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Integrated Management of *Sclerotium rolfsii* (Sacc.) in Groundnut (*Arachis hypogaea* L.) under Pot Culture Conditions

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ABSTRACT

Collar rot of groundnut caused by *Sclerotium rolsfii* is a disease of significant economic importance in groundnut-growing areas of the world. In the present trial an integrated approach was followed in pot culture conditions for assessing management of *S. rolfsii* in groundnut using different biocontrol agents, chemical treatments and organic amendments. The trial was designed as a randomized complete block containing eight treatments at 45 and 90 days after sowing each replicated three times. The treatment combinations were: 1) untreated control; 2) inoculated with *Pseudomonas fluorescens* FPD-10; 3) *P. fluorescens* FPD-15; 4) *Trichoderma harzianum*; 5) neem cake; 6) Captan; 7) *P. fluorescens* FPD-10 + *T. harzianum* and applied with neem cake + Captan and 8) *P. fluorescens* FPD-15 + *T. harzianum* and applied with neem cake + Captan. All treatments were inoculated with *S. rolfsii* and *Bradyrhizobium* sp. NC-92 at the time of sowing. All treatments tested recorded significantly lower percentage of pods infected with *S. rolfsii* and resulted in higher pod yield compared to untreated control. The highest pod yield was recorded in plants receiving *P. fluorescens* FPD-10, followed by combination of different treatments with FPD-10 and combination of different treatments with *P. fluorescens* FPD-15. Although individual applications of either *T. harzianum* or neem cake or captan did not give similar results as single inoculations of either FPD-10 or FPD-15, it did significantly reduce the pod infection caused by *S. rolfsii* and improved pod yield. Since most of the treatments tested in this trial reduced pod infection and increased pod yield it is necessary that these treatments be tested under field conditions before they can be exploited in a commercial set up.

Keywords: collar rot, plant growth promoting rhizobacteria, *Pseudomonas fluorescens*, *Trichoderma harzianum*

INTRODUCTION

The indiscriminate use of chemical pesticides and fertilizers in modern agriculture has resulted in the development of several serious problems. These include pesticide resistance in pests, resurgence of target and non-target pests, destruction of beneficial organisms, and presence of chemical residues in food, feed and fodder. The use of chemical fertilizers has also been necessary due to cultivation of high yielding varieties. This has resulted in degradation of soil health (Cook 1991). Hence alternative methods are being envisaged in an ecofriendly approach aimed at sustainable agriculture. Biological methods offer an excellent alternate strategy for effective control of various diseases and augmentation of nutrient availability in the rhizosphere.

Combined use of different biocontrol agents or integration of biocontrol agents with other disease management options, with identifiable differences in their mechanisms of action, has improved disease protection and the activity spectrum of biocontrol agents (Jetiyanon and Kloepper 2002). The combined use of reduced doses of fungicides and biocontrol agents offered an effective control of soilborne diseases where chemical control alone was unaffordable (Duffy 2000; Kondoh *et al*. 2001). In some cases the combined application of fungicide and fungicide-tolerant biocontrol agents reduced the severity of stem rot, damping off and postharvest rot in groundnut (*Arachis hypogaea* L.), tomato (*Lycopersicon esculentum* L) and pear (*Pyrus communis* L.), respectively (Kondoh *et al*. 2001; Manjula *et al*. 2004).

Plant growth-promoting rhizobacteria (PGPR) offer an excellent combination of traits useful both in disease control and increased nutrient availability. The fluorescent pseudomonads stand out among PGPRs due to their high level of genetic variability and competitiveness in the soil. Hence, these have been advocated as effective and economical bioinoculants for use in integrated nutrient and pest management systems. Studies have shown that they have been used as seed inoculants to suppress plant pathogens, promote plant growth and increase crop yields (Defreitas and Germida 1990; Dey *et al*. 2004). Groundnut is an important oilseed crop (Brown 1999) but the maximum productivity has not been reached due to a large reduction in yield owing to a number of diseases (Mayee and Datar 1988; Ganesan and Sekar 2004). Among different diseases of groundnut, collar rot caused by *Sclerotium rolfsii* is a disease of considerable economic importance in groundnut production. Control of the fungus is difficult as it does not produce asexual spores and overwinters as sclerotia, the primary inocula for the following season, on plant debris and in soil (Punja 1988). It is suggested that the available sources of host plant resistance and chemical control need to be strengthened for effective management of this disease in groundnut (Podile and Kishore 2002). One of the ways to reduce the loss is to grow resistant varieties which need concentrated efforts in plant breeding. Alternatively, these can be controlled by using biocontrol agents (Abeysinghe 2009; Ha 2010; Ozgonen *et al*. 2010). The efficacy of control may be improved by using an integrated approach involving different biocontrol agents, chemical treatments and organic amendments. In the present study an attempt was made to study the effect of *Pseudomonas fluorescens* FPD-10 and FPD -15, *Trichoderma harzianum*, captan and neem cake on control of *Sclerotium rolfsii* in groundnut under pot culture conditions.

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MATERIALS AND METHODS

An integrated approach was followed for assessing the management potential of *Sclerotium rolfsii* in groundnut by using *Pseudomonas fluorescens* FPD-10 and FPD-15, *Trichoderma harzianum*, captan and neem cake under pot culture conditions. The trial was designed as a randomized complete block with eight treatments at 45 and 90 days after sowing each replicated three times. The treatment combinations were: 1) untreated control; 2) inoculated with *P. fluorescens* FPD-10; 3) inoculated with *P. fluorescens* FPD-15; 4) inoculated with *T. harzianum*; 5) applied with neem cake; 6) applied with Captan; 7) inoculated with *P. fluorescens* FPD-10 + *T. harzianum* and applied with neem cake + Captan and 8) inoculated with *P. fluorescens* FPD-15 + *T. harzianum* and applied with neem cake + Captan. All the treatments were inoculated with *S. rolfsii* and *Bradyrhizobium* sp. NC-92 at the time of sowing.

Soil type, seeds and fertilizer

The soil used in the study was medium black clay collected from 0-15 cm depth of E-block, plot number 125 of Main Research Station (MRS), UAS, Dharwad. The collected soil was mixed thoroughly, sieved and filled in earthen pots of 30 cm diameter and 30 cm height at the rate of 12 kg pot^{-1}. The required quantity of farm yard manure (90 g pot^{-1}) was added to each pot and then mixed with the soil. The soil used in the trial had a pH of 7.6, organic carbon (0.40%), available nitrogen (170 Kg ha^{-1}), available phosphorus (30 Kg ha^{-1}) and available potassium (290 Kg ha^{-1}). Groundnut (*Arachis hypogaea* L.) seeds of variety JL-24 obtained from MRS, UAS, Dharwad were used in the trial. The recommended dose of fertilizer for groundnut (25:75:25 Kg NPK ha^{-1}) was applied. Nitrogen in the form of urea, phosphorus in the form of single superphosphate and potash in the form of muriate of potash were applied in calculated quantities at the time of sowing.

Seed inoculation and sowing

Disease-free, healthy and bold seeds of var. JL-24 were used for sowing in the pots. Neem cake was added at the rate of 100 kg ha^{-1} as per the treatment schedule. Captan was used at a rate of 3 g kg^{-1} of seeds to treat the seed material before sowing and these seeds were coated with lignite based *Bradyrhizobium* at 300 g $acre^{-1}$ of seed material. Four groundnut seeds per pot were dibbled. As per the treatment details, the antagonist strains of bacteria (FPD-10 and FPD-15) were inoculated to the seeds by adding 5 ml each on each seed and then covered with soil. The culture of *Trichoderma harzianum* was added to the pots at the rate of 20 g Kg^{-1} of soil.

The observations which were recorded during the trials included the number of wilted seedlings up to harvest, total population of fluorescent pseudomonads on the rhizoplane and total population of *T. harzianum* in the rhizosphere soil were assessed at 45 and 90 DAS. The groundnut crop was harvested after 105 days of sowing by uprooting the plants and separating the pods. The total number of pods was counted and their weights recorded. The number of infected pods was counted and their weights were recorded.

Microbial cultures used in the study

The bacterial cultures used in the study were obtained from the Department of Agricultural Microbiology, UAS, Dharwad while the fungal cultures were obtained from the Department of Plant Pathology, UAS, Dharwad.

Preparation of giant culture of *Sclerotium rolfsii*

Sand-corn meal medium was used to prepare the giant culture of *Sclerotium rolfsii* Sacc. It was prepared by mixing 95 parts of sand with 5 parts of maize grits. Twenty kg sand-corn meal medium was prepared and transferred equally to three bottles and sterilized at 15 lb pressure for 30 min. The bottles were inoculated with a fresh culture of *S. rolfsii* and incubated at 27 ± 1°C for 20 days. The bottles were shaken everyday to get uniform growth of *S. rolfsii.* This giant culture was used for the pot culture experiment at the rate of 4% (w/w).

Preparation of *Trichoderma harzianum* culture

T. harzianum culture was prepared by using wheat bran and biogas spent slurry. Both wheat bran and biogas spent slurry were mixed in equal proportions (1: 1). The mixture was placed in a bottle, moistened with water until it was completely wet and then sterilized. Three kilograms of wheat bran and biogas spent slurry was used. The sterilized bottle was inoculated with a fresh culture of *T. harzianum* and incubated at 30°C for 5 days. The culture was used at the rate of 20 g Kg^{-1} of soil in pot culture trials.

Preparation of bacterial antagonist strains

Pseudomonas fluorescens FPD-10 and FPD-15 maintained on King's B agar medium (KBA) (King *et al*. 1954) were multiplied in flasks containing 25 mL of King's B broth for 3 days. The population of FPD-10 and FPD-15 at the time of sowing was 9.5×10^8 and 8.2×10^8 cfu mL^{-1}, respectively.

Enumeration of total fluorescent pseudomonad population on the rhizoplane

The plants were carefully uprooted from the pots at 45 and 90 DAS without damaging the root system. The soil adhering to root system was dislodged and rinsed in sterile tap water. The root system was finally washed with sterile distilled water and air dried. One gram of the sample so obtained was dispensed into 100 mL sterile water blank and shaken for 30 min on a rotary shaker. Following serial dilution technique, different dilutions were prepared and aliquots of one mL were plated for enumeration using KBA. The plates were incubated at 30°C for 48 hrs and colony forming units were recorded.

Enumeration of *Trichoderma harzianum* population in the rhizosphere soil

The rhizosphere soil of groundnut crop was collected and the *T. harzianum* population was assessed by 10-fold serial dilution and plating on *Trichoderma* selective agar medium (TSM). The plates were incubated at 30°C and observations were recorded after 7 days of incubation.

Statistical analysis

Treatments were assigned to the experimental units (pots) in a completely randomized design with three replicates. Sampling and measurements of various response variables were carried out at 45 and 90 days after sowing (DAS). Friedman's Nonparametric ANOVA was applied to test the null hypothesis when analyzing the count data on bacterial and fungal populations. The Bonferroni follow-up procedure was used to compare different treatments (Conover and Iman 1981). Analysis of variance was performed by running general linear model (GLM) procedure of SAS. The threshold level of significance used in *F*-test was $P = 0.05$. Critical difference values were calculated whenever the *F*-test was significant. The means of different treatments were compared using procedure LSMEANS of SAS.

RESULTS

Population of fluorescent pseudomonads on the rhizoplane of groundnut

All the treatments receiving inoculation of either FPD-10 or FPD-15 differed significantly over the untreated control at 45 and 90 days after sowing (DAS). However, the population of fluorescent pseudomonads in the rhizoplane of roots that received captan, neem cake and *T. harzianum* did not differ significantly when compared with the untreated control at 45 DAS (**Fig. 1**). At 90 DAS, the treatment receiving application of captan (36.33×10^5 cfu g^{-1} root sample) had significantly higher population of fluorescent pseudomonads than the untreated control plant roots (31×10^5 cfu g^{-1} root sample) (**Fig. 1**). Among the two fluorescent pseudomonads, FPD-10 was able to enhance the total fluorescent

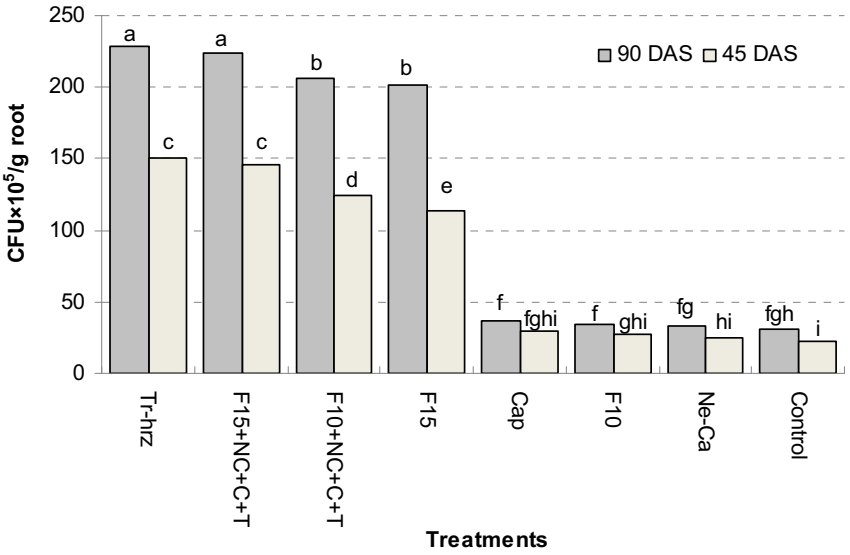

Fig. 1 Population of total fluorescent pseudomonads on the rhizoplane of groundnut (CFU×10^3/g root) inoculated with *Sclerotium rolfsii* at different growth stages. Treatments with the same letter are not significantly different at $p = 0.05$. Treatments: F15+NC+C+T = FPD-15 + neem cake + Captan + *T. harzianum*, F10+NC+C+T = FPD-10 + neem cake + Captan + *T. harzianum*, F10= FPD-10, F15 = FPD-15, Cap = Captan, Ne-Ca = neem cake, Tr-hrz = *Trichoderma harzianum*, Control, DAS = days after sowing.

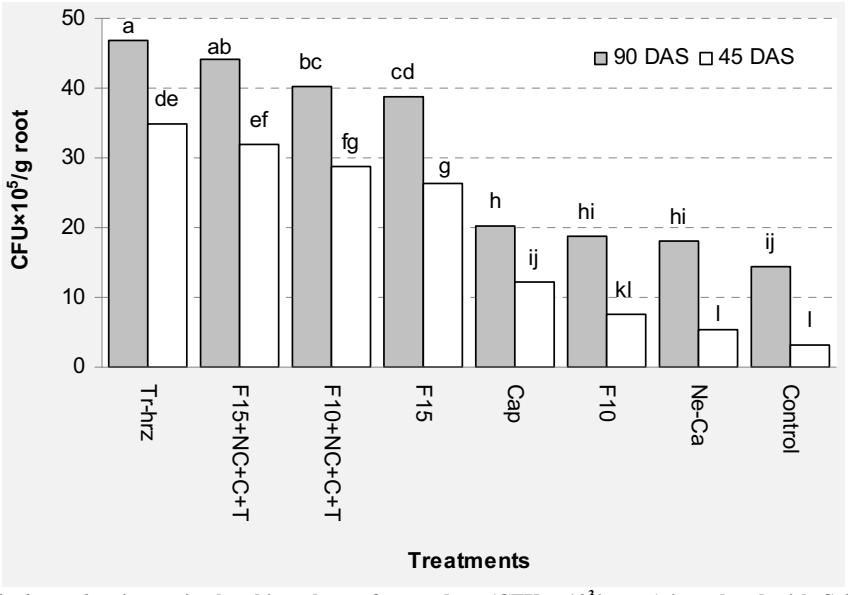

Fig. 2 Population of *Trichoderma harzianum* in the rhizosphere of groundnut (CFU × 10^3/g root) inoculated with *Sclerotium rolfsii* at different growth stages. Treatments with the same letter are not significantly different at $p = 0.05$. Treatments: Tr-hrz = *Trichoderma harzianum*, F15+NC+C+T = FPD-15 + neem cake + Captan + *T. harzianum*, F10+NC+C+T = FPD-10 + neem cake + Captan + *T. harzianum*, F15 = FPD-15, Cap = Captan, F10 = FPD-10, Ne-Ca = neem cake, Control, DAS = days after sowing.

pseudomonad population (125 × 10^5 cfu g^{-1} root sample) than FPD-15 (113 × 10^5 cfu g^{-1} root sample) at 45 DAS. FPD-10 inoculated plants had significantly higher fluorescent pseudomonad population than FPD-15 inoculated plant roots at 90 DAS (**Fig. 1**). The combination of FPD-15 + *Trichoderma harzianum* + neem cake + Captan (150.33 × 10^5 cfu g^{-1} root sample) resulted in higher fluorescent pseudomonad colonies than FPD-10 + *Trichoderma harzianum* + neem cake + Captan (145.33 × 10^5 cfu g^{-1} root sample) but they did not differ significantly at 45 DAS. At 90 DAS, however, both treatments had a higher number of fluorescent pseudomonad colonies than inoculation of FPD-10 and FPD-15 alone at 45 and 90 DAS (**Fig. 1**).

Population of *Trichoderma harzianum* in the rhizosphere of groundnut

The population of *T. harzianum* was highest in the rhizosphere of plants treated with *T. harzianum* alone (35 × 10^3 g^{-1} soil and 42.33 × 10^3 g^{-1} soil at 45 and 90 DAS, respectively). The inoculation of *T. harzianum* alone, FPD-15 + *Trichoderma harzianum* + neem cake + Captan and FPD-10 + *Trichoderma harzianum* + neem cake + Captan gave significant increases in *T. harzianum* population over untreated control at 45 DAS and 90 DAS (**Fig. 2**). The native population of *T. harzianum* in pots increased from 4.67 × 10^3 (at 45 DAS) to 6.00 × 10^3 g^{-1} soil (at 90 DAS). Inoculation of FPD-10 and FPD-15 encouraged the growth of *T. harzianum*, but not significantly. The soil receiving the consortia of antagonists had interestingly lower *T. harzianum* than soils that received *T. harzianum* alone (**Fig. 2**). Addition of neem cake improved native *T. harzianum* population from 6.00 × 10^3 to 9.00 × 10^3 g^{-1} soil, but the difference was not significant.

Pod weight per plant

The fresh weights of pods were recorded and it was found that the pod weight increased in seeds treated with biocontrol agents and captan. Among the treatments tested, inocu-

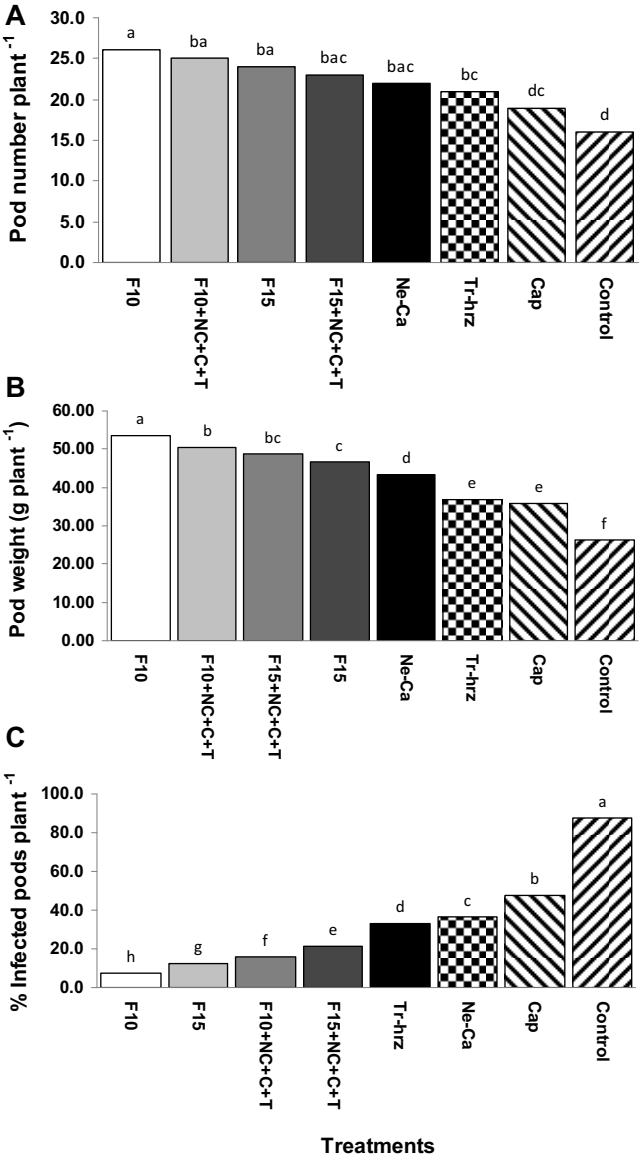

Fig. 3 Effect of pathogen control agents on yield parameters [A (pod number), B (pod weight)] and disease severity (C) of groundnut inoculated with *Sclerotium rolfsii.* Bars with the same letter are not significantly ($p \leq 0.05$) different from each other. Treatments: Cap = Captan, Control, F10 = FPD-10, F10+NC+C+T = FPD-10 + neem cake + Captan + *T. harzianum*, F15+NC+C+T = FPD-15 + neem cake + Captan + *T. harzianum*, F15 = FPD-15, Ne-Ca = neem cake, Tr-hrz = *Trichoderma harzianum.*

lation of FPD-10 resulted in highest pod yield (53.4 g), prominently higher than untreated control (26.1 g). Inoculation of FPD-10 and FPD-15 recorded significantly higher pod yield than the plants that received seed treatment with captan, addition of neem cake and *T. harzianum* (**Fig. 3A**). Integrated control with FPD-10 recorded significantly higher pod yield (50.5 g) than integrated control with FPD-15 (48.9 g). The consortia performed significantly better than individual treatment with *T. harzianum*, captan and neem cake with regard to pod yield (**Fig. 3A**).

Pod number per plant

The pod number per plant was highest in plants inoculated with FPD-10 (26) followed by the treatment receiving FPD-10 + *T. harzianum* + neem cake + Captan (25). The plants inoculated with FPD-10 had higher number of pods per plant than plants that were inoculated with FPD-15 and *T. harzianum* alone. The number of pods recorded from plants inoculated with FPD-10 differed significantly compared to plants that received seed treatment with captan, addition of neem cake and *T. harzianum* (**Fig. 3B**). The combination of FPD-10 + *T. harzianum* + neem cake + Captan (25) recorded higher pod numbers compared to the treatment FPD-15 + *T. harzianum* + neem cake + Captan (23) (**Fig. 3B**) but they did not differ significantly with each other. Although the plants treated with neem cake recorded higher pod numbers per plant than plants treated with captan and *T. harzianum*, the difference was not significant (**Fig. 3B**).

Percent infected pods

The percentage of pods infected with *S. rolfsii* was highest in the untreated control treatment (87.5%) while the lowest percentage of pods infected with *S. rolfsii* was recorded in plants that received inoculation of FPD-10 (7.7%) followed by FPD-15 (12.5%) (**Fig. 3C**). Both FPD-10 and FPD-15 significantly reduced the percentage of infected pods compared to the untreated control, *T. harzianum*, captan and neem cake. Although integrated control containing bacterial strains, *T. harzianum*, captan, and neem cake reduced the percentage of infected pods, it was significantly lower than the reduction of infection brought about by FPD-10. The integrated approach also significantly reduced the percentage of infected pods as compared to seed treatment with captan (**Fig. 3C**).

DISCUSSION

Agricultural practices currently are chemical intensive and currency demanding and this chemical intensive nature has resulted in excessive and indiscriminate reliance on both pesticide and fertilizer application and this in turn has resulted in a drastic change in the soil structure and chemical properties apart from creating pollution problems. Sustainable agriculture therefore aims at integrated use of biocontrol agents, organic matter and chemical control measures. Hence the feasibility of using *Pseudomonas fluorescens* FPD-10 and FPD-15 along with *Trichoderma harzianum*, captan and neem cake in controlling *Sclerotium rolfsii* was studied and the results pertaining to that trial are discussed in this section.

In the present trial among the two fluorescent pseudomonads, *Pseudomonas fluorescens* FPD-10 was able to enhance the population of total fluorescent pseudomonads much higher than *P. fluorescens* FPD-15 at both days of sampling (45 and 90 DAS). In studies conducted earlier it has been reported that FPD-10 has a better potential to colonize groundnut roots than FPD-15 (Patil *et al*. 1998). The population of introduced antagonistic strains FPD-10 and FPD-15 increased rapidly and brought down the number of *Sclerotium rolfsii* infected pods. In addition to that these strains of *P. fluorescens* increased the number and weight of pods significantly compared to the control and other treatments. The efficiency in increasing the number and weight of pods and decreasing the percentage of infected pods was significantly better in FPD-10 treated plants compared to all other treatments. Similarly, when *P. aeruginosa* was applied as seed treatment, it rapidly colonized groundnut rhizosphere and was able to control collar rot disease (Kishore *et al*. 2005). The use of either *P. fluorescens* or *Trichoderma virens* or Thiram alone or in combination with each other significantly reduced the stem rot caused by *S. rolfsii* in groundnut plants compared to control under greenhouse conditions (Manjula *et al*. 2004). In another trial, pre-treatment of peanut seeds with *Bacillus subtilis* protected peanut seeds from the negative effect of *S. rolfsii* and significantly increased growth parameters of pods compared with the negative control (Abd-Allah 2005). Seed treatment of chick pea seeds with either *P. fluorescens* strain *Pf4* and *P. aeruginosa* strain *Pag*, protected the field grown plants from *S. rolfsii* infection (Singh *et al*. 2003). The plant mortality rates were significantly lower in bacterized seeds compared to untreated control. Abeysinghe (2009) studied the biocontrol efficacy of *Pseudomonas fluorescens* CA05, *Pseudo-*

monas putida CA28 and *Bacillus subtilis* CA32 alone and in combination was tested against *Rhizoctonia solani* and *S. rolfsii* under greenhouse conditions. The *R. solani* and *S. rolfsii* populations were dramatically reduced after 30 days of transplanting in bacterial treated pots compared to the controls indicating the biocontrol ability of these rhizobacteria. He suggested that a combination of *B. subtilis* with *Pseudomondas* strains can lead to greater plant protection against *R. solani* and *S. rolfsii* than the biocontrol exhibited by these strains when they were used individually.

The mechanisms by which these fluorescent pseudomonads and all other plant growth promoting rhizobacteria bring about biocontrol has been attributed to the production of siderophores (Pal *et al*. 2001), antibiotics (Anjaiah *et al*. 1998; Pal *et al*. 2001), cyanide (Pal *et al*. 2000), lytic enzymes (Chernin and Chet 2002) and competition for infection sites and nutrients (Mohamed and Caunter 1995) and induction of systemic resistance in the host plant (Liu *et al*. 1995).

The use of *T. harzianum* alone also significantly reduced the pod infection and improved the pod yield compared to the control. Similarly, four isolates of *Trichoderma* spp. significantly reduced the disease incidence of stem rot of tomato plants caused by *S. rolfsii* in field trials and increased the yield compared to control (Chamswarng *et al*. 1992). In another greenhouse trial, inoculation of mint plants with either *T. harzianum* or *T. virens* significantly reduced the collar rot caused by *S. rolfsii* and was accompanied by significant increase in herb and oil yield (Singh and Singh 2004). Application of *Trichoderma* spp. to pine seedlings brought about a 57% reduction in damping-off in pine seedlings caused by *S. rolfsii* under greenhouse conditions (Widyastuti *et al*. 2003). Although the combination of *T. harzianum*, neem cake and captan along with either FPD-10 or FPD-15 did not give similar results as single inoculations of FPD-10 or FPD-15, it did significantly reduce the pod infection caused by *S. rolfsii*. The application of *T. harzianum*, captan and neem seed extract two days after pathogen inoculation significantly reduced damping off disease caused by *S. rolfsii* in greenhouse grown tomato plants (Okereke and Wokocha 2006). The level of disease suppression in their studies was much higher in *T. harzianum* treated plants compared to captan and neem seed extract treated tomato plants which is similar to the results obtained in our trials with groundnut plants. In another study soil application of *T. viride*, *P. fluorescens*, neem cake, *T. viride* + neem cake, *P. fluorescens* + neem cake significantly reduced the stem rot incidence compared to control in groundnut plants 60 days after sowing (Karthikeyan *et al*. 2006). Bosah *et al*. (2010) reported that *Trichoderma* spp. proved to be the most effective biocontrol agent against *S. rolfsii* and inhibited the growth of the pathogen by 80% under *in vitro* conditions. Similarly, mutants of *Trichoderma harzianum* 4572 significantly controlled the growth of *S. rolfsii* compared to the wild type strain in soybean plants under both glasshouse and field conditions (Singh and Upadhyay 2009). In another trial, seeds of both mungbean and sunflower pelleted with conidia of *Trichoderma harzianum* reduced the incidence of *S. rolfsii* and significantly increased plant height of both mungbean and sunflower plants compared to control and other antagonists (Yaqub and Shahzad 2008).

The improved native population of *T. harzianum* observed due to inoculation of FPD-10 and FPD-15 indicates a positive interaction. The treatments receiving application of *T. harzianum* significantly reduced the infection caused by *S. rolfsii* and reduced the number of infected pods. Similar results of significant reductions in the activity of *S. rolfsii* by treatment of peanut plants with *T. harzianum* have been reported earlier in other studies (Muthamilan and Jayarajan 1996; Ganesan and Sekar 2004; Ganesan *et al*. 2007). The treatment receiving application of *T. harzianum* in this trial significantly improved the yield parameters of peanut. Similarly, the application of *T. harzianum* significantly increased the growth and yield parameters of peanut crop compared to the control (Ganesan *et al*. 2007).

The mechanisms involved in inhibition of pathogens by biocontrol agents are more complex and it varies with antagonist, pathogen and the host which are involved in the interaction. However, the mechanisms are affected by soil type, temperature, pH, plant moisture, soil environment and presence of other members of soil microflora. The idea of using several biocontrol agents, chemicals and organic amendments with several mechanisms of control fits in well with the concepts of integrated pest management wherein several means of disease suppression are applied concurrently. In this scenario when one or more means/mechanisms are not effective the others will compensate for the absence of the former mechanism (Guetsky *et al*. 2002). Studies conducted earlier have suggested using more than one type of bioagent for the management *S. rolfsii* in addition to using both chemical and bio agent tools for its better management (Palaiah *et al*. 2007). It is suggested that further screening of these PGPR strains for biocontrol potential of other plant pathogens might confirm the range of biocontrol activity. Field experimentations to conclusively prove the biocontrol potential of FPD-10 and FPD-15 in addition to test all other treatments are necessary for their commercial exploitation.

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