}	5693.42^{de}	5239.46^{cd}	305.00^{cd}	121.67^{cd}	38.33^{cd}
8	T_8 –*Pf+Pl*	6.33^{c}	5.00^{b}	9066.98^{b}	5800.79^{c}	328.33^{bc}	131.67^{bc}	41.67^{bc}
9	T_9 –*Tv+Pf+Pl*	8.00^{a}	6.33^{a}	13003.37^{a}	8237.57^{b}	416.67^{a}	166.67^{a}	53.00^{a}
10	T_{10} - Carbofuran	5.00^{d}	3.00^{d}	7651.85^{bc}	3847.31^{de}	178.33^{f}	96.67^{de}	30.67^{d}
11	T_{11} - Carbendazim	6.00^{c}	5.67^{a}	8746.41^{b}	10073.78^{a}	308.33^{cd}	120.00^{cd}	38.00^{cd}
12	T_{12} – Carbofuran+Carbendazim	7.00^{b}	5.33^{b}	13233.98^{a}	9138.91^{ab}	341.67^{bc}	131.67^{bc}	41.67^{bc}
13	T_{13} - Control	3.00^{f}	1.33^{e}	831.39^{f}	741.76^{f}	70.00^{g}	71.67^{e}	22.33^{e}
S. Em ±		0.22	0.18	399.85	345.65	12.06	6.48	2.09
CD @ 5%		0.64	0.53	1160.26	1354.39	35.00	18.80	6.05

DAI- Days After Inoculation;

Table 3: Efficacy of various treatments on nematode population density, lesion index in banana cv. Nanjanagud Rasabale inoculated with *R. similis* and *Foc* under pot conditions

Sl. No.	Treatments	Soil Nematode Population (per 200 cc soil)				Number of Lesions	Lesion Index (0-4)
		30 DAI	60 DAI	90 DAI	At harvest		
1	T_1 - *T. viride*	150.67^{d}	133.33^{d}	141.33^{e}	173.33^{d}	78.33^{a}	3.00^{a}
2	T_2 - *P. fluorescens*	101.33^{ef}	70.67^{f}	78.67^{f}	112.00^{ef}	44.67^{c}	2.67^{a}
3	T_3 - *P. lilacinus*	118.67^{e}	78.67^{ef}	92.00^{f}	122.67^{e}	30.33^{d}	2.00^{b}
4	T_4 - Neem cake	190.67^{c}	149.33^{d}	225.33^{d}	262.67^{c}	59.67^{b}	3.00^{a}
5	T_5 - FYM	204.00^{c}	213.33^{c}	316.00^{c}	425.33^{b}	67.33^{b}	3.00^{a}
6	T_6 –*Tv+Pf*	81.33^{fg}	60.00^{fg}	73.33^{fg}	80.00^{f}	23.67^{de}	1.67^{b}

7	**T_7 –*Tv+Pl***	65.33^{gh}	46.67^{gh}	53.33^{g}	87.33^{ef}	15.33^{ef}	1.00^{c}
8	**T_8 –*Pf+Pl***	61.33^{gh}	33.33^{hi}	28.00^{h}	33.33^{g}	11.33^{fg}	1.00^{c}
9	**T_9 –*Tv+Pf+Pl***	49.33^{h}	24.00^{i}	17.33^{h}	24.00^{g}	4.67^{fg}	1.00^{c}
10	**T_{10} - Carbofuran**	110.67^{ef}	78.67^{ef}	117.33^{e}	162.67^{d}	2.33^{g}	0.67^{c}
11	**T_{11} - Carbendazim**	388.00^{a}	453.33^{a}	602.67^{a}	805.33^{a}	84.33^{a}	3.00^{a}
12	**T_{12} - Carbofuran + Carbendazim**	106.67^{ef}	97.33^{e}	132.00^{e}	253.33^{c}	7.67^{fg}	1.00^{c}
13	**T_{13} – Control**	298.67^{b}	353.33^{b}	452.00^{b}	413.33^{b}	88.67^{a}	3.00^{a}
S. Em ±		7.05	5.09	5.88	9.73	2.56	0.16
CD @ 1%		20.45	14.78	17.05	28.23	7.43	0.46

Table 4: Efficacy of various treatments on wilt incidence and wilt severity in banana cv. Nanjanagud Rasabale inoculated with *R. similis* and *Foc* under pot conditions

Sl. No.	Treatments	Wilt Incidence (%)	Wilt score (LSI) (1-5)	Wilt Severity (%)	Wilt score (RDI) (1-8)
1	**T_1 - *T. viride***	100.00 (89.96)^{a}	3.00	60.00 (50.75)^{bc}	4.67^{cd}
2	**T_2 - *P. fluorescens***	88.89 (78.21)^{a}	2.33	46.67 (43.06)^{cde}	3.67^{de}
3	**T_3 - *P. lilacinus***	100.00 (89.96)^{a}	3.00	60.00 (50.75)^{bc}	4.67^{cd}
4	**T_4 - Neem cake**	100.00 (89.96)^{a}	3.00	60.00 (50.75)^{bc}	6.00^{ab}
5	**T_5 – FYM**	100.00 (89.96)^{a}	3.33	66.67 (54.97)^{b}	6.33^{ab}
6	**T_6 –*Tv+Pf***	77.78 (66.46)^{ab}	1.67	26.67 (26.14)^{de}	1.67^{gh}
7	**T_7 –*Tv+Pl***	77.78 (66.46)^{ab}	2.00	40.00 (39.22)^{cde}	3.33^{ef}
8	**T_8 –*Pf+Pl***	55.56 (48.23)^{bc}	2.00	40.00 (39.22)^{cde}	2.33^{fg}
9	**T_9 –*Tv+Pf+Pl***	22.22 (23.50)^{cd}	1.33	13.33 (13.07)^{e}	1.00^{h}
10	**T_{10} - Carbofuran**	100.00 (89.96)^{a}	2.67	53.33 (46.90)^{bcd}	5.67^{bc}
11	**T_{11} - Carbendazim**	0.00 (0.00)^{d}	1.00	0.00 (0.00)^{e}	1.33^{gh}
12	**T_{12} - Carbofuran +Carbendazim**	0.00 (0.00)^{d}	1.00	0.00 (0.00)^{e}	1.00^{h}
13	**T_{13} – Control**	100.00 (89.96)^{a}	4.67	93.33 (81.11)^{a}	7.00^{a}
S. Em ±		6.64	-	5.88	0.27
CD @ 1%		19.25	-	17.08	0.79

Figures in parenthesis are angular transformed values; LSI-Leaf Severity Index; RDI- Rhizome Discolouration Index

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